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The Institution of Engineers (India) Forum

The Global Energy Transition: An India perspective

30 June 2022

Agenda

- The global energy transition is accelerating, driven by the convergence of factors:
 - 1. Technology-Driven Deflation in Renewables (=> FF hyperinflation)
 - 2. Global Policy Developments in Decarbonisation
 - 3. CO_2 Pricing (& CBAM)
 - 4. Global Finance Zero Emissions (GFANZ) Pledges US\$130 trillion
 - 5. The Climate Science
- Global Capital Flight from Fossil Fuels, Yet to Sufficiently Pivot
- Australia's Integrated System Plan (ISP) to 2050
- India's Ambitious 450GW of VRE by 2030
- The Convergence of Power, Industry and Transport Sectors
- Green Hydrogen Huge Hype, But Capital is Flowing

The global energy transition is accelerating. This is driven by the convergence of 5 factors

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1. Technology-Driven Deflation

Ongoing Renewable Energy and Battery Deflation



Source: Bloomberg New Energy Finance

1. Technology-Driven Deflation

RE deflation has given way to fossil fuel hyperinflation in 2022





2. Global Policy Developments



* Bubbles show targets; dashed lines show indicative paths to achieve them; Japan and South Korea's greenhouse gas targets are shown in terms of carbon dioxide; China's 2030 target is authors' estimate based on carbon intensity target for 2030 and authorities' desire for GDP growth to 2035

Sources: CEIC Data; International Energy Agency; RBA

3. Emissions – CO₂ Prices are Rocketing Up

The Five-Year EU ETS Pricing (\mathcal{E}/t)



4. Global Finance Zero Emissions Pledges

UN Net Zero Finance Alliance 1.5°C

New Financial Alliance for Net Zero Emissions Launches

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PRESS RELEASE ISSUED ON BEHALF OF THE COP25 and COP26 CLIMATE CHAMPIONS

Industry-led and UN-convened Net Zero Banking Alliance also announced today, co-launched by the UNEP Finance Initiative and the Financial Services Taskforce of the Sustainable Markets Initiative

• The Glasgow Financial Alliance for Net Zero (GFANZ), chaired by Mark Carney, UN Special Envoy on Climate Action and Finance, brings together over 160 firms (together responsible for assets in excess of \$70 trillion¹) from the leading net zero initiatives across the financial system to accelerate the transition to net zero emissions by 2050 at the latest.

• All GFANZ member alliances must be accredited by the UN Race to Zero campaign. They must use sciencebased guidelines to reach net zero emissions, cover all emission scopes, include 2030 interim target setting, and commit to transparent reporting and accounting in line with the UN Race to Zero criteria.

• 43 banks from 23 countries (with assets of \$28.5 trillion) form the Net-Zero Banking Alliance (NZBA) today - which joins GFANZ - with its members committing to align operational and attributable emissions from their portfolios with pathways to net-zero by 2050 or sooner.

US\$130 trillion by Nov 2021 (+90% in 6 months)

A Tectonic Shift Accelerates

In January of last year, I wrote that climate risk is investment risk. I said then that as markets started to price climate risk into the value of securities, it would spark a fundamental reallocation of capital. Then the pandemic took hold – and in March, the conventional wisdom was the crisis would divert attention from climate. **But just the opposite took place, and the reallocation of capital accelerated even faster than I anticipated.**

From January through November 2020, investors in mutual funds and ETFs invested \$288 billion globally in sustainable assets, a 96% increase over the whole of 2019.¹ I believe that this is the beginning of a <u>long but rapidly accelerating transition</u> – one that will unfold over many years and reshape asset prices of every type. We know that climate risk is investment risk. But we also believe the climate transition presents a historic investment opportunity.

