VASUDHA FOUNDATION
Green ways for a good earth!

MARCH 2023

CAPTURING A DECADE OF INDIA'S CLEAN ENERGY JOURNEY

The Coffee Table Book 'Capturing a decade of India's Clean Energy Journey' is the eighth edition of the India Power Outlook Series Initiative by Vasudha Foundation. The Power Outlook Series Initiative is an endeavor to provide the current status of India's power and energy sector with a focus on significant and emerging developments. The quarterly series is aimed at developing a more informed understanding of the sector by analysing key trends and transitions, thus enabling informed dialogues amongst various stakeholders. We hope this series offers help to all stakeholders to navigate various developments shaping the clean energy transition. Moreover, we focus on what is required for relieving the sector of its inefficiencies and shortcomings.

Volume 8 comprehensively captures the key transitions and developments that the energy sector witnessed in the last decade. It further elaborates on the current and critical developments such as green hydrogen, e-mobility, new solar and wind technological developments, energy-efficient appliances, etc., that will shape the clean energy journey for India. The themes of the last seven volumes are captured below:

Volume 1: Current State of Play – February 2020
Provides a brief narrative of the Indian power sector and its policy implications across the power sector value chain.

Volume 2: The Road to Clean Electricity - July 2020
Provides an overview of renewable energy in India and assesses its progress across the value chain.

Volume 3: Unpacking the impact of electricity demand – February 2021
Deep dives into assessing the impacts of electricity demand.

Volume 4: Decarbonizing the Power Sector: October 2021
Discusses the role of states and end-users in its race to decarbonize the power sector.

Volume 5: India's 2030 targets: Stepping stones to Net Zero by 2070- March 2022
Captures the high-level insights of the COP 26 and a sentiment analysis

Volume 6: Clean Energy Policy Update- June 2022
A compendium of the latest clean energy initiatives

Volume 7: Building Power Sector Resilience under extreme weather conditions- September 2022
Conducts a thorough assessment of the rise in extreme weather events and its possible impacts on the power sector value chain

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March, 2023
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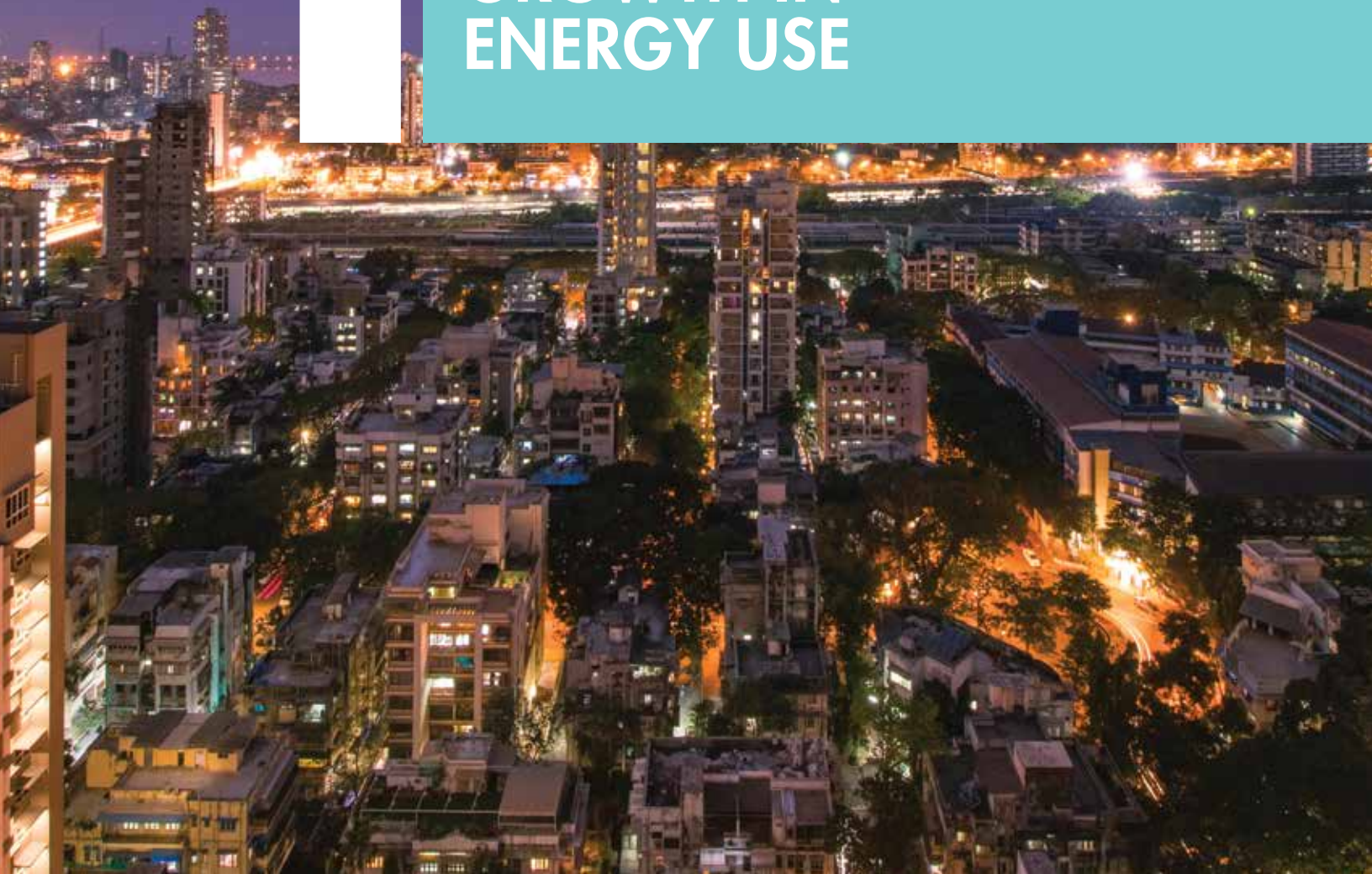
CAPTURING A DECADE OF INDIA'S CLEAN ENERGY JOURNEY

CONTENTS

1

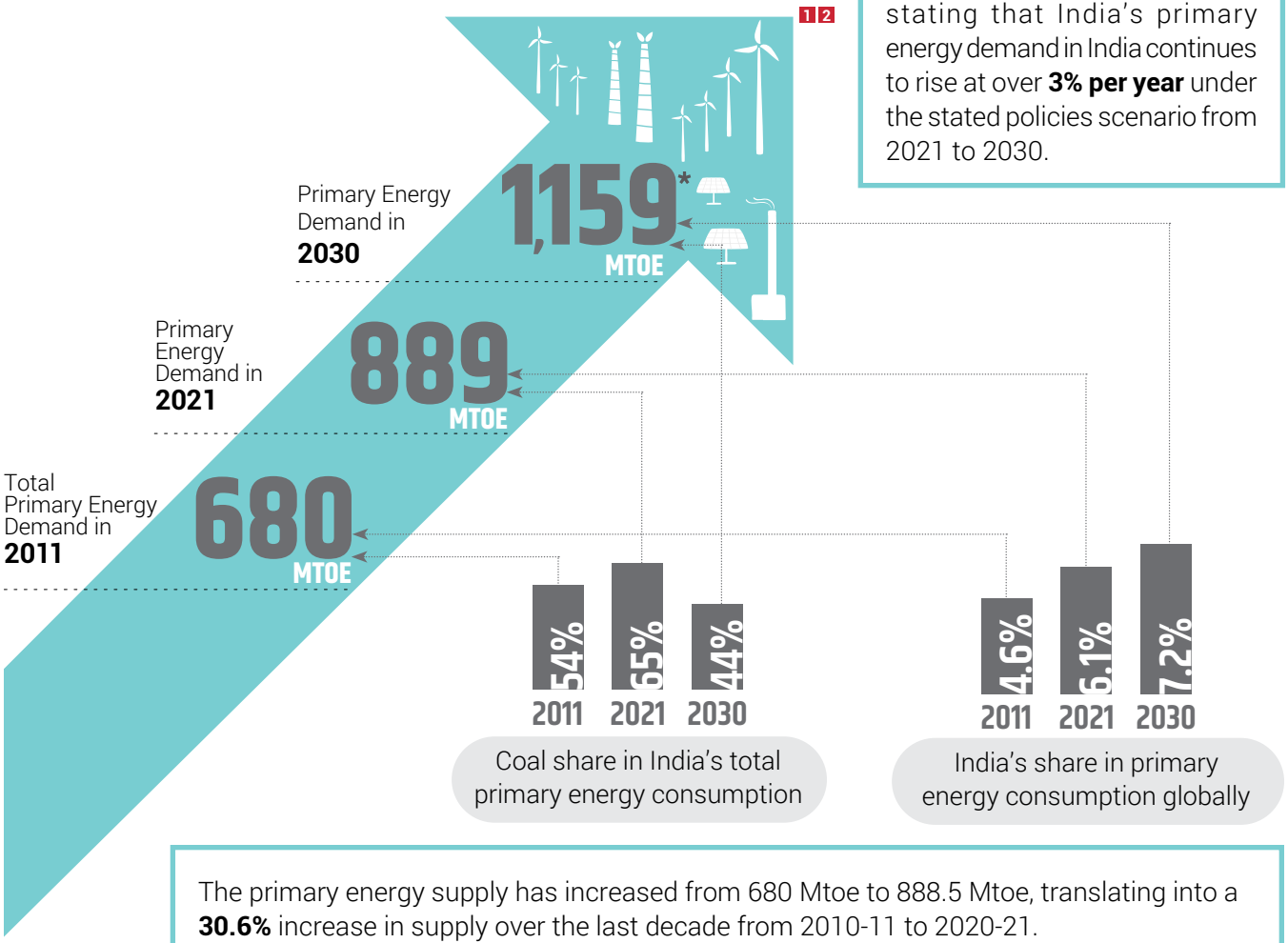
UNPARALLELED GROWTH IN ENERGY USE



1 UNPARALLELED GROWTH IN ENERGY USE

1.1 Ballooning Primary Energy Demand

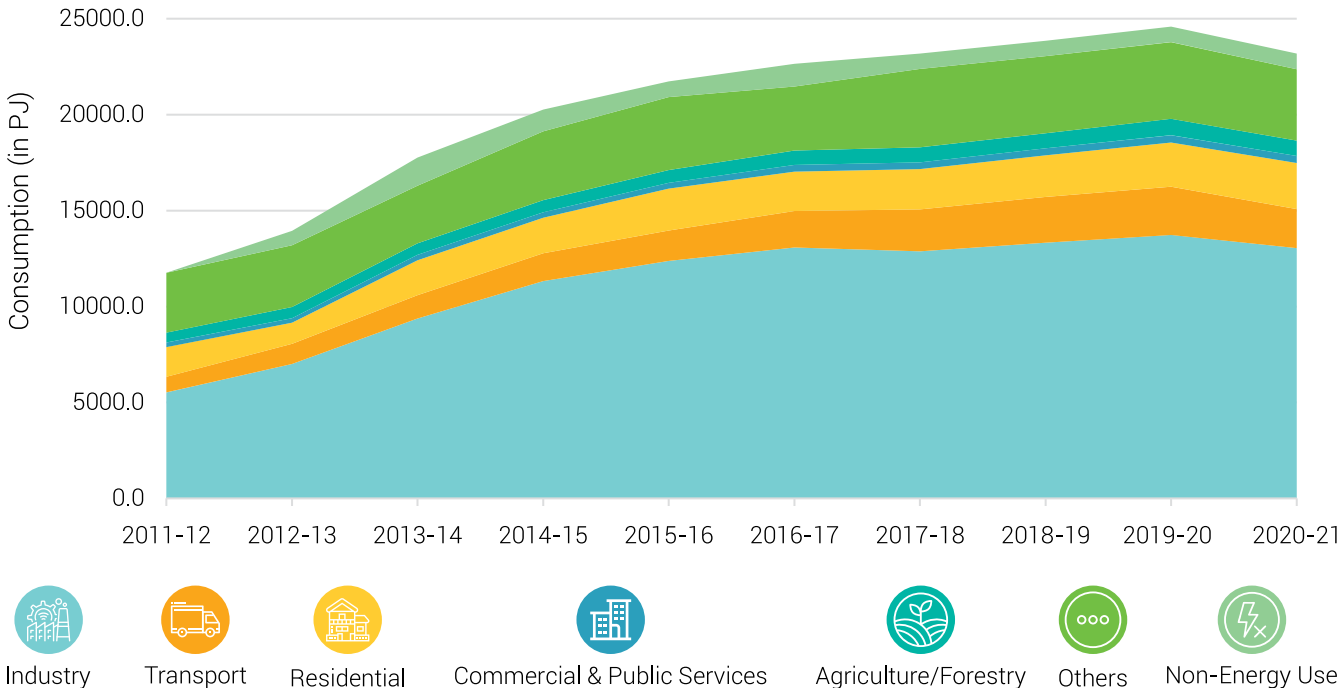
*Estimated using WEO report stating that India's primary energy demand in India continues to rise at over **3% per year** under the stated policies scenario from 2021 to 2030.



The primary energy supply has increased from 680 Mtoe to 888.5 Mtoe, translating into a **30.6%** increase in supply over the last decade from 2010-11 to 2020-21.

1.2 Increasing final energy consumption

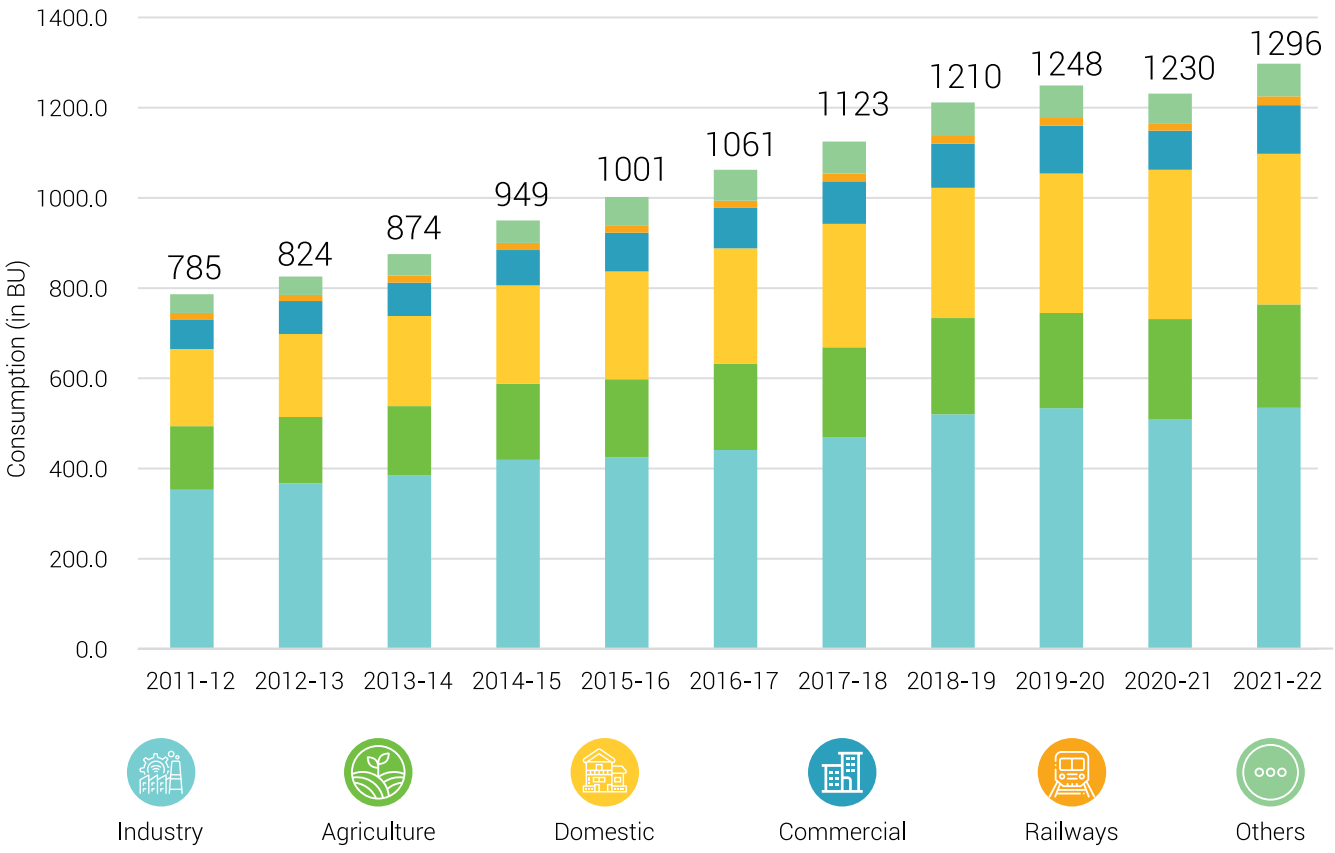
Sector-wise Energy Consumption Trend [3]



- With 23 exajoules (EJ) of final energy consumption, India is the third largest energy-consuming country after China and the United States of America.
- While the Indian agriculture sector is key from an economic perspective, its share of the nation's final energy consumption has remained between 4-5%.
- The industry sector in India consumed 13 EJ in 2020-21, constituting more than 50% of India's total final energy consumption.
- The transport sector is dominated by road transport and the ever-increasing demand for private cars resulted in the highest increase in sectoral energy consumption rising from 0.8 EJ in 2011-12 to 2 EJ in 2020-21.

1.3 Rising electricity consumption and supply capacities

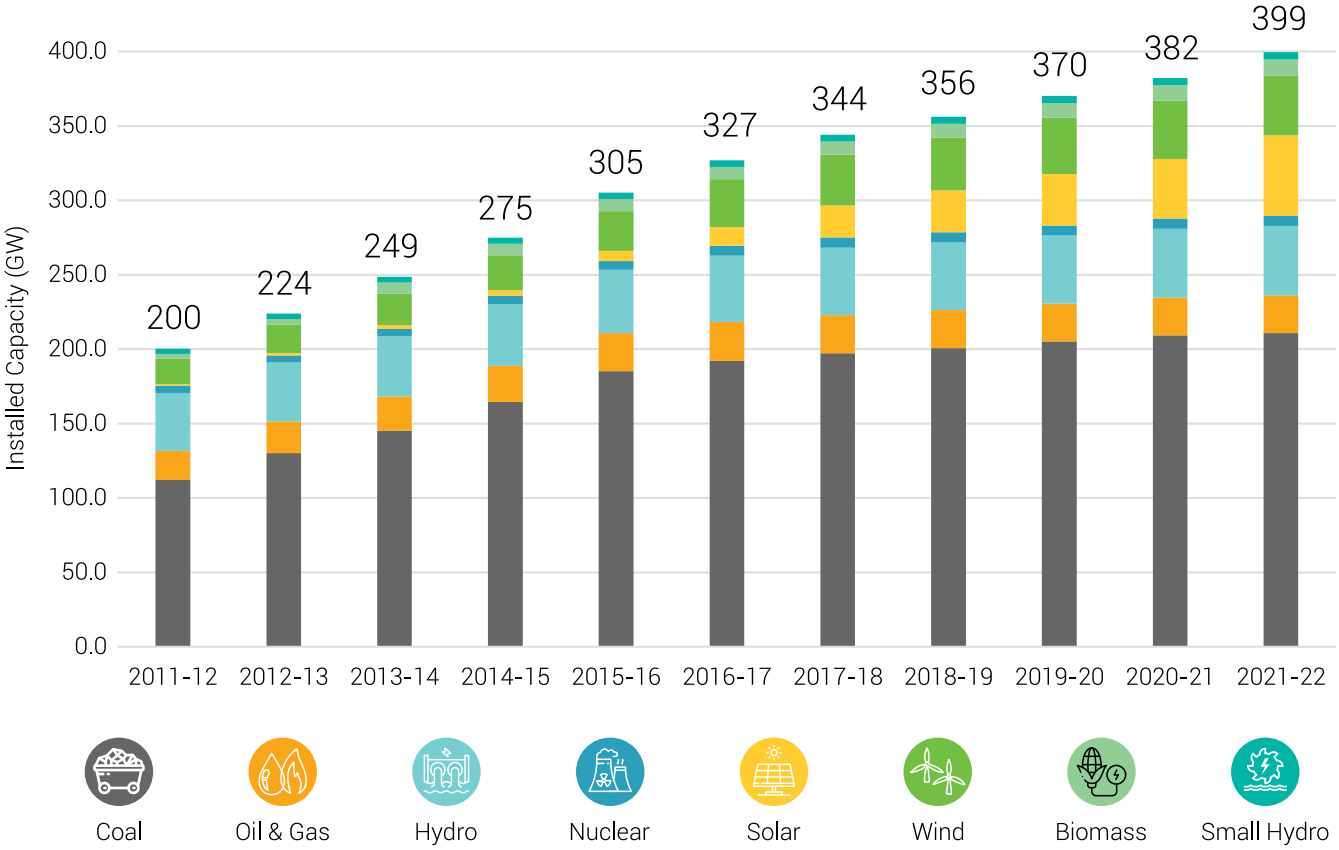
Sector-wise Electricity Consumption Trend [3]



- The electricity consumption has risen at a rate of 5% per annum and nearly doubling itself in the last decade from 785 Billion Units (BU) in FY12 to1,296 BU in FY22 (inlcuding captive).
- Industrial and residential electricity demand continue to rise at a steady pace to take the largest pie of the total electricity share.

