Overall Energy & Electricity Sector

100% RE Based Electricity Sector Planning for Goa

Re-Energy Plan & Action Plan of Goa 2022

Approach of making the State green

1.0 **Greening of the electricity** supply. Replacing fossil-based electricity with renewable energy. Procure green electricity only from the market.

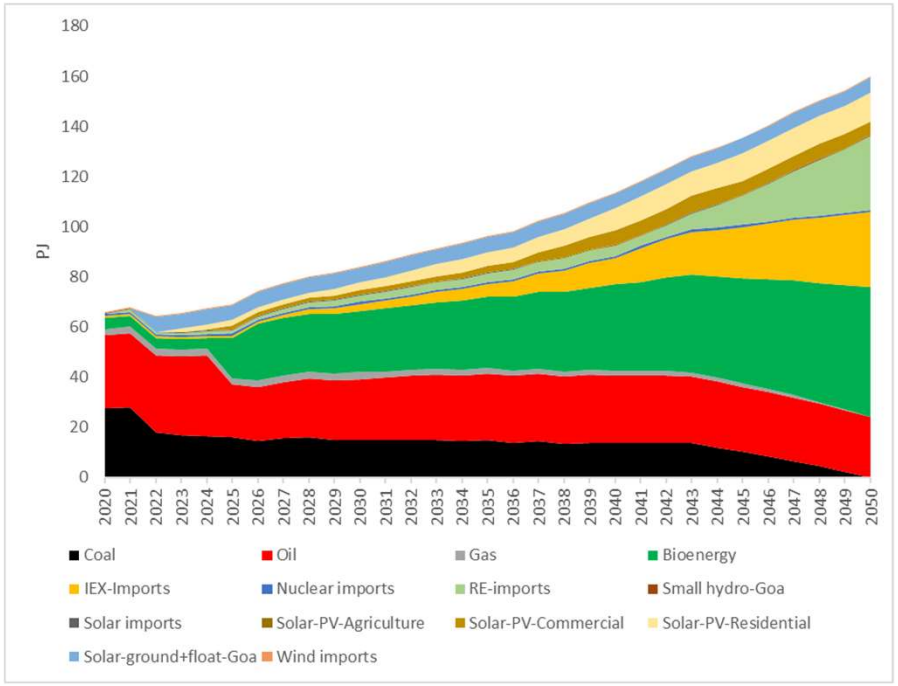
2.0 **Electrification of technology** use as much as possible. Reducing direct use of fossil fuels like coal, oil and gas as much as possible and replace them with electricity where electricity itself is green.

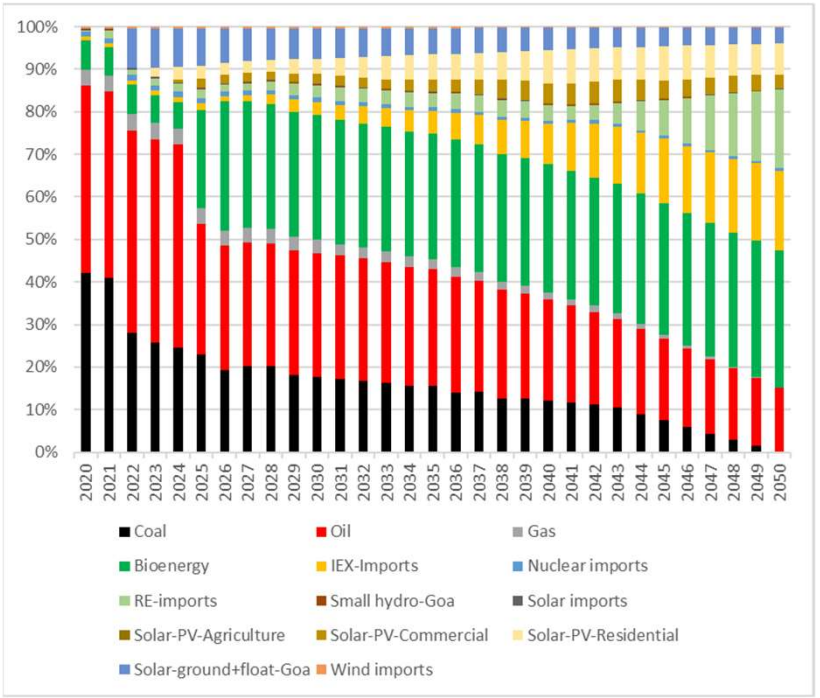
3.0 **Blending of transport fuels (petrol, diesel) with biofuels** (ethanol and biodiesel) to the maximum extent possible i.e. 20%. (Implementation of B-20 Policy of Govt. of India, i.e use of 20% blended fuel by 2023)

4.0 **Demand management and energy efficiency** to reduce losses of energy and rationalization of energy demand.

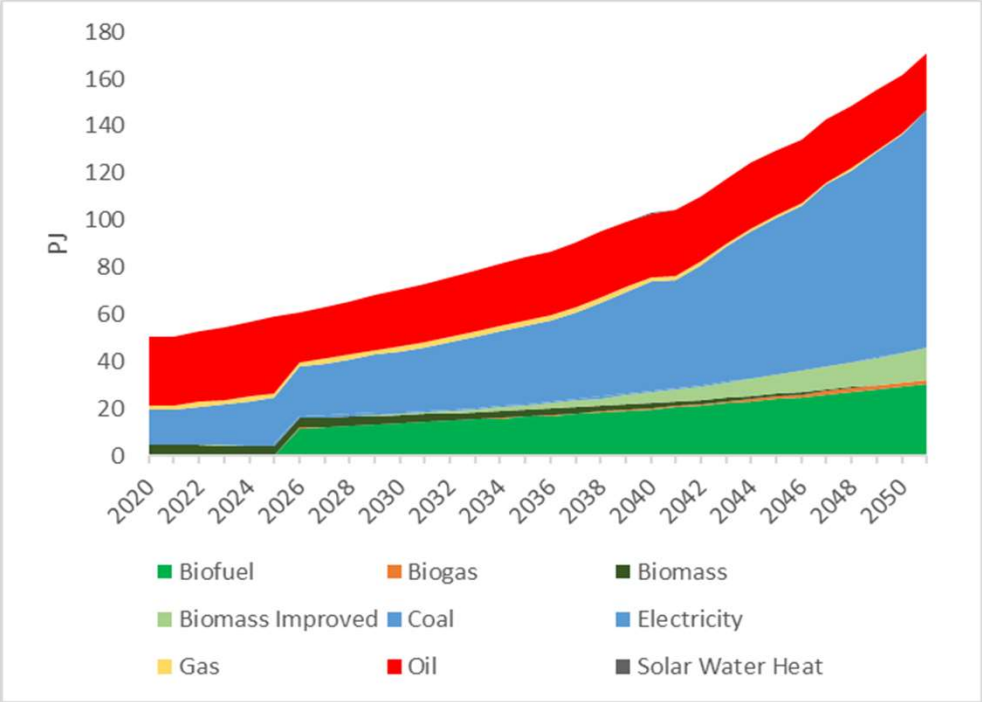
5.0 **Use of carbon neutral fuels** like biomass.

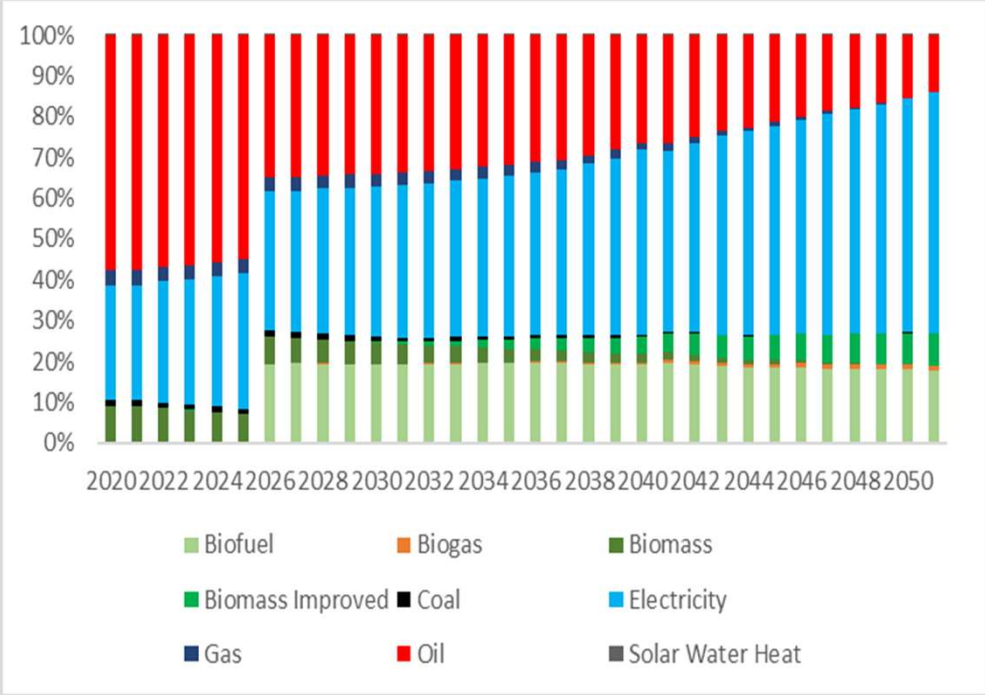
Primary Energy Supply Mix of Goa
(Deep RE/ 100% RE penetration Scenario)





Energy Consumption Mix of Goa
(Deep RE/ 100% RE penetration Scenario)





