“Renewable Energy for Climate Change Mitigation”

Workshop on Integrating Climate Action in the Development Planning of Puducherry Union Territory

Organized by:

The Energy and Resources institute (TERI)

New Delhi

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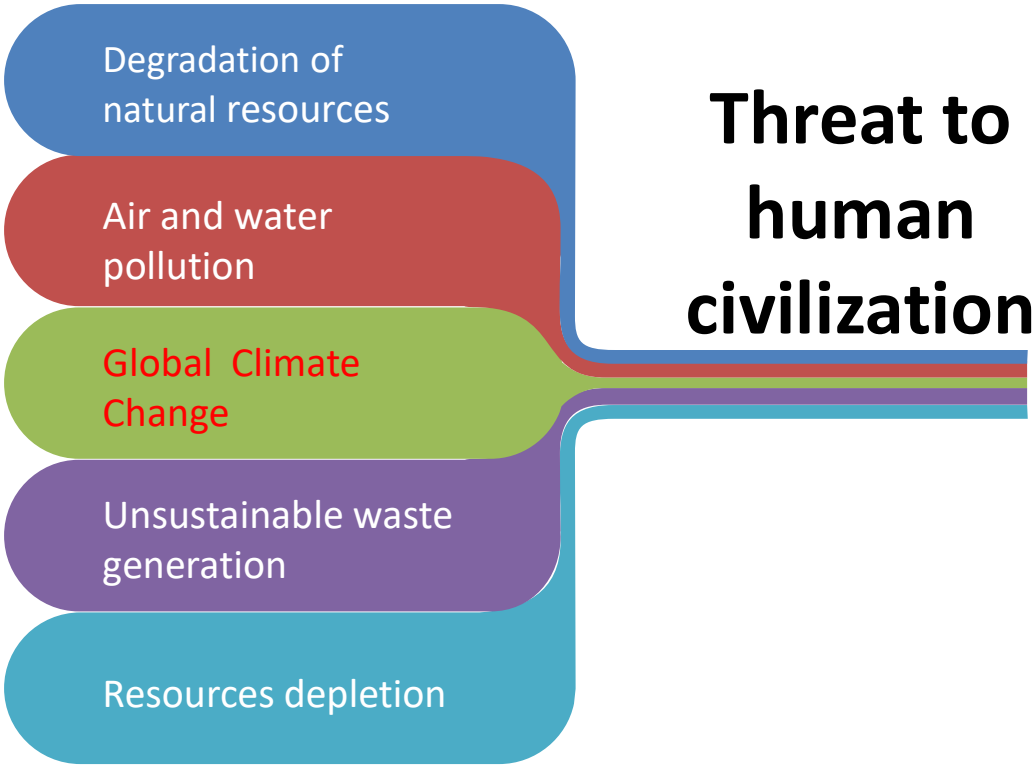
Senior Fellow and Director
TERI

Flow of the presentation

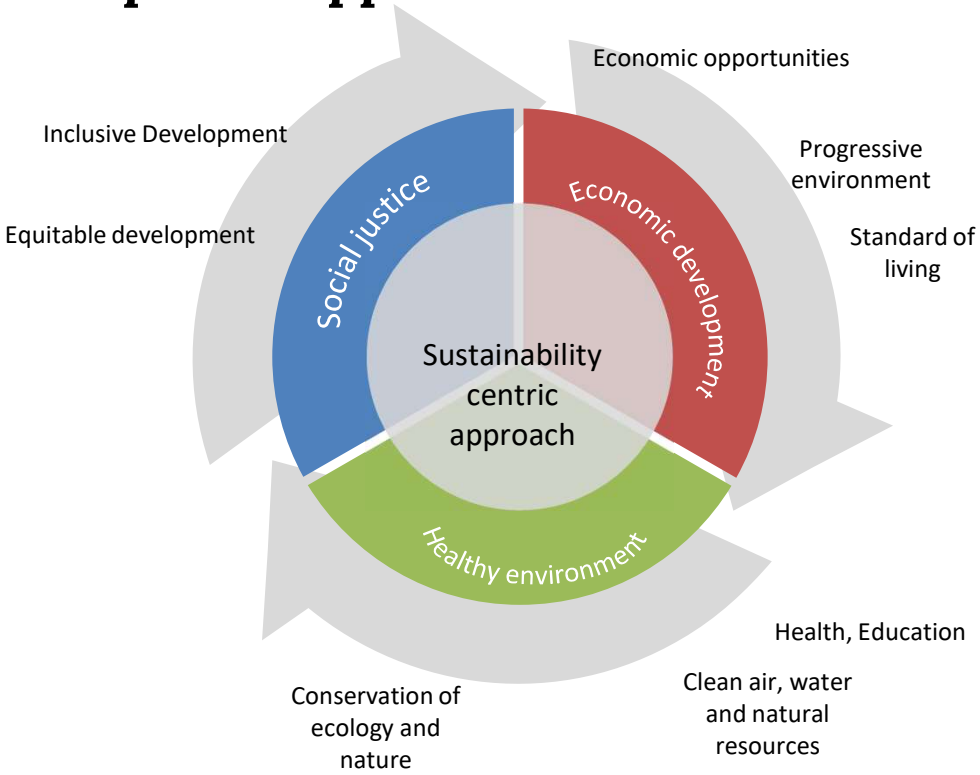
- Energy and its impacts
- Renewables : Introduction
- Puducherry Power system
- Possible RE interventions
- Progress so far
- Way forward

Impacts of uncontrolled and rapid development

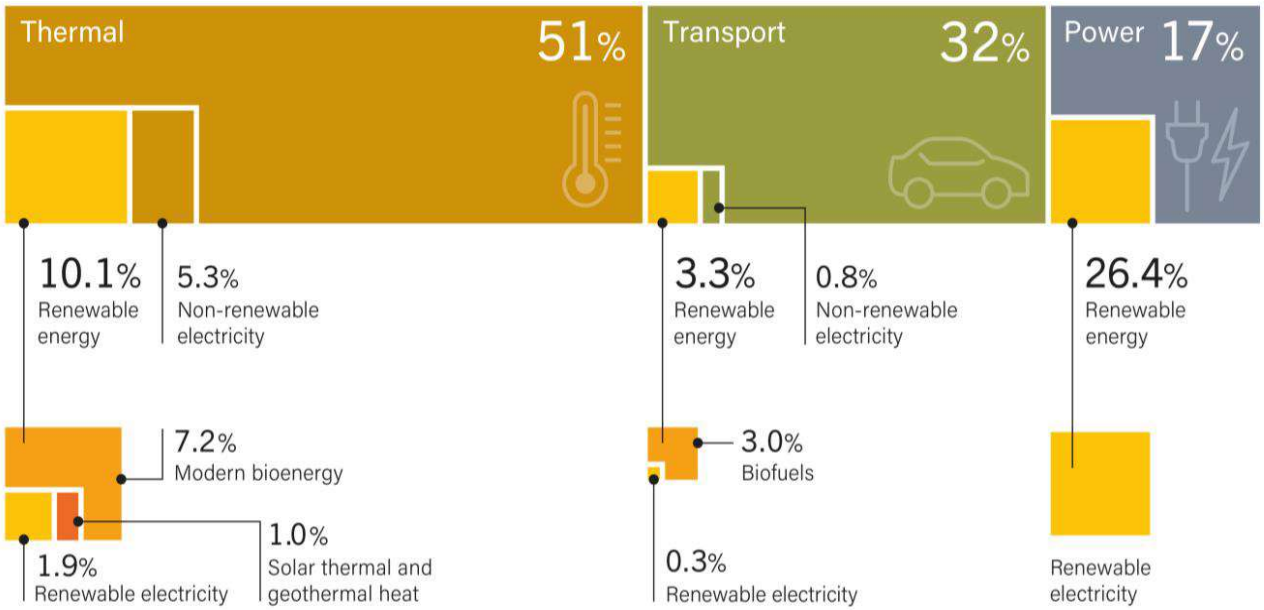


Sustainability centric development approach

- Quality of life
  - Physical needs
  - Emotional
  - Spiritual
  - Intelligence