* In 2020-21, a slight decrease in electricity consumption is observed owing to the COVID-19 pandemic.

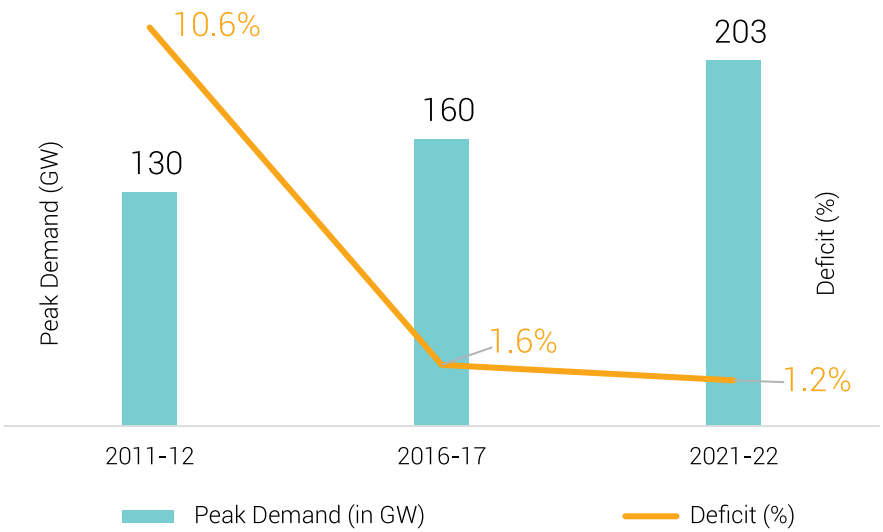
India's electricity installed capacity [4] [5]



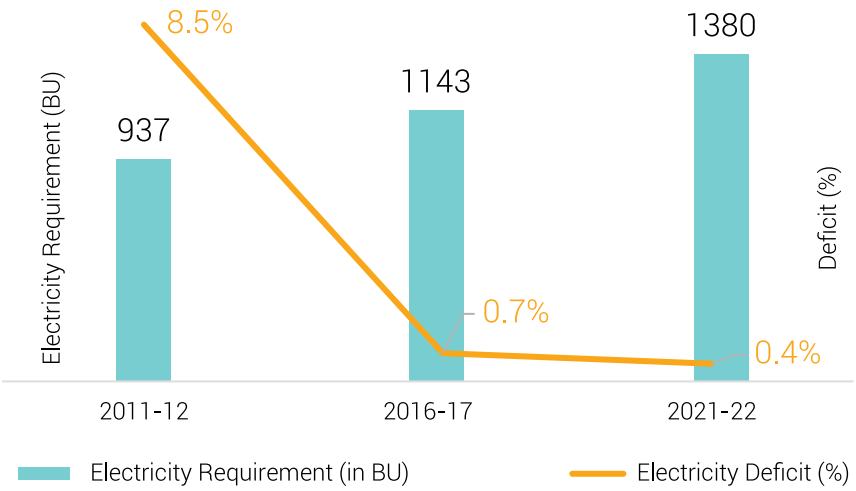
- In line with the demand, the electricity capacity has increased at a rate of 7% per annum in the last decade.
- The power system has doubled itself from 200 GW in 2011-12 to 399 GW in 2021-22. As on January 2023, India has installed a total power system capacity of 411.6 GW.
- The decade of 2011 and 2022 has seen a remarkable addition of clean energy particularly from wind and solar – 0.9 GW to 63.3 GW for solar and 17.4 GW to 41.9 GW for wind.

1.4 Improving reliability of power supply

Peak Demand Vs Deficit [6] [7]



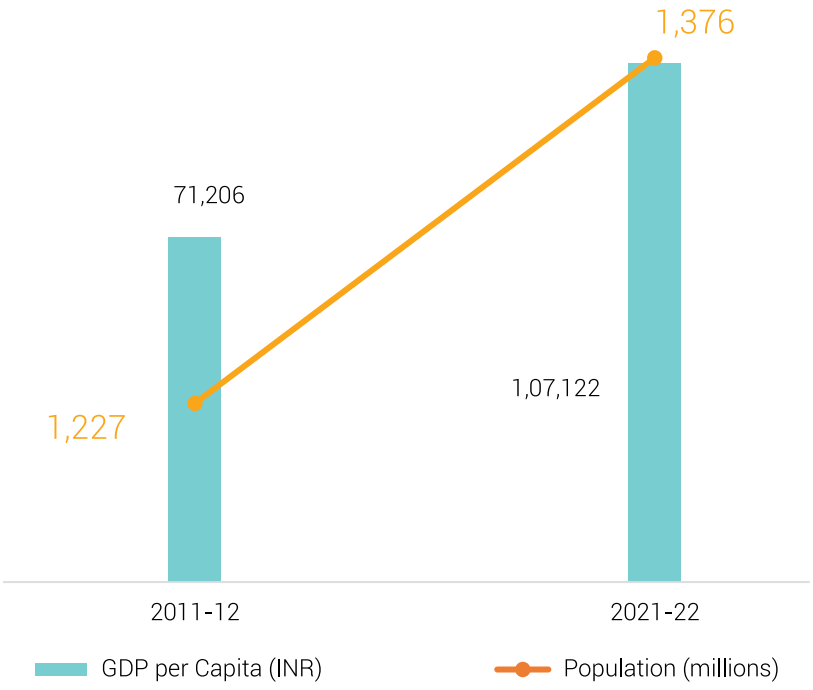
Electricity Requirement Vs Deficit [6] [7]



- The decade saw a phenomenal improvement in the reliability of power supply. The peak demand shortages plummeted from 10.6% to 1.2%, and the electricity demand shortage has been reduced to a mere 0.4%.

1.5 Key Drivers for Energy Growth

1.5.1 GDP per capita vs Population[8][9]

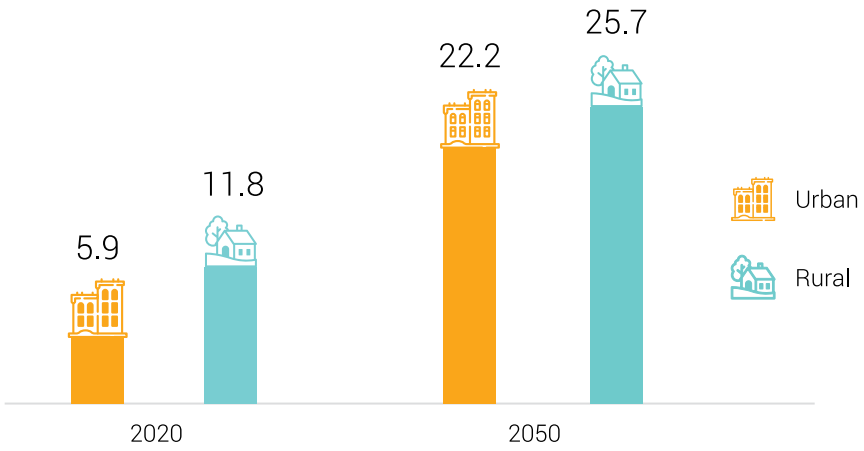


- GDP per capita has increased at a year-on-year growth rate of 4.2% between 2011-12 to 2021-22, while the population has increased with a CAGR of 1.2% during the same period.

1.5.2 Expanding built up area

Urban & Rural Residential Built-up Area

(in billion metre square)

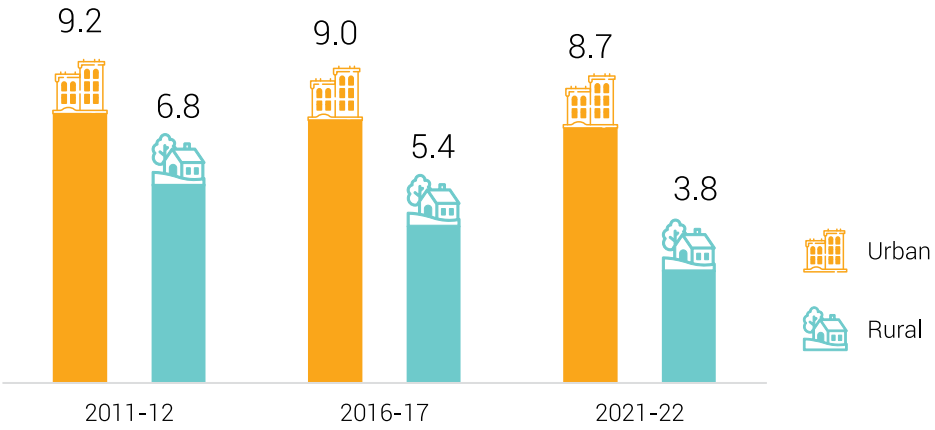


- The 'World Population Prospects 2022[10], by United Nations projects India's population to rise to 1,667 million by 2050.
- India is expected to urbanize 50% of its population by 2050[10]. This translates to an urbanized fleet of almost 834 million. To put this in perspective, this will be almost two times the population of United States of America in 2050[11].

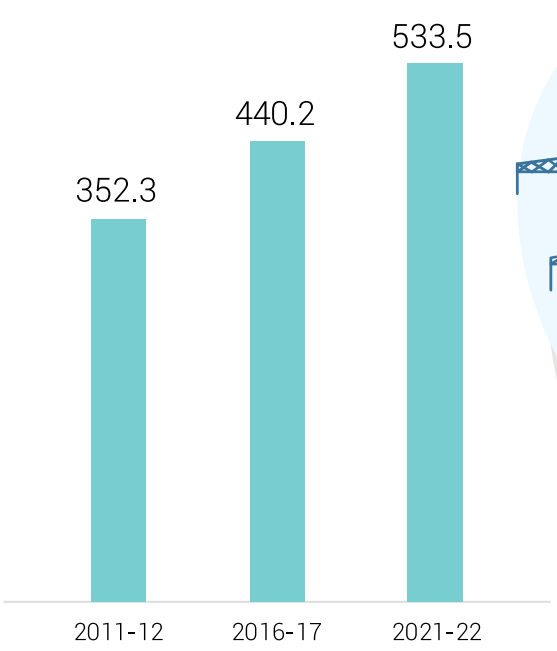
- While the number of people added per year has marginally decreased over the years, there is a rising trend in the number of people residing in urban areas than in rural areas. As per National Commission On Population, India's urbanisation rate has risen from 31% in FY 2012 to 35% in FY 2022[9].

Number of people added per year

(in millions)



1.5.3 Rising Industrial Electricity Consumption[13]

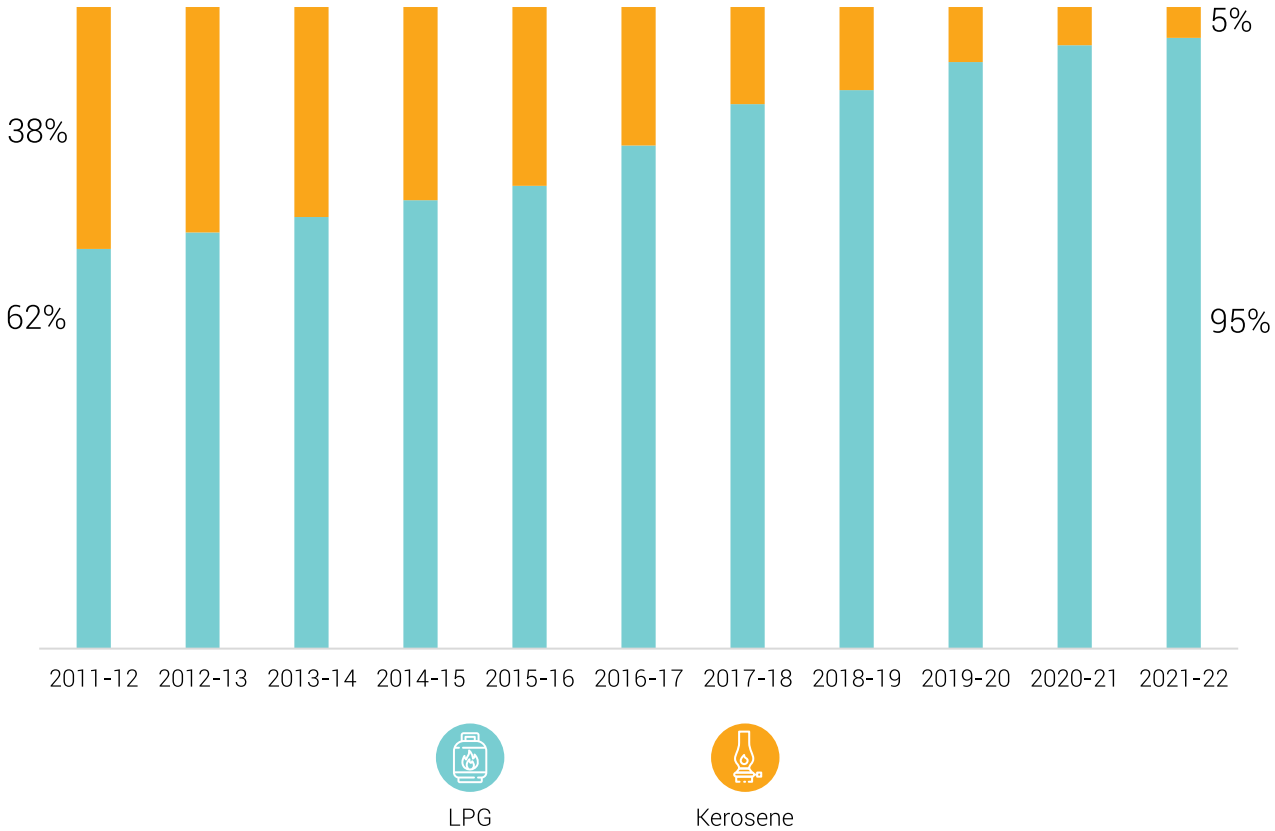


* Including captive

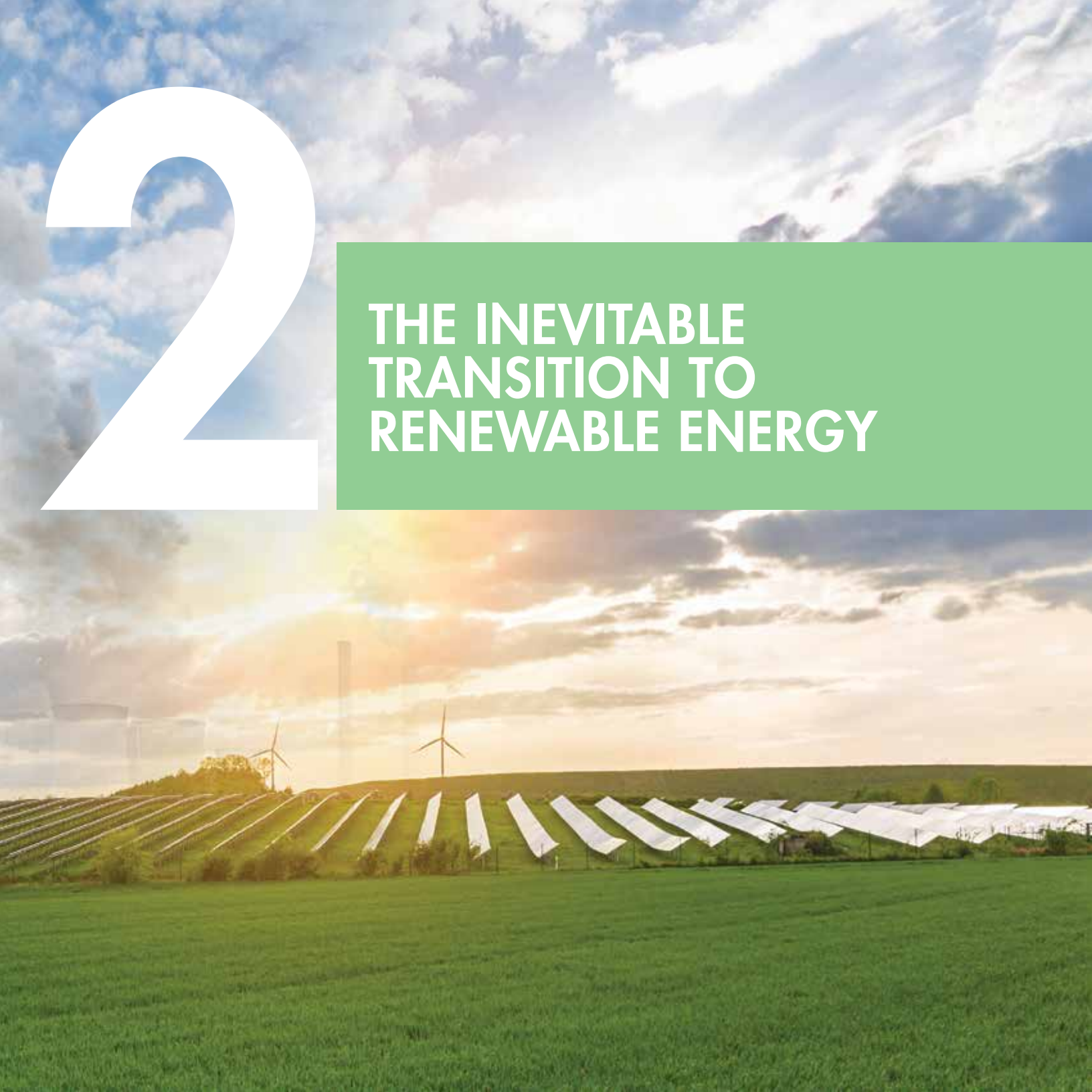
- A boost in industrial growth has resulted in a remarkable increase of 51% in industrial electricity consumption in India since 2011-12, making it the highest electricity consuming sector.

1.5.4 Penetration of cleaner fuels (LPG replacing Kerosene)

LPG and Kerosene consumption in Residential Sector [14]



- The Pradhan Mantri Ujjwala Yojana (PMUY) has propelled the growth of cleaner fuels like LPG, PNG and replaced kerosene or biomass for cooking in households.
- Hence, the share of LPG consumption in the residential sector has risen from 62% in 2011-12 to 95% in 2021-22.
- LPG active domestic connections has doubled itself from 14.86 crore in 2015 to 30.53 crore in 2022.