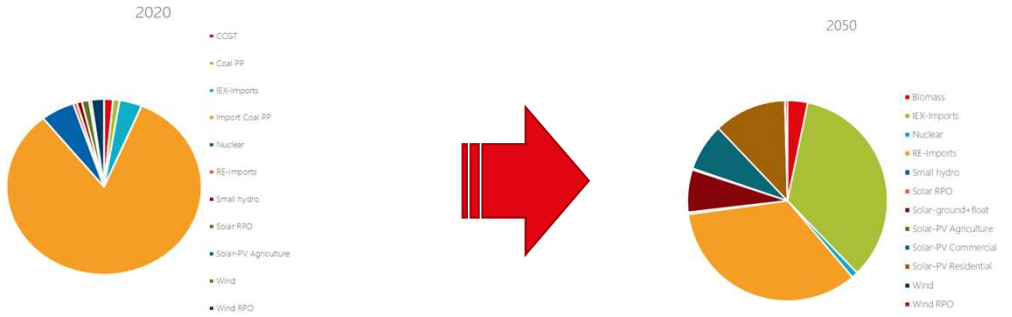
Greening of electricity

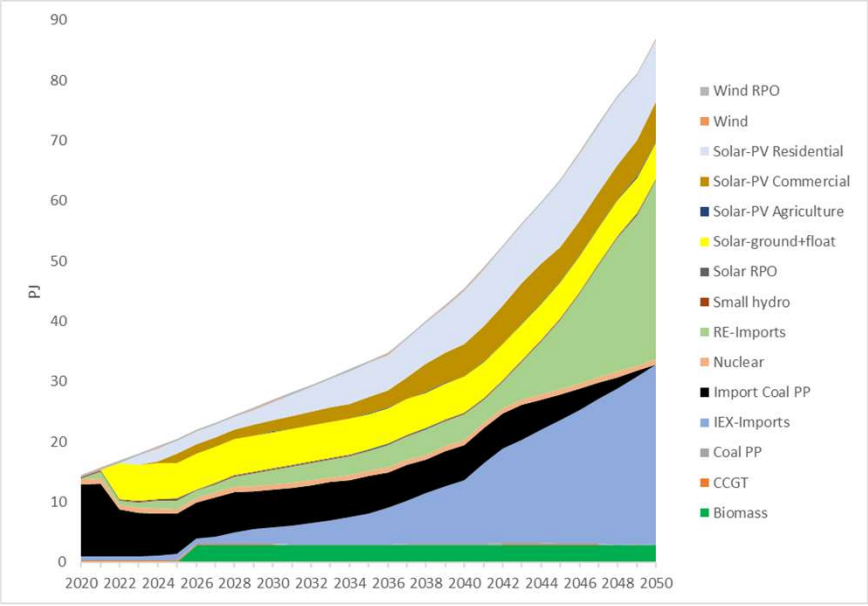
100% RE based power supply plan for Goa

RE intervention in Electricity supply

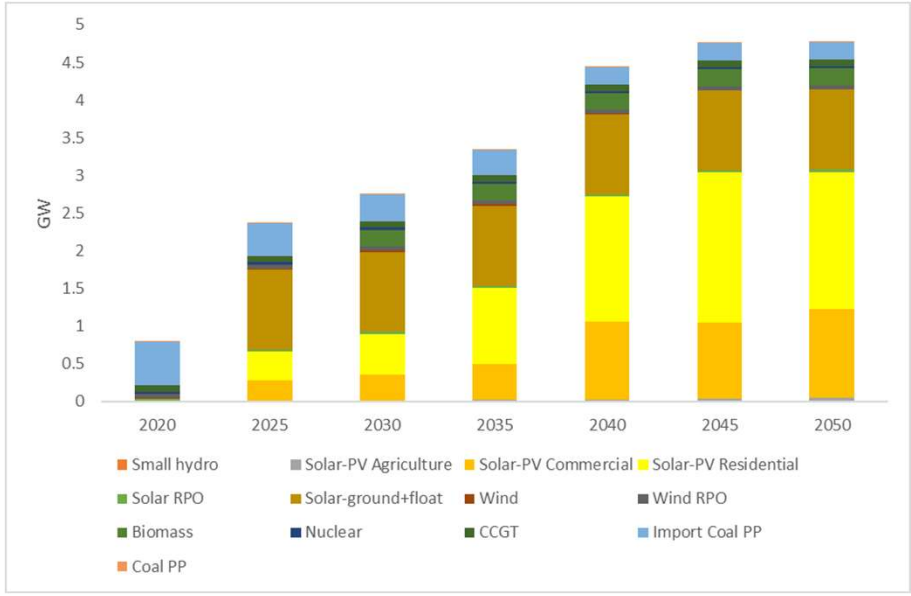
- 1.0 Augmenting State RE potential
- 2.0 Conversion of existing PPAs to RE PPAs
- 3.0 Use of market instruments for RE power procurement
- 4.0 RE off-seting

Optimal generation mix of Goa in order to achieve 100% renewable energy-based power supply





Generation mix of Goa for 100%RE



Share of power purchase in Goa in FY2019-20

100% renewable energy-based power supply

- *100% renewable energy-based power supply is possible through enhanced green power import and promotion of within State RE generation.*
- *These import channels could be power exchange, bilateral trade, RPOs and simple green power imports replacing expired PPAs of thermal power.*

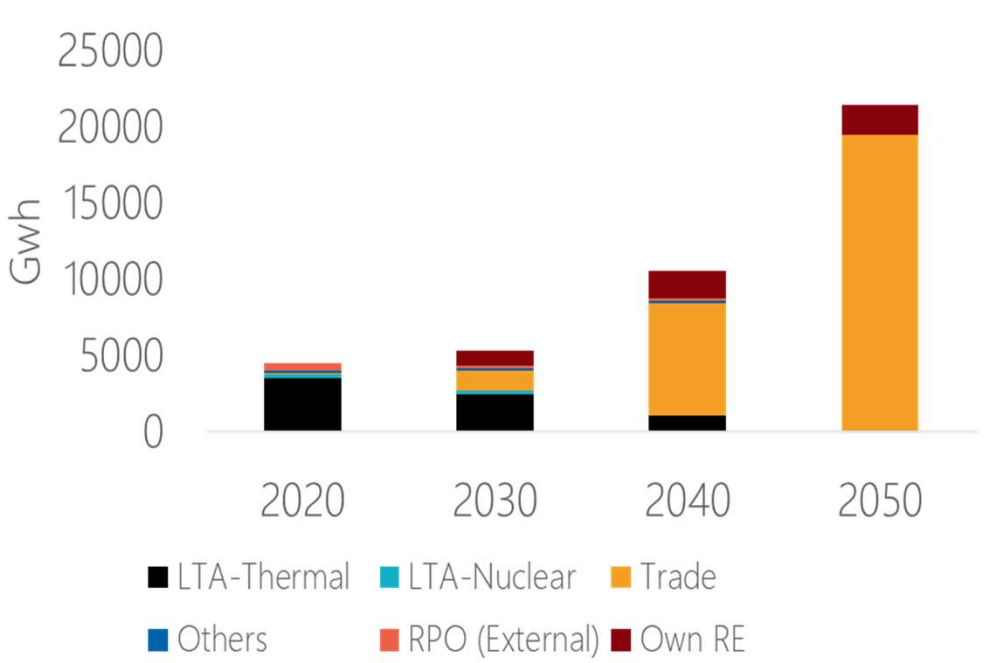
✓It is estimated that by 2050 the State of Goa needs to install around 4 GW of solar plants of various types including ground mounted, floating and agro-photovoltaic.

✓There is an estimate of 9 MW potential of on-shore wind at 120-meter height.

✓More than 75% of the electricity requirement shall be imported in the State of Goa from renewable energy sources by 2050. Remaining 25% can be procured from within State sources of Solar/wind/Biomass/tidal etc.

100% RE transition in power supply

Type of Supply	Total Purchase (Gwh)	% of Supply
LTA-Thermal	3533	79%
LTA-Nuclear	232.4	5%
Trade	150.8	3%
Co-gen	169	4%
RPO	415	9%
Total	4500.2	100%



Proposed plan of making power supply green

Particulars	FY 30	FY 35	FY 38	FY 40	FY 45	FY 50
Existing Tied Up Capacity (MW)	562	498	385	385	310	310
Existing tied-up RE Capacity (MW)	385	385	385	385	310	310
Min. Power Supply Required to meet Base Load (MW)	731	979	1166	1310	1640	2009
Need to tie up LT – RE (MW)	170	481	781	925	1330	1699
Peak Load met through ST-RE (MW)	175	234	278	313	392	480
Total RE Power (MW)	729	1100	1444	1623	2032	2489
RE %	80%	91%	100%	100%	100%	100%

Available options to achieve 100% RE In Goa

Short Term Power Procurement Options (0-3 months)

Bilateral Contracts	Green Term Ahead Market (GTAM)	Green Day Ahead Market (GDAM)
• Bilateral contracts are for a period up to three months • Purchasing RE power through Short Term Bilateral contracts will help Goa to meet its seasonal load deficit and increase its RE portion	• Green-Term Ahead Market (G-TAM) is a market segment for trading in renewable energy providing a range of products allowing participants to buy/sell green electricity on a term basis for a duration of up to 11 days ahead	• G-DAM is very similar to Day-Ahead-Market (DAM) and is a physical green electricity trading market for deliveries for any/some/all 15 minute time blocks in 24 hours of next day starting from midnight.

Medium Term Power Procurement Options (3 months to 5 years)

- Ministry of Power issues Pilot Schemes to facilitate procurement of aggregated power for a period of three years
- These procurements are done through competitive bidding process, on the DEEP e-bidding Portal
- Goa has the option to procure power, from time to time, through competitive bidding process under such schemes, to cater its larger deficit in upcoming years
- Goa can also opt for seasonal contracts with Hydro/Solar/wind generating stations

Long Term Power Procurement Options: (5 years and above)

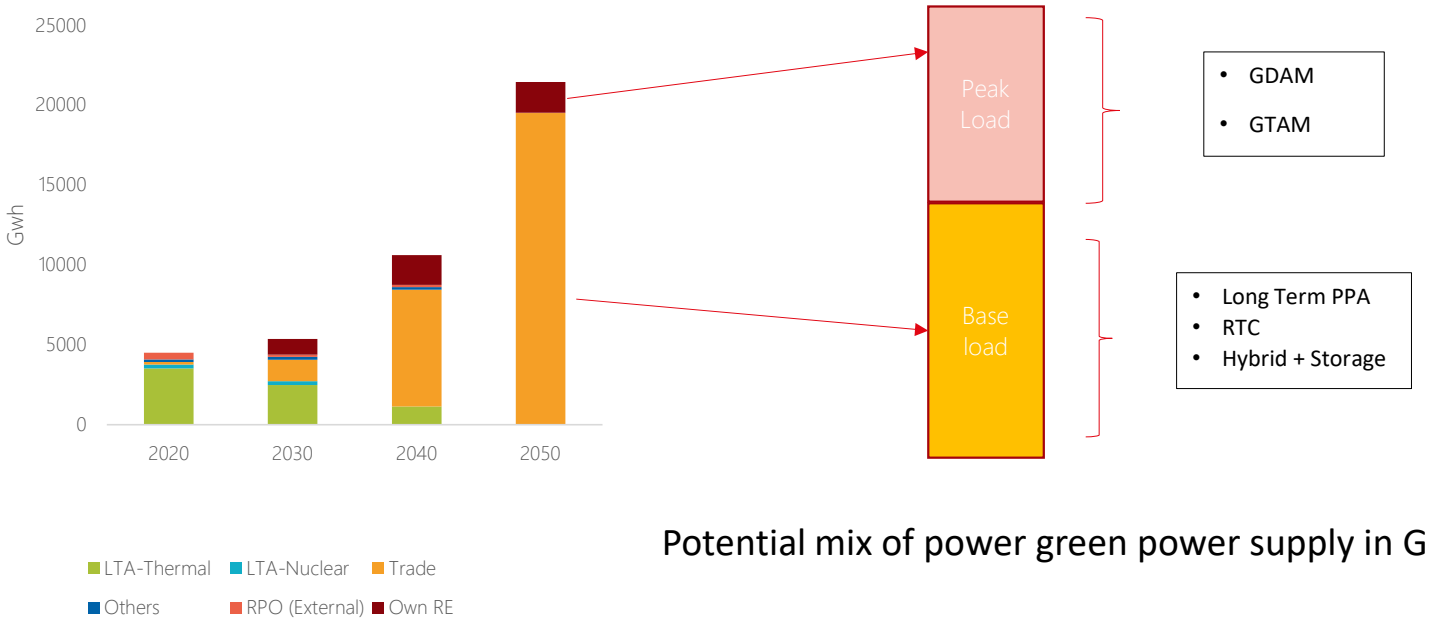
Own Generation

- As per the assessment of this study Goa has a potential of 4200 MW Renewable Energy
- Goa has the potential of 880 MW of ground mounted solar and 3200 MW of roof-top potential. Goa can tap into that potential and set up solar power plants of its own.
- Goa also has potential of Biomass and Tidal energy. It is roughly estimated that there is around 20-38 Million Tonnes of biomass which can produce around 100-200 TWh of energy in a year.