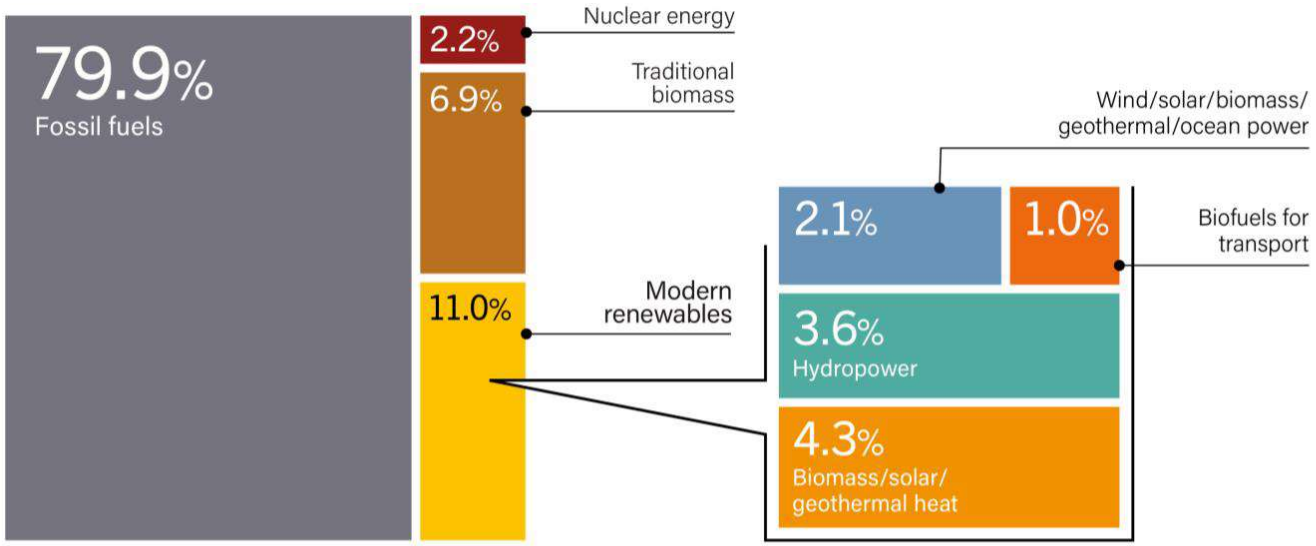


Energy demand global scenario



More than 80% of the energy is consumed in heating, cooling and transport

RE share in Energy Demand

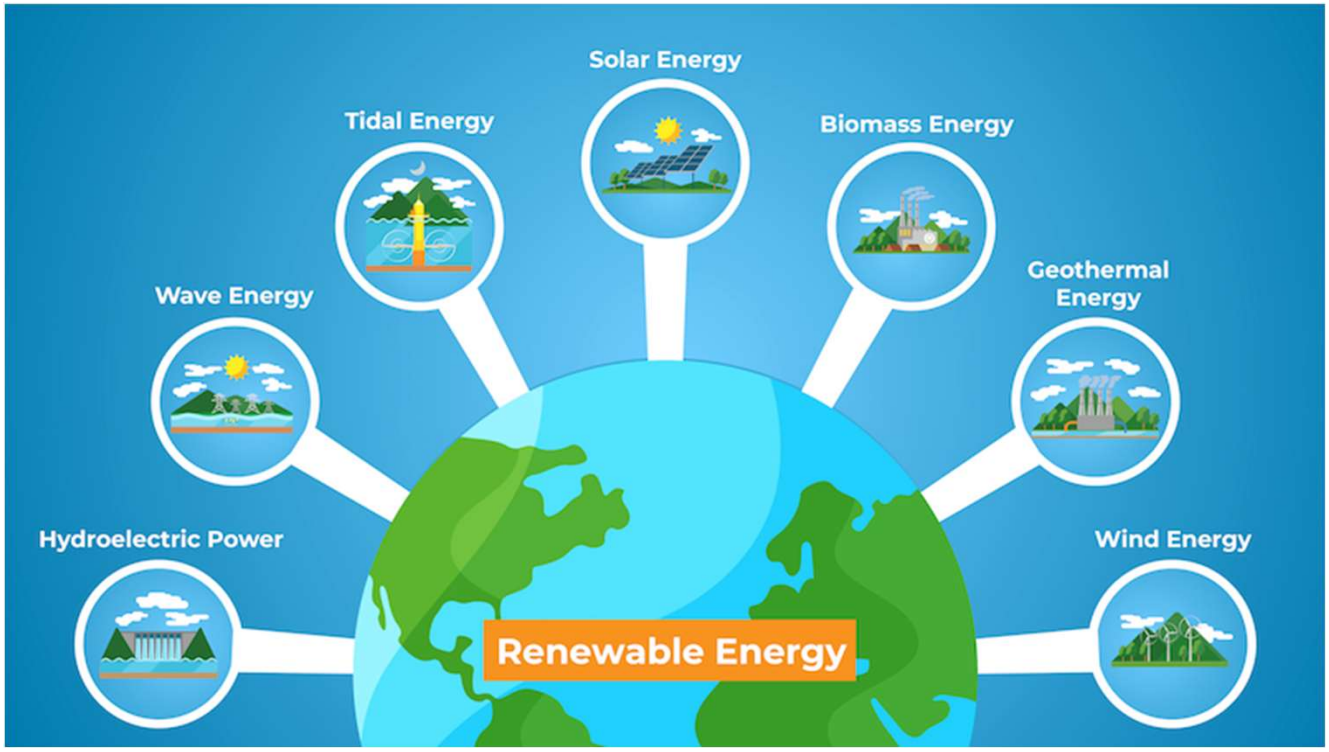


Note: Data should not be compared with previous years because of revisions due to improved or adjusted data or methodology. Totals may not add up due to rounding.

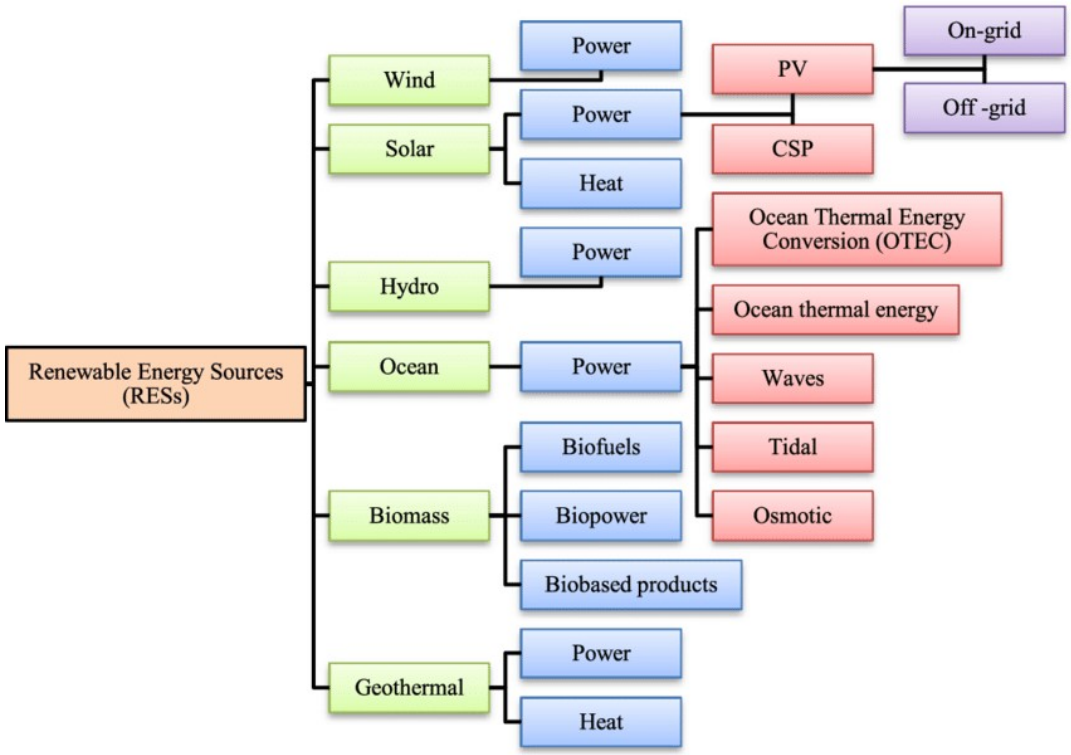
Source: Based on IEA data.