2

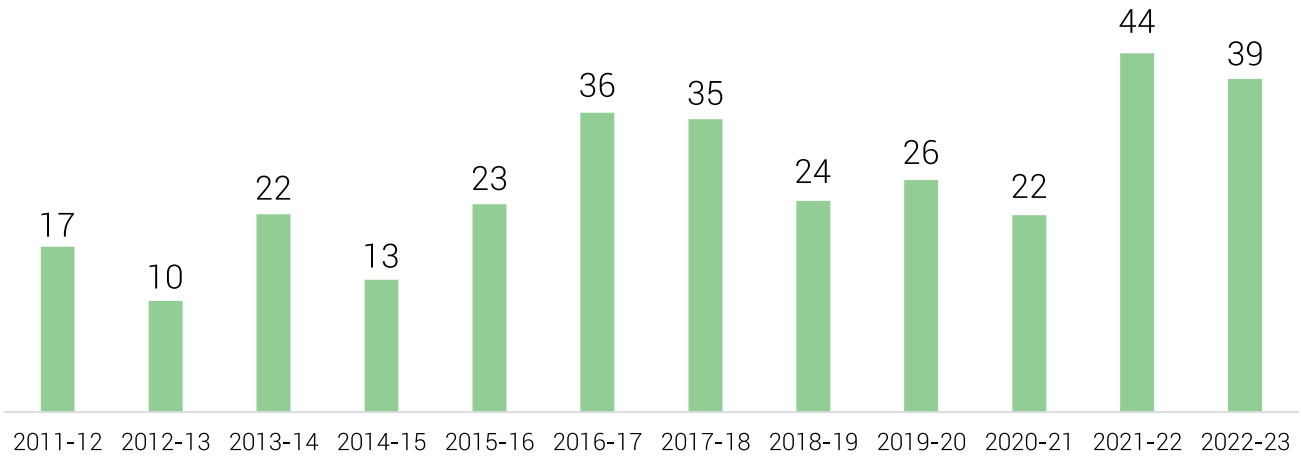
THE INEVITABLE TRANSITION TO RENEWABLE ENERGY

2 THE INEVITABLE TRANSITION TO RENEWABLE ENERGY

2.1 Robust RE Growth

2.1.1 Rising RE Capacity Addition

Rate of renewable energy capacity addition in India (MW/day) [5] [13]

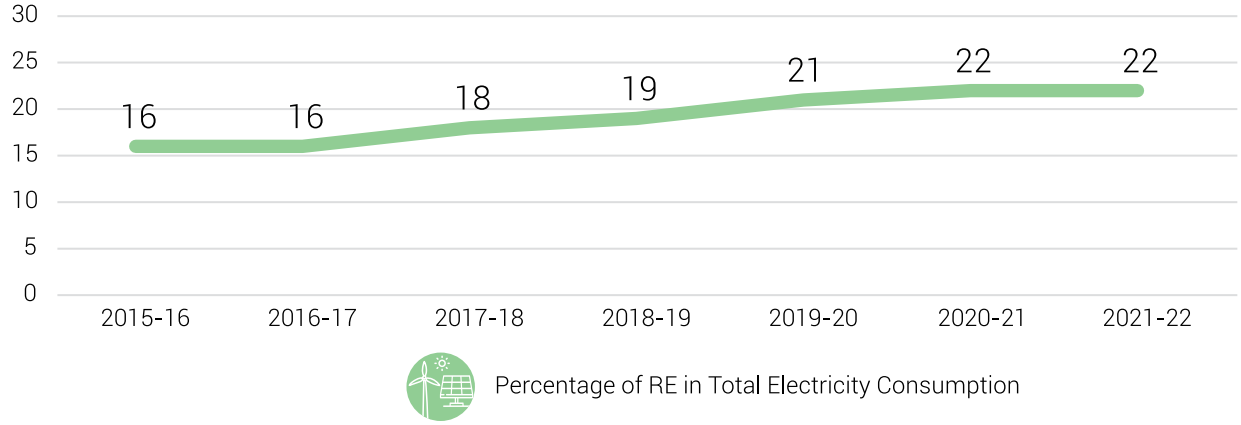


(As on January 2023)

The data for RE capacity Includes Large Hydro

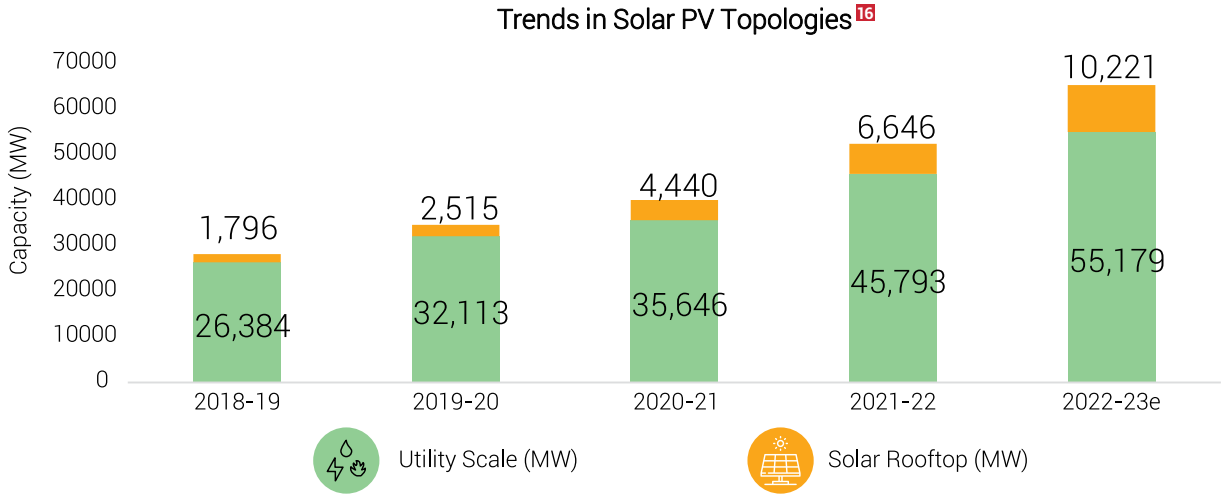
- In 2022-23, over a 10 months period, the RE capacity installations average at 39 MW/day as compared with 17 MW/day in 2011-12, registering more than a two-fold increase.
- The rate of RE capacity addition has increased from 6,366 MW/per year in 2011-12 to 15,965 MW/year in 2021-22.
- This translates to a cumulative RE capacity (including large hydro) of 64 GW in 2011-12 to 157 GW in 2021-22.

2.1.2 Growing role of renewables in total electricity consumption[5]



- The trend of RE (including large hydro) in total electricity consumption at the national level is increasing rapidly and is around 20% mark in 2021-22.

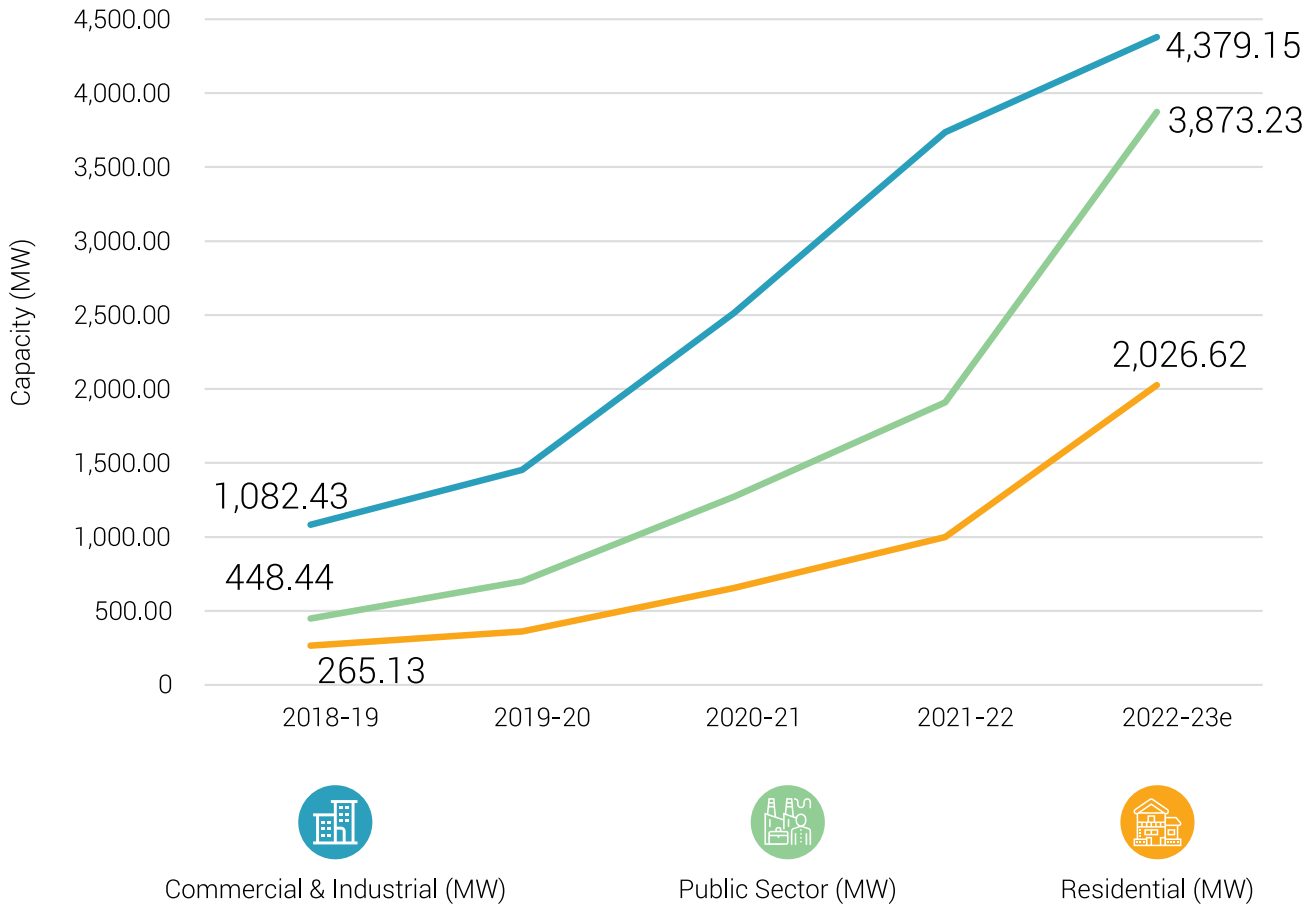
2.1.3 Increasing penetration of Rooftop Solar



- In 2022-23, rooftop solar will be around 10.2 GW in comparison to just 1.7 GW in 2018-19.
- The rooftop solar capacity addition has grown at a CAGR of 56.9% in the last 5 years.

2.1.4 Robust rooftop solar growth led by Commercial and Industrial sector

Solar Rooftop Customer Category Trend [16]

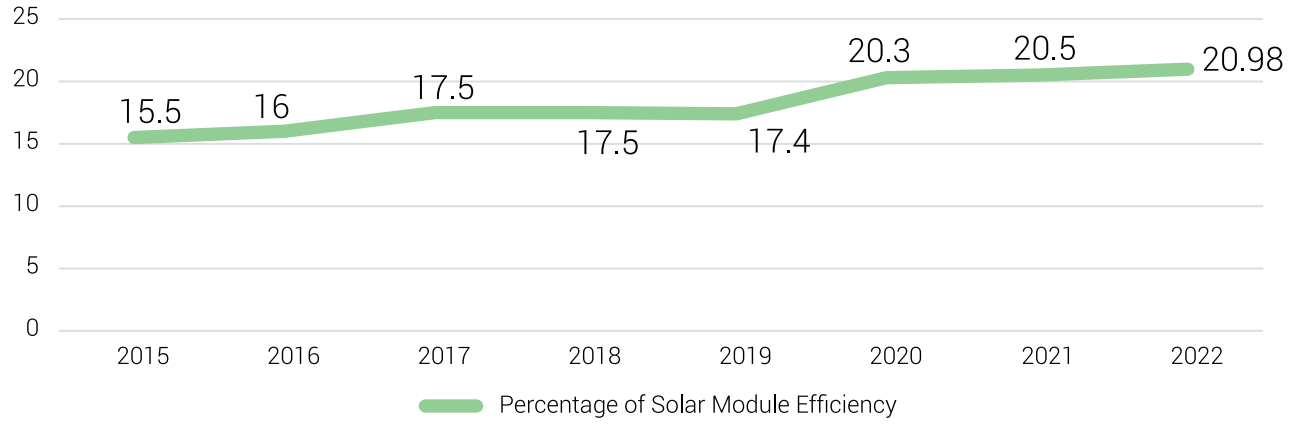


- Most installations have occurred in commercial and industrial segments owing to the better economic sense established over several years.
- While all the categories have shown a tremendous increase, the public sector stood out with the installed capacity set to increase 7-fold by 2022-23.

2.2 Key drivers for rising RE growth

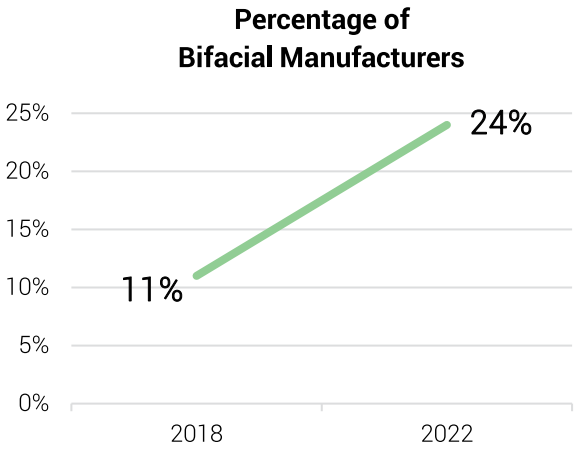
2.2.1 Deploying efficient RE technologies on the ground

Improving Efficiency of Solar Modules[17]



- The efficiency of solar modules is increasing year-on-year and hovers around the 21% mark.

Bifacial modules garnering significant interest[18]



- Using bifacial modules for large-scale utility projects helps in reducing the Levelised Cost of Energy (LCOE). Moreover, bifacial modules are resistant to Potential Induced Degradation (PID).
- In India, the percentage of bifacial module manufacturers has increased from 11% in 2018 to 24% in 2022.

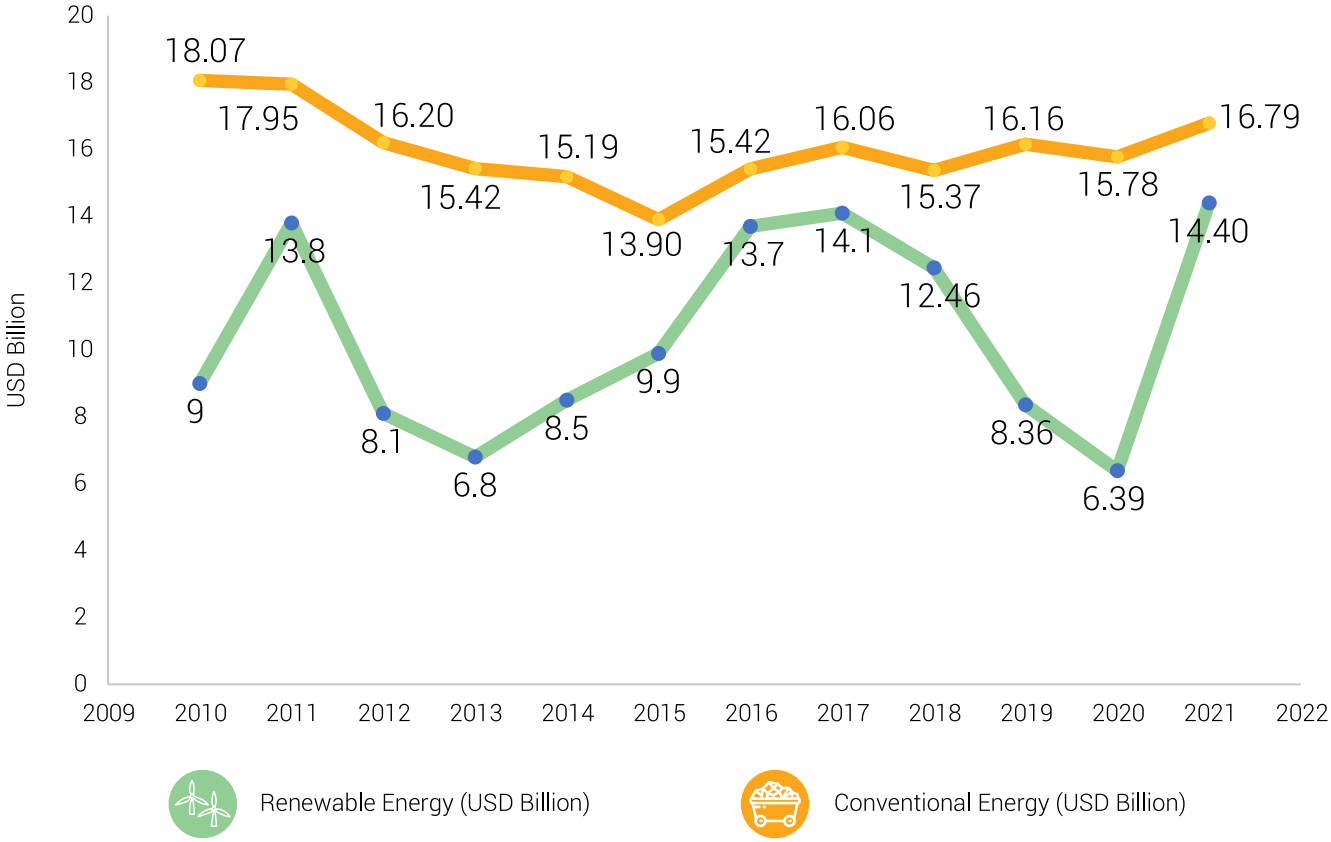
Key Facet

Total number of solar PV manufacturers in 2018 were 28 in comparison to 59 manufacturers in 2022.

Soaring heights of Wind Turbines[19]

- The wind turbine power generating capacity is captured above the bars in MW.
- With the significant increase in rotor diameter (14%) and the hub height (23%) of Wind Turbine Generators (WTGs) in 2022 in comparison to 2019, there is a concurrent increase in the power generation capacity (52%). Thus, a reduced number of wind turbines will be needed to generate the same amount of power.

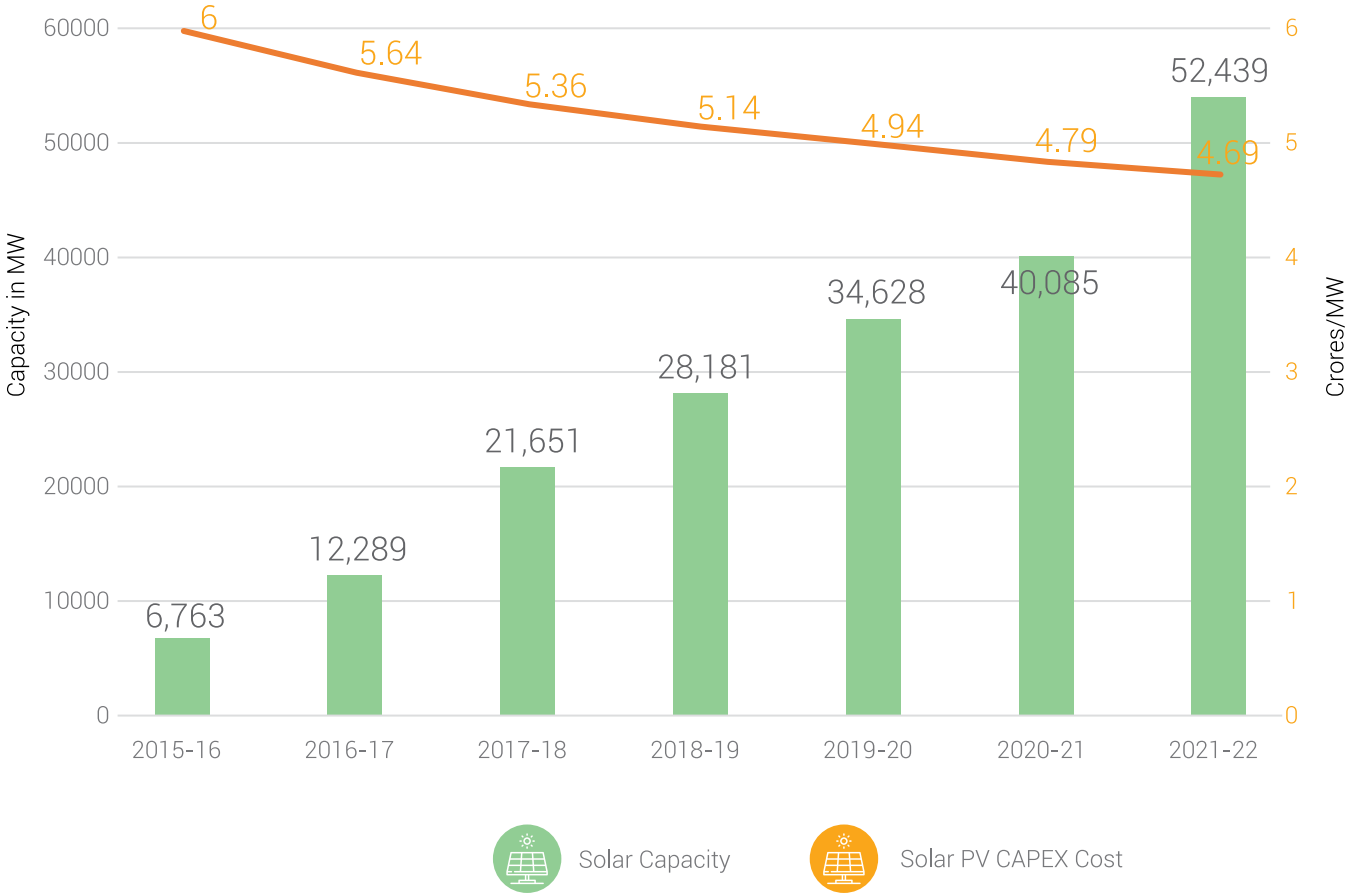
Rising investments in Renewable Energy 20 21 22 23 24



- Investments in Renewable Energy is increasing at a CAGR of 4.36% since 2010. However, the amount is still far away from the needed USD 18.5-25 Billion/year to meet India's 2030 RE targets.
- For conventional energy, the investments are decreasing at a CAGR of 0.67% from 2010 showcasing India's commitment to decarbonizing the power sector.