BlackRock (AuM US\$10 trillion) Larry Fink 2021 CEO Letter

5. The Climate Science

There is no economy on an unliveable planet



Fossil Fuel Capital Flight

Incumbent Fossil Fuel Capital Flight

Capital Flight from Fossil Fuels, but Not Sufficient Scaling Up on RE

There is a wide range of investment strategies across different parts of the oil and gas industry; only the Middle East NOCs are planning to spend more in 2022 than in 2019



Incumbent Fossil Fuel Capital Flight

Looking at the Global Power Sector – Thermal Power's share is small, and shrinking

Solar PV is leading power sector investment, with positive signs for transmission and distribution networks and an acceleration in battery energy storage



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Notes: Gas-fired generation investment includes both large-scale plants and small-scale generating sets and engines; hydropower includes pumped-hydro storage. Sources: IEA analysis based on calculations from IRENA (2022) and Platts (2022).

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China Leads the World on RE Investing



Source: IEA World Energy Investment 2022 Notes: RPG = renewable power generation; FFPG = fossil fuel power generation.

> China leads the world on wind & solar installs & manufacturing, EV & batteries, hydro, PHS, nuclear, grid T&D + smart meters – and H2.

Chinese chemical manufacturer Ningxia Baofeng Energy Group has commissioned the world's largest green hydrogen project in central China's Ningxia Autonomous Region with a 150MW alkaline electrolyser powered by a 200MW solar array.

Baofeng Energy's unprecedented facility achieves full commissioning as Chinese oil giant Sinopec breaks ground on 260MW plant

Australia's Electricity Sector

Australia's Electricity Sector

Australia's Integrated System Plan to 2050



Source: AEMO ISP, 30 June 2022

India's Electricity Sector

VRE installs doubled in 2021/22, but need to double again to 35-40GW pa.

India's Electricity Capacity and Generation (FY2021/22)

	Capacity		Generation		Capacity	Increase
	GW	%	TWh	%	Utilisation	GW yoy
Coal-fired	210.7	52.7%	1,015.7	71.8%	55.2%	1.4
Gas-fired	24.9	6.2%	31.3	2.2%	14.3%	0.0
Diesel-fired	0.5	0.1%	0.5	0.0%	12.0%	0.0
Large Hydro	46.7	11.7%	163.4	11.6%	40.2%	0.5
Nuclear	6.8	1.7%	42.2	3.0%	71.1%	0.0
Renewables	109.9	27.5%	152.5	10.8%	17.0%	15.4
Bhutan (Import)	n.a	n.a	8.8	0.6%	n.a.	
Total	399.5	100.0%	1,414.5	100.0%		17.3

Source: CEA, CEF Calculations

VRE installs doubled in 2021/22, but needs to double again to 35-40GW pa. FY2022/23 off to a good start, 3.3GW of VRE in 2 months, 101% of net new capacity adds.

India's Installed Electricity Capacity (GW) end FY2021/22 vs YTDFY2022/23

Generation Source	Mar-22	May-22	Change (GW)	% of new capacity
Renewables	109.9	113.2	3.3	101%
Large Hydro	46.7	46.7	0.0	0%
Nuclear	6.8	6.8	0.0	0%
Thermal	236.1	236.1	0.0	-1%
Total Ongrid Capacity	399.5	402.8	3.3	100%

Source: CEA, MNRE, Climate Energy Finance calculations

NTPC's 92 MW Kayamkulam floating solar project now fully operational

The 92 MW Kayamkulam floating solar project in Kerala is now fully operational, with its last-part capacity of 35 MW commissioned recently.

JUNE 25, 2022 UMA GUPTA

FLOATING SOLAR HIGHLIGHTS KERALA

With this plant's commissioning, NTPC has now built over 2GW of VRE, underpinning a clear start in its critically important transition from a thermal power giant to an Indian energy leader.



Image: NTPC

Share f 🎔 in 🕲 😂

NTPC, India's largest integrated energy company, has declared its 92 MW Kayamkulam floating solar project in Kerala is now fully commissioned, with its last-part capacity of 35 MW starting to feed electricity into the grid recently.

VRE is a third of the price of imported thermal power generation, and half the price of new pithead coal power in India.