REN21 RENEWABLES 2020 GLOBAL STATUS REPORT

Renewable Energy Technologies



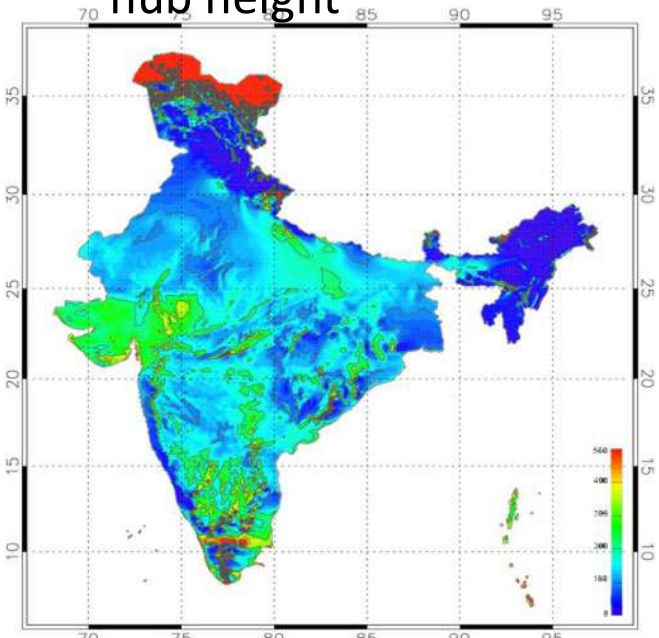
Renewable Energy Technologies



Solar Technologies

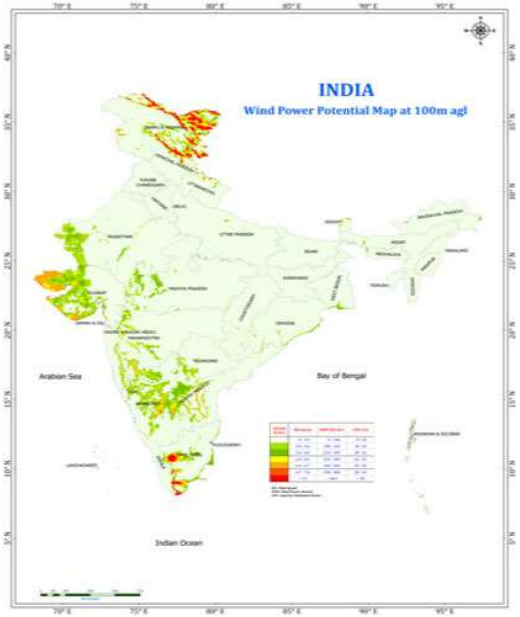
Wind energy basics

Wind energy potential at 80 m hub height



Gross potential= 102,788 MW

Wind energy potential at 100 m hub height



Gross potential- 302,251 MW

- Wind power density min 200 W/m^2
- Wind speed:
  - Min 2- 5 m/s

Source : http://inwea.org/wind-energy-in-india/wind-power-potential/

Turbine technologies

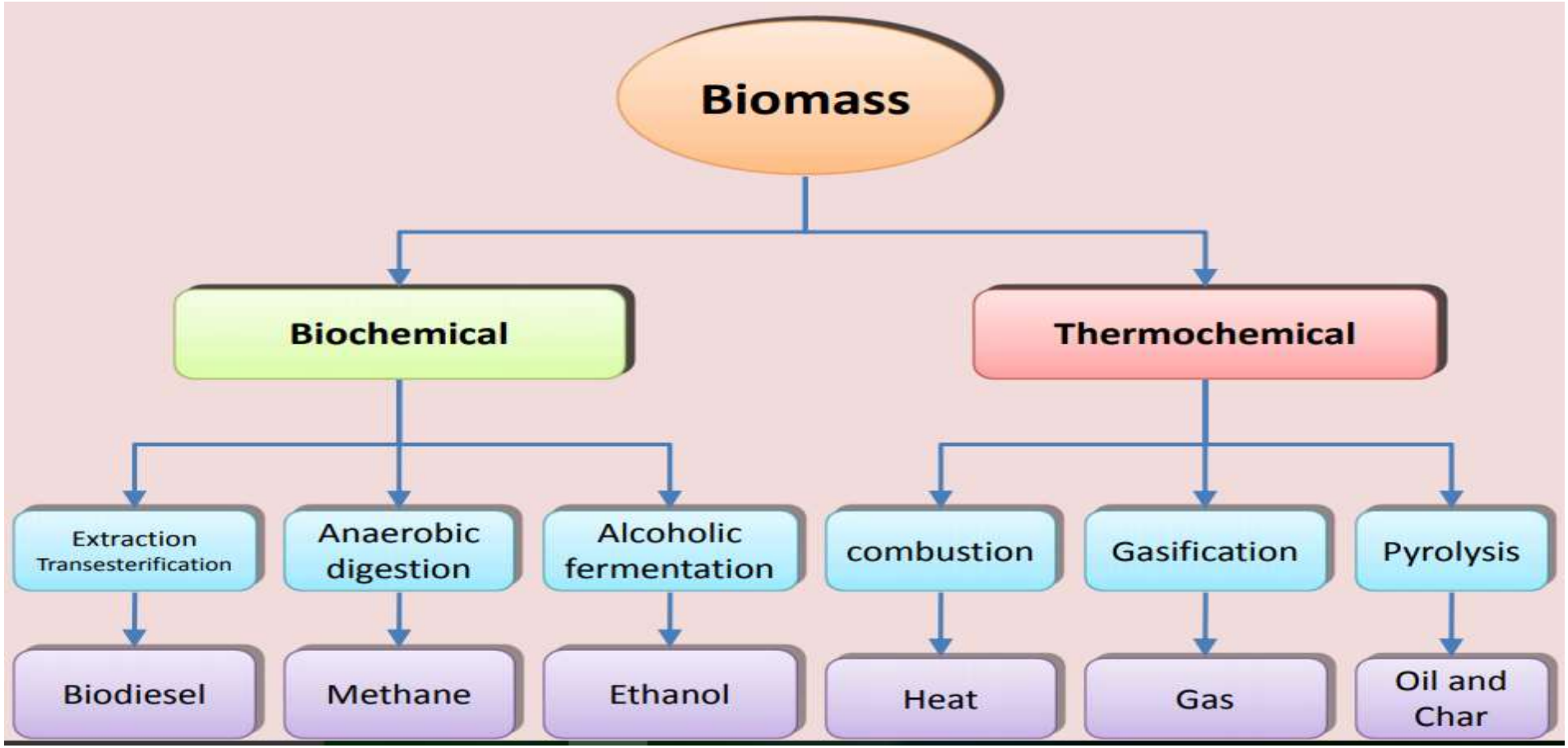
- India
  - India has 8 manufacturers
  - Manufacturing capacity 9.5 GW per year
  - 250 kW to 2.1 MW capacity turbines
- Global
  - Maximum capacity – 9.5 MW turbine
  - Offshore wind industry is expanding

Suzlon 88-100 turbine
Rated power 2.1 MW
Rotor diameter 88 m
Cut-in wind speed – 4m/s
Rated wind speed 14m/s
Swept area 6,082 m^2
Rotational speed 15 rpm
Hub height – 80m

Wind industry

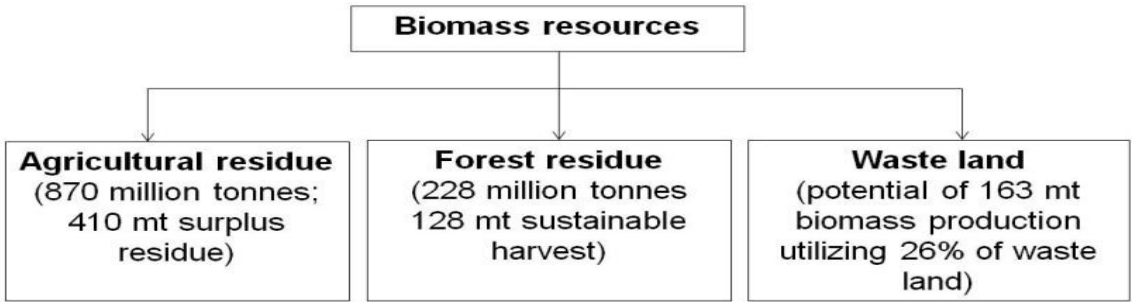
- 13 turbine manufacturing companies
- 35 wind turbine models from 250kW to 2750 kW capacity
- EPC, developers and servicing companies

Biomass Energy recovery routes



Biomass Energy in India

- **Biomass energy** an important **renewable energy resource** for India
- **150 million tonnes** per annum of **surplus biomass** is generated from different sources
- Many unutilized biomass residues such as pine needles, lantana etc. are also available.

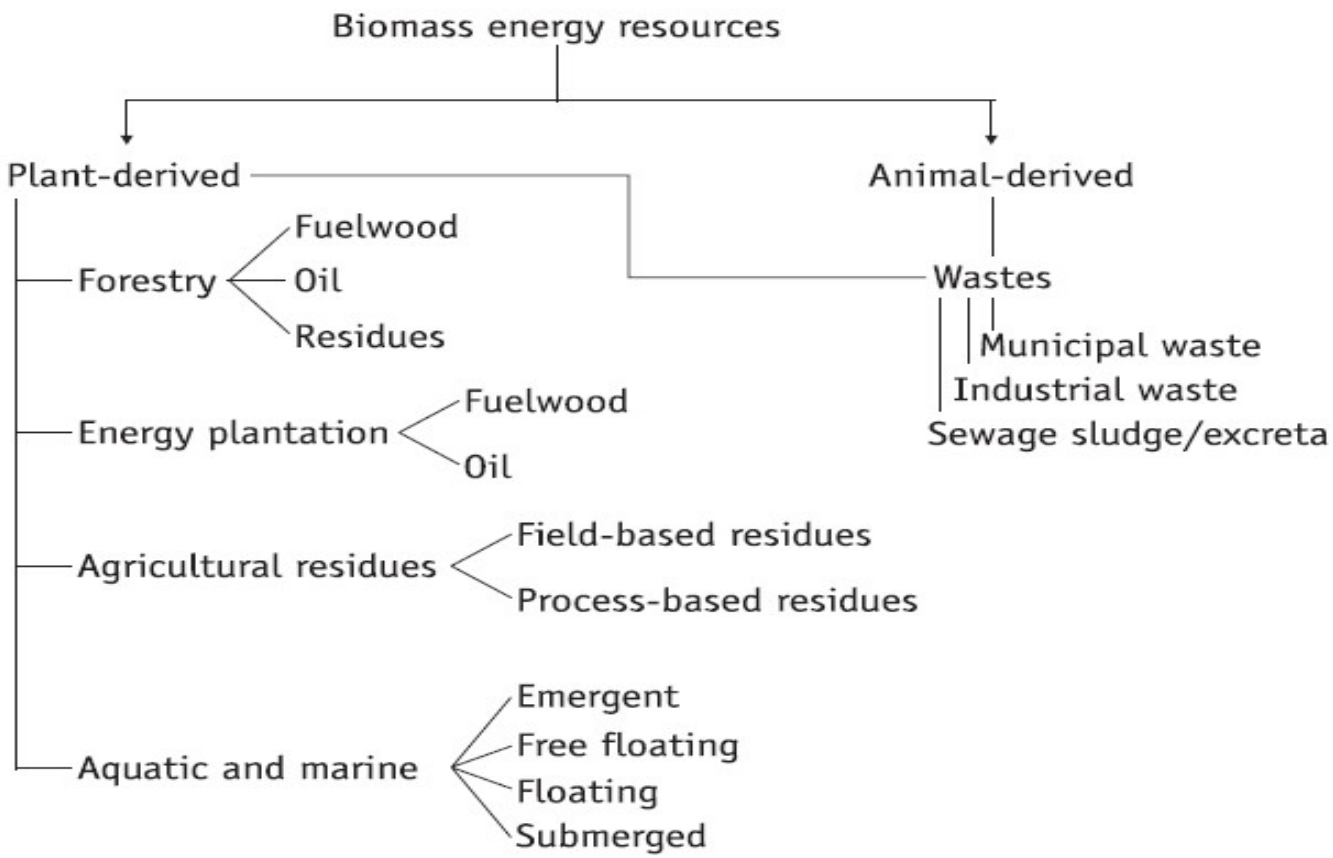


- **Gasification technology** a viable alternative for efficient utilisation of surplus biomass
- **Biomass energy** is fast emerging as a potential for meeting **India's energy security** and for its **low-carbon development path**