Competitive Selection Process

- Goa has the option to go for competitive bidding process for procurement of Long-Term Renewable Energy using tendering process
- This process will ensure competitive power tariff for Goa, as the tendering process allows Goa to select the lowest bidder

The potential mix of power supply for Goa to meet the 100%RE supply target



Potential mix of power green power supply in Goa

Action Plan for 100% RE Supply

Augmenting State RE potential of 4 GW by 2050

- ✓ Creating climate fund for supporting RE capacity addition within /outside of the State (RE off-set).
- ✓ Setting up State owned / private owned RE power plants in gradual manner.
- ✓ Assessment of RE potential across the State: Solar/ Wind/ Biomass/Tidal

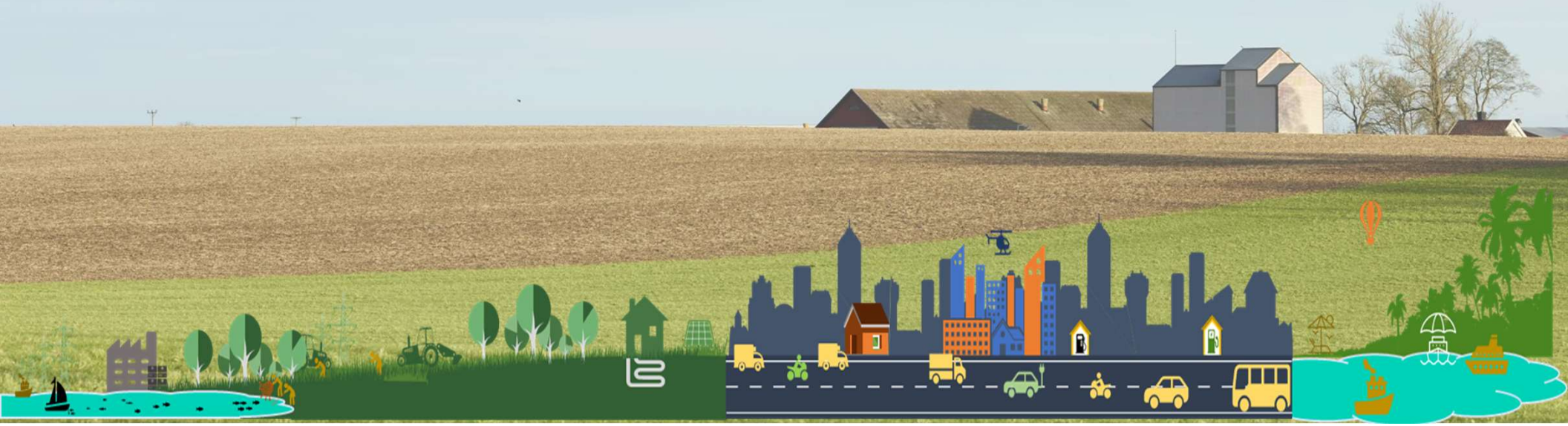
Augmenting green power procurement of 17 Twh (or 2000 MW base load + 700 MW peak) by 2050

- ✓ Procuring green power through long/ medium term PPAs
- ✓ Optimal procurement plan for green power through short term options like Bilateral Market, GTAM, GDAM, HPO

Enabling Action Plans

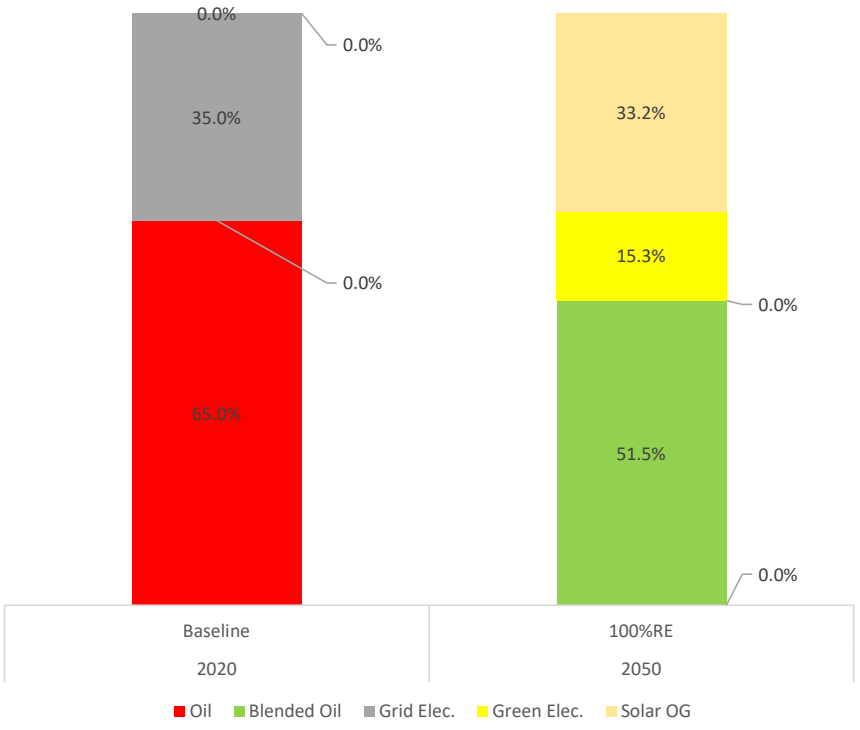
- ✓ Incentivizing the development of Agro PV in Goa
- ✓ Development of vertical PV on farmlands/
- ✓ Promoting development of Waste-to-Energy plants in the State,
- ✓ Devising and implementing a state policy around biomass residue management.
- ✓ Undertake advanced load forecasting to ensure grid integration of renewables.
- ✓ Introducing smart grid regulations in Goa

Renewable Energy in Agriculture Sector



Energy Consumption

- Goa's agriculture sector is highly carbon intensive as almost 100% of its energy requirement is fulfilled through use of fossil fuels like diesel and grid electricity
- In 2020 total energy consumed in the sector for farm activities including irrigation is around 0.18 PJ Total CO_2 emissions from the sector is around 8.6 $KTCO_2$ which can go up to 18.3$KTCO_2$ by 2050
- To decarbonize the sector in the State there will be three major sources of energy
  a) blended diesel (B-20),
  b) green electricity in the grid
  c) solar pumps and off-grid system



Change in fuel mix for decarbonization of agriculture sector

RE intervention in agriculture

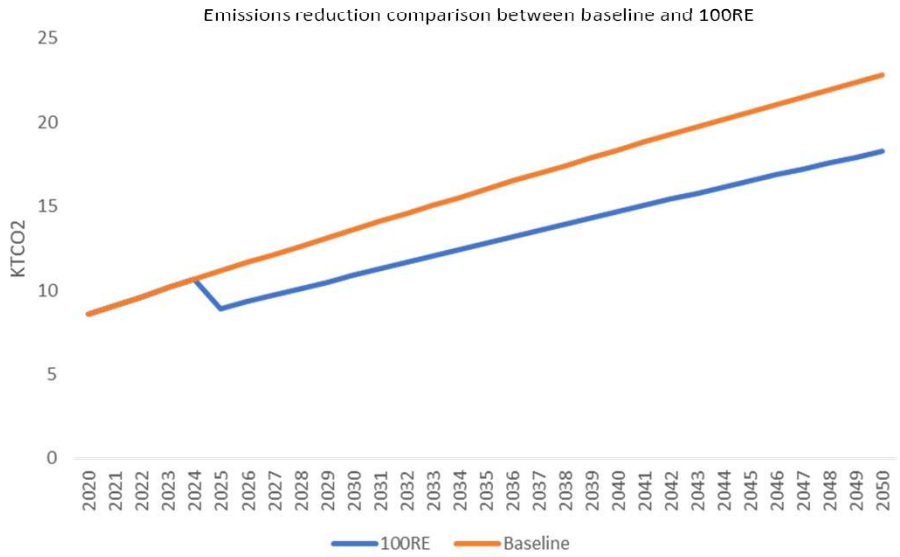
1.0 Use of B-20 for all farm machines by 2050

2.0 Use 100% green electricity for all farm activities including pumps by 2050

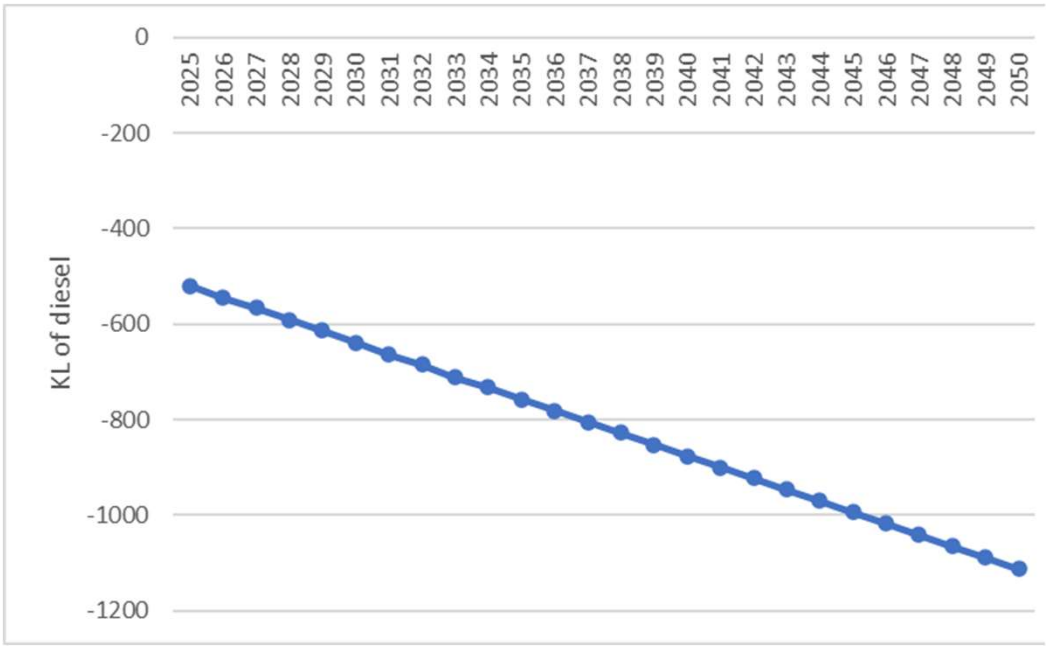
3.0 100% KUSUM Program Implementation and Achieving 150 MW Agro-PV capacity by 2050

Emissions Reduction

GHG emissions reduction through use of blended fuels in farm machines and use of Solar pumps for irrigation could reach up to 90KtCO_2 cumulatively between 2020 and 2050.



Reduction of Fossil Fuel Consumption



Saving of diesel consumption in agriculture sector

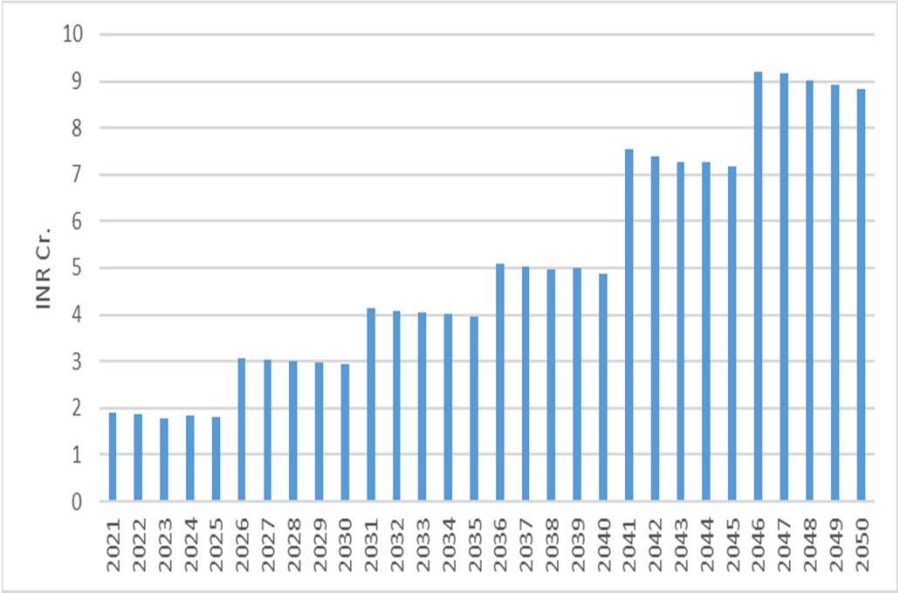
- State needs to supply 800~1700 KL of biofuels annually to achieve the 20% blending target.
- Use of blended oil the sector can save around 500-1100 KL of diesel every year

Investment for Solarization of Pumps

Agriculture sector of Goa is expected to use around 38200 units of solar pumps with an average capacity of 5HP by 2050

It is estimated that to solarize around 38K pumps by 2050 it would require regular and consistent investment

It is estimated that cumulative 150 Cr. Investment is required between now and 2050 to make the irrigation pumping solarized in the State



Investment demand for solarization of pumps in Goa

Action Plan for RE intervention in Agriculture Sector

Use of B-20 for all farm machines.	Use 100% green electricity for all farm activities including pumps by 2050	100% KUSUM Program Implementation
✓ Bringing State regulation for farm machine fuel blending aligned to National Policy on Biofuels – 2018 (NPB–2018). ✓ Plan of procuring and production of biofuels within State (800~1700KL /year) including pricing mechanism for incentivization of uptake. ✓ Setting up State owned / private owned biofuel manufacturing units in gradual manner.	✓ Identification & assessment of land areas within agriculture land-use for Agro-Photovolatics (APV) ✓ Conducting scientific assessment of impacts of APV on crop production ✓ Pilot Testing of APV ~ 10 MW ✓ Scale up plans for APV to the tune of 150 MW.	✓ Setting up state monitoring unit for following up the KUSUM program implementation. ✓ Converting grid electric pumps to solar pumps