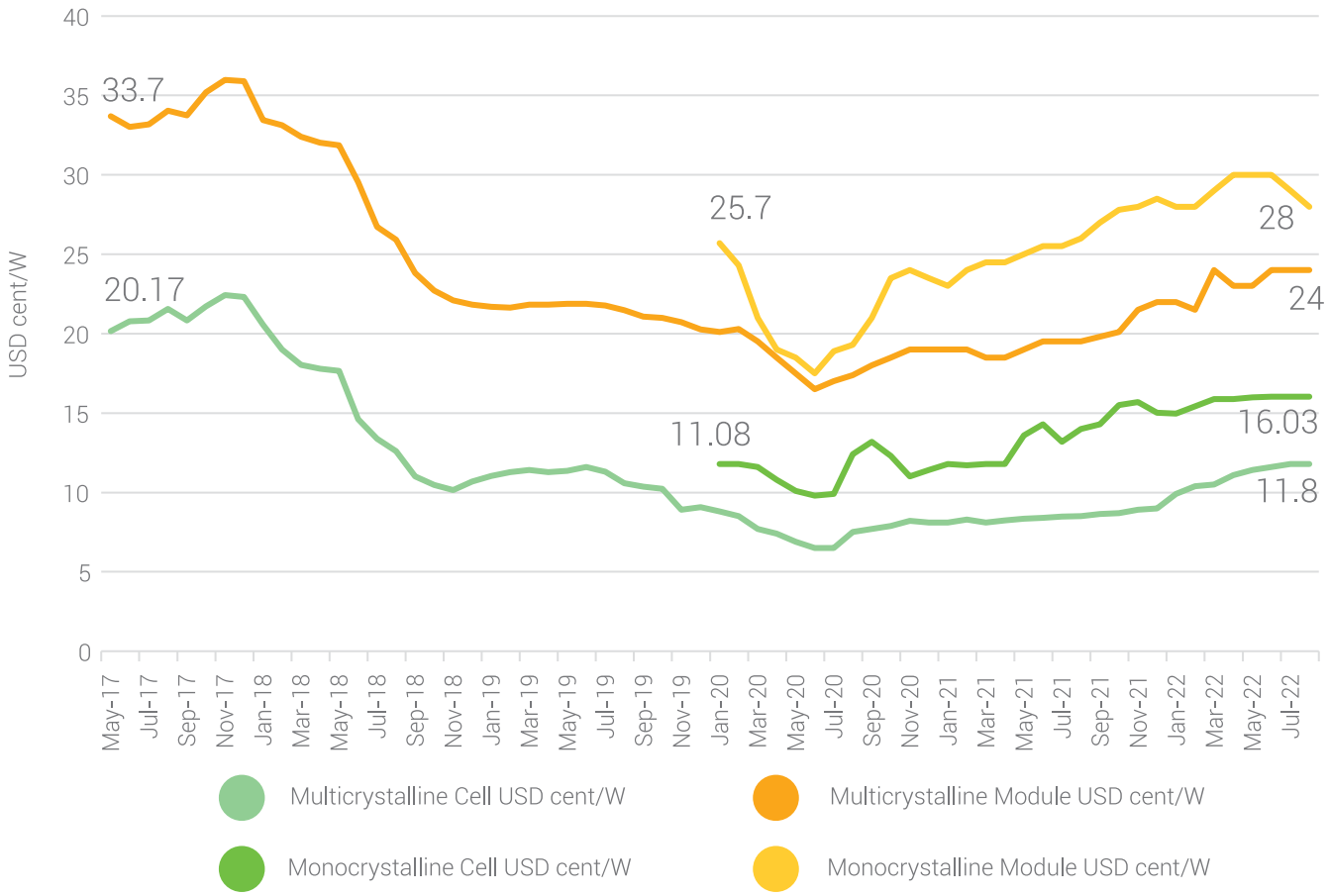
2.2.2 Declining costs for RE installations

Solar PV plant CAPEX Cost trend In India[25]



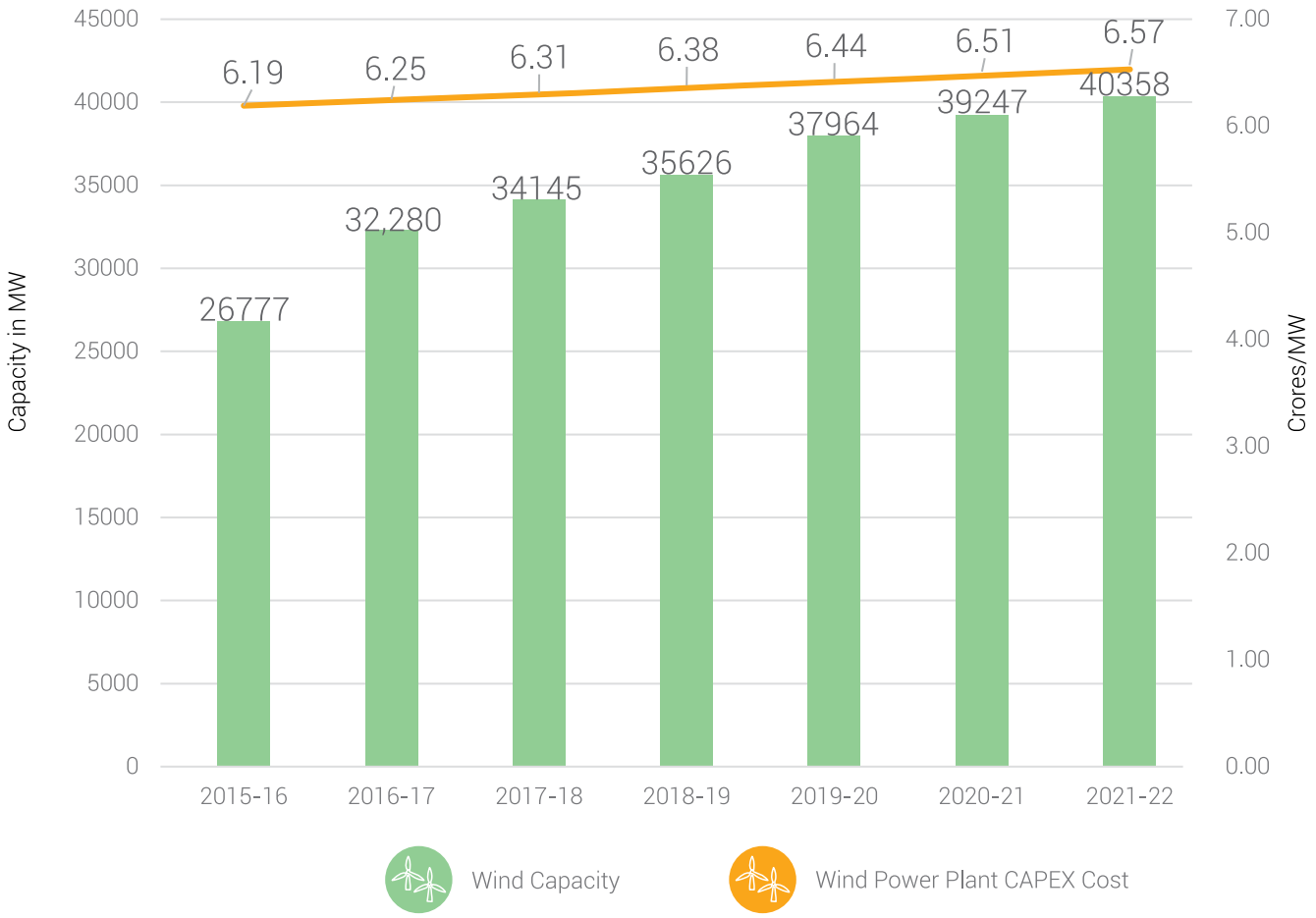
- Solar capacity has increased eight times in the last 7 years emboldened by the decrease in per MW CAPEX cost.

Solar PV Module cost trends [25]



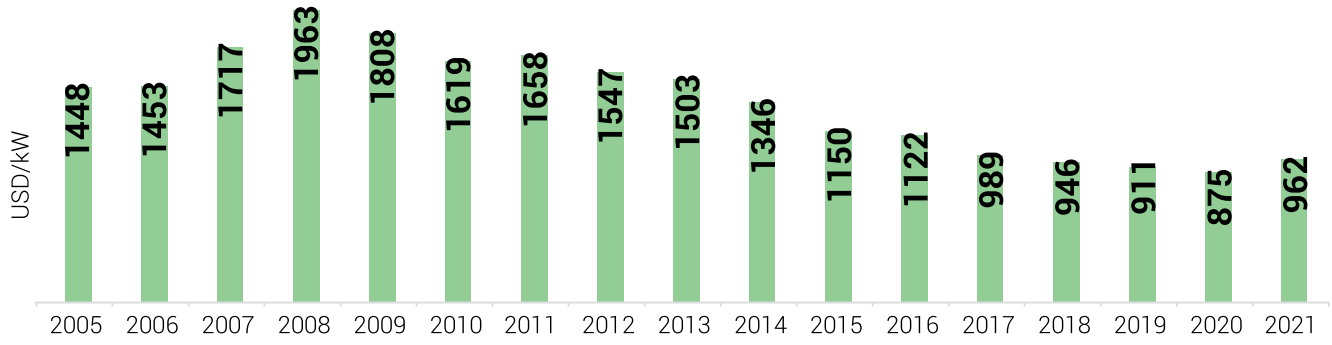
- Prices for both mono-crystalline and multi-crystalline cells and modules decreased till 2020. However, post that, strict COVID restrictions in China and the increase in commodity prices due to the Russia-Ukraine war have led to an increase in the cost.

Wind power plant CAPEX Cost trend in India[26]



- The wind capacity and CAPEX have plateaued in the last four years with an average installation of 1.5 GW/ year. This indicates that there are several issues marring the growth of the wind ecosystem.

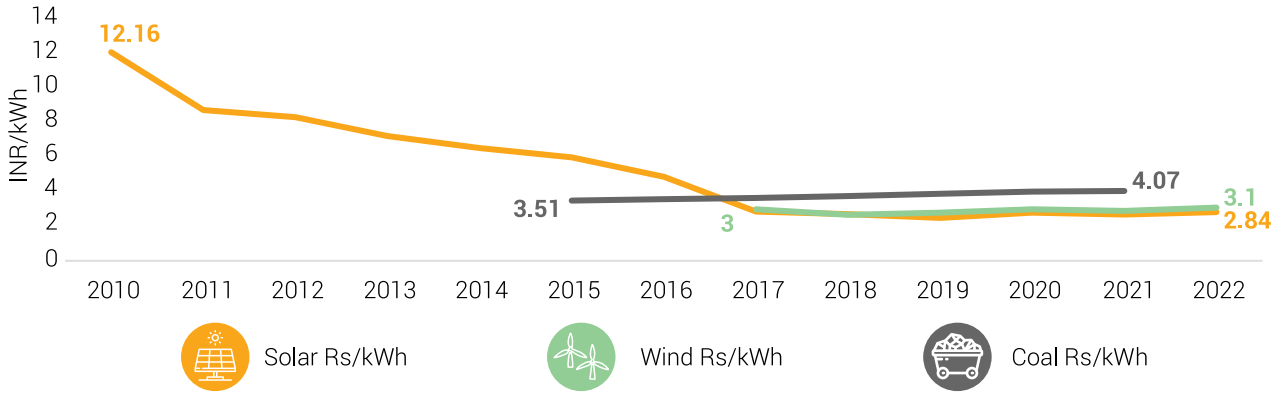
Wind Turbine Generator Cost Trend [27]



- For wind, since India has a large capacity for manufacturing wind turbines, the global shocks did not have much impact. Between 2015 and 2021, the cost of turbines has been reduced by a CAGR of 4.6%.

2.2.3 Renewable energy continuing to make economic sense

Tariff Trend [29]



- Solar PV tariffs have decreased substantially since 2010. Over the past 2–3 years, the tariff is hovering between INR 2-3/kWh. For Wind, the reverse auctions kicked in 2017 and since then the tariffs have seen a consistent trend revolving around INR 3/kWh.
- In comparison to coal-based generation, both renewable energy technologies started making better financial sense since 2017.

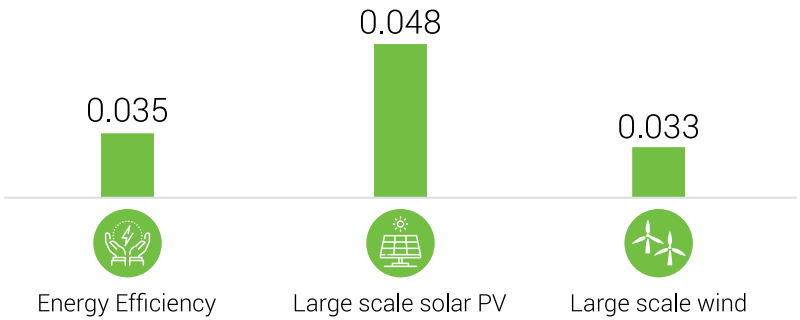
3

"LOW-COST NO-REGRET" ENERGY EFFICIENCY STRATEGY CONTINUES TO BE THE BEDROCK

3 "LOW-COST NO-REGRET" ENERGY EFFICIENCY STRATEGY CONTINUES TO BE THE BEDROCK

3.1 Energy Efficiency placed on a level playing field with RE

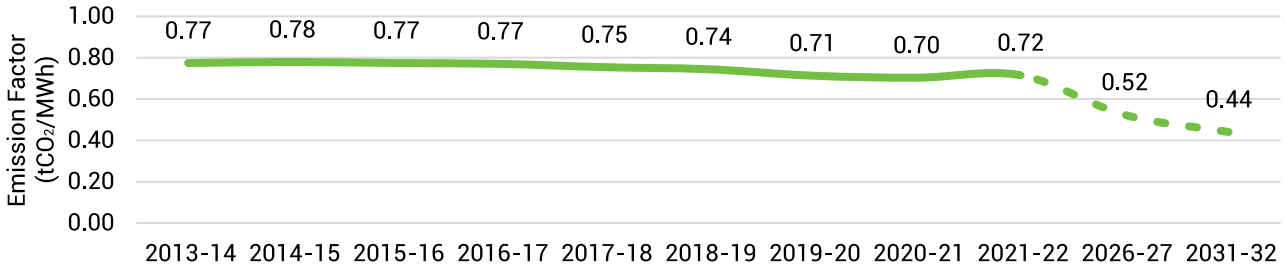
Global Weighted Average LCOE of Various Interventions (USD $/kWh) [29]



- Since the LCOE of EE is at par with other RE generation technologies, it is worth consideration as a prudent strategy.

3.2 Greening the Grid

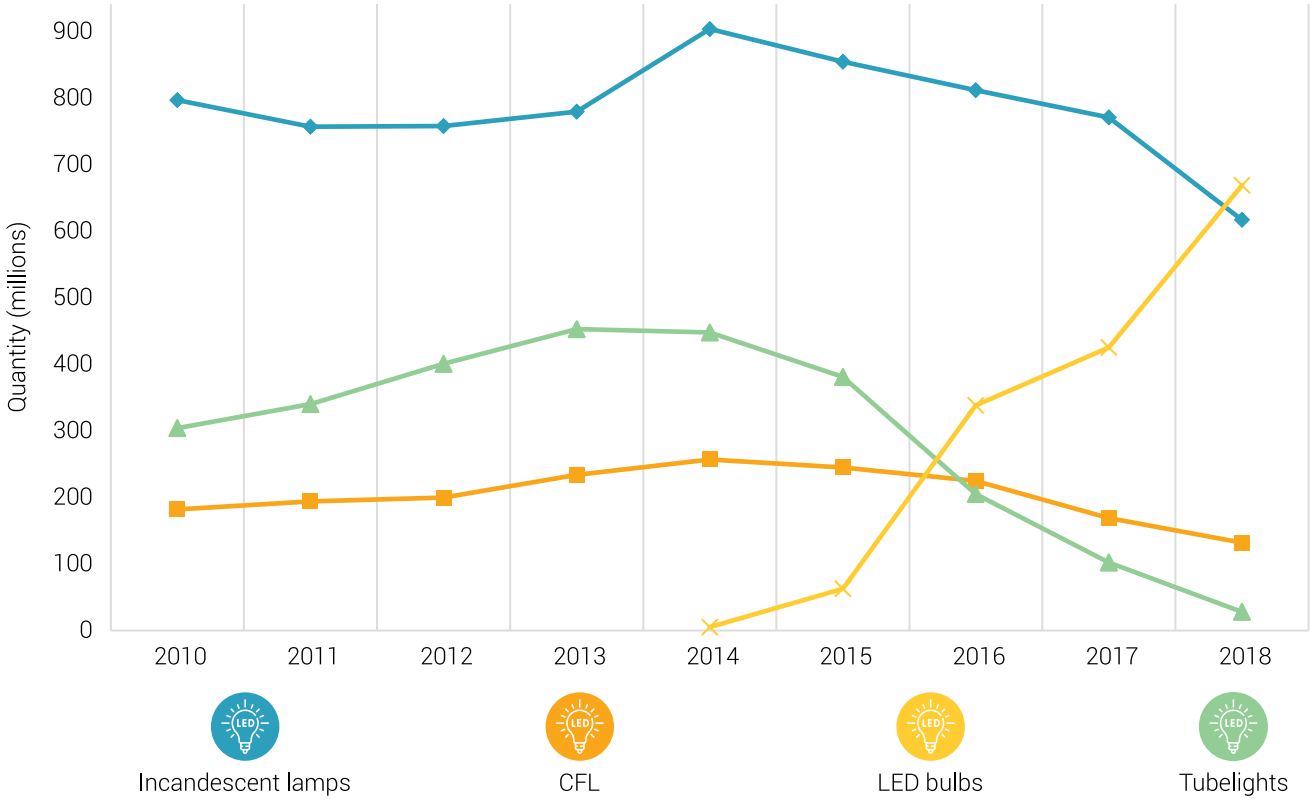
Weighted Average Emission Rate incl. RES [30]



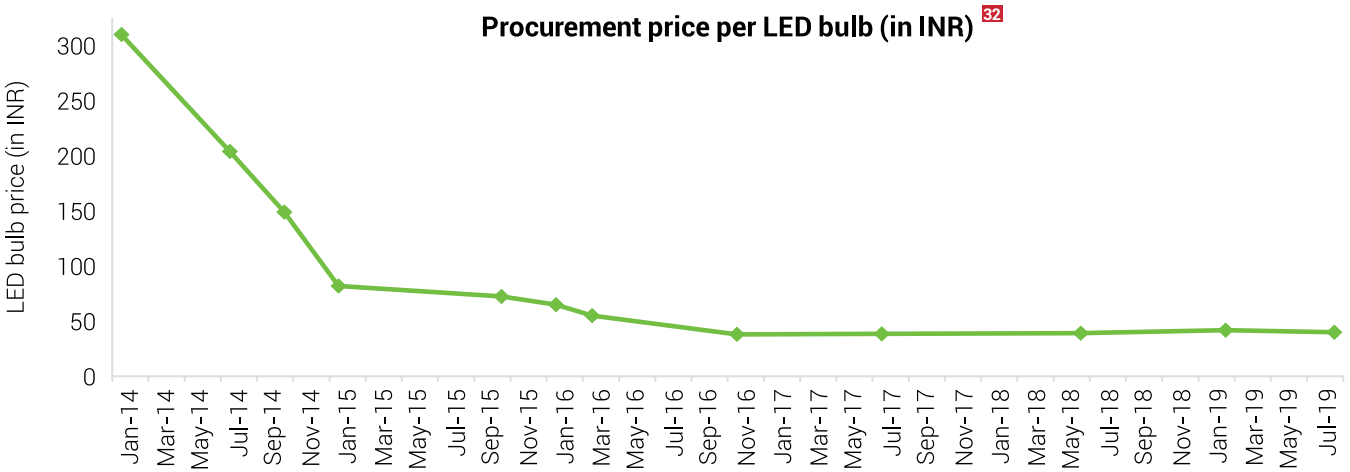
- The grid emission factor is a metric to measure the CO_2 released with each unit of electricity produced. The power generation is one of largest sources of emissions in India. Hence, decarbonisation of the electricity grid holds utmost importance. The average emission rate in 2021-22 is 0.72 kgCO_2/kWh which is proposed to be lowered to 0.52 by 2026-27 and further to 0.44 by 2031-32.

3.3 Revolutionizing the lighting sector of India

Sales trends of lamps with different lighting technologies [31]

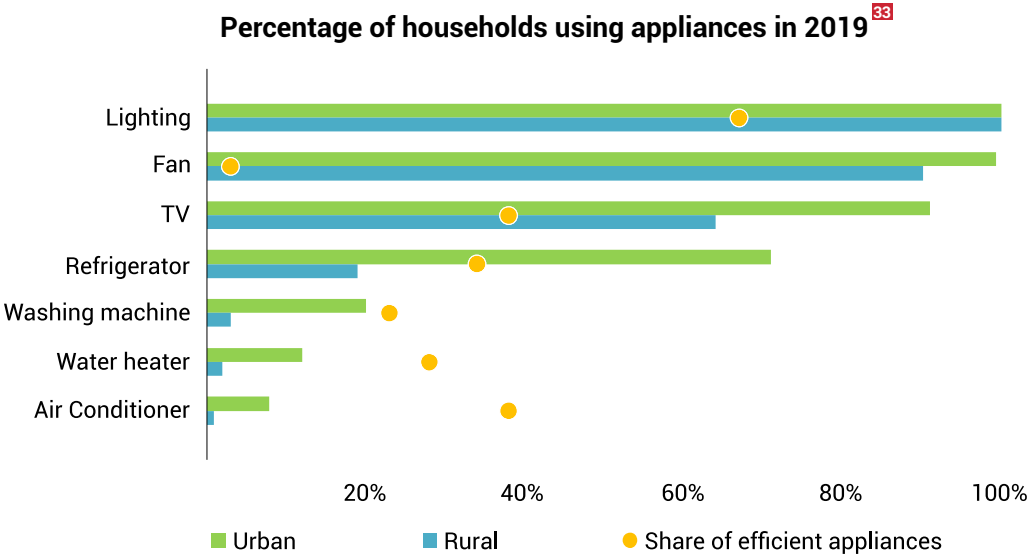


- As on 15th February 2023, total 36.86 Crore LEDs were distributed under the UJALA scheme launched in January 2015.
- Odisha is leading the LED distribution programme and has distributed 5.22 Crore LEDs in the state. Gujarat and Uttar Pradesh are other leading states having distributed 4.14 Crore and 2.62 Crore LEDs respectively.