Biomass types

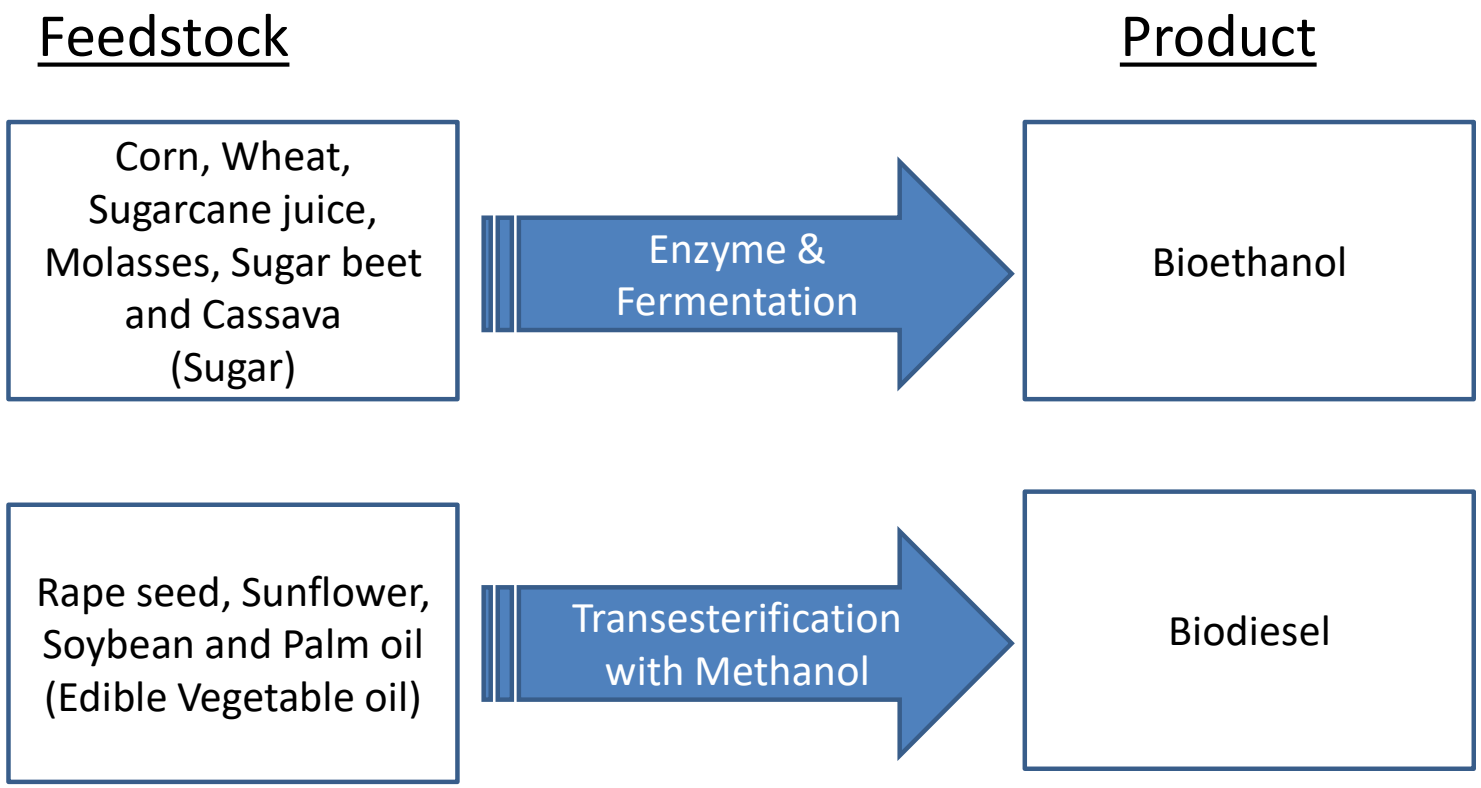
Virgin	Terrestrial biomass	Forest biomass Grasses Energy crops Cultivated crops
	Aquatic biomass	Algae Water plant
Waste	Municipal waste	Municipal solid waste Biosolids, sewage Landfill gas
	Agricultural solid waste	Livestock and manures Agricultural crop residue
	Forestry residues	Bark, leaves, floor residues
	Industrial wastes	Demolition wood, sawdust Waste oil or fat

Classification of biomass resources on the basis of their origin



First Generation Biofuels

Biofuels produced using edible crops and vegetable oils.



Second Generation Biofuel

Food vs. Fuel

- Large-scale production of crop based (first generation) biofuels may not be feasible without adversely affecting global food supply or encroaching on other important land uses.

- Biofuels from non crop, non edible feedstock with limited use of land without affecting food supply leads to second generation Biofuels (Bioethanol & Biodiesel). It would be possible to produce a large portion of transportation fuels using advanced biofuel technologies.

Third Generation Biofuels

Production of sustainable Biofuel (Biodiesel) from algae and aquatic biomasses.

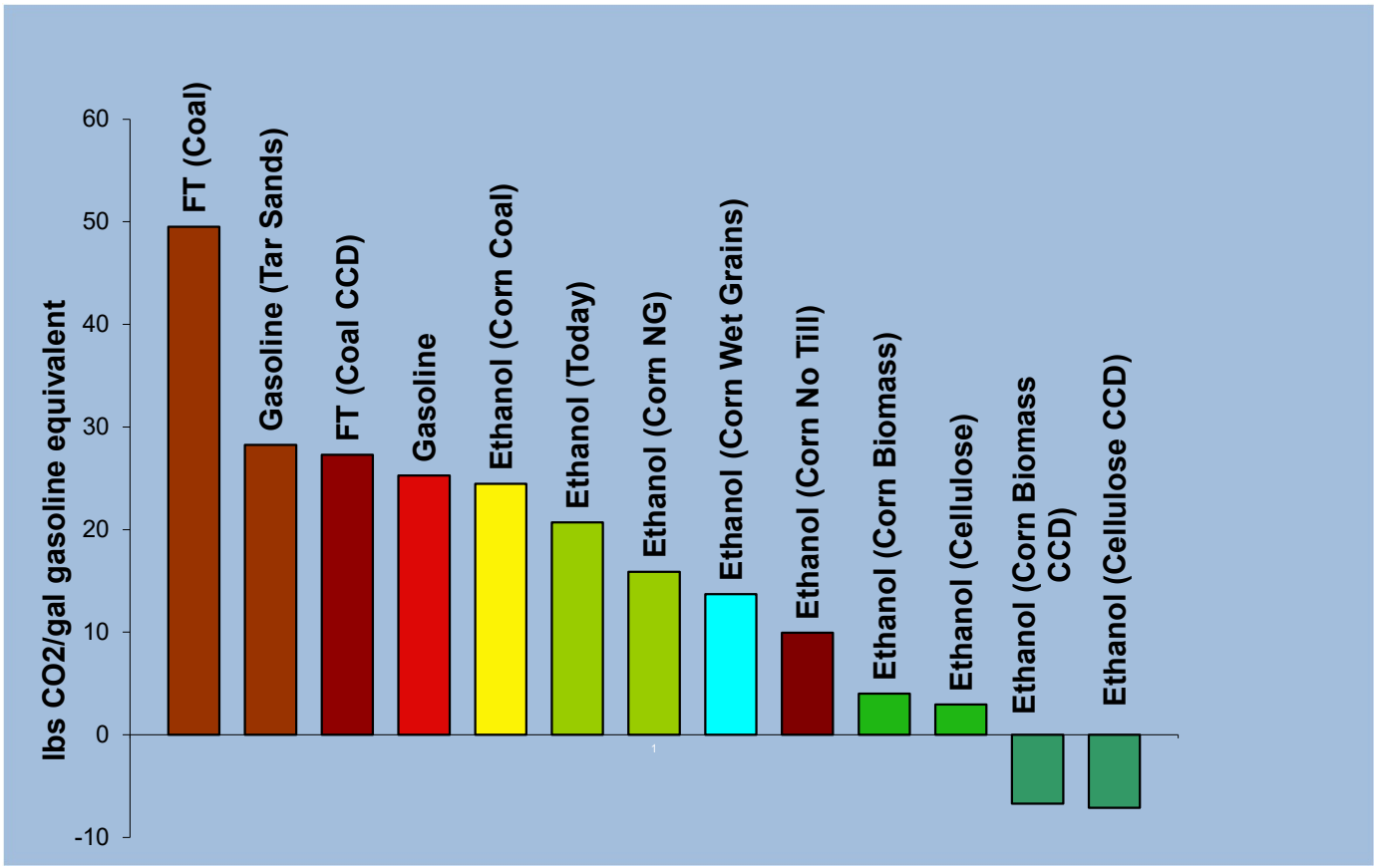
Algal Biofuel Process Systems

- Open Pond System
- Hybrid System,
- Modular Closed Photobioreactor,
- Heterotrophic Fermentation,
- Integrated Cultivated System.