Enabling action plans for RE intervention in agriculture

- Distribution of energy efficient pumps to replace existing inefficient electric pumps
- Promote installations under PM KUSUM scheme in the state
- Increase construction of energy efficient cold storage working on solar power
- Incentivize the manufacturers for producing solar Powered tractors
- Providing access to innovation fund for R&D
- Regulatory provision of waiver of road tax of solar/RE powered farm machines
- Undertake awareness Programme for disseminating benefits of energy efficient pumping

Renewable Energy in Buildings

In the state of Goa

Electricity Consumption from building sector

- Residential and commercial buildings are consuming around 13% of total final energy in 2020 which is expected to go up to 36% by 2050
- As per Electricity Dept record, until March 2021 there are 1542 LT category hotels and 214 HT category hotel consumers
- It is estimated that hotels are consuming around 9~11% of electricity consumed by the entire commercial segment in the State

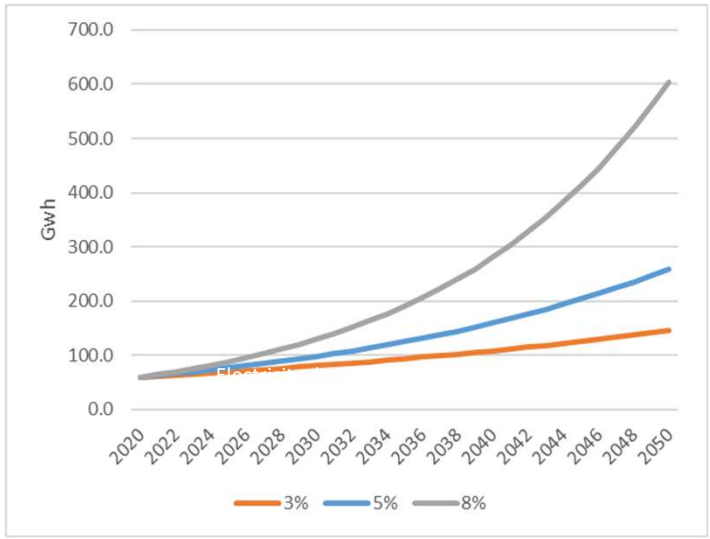
Category of Hotel	No. of Units	Avg. No. of Rooms /Hotel	Total Rooms	Type of Connecti on	Average Kwh /Room
A	52	100	5200	HT	1400 Kwh per year / room
B	182	50	9100	HT/LT	
C	1057	25	26425	LT	
D	2563	5	12815	LT Domestic	
Total	3854		53540		

Energy consumption in hotels by category

Energy Demand in Hotels

By 2050 if the tourism grows at an annual rate of 3% (average growth rate of last 5 years) then by 2050 total electricity demand from the hotels would reach up to 145 GWh

the projected electricity demand by the hotels in Goa under three different growth scenarios of 3, 4 and 8% per annum.

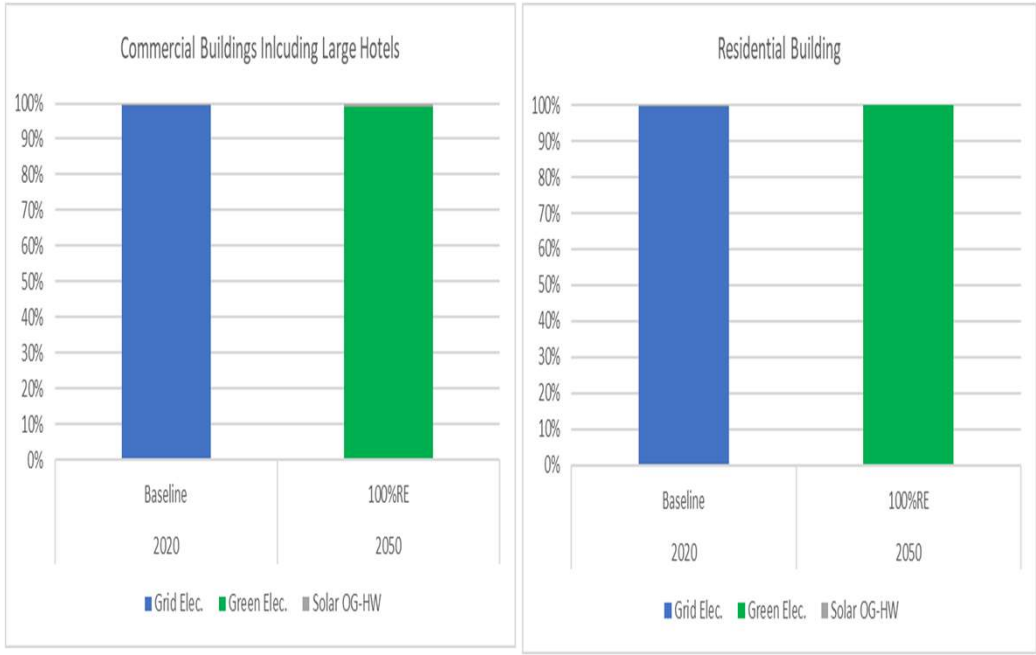


Decarbonization of Building sector

It is estimated that to decarbonize the sector in the State there will be three major sources of energy:

- Green electricity in the grid
- Off-grid solar use and
- Solar thermal for hot water system.

This fuel mix can replace 100% of the fossil fuel consumption by 2050



Change in fuel mix for decarbonization of building sector

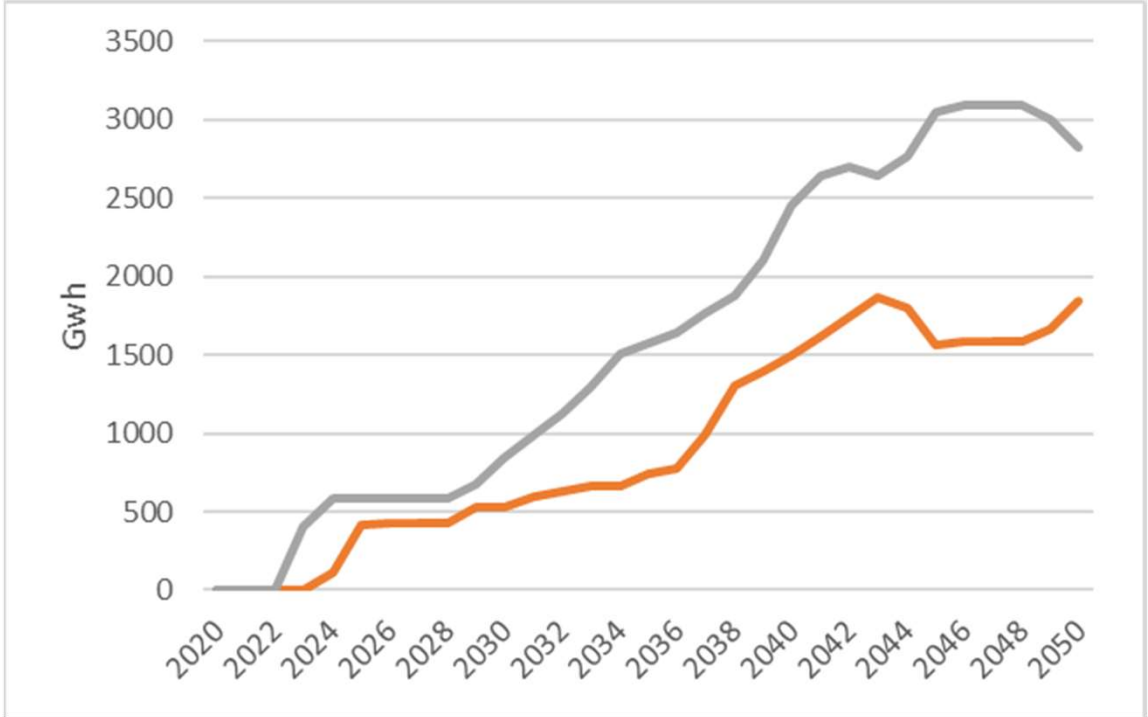
RE Intervention Activities

1.0 Use 100% green electricity for all building operational activities by 2050

2.0 100% solarization of all thermal energy requirement for heating (hot water) by 2050

Solar Roof-Top for Buildings

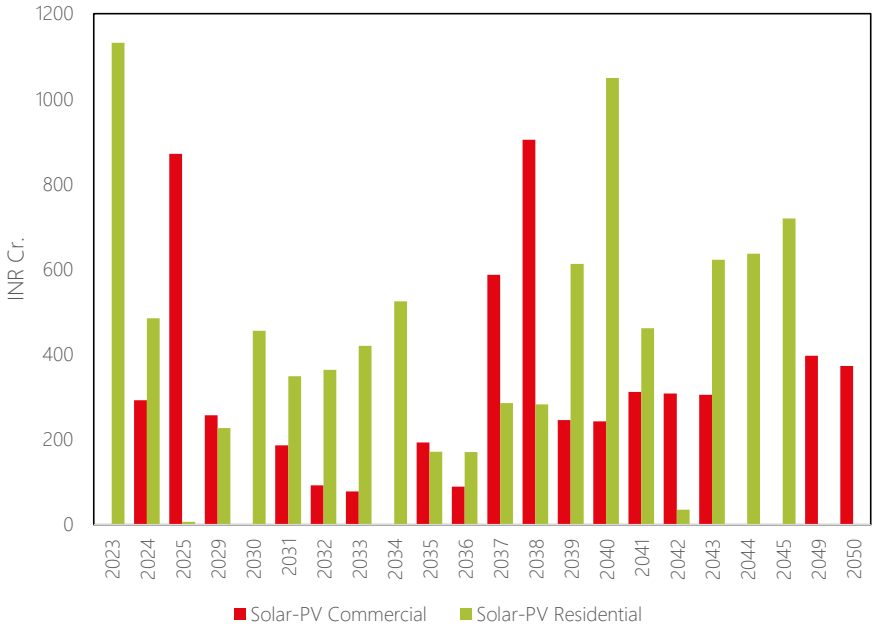
- There is an estimated potential of 3 GW of roof-top solar PV system which are required to be fully utilized
- It is estimated that the roof top capacities for commercial building will be 1.18 GW and 1.8 GW for residential building by 2050
- These 3 GW installations could supply around 4672 GWh of electricity for building operation in the State of Goa by 2050.



