



Clean Energy Roadmap for the State of Goa



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DR. PRAMOD SAWANT
CHIEF MINISTER, GOA

MESSAGE

"Goa's journey towards a sustainable, low-carbon future is an ambitious one. This shift towards 100% renewable energy by 2050 is both a challenge and an opportunity.

Our state, small in size but rich in renewable resources, is uniquely positioned to make this leap. We are not just mitigating our carbon footprint, but creating a brighter, cleaner future for the generations to come.

As we embark on this journey, we must also ensure that we balance our developmental aspirations with our environmental responsibilities. I intend to promote offgrid rooftop solar and I invite every Goan to join us on this transformative path, making renewable energy an integral part of our lives."

Dr. Pramod Sawant
Chief Minister, Goa State



SHRI. RAMKRISHNA DHAVALIKAR
POWER MINISTER, GOVT. OF GOA

MESSAGE

"It is with great enthusiasm that we outline Goa's roadmap to achieve 100% renewable energy by 2050.

This isn't just about changing how we generate and consume energy. It's about envisioning a future where our dependence on high-emissive fuels is a thing of the past.

By harnessing our abundant renewable resources, we can shape a more resilient, more sustainable energy sector. Through this transition, we also aim to spur economic growth and create new opportunities for our citizens.

I am confident that together, we can make this vision a reality and set a benchmark for other states to follow."

Minister for Power/New & Renewable Energy
Govt. of Goa

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AMI	Advanced Metering Infrastructure	FCV	Fuel Cell Vehicles RES
AMSC	Agriculture Machinery Service Centers		Reference Energy System
BAU	Business as Usual	FY	Financial Year SAPCC State Action Plan on Climate Change
BEE	Bureau of Energy Efficiency	Gcal	Giga Calorie SCADA Supervisory Control and Data Acquisition
CAGR	Compound Annual Growth Rate	GCV	Gross Calorific Value
CBG	Compressed Biogas	GEDA	Goa Energy Development Agency
CEA	Central Electricity Authority	GHG	Green House Gases
CO ₂	Carbon Dioxide	GIS	Geographical Information System
CO ₂ e	Carbon Dioxide Equivalent	GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
CoE	Centre of Excellence	GSDP	Gross State Domestic Product
Cr	Crore	GW	Gigawatt
CSO	Civil Society Organisation	GWh	Gigawatt Hour
DC	Designated Consumers	HH	Household
DoP	Department of Power	INR	Indian Rupee
DR	Demand Response	IPDS	Integrated Power Development Scheme
DRS	Demand Response System	IPP	Independent Power Producers
DSM	Demand Side Management	KV	Kilovolt
EAP	Energy Action Plan	kWh	Kilo Watt Hour
ECBC	Energy Conservation Building Code	LC	Low Carbon
EE	Energy Efficiency	LMV	Light Motor Vehicle
EEPS	Energy Efficient Pump Set	LPG	Liquified Petroleum Gas
EESL	Energy Efficiency Services Ltd	MNRE	Ministry of New and Renewable Energy
EP	Energy Plan	MoPNG	Ministry of Petroleum and Natural Gas
ESCO	Energy Service Company	MSME	Micro Small and Medium Enterprises
ESOPB	Economic & Statistical Organisation, Government of Punjab	MSW	Municipal Solid Waste
EV	Electric Vehicle R&D Research and Development	MT	Metric Tonne
FBC	Fluidized Bed Combustion RE Renewable Energy	MtCO ₂	Million Tonne of CO ₂

Mtoe	Million Tonne of Oil Equivalent	R&D	Research and Development
MU	Million Unit	RE	Renewable Energy
MW	Mega Watt	RES	Reference Energy System
NRSE	New and Renewable Sources of Energy	SAPCC	State Action Plan on Climate Change
PAT	Perform Achieve & Trade	SCADA	Supervisory Control and Data Acquisition
PES	Primary Energy Supply	SDG	Sustainable development Goals
PLF	Plant Load Factor	SHR	Station Heat Rate
PMU	Project Management Unit	SLDC	State Load Dispatch Centers
PMUY	Pradhan Mantri Ujjwala Yojana	T&D	Transmission and Distribution
PNG	Piped natural Gas	TO	Tone of Oil Equivalent
PSPCL	Punjab State Power Corporation Limited	TWh	Tera Watt Hour USD United States Doller
PV	Photo Voltaic		

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Introduction

Goa is a small state with plenty of natural resources including renewable energies with relatively small quantum of energy demand (compared to other large states in India) which creates the possibility of transitioning towards 100% renewable energy. Here the document explains how the State can transit towards low carbon pathway from high emissive pathway with the help of renewable energy.

Goa has 3.5 times high per capita income of the national average while its per capita electricity consumption is 2 times the national average (Goa Economic Survey 2021). As a matter of fact, Goa is also having high per capita vehicle ownership which is around 650 vehicle per 1000 people and 3 times higher than national average of per capita emissions (Vahan Dashboard, MoRTH). All these indicate that the State of Goa requires to transit towards low carbon pathways while maintaining the developmental aspiration of the State. The final energy demand is projected to increase from 46.8 PJ in 2020 to 166.1 PJ in 2050 growing at a CAGR of 4.3%. It is observed that around 62% of the total final energy consumption in the State in 2020 is supplied through oil followed by electricity and biomass at 22.7% and 9.9% respectively which are expected to shift towards electricity as predominant fuel (48.7%) followed by 47% of oil share by 2050. The share of coal use at final energy level is expected to continue at the same level of around 2% between 2020 and 2050. The share of gas at final energy use could decrease from 5% in 2020 to just 2.2% in 2050.

In terms of sectoral energy use, transport is the highest at 57.2% followed by industry (13.7%) and buildings (14%) in 2020. Under the baseline condition, it is projected that the share of industrial energy consumption will increase from 13.7% in 2020 to 22.2% by 2050 given the current rate of industrial development and continuous energy efficiency improvement. Transport sector will remain the largest energy consumer of the

state with its consumption increasing from 26.7 PJ in 2020 to 69.7 PJ by 2050 growing at a CAGR of 3.2%.

Current fuel consumption pattern of Goa indicates that without policy intervention the state will continue using emissive fuels like solid (coal), liquid (petrol, diesel, ATF etc.) and gaseous (LPG, PNG, CNG etc.) hydrocarbons until foreseeable future. Renewable energy has started playing an increasingly important role for augmentation of grid power, providing energy access, reducing consumption of fossil fuels, and helping Goa to pursue its low carbon development path.



Background of the Project

Energy is a critical input for economic and social development of a country and a state as it determines its prosperity level. However, it is a complex process to decipher the supply and end-use of energy at the central, state and sectoral levels of the economy. Energy is a commodity that goes through a process of conversion in order to generate useful outputs. The network of energy system comprises of primary energy, secondary energy (electricity or fuels such as gasoline), final energy (heat, kinetic energy, light etc.) and useful energy (end-use at sectors such as agriculture/transport/industry/household). India as a country faces multi-faceted energy challenges, which are thereby driving the state governments to also transform their energy systems. Energy supply, energy security, improving electricity access and availability of clean cooking fuels and technologies have become pivotal interventions. Diversifying the energy mix and shifting to a low-carbon energy system is therefore quintessential for meeting

global and national NDC commitments pertaining to climate change. These interventions could also assist in implementing the 2030 SDG agenda of ensuring access to affordable, reliable, sustainable and modern energy for all. These challenges could be met by reinventing the sector as a whole from generation to end-use. This can be achieved through replacing conventional energy generation technologies with low-carbon technologies, rapid increase of renewable energy in the energy mix and enhancing energy efficiency in end-use sectors. A wide range of low-carbon energy technologies have emerged and require expansion at scale, to meet the increasing demand and subsequently achieve full access to electricity and economic growth in these dynamically developing regions.

In this context, the objective of this study is to assess the prevailing energy situation of the state of Goa in terms of supply, demand and consumption pattern along with its energy resource availability. Developing green and clean Goa is an overarching goal covering the multi-dimensional aspects of economic, social and environmental condition of the State. State Energy Vision was prepared based on a consultative process with key stakeholders from Govt. of Goa clearly articulating the sectoral and sub-sectoral priorities and targets. Given the objectives of promoting renewable energy use in Goa, the project activity goes further down to the State's energy supply and demand analysis to identify scope of renewable energy use in various aspects of State economic activities and not only restricted to electricity generation only. Using the vision as a base, a scientifically proven energy model framework known as OSeMOSYS1 has been used for the long-term outlook planning, based on the historical trend of the State of Goa's energy system. The process further leads to developing the State's energy and renewable energy vision focusing towards increasing the scope of utilisation of RE in various demand sectors like agriculture, industry, transport etc.



100% RE Based Energy Profile of Goa

In the process of transitioning towards 100% renewable energy based system in the State of Goa, it is important to understand the long-term energy supply and demand mix for the State. Given the energy consumption profile of the State of Goa four different aspects have been identified in order to make the State 100% RE based by the year 2050. The basic principle of making the State renewable energy based are as follows:

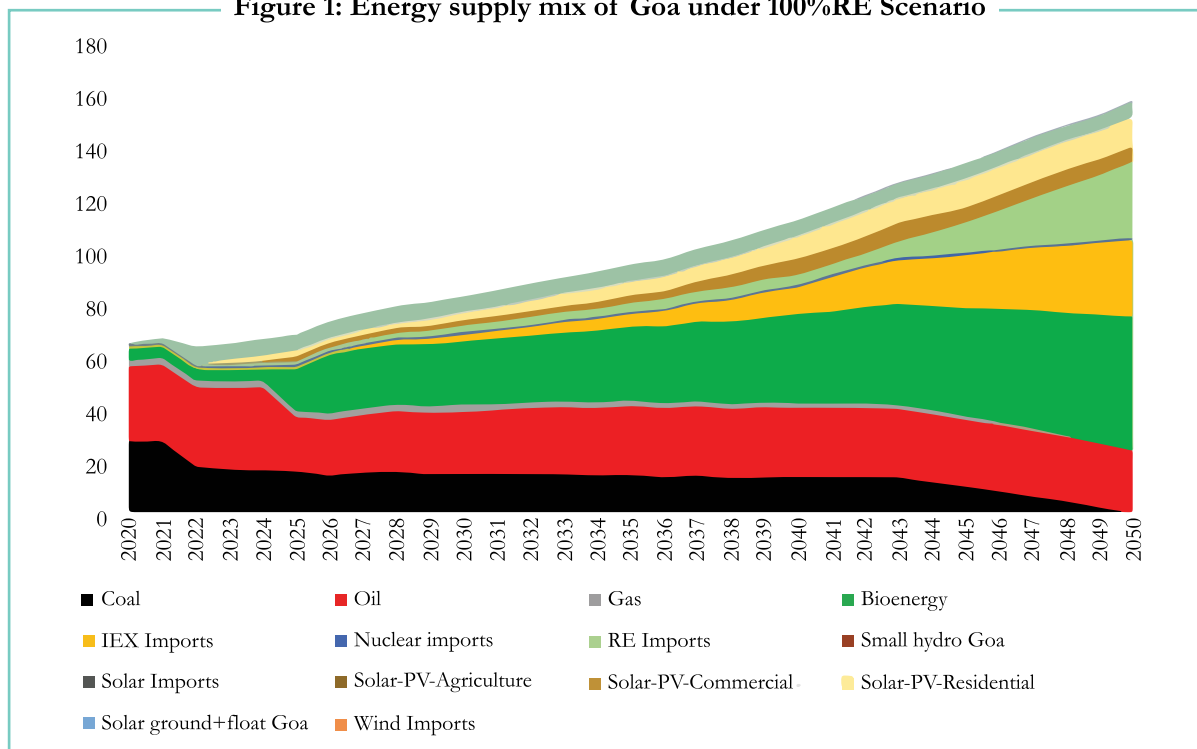
1. **Electrification of technology** use as much as possible. Reducing direct use of fossil fuels like coal, oil and gas as much as possible and replace them with electricity.
2. **Greening of the electricity** supply. Replacing fossil-based electricity with renewable energy. Procure green electricity only from the market.
3. **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. **Demand management and energy efficiency** to reduce losses of energy and rationalisation of energy demand.

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

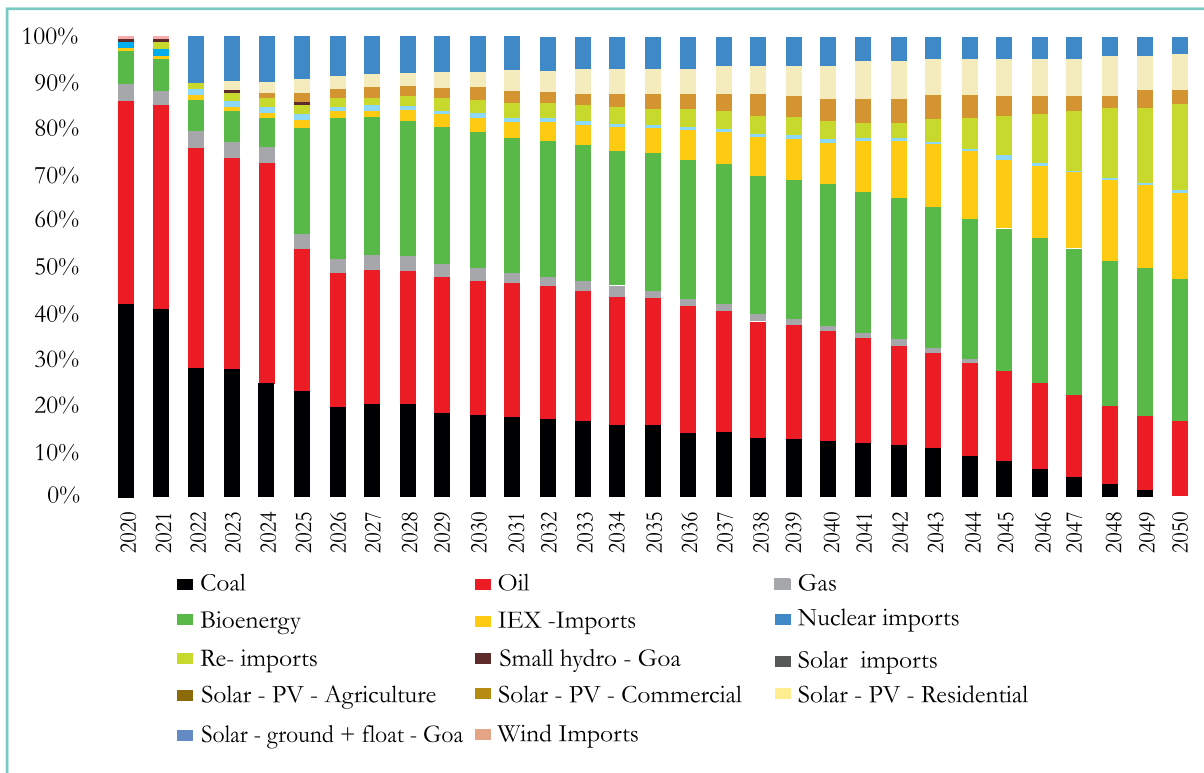
In the process of RE transition (based on above mentioned four principles) it is observed that coal supply in the State is phasing down to zero by 2050 while the oil supply still remains in the system mainly due to consumption by transport sector. It is rather difficult to replace entire oil demand in the transport sector to non-emissive fuels mainly due to technology barrier, availability of alternative fuels with required volume and costs. It is also observed that bioenergy is going take a major share in the State's overall energy supply which will be around 30% by 2050. By 2030 around 50% of the energy supply will become non-emissive and renewable energy based which further increases to 85% by 2050. Figure 1 shows the energy supply mix of the State of Goa under the 100% RE scenario.

Figure 1: Energy supply mix of Goa under 100%RE Scenario



Data Source: The Celestial Earth

¹ For further detail please see : <http://www.osemosys.org/>



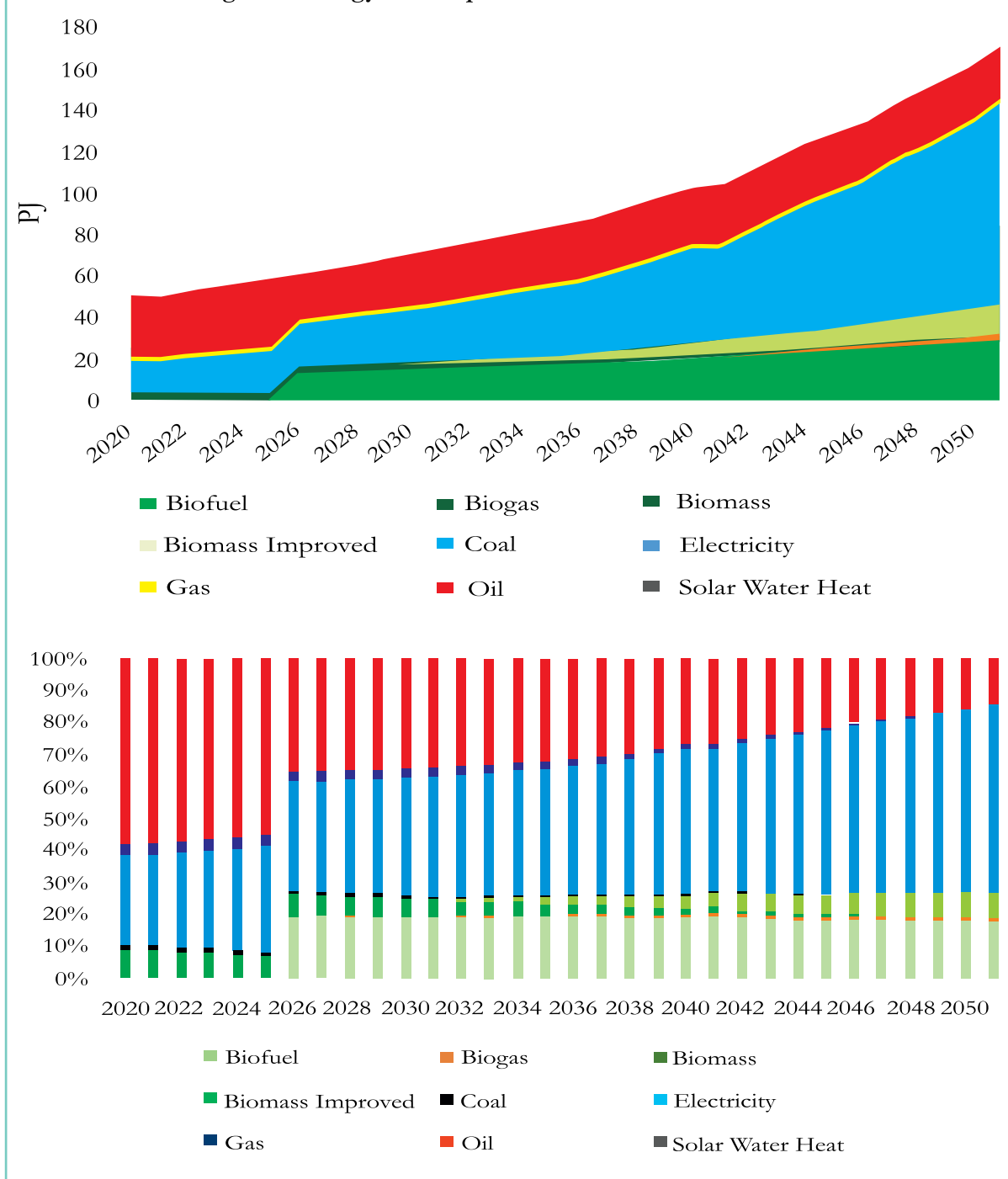
Data Source: *The Celestial Earth*

In the context of final energy consumption, it is projected that the share of electricity in total consumption mix is expected to be around 60% by 2050 compared to 28% during 2020. Use of conventional biomass through direct firing has been stopped in the State by 2050 and it is replaced through improved biomass cook stoves. Biogas becomes one of the major sources of cooking energy and becomes 1% share of total energy consumption in the State by 2050 compared to nil in 2020. Oil is the single largest source of energy in the State as on 2020 (around

58%) but in the process of RE transition the share drops to only 14% along with steady increase in biofuel share to 18% in 2050. Another important aspect of greening the energy sector is use of biofuel and replacing liquid hydrocarbon like petrol and diesel. Based on current maximum technical and commercial blending possibility, it is estimated that biofuel can replace around 18% of petroleum fuel demand in transport sector in the State of Goa starting 2025. Year 2025 is the target year of National Biofuel Policy for implementing B-20 plan for all IC vehicles in the country.