Fourth Generation Biofuels

- Production of sustainable biofuels from specially created plants or biomass with greater yields and easier cellulosic breakdown.
- Additionally, they can be developed on land and water bodies that are unfit for agriculture.
- It would be co-processed using hydro processing facility in petroleum refining industry.
- It should possess greater environmental benefits, be cost competitive, and producible in sufficient amounts as Drop-In fuel to have a meaningful impact on fuel demands.
- Most importantly, the net energy derived from the feedstock should exceed the amount that is required for production.

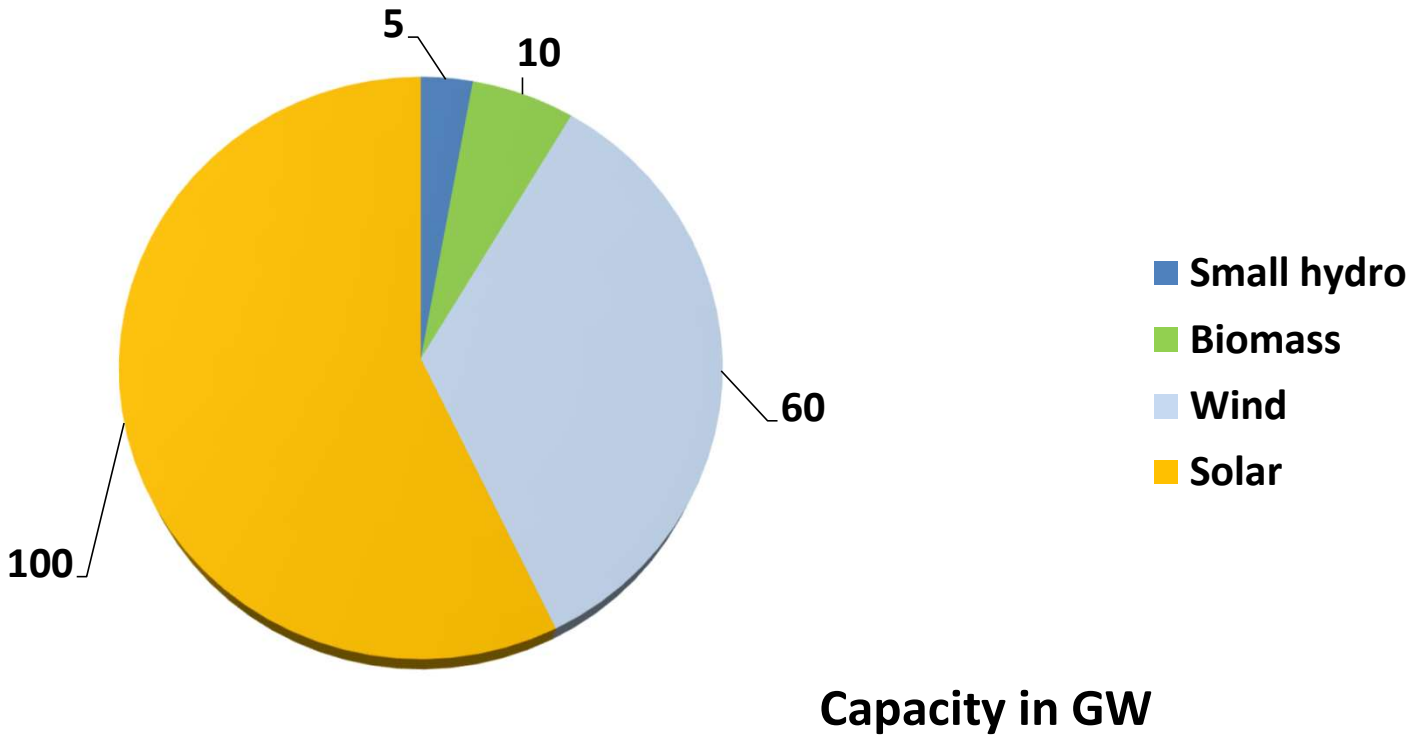
CO_2 Emission from Alternate Fuels



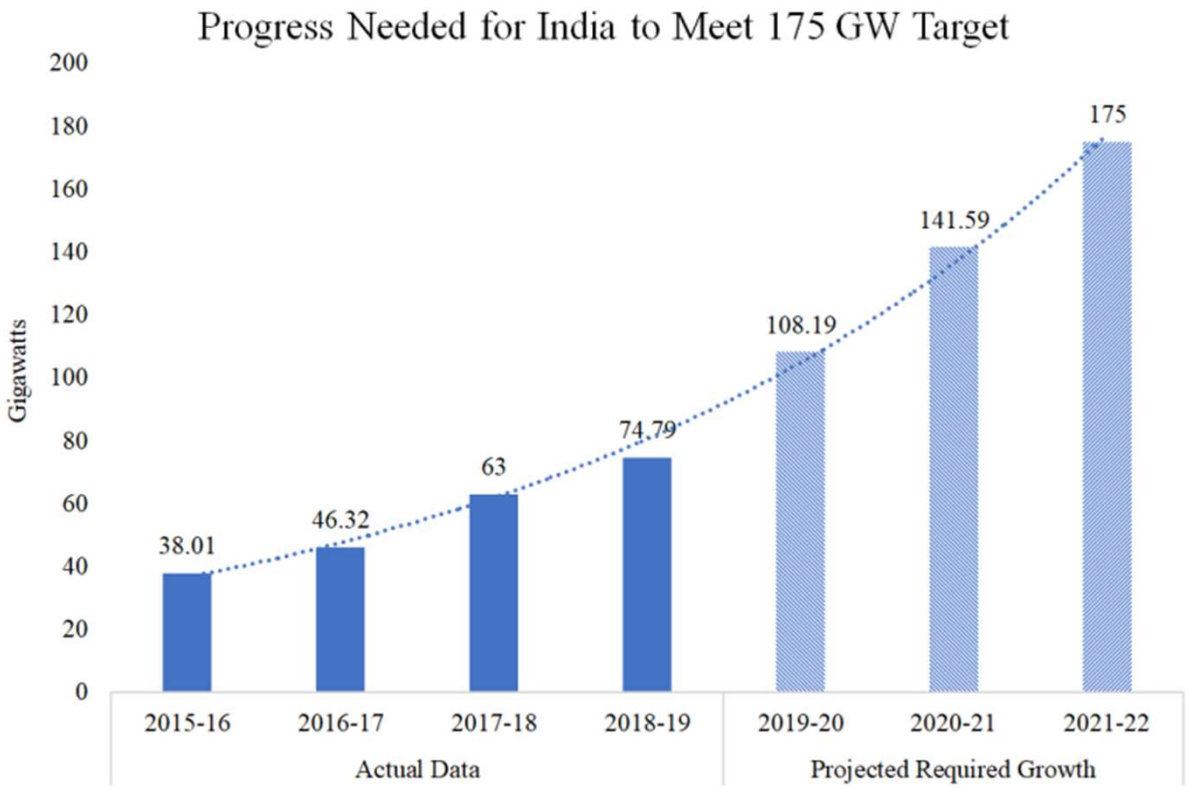
Wave and Tidal Energy Potential (MW) of India

State	Tidal power potential	Wave power potential
Gujarat	10,425	4100
West Bengal	900	na
Odisha	400	600
Tamil Nadu	230	10,600
Maharashtra	200	8100
Andha Pradesh	100	6900
Karnataka	100	6100
Kerala	100	4900
Total	**12,455**	**41,300**

Renewable Power Target -175 GW by 2022



Growth of Renewables



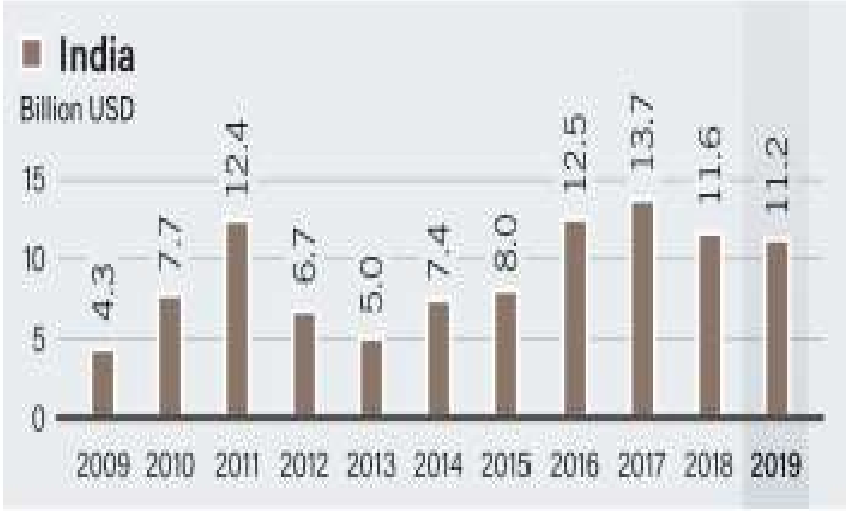
India: 8 levers are identified in the INDC, of which 6 are also quantified