Tipping points for energy transition in the power sector



Levelized cost of electricity

Source: EY Analysis Note: Fully installed BESS capex is exclusive of duties & taxes

India has 102GW of contracted renewables capacity in the pipeline

Contracted capacity of utility scale RE power generation projects in pipeline (MW)								
RE Technology		Total						
	Announced	Permitting	Under Construction	(MW)				
Biomass	61			61				
Floating solar	890	444	345	1,679				
Hybrid (Solar +wind)	1,950	4,270	2,485	8,705				
Open access	4,540	605	3,108	8,253				
RE + Storage	111	1,220	35	1,366				
Solar PV	16,717	34,269	9,973	60,959				
Storage	7,490			7,490				
Wind	4,545	2,558	7,148	14,251				
Grand Total	36,304	43,366	23,094	1,02,764				

Source: EY Analysis based on JMK Research

The good news is the global & Indian capital capacity is building, rapidly

Tim Buckley, Director Energy Finance Studies Saurabh Trivedi, Research Analyst February 2021



Institute for Energy Economics and Financial Analysis IEEFA.org

Capital Flows Underpinning India's Energy Transformation

Global Capital Is Primed and Ready

Executive Summary

With India recording an 18% year-on-year decline to a new record low solar tariff of Rs1.99/kWh with zero inflation indexation - which translates into a levelised cost of energy (LCOE) of below Rs1.30/kWh - solar continues on its strongly deflationary trajectory. Even the pandemic is unable to stop this momentum, with solar module costs dropping 20% year-on-year. Hero Future Energies CEO Sunil Jain forecasts that Indian solar will likely reach just Rs1.00/kWh by 2030, delivering India massive energy security and deflation benefits, while also helping to address the need for sustainable growth.

While ongoing economies of scale and technology improvements are driving double digit annual cost reductions in solar modules, the solar deflation of 2020 was equally driven by dramatically lower interest rates - with long term OECD rates hitting six-decade lows of just 0-1%. This in turn is driving global capital managers to seek out higher return opportunities, and the US\$500bn electricity infrastructure opportunity presented by India offers this in spades. Backed by clarity, transparency and relative stability of government energy and climate policy under Prime Minister Narendra Modi, the offer of 25-year power purchase agreements at scale, secured by a central government sovereign guarantee, is mobilising a huge global capital pool.

Whilst 2020 saw economic setbacks in India, the year also saw significant capacity building in the renewable and grid infrastructure sectors, with a deepening of the engineering, procurement and construction (EPC), management and financing capacity across India which will likely pay dividends in 2021 and beyond.

BlackRock-led consortium to invest Rs 4,000 cr in Tata Power Renewables

The BLK SPV, along with Mubadala as co-investor, will invest Rs 4,000 crore in two equal tranches of Rs 2,000 crore each

Business Standard Web Team 14 April 2022



Tata Power said on Thursday that a BlackRock Real Assets-led consortium, including Mubadala Investment Company, would invest Rs 4,000 crore for a 10.53% stake in the company's renewable energy unit. This translates to a base equity valuation of Rs 34,000 crore for Tata Power Renewables, the company said in a stock exchange filing.

Key investors are finding opportunity in India's \$500bn renewable energy infrastructure development market. Indian entities with more than 100MW of operational assets are shown.

Renew Power (5,400MW) Goldman Sachs CPPIB (Canada) Abu Dhabi Investment Authority GS E&C (South Korea)

Greenko Energy (4,800MW) GIC (Singapore) Abu Dhabi Investment Authority ORIX Corp (Japan)

Adani Green Energy Ltd (3,125MW) Adani Family Total (France)

Tata Power / Tata Cleantech Capital (2,667MW) Tata Group

ACME Group (2,500MW)

SB Energy (2,000MW) CPPIB (Canada) Bharti India

Azure Power (1,800MW) CDPQ (Canada)

Green Infra Wind Energy Limited (1,730MW) Sembcorp (Singapore)

NLC Limited (1,421MW) Government of India

Hero Future Energies (1,300MW) Hero MotoCorp Masdar Clean Energy (Abu Dhabi) IFC Global Infrastructure Fund

NTPC Ltd (1,070MW) Government of India

O2 Power (n/a) EQT (Sweden) Temasek (Singapore)

Engle of France (813MW) Edelweiss (India)

Note: These figures exclude hydro.