- The UJALA scheme was the biggest bulk procurement energy efficiency programme that resulted in large scale production and penetration of LEDs in India. Between 2014 to 2017, the procurement price of a 7W LED saw a significant decline from INR 310 to INR 38.

3.4 Five-star appliances making headway in Indian buildings



- Owing to various large scale energy efficiency programmes such as UJALA and Standards and Labeling Program, the lighting sector accounted for the highest penetration of efficient appliances followed by TV and Air conditioning.

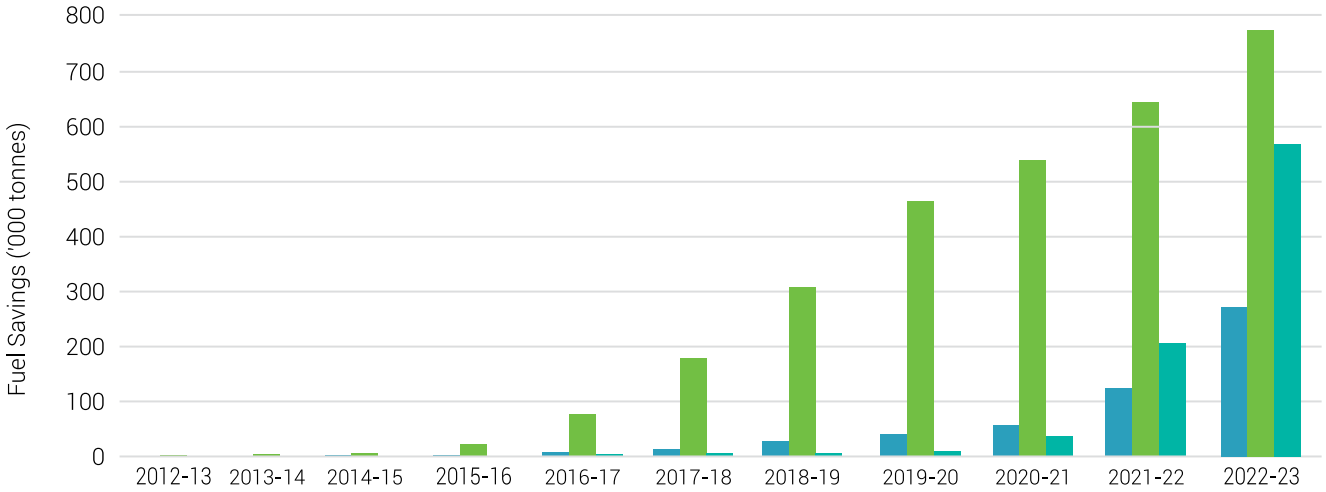
3.5 Mandating Energy Efficiency improvements in the industry sector[34]

PAT Cycle I (2012 to 2015)	• DCs Notified: 478 • Estimated energy consumption reduction: 6.69 Mtoe
PAT Cycle II (2016-17 to 2018-19)	• DCs Notified: 621 • Estimated energy consumption reduction: 8.87 Mtoe
PAT Cycle III (2017-18 to 2019-20)	• DCs Notified: 116 • Estimated energy consumption reduction: 1.06 Mtoe
PAT Cycle IV (2018-19 to 2020-21)	• DCs Notified: 106 • Estimated energy consumption reduction: 0.70 Mtoe
PAT Cycle V (2019-20 to 2021-22)	• DCs Notified: 110 • Estimated energy consumption reduction: 0.51 Mtoe
PAT Cycle VI (2020-21 to 2022-23)	• DCs Notified: 135 • Estimated energy consumption reduction: 1.28 Mtoe
PAT Cycle VII (2022-23 to 2024-25)	• DCs Notified: 509 • Estimated energy consumption reduction: 6.63 Mtoe

- Implementation of PAT Cycle-I has resulted in energy savings of 8.67 Mtoe which is 1.25% of India's total primary energy supply and translating into emission reduction of about 31 million tonnes of CO_2 (1.93% of India's emissions).
- PAT Cycle-II has resulted in total energy savings of about 13.28 Mtoe which is 1.46% of India's total primary energy consumption in 2018-19. The energy savings translate into avoiding emission reduction of 61 million tonnes of CO_2 (2.5% of India's emissions).
- Increased investments reported for energy efficient technologies in PAT Cycle-I and Cycle-II are INR 26,000 Crore and INR 43,721 Crore, respectively.
- PAT Cycle-III has achieved 65% higher energy savings over the estimated energy consumption reduction of 1.06 Mtoe.

3.6 Electrification leading to efficiency in the transport sector

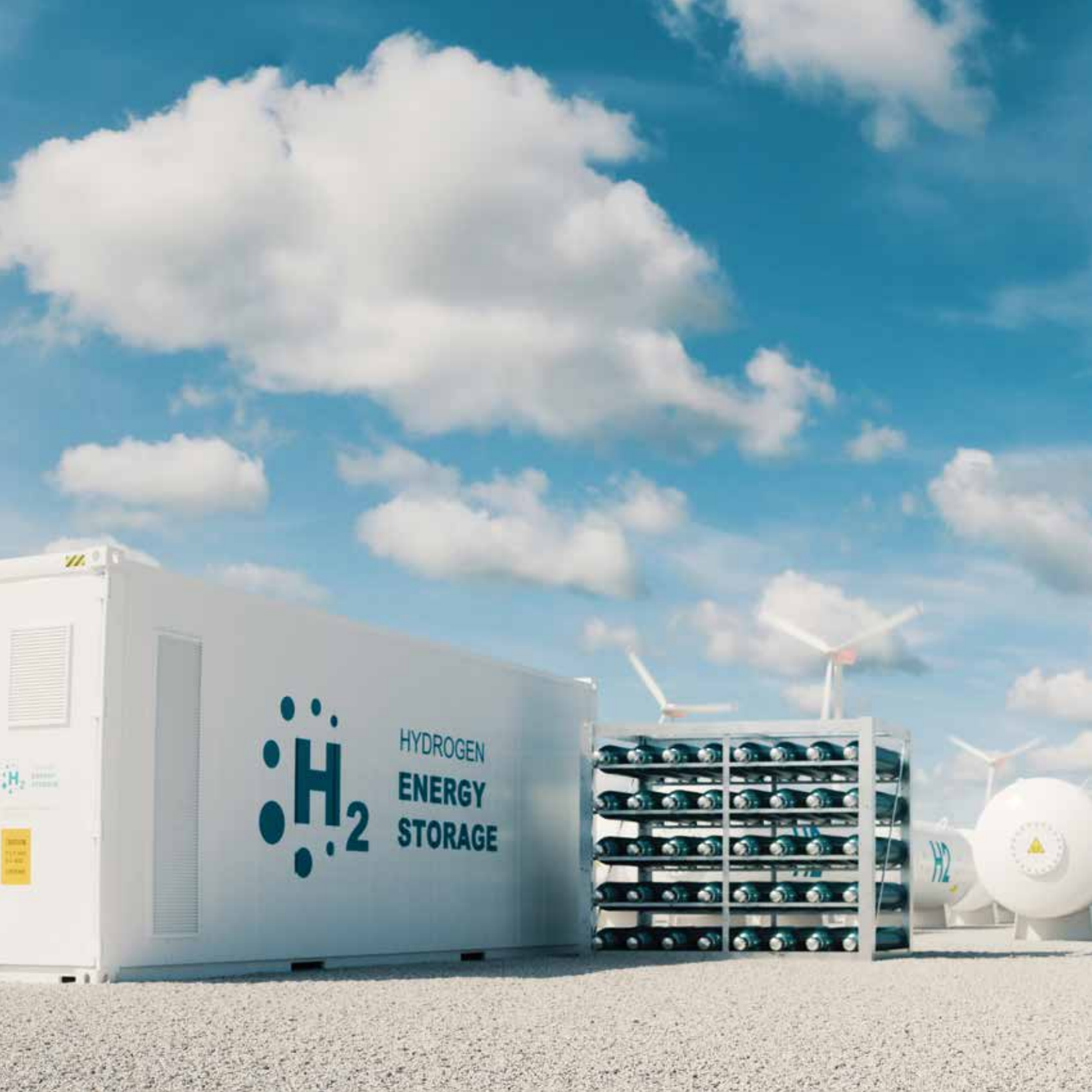
Estimated Fuel Savings due to EV penetration [35][36]



	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23
Petrol	1	1	2	3	7	14	28	41	58	125	278
Diesel	2	4	6	22	78	180	309	464	540	639	777
CNG	0	0	0	1	4	6	7	10	38	207	571

Petrol Diesel CNG

- The number of EVs registered in the country has seen phenomenal growth rising from 4,065 electric vehicles in 2012-13 to 4,38,763 EVs in 2021-22. Further, the number of EV's registered have almost doubled to 9,13,882 in the 2022-23 (as on 31st January 2023).
- The total savings due to electric vehicle penetration has been estimated based on the year-on-year electric vehicle registration data from VAHAN Dashboard.
- To estimate the fuel-wise savings: segment-wise average km run in a year and vehicle efficiency taken from different sources. Fuel-wise distribution of the electric vehicles was done based on the share of petrol, diesel, and CNG based vehicle registered w.r.t total vehicle registered in that particular year in order to estimate the fuel-wise savings.


HYDROGEN
ENERGY
STORAGE

4 ADVANCES IN NEW TECHNOLOGIES CAN BE A HAIL OF SILVER BULLETS

4 ADVANCES IN NEW TECHNOLOGIES CAN BE A HAIL OF SILVER BULLETS

4.1 Making RE Dispatchable via Energy Storage

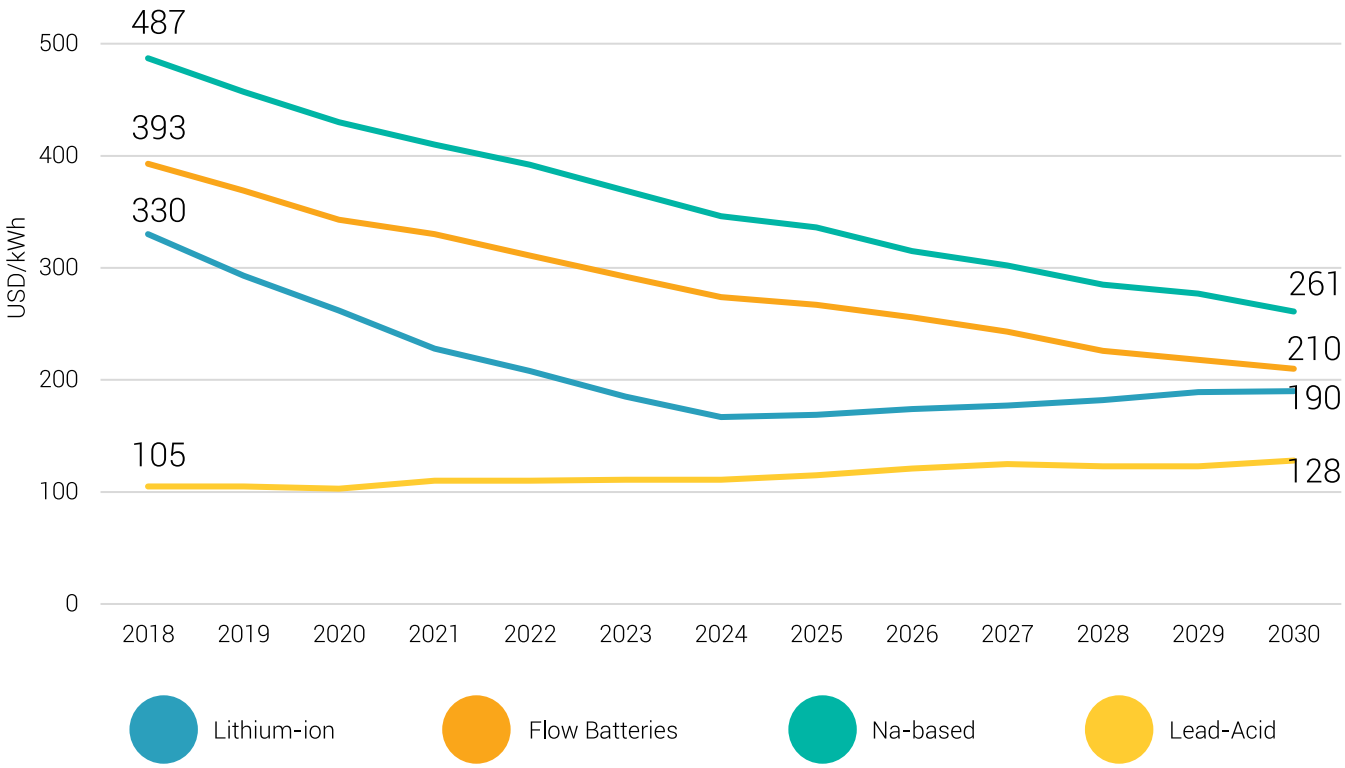
4.1.1 Mainstreaming Gravimetric Energy Storage [37][38][39][40]

	Energy Vault	Gravitricity	Gravity Power
Structure Type	Boxlike Buildings	Shaft of Old Mines	Piston
Capacity (MWh)	35	20	3200
Roundtrip Efficiency	90%	80%	80%
Response Time (sec)	2.9	<1	<1
Lifecycle (yrs)	40	50	>40

- Battery energy storage cannot be the sole technology relied on to make RE dispatchable. Gravimetric energy storage of various OEMs can come to aid. Their round-trip efficiency is on par with battery technology and at the same time, the project life cycle is four times better with minimal maintenance needed.

4.1.2 Declining Cost of Various Battery Technologies

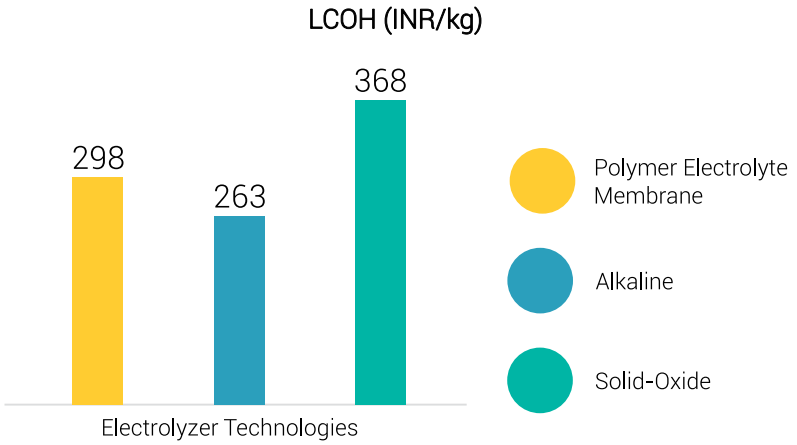
Technology-wise Trend of Battery Prices [41]



- Li-ion battery prices have reduced considerably but the prices are expected to increase slightly till 2030 owing to its ongoing value chain issues.
- Metal-air batteries are another key technology to look out for as it brings safety and reliability into the picture. The current cost of metal-air battery hovers around USD 250/kWh which is expected to decrease owing to an increase in R&D investments.

4.2 Green Hydrogen to Decarbonize the Hard-to-Abate Sectors

4.2.1 Levelised Cost of Hydrogen (LCOH) trends for various electrolyser technologies[36]



Of all the three technologies, Alkaline electrolysers provide the lowest levelised cost of generating green hydrogen in India at around INR 263/kg. This is keeping in mind that the price of electricity considered for analysis is INR 3.32/kWh (ex-busbar of solar PV plant).

4.2.2 Water and Electricity needed to meet India's green hydrogen target[36]

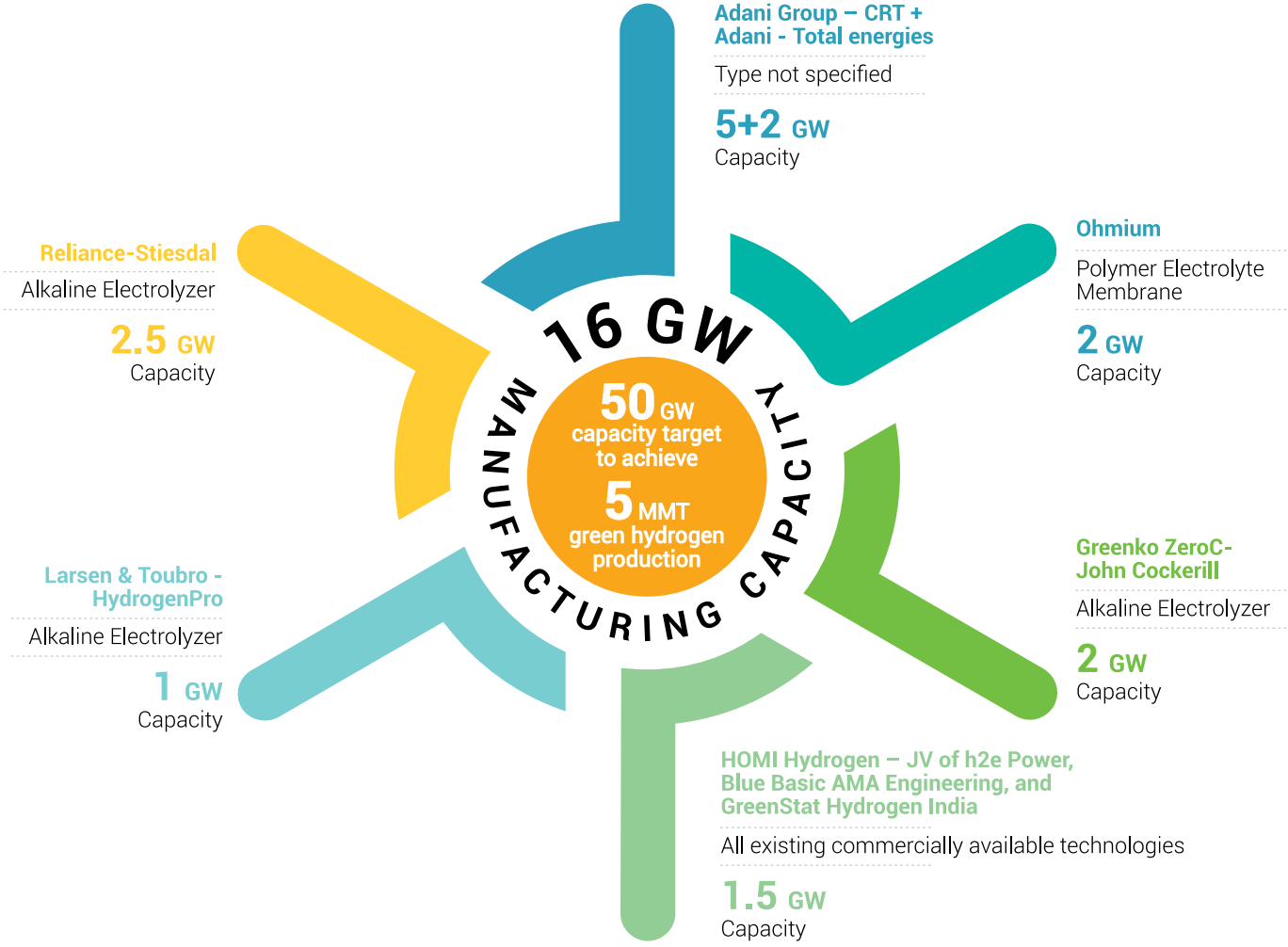
Total Amount of High-purity Water Needed **45** Billion Liters	Total Electricity Needed (If High-purity Water is Available) **250** BUs
Total RE Capacity @30% CUF (If Fresh Water is Available) **90** GW	Total Electricity Needed (If Fresh Water is not Available) **282** BUs
Total RE Capacity @30% CUF (If Fresh Water is not Available) **107** GW	RE Capacity as of September 2022 (including large hydro) **160** GW

- Green Hydrogen is likely to be at the heart of the global race to achieve economy-wide net-zero emissions.
- India has a target of achieving 5 MMT of Green Hydrogen production capacity by 2030. The enabling factors to achieving this target are mentioned in the adjacent figure.