Figure 2: Energy consumption mix under 100%RE scenario



Data Source: The Celestial Earth

100% RE Based Electricity Supply

In the context of 100% greening the electricity supply of the State of Goa it is observed that Goa's imported electricity plays the most crucial role followed by within state new solar capacity addition. More than 60% of the electricity in the

State is envisaged to be procured through imports sourced through various routes such as Power Exchange, and bilateral PPAs. The main activities to be performed to make the State's electricity supply 100% RE based are as follows:

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

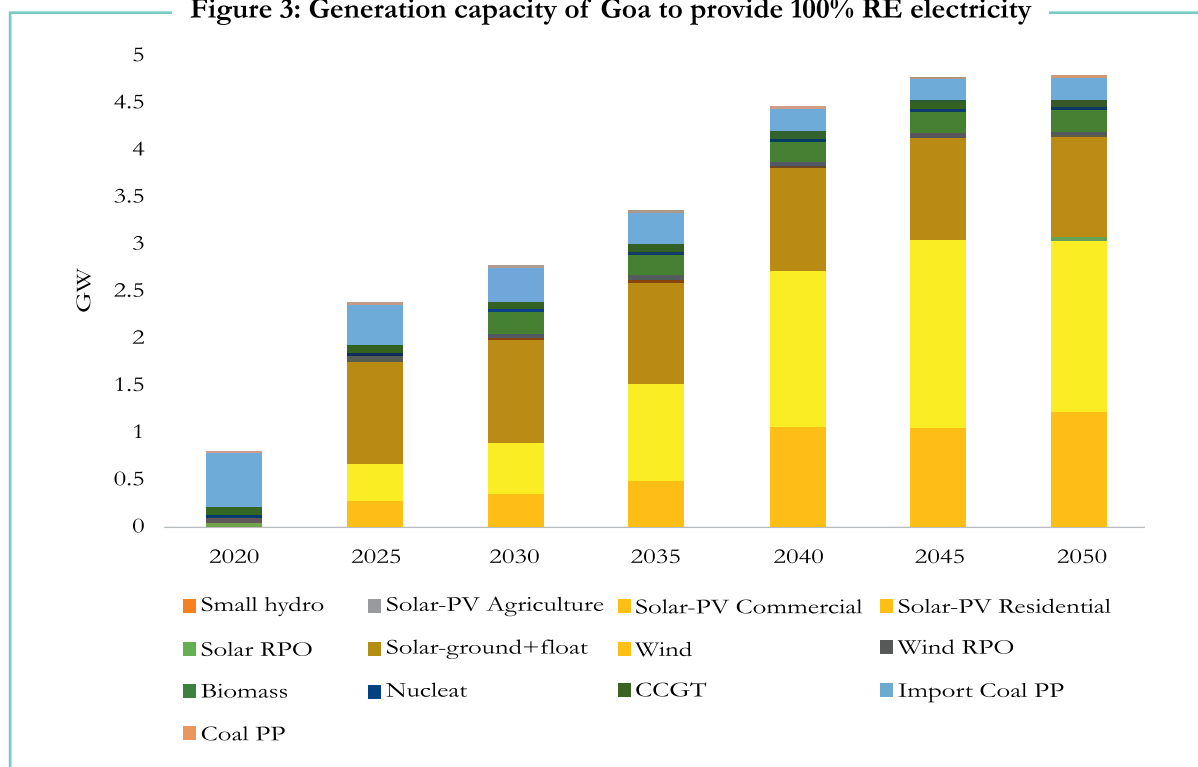
4.0 RE off-setting

4.1 Augmenting State RE Potential

In the context of augmenting the solar potential of the State, 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. Currently there is only solar RPO which is coming from outside of the State. Goa has very limited potential of wind energy within State boundary which is closely around 1 MW with 80-meter mast height. However, there is an estimate of 9 MW potential of on-shore wind at 120 meter height. It is observed that to enhance the renewable energy supply in the State, it is important that State owned RE potentials are augmented. Figure 3 below shows the generation capacities within and outside of the State of Goa which could provide 100% RE electricity to the State.



Figure 3: Generation capacity of Goa to provide 100% RE electricity



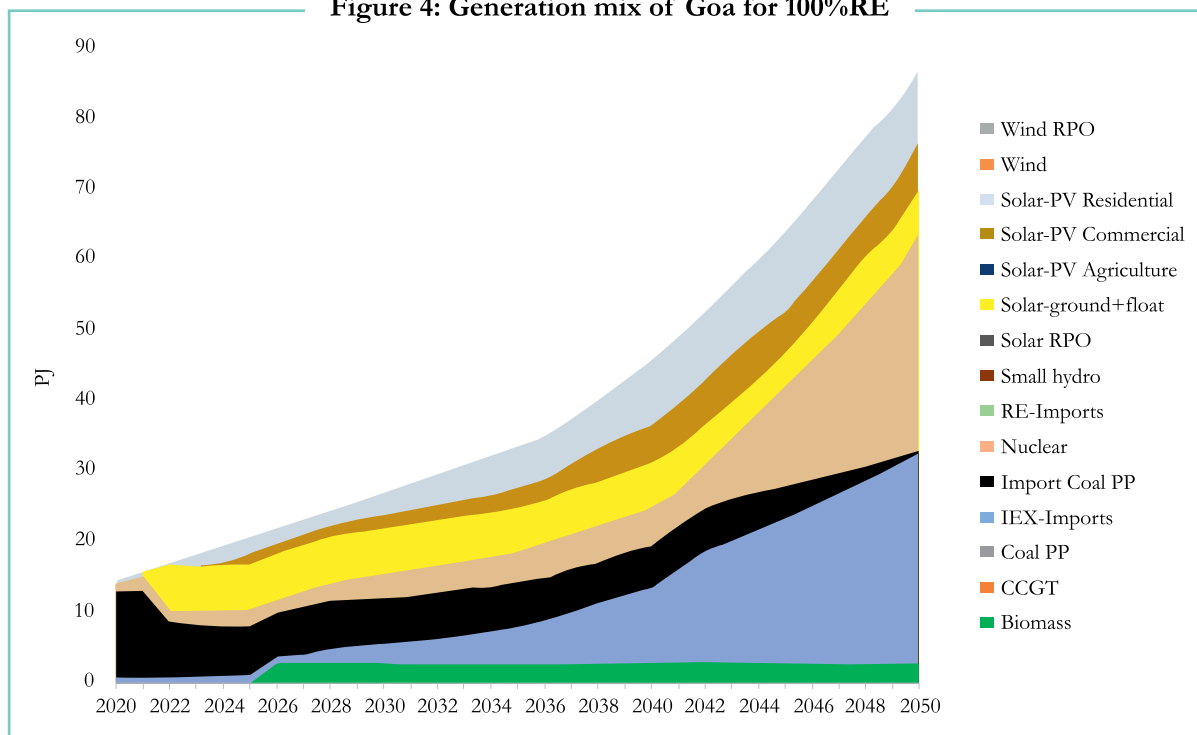
Data Source: The Celestial Earth

Based on the projected generation capacity mix for achieving 100%RE power supply in the State it is further envisaged that 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. In 2020, the share of within state generation is only around 4% which is coming from couple of Co-generation plants of private sector companies. 100% RE based power supply, therefore, could promote use of within State RE resources to its fullest possibility. Figure 4 shows the optimal generation mix of Goa in order to achieve 100% renewable energy-based power supply in the

State. The model projects that given the State's RE potential and increasing energy demand in the future (including electricity), 100% renewable energy-based power supply is possible through enhanced green power import only through various options / channels. These import channels could be power exchange, bilateral trade, RPOs and simple green power imports replacing existing PPAs of thermal power. RE import could be even possible by setting up state owned RE plants in other states where potential is high. Figure 4 below shows one possible option of greening the power supply in the State but there could be alternative as well which are subject to further assessment.



Figure 4: Generation mix of Goa for 100%RE



Data Source: The Celestial Earth

4.2 Augmenting Green Power Procurement

Considering the requirement of power to fulfil Goa's increasing demand due to economic and social development including the impacts of climate change and certain expiration of PPAs due to maturity a comprehensive planning is necessary.

Goa has been enjoying low-cost reliable power supply over the past several decades and has been observing relatively low AT&C losses with more than 90% billing efficiency. As a matter of fact, Goa's average selling price of power adjusted after regulatory subsidy is around Rs.4.9/unit which is still Rs.0.6 /unit in deficit (as of 2019-20). Table 1 below shows the status of power purchase in Goa in the year 2019-20.

Table 1: Share of power purchase in Goa in FY 2019-20

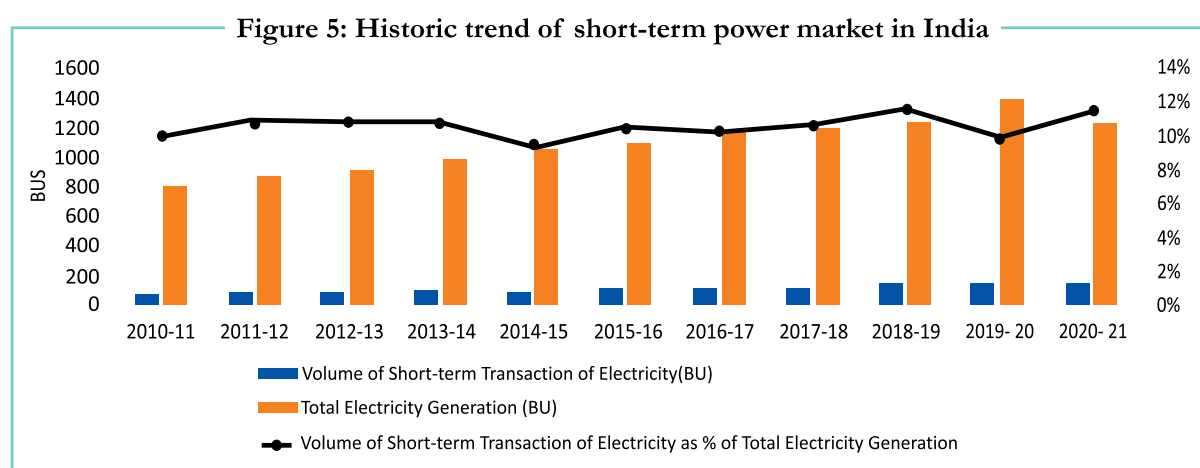
Type of Supply	Total Purchase (Gwh)	Total Sales (Gwh)	% of Supply	Avg. cost of purchase (Rs./KWh)	Avg. Price of Sale (Rs./KWh) including subsidy	Revenue Deficit (Rs./KWh)
LTA-Thermal	3533	3722.97	79%	2.96	4.89	0.6
LTA-Nuclear	232.4		5%	2.81		
Trade	150.8		3%	4.68		
Co-gen	169		4%	2.39		
RPO	415		9%	4.59		
Total	4500.2		100%	3.66		

Source: Data shared by the ED, Govt. of Goa and Report of Performance of Power Utilities 2019-20.

This indicates that to meet its increased power requirement over the years including, climate induced power demand, a holistic approach is required for the electricity sector in the State to meet all the requirements of power supply like reliability, affordability and efficiency. In the backdrop of expiring PPAs with possibility of renewal and replacement, it is assumed that the State has options of increasing power procurement from outside State through green technologies like solar, wind, hybrid and even with combined system with battery storage. To have a better approach to this portfolio, we have categorized the available options into three different categories based upon the timelines of Goa's goals. These options have been categorised as Short Term, Medium Term and Long Term Options. The various options under these segments have been detailed in the following section.

A. Short Term Power Procurement Options (0-3 months)

The Short-term Power procurement options varies from a period of same day up-to 3 months procurement options. This will help them in fulfilling Goa's RPO obligation as well as increase renewable energy component in the energy mix. As the product price varies in the market on daily basis, Goa may not to procure this power on regular basis and can decide on case-to-case basis as per their daily load requirements. It is observed that (Figure 5) in the last one decade (FY2010-FY2020) the short term transaction of power in the country grew at the CAGR of 6% while the share of the traded power remains at 10~12% only of total power consumed.



Data Source: The Celestial Earth

Some of these short-term renewable energy options for Goa has been explained below:

Bilateral Contracts

Goa has the option to purchase short-term power through competitive bidding process, on DEEP e- bidding platform. These 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 in its total portfolio.

Green Term Ahead Market (GTAM)

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. This market segment

features contracts such as Green-Intraday, Green-Day-ahead Contingency (DAC), Green-Daily and Green-Weekly.

Transactions through GTAM are bilateral in nature. The contracts under Green Term Ahead Market can be used to ensure delivery of electricity for a few days in advance. Through GTAM, there is no difficulty in accounting for Renewable Purchase Obligations (RPO) of the obligated entities. GTAM contracts are segregated into Solar RPO & Non-Solar RPO. Energy scheduled through GTAM contract shall be considered as deemed RPO compliance of the buyer.

Highlights of GTAM:

- ⦿ A market mechanism to facilitate accomplishment of national renewable energy

capacity addition and effective integration of green energy in the country

- Trading of 15-minute time block in G-Intraday and G-DAC; whereas trading of certain time of blocks in G-Daily and G-Weekly
- All contracts under G-TAM are at national level.
- Through GTAM, the obligated entities can purchase renewable energy at market competitive rate and can also purchase power for a certain period in advance.

Green Day Ahead Market (GDAM)

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.

Highlights of Green-Day-Ahead Market

- The distribution utilities would also be able to sell surplus renewable power generated in their respective areas.
- The obligated entities (distribution licensee, open access consumers, and captive power consumers) would also be able to meet the RPO target by directly buying green power from the power exchange(s).
- Other benefits of GDAM include reduction of curtailment of green power, assured instant payment to Renewable Energy generators on the day of delivery itself, increase green energy options for buyers and tapping into the unlocked renewable energy potential of India.

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

Recently, 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. The Pilot Scheme I and Pilot Scheme II had PFC Consulting Limited as the Nodal Agency and PTC India Limited as the aggregator, who facilitated the supply of power to various utilities. 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.

Seasonal Contracts

Goa can also opt for seasonal contracts with Hydro/Solar/wind generating stations. These bilateral transactions usually vary between three months and five years. To procure this power, Goa may opt for competitive bidding process on DEEP e-bidding portal, which ensures competitive tariffs.

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

Own Generation

Goa has a potential of 4200 MW Renewable Energy as per the assessment of this study. Considering Goa has the potential of 880 MW of ground mounted solar and 3200 MW of roof-top potential and having a comparatively good solar irradiation pattern, Goa can think of tapping into that potential and set up solar power plants of its own. This will enable Goa to have its own Renewable energy supply source. Goa is already planning to set up floating solar power plants on four dams (namely Selaulim, Amthanem, Anjunem and Chapili).

Along with the Solar Energy Goa also has potential of Biomass and Tidal energy. As Goa's major crops are paddy, sugarcane, cashew and coconut, which are relatively good source for biomass production having mid-range energy content (15-25 MJ/kg); 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. The Biomass potential of Goa has been estimated to be ~26 MW, which can help it to achieve cleaner power from its own generation sources.

However, installation of Solar power plant is a land intensive project. For a plant of 1 MW Solar energy, approximately 5 acres of land space is required. Based upon Goa's demographics, Goa may consider the option of procuring its required power from outside the state, along with concentrating on projects like PM KUSUM Yojana, Rooftop Solar etc.

Competitive Selection Process

Goa has the option to go for competitive bidding process for procurement of Long-Term Renewable Energy using tendering process either through its own website or by using third party tender portal. This process will ensure competitive

power tariff for Goa, as the tendering process allows Goa to select the lowest bidder. For procurement of renewable power, some of the suitable options under Long Term method have been highlighted below:

Solar Energy

Solar Energy in India has achieved a state of grid parity. Grid parity occurs when alternate sources of energy like renewable energy can generate power at a levelized cost of electricity that is less than or equal to the price of power from grid. Solar energy has the potential to fulfil Goa's day peak energy demand. With solar tenders bringing competitive winning tariffs on the table over the last few years, Goa has the option to go for Long Term tie-ups with solar power generators.

Round The Clock (RTC) Renewable power

Round-The-Clock (RTC) Renewable energy supply with the help of battery storage or combination of Solar/Wind/Hydro overcomes the intermittency associated with solar and wind, which generate energy only when there is enough sunshine and wind. Such projects provide generation flexibility to meet the peak loads of distribution companies, which typically change with seasons and undergo pattern shifts over time. With ample energy storage capacity, they can provide flexibility to dynamically requisition firm, hourly energy matching the evolving demand curve.

Wind-Solar Hybrid

Wind-Solar Hybrid projects have gained traction in India following the announcement of the National Wind-Solar Hybrid Policy 2018. As we understand that Solar and Wind are intermittent power generation sources, and they generate power at different intervals and during complementary seasons. Wind power is generally more productive during the night hours while solar energy is only generated during daytime. The Capacity Utilisation Factor (CUF) for standalone solar power and standalone wind energy are also low. Combining these two results into a more dependable power that meets demand as well as higher CUF.