Torrent Power (787MW) Mehta Family

Continuum Wind Energy (757MW) Morgan Stanley Infrastructure Partners

Vector Green Energy (652MW) Global Infrastructure Partners

Spring Energy (648MW) Actis Capital UK

Vena Energy (595MW) Global Infrastructure Partners GIC (Singapore) PSP Investments (Canada)

Blueleaf (474MW) Macquarie Group

Amplus Energy Solutions (450MW) PETRONAS Group (Malaysia)

Actis Long Life Infrastructure Fund (400MW) Actis Capital UK

Virescent Infrastructure (317MW) KKR US

Green Growth Equity Fund / Ayana Renewable Power (300MW) National Investment and Infrastructure Fund CPPIB (Canada) Ontario Teachers' Pension Plan AustralianSuper Abu Dhabi Investment Authority CDC Group UK Lightsource BP / BP Plc

Fortum (250MW) Fortum (Finland) EDEN Renewables (207MW) Total Eren EDF Renewables

ENEL India (172MW) ENEL (Italy)

Cleantech Solar (n/a) Shell Climate Fund Managers (Netherlands)

Rising Sun Energy (140MW) Yinson Holding / Yinson (Malaysia)

NHPC Ltd (100MW) Government of India

Fourth Partner Energy (n/a) TPG US ResponAbility Investments (Switzerland)

Key Investor Category

Private Equity

Sovereign Wealth Funds

Global Pensions and Infrastructure Funds

Global Fossil Fuel Utilities

Oil and Gas Majors

Indian Power Billionaires

Indian Government Finance Organizations

Multilateral Development Banks and Development Finance Institutions

Indian State-Owned Enterprises

Other players

India: 450GW by 2030: Capacity Building

Industry-Energy-Transport Convergence

²⁴ Industry-Energy-Transport Convergence: Global Investor Demands

Rio Tinto to strengthen performance, decarbonise and grow



20 October 2021

LONDON--(BUSINESS WIRE)-- Today, Rio Tinto is outlining the actions being taken to strengthen the business and improve performance. It is also unveiling a longer-term strategy to ensure it thrives in a decarbonising world and continues to deliver attractive shareholder returns, in line with its policy.

The deployment of the Rio Tinto Safe Production System is underway to ensure the Group regains its position as Best Operator. The Group is combining systematic long-term programmes with rapid improvement activities targeted at bottlenecks in order to reduce operational variability and increase resilience.

Governments are setting more ambitious targets and accelerating actions on climate change. Society at large is also demanding companies take more action to decarbonise. To meet the challenge, stay relevant and capture the opportunity Rio Tinto is raising its ambition and taking actions.

The Group is unveiling a new target to reduce its Scope 1 & 2 carbon emissions by 50 per cent by 2030, more than tripling its previous target. A 15 per cent reduction in emissions is now targeted for 2025, five years earlier than previously. These targets are supported by around \$7.5 billion of direct investments to lower emissions between 2022 and 2030.

²⁵ Industry-Energy-Transport Convergence: Green Steel

SSAB / Vattenfall / LKAB HYBRIT £3.56bn Investment plan



Regulatory press releases

SSAB plans a new Nordic production system and to bring forward the green transition

JANUARY 28, 2022 7:15 CET

5 MIN RE/

SSAB's Board has taken a policy decision to fundamentally transform Nordic strip production and accelerate the company's green transition. The decision was taken against the background of strongly growing demand for fossil-free steel. The plan is to replace the existing system with new mini-mill technology, which will result in a broader product program and improved cost position. The ambition is to largely eliminate carbon dioxide emissions around 2030, 15 years earlier than previously announced. However, to achieve this ambition, the necessary infrastructure, access to fossil-free electricity in particular, must be in place in time.