Roof-top generation projection from commercial and residential

Investment Demand for building solarization

- To achieve required level of roof top capacity addition in the State of Goa, for commercial building solar roof-top around Rs.337 Cr/ year investment is required compared to Rs.450 Cr./ year for residential buildings.
- Between 2022 and 2050 commercial building solar roof-top program needs cumulative investment of Rs. 5700 Cr whereas for residential buildings the total investment demand is around Rs.9000 Cr



Investment demand for solar roof-top capacity addition

Action Plan for 100%RE intervention in buildings

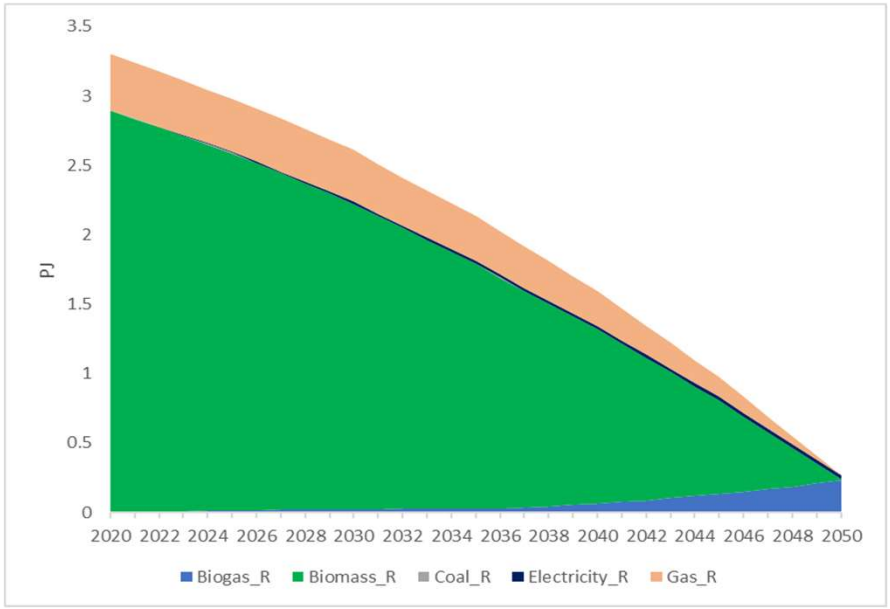
Goals	Targets	Activities
100% Renewable Energy & Green Electricity Based Building Energy Supply in the State of Goa by 2050	Implementation of ECBC Targets for Commercial Building	i) Developing building approval byelaws ii) Training and capacity building of the ULB authorities for approval of ECBC compliant building plans. iii) Scaling up of the ECBC norms to residential and all commercial buildings in the State.
	Developing & implementing Targets for Net Zero Commercial Buildings in Goa	i) Developing the plans and policies for Net Zero Buildings in Goa. ii) Benchmarking specific energy consumption of the hotels by category iii) Create incentives for the hotels to participate in 100% green energy use and becoming net zero hotel. iv) Making all A category hotel Net Zero v) Making all B category hotel Net Zero
	Supplying 100% green electricity for all building activities by 2050	i) Target oriented Solar net-metering plan for residential prosumers in the State (Expansion of capital subsidy program for benchmark costs and enhanced unit capacity >500KW) ii) Target oriented Solar net-metering plan for commercial prosumers in the State (Expansion of capital subsidy program for benchmark costs and enhanced unit capacity >500KW) iii) Assessment of battery connected solar roof-top financing plan for achieving 3 GW capacity addition by 2050. iv) Assessment of potential of building integrated solar PV in the State and align the same to ECBC compliance

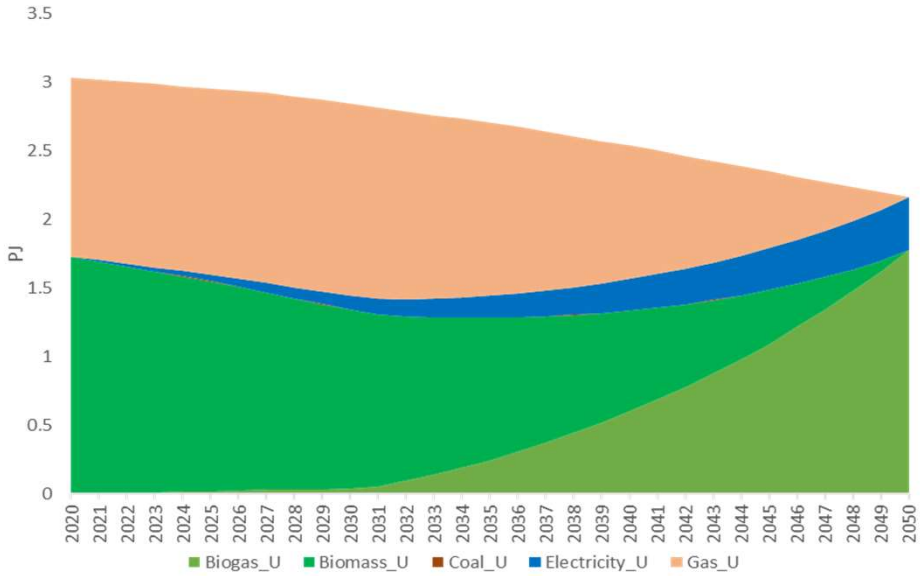
Renewable Energy in Cooking

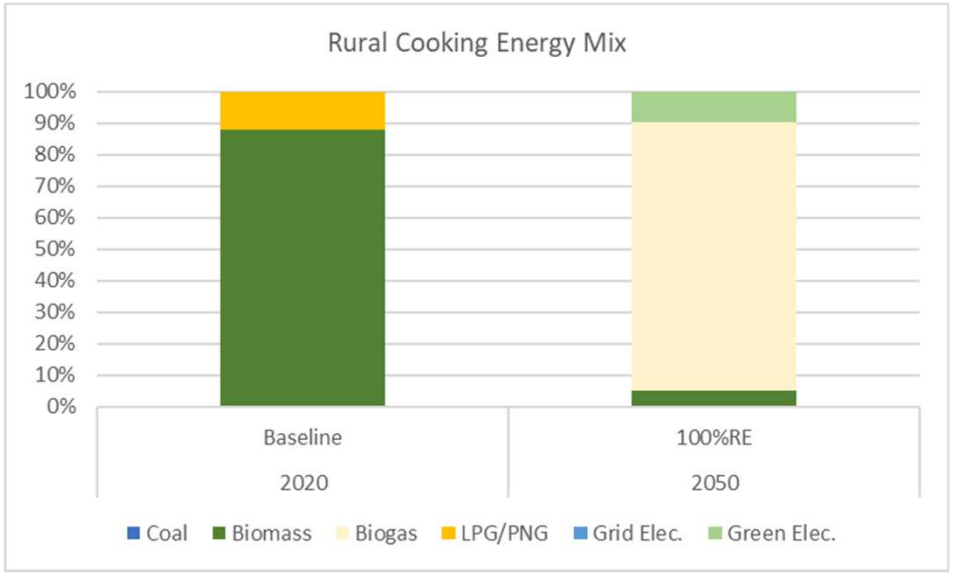
In the state of Goa

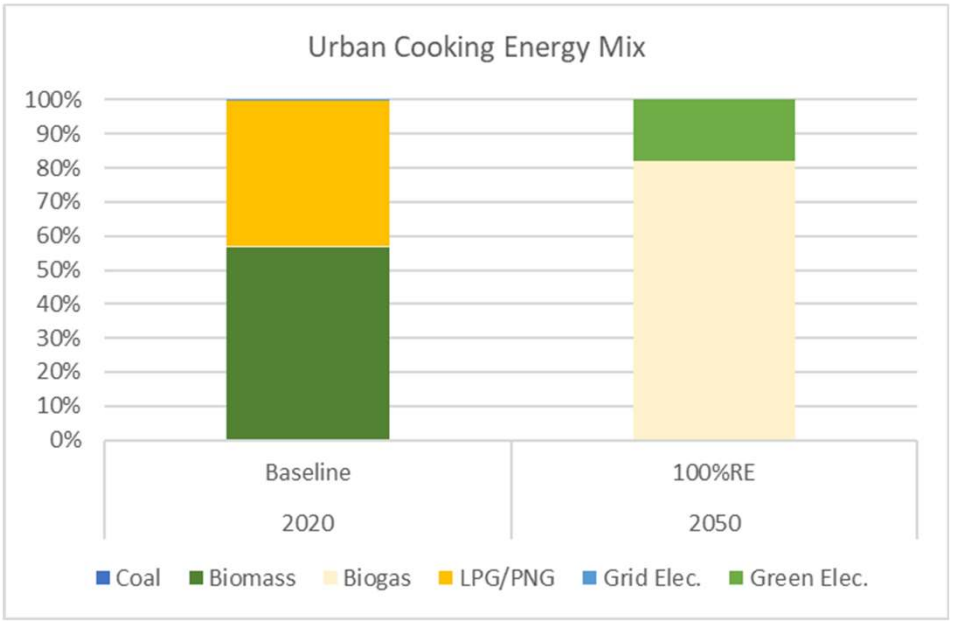
Decarbonized Cooking Energy Consumption

- In the State of Goa, there is a distinct different between cooking energy mix between urban and rural households
- It is estimated that in the State share of cooking energy is around 13% in 2020 of total energy consumption.
- 52% of the energy is consumed by the rural households and 48% by the urban households
- It is estimated that by 2050 total energy demand in the sector reduces to 2.4 PJ from 6.3 PJ in 2020 mainly due to efficient use of cooking technologies and high-quality fuel (high energy content).





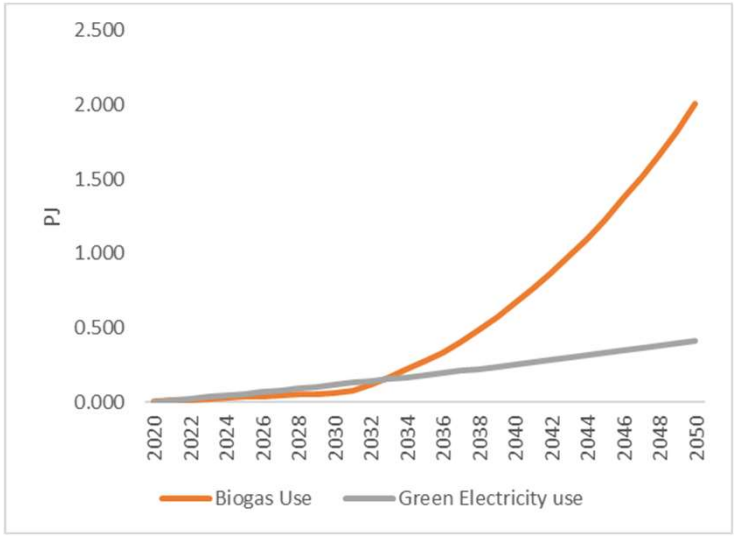




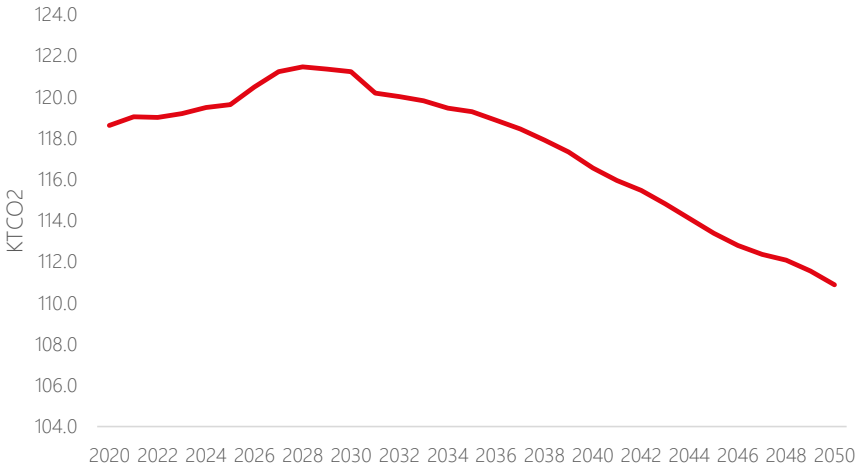
Change in fuel mix for decarbonized cooking sector

RE Intervention activities in cooking sector

- It is estimated that use of biogas and green electricity increases from almost nil to 2 PJ and 0.41 PJ by 2050
- It is also projected that by 2050 emissions will go down to 110 KTCO2 which is around 6.5% less than the 2020 base year emissions from the sector



Growth of biogas and green electricity for cooking



Emission reduction by 2050

Action Plan for decarbonization of cooking sector

Creating infrastructure and support facilities for 100% penetration of electricity and biogas in rural areas.

- ✓ Conducting state-wide biogas potential assessment to meet the demand of 2 PJ equivalent biogas i.e around 50 million Cub. Meter of gas
- ✓ Training and awareness generation of the users for biogas based cooking
- ✓ Introduce financial incentive schemes to promote and adopt biogas based cooking system in rural Goa.
- ✓ State shall invest in R&D to improve the thermal efficiency of biogas stoves and promote innovation in bulk procurement of such stoves.
- ✓ Setting up biogas production facilities through private sector participation

Creating infrastructure and support facilities for 100% penetration of electricity and biogas in urban areas.