Key Assumptions

- 50 kWh of electricity needed to produce 1 kg of hydrogen
- 9 kg of purified water needed to produce 1 kg of green hydrogen
- 6.453 kWh of electricity needed to purify 10 kg of water

4.2.3 Upcoming Electrolyser Manfacturing Capacity in India [42][43][44][45][46][47][48]

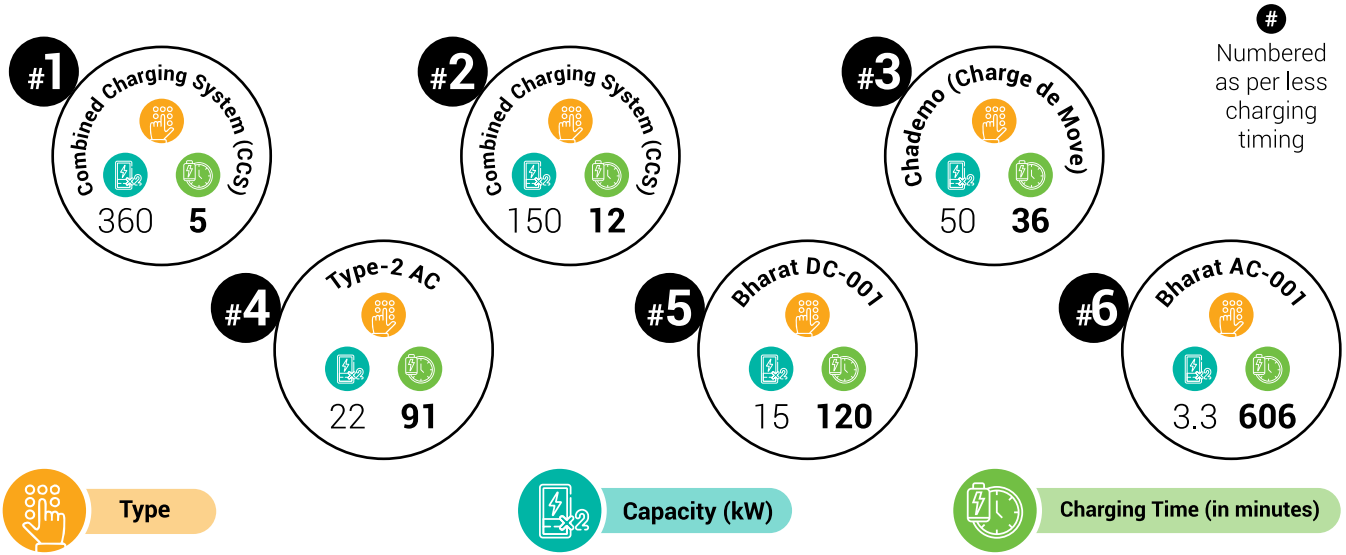


- 16 GW of electrolyser manufacturing capacity is expected to be operational by 2025 in India. Of this, alkaline electrolyzer technology is the preferred technology type.
- For India to meet its 5 MMT target of green hydrogen by 2030, around 50 GW of electrolyzer capacity must be online by 2030. Clearly, there is a huge opportunity for the private sector to ride this bandwagon.

4.3 Ratcheting up Transport Sector Electrification

4.3.1 Reduction in charging time for Electric Vehicles

Existing Charging Capabilities[36]



Future Scope	Type	Expected Year	Technology	Charging Time (in minutes)
	Quantum Charging with Global Operation	2035	DC	0.15

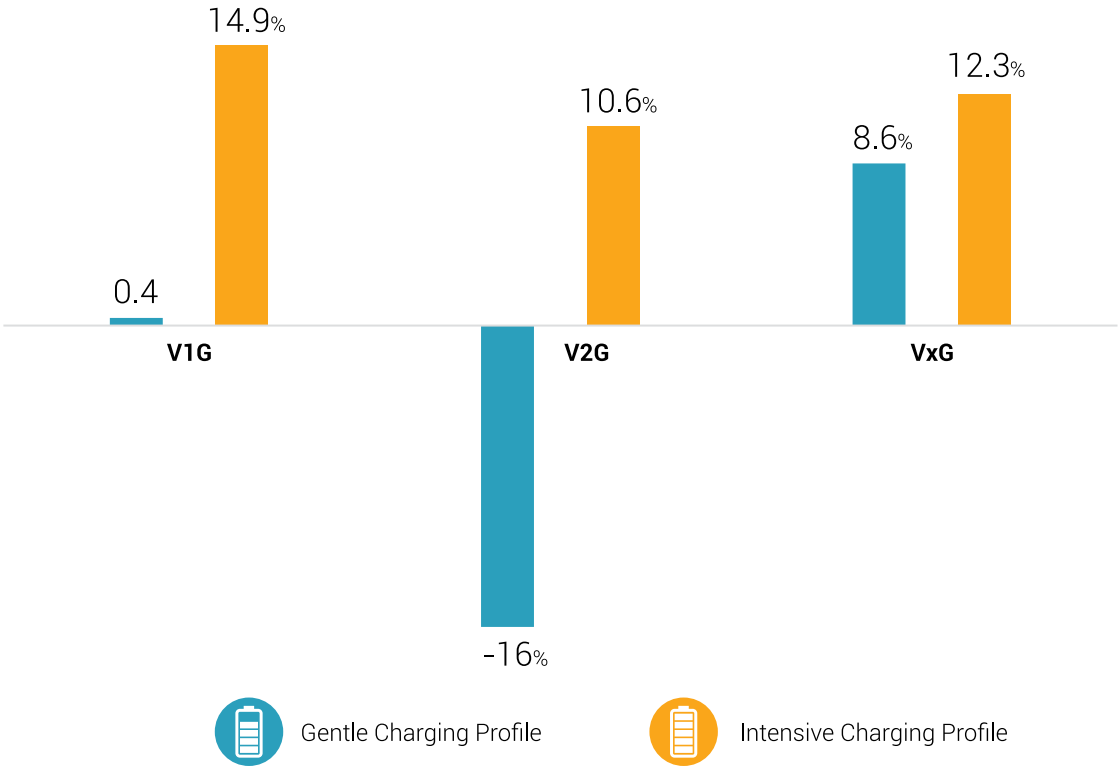
- With a 150 kW DC charger, the charging time to boost 210 km will be around 12 minutes.
- With quantum charging prospects getting clearer, the charging time can be reduced to less than half a minute by 2035.

Key Assumptions

- Battery Capacity of EV- 50 kWh
- Current SOC- 20%
- Final SOC- 80%
- Battery Capacity to be Charged- 30 kWh
- Per kWh Distance Travelled – 7 kms/ kWh
- Total Distance Boost- 210 kms

4.3.2 Settling the debate on VxG viability

Impact of Various Strategies on Battery Degradation for a Year (%) [49]



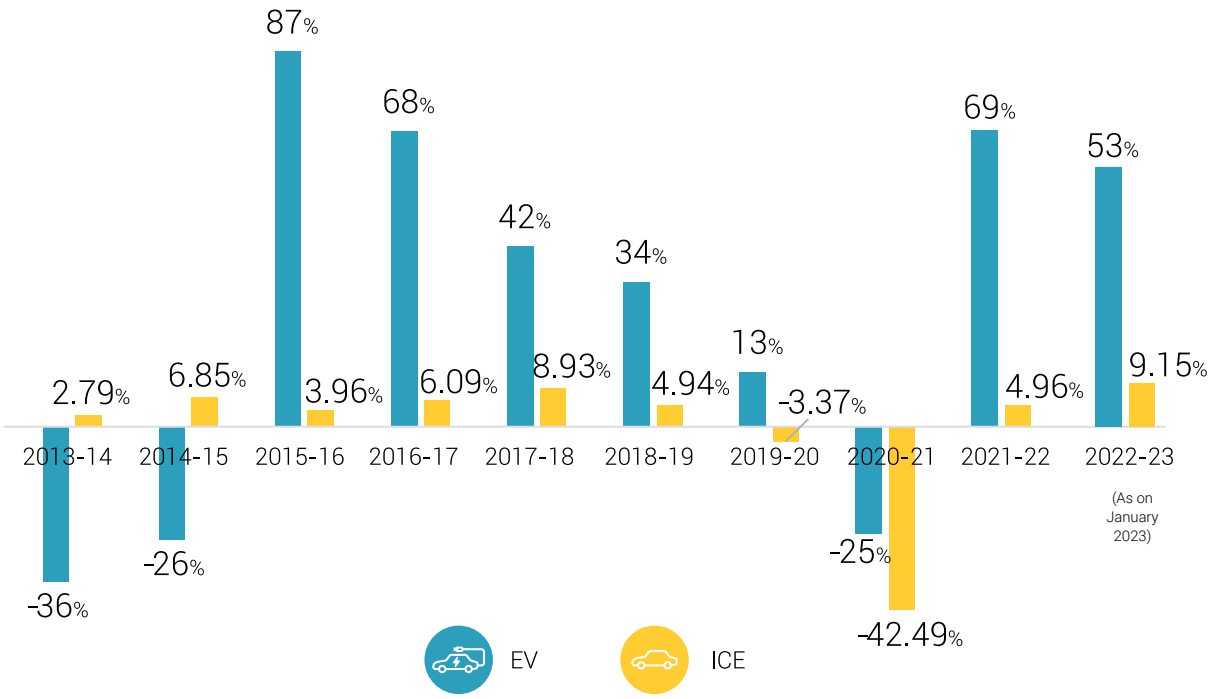
- Cenex along with several other partners demonstrated the impact of V2G on battery life. Two profiles of vehicles were kept under the lens i.e., the Gentle profile where the SOC doesn't drop significantly during the day, and the Intensive profile which has a higher Depth of Discharge.
- It was seen that the VxG strategy balances both calendar and cycle ageing which has improved the battery life by 8.6% in the gentle profile and 12.3% in the intensive profile over a year.

5 RAMPING UP THE PACE OF ELECTRIFICATION OF END-USE APPLICATIONS

5 RAMPING UP THE PACE OF ELECTRIFICATION OF END-USE APPLICATIONS

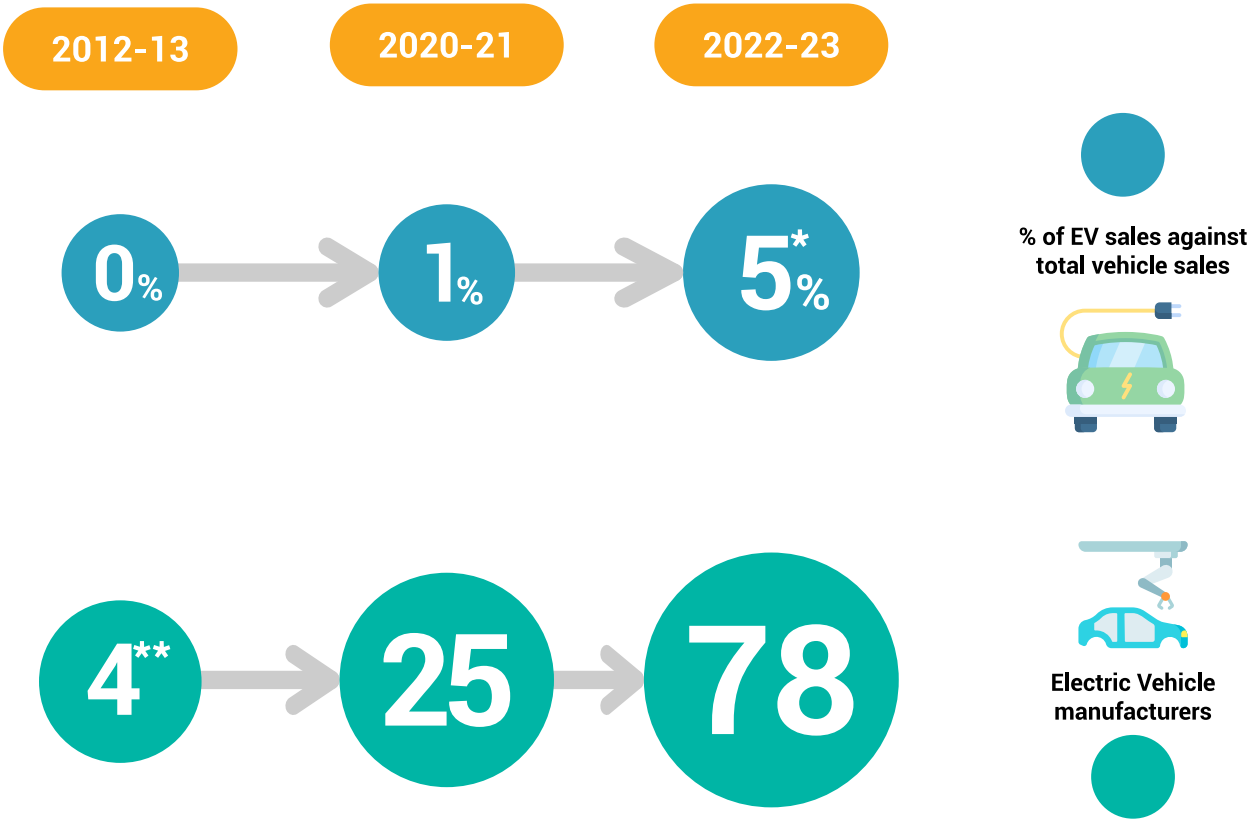
5.1 Growing technology-wise Vehicle Penetration in India

Growth of Technology-wise Vehicle Penetration in India [50]



- Penetration of electric vehicles has increased rapidly year on year. In 2022-23, a 53% increase in EVs was observed in comparison to the previous year.
- On the flip side, the percentage increase of ICE vehicles has remained low.

5.2 Concomitant increase in EV uptake and EV manufacturers[51]

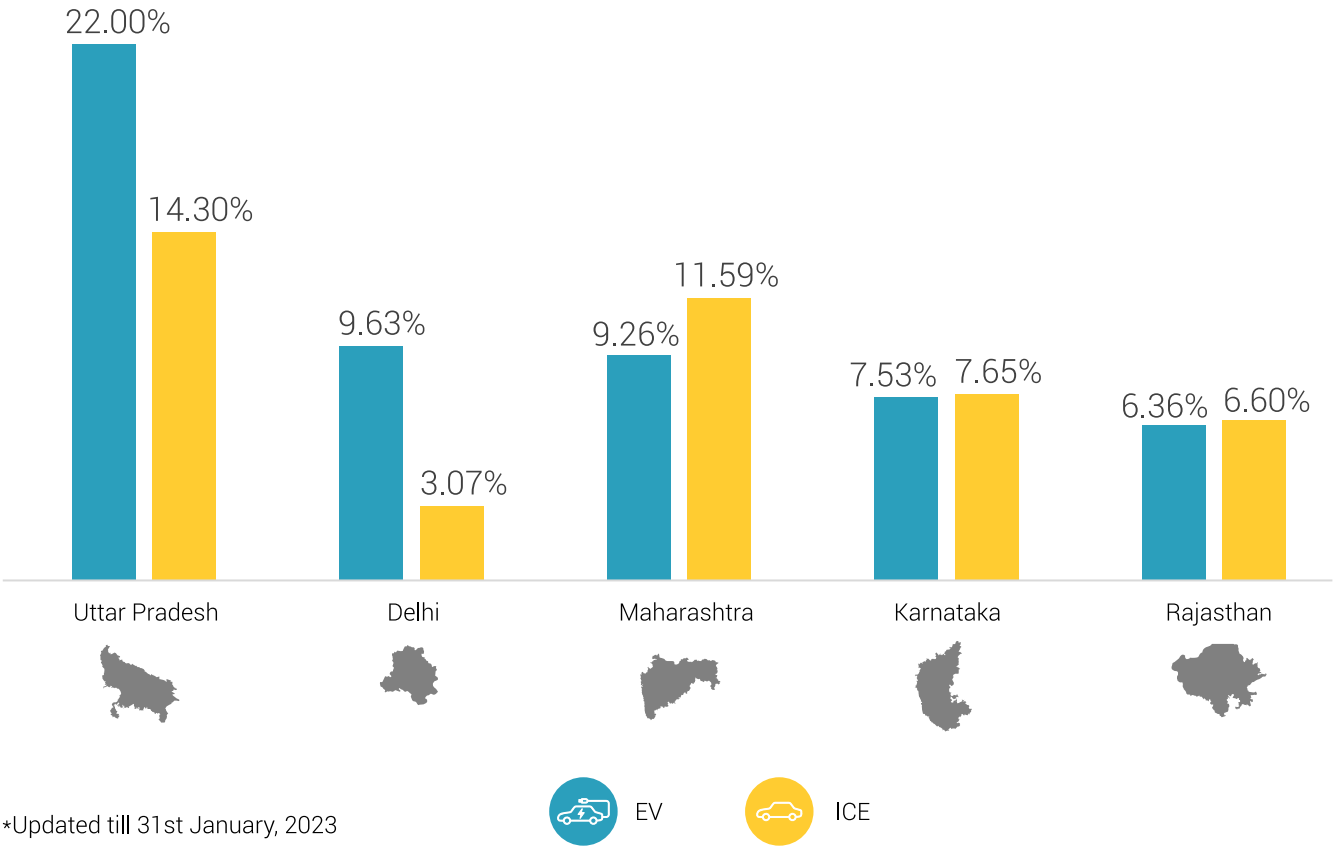


*Data for 2022-23 was considered till 31st January 2023
**Data for 2012-13 was considered based on desk research as the FAME scheme was not launched then.

- Faster Adoption and Manufacturing of Hybrid & Electric Vehicles-1 (FAME-1) launched in 2015 and the successive phase launched in 2019 have been the bedrock for India's strategy to electrify the transportation sector in conjunction with the timely release of state EV policies.

5.3 Leading States with highest EV shares

States with highest EV/ICE share against total respective vehicle category* [50]

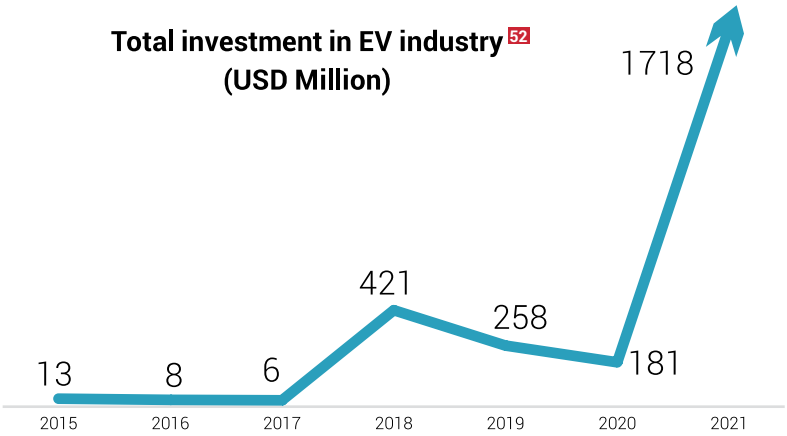


*Updated till 31st January, 2023

- Uttar Pradesh (UP) emerges as the shining star in India's EV journey. To date, 22% of total EVs sold in India belong to UP.
- Delhi comes second with 9.63% of the total EV share owing to its progressive EV policy.