Source: SSAB Sweden, 28 January 2022: https://www.ssab.com/en/news/2022/01/ssab-plans-a-new-nordic-production-system-and-to-bring-forward-the-green-transition

Green Hydrogen

The Scaling Up of Hydrogen

Electrolyser Installs: Scaling Up 10-fold in 2 Years

Capacity of electrolysers for hydrogen production by commissioning year, by intended use of hydrogen, 2010-2022E



Notes: 2022E values represent estimates based on successful completion of all projects publicly stating a 2022 commissioning data as of the start of 2022. MWe = megawatts of electricity input; in some cases, this is calculated from hydrogen output volumes where otherwise not stated. Includes electrolysers for the supply of hydrogen for energy purposes or as an alternative to fossil fuels in industry, such as chemical production and oil refining.

India: 5Mtpa of GH2 by 2030

Energy Minister RK Singh considering a mandatory purchase obligation for 10% GH2 on fertiliser, refineries & steel in initial years.

India's new interim H2 strategy 'will push down cost of green hydrogen by up to 75% by 2030'



23 February 2022 By Leigh Collins Recharge 1

India's decision last week to waive electricity transmission fees for green hydrogen production will help reduce the cost of renewable H₂ to about \$1.50/kg by 2030 — as much as 75% lower than today's prices, according to a senior Indian oil company executive.

India unveiled the first part of its national hydrogen strategy last week, which amounted to less than two pages of bullet points — the most significant of which was the waiver of interstate transmission charges for 25 years for green hydrogen and ammonia projects commissioned before 30 June 2025.

This would reduce costs by as much as 50%, according to SSV Ramakumar, director for research and development at Indian Oil Corporation, the country's largest oil refiner and biggest hydrogen consumer. "Now, more or less, we will get green electricity almost at the cost of production," he said. "That is going to push down the green hydrogen production cost by up to 40-50%, subject to the cost of the electrolyser."

The removal of inter-state transmission fees would help push the cost of green hydrogen from about \$5-6/kg today to below \$2/kg over the next five to six years, and to around \$1.50/kg by the end of the decade, he said.

(US\$/Kg_H2) 4.002.00 0.00 2021 2025 2030 2035 2040 2045 2050 Gray hydrogen (gas) Gray hydrogen (coal) Blue hydrogen (coal) Blue hydrogen (gas) Green hydrogen (solar)

Source: Forecasts and graph compiled by MGSSI based on data from BloombergNEF

Figure 7: Hydrogen production cost (LCOH2) forecasts (India)

India: A Huge Domestic Market Potential

India's top two billionaires have announced huge 2030 aspirations

Adani And TotalEnergies To Create The World's Largest Green Hydrogen Ecosystem



Adani New Industries Ltd to invest USD 50 Bn in green hydrogen

This is India's largest commitment to green hydrogen by a company

Ahmedabad, **14 June 2022**. Adani, India's fastest-growing diversified business portfolio, and energy supermajor TotalEnergies of France, have entered into a new partnership to jointly create the world's largest green hydrogen ecosystem. In this strategic alliance, TotalEnergies will acquire 25% minority interest in Adani New Industries Ltd (ANIL) from Adani Enterprises Ltd (AEL).

The new partnership, centered on green hydrogen, is expected to transform the energy landscape both in India and globally. Both Adani and TotalEnergies are pioneers in energy transition and clean energy adoption, and this joint energy platform further strengthens the public ESG commitments made by both companies.

ANIL's ambition is to invest over USD 50 billion over the next 10 years in green hydrogen and associated ecosystem. In the initial phase, ANIL will develop green hydrogen production capacity of 1 million ton per annum before 2030.

India: A Huge Domestic Market Potential

India's top two billionaires have announced huge 2030 aspirations

Reliance's \$75 billion plan aims to make India a hydrogen hub

Analysts say Reliance is likely to opt for hydrogen in a bid to avoid India's wholesale electricity market, which is dominated by financially stressed utilities

Rajesh Kumar Singh & Debjit Chakraborty | Bloomberg January 30, 2022



Billionaire Mukesh Ambani's ambitious effort to pivot his conglomerate <u>Reliance Industries</u> Ltd. toward green energy could transform India into a clean-<u>hydrogen</u> juggernaut.