- ✓ Training and awareness generation of the users for induction cooking (electric cooking).
- ✓ Introduce financial incentive schemes to promote and adopt induction cooking system in urban Goa.
- ✓ Setting up targets of penetration of induction cookers in urban households in Goa

Enabling policy for decarbonization of cooking Sector

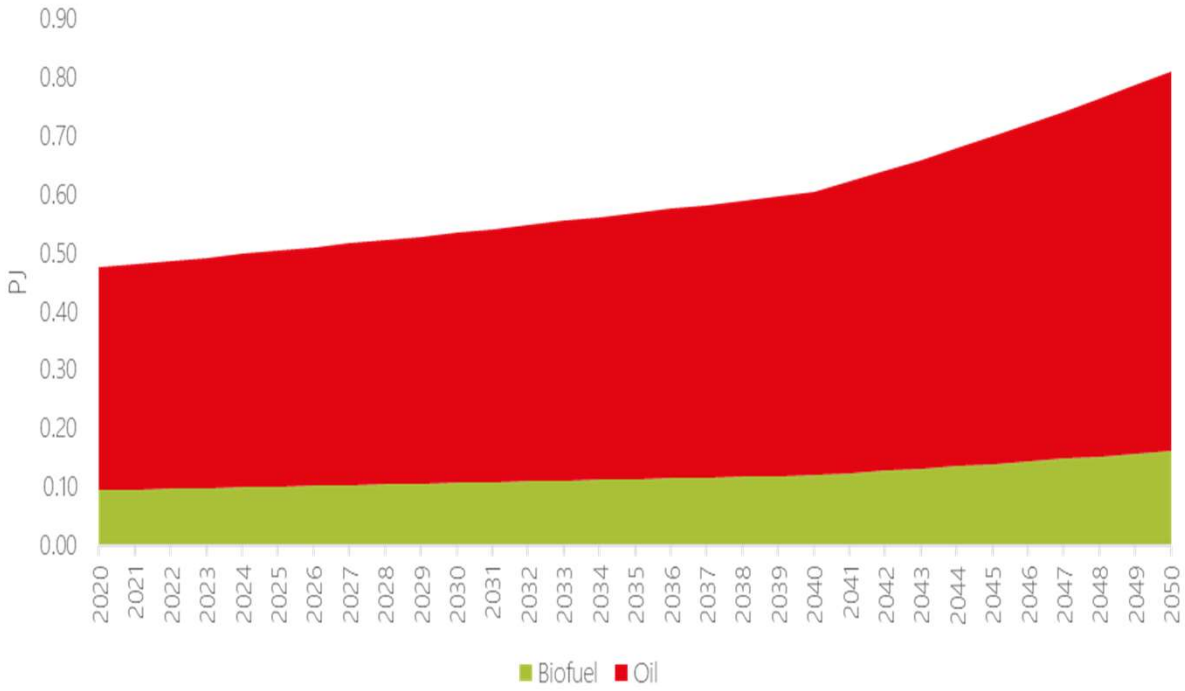
- ✓ Facilitate setting up of biogas plants through setting up co-operatives and providing access to climate fund.
- ✓ Provide financial support to end user to increase the penetration of electric cooking equipment
- ✓ Create awareness among the restaurant owners / commercial cooking facility owners for use of bio-briquettes for tandoor / smoky cooking instead of coal.
- ✓ Create necessary supply chain for easy access to bio-briquettes.
- ✓ Create awareness among consumers for use of DME blended LPG for cooking.
- ✓ Commercial / restaurant cooking can be encouraged to shift to Methanol Canister Cookstove.

Renewable Energy in Fishery

Energy Consumption

- Fishery sector in Goa consumes around 0.9% of total energy consumed with a consumption of around 16000 KL of petrol & diesel per annum.
- It is proposed to use blended fuel (20% blending of biofuel) for fishing activities which could save around 3200 KL of diesel /petrol per annum. Use of blended fuel could reduce around 236 KtCO2 between 2020 and 2050.

Fuel mix of fishery sector under 100%RE Scenario



RE Intervention Activities in fishery sector

01.

Use of blended fuel for all fishing boats including solar

02.

20% blending of biofuels in all categories of vehicle used for fishing (pre and post harvesting)

03.

100% use of green electricity for post harvesting activities mainly cold storages

Action Plan for decarbonization of fishery sector

Increase the penetration of solar/hybrid boats for fishing

- ✓ State shall develop fishing boat solarization policy to mainstream use of solar, wind and hybrid technologies for fishing boats to minimize the fuel cost and emissions reduction.
- ✓ Awareness programs of the fishermen for use of solar, biofuel blended fuels for their fishing boats.
- ✓ Pilot testing of new boat technologies along with new boat material

Promoting RE for post harvesting activities

- ✓ Promoting solar dryer for fish preservation: Conducting assessment study.
- ✓ Promoting solar based cold chains for fish storage.
- ✓ Promoting use of EVs for market connectivity between fishing jetty and market.

RE based aquaculture

- ✓ Developing RE based aquaculture policy for Goa.
- ✓ Piloting solar-thermal aerator.
- ✓ Piloting wind power aerator (use of low speed wind potential of Goa for aquaculture)

Post Harvesting RE intervention

- ✓Developing new and retrofitting existing fish cold storages with RE power supply.
- ✓Convert all existing 2 & 3 Wheelers attached with icebox to RE based
- ✓ Fish carrying trucks use blended fuel

Renewable Energy in Industry

Energy mix in Industrial sector

Industrial energy share in the State of Goa in 2020 is around 19% which is expected to increase to almost 23% by 2050

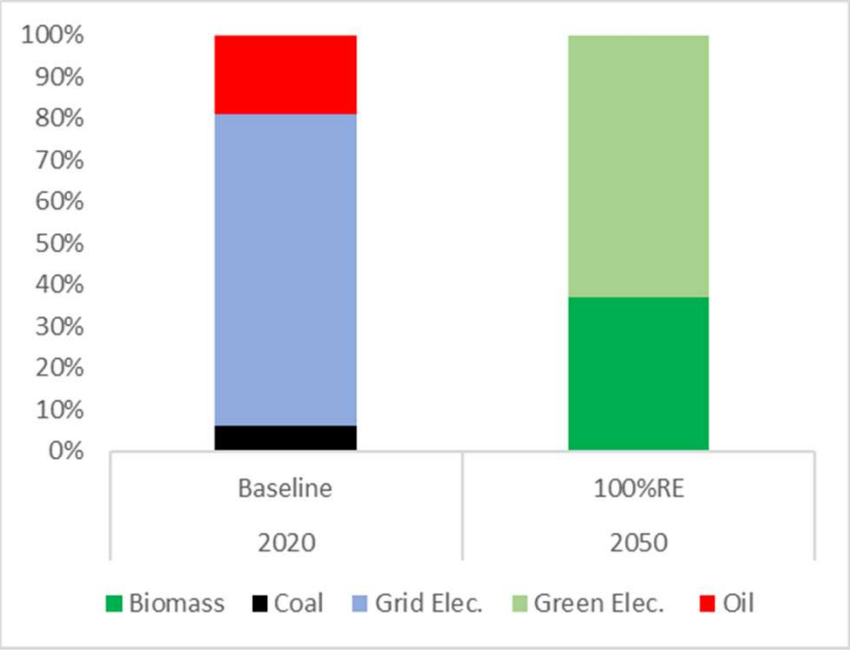
It is projected that industrial energy consumption will grow at 6% per annum basis with not much changes in fuel mix

Currently the major fuel of Industrial energy mix is electricity followed by oil and coal

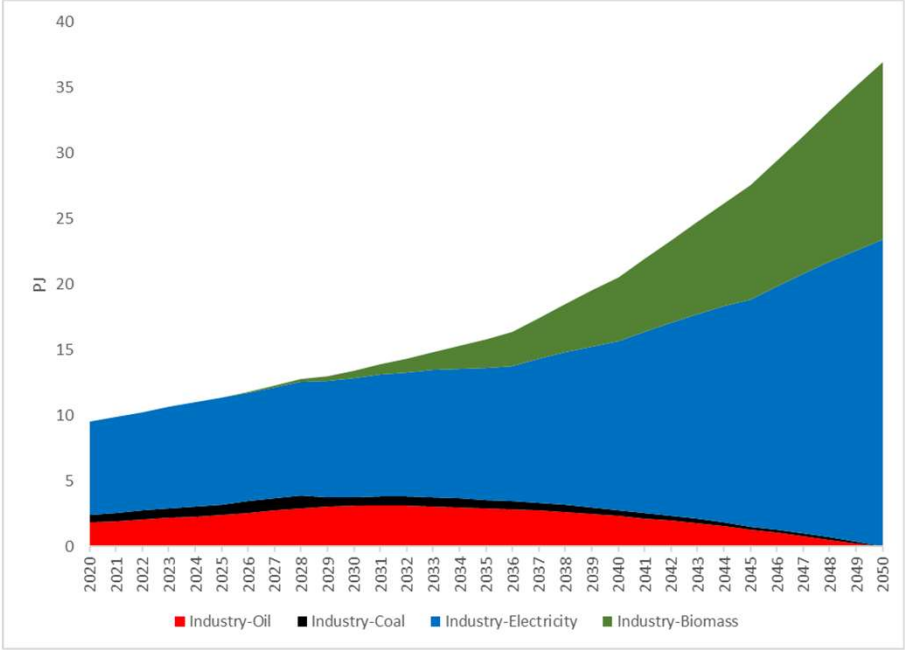
By 2050 37% of the industrial energy will be supplied through biomass while 63% will come from electricity which will be supplied through renewable sources

The transition required in the industry sector in the State of Goa to make it 100% RE based

- Based on the planned RE intervention in the sector the study obtained the following industrial fuel mix which is completely decarbonized.

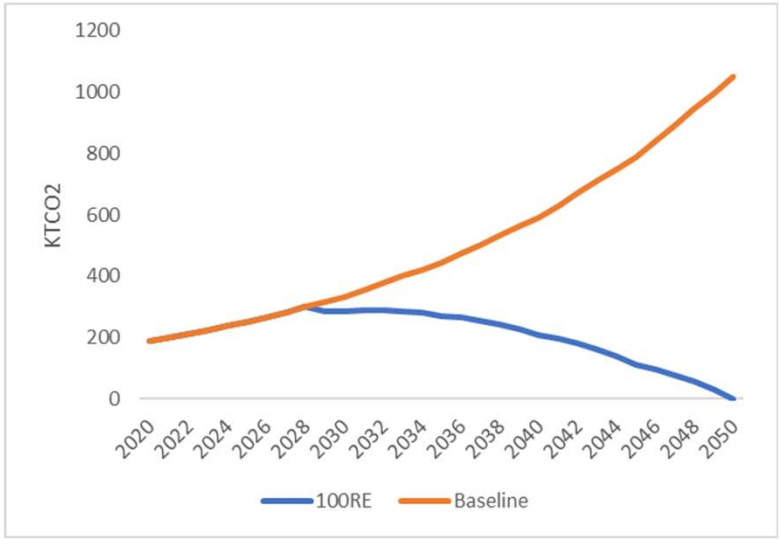


Change in fuel mix for decarbonized industry sector



Industrial energy mix of Goa under 100% RE Scenario

Emission reduction in Industrial sector



Emissions reduction from industry sector due to RE intervention

- Fuel shift in the industry sector brings huge benefits to emissions reduction from the sector itself
- Complete decarbonization of the sector can reduce cumulative emission of around 9.5 MtCO2 between 2020 and 2050 which could be attributed to replacement of coal and oil

1.0 100% replacement of coal use by biomass

2.0 100% replacement of oil use by biofuels/green electricity

3.0 100% use of green electricity

Major renewable energy interventions in the sector

Action Plan for decarbonization of industry

Increase the penetration of energy efficiency to save 20% energy by 2050	Developing models for implementation of emission mitigation measures	Promote the transition from fossil based energy sources to clean energy alternatives.
✓ Develop energy benchmarking for the industrial subsector and MSME clusters. ✓ Technology transfer support for the MSME sector to ensure the availability of the best operating technologies. ✓ Providing R&D support to develop innovative energy efficient technologies. ✓ Incentivize adoption of energy efficient technologies and processes as well as development of energy efficiency services market through climate fund.	✓ Developing collaboration platform for technology providers, technology distributor, R&D labs, technical institutions to share relevant technical inputs to industry beneficiaries. ✓ Develop and demonstrate green hydrogen projects.	✓ Mandating industries to set-up captive solar plants especially rooftop solar systems to meet their electricity demand ✓ Providing fiscal incentives to industries to promote the use of biomass/biogas through captive or procurement process. ✓ Providing technology support to the industries for transitioning to green hydrogen ✓ Develop green hydrogen policy for the State including use of Green H2 by the industries. ✓ Develop Net Zero Emissions policy for the industry zones in the State