5.4 Increasing Investments in India's EV market

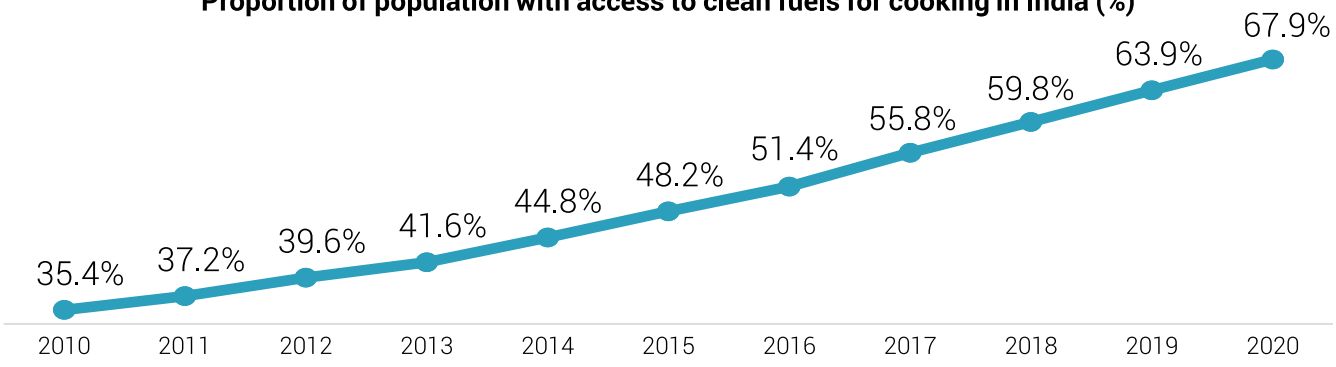
Total investment in EV industry[52] (USD Million)



- The interest of investors in the electrification of the transport sector is soaring.
- In 2021, the total investments in the EV sector in India touched USD 1.7 billion which is around 9.5 times the previous year. Over the next 5 years, investments to the tune of USD 12.6 billion are estimated.[53]

5.5 Growing share of the population with access to clean cooking fuels[54]

Proportion of population with access to clean fuels for cooking in India (%)[55]



- Due to many government interventions such as PMUY, almost 68% of the population now has access to cleaner cooking fuels. However, the Indian Residential Energy Survey (IRES) that was conducted in 2020 indicates that more than 70% of Indian households use LPG as a primary fuel, but more than half of Indian households still have not fully switched to modern, clean cooking fuels or technologies.[56]
- It further stated ~5% of the total households have shifted to electric cooking or RE based cooking solutions. This translates to a penetration of 10.3% in urban households and only 2.7 % among rural households.[57]

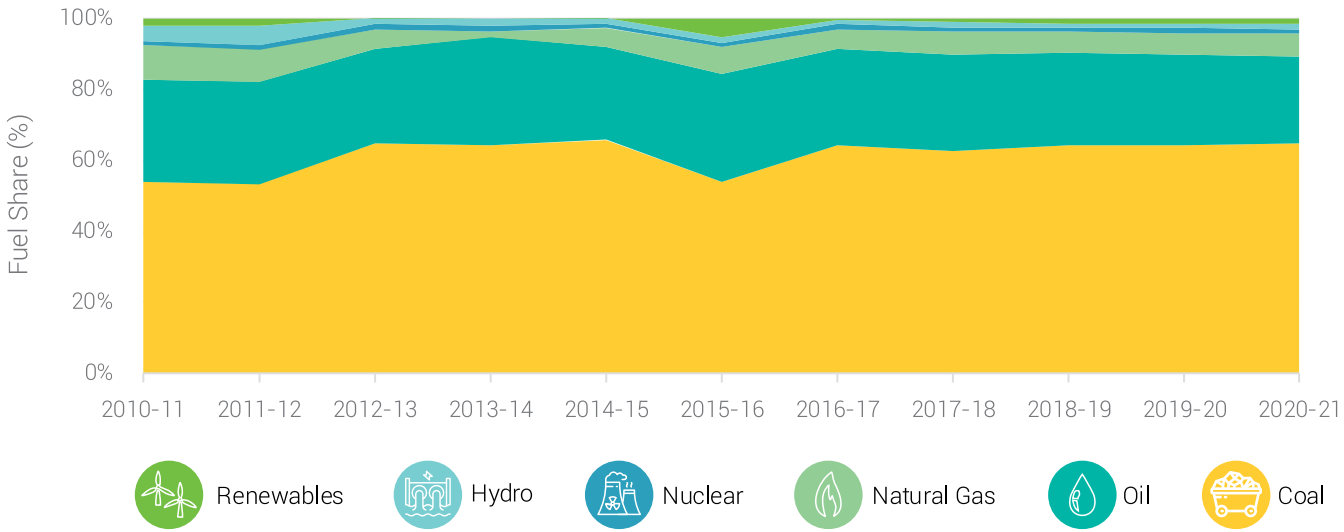
6

THE COMPLEXITIES OF ENERGY SECURITY

6 THE COMPLEXITIES OF ENERGY SECURITY

6.1 Contribution of various energy sources for meeting energy demand

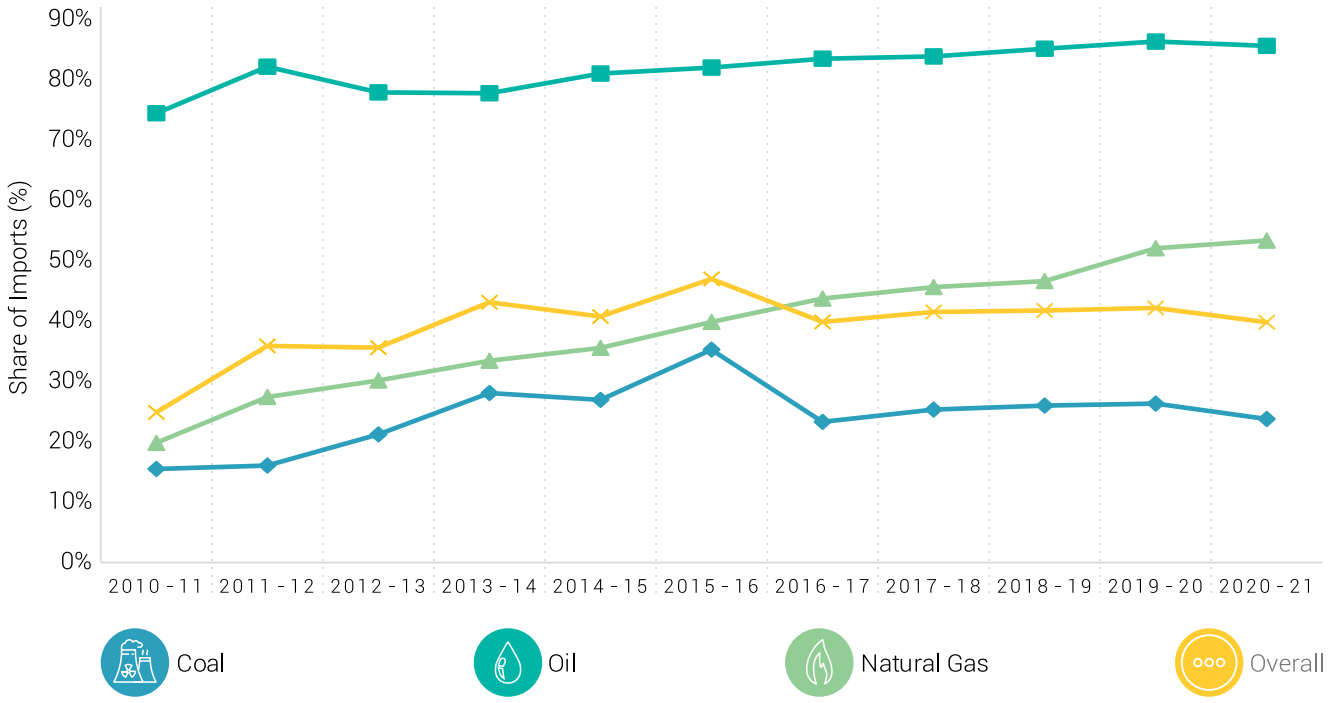
Fuel share in Primary Energy (%) [3] [58]



*The primary energy demand excludes the traditional use of solid biomass.

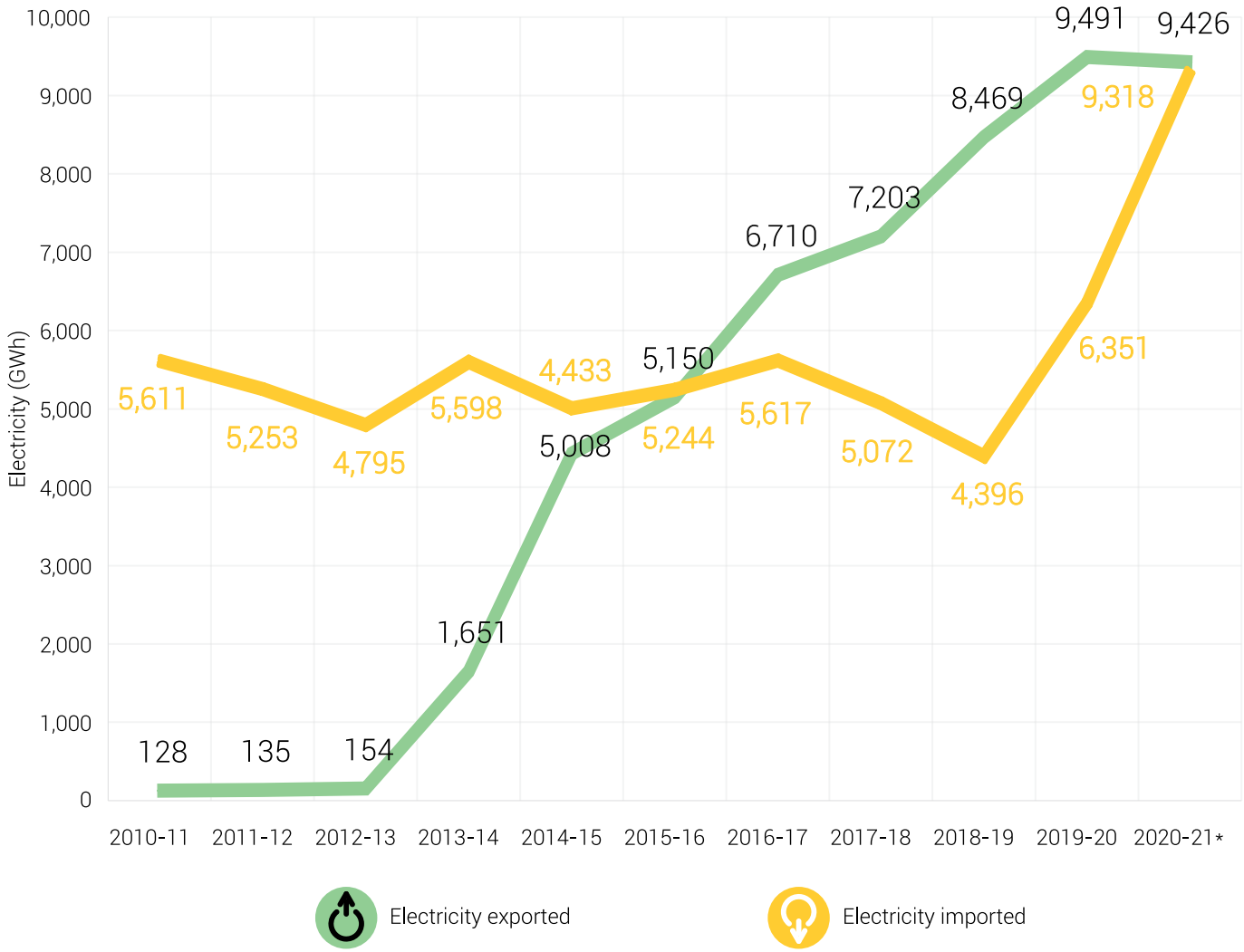
- The share of coal and oil has remained at a high of 80%-90% of the primary energy supply in the last decade.
- Further, India has been adding large-scale Renewable energy to decarbonize its power sector. The share of electricity generation from renewables (excluding large hydro) has almost doubled itself from 6.5% to 12.2% over the last decade of FY12 and FY22.
- Traditionally Biomass has been a source that is dominantly used for cooking and heating purposes in rural households. In 2021, this accounted for 22%-32%[59] [60] of the total primary energy use in India.

6.2 Share of Imports in Fuel Sources Supply[3]



- Despite the ballooning energy demand in the last decade, the import dependency has almost hovered between 30-40% of the total primary energy demand.
- However, India's energy imports rose by 61% in the last 10 years from 9,139 PJ in 2010-11 to 14,671 PJ in 2020-21.
- India possesses the world's fifth-largest coal reserves but is also one of the world's major coal importers.
- The rising need for clean cooking and transport use has more than doubled the share of Natural gas imports from 20% to 50% between 2010-11 and 2020-21.
- While the demand for imported crude oil has risen sluggishly at a 2% CAGR; this translates to meeting more than 90% of the crude oil supply for the country.

6.3 Increasing electricity exports [3]

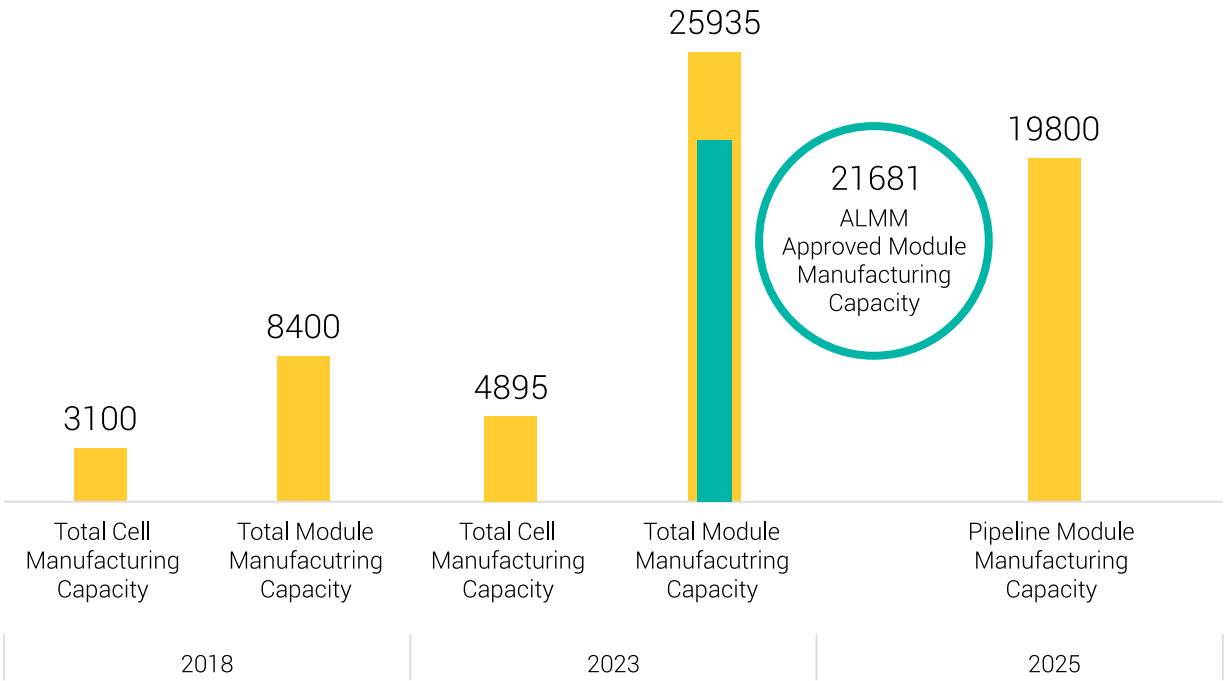


For the first time in 2016-17, India became a net exporter of electricity.

6.4 Filip to domestic manufacturing of RE technologies

6.4.1 Solar PV modules

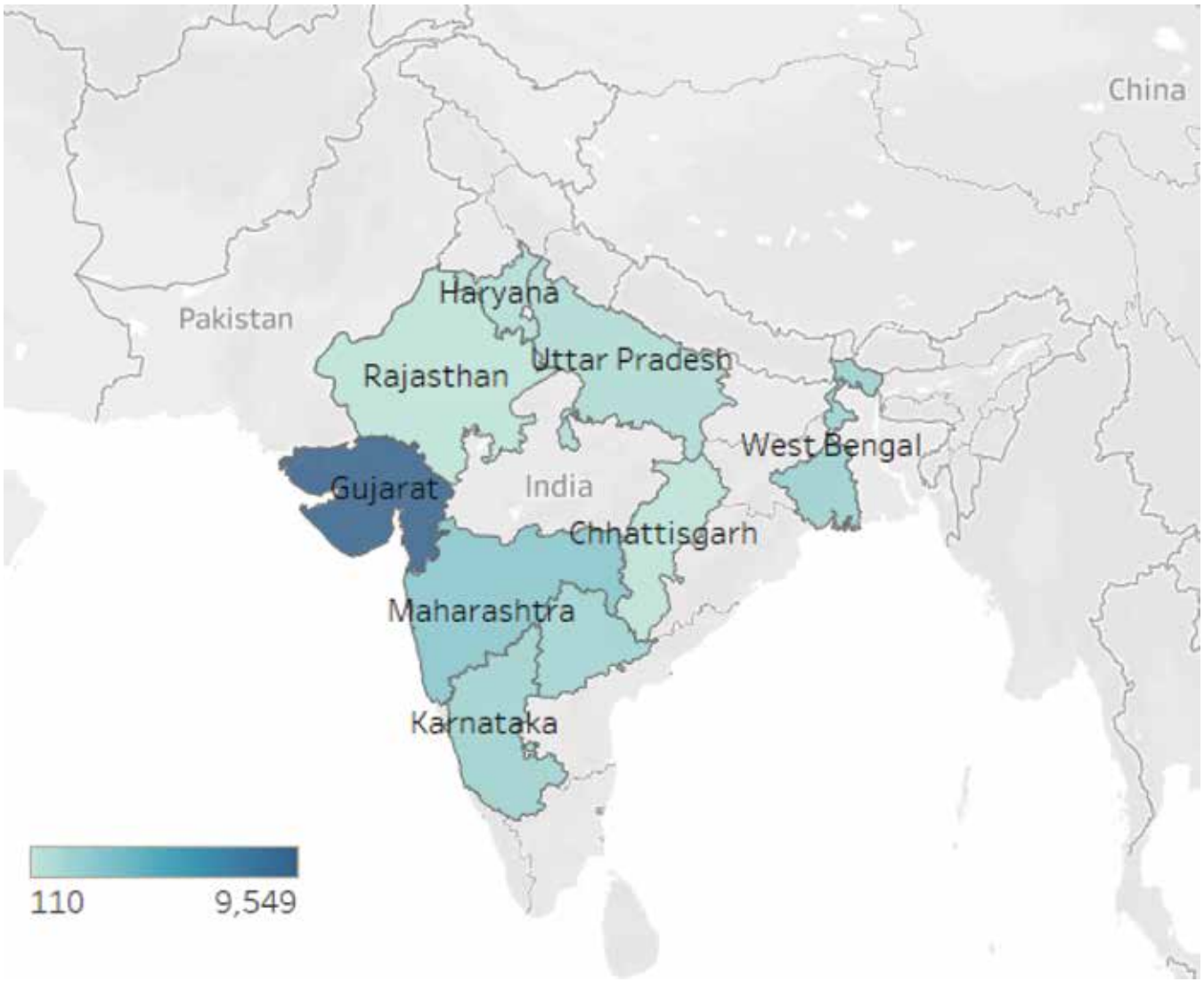
Trend of Solar PV Manufacturing Capacity in India (MW)[61]



(As on January 2023)

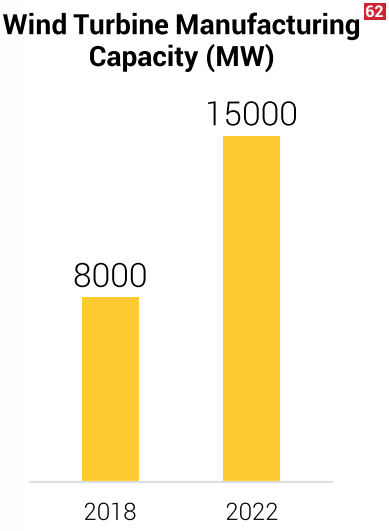
- The total module manufacturing capacity has more than doubled since 2018 and is around 21 GW under the Approved List of Models and Manufacturers (ALMM) of Solar PV banner as of January 2023. However, the total manufacturing capacity exceeds 25 GW.
- There is also a lucrative pipeline of module manufacturing capacity of ~20 GW by 2025.
- Though the cell manufacturing capacity has increased by ~1.5 times since 2018, this is bound to increase further owing to the PLI scheme.

State-wise Solar PV manufacturing

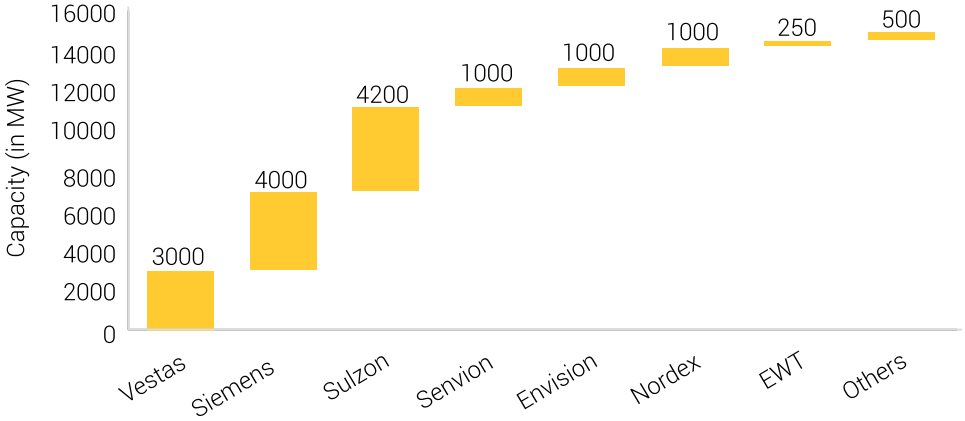


- Gujarat leads solar manufacturing across all the States in India with 9,549 MW of capacity. The distant second is Maharashtra with one-fourth the value of Gujarat at 2,446 MW.

6.4.2 Wind Turbines

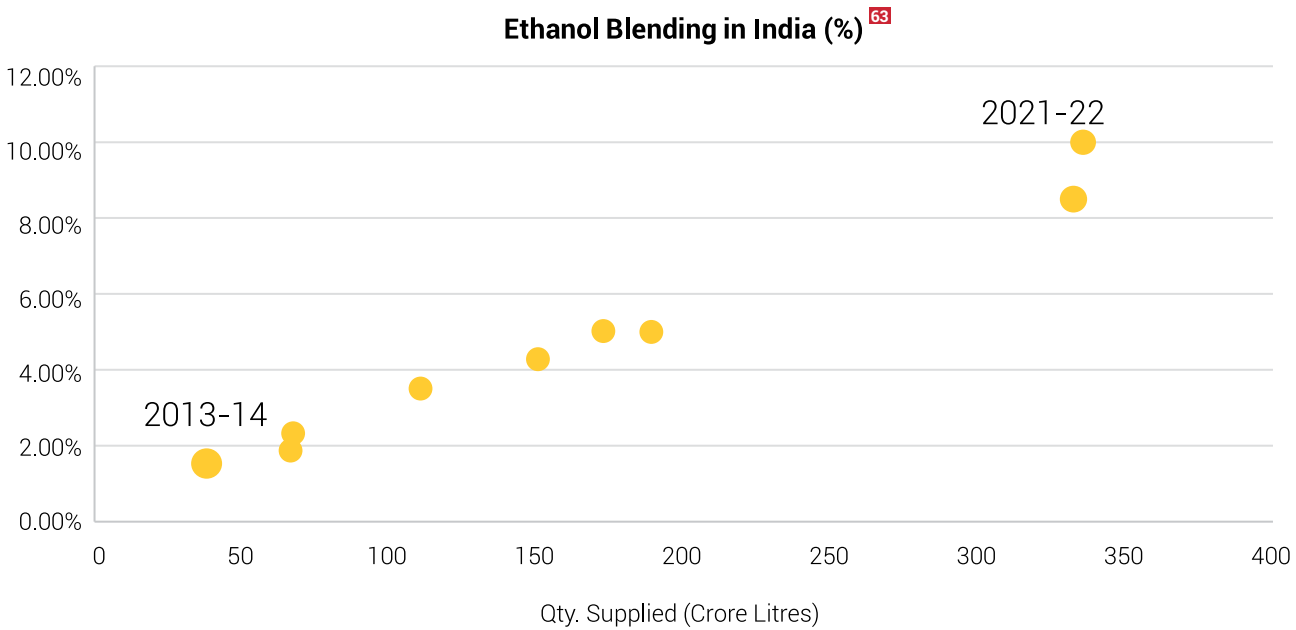


- The Wind Turbine Generator (WTG) manufacturing capacity has almost doubled since 2018 and has reached 15 GW in 2022.