Adding battery storage systems to the wind-solar hybrid plants will not only drastically increase the CUF of these plants but will also act as a more

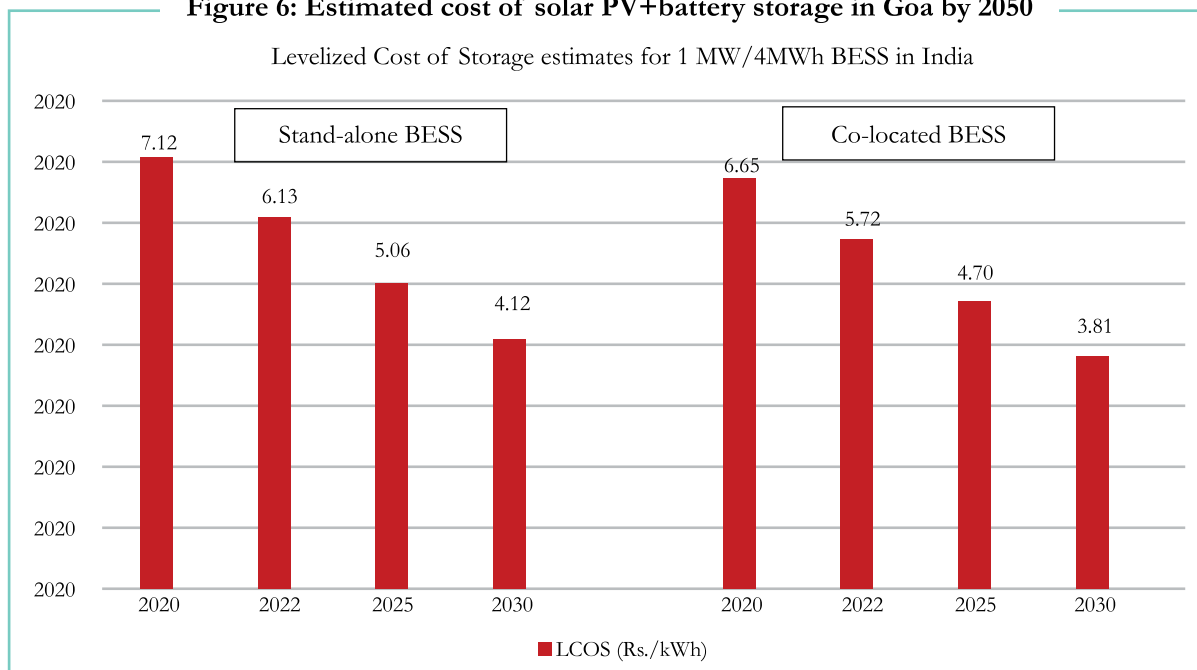
dependable power source. As the storage costs have drastically reduced by ~80% over the last few years and a further decline of the same is expected in the coming years, Wind-Solar Hybrid power plants with storage facilities will play a pivotal role in meeting the energy demands of the state in the coming years.

In the Indian context it has been estimated that the cost of stand-alone battery service could be around Rs.6.13/kWh with the costs estimates as of 2020. This could be reduced rapidly to just Rs.4.12/KWh by the end of this decade (2030). With the added average cost of power purchase of Rs. 2.5/kWh the total supply cost of RE power with storage could be in the range of Rs.8.5/KWh in 2020. It is estimated that (LBNL, 2020) the storage cost in India can reduce at the rate of 6.5% per annum basis which can make it more reasonable in the coming years. Based on the Indian grid condition and especially based on Goa's RE supply system, the cost of grid level storage has been estimated along with solar integration following the LBNL Study published in 2020². Figure 6 below shows the trajectory of the grid connected battery+solar PV system levelized cost in Goa between 2020 and 2050. (For detail estimate please see Annex-I).



² Estimating the Cost of Grid-Scale Lithium-Ion Battery Storage in India (2020), Deorah et.al.

Figure 6: Estimated cost of solar PV+battery storage in Goa by 2050



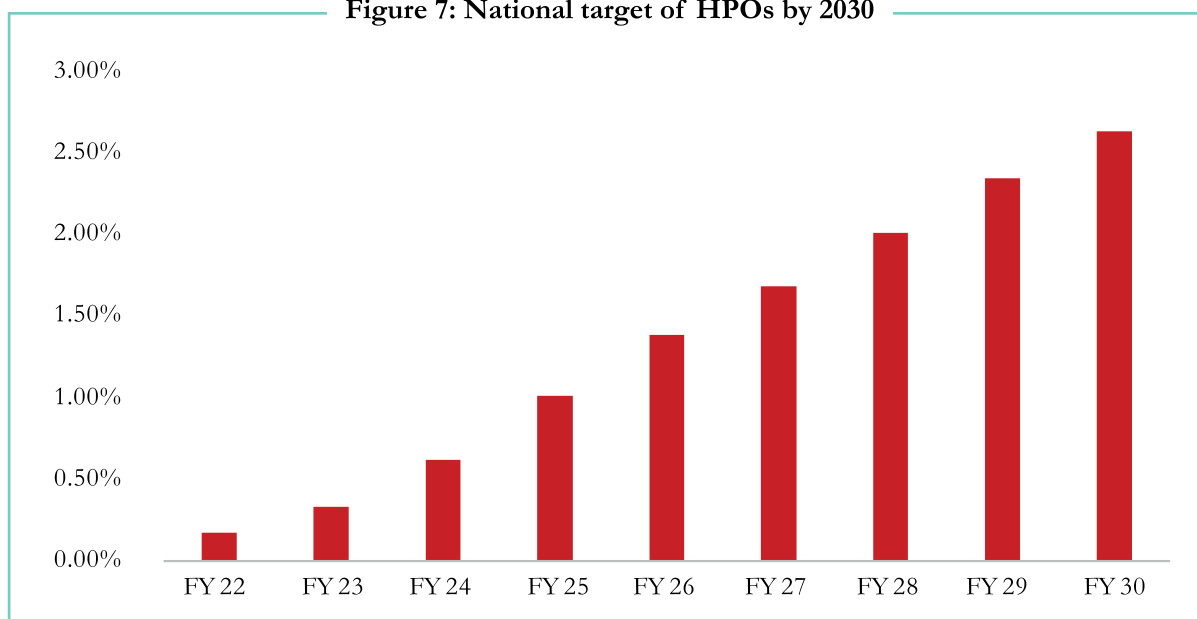
Data Source: The Celestial Earth

Hydro Power

On 8th Mar'19, the Govt. of India has issued an order detailing various policy measure to promote hydro-power in India inter-alia declaring large HPPs including pumped storage projects having capacity more than 25 MW which comes into commercial operation after 8th Mar'19 as RE source. With an objective to add 30 GW of hydro-

power by FY 30, MoP has issued HPO trajectory for all the states. HPO benefits may be met from the power procured from large hydropower projects commissioned on and after March 08, 2019, and up to March 31, 2030, in respect of 70% of the total generated capacity for 12 years from the date of commissioning. The HPO percentage of every year as defined by the government for the next decade is as below:

Figure 7: National target of HPOs by 2030



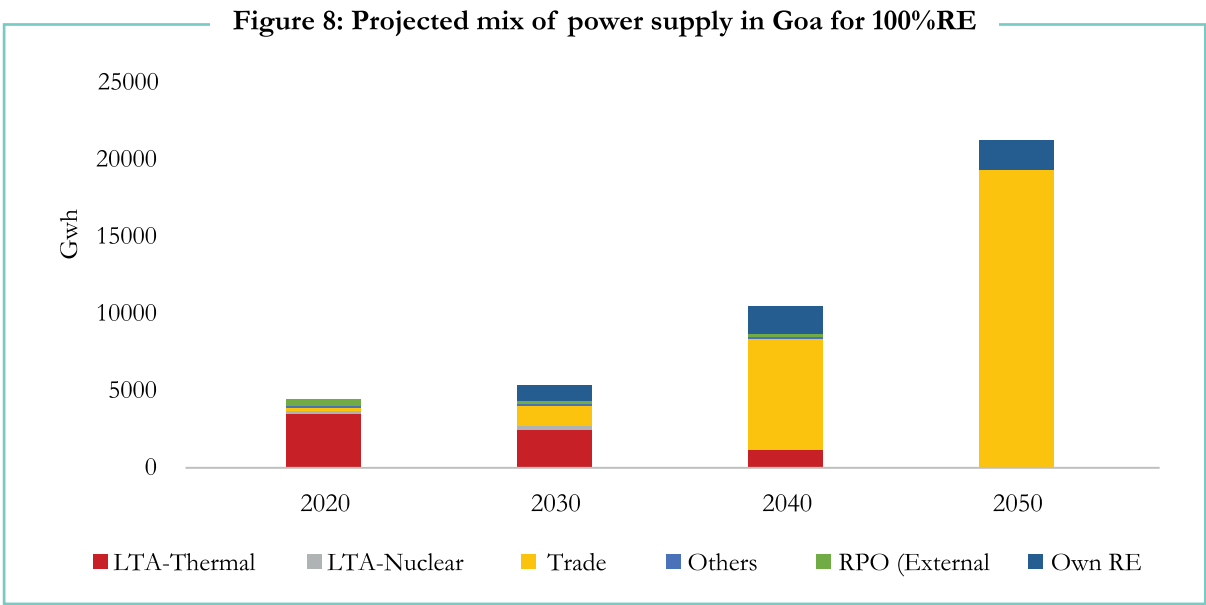
Data Source: The Celestial Earth

Procuring hydropower from the plants commissioning after 2019 will enable Goa to meet its HPO target as well as to increase green energy component in its energy mix.

In the process of making the power supply of Goa renewable energy based, it is proposed that the State gradually moves to green power trade through various trading instruments. Currently the

State is complying its RPO requirement through external sources only. The figure 8 below shows the potential mix of power supply of Goa which

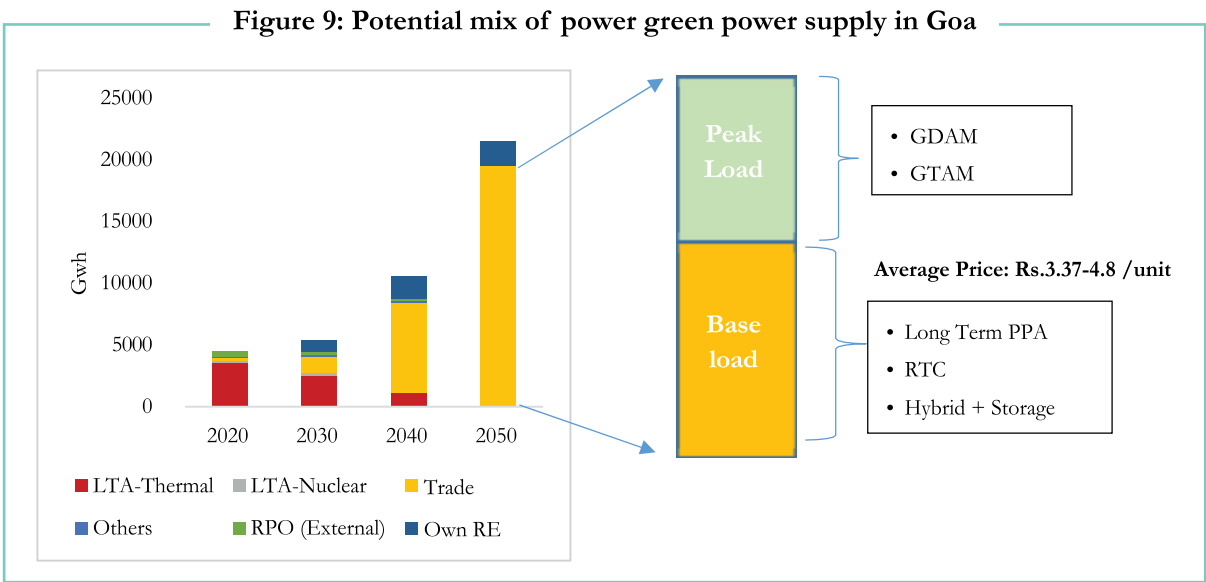
could make the State to achieve 100% RE supply mix by 2050.



Data Source: The Celestial Earth

Figure 9 below shows the potential mix of power supply for Goa to meet the 100%RE supply target in the years to come. It is to be noted that

the precise portfolio cost of power purchase needs additional study with minute detail which is beyond the scope of this study.



Data Source: The Celestial Earth

The study further estimated the mix of power supply options for Goa to help the State to achieve 100% RE based power supply status soon. Table below shows the proposed mix of power supply options for Goa between 2020 and 2050 which indicates that by 2038 the State can achieve 100%

RE supply mix provided the following conditions hold:

- a) The power demand projections stand valid between now and 2040 and the growth rate stands at 4.8% per annum.

- b) Goa has a tied-up capacity primarily based on thermal power, of which the existing PPAs will gradually either be expired or to be renewed further by FY 2037 through renewable only.
- c) Goa must arrange power under long-term PPAs to meet its base demand and source of power should be renewable energy (probably with battery storage).
- d) Peak demand should be fulfilled through short term RE power procurement option.
- Table 2 below shows the proposed energy supply mix of Goa to ensure 100% RE supply base to the State by 2038.

Table 2: Proposed power supply mix of Goa for 100% RE

Particulars	FY 25	FY 30	FY 35	FY 38	FY 40	FY 45	FY 50
Existing Tied Up Capacity (MW)	731	562	498	385	385	310	310
Existing tied-up RE Capacity (MW)	385	385	385	385	385	310	310
Min. Power Supply Required to meet Base Load (MW)	601	731	979	1166	1310	1640	2009
Need to tie up LT – RE (MW)	0	170	481	781	925	1330	1699
Peak Load met through ST-RE (MW)	14	175	234	278	313	392	480
Total RE Power (MW)	399	729	1100	1444	1623	2032	2489
RE %	65%	80%	91%	100%	100%	100%	100%

Source: Authors' estimated based on the model projected power demand in the State between 2020 and 2050, existing PPA information provided by the Elec. Dept. of Goa.

4.3 Action Plan for 100% RE Supply

Following section describes in detail list of activities and their corresponding timeline to achieve the targets to make the State electricity

supply green. Table 3 shows the details of activities suggested for the power sector to be become RE driven.



Table 3: RE intervention activities in power sector

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
100% Renewable Energy Based Electricity Supply in the State of Goa by 2050	Augmenting State RE potential of 4 GW by 2050	i) Assessment of RE potential across the State: Solar/ Wind/ Biomass/Tidal	2025		
		ii) Creating climate fund for supporting RE capacity addition within /outside of the State (RE off-set)	2025		
		iii) Setting up State owned / private owned RE power plants in gradual manner.	2025	2030: 2 GW	2035:2.5 GW 2040: 3 GW 2050: 4GW
	Augmenting green power procurement of 17 Twh (or 2000 MW base load + 700 MW peak) by 2050	i) Procuring green power through long/ medium term PPAs		2035: 480 MW	2040: 925 MW 2050: 1699 MW
		ii) Optimal procurement plan for green power through short term options like Bilateral Market, GTAM, GDAM, HPO	2025		

Data Source: The Celestial Earth

4.4 Ancillary Action Plans for Power Sector

These action plans are required to create an enabling environment in the State to promote RE interventions in the power sector to make it 100% RE based through target-oriented activities mentioned in the Section 4.3.



Table 4: Ancillary action plans for power sector

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
Power Generation- Renewable	Utilisation of renewable energy potential of state	Establishing the potential of renewable energy within the state	Short	Technical
		Incentivizing the development of Agro PV in Goa	Medium to Long	Financial
		Development of vertical PV on farmlands	Medium to Long	Technical
		Promoting development of biomass power plants to increase share of renewables within state	Short to Long	Technical / Financial
		Promoting development of Waste-to-Energy plants in the State	Short to Long	Technical / Financial
		Provide regulatory support (net metering, preferential tariff etc.) to the private sector to increase penetration of solar rooftop enabling environment for increased penetration	Short	Regulatory/ Policy
		Updating and Implementing Goa Solar Policy, 2019.	Short	Regulatory/ Policy
		Devising and implementing a state policy around biomass residue management	Short	Regulatory/ Policy
		Supporting Research & Development of RE potential assessment and implementation with GEDA.	Short to Medium	Market Development
Power Transmission and Distribution	Ensure grid stability due to integration of renewables	Undertake advanced load forecasting to ensure grid integration of renewables	Short	Technical
		Increasing penetration of power storage infrastructure and grid stabilisation techniques.	Medium to Long	Technical
	Strengthening of transmission and distribution network	Modernize the power distribution system within the state (viz. smart metering, demand control, network planning system to understand loading status of the network etc.)	Short to Long	Technical
		Introducing smart grid regulations in Goa	Short	Policy

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
		Installation of infrastructure to prevent losses due to theft and damages due to natural disasters and introduction of smart meters and plan of underground cabling.	Short to Long	Technical

Data Source: The Celestial Earth

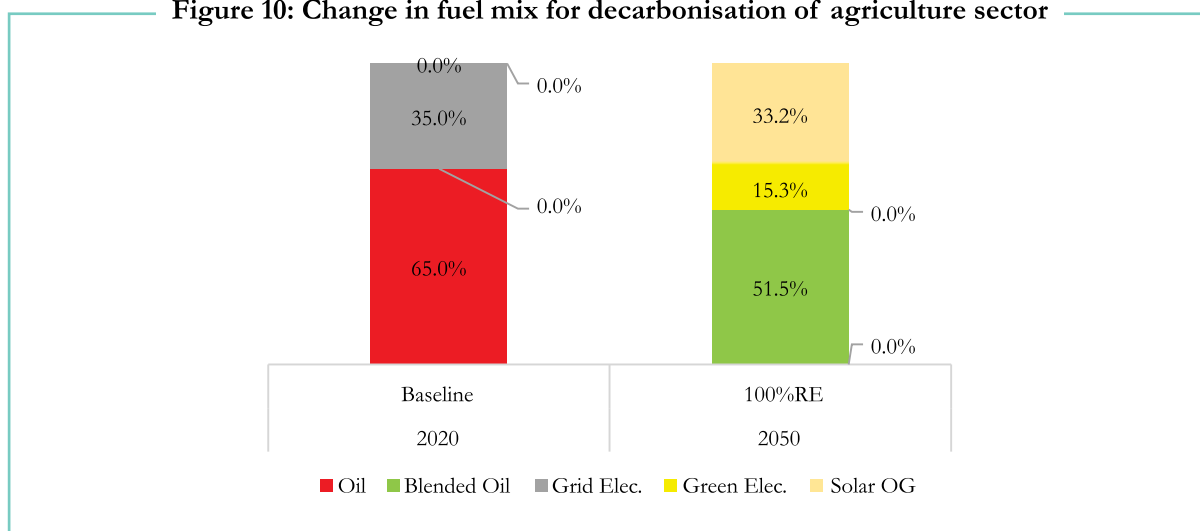


Renewable in Agriculture

Currently 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 which is mostly coming from thermal sources. In 2020 total energy consumed in the sector for farm activities including irrigation is around 0.18 PJ. 100% of the energy consumed was fossil fuel based. Total CO₂ emissions from the sector is around 8.6 KTCO₂ which can go up to 18.3KTCO₂ by 2050. Under the plan of 100% RE for all sectors in Goa, it is projected that in the agriculture sector there are

several opportunities to decarbonize the sector through interventions of RE technologies and fuel shifting towards green energy. It is estimated that 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 and c) solar pumps and off-grid system (including decentralized solar PV). This fuel mix can replace more than 50% of the fossil fuel consumption by 2050. Figure 10 below shows the technology and fuel transition required for the sector to move towards deep decarbonisation.