Reduction levers			Included in INDC?	Specification
Energy	Non-fossil	Wind	✓	Wind: 60 GW by 2022
		Solar	✓	100 GW by 2022
		Other	✓	Biomass: 10 GW by 2022 Nuclear: 63 GW by 2032
	Energy efficiency	Buildings	✓	E.g. Energy Conservation Building Code
		Industry	✓	E.g. Perform, Achieve and Trade scheme
		Transport	✓	E.g. Vehicle fuel efficiency standard
	Fuel shifts	Coal to gas	✗	Not mentioned in the INDC
		Transport (NG/ biofuels)	✓	20% blending of biofuels
Non energy		Specification	✗	Not mentioned in the INDC
Other	Non-core energy	Methane	✗	Non-CO2 emissions are not mentioned specifically in the INDC. However, various measures related to reducing emissions from waste are included.
		Nitrogen oxide	✗	
		Other	✗	
	LULUCF[1]	Afforestation	✓	Additional (cumulative) carbon sink of 2.5 to 3 billion tonnes of CO_2 equivalent through additional forest and tree cover by 2030.
		Reforestation	✗	

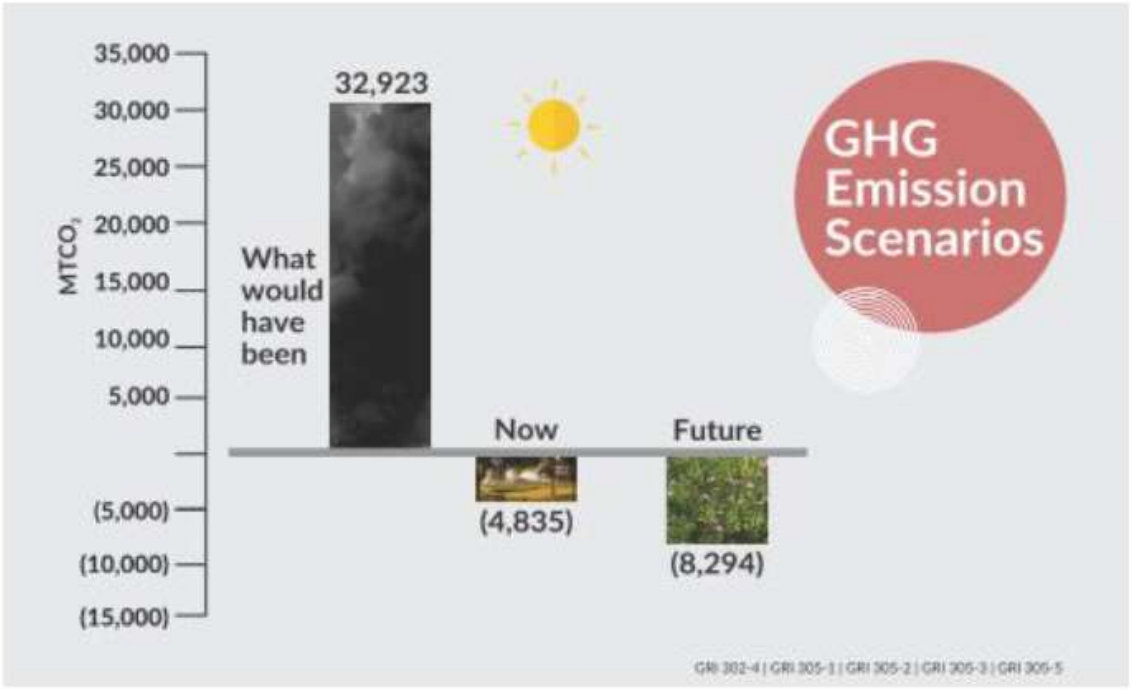
1 LULUCF: Land Use, Land Use Change and Forestry

Drivers for Energy Transition

Government Push	• Policies • Regulations • NDC Targets
Financial instruments	• Tax benefits • Low interest loans • ESG investments • Clean energy funds
Global initiatives	Climate Change commitments RE100 Climate funds



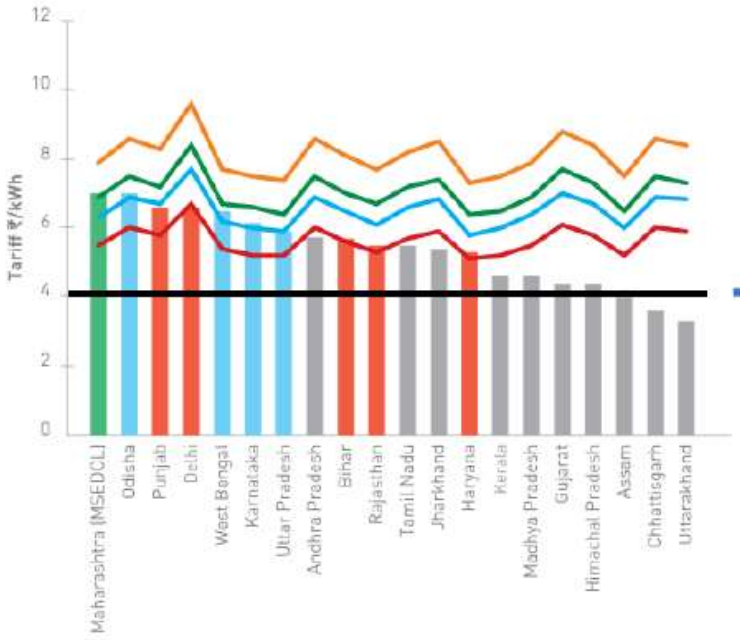
Creating Impact- Magarpatta City



The 2018-19 Sustainability report of Magarpatta City, Pune was awarded as "Asia's Best First Time Sustainability Report" by Asia Sustainability Reporting Awards

Roof top solar

State-wise industrial tariff (HT) vs LCOE of solar power (100 kW system, ₹/kWh)[20]



This was in 2014

This is now

RE potential assessment for Industry

TERI's TEAM technology for kitchen waste to bio gas

- It uses kitchen/ garden waste
- Available from 50kg/ day to 2 ton /day
- Odourless / compact
- Gas can be used back for cooking / common facilities

Saal Leaf Plate making

Solar Powered Loom

Under the CSR initiative of Indus Towers, installation of 102 hybrid units (solar + grid) to supply power to 408 power looms, in and around Varanasi, is underway

- Capacity of each Solar PV Unit : 2 KWp
- Lithium Battery capacity: 6 KWh
- Power Conditioning Unit: 5 KVA
- Electrical Motor : 0.5 hp (230V , 50 Hz)
- No. of connected Looms with each unit : 4

Battery Powered Boat

Under the CSR initiative of Indus Towers, Installation of 4 Solar Charging Stations for running 40 Battery Operated Boats at Varanasi is underway.

- Capacity of each Charging Station : 5 KWp
- Lithium Battery used for each boat : 2.2 KWh
- Propeller :
  - ✓ Hydrodynamic Weed less Wedge Propeller
  - ✓ Max Load Thrust : 100 lbs
  - ✓ Weight : 28 lbs
  - ✓ Input Power : 48 V DC
- Passengers: 10-15 persons per boat

Biomass gasifier based cold storage cum power generation

Biomass Gasifier – Thermal Applications

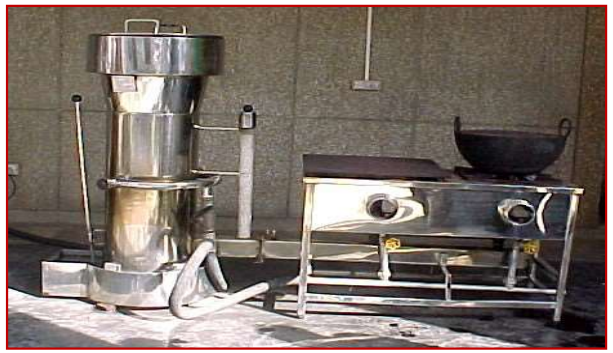
Silk reeling

Dyeing oven

Rubber drying

Retrofitted with bakery oven

Large scale cooking



A cooking oven

Overview: Hydrogen value chain

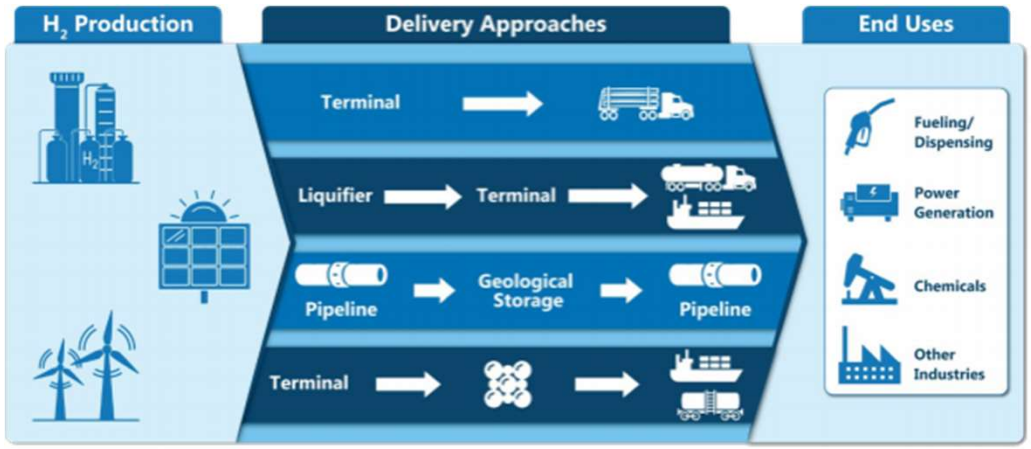
Storage and transportation of hydrogen could be a potential challenge for scaling up the hydrogen economy for India.