- Of 15 GW, Siemens Gamesa, Vestas, and Suzlon have a total manufacturing capacity of 11.2 GW comprising 75% of the total manufacturing capacity in India.

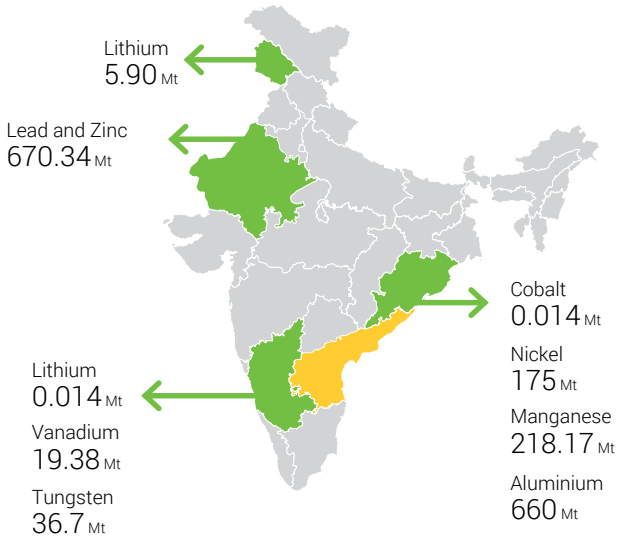
6.5 Increasing ethanol blending in India



- India has reached halfway to realizing its 2025-26 ethanol blending target of 20%.
- The ramp-up in ethanol production has taken steam in the last two years when the ethanol production capacity doubled from 173 crore liters in 2019-20 to 332 crore liters in 2020-21.

6.6 Increasing reliance on lithium imports

India's Reserve (in million tonnes) [64] [65]



257.77 GWh
India's battery energy storage required by 2032

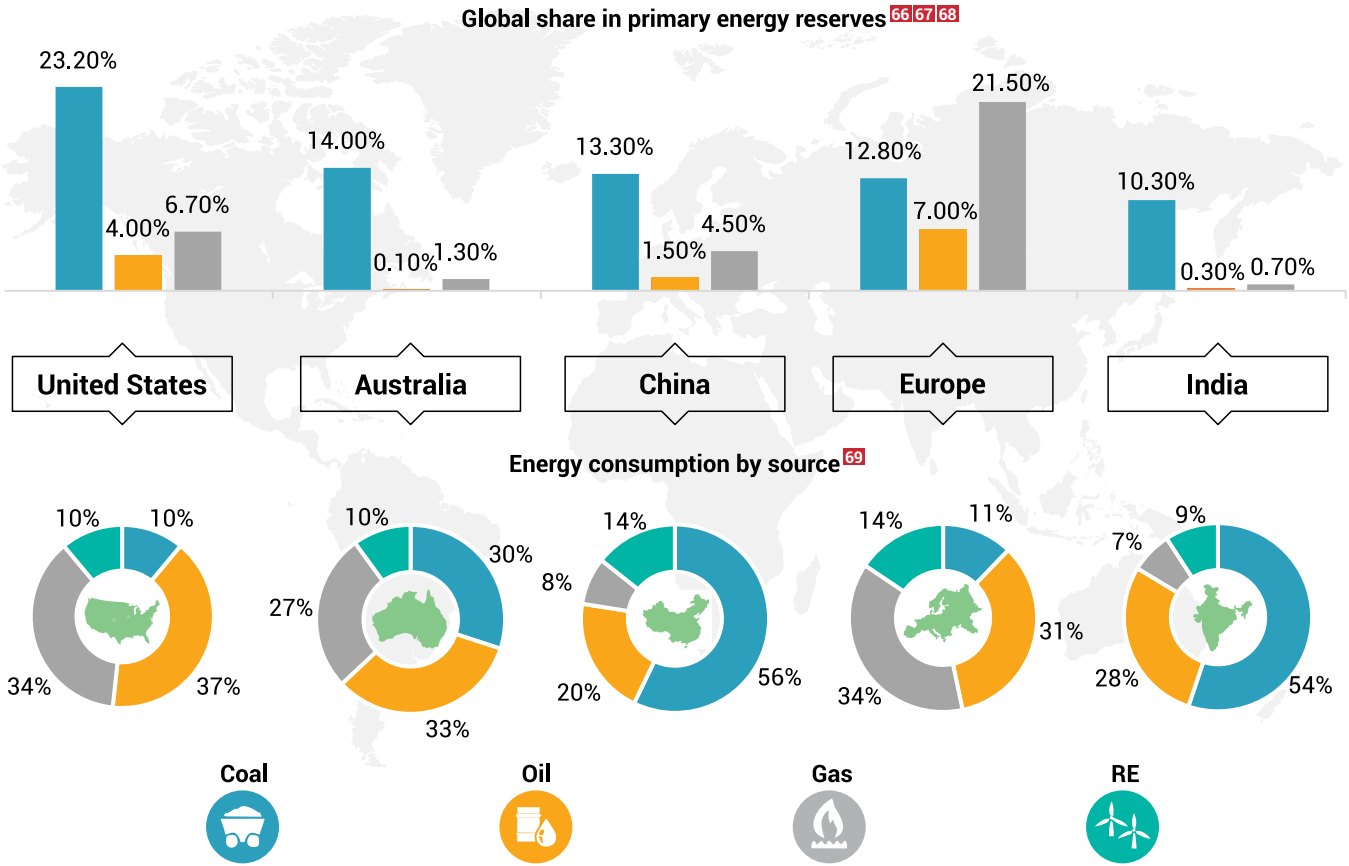
- By 2032, India's battery energy storage requirement will be around 257.77 GWh. It is of paramount importance that we explore looking at multiple battery chemistries.
- Recently, Geological Survey of India (GSI) have intimated the presence of around 5.9 million tonnes of lithium in Reasi district of Jammu and Kashmir (UT). Though these kind of reserves put India on the global map, these are still less in comparison to other mineral reserves.
- Aluminium is the most abundant mineral/ metal found in India. The focus should be enhanced to transition Aluminium-air batteries from lab to market.
- Odisha leads the way by having the highest reserves of several key minerals/ metals.

7

INDIA AND GLOBAL STANDARDS

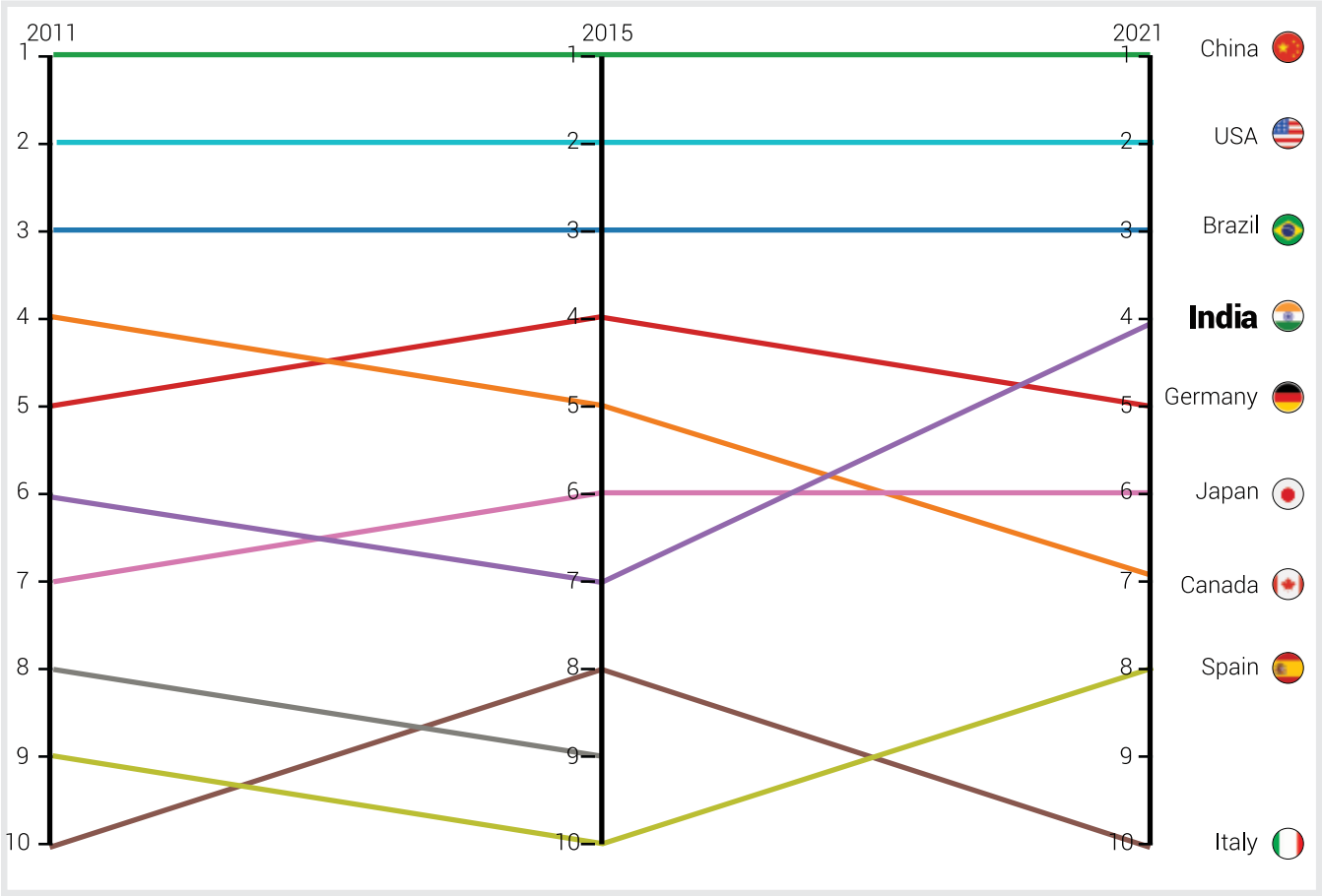
7 INDIA AND GLOBAL STANDARDS

7.1 Global share of primary energy reserves in India



- India accounts for almost 10% of the global coal reserves.
- Oil & Gas share in the global reserves are 0.3% and 0.7% in the year 2020, respectively.

7.2 Leading RE deploying countries

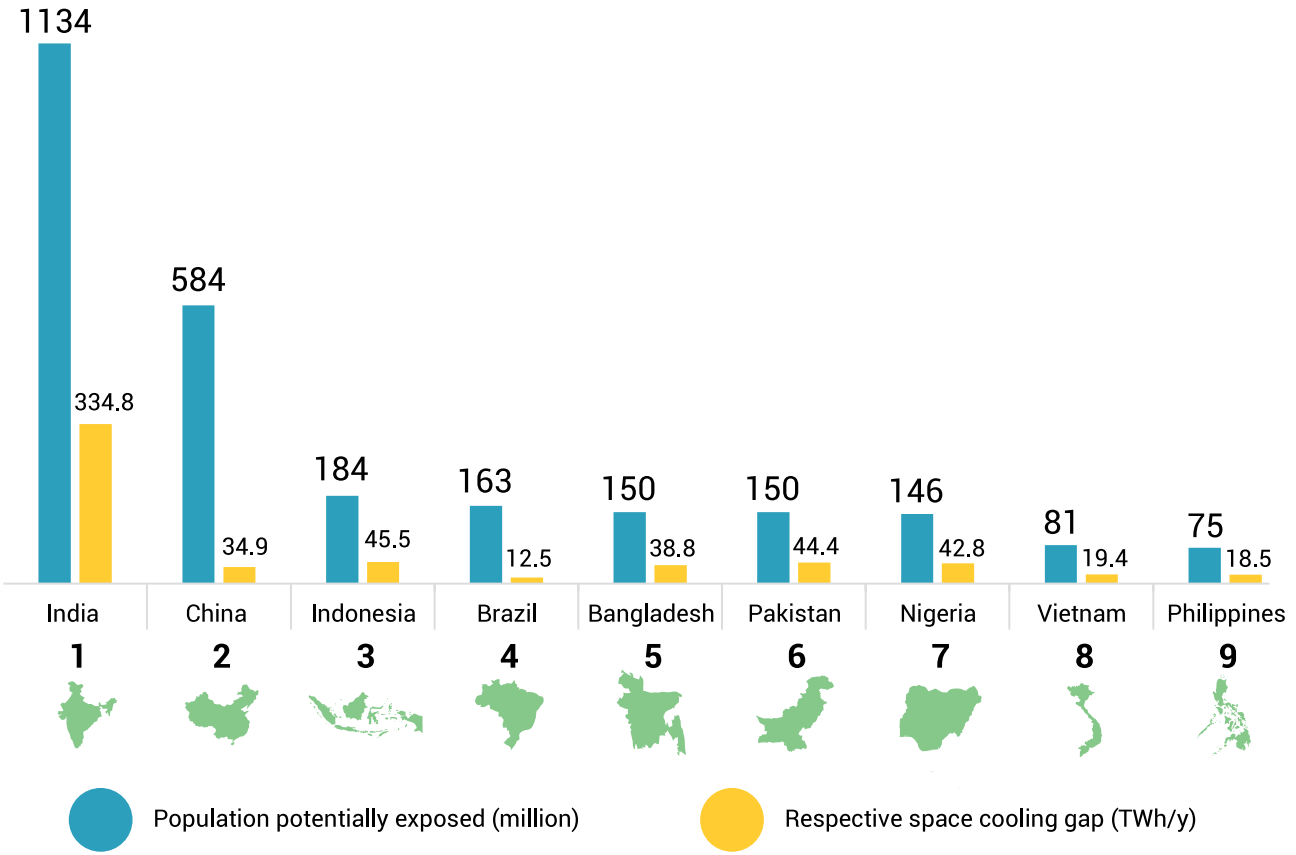


Brazil
Canada
China
Germany
India

Italy
Japan
Russia
Spain
USA

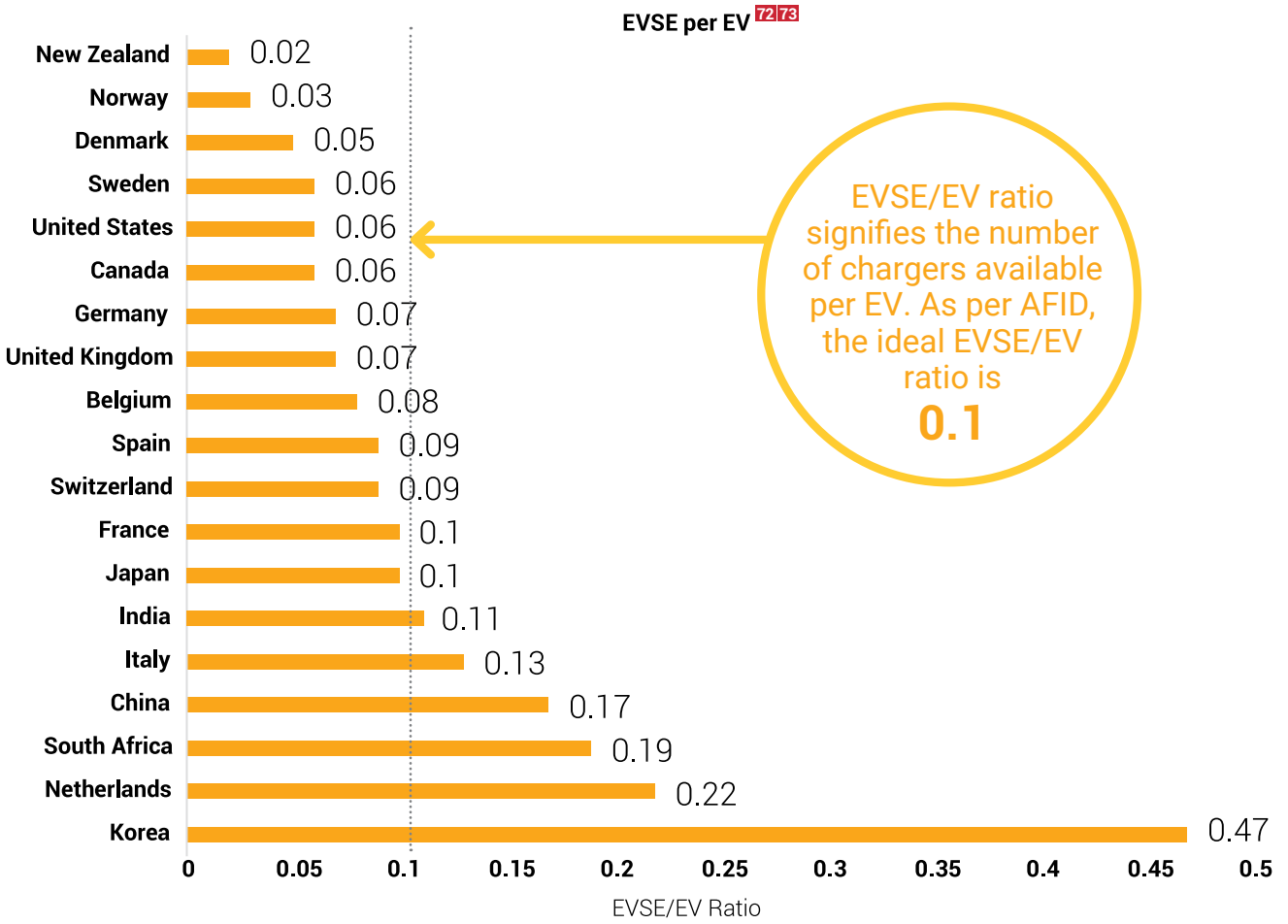
- The top-10 RE deploying cohort of nations has remained fairly consistent with at least 9 countries making the list in 2022 as well in comparison to 2011.
- With a total RE capacity of around 152 GW, India has improved its ranking from 7th in 2015 to 4th in 2021. This underscores India's consistent strides to meet global climate commitments.

7.3 Global comparison on space cooling energy demand gap [70]



- The cooling energy gap [71] is calculated as a difference between the cooling demand with universal access to fans and AC vs the current access.
- India represents 44% of the total global space cooling gap. This is the highest amongst all countries in the global south.
- ~1.1 billion Indian people will be potentially exposed to heat stress and affected by the cooling gap of 335TWh/ year for an indoor temperature of 26 degrees Celsius. This is also the highest among all the countries in the Global South.

7.4 EV charger per EV across the world



- South Korea leads globally with a ratio of 0.47 signifying that the country has more public chargers and a smaller percentage of EVs.
- In India, the deployment of public chargers is ramping up with around 6561 public chargers already deployed and around 4 lakh public chargers are targeted till 2026. It is heartening to know that India's EVSE/EV ratio is at par with the ideal standard.

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Abbreviations

AC	Air Conditioner
AC	Alternating Current
AFID	Alternative Fuel Infrastructure Directive
BU	Billion Unit
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CFL	Compact Fluorescent Lamp
CUF	Capacity Utilization Factor
DC	Direct Current
EE	Energy Efficiency
EJ	Exajoule
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FAME	Faster Adoption and Manufacturing of Hybrid and Electric Vehicles
GDP	Gross Domestic Product
GW	Gigawatt
ICE	Internal Combustion Engine
LCOE	Levelised Cost of Energy
LCOH	Levelised Cost of Hydrogen
LED	Light Emitting Diode
MMT	Million Metric Tonne
MTOE	Million Tonne of Oil Equivalent
MW	Megawatt
OEMs	Original Equipment Manufacturers
PAT	Perform Achieve and Trade
PID	Potential Induced Degradation
PJ	Petajoule
PMUY	Pradhan Mantri Ujjwala Yojana
RE	Renewable Energy
SoC	State of Charge
UJALA	Unnat Jyoti by Affordable LEDs for All
V1G	Smart charging without feeding back into the grid
V2G	Smart bi-directional charging
VxG	Blended approach of V1G and V2G
WEO	World Energy Outlook
WTGs	Wind Turbine Generators

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