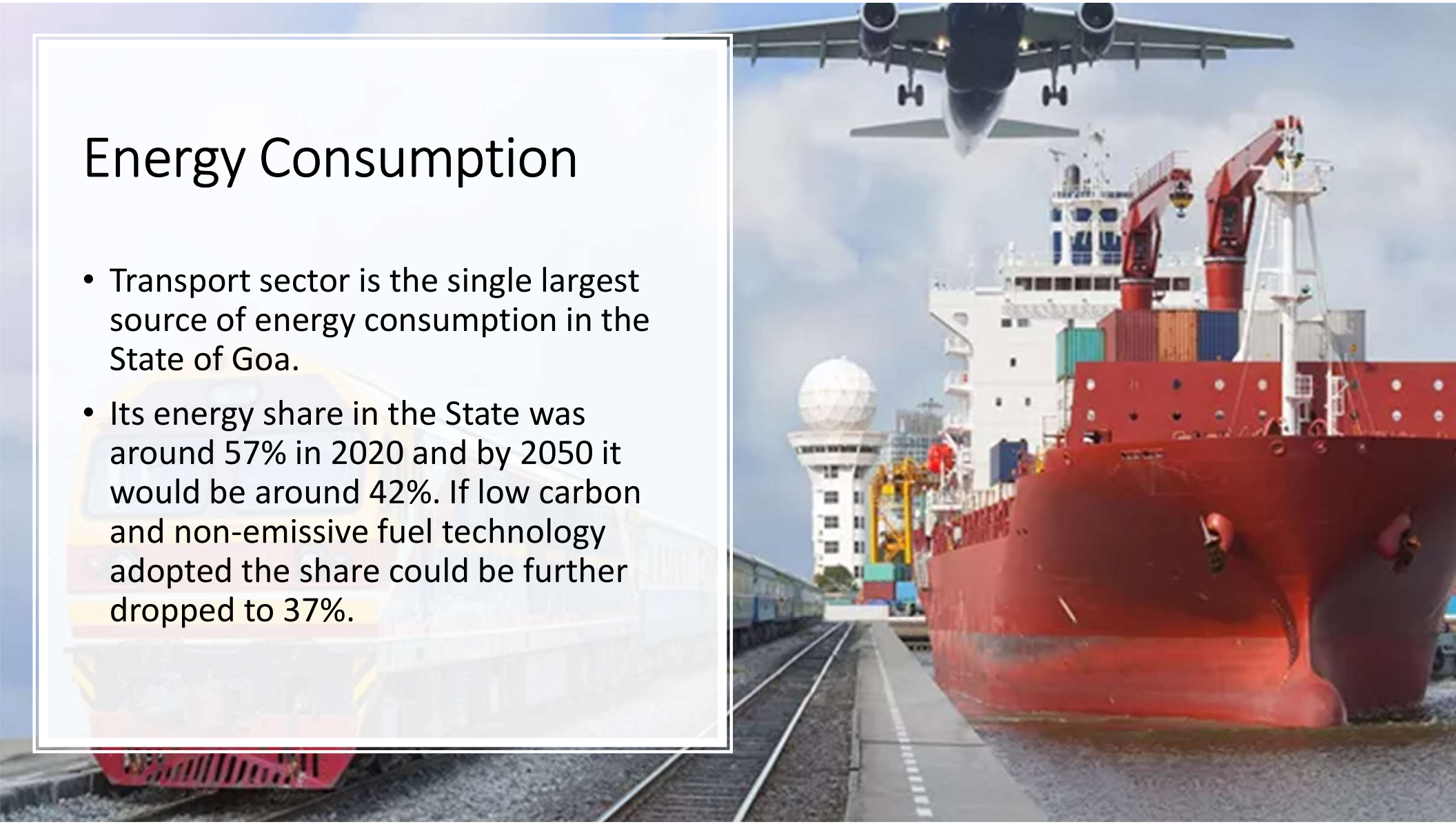
Enabling action Plan for RE intervention in industries

- Technology transfer support for the MSME sector to ensure the availability of the best operating technologies
- Provide necessary technical and financial support to promote use of solar-wind hybrid system for captive power generation
- Providing fiscal incentives to industries to promote the use of biomass residue through co-firing
- Provide necessary technical and financial support to promote use of solar-thermal concentrator for industrial process heat.
- Encouraging industries to adopt ESG norms through awareness and capacity building
- Encouraging MSME to take advantage of Umbrella Scheme (Goa State Incentives to Encourage Investments Scheme, 2017) to promote energy conservation and efficiency in their respective processes.

Goa Transport Sector

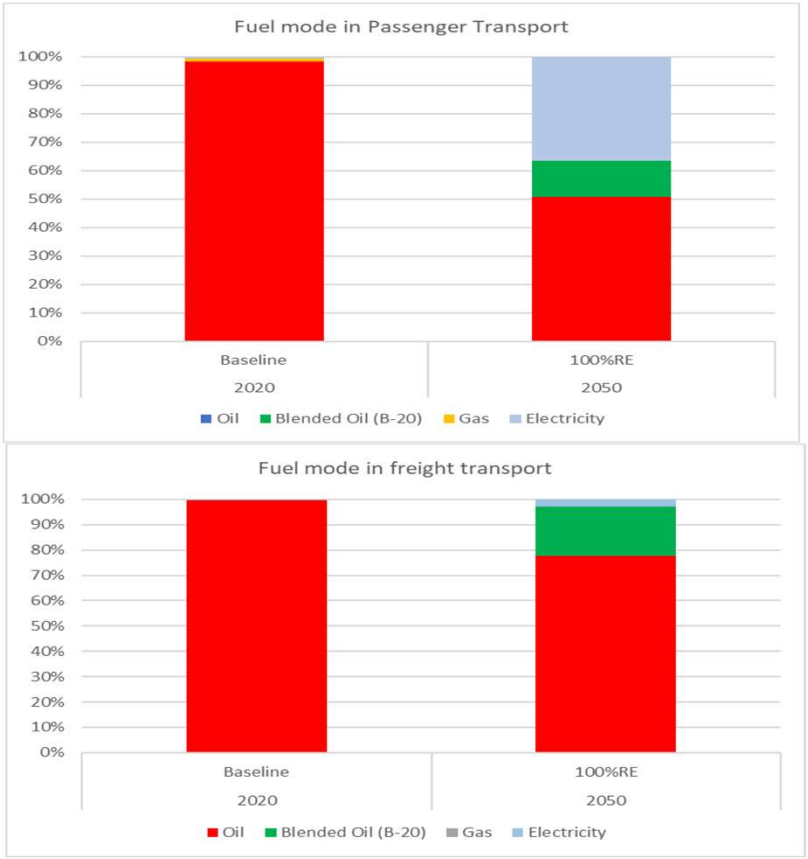
Energy Consumption

- Transport sector is the single largest source of energy consumption in the State of Goa.
- Its energy share in the State was around 57% in 2020 and by 2050 it would be around 42%. If low carbon and non-emissive fuel technology adopted the share could be further dropped to 37%.

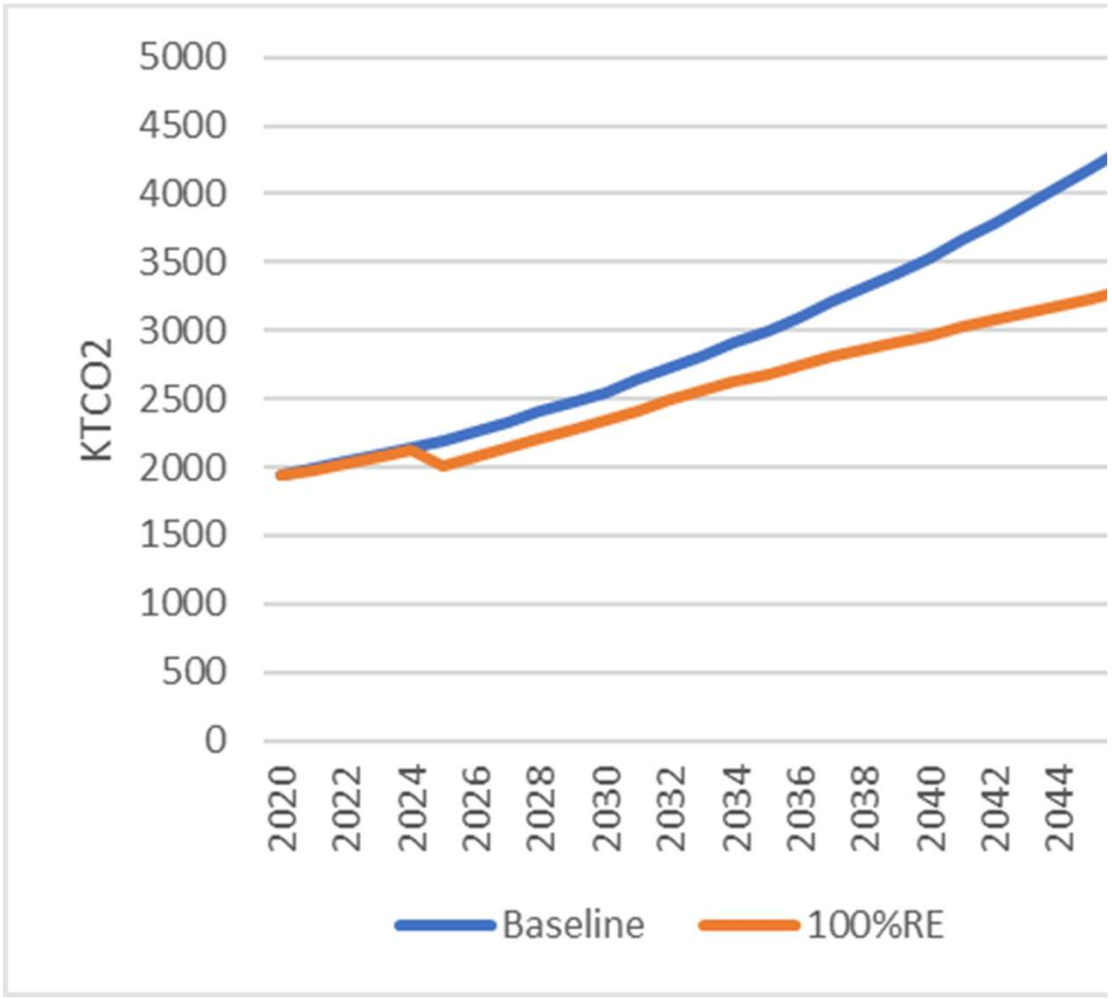


Decarbonization of transport sector

- Low carbon technologies and zero emissive fuel shifting by 2050 will impact the share of transport energy which would be around 37.6%.
- Due to fuel shifting and introduction of renewable energy in the transport sector there is a potentiality of reduction of 4.5% of energy demand share by 2050.