Figure 10: Change in fuel mix for decarbonisation of agriculture sector



Data Source: The Celestial Earth

5.1 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

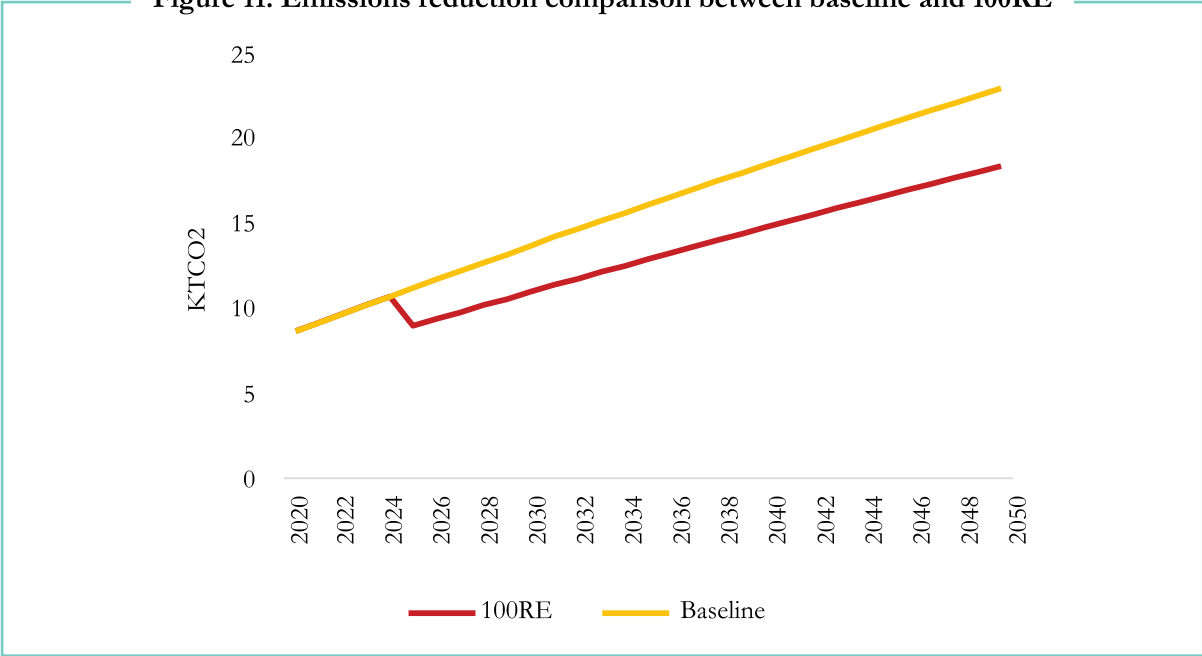
3.0 100% KUSUM Program Implementation and Achieving 150 MW Agro-PV capacity by 2050

5.2 Emissions Reduction

GHG emissions reduction through use of blended fuels in farm machines and use of Solar

pumps for irrigation could reach upto 90KTCO₂ cumulatively between 2020 and 2050.

Figure 11: Emissions reduction comparison between baseline and 100RE



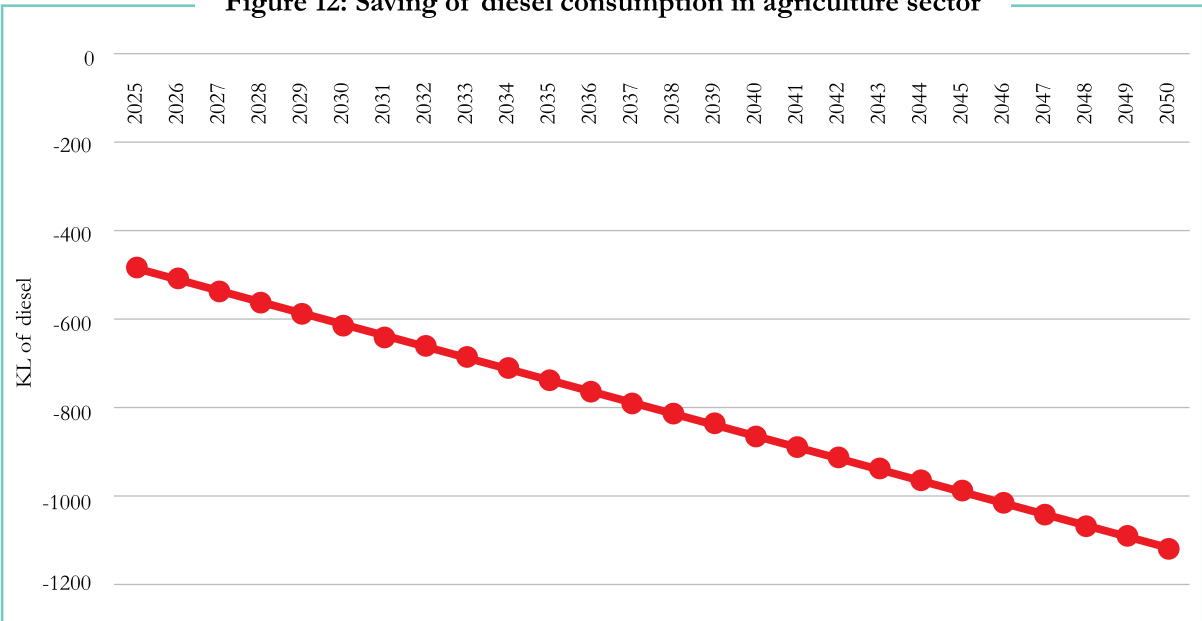
Data Source: The Celestial Earth

5.3 Reduction of Fossil Fuel Consumption

In the process of achieving the 100%RE scenario for the agriculture sector it is estimated that due to use of blended oil the sector can save around 500-1100 KL of diesel every year which could

also help to save around Rs.4~9 Cr per year. State needs to supply 800~1700 KL of biofuels annually to achieve the 20% blending target.

Figure 12: Saving of diesel consumption in agriculture sector



Data Source: The Celestial Earth

5.4 Solarisation of Pumps

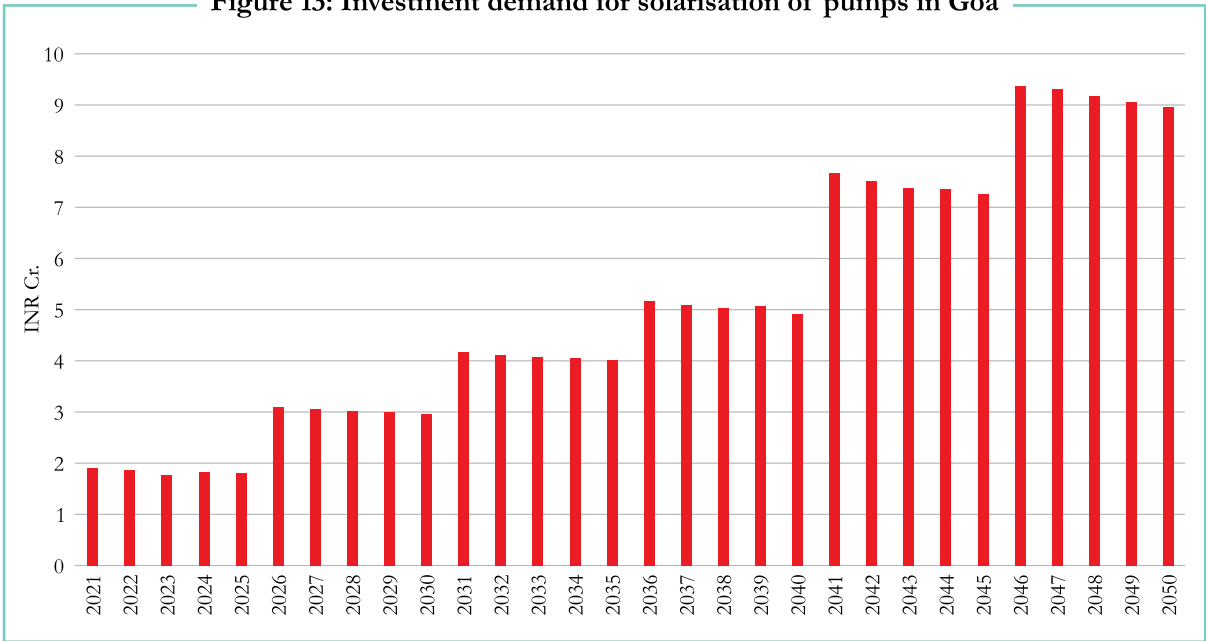
Under the 100%RE plan, agriculture sector of Goa is expected to use around 38200 units of solar pumps with an average capacity of 5HP by 2050. In 2030 the number of solar pumps will be around

27000. This will ensure successful implementation of KUSUM program in the State with an estimated plan of 150 MW of dedicated solar pumps by 2050.

5.5 Investment Requirement

To make the agriculture sector RE based, solarisation of irrigation pumps is essential. 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.

Figure 13: Investment demand for solarisation of pumps in Goa



Data Source: The Celestial Earth

5.6 Action Plan for RE Intervention in Agriculture Sector

Following section describes in detail list of activities and their corresponding timeline to achieve the sectoral targets and goal. Table 1 shows the details of activities suggested for the agriculture sector to become RE driven.



Table 5: Target oriented RE intervention activities in buildings

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
100% Renewable Energy Based Agricultural Activities in the State of Goa by 2050	Use of B-20 for all farm machines.	i) Bringing State regulation for farm machine fuel blending aligned to National Policy on Biofuels – 2018 (NPB-2018).	2024		
		ii) Plan of procuring and production of biofuels within State (800~1700KL /year) including pricing mechanism for incentivisation of uptake.		500 KL/Y	>1500 KL
		iii) Setting up State owned / private owned biofuel manufacturing units in gradual manner.	2025		
	Use 100% green electricity for all farm activities including pumps by 2050	i) Identification & assessment of land areas within agriculture land- use for Agro-Photovoltaics (APV)	2023	2025: 10MW	2035: 75 MW 2040: 100MW
		ii) Conducting scientific assessment of impacts of APV on crop production	2024	2030: 50 MW	2050: 150 MW
		iii) Pilot Testing of APV ~ 10 MW			
	100% KUSUM Program Implementation	i) Setting up state monitoring unit for following up the KUSUM program implementation.	2024		2040: 25000 pumps
		ii) Converting grid electric pumps to solar pumps	2025: 5000 pumps	2030: 15000 Pumps	2050: 38000 Pumps

Data Source: The Celestial Earth

5.7 Enabling Action Plans for RE Intervention in Agriculture

These action plans are required to create an enabling environment in the State to promote RE interventions in the agriculture sector through target-oriented activities mentioned in the Section 4.6.



Table 6: Ancillary action plans for agriculture sector

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
Agriculture Sector	Increase penetration of energy efficiency and solar power in value chain	Increasing productivity of farmers using renewable energy (including solar, CBG, etc.). Reduction of cultivation cost by replacing expensive fossil fuels	Short to Long	Technical
		Distribution of energy efficient pumps to replace existing inefficient electric pumps	Short to Medium	Technical
		Increase construction of energy efficient cold storage working on solar power	Short to Long	Technical
		Develop co-operatives to provide financial support for procurement of solar pumps and energy efficient pumps by farmers	Short to Medium	Financial
		Promote installations under PM KUSUM scheme in the state	Short	Capacity building / awareness generation
		Facilitation of e-tractors for farmers	Short to Long	Technical
		Promotion of Micro Irrigation to increase water use efficiency in irrigation	Short to Long	Awareness generation
	Agri-machinery innovation and RE intervention	Agriculture Machinery manufacturers should produce machineries to be operated by renewable energy such as solar Power	Short to Medium	Technical
		Incentivize the manufacturers for producing solar Powered tractors	Short to Medium	Financial
		Creating performance testing facility at Farm Machinery Training and Testing Institutes (FMTTIs) for RE powered farm machineries.	Short to Medium	Technical / Financial
		Providing access to innovation fund for R&D	Short	Financial
		Regulatory provision of waiver of road tax of solar/RE powered farm machines	Short	Financial
		Subsidy fund for scrapping old and diesel-powered tractor in the State	Short / Medium	Financial

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
Horticulture Sector	Capacity building / Awareness creation	Undertake awareness Programme for disseminating benefits of energy efficient pumping and irrigation systems as well as solar powered pumps to farmers through co-operatives, gram panchayats etc.	Short to Medium	Awareness generation
		Continue promotion of crop diversification	Short to Long	Awareness generation
	Increase use of renewable energy in post harvesting activities	Assessment of biomass and biofuel potential of the State out of all horticulture produce	Short	Technical
		Piloting of Solar Dryer for post harvesting drying activities	Short	Technical
		Incentivisation of shifting from conventional dryer to solar dryer	Short to medium	Financial
		Piloting of biofuel production from the cashew waste and plan for scale up	Short to Medium	Technical
		Support to create market linkage for biomass supply to industries	Medium to Long	Technical

Data Source: The Celestial Earth



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Renewable Energy in Buildings

Buildings including residential and commercial are consuming around 13% of total final energy in the State of Goa in 2020 which is expected to go up to 36% by 2050. It is also projected that the commercial building energy consumption (average 8% per annum) will be higher than residential buildings (average 7% per annum) which further indicates that hotels, shopping malls, hospitals, educational institutions will be growing faster in the State and will more and more consume energy.

Given Goa's plan of tourism expansion following the recent publication of the State Tourism Policy 2021, it is assumed that hotels could be the hotspots of energy consumption in the State in the years to come. In 2020 there are around 3800 registered hotels in the State categorized as A, B, C, & D based on their class of services and consumed around 60 GWh of electricity (excluding D category) (Source: ED, Govt. of

Goa, 2021). There are around 55,000 rooms under four different categories of hotels providing room accommodation service to around 80~90 Lakhs tourists per year. Hotels are using both HT and LT categories of supply. As per Electricity Dept record, until March 2021 there are 1542 LT category hotels and 214 HT category hotel consumers. It further indicates that entire D category and around 200 C category hotels are not taking electricity as hotel customer from the electricity department and most likely they are connected as LT Domestic. It is estimated that hotels are consuming around 9~11% of electricity consumed by the entire commercial segment in the State and 3% of total building energy consumption (Source: Electricity Dept. Govt. of Goa). On an average per occupied room in Goa is consuming around 1400 kWh of electricity annually.

Table 7: Energy consumption in hotels by category

Category of Hotel	No. of Units	Avg. No. of Rooms/Hotel	Total Rooms	Type of Connection	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		

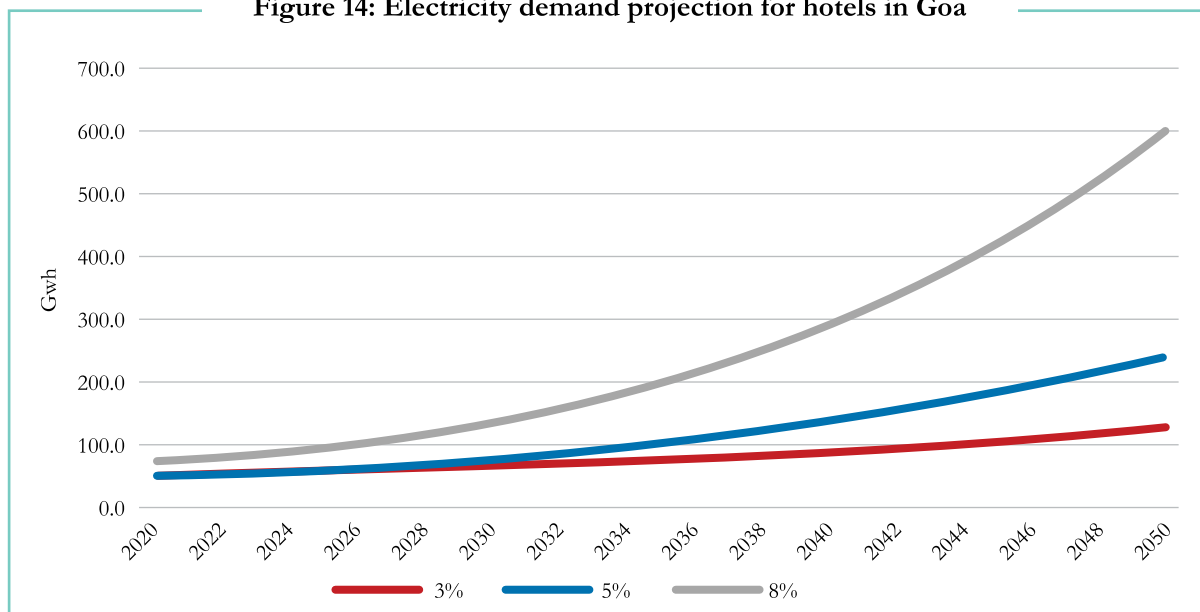
Data Source: The Celestial Earth

Note: No. of hotels by category is provided by the Tourism Dept. and electricity consumption by category is estimated using the electricity consumption data provided by the Electricity Dept. of Goa for Hotel category for the FY 20-21.

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. Figure 5 below shows the projected electricity demand by the hotels in Goa under three different growth scenarios of 3, 4 and 8% per annum.

Under the plan of 100% RE for all sectors in Goa, it is projected that in the building sector (which includes hotels as well) there are several opportunities to decarbonize it through interventions of RE technologies and fuel shifting towards green energy. It is estimated that to decarbonize the sector in the State there will be

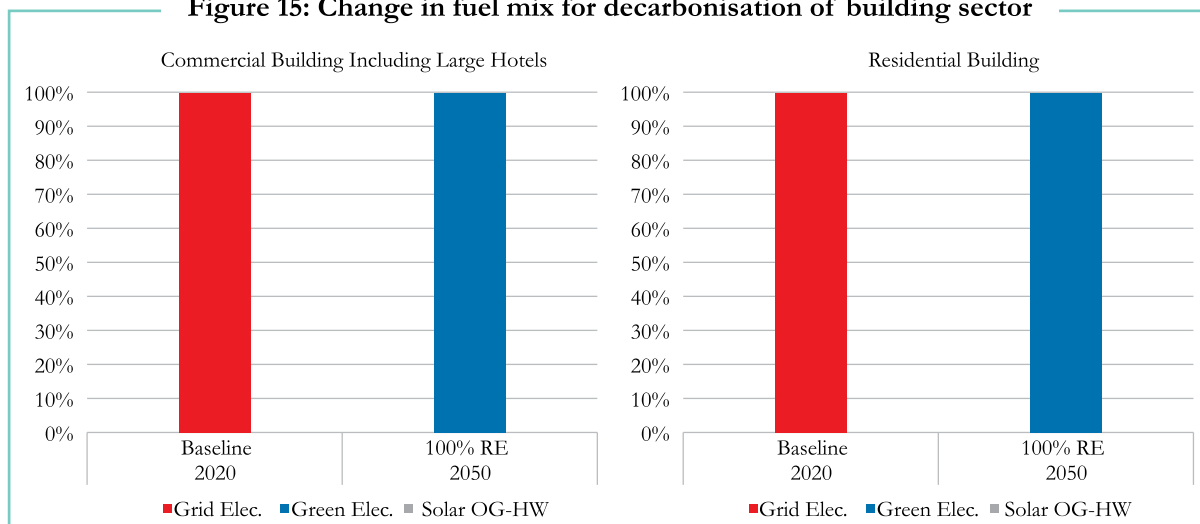
Figure 14: Electricity demand projection for hotels in Goa



three major sources of energy: a) green electricity in the grid, b) Off-grid solar use and c) solar thermal for hot water system. This fuel mix can replace 100% of the fossil fuel consumption by 2050. Figure 5 below shows the technology and fuel transition required for the sector to move towards deep decarbonisation. It is interesting to

observe that as a least cost option to decarbonize the building sector, using grid supplied green electricity is a cheaper option rather than setting up roof-top facilities. In Goa where the entire grid is getting green, need of standalone roof top supply is reduced. Through net metering entire electricity can be wheeled back to the grid.