Ambani, Asia's richest man, announced plans earlier this month to invest \$75 billion in renewables infrastructure including generation plants, solar panels and electrolyzers. There is growing speculation that the strategy entails transforming all of that clean power into hydrogen, one of the largest endorsements in the next-generation fuel.

Analysts say Reliance is likely to opt for <u>hydrogen</u> in a bid to avoid India's wholesale electricity market, which is dominated by financially stressed utilities and plagued by delayed payments.

"Reliance is preparing itself to capture the entire value chain of the green <u>hydrogen</u> economy," said Gagan Sidhu, director at the Centre for Energy Finance at New Delhi-based think tank. "They clearly have seen the writing on the wall."

Green hydrogen -- made from water and clean electricity -- is seen as crucial for the world's emissions reduction goals, helping consumers and key industries such as steel transition to lower-carbon fuels. Prime Minister Narendra Modi last year announced a plan to make India, the world's third-biggest emitter of greenhouse gases and a major energy importer, into a global hub for production and export of the fuel.

Reliance Industries seeks to be world's top blue hydrogen maker

RIL will re-purpose a Rs 30,000-crore plant that currently converts petroleum coke into synthesis gas to produce blue hydrogen for US\$1.2-1.5 a kg

Press Trust of India 12 Feb 2022



This second article suggests some backsliding by RIL – absent a carbon price, GH2 costs more than fossil H2 (and there is no such thing as blue H2 in India).

Billionaire Mukesh Ambani's <u>Reliance Industries</u> Ltd is targeting to become one of the largest producers of blue <u>hydrogen</u> globally, producing the zero-emission fuel at costs that will be half of the global average. The operator of the world's largest oil refining complex will re-purpose a Rs 30,000 crore plant that currently converts petroleum coke into synthesis gas to produce blue <u>hydrogen</u> for \$1.2-1.5/kg, Reliance said in a presentation detailing the separation plan.

Reliance, which has set a net-zero carbon emission target for its businesses by 2035, is looking at blue hydrogen in the interim period to reduction in cost of green hydrogen. "In the interim, till cost of green hydrogen comes down, RIL can be the first mover to establish a hydrogen ecosystem, with minimal incremental investment, in India." RIL said.

Syngas has potential to produce hydrogen at a competitive cost of \$1.2-1.5 per kg, it said. Green hydrogen produced with renewable resources costs between \$3-6.55 per kg, according to the European Commission's July 2020 hydrogen strategy.

Fossil-based hydrogen costs about \$1.80, and the commission estimated the cost of blue hydrogen at about \$2.40-3/kg. Ambani had previously stated that his group is aiming to produce green hydrogen at \$1/kg by the turn of this decade. Last month, he announced plans to invest about \$75 billion in renewables infrastructure.

Oz: BP Builds Out its GH2 Potential

bp to lead and operate one of the <u>worlds</u> largest renewables and green hydrogen energy hubs based in Western Australia

BP PRESS RELEASE: 15 June 2022



Australia

bp today agreed to acquire a 40.5% equity stake in and to become operator of the Asian Renewable Energy Hub (AREH), which has the potential to be one of the largest renewables and green hydrogen hubs in the world.

- bp to take a 40.5% stake and operatorship of the AREH project in the Pilbara, WA
- AREH to support development of up to 26GW of combined solar and wind power generating capacity
- At full scale AREH could produce 1.6 Mtpa of green hydrogen or 9 Mtpa of green ammonia making it one the largest green hydrogen projects in the world

Based on the development of world-scale renewable power generation, AREH, in the Pilbara region of Western Australia, intends to supply renewable power to local customers in the largest mining region in the world and also produce green hydrogen and green ammonia for the domestic Australian market and export to major international users.

This important announcement is all about leading EU Oil Majors scaling up RE / GH2 ambition and project proposal pipelines towards the ~50GW by 2030 levels. But a price on GH2 is key to making viable long term PPAs commercially available – no sign of that in Japan or Korea as yet.