Change in fuel mix for decarbonized transport sector



Emissions reduction from the transport sector due to RE intervention

Emission Reduction

- RE intervention in the transport sector could reduce cumulatively around 15 MtCO2 between 2020 and 2050 due to fuel shifting towards biofuels and electricity
- Major reduction is happening in the passenger segment due to 100% electrification of 2 wheelers, cars and taxies

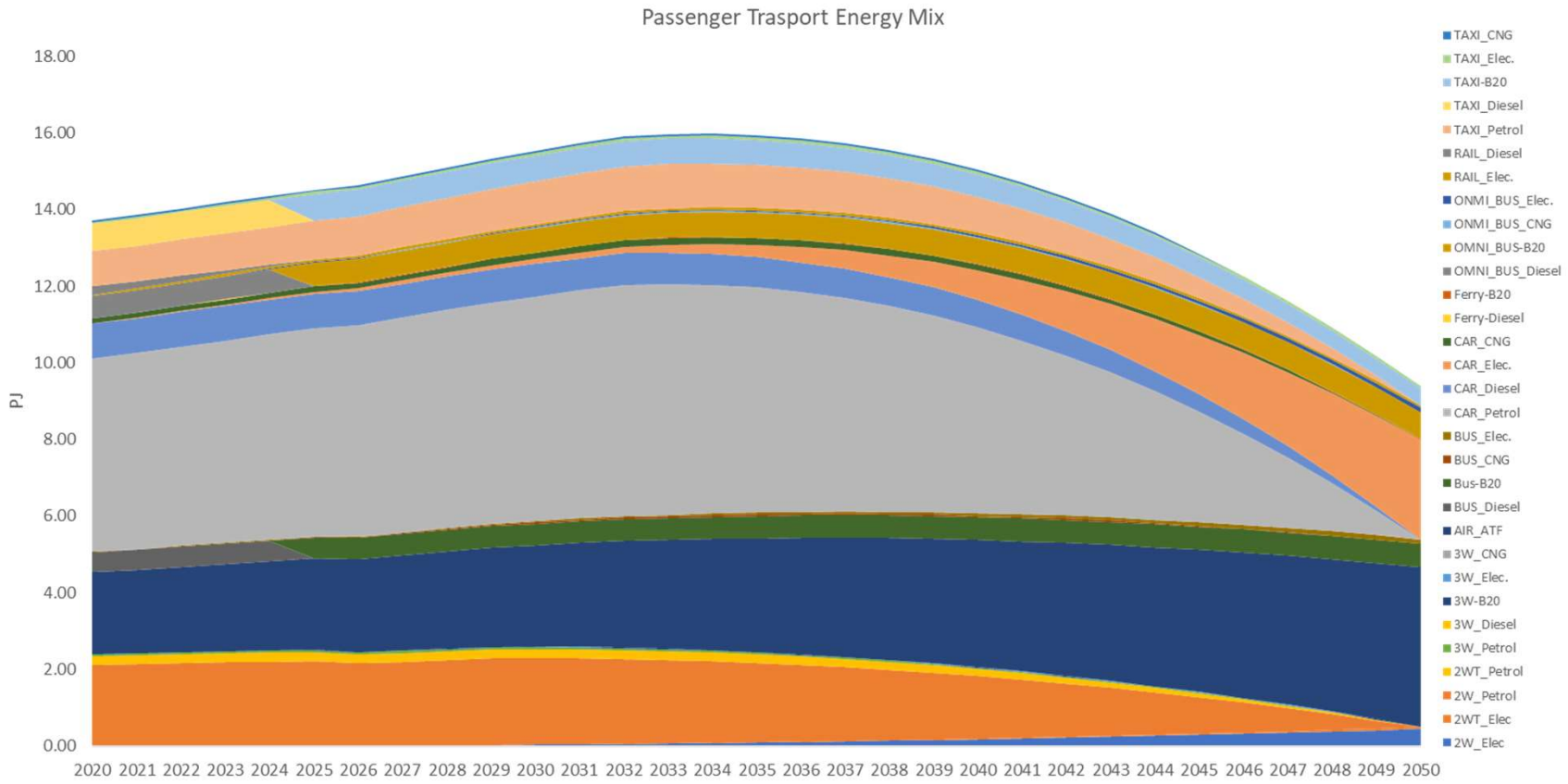
RE Intervention Activities in transport sector

1.0 100% electrification of 2 Wheeler, Cars & Taxies

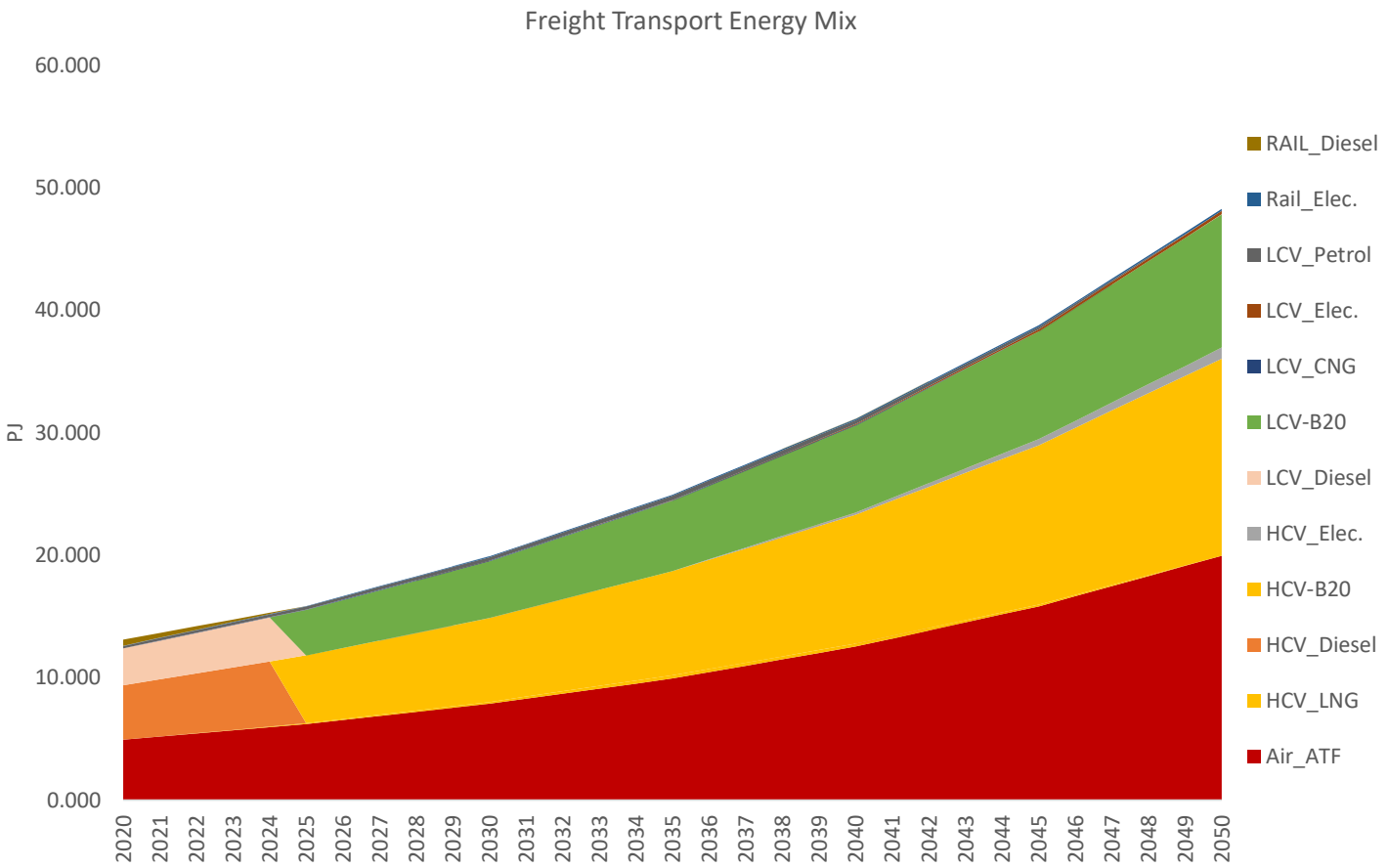
2.0 20% blending of biofuels in all categories of vehicle

3.0 100% use of green electricity for EV charging

Energy mix in Passenger Transport with RE intervention



Energy mix in Freight Transport with RE intervention



Action Plan for decarbonization of transport sector

Increase the penetration of electric vehicle in passenger segment	Increase the penetration of electric & hydrogen vehicle in freight segment	EV & Hydrogen Vehicle Promotional Policy
✓ State shall implement the State Electric vehicle policy of Goa 2020 to provide adequate and effective fiscal and financial incentives to motivate consumers to buy EVs. ✓ Market development for End-of Life/Recycler for existing vehicle and batteries ✓ Policy to set up adequate charging infrastructure (both public and private based) ✓ Skill development required for the development and up keeping of EV. ✓ Increase share of electric buses in the State ✓ 100% electrification target for 2 Wheelers ✓ 100% Electrification target of Taxies. ✓ Solarization of ferry boats	✓ Develop awareness among the commercial fleet operators on the benefits of EVs adoption ✓ Developing adequate infrastructure for handling freight-vehicle green hydrogen requirement	✓ Dovetailing State EV policy to Vehicle Scrape Policy ✓ Creating EV promotional fund for faster adoption of EV in the commercial / non-private category ~Providing access to Tourist Vehicle Operators ✓ Creating necessary regulatory changes in vehicle registration process to promote LNG use in Goods carrier.

Resource mobilization for 100% RE

For the State of Goa

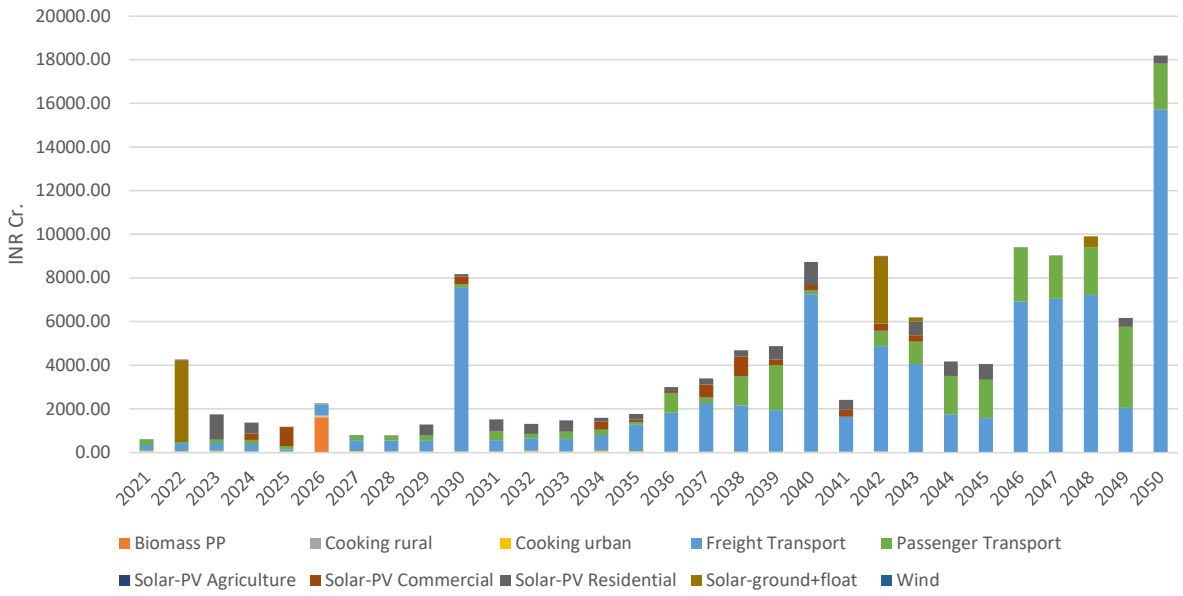
Social impacts of 100% RE

- It is estimated that while implementing 100% RE plan in the State of Goa, it can crate around 15000 additional jobs (with 5 year term) between 2020 and 2050
- Annually the State can create 500 jobs exclusive for solar and wind energy generation within the State

RE Technology	Job Potential (Job Years/MW)	Total Capacity	Total Jobs Years	No. of Jobs (5 years contract)
Solar PV (GM)	3.45	800 MW	2760	552
Solar PV (RT)	24.7	3000 MW	74,100	14,820
Wind (on-shore)	1.27	1 MW	1.2	-

100% RE investment demand

- The State requires significant amount of investment which is closely around INR 133,260 Cr to implement 100% RE plan between 2020-2050.
- Per year investment requirement is around INR 4400 Cr. (around USD 550 million) which is closely around 5.6% of the State GDP at current price in 2020-21



YoY Investment demand for 100% RE Plan for Goa

Green Technology Fund for Goa

- Green technology fund is to Support to new RE technology R&D, adoption at large to small scale
- The fund could initially target small to medium scale projects with a value of INR 25 lakh to INR 1 crore and could have an initial fund scope of INR 150 crore.
- The fund can be scaled up in the future to fund projects with investment requirement of above INR 1 crore, based on the availability of funds and the utilization of the initial fund allocation.
- The fund can focus on projects/initiatives implemented in agriculture, residential and commercial buildings, transport, SMEs etc.
- The source of fund could be through state budgetary allocation (use of existing carbon cess budget), future pollution tax, central government funding schemes or CSR spend of public/private entities. Fund can also leverage soft and blended financing available through multilateral banks like the World Bank

Thank You