Figure 15: Change in fuel mix for decarbonisation of building sector



Data Source: The Celestial Earth

6.1 RE Intervention Activities:

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

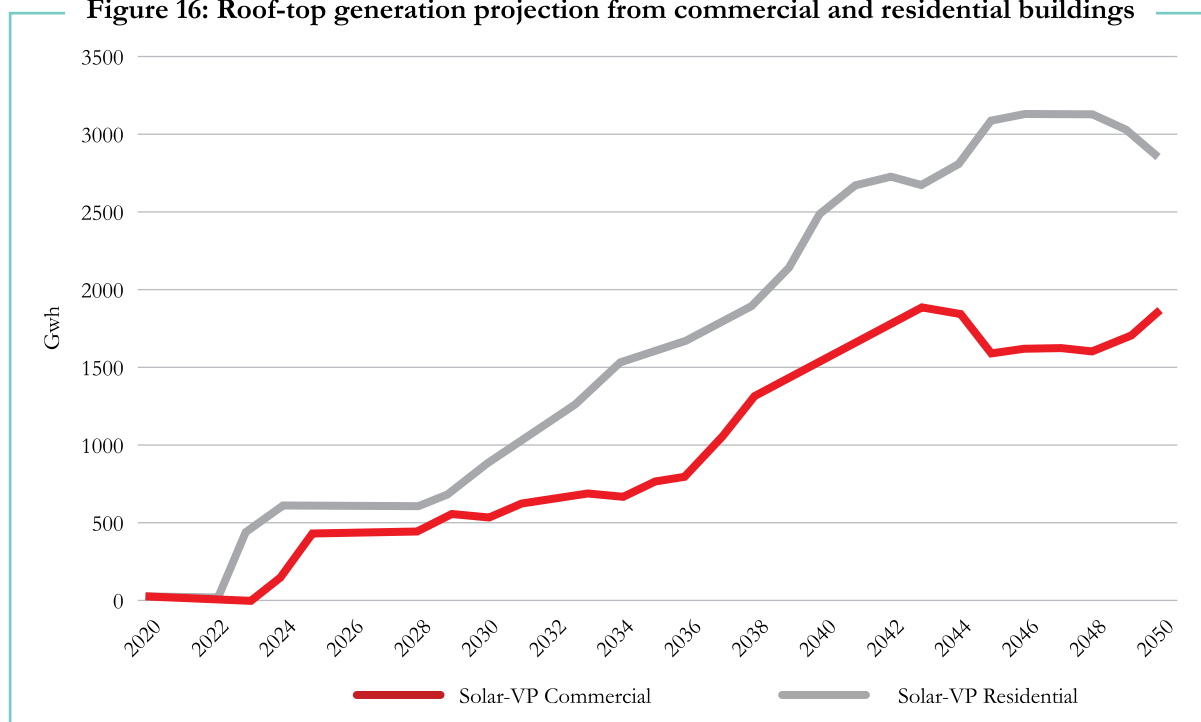
2.0 100% solarisation of all thermal energy requirement for heating (hot water) by 2050

6.2 Solar Roof-Top for Buildings

Under the 100%RE scenario it is estimated that the state of Goa is required to utilize its full potential of solar off-grid for electricity and heating purposes. 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 for commercial building there will be around 1.18 GW of roof-top capacities to be added by 2050 and for residential building there will be around

1.8 GW to be added during same time. These 3 GW installations could supply around 4672 Gwh of electricity for building operation in the State of Goa by 2050. Commercial roof top solar can provide around 1800 Gwh of electricity by 2050 compared to 2800 GWh by residential roof-top PVs by 2050. Therefore, it can be assumed that majority of the electrical load from residential and commercial building including hotels could be shifted to solar base through planned activities.

Figure 16: Roof-top generation projection from commercial and residential buildings

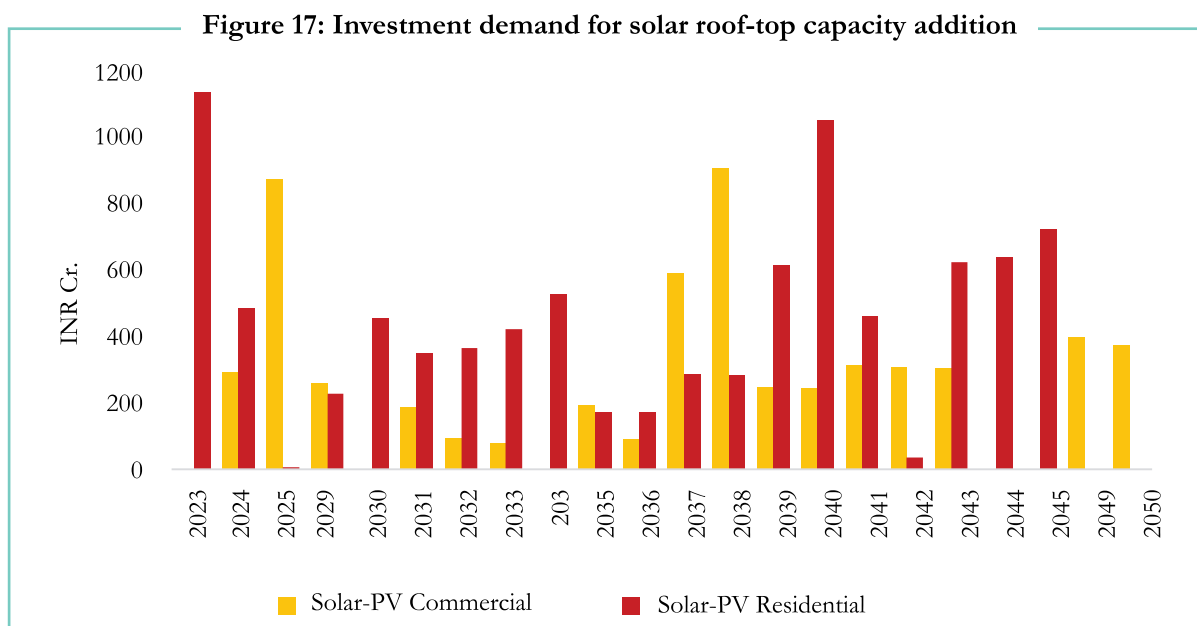


Data Source: The Celestial Earth

6.3 Investment Demand for Building Solarisation

To achieve required level of roof top capacity addition in the State of Goa there will be the requirement of steady investment. It is estimated that 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. Figure 8 below shows the projected investment demand in the State of Goa for roof-top capacity addition.





Data Source: The Celestial Earth

6.4 Action Plan for 100%RE Intervention in Buildings

Following section describes in detail list of activities and their corresponding timeline to achieve the sectoral targets and goal. Table 3 shows the details of activities suggested for the building sector to be become RE driven.

Table 8: RE intervention activities in buildings

Goals	Targets	Activities	Targeted Timeline				
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)		
100% Renewable Energy & Green Electricity Based Building Energy Supply in the State of Goa by 2050	Implementa- tion of ECBC Targets for Commercial Building	i) Developing building approval byelaws	2023				
		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.	2025			2030	
	Developing & implemen- tingTargets for Net Zero Commercial- Buildings in Goa	i) Developing the plans and policies for Net Zero Buildings in Goa.	2024				
		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.	2025				
		iv) Making all A category hotel Net Zero	2025			2030	2040
		v) Making all B category hotel Net Zero					

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
	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)	2025: 100MW (individual net-metering)	2030: 500 MW (Group net-metering)	2040: 1.0 GW 2050: 1.5 GW (all category)
		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)	2025: 100 MW	2030: 500M W	2040: 800 MW 2050: 1.2 GW
		iii) Assessment of battery connected solar roof-top financing plan for achieving 3 GW capacity addition by 2050.	2024		
		iv) Assessment of potential of building integrated solar PV in the State and align the same to ECBC compliance	2025		

Data Source: The Celestial Earth

6.5 Enabling Action Plans for RE Intervention in Buildings

These action plans are required to create an enabling environment in the State to promote RE

interventions in the building sector through target-oriented activities mentioned in the Section 6.4.

Table 9: Ancillary action plans for building sector

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
Commercial Buildings	Market development to facilitate the implementation of ECBC code	Undertake awareness programs on building energy conservation and efficiency as well as building labelling systems for the end users (consumers)	Short to Medium	Awareness
	Market development to facilitate the implementation of ECBC code	Provide support to businesses (institutional and regulatory) to provide ECBC compliant building material and building energy management system	Short to Medium	Market Development / Policy & regulatory
	Increase the uptake of renewable energy integration	Creation of Center of excellence to promote green buildings and strengthening R&D activities in collaboration with academia, industry, technical institutions, etc.	Medium to Long	Market Development

Sub-sector	Activity	Sub-activity	Time Period	Type of intervention
Residential Buildings		Undertake the energy conservation buildings awards to incentivize uptake of energy efficiency and energy conservation	Short to Long	Financial
		Encouraging development of building integrated PV & provisioning of financial support from climate fund	Short to Long	Technical/ Financial
		Change in building byelaws and building plan approval process to make it mandatory for creating EV Charging Space for all commercial and hotel building.	Short - Medium	Regulatory
	Increase the uptake of energy efficiency and energy conservation measures/ activities	Undertake replacement of inefficient electrical equipment/ appliances with BEE star labeled energy efficient appliances and solar water heaters	Medium to Long	Financial
		Develop and undertake pilot projects for demand side management (DSM) and demand response (DR) programs	Medium to Long	Technical
		Develop and implement loyalty program for building efficiency. Certification and incentives from the Govt. to make green and net zero building etc.	Short to Medium	Financial
	Increase the uptake of energy efficiency and energy conservation measures	Develop awareness of retail buyers on the benefits of energy efficiency for buildings and building labelling program	Short to Medium	Awareness
		Develop implementation roadmap for demand side management (DSM) and demand response (DR) programs for building energy conservation.	Medium to Long	Technical
		Develop implementation roadmap of ECBC code for residential buildings	Short to Long	Institutional
		Provide financial incentives to increase uptake of solar water heaters	Short to Long	Financial
		Develop awareness on various rating systems including BEE, IGBC and GRIHA rating system	Short to Medium	Awareness
		Create awareness of vernacular building design (traditional building design) and its impacts on overall energy requirement for building operation.	Short to Medium	Awareness

Data Source: The Celestial Earth

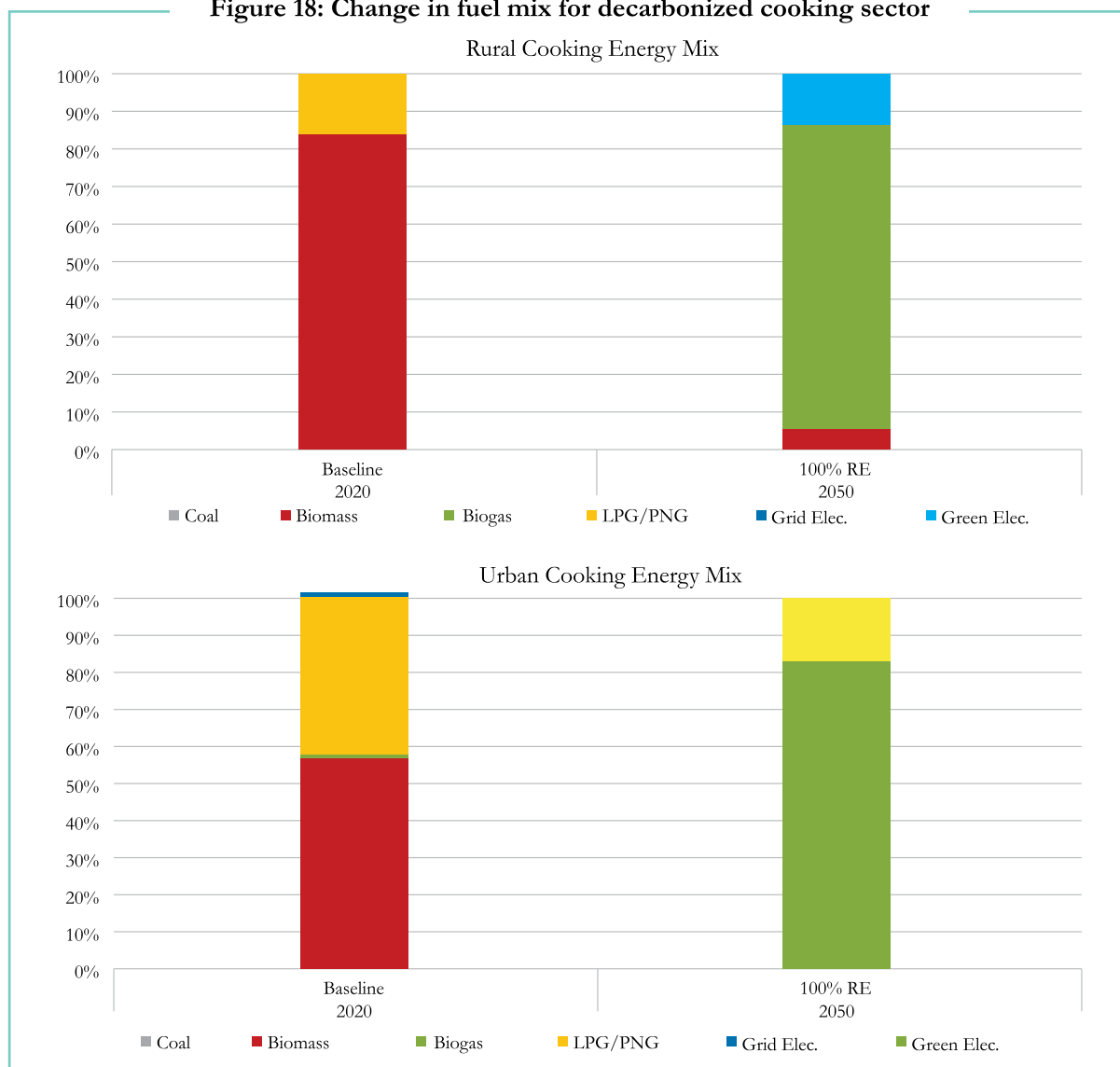
Renewable Energy in Cooking

Cooking is an important part of household energy consumption. In the State of Goa, there is a distinct difference between cooking energy mix between urban and rural households. The state is having one of the highest LPG penetration ratios in the country which is around 145% which indicates that all the households in the State are having access to LPG.

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. In the process of cooking sector decarbonisation, 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). Figure 9 below shows the potential transition of cooking fuels in the State to achieve decarbonisation. It is observed that biogas and electricity are the two main transition fuels for the state which can replace the conventional fuels like biomass and LPG.

Figure 18: Change in fuel mix for decarbonized cooking sector



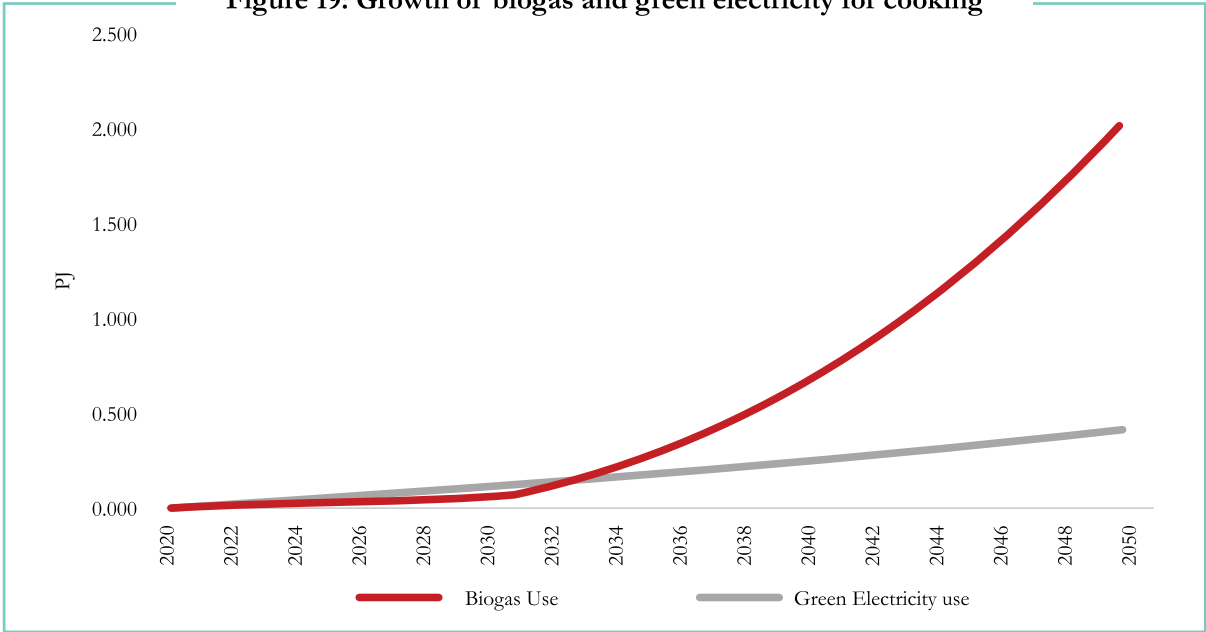
Data Source: The Celestial Earth

7.1 RE Intervention Activities in Cooking Sector

In the context of transition to low carbon fuel sources (100% RE) for cooking, major intervention will be in terms of utilisation of biogas for rural and urban cooking replacing biomasses and LPG. Electricity is another source

of clean energy supply for cooking in the State especially when the electricity is coming purely from renewable sources. It is estimated that use of biogas and green electricity increases from almost nil to 2 PJ and 0.41 PJ by 2050 respectively. Figure 10 below shows the increase of biogas and green electricity use in cooking sector in the State to make it decarbonized.