Existing infrastructure is limited and could be insufficient to support the widespread use of hydrogen as an energy carrier.

Globally, most hydrogen is transported using pipelines. However, pipelines need to be designed with higher specifications to minimize leakage and embrittlement.

Alternatively, hydrogen can be transported in the form of ammonia, methanol, and Liquid Organic Hydrogen Carriers (LOHCs). These fuels will have higher energy conversion costs. At lower volumes, transporting hydrogen using trucks could be a viable option

Hydrogen value-chain



Source: CleanH2.org

Potential- Green Hydrogen

S.no	Source	Gross Potential (a)	Installed Capacity (b)	Under Construction (c)	Under Planning (d)	Resource requirement for 2022 target (e)	Resource requirement for 2030 target (f)	Resource available for Green Hydrogen Production (g)= (a)-{(b)+(c)+(d)+(e)+(f)}	CUF
1	Solar	748	90	14	24	10	200	410	22%
2	Wind*	302	40	12		10	100	140	29%
3	Micro Hydel	21	5	-	-	-	-	16	40%
4	Large hydro	148	47	13	11	-	25	52	45%
5	Tidal	12	-	-	-	-	-	12	10%
6	Geothermal	10	-	-	-	-	-	10	71%
7	Offshore wind	71	-	-	-	-	-	71	30%
8	Biomass	42	10	-	-	-	-	32	40%
Total (GW)		**1354**	**192**	**39**	**35**	**20**	**325**	**743**	

743 GW of non fossil potential would be available for green hydrogen production

*Potential considered at 100 m hub height

Source: NISE,NIWE,MNRE,CEA, Teri Analysis

Potential - Green Hydrogen

Source	Net potential	CUF	Net available capacity (GWhr)	HHV of Hydrogen (GWhr)*	Hydrogen potential (MT per annum)
	(a)	(b)	(c) = (a x b x 8760 hrs.)	(d) = (c x electrolyser efficiency)	(e) = (d x 10^6 /39.39/1000/10^6)
Solar	451	22.00%	869167.2	564959	14
Wind	140	29.00%	355656	231176	6
Micro Hydel	16	40.00%	56064	36442	1
Large hydro	52	45.00%	204984	133240	3
Tidal	12	10.00%	10512	6833	0.5
Geothermal	10	71.00%	62196	40427	0.5
Offshore wind	71	30.00%	186588	121282	3
Biomass	32	40.00%	112128	72883	2
Total			**1857295.2**	**1207242**	**30**

Assuming that the net potential of RE is the power available to a hypothetical commercial-grade electrolyzer, and its efficiency is 65% (as per existing commercially available electrolyzers) the total potential of Hydrogen in India works out to ~ 30 MT per annum.

*HHV of Hydrogen is 39.39 kWh/kg

Source: TERI Analysis

National Hydrogen Mission

- The Government of India has **allotted Rs 25 crore in the Union Budget 2021–22** for R&D in hydrogen energy and intends to produce three-fourths of its hydrogen from renewable resources by 2050.

- In July 2021, The Minister for Power, announced the introduction of **Green Hydrogen Consumption Obligation** (similar to Renewable Purchase Obligations) in fertilizer production and petroleum refining. A green hydrogen bid in the next four-five months is also expected.

- India also plans to call **bids for 4 GW electrolyzer capacity**. The government could also extend the production-linked incentive (PLI) scheme for manufacturing electrolyzers to produce green hydrogen.

- TERI analysis indicates that H_2 demand could increase to 28 Mt by 2050, driven by demand from industrial sectors. Expanding in existing sectors - fertilizer and refineries, or growing into new sectors, such as steel.

- Estimates suggest that, demand for hydrogen in the transport sector will see growth mainly in the heavy-duty and long-distance segments. H_2 could also play a role in the power sector as a long-term storage vector.

Hydrogen demand could at least multiple 3 fold by 2050, likely to be driven by industry

- H2 demand in India today is around 6 Mt, mainly in fertilisers (ammonia) and refineries.
- Steel sector is also expected start consuming hydrogen, replacing coal to process iron ore
- By 2050, this could increase at least 3 fold, largely driven by growth in industry.
- Transport will see some growth, mainly from heavy-duty and long-distance transport.
- There is the potential for some limited use of hydrogen in the power sector.

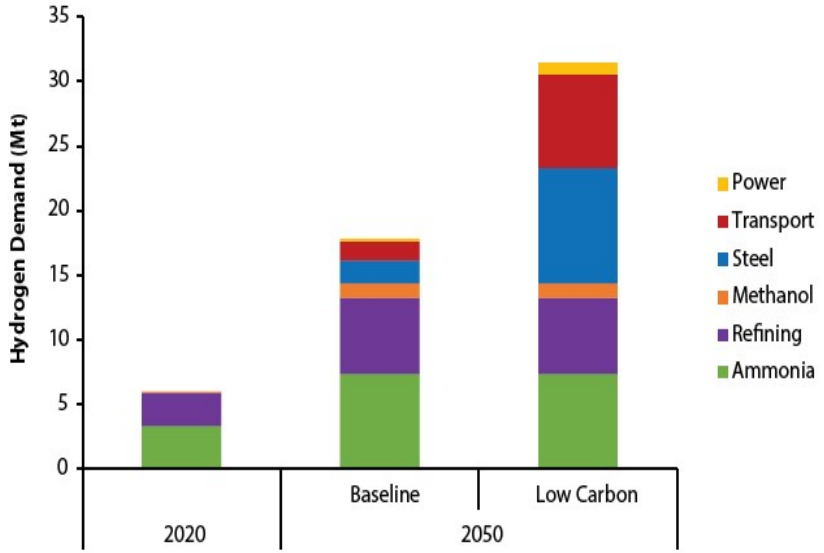


Figure 4: Baseline and Low Carbon scenarios, 2020 and 2050

Source: TERI analysis

Note: Demand projections exclude potential use of hydrogen in shipping, aviation, and petrochemicals, which are not covered in this report.

Some initiatives by Indian industry

IOCL

- Announced development of India's first green H_2 plant at Mathura.
- MoU with Tata Motors -15 H_2-powered fuel-cell buses developed in collaboration with ISRO.
- Developing Type-3 High Pressure H_2 Cylinder and material-based H_2 storage.
- Green H_2 from biomass

NTPC

- Fuel cell based micro grid in Ladakh.
- Hydrogen storage for renewable power.
- Green methanol plant (H_2 plus carbon capture and utilization).
- Green ammonia production.
- Plans for Green H_2 generation in Gujarat.

BHEL

- Fuel cell technology development and testing infrastructure.
- Business plan across the value chain (supply/ EPC/ Project design etc.).
- Hydrogen buses

Reliance Industries

- Announced investment in four "giga factories" to manufacture photovoltaic modules, batteries, fuel cells and electrolyzers.
- Set out a 1-1-1 target of bringing down the cost of green H_2 to under $1 per 1 kg in 1 decade.

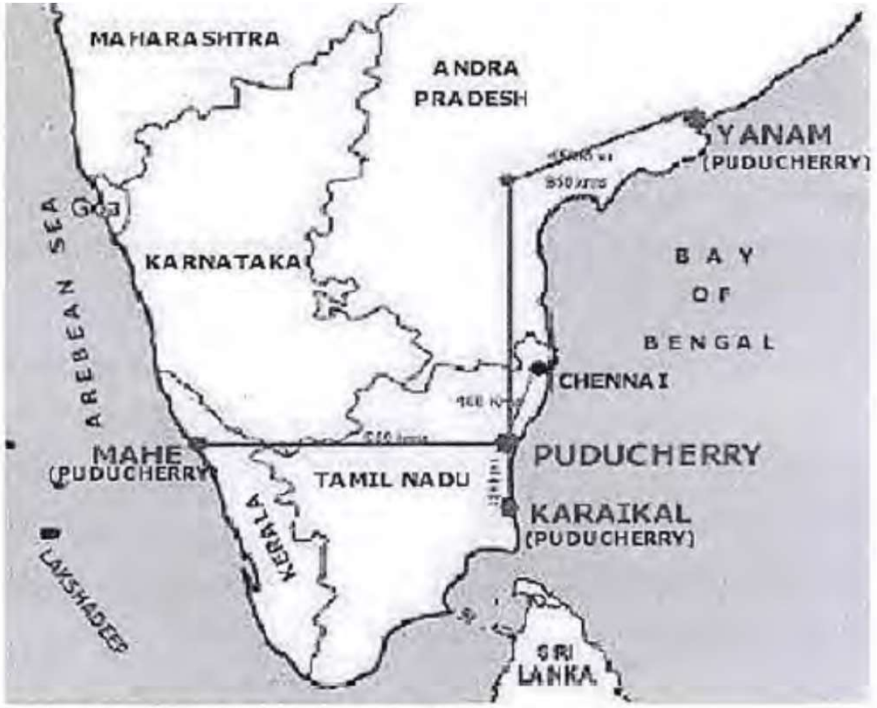
Adani Enterprises

- Announced plans to invest across the entire green energy value chain.
- MoU with Maire Tecnimont to develop projects in producing ammonia, and hydrogen, and from renewable feedstock.