Figure 19: Growth of biogas and green electricity for cooking

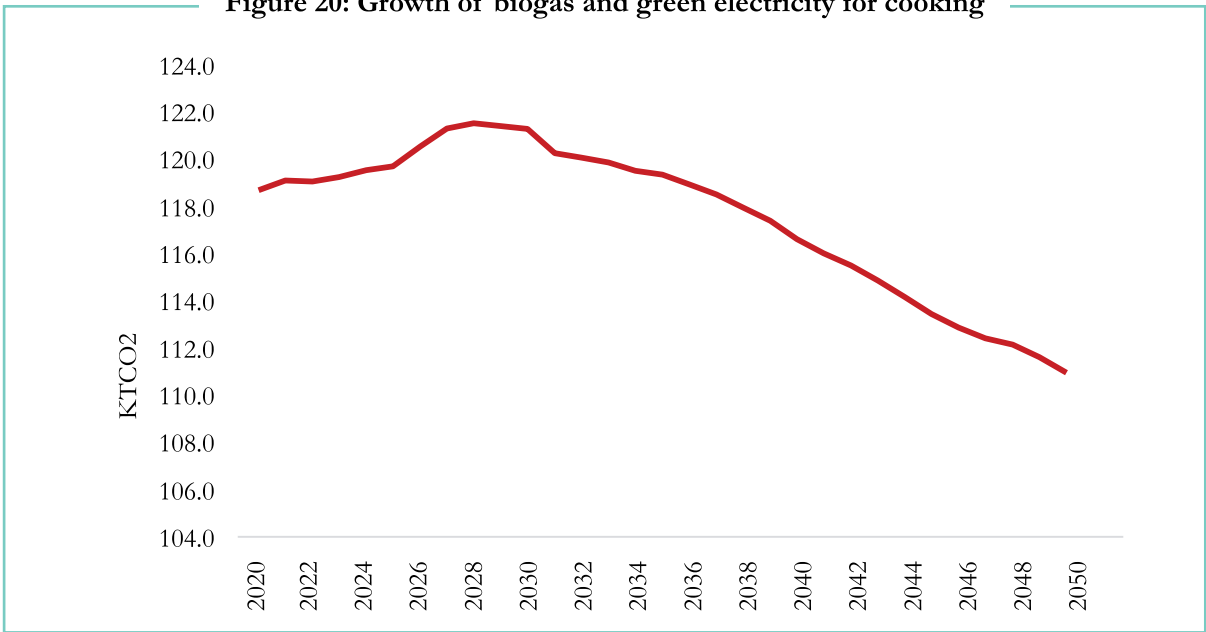


Data Source: The Celestial Earth

Based on the 100% renewable fuel intervention plan for cooking sector in Goa, it is 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.

Figure 20: Growth of biogas and green electricity for cooking



Data Source: The Celestial Earth

State shall increase the use of biogas/ CBG and electric cooking in urban and rural areas and move away from emission intensive cooking fuel and inefficient cooking practices.

7.2 Action Plan for Decarbonisation of Cooking

State shall work towards complete phase out of the use of biomass for cooking by 2050 and shall replace it with the increased use of electricity and biogas.

Table 10:RE intervention activities in cooking

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
100% Renewable Energy & Green Electricity Based Cooking in the State of Goa by 2050	Creating infrastructure and support facilities for 100% penetration of electricity and biogas in rural areas.	i) Conducting state-wide biogas potential assessment to meet the demand of 2 PJ equivalent biogas i.e around 50 million Cub. Meter of gas	2024 (North & South Goa District Level		
		ii) Training and awareness generation of the users for biogas based cooking	2025		
		iii) Introduce financial incentive schemes to promote and adopt biogas based cooking system in rural Goa.	2025		
		iv) State shall invest in R&D to improve the thermal efficiency of biogas stoves and promote innovation in bulk procurement of such stoves.	2025		
		v) Setting up biogas production facilities through private sector participation	2025 : 5 MCM	2035: 15 MCM	2050: 50 MCM
	Creating infrastructure and support facilities for 100% penetration of electricity and biogas in urban areas.	vi) Training and awareness generation of the users for induction cooking (electric cooking)	2025		
		vii) Introduce financial incentive schemes to promote and adopt induction cooking system in urban Goa.	2025		
		viii) Setting up targets of penetration of induction cookers in urban households in Goa	2025: 50K Household	2035: 150K House- hold	2050: 250K Household

Data Source: The Celestial Earth

7.3 Enabling Action Plans for RE Intervention in Cooking

These action plans are required to create an enabling environment in the State to promote RE interventions in the cooking sector through target-oriented activities mentioned in the Section 7.2. Goa being the tourism hub of the country has several hundred restaurants using commercial cooking facilities. Many restaurants and public

kitchens in Goa use tandoors that use coal for the purpose of delicious food. There are more than 3000 restaurants in Goa which are using tandoors. It is estimated that per day each tandoor consumes around 30 kg of coal which is cumulatively coming around 22500 MT of coal consumption per year. Coal use in tandoors can be completely replaced by bio-briquettes which contains almost same calorific value and can provide same smell (smoky) to the food. Following table shows the list of ancillary activities proposed for the State.

Table 11: Ancillary action plans for cooking sector

Sector	Activity	Sub-activity	Time Period	Type of intervention
Rural	Increase penetration of biogas	Facilitate setting up of biogas plants through setting up co-operatives and providing access to climate fund.	Short to Medium	Financial
		Undertake awareness programmes for disseminating benefits of switching to biogas as a cooking fuel	Short to Medium	Awareness
	Increase penetration of electricity	Assess power distribution infrastructure development required to support use of electricity in cooking and develop implementation roadmap	Medium to Long	Technical
Urban	Increase penetration of electricity as fuel	Improve the quality of electricity access (viz. reliability, line harmonics, voltage variation etc.)	Short to Medium	Technical
		Improve the energy efficiency of induction cook stoves	Medium to Long	Technical & Financial
		Provide financial support to end user to increase the penetration of electric cooking equipment	Short to Medium	Financial
		Undertake stakeholder outreach programs through mass media channels to create awareness on benefits of using electricity for cooking	Short to Medium	Awareness
Rural and urban	Increase use bio-Briquettes	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.	Short to Long	Technical
	Promoting Methanol Blended LPG use	Create awareness among consumers for use of DME blended LPG for cooking. Commercial / restaurant cooking can be encouraged to shift to Methanol Canister Cookstove.	Short to Medium	Technical

Data Source: The Celestial Earth

7.4 Invest Demand for Clean Cooking

It is estimated that State needs around 50 million m3 of biogas to provide required cooking

energy in the State in rural and urban areas together. Based on the cost of setting up the plant of Rs.7500/m3 it is estimated the following investment demand in the State to meet the biogas demand. Table below shows the investment demand for biogas plants in the State of Goa.

Table 12: Investment demand for biogas production in Goa

Year	Total Capacity (Million m3)	Unit Cost (INR Cr./ Million m3)	Total Cost (INR Cr.)
2025	5	750	3750
2035	15		11250
2050	30		22500

Data Source: The Celestial Earth

It is also estimated that for electric cooking apparatus (mainly induction cooking) the total cost of supply of the equipment per household basis

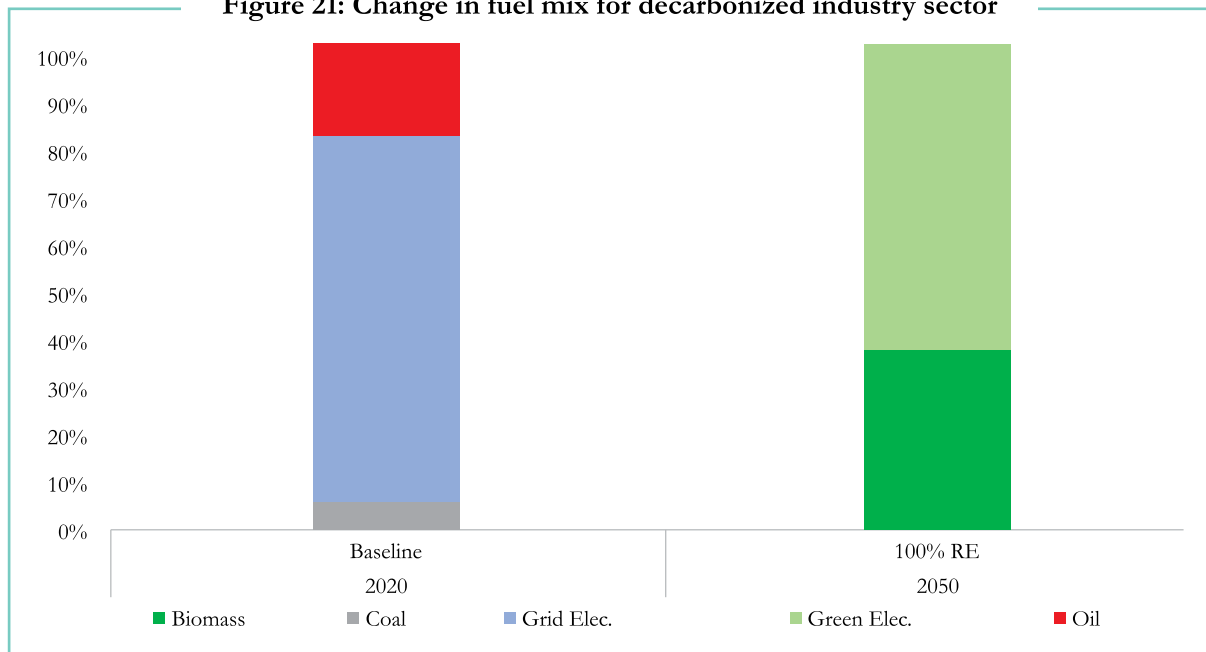
would reach upto INR.2.5 Cr. per year to meet the target of achievement by 2050.

Renewable Energy in Industry

Industrial energy share in the State of Goa in 2020 is around 19% which is expected to increase to almost 23% by 2050 as an effect of several industry promotion policies. Goa is expected to become one of the major industry hubs in the western region of India by middle of the century (Dept. of Industry, Govt. of Goa, 2021). It is projected that industrial energy consumption will grow at 6% per annum basis with not much changes in fuel mix. Figure 21 shows the transition

required in the industry sector in the State of Goa to make it 100% RE based. Currently the major fuel of Industrial energy mix is electricity followed by oil and coal. In the process of decarbonizing the industry sector it is projected that biomass will play an important role indeed. 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.

Figure 21: Change in fuel mix for decarbonized industry sector

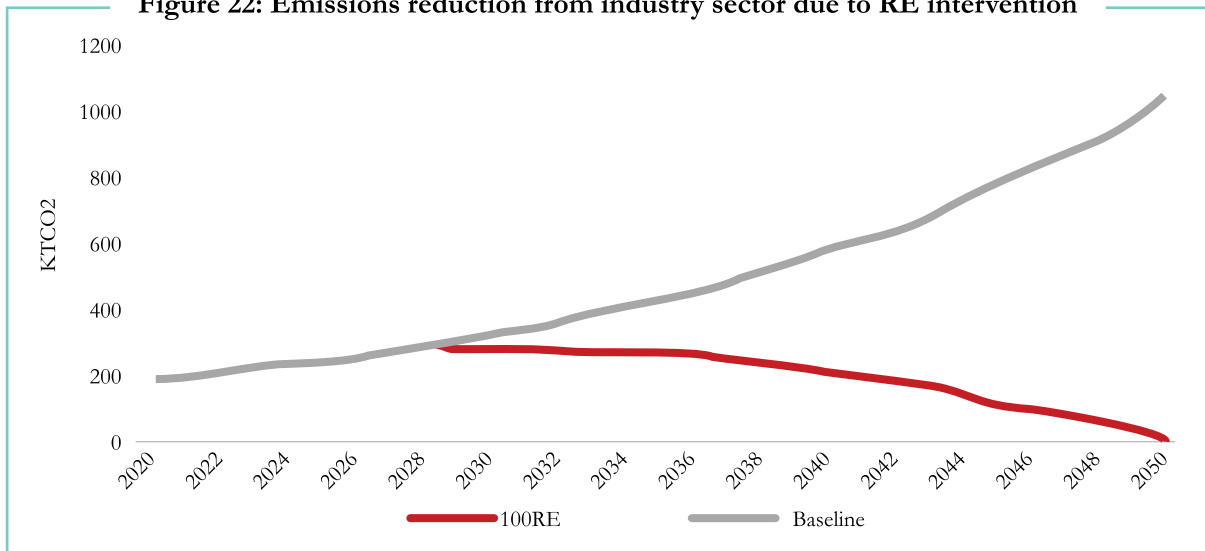


Data Source: The Celestial Earth

Fuel shift in the industry sector brings huge benefits to emissions reduction from the sector itself. Complete decarbonisation 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. (Electricity related emissions are not attributed to industry specifically). Figure 22 shows the emissions profile of the industry sector under the 100%RE intervention plan.

Figure 22: Emissions reduction from industry sector due to RE intervention



Data Source: *The Celestial Earth*

8.1 RE Intervention Activities

1.0 100% replacement of coal use by biomass

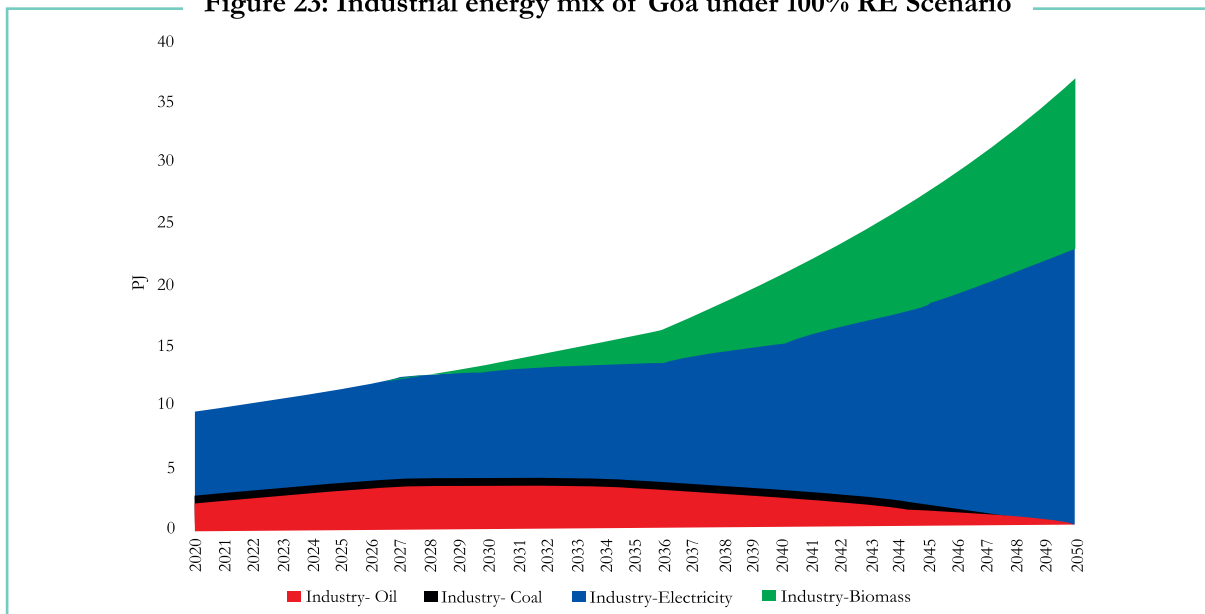
2.0 100% replacement of oil use by biofuels/green electricity

3.0 100% use of green electricity

While implementing the 100% RE based fuel supply for industrial energy supply, it is considered that technology and fuel transitions are gradual and smooth. Based on the planned RE

intervention in the sector the study obtained the following industrial fuel mix which is completely decarbonized.

Figure 23: Industrial energy mix of Goa under 100% RE Scenario



Data Source: *The Celestial Earth*

8.2 Action Plan for Decarbonisation of Industry

State shall work towards complete phase out of the use of coal and oil for industrial energy demand by 2050 and shall replace it with the increased use of green electricity and biomass.

Industry sector is the second most energy intensive sector in the state. In order to achieve

decarbonisation of the industry sector various measures are widely considered and promoted, which includes high penetration of energy efficient equipment, transition to clean energy sources, increasing use of available biomass to meet thermal energy demand of the sector, clean electricity generation and electrification of the industrial process. Table 8 below shows the targets and activities proposed for the sector to decarbonize it by 2050.

Table 13:RE intervention activities in industries

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
100% Renewable Energy & Green Electricity Based industry in the State of Goa by 2050	Increase the penetration of energy efficiency to save 20% energy by 2050	i. Develop energy benchmarking for the industrial subsector and MSME clusters.	2024		
		ii. Technology transfer support for the MSME sector to ensure the availability of the best operating technologies.		2030	
		iii. Providing R&D support to develop innovative energy efficient technologies.	2025		
		iv. Incentivize adoption of energy efficient technologies and processes as well as development of energy efficiency services market through climate fund.	2025		
	Developing models for implementation of emission mitigation measures	v. Developing collaboration platform for technology providers, technology distributor, R&D labs, technical institutions to share relevant technical inputs to industry beneficiaries	2025		
		vi. Develop and demonstrate green hydrogen projects		2030	
		vii. Mandating industries to set-up captive solar plants especially rooftop solar systems to meet their electricity demand	2025		
	Promote the transition from fossil based energy sources to clean energy alternatives.	viii. Providing fiscal incentives to industries to promote the use of biomass/ biogas through captive or procurement process.		2027 (Pharmaceutical / Chemical industries to start with)	2035- 2040
		ix. Providing technology support to the industries for transitioning to green hydrogen			
		x. Develop green hydrogen policy for the State including use of Green H2 by the industries.	2025		
		xi. Develop Net Zero Emissions policy for the industry zones in the State	2025		

Data Source: The Celestial Earth

8.3 Enabling Action Plans for RE Intervention in Industries

These action plans are required to create an enabling environment in the State to promote RE interventions in the industry sector through target-oriented activities mentioned in the Section 7.2. Goa's industry sector is the single largest contributor to the State GDP (around 45%) and therefore, its sustainable growth is an important factor for overall development of

the State. Energy being the most critical factor input for Industrial processes, its efficient use is essential for the sector's growth and development. It is estimated that Average specific energy consumption of industries in the State is around 0.03 TOE per Rs.100,000 output value. It is observed that non-metallic minerals and plastic production are the highest energy consuming industries in the State. Following table summarizes the action plans required to support the sector for deeper consumption of renewable energy.

Table 14: Enabling action plans for industry sector

Sector	Activity	Sub Activity	Timeline	Type of Intervention
Large Industries and MSMEs	Energy savings through energy efficiency measures	Develop energy benchmarking for the industrial zones and MSME clusters	Short to Medium	Technical
		Scheme of incentivisation of energy and emissions efficient industry zones	Short to Medium	Financial
		Technology transfer support for the MSME sector to ensure the availability of the best operating technologies	Short to Medium	Technical
		Providing R&D& piloting support to develop innovative energy efficient technologies through State Climate Fund.	Short to Long	Technical
		Implementation of ISO 50001 for energy management in MSMEs	Short to Medium	Technical
		Mandatory energy audits for MSMEs to monitor their energy use	Short to Long	Technical
	Promoting clean energy use in industries	Provide necessary technical and financial support to promote use of solar-wind hybrid system for captive power generation	Short to Medium	Technical
		Providing fiscal incentives to industries to promote the use of CBG	Short to Medium	Financial
		Providing fiscal incentives to industries to promote the use of biomass residue through co-firing	Short to Medium	Financial
		Provide necessary technical and financial support to promote use of solar-thermal concentrator for industrial process heat.	Short to Medium	Technical
		Encouraging industries to adopt ESG norms through awareness and capacity building	Short to Long	Policy and Regulatory
		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.	Short to Long	Policy and Regulatory
		Encouraging all industries to take advantage of Goa State Investments Scheme, 2017 to promote energy conservation and efficiency in their respective processes	Short to Long	Policy and Regulatory

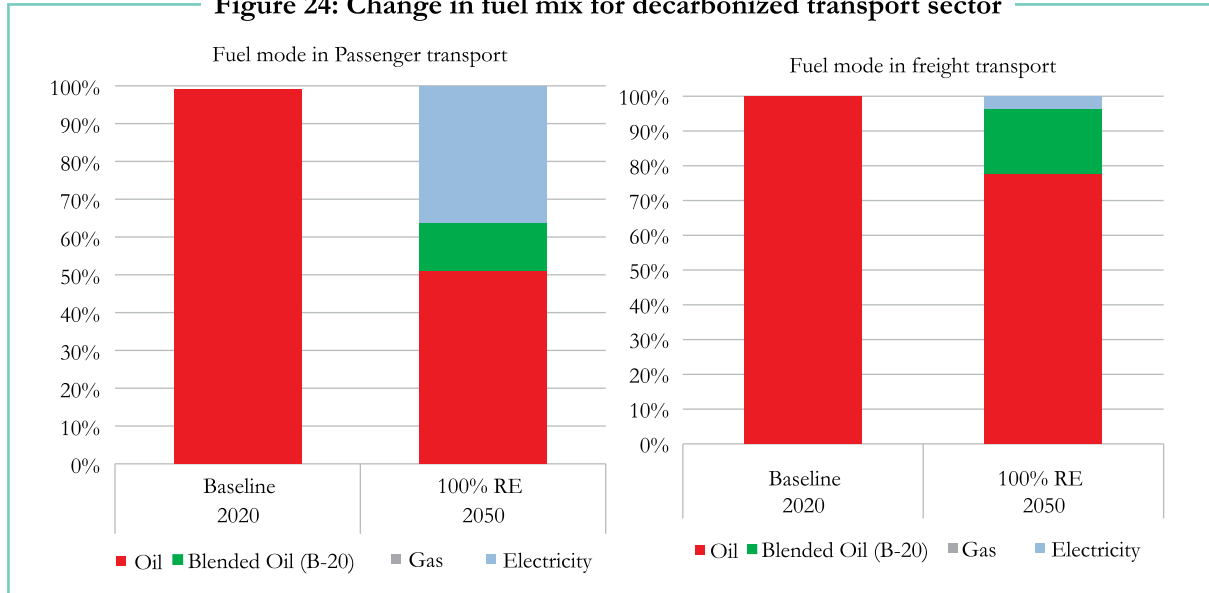
Data Source: The Celestial Earth

Renewable Energy in Transport

Transport sector is the single largest source of energy consumption in the State of Goa. Its energy share in the State was the single largest in 2020 which was around 57%. It is projected that given the growth of vehicular population in the State and also the vehicle density, the share of transport energy by 2050 would be around 42%. However, if the low carbon technologies and zero emissive fuel shifting happens then by 2050 the share of transport energy to overall energy demand in the State 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.

In the context of making the transport sector decarbonized, it is observed that passenger and freight segment of the transport sector needs different fuel mix. Due to technological limitation, freight vehicles are yet to be commercially viable to run on electricity. Blended fuel (ethanol & biodiesel) is going to play a crucial role in the State's transport decarbonisation process for both passenger and freight segment. However, electric vehicles are mostly going to be in the passenger segment where 2 wheelers and 4 wheelers will be fully converted to electric. Figure 24 shows the fuel mix change required to decarbonize the transport sector in the State of Goa by 2050. It is observed that 100% decarbonisation of the transport sector is infeasible at the current level of technological development and their commercial utilisation.

Figure 24: Change in fuel mix for decarbonized transport sector

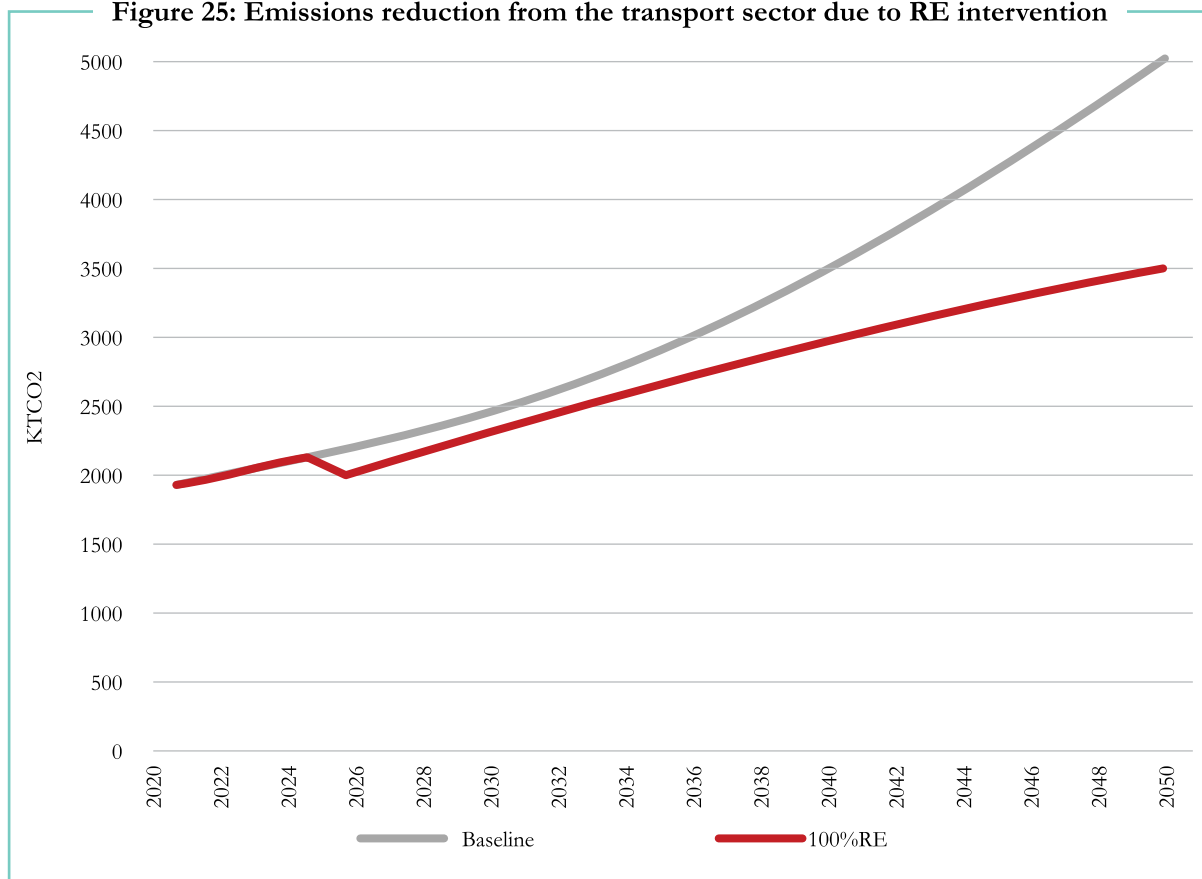


Data Source: The Celestial Earth

In terms of emissions, RE intervention in the transport sector could reduce cumulatively around 15 MtCO₂ between 2020 and 2050 due to fuel shifting towards biofuels and electricity (green power). Major reduction is happening in the passenger segment due to 100% electrification of

2 wheelers, cars and taxis. Consumption of fossil fuels continue for the air transportation as there is hardly any alternative to replace ATF as of now. Figure 25 shows the potential emissions reduction in the transport sector due above shown (See Figure 24) fuel mix in 2050.

Figure 25: Emissions reduction from the transport sector due to RE intervention



Data Source: The Celestial Earth

9.1 RE Intervention Activities in Transport Sector

Major renewable / clean fuel interventions in the sector are as follows:

1.0 100% electrification of 2 Wheeler, Cars & Taxies

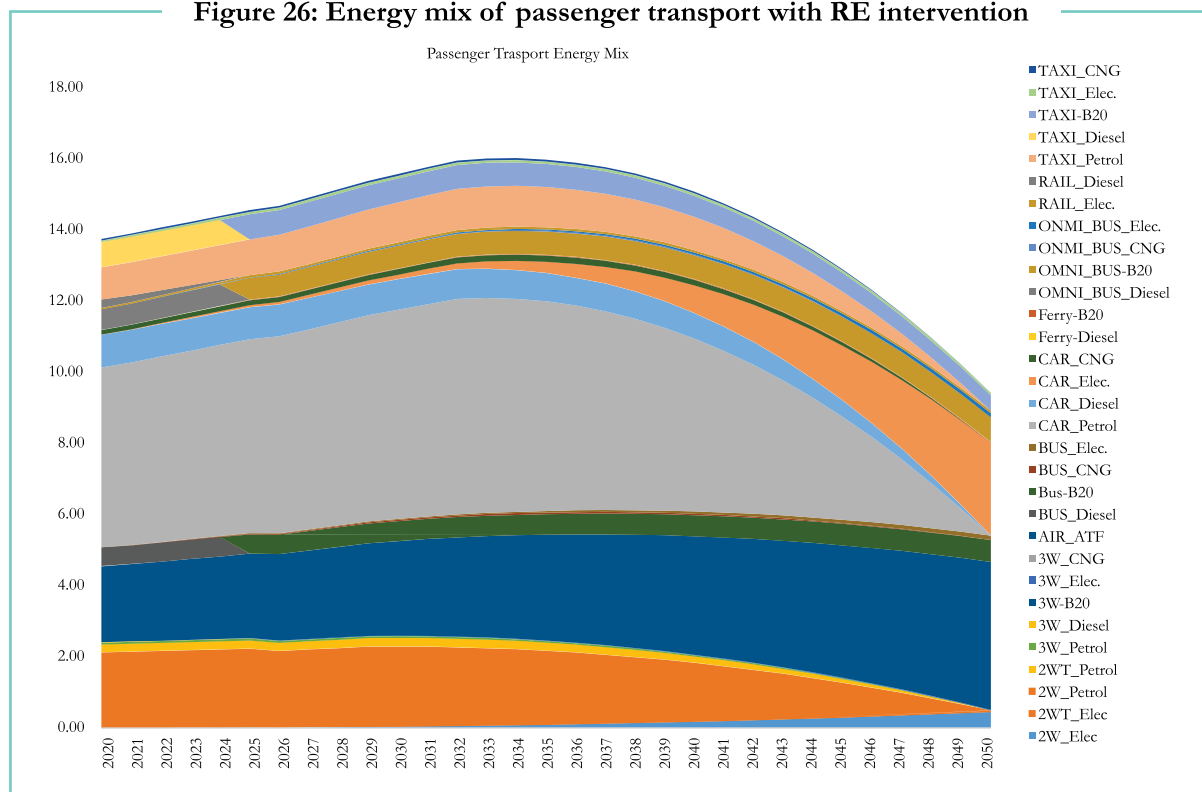
2.0 20% blending of biofuels in all categories of vehicle

3.0 100% use of green electricity for EV charging

While implementing the 100% RE based fuel supply for the transport energy supply, it is considered that technology and fuel transitions are gradual and smooth. Based on the planned

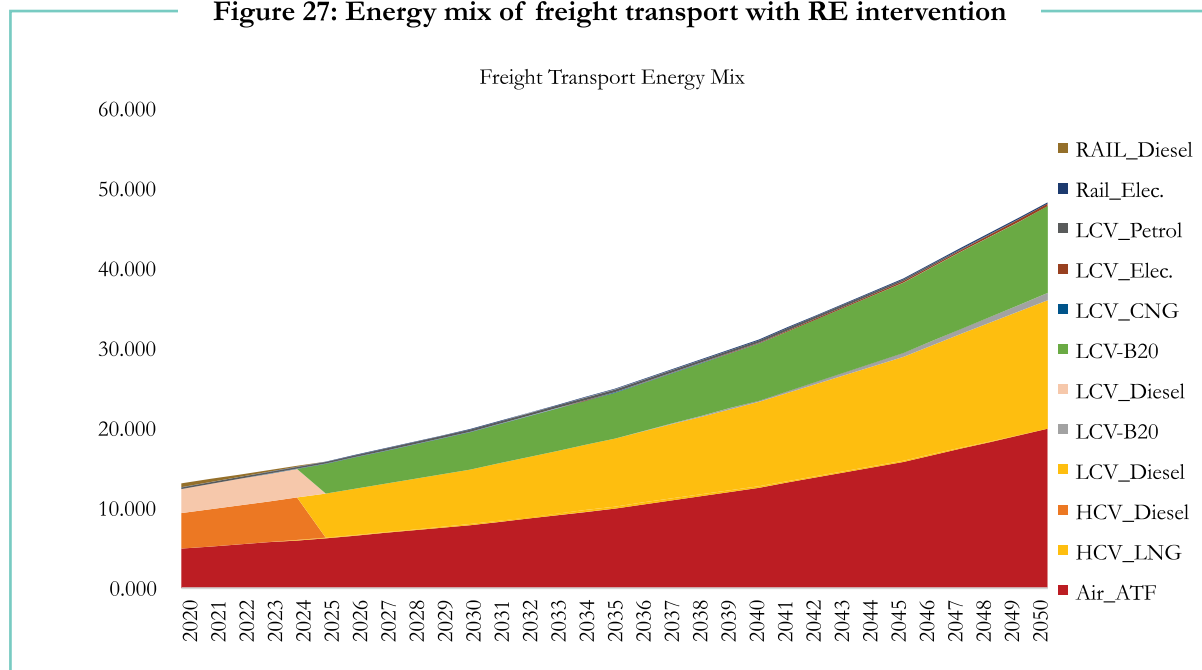
RE intervention in the sector the study obtained the following transport energy mix which is significantly decarbonized (except air transport).

Figure 26: Energy mix of passenger transport with RE intervention



Data Source: The Celestial Earth

Figure 27: Energy mix of freight transport with RE intervention



Data Source: The Celestial Earth

9.2 Action Plan for Decarbonisation of Transport Sector

State shall work towards complete phase out of oil from transport energy demand by 2050 and shall replace it with the increased use of green electricity and biofuel.

Transport sector is the most energy intensive sector in the state. In order to achieve decarbonisation of the sector various measures are widely considered and promoted, which includes transition to clean energy sources, increasing use of green electricity for charging the batteries etc. Table 15 below shows the targets and activities proposed for the sector to decarbonize it by 2050.

Table 15:RE intervention activities in transport

Goals	Targets	Activities	Targeted Timeline		
			Short (2020- 2025)	Medium (2025- 2030)	Long (2030- 2050)
100% Renewable Energy & Green Electricity Based Transport in the State of Goa by 2050	Increase the penetration of electric vehicle in passenger segment	i) 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.	2023		
		ii) Market development for End-of Life/Recycler for existing vehicle and batteries	2025		
		iii) Policy to set up adequate charging infrastructure (both public and private based)	2025		
		iv) Skill development required for the development and up keeping of EV.	2025		
		v) Increase share of electric buses in the State	2025: 10%	2030: 25%	2040: 45% 2050: 75%
		vi) 100% electrification target for 2 Wheelers	2025: 25%	2030: 50%	2040: 75%
		vii) 100% Electrification target of Taxies.		2030	2050: 100%
		viii) Solarisation of ferry boats		2030: 30%	2050: 50%
	Increase the penetration of electric & hydrogen vehicle in freight segment	i) Develop awareness among the commercial fleet operators on the benefits of EVs adoption	2025		
		ii) Developing adequate infrastructure for handling freight-vehicle green hydrogen requirement			2045

Data Source: The Celestial Earth

9.3 Enabling Action Plans for RE Intervention in Transport Sector

These action plans are required to create an enabling environment in the State to promote RE interventions and decarbonize the transport sector through target-oriented activities mentioned in the Section 8.2.



Table 16: Ancillary action plans for transport sector

Sector	Activity	Sub Activity	Timeline	Type of Intervention
Passenger Transport	Promote uptake of Electric Vehicles (EV)	Confluence of EV policy and vehicle scrappage policy in Goa	Short to Medium	Regulatory/ Policy
		Creating EV promotional fund for faster adoption of EV in the commercial / non-private category ~Providing access to Tourist Vehicle Operators	Short to Medium	Regulatory/ Policy
	CBG Production	Market development for CBG	Short to Long	Technical
Freight Transport	Promote uptake of Electric Vehicles /LNG	Creating necessary regulatory changes in vehicle registration process to promote LNG use.	Medium to Long	Technical
		Creating necessary regulatory changes in vehicle registration process to promote vehicle scrapping.	Short to Medium	Technical

Data Source: The Celestial Earth



Renewable Energy in Fishery

Fishery sector in Goa consumes around 0.9% of total energy consumed by the State mainly due to its diesel & petrol consumption for fishing activities. Currently the fishery sector is consuming around 16000 KL of petrol & diesel per annum which is the target fuel for replacement under the plan of 100% RE based fishery in the State. In this context 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.

10.1 RE Intervention Activities in Fishery Sector

Major renewable / clean fuel interventions in the sector are as follows:

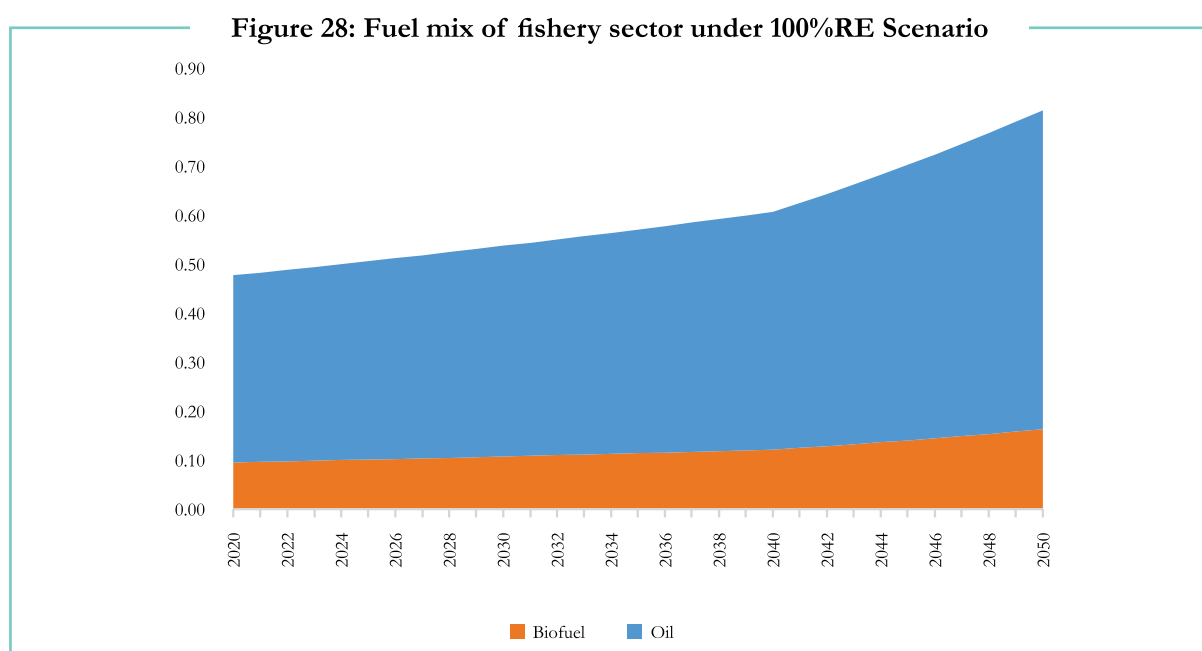
1.0 Use of blended fuel for all fishing boats

2.0 20% blending of biofuels in all categories of vehicle used for fishing (pre and post harvesting)

3.0 100% use of green electricity for post harvesting activities mainly cold storages

While implementing the 100% RE based fuel supply for the fishing sector it is considered that technology and fuel transitions are gradual and

smooth. Based on the planned RE intervention in the sector the study obtained the following energy mix.