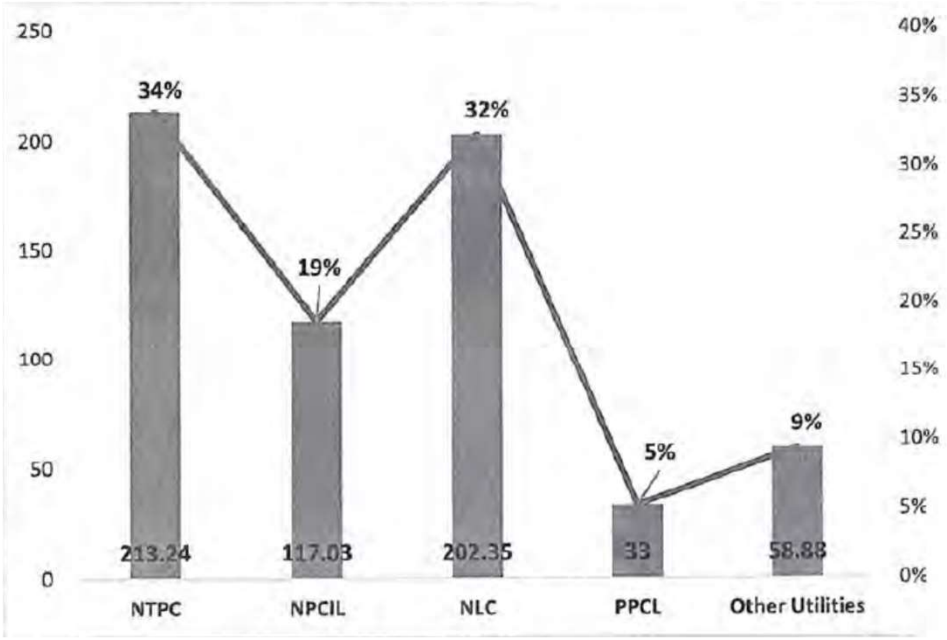
ACME Group

- Set up the world's first integrated commercial-scale pilot plant for Green Hydrogen and Green Ammonia production in Rajasthan in 2021.

Puducherry Power System



Power supply position



Source: Business plan Petition, Dept of Electricity, Puducherry

Power Consumption Times Series Data

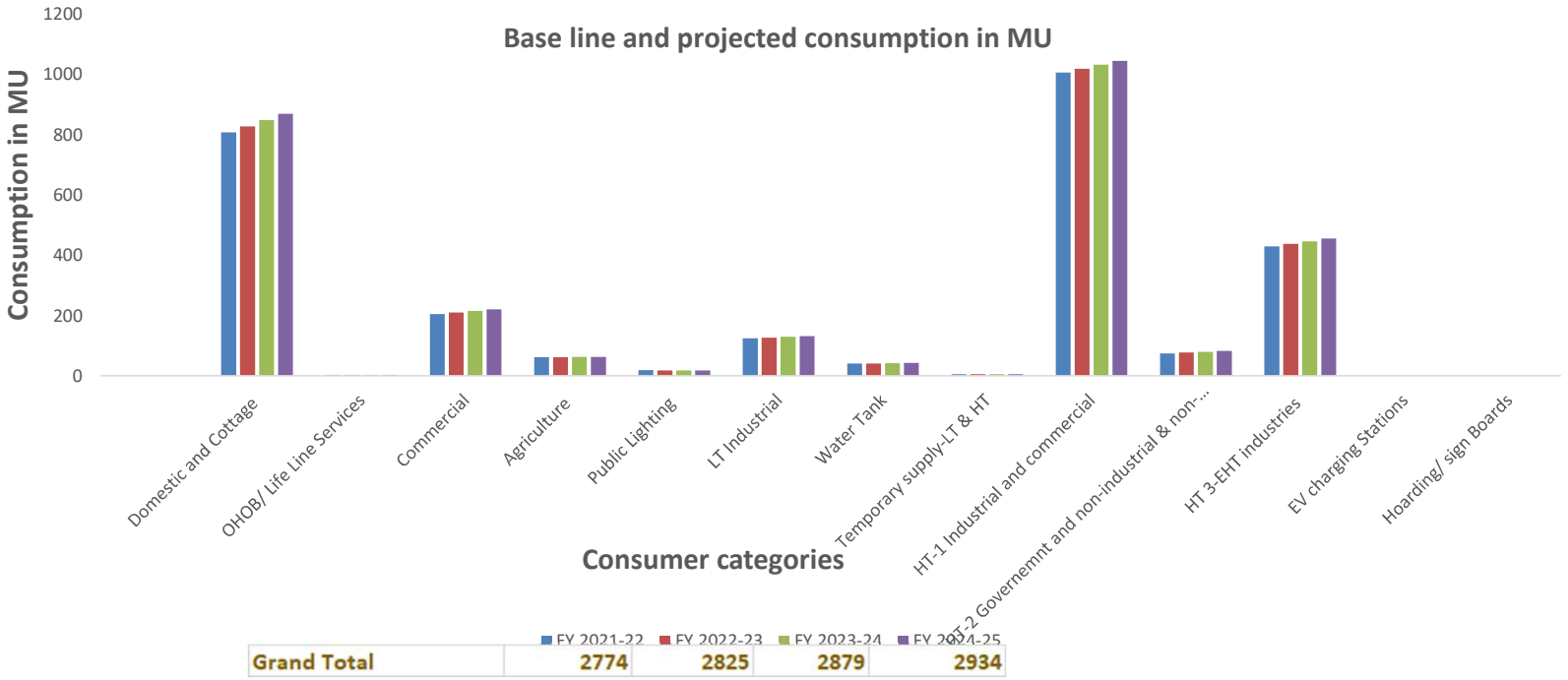
Parameters	Year					
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Residential	610.38	645.22	685.00	720.22	733.52	721.80
Industry	1,479.53	1,449.75	1,425.00	1,425.00	1,509.08	1,614.24
Commercial	181.00	182.22	198.00	198.00	216.41	212.85
Total	2,270.91	2,277.19	2,308.00	2,343.22	2,459.01	2,548.89

Sectorial emissions

Installed Capacity of Power Utilities in UT of Puducherry as on 31.10.2021 (Figures in MW)

Ownership/Sector	Modewise breakup								Grand Total
	Thermal					Nuclear	Hydro	RES*	
	Coal	Lignite	Gas	Diesel	Total				
State	0	0	32.50	0	32.50	0	0	0	32.50
Private	0	0	0	0	0	0	0	5.51	5.51
Central	140.80	111.80	0	0	252.60	86.00	0	0	336.50
Total	140.80	111.80	32.50	0	285.10	86.00	0	5.52	382.62
* - Renewable energy systems									

Annual consumption in UT



Grand Total	2774	2825	2879	2934

Source: *Business Plan Petition, Dept of Electricity, UT Puducherry*

GoI schemes and SDGs

Scheme	Targets	Impacts on sustainability and SDGs
Renewable Power	450 GW by 2030	• Green job creation • GHG emission reduction
National Solar Mission	100 GW by 2022	• Rural employment • Industry development • International partnerships (ISA) • GHG reductions
Wind revolution	60 GW by 2022	• Rural employment • Industrial development • GHG emission reduction
Hydro mission	5 GW by 2022; 80 GW by 2030	Decentralised rural electrification; livelihood generation; improved quality of life
National Biofuels Policy and SATAT	E20 by 2025; 5000 BCNG plants	• GHG emission reduction; Recycling of agricultural, industrial and municipal waste (250million tonnes per annum) • INR 100,000 crore (USD 13.8 billion) Potential reduction in India's annual fuel import bill by using biofuels

How industries can play role

- Switching to renewables
- Adapting strategies to reduce carbon foot print of supply chain through EE, renewables, circular economy
- Diversification into RE sector
  - Hydrogen economy
  - Energy storage
  - Electrification of industrial activities
  -

Potential areas for RE interventions

- Solar PV and thermal
  - Industrial systems
  - Rooftop solar systems
  - Irrigation systems
  - Floating solar systems
- Wind
  - Off shore
- Bioenergy
  - Waste to energy (rural / urban)
  - Biofuels
- Hydrogen
  - Industrial applications

Thank You!

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