Data Source: The Celestial Earth

10.2 Action Plan for Decarbonisation of Fishery Sector

State shall work towards complete phase out of oil from fishery energy demand by 2050 and shall replace it with the increased use of green electricity and biofuel.

Fishery sector is an energy intensive sector in the state and livelihood of the fishermen depends on the cost of fuels as well. Higher the fuel price

lower the income from the fish harvest. Each deep-sea trawler spends around Rs.5000 for two hours per day just for idling in the middle of the sea during fish catching. In order to achieve decarbonisation of the sector various measures are widely considered and promoted, which includes transition to clean energy sources, increasing use of green electricity for charging the batteries etc. Table 10 below shows the targets and activities proposed for the sector to adopt to make it decarbonized by 2050.

Table 17:RE intervention activities in transport

Goals	Targets	Activities	Targeted Timeline		
			Short (2020-2025)	Medium (2025-2030)	Long (2030-2050)
100% Renewable Energy & Green Electricity Based Fishery in the State of Goa by 2050	Increase the penetration of solar/hybrid boats for fishing.	i) State shall develop fishing boat solarisation policy to mainstream use of solar, wind and hybrid technologies for fishing boats to minimize the fuel cost and emissions reduction.	2024		
		Renewable Energy & Green Electricity Based Fishery in the State of Goa by 2050	2025		
		Pilot testing of new boat technologies along with new boat material	2025: Demo boat for Association to test	2030: 5 boats to individual volunteers	
	Promoting RE for post harvesting activities	i) Promoting solar dryer for fish preservation: Conducting assessment study	2025		
		ii) Promoting solar based cold chains for fish storage	2025		
		iii) Promoting use of EVs for market connectivity between fishing jetty and market.	2025		
	RE based aquaculture	i) Developing RE based aquaculture policy for Goa.	2025		
		ii) Piloting solar-thermal aerator		2030	
		iii) Piloting wind power aerator (use of low speed wind potential of Goa for aquaculture)		2030	
	Post Harvesting RE intervention	iv) Developing new and retrofitting existing fish cold storages with RE power supply		2030: 16	2040: 30 2050: 50

Goals	Targets	Activities	Targeted Timeline	
		v) Convert all existing 2 & 3 Wheelers attached with icebox to RE based	2025: All 2 / 3 Wheelers using blended fuel (B-20)	2030: 100% of the 2 & 3 wheelers become electric.
		vi) Fish carrying trucks use blended fuel	2025: All fish carrying trucks use blended fuel	

Data Source: The Celestial Earth

In Fisheries & Aquaculture HSD oil is used as the main fuel in fishing vessels and in power generators on-board that ensure backup-power. Further, electricity is essential for most of the semi-intensive, intensive, modern technology-driven aquaculture systems, cold storage and transport facilities. The energy consuming activities in aquaculture includes manufacturing of feed, pumping and aeration and farm illumination. Aeration accounts of 68% of total energy consumption in aquaculture. It is estimated that more than 50% of total costs of fishing goes for energy (FAO, 2015) in Asia. Therefore, minimizing energy consumption and shifting towards low cost energy would be the most desirable option in fishing.

Each deep-sea trawler spends around Rs.5000 for two hours per day just for idling in the middle of the sea during fish catching. This comes around Rs.15 lakhs (average) a day which is spent just on idling in the deep sea (Fish Afarmer Association). There are 300 trawlers who are active in Goa for deep sea fishing. Renewable energy-based energy supply system for deep sea fishing trawlers is a viable option for the fishermen. It is estimated that during harvesting, energy consumption (mainly diesel) is around 0.16 litre/ kg of fish catch in Goa, while according to a literature, the electricity consumption in the sector is 0.2553 kWh/kg of fish catch.

Aquaculture is also highly energy intensive activities. It requires continuous aeration and monitoring of water chemical composition

for good and healthy growth of fishlings. For aquaculture energy consumption reduction could lead towards enhanced farmer income and sustainable business.

Post-harvest activities in the sector includes cooling, freezing, cold storage, curing, drying, canning, processing etc. In terms of post harvesting facilities, Goa has 16 fish cold storages with around 7000-ton capacity. Under the Blue revolution Scheme of GoI, Goa has 20 auto-rickshaws (3-wheelers) and 50 motor cycles (2-wheelers) attached with ice-boxes used for carrying fish catches from landing jetties to the markets. Besides, Goa has 20 trucks with 10 ton capacity and 6 trucks with 6-ton capacity with cold storage insulation for carrying fish catches. State also has 3 ice making units dedicatedly working for fishery requirement (Fishery Department, Govt. of Goa, 2021). It can be noted from the above that electricity and diesel are two main components for energy consumption in the sector. The energy consumption in the sector will also increase due to increased production. Hence there is a dire need to decarbonise the sector.

10.3 Enabling Action Plans for RE Intervention in Fishery Sector

These action plans are required to create an enabling environment in the State to promote RE interventions and decarbonize the fishery & aquaculture sector through target-oriented activities mentioned in the Section 10.2.

Table 18: Enabling action plans for fishery sector

Sector	Activity	Sub Activity	Timeline	Type of Intervention
Fish harvesting	Promote harvesting boat and equipment efficiency	Improved vessel propulsion with reduced drag for less fuel consumption	Short to Medium	Regulatory/ policy
		Use of blended fuel like biodiesel with diesels without compromising the vessel performance (trip time, catch value and safety at sea etc.)	Short to Medium	Regulatory/ Policy
		Modification of fish catching gear as per requirement leads to reduce per ton fuel consumption	Short to Long	Technical
		Maintaining right balance between vessel engine capacity and its corresponding fishing duties. Mismatch could lead towards unnecessary fuel consumption	Short to Long	Technical
Aquaculture	Promote energy efficiency in aquaculture	Shifting towards optimally formulated, more stable and manageable compound feeds, with more reliable performance and less waste	Medium to Long	Technical
		Diversifying raw material sources and reducing the embodied energy and other energy inputs associated with feed	Short to Medium	Technical
		Improving processing systems to reduce energy consumption, optimize feed quality, reduce production and handling waste.	Short to Medium	Technical
Post Harvesting	Promote energy efficiency and RE intervention in post harvesting activities	Incentivizing shifting towards RE based (mainly wind-solar hybrid) cold storage facilities to minimize grid power use.	Medium to long term	Financial

Data Source: The Celestial Earth



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Resource Mobilisation for 100% RE

Preparing energy action plan for the State and providing list of activities to be performed is an important task while developing the multi sectoral planning document for the State but the effort will remain unfinished unless the State is provided with the required financial and human resources to implement the action points. As a matter of fact, energy planning without financial and human resource planning is incomplete. Keeping the importance in priority, the study assessed both the resources' requirement in the State of Goa between now and 2050.

11.1 Social Impacts of 100% RE

The study investigated the potential social impacts of very high level of renewable energy use in the state to make it a green State in the country through an assessment of employment generation. Table 18 shows the scope of employment per unit of RE intervention in the economy and corresponding total employment generation.

Table 19: Potential of job creation in Goa for 100%RE

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	-

Source: Greening Indian Workforce, 2017, CEEW

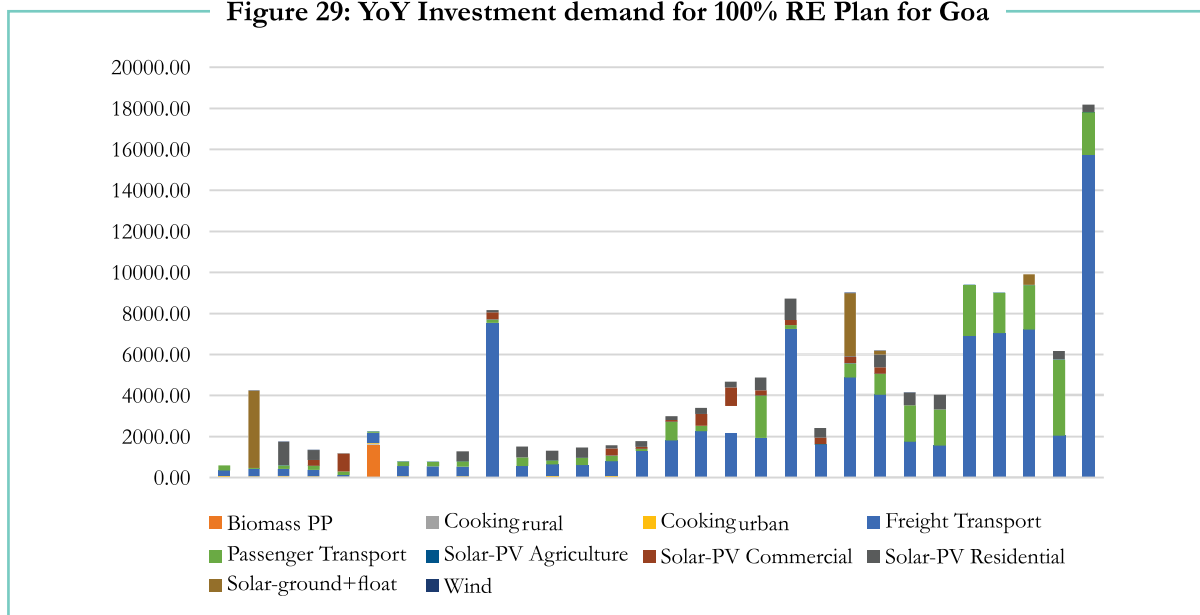
It is estimated that while implementing 100% RE plan in the State of Goa, it can create around 15000 additional jobs (with 5 year term) between 2020 and 2050. As a matter of fact, annually the State can create 500 jobs exclusive for solar and wind energy generation within the State.

11.2 100% RE Investment Demand

It has been estimated that to implement 100% RE plan in Goa, the State requires significant amount of investment which is closely around INR 133,260 Cr. (USD 17 billion approx.) between 2020 and 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. Figure 29 shows the year-on-year investment demand for the State to implement the 100% RE plan as explained in the earlier sections by each sector. Investment is back-loaded mainly due to the time

leverage the model has used to get the individual technology cost lower over the longer time horizon. Therefore, investments are much higher in the later part of the model horizon (after 2040) compared to the initial 20 years between 2021 and 2040. This has given an opportunity to create a financial mechanism in the State to achieve the target of 100% RE Plan in a reasonable way. It is also observed that certain sectoral investments are lumpy and cyclical. For example, investment in freight transport which is predominantly for introduction of electric heavy duty trucks in the State, requires overnight capital expenditure to procure the vehicles to meet the target. However, due to 15 years of vehicle life, such investment will occur in every 15-year period which we again observe between 2030 and 2046. Another important aspect of this investment cost is it is only the EPC and technology transition costs and it does not include other infrastructural costs required for technology functioning. For example, this cost does not include EV charging station cost.

Figure 29: YoY Investment demand for 100% RE Plan for Goa



Data Source: The Celestial Earth

In the process of mobilizing resources to support the overall transition activities in the State of Goa, thus the study is proposing to create the State Climate and Clean Technology Fund which can cater the need of investments in various sectors to promote, test, implement and scale-up renewable energy intervention as required.

**Green Technology Fund for Goa
(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 (25 Cr. State contribution). This is expected to help mainstream the uptake of clean technology by the end users i.e. retail, industrial and institutional consumers as well as stimulate the growth of the energy services industry in the state. 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 utilisation of the initial fund allocation.

The fund can focus on projects/initiatives implemented in agriculture, residential and commercial buildings, transport, SMEs etc. The fund could have a three-tier structure, wherein the Steering Committee could have over-arching jurisdiction on the fund functions and could be assisted by the Fund Management Committee, which could undertake the overall management and utilisation of the Fund. The Management

Committee could be supported by the Technical Committee on technical aspects of the proposals put forward for funding by the beneficiaries.

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. In the long term, the fund can provide allocation from state government, state government owned entities, development / financing agencies and private sector entities to provide seed funding for start-ups from Goa, operating in manufacturing activities or providing services related to the focus areas stated above. Fund shall give priority to innovative ideas and technologies to incubate within the State and can support fully to become mature. This can help to increase private sector participation and aid in the development of clean energy market in the state.

Institutional Arrangement

Success of developing the energy plan and action plans depends on their implementation on ground in a realistic manner. It is thus essential that the plan is adequately understood and its implementation activities and progress are monitored on a regular basis.

In the process of MRV (measuring, reviewing and verifying) the plans are successfully implemented. The report here highlights the process of implementation of the Action Plan in Goa through a special Task Force which could be created under the chairmanship of the Hon. Chief Secretary of the State along with a high powered committee comprising of senior officials from key departments. The Steering Committee created for overseeing the project can also be converted into GOA EAP Implementation Task Force through proper channel.

Goa Energy Development Agency shall remain the custodian of the Action Plan and its related information including model, database and web-tool for its regular use. GEDA will host the Decision Support Tool and shall maintain a technical team to own, operate and modify the Goa RE Action Plan model and its related technical documents. Adequate computing facility will be created inside GEDA to host and operate the energy model developed under the project.

To operationalize the Energy Action Plan and to conduct pilot projects followed by scaling up activities, GEDA shall create a technical committee comprising of experts from local institutes including IIT and IIM which can guide incubated ideas. Climate Fund can be utilized to support the committee activities which are to promote, incubate and pilot test new technologies that can minimize use of fossil fuels and can enhance RE use.

Table 19 summarizes the roles and responsibilities of different departments in the State to implement the proposed actions to enhance and reach 100% renewable energy intervention in the State.



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Table 20: Summary of responsibilities of the departments

Goal	Targets	Institutions/Departments
100% Renewable Energy Based Electricity Supply in the State of Goa by 2050	Augmenting State RE potential of 4 GW by 2050	Electricity Dept. / Renewable Energy Dept.
	Augmenting green power procurement of 17 TWh (or 2000 MW base load + 700 MW peak) by 2050	Electricity Dept. / State Load Dispatch Center
100% Renewable Energy Based Agricultural Activities in the State of Goa by 2050	Use of B-20 for all farm machines.	Agriculture Dept.
	Use 100% green electricity for all farm activities including pumps by 2050	Agriculture Dept./ Horticulture Dept. / RE Department
	100% KUSUM Program Implementation	Agriculture Dept./ Irrigation Dept. / RE Department
100% Renewable Energy & Green Electricity Based Building Energy Supply in the State of Goa by 2050	Implementation of ECBC Targets for Commercial Building	Town & Country Planning
	Developing & implementing Targets for Net Zero Commercial Buildings in Goa	Town & Country Planning/ Renewable Energy Dept. / Tourism Dept.
	Supplying 100% green electricity for all building activities by 2050	Electricity Dept. / TCP/ Tourism Dept.
100% Renewable Energy & Green Electricity Based Cooking in the State of Goa by 2050	Creating infrastructure and support facilities for 100% penetration of electricity and biogas in rural areas.	Renewable Energy Dept./ Electricity Dept.
	Creating infrastructure and support facilities for 100% penetration of electricity and biogas in urban areas.	Renewable Energy Dept.
100% Renewable Energy & Green Electricity Based industry in the State of Goa by 2050	Increase the penetration of energy efficiency to save 20% energy by 2050	Industry Dept.
	Developing models for implementation of emission mitigation measures	Industry Dept. / Environment Dept./ Pollution Control Board.
	Promote the transition from fossil based energy sources to clean energy alternatives.	Industry Dept. / Environment Dept./ Pollution Control Board.
100% Renewable Energy & Green Electricity Based Transport in the State of Goa by 2050	Increase the penetration of electric vehicle in passenger segment	Transport Dept. / Captain of Ports
	Increase the penetration of electric & hydrogen vehicle in freight segment	Transport Dept./
100% Renewable Energy & Green Electricity Based Fishery in the State of Goa by 2050	Increase the penetration of solar/ hybrid boats for fishing.	Fishery Dept. / Renewable Energy Dept.
	Promoting RE for post harvesting activities	Fishery Dept. / Renewable Energy Dept.
Climate / Green Fund	Creating State Fund for supporting activities	Dept. of Finance / GEDA

Data Source: *The Celestial Earth*

References

- (MoRTH), M. o. (2021). Vahan Dashboard. Retrieved from <https://vahan.parivahan.gov.in/vahan4dashboard/>
- (2014). 4th Census of Minor Irrigation Schemes Report. New Delhi: Ministry of Water Resources, River Development and Ganga Rejuvenation Minor Irrigation (Statistics) Punjab. Retrieved from <http://164.100.229.38/sites/default/files/4thmicensusreport.pdf>
- Acharya, M., & Devraj, S. (2019). Floating Solar Photovoltaic (FSPV): A Third Pillar to Solar PV Sector? TERI, Renewable Energy Technologies. Delhi: TERI. Retrieved 03 17, 2022, from <https://www.teriin.org/sites/default/files/2020-01/floating-solar-PV-report.pdf>
- Annual Survey of Industries, M. (2019). Annual Survey of Industries. Kolkata: MOSPI. Retrieved 02 25, 2022, from <http://microdata.gov.in/nada43/index.php/catalog/150/download/1907>
- CEA. (2022, 02 24). Dashboard - Central Electricity Authority. Retrieved 02 24, 2022, from <https://cea.nic.in/dashboard/?lang=en>
- DIRECTORATE OF PLANNING, S. &. (2020). Goa Economy in Figures-2020. Panjim: DIRECTORATE OF PLANNING, STATISTICS & EVALUATION. Retrieved 03 24, 2022, from <https://www.goa.gov.in/wp-content/uploads/2020/11/Goa-Economy-in-Figures-2020.pdf>
- Directorate of Planning, S. &. (2021). ECONOMIC SURVEY 2020-21. Government of Goa. Directorate of Planning, Statistics & Evaluation. Retrieved from <http://goadpse.gov.in/Economic%20Survey%202020-21.pdf>
- Goa, F. D. (2020). Home » FORESTS OF GOA » Forest & Tree Cover. Goa: Forest Department Government of Goa. Retrieved 03 24, 2022, from <https://forest.goa.gov.in/node/11>
- (2020). Handbook on Fisheries Statistics. Goa: Department of Fisheries. Retrieved 03 25, 2022, from https://dof.gov.in/sites/default/files/2021-02/Final_Book.pdf
- IEA. (2010). ETSAP. London: IEA. Retrieved 03 25, 2022, from https://iea-ctsap.org/E-TechDS/PDF/T12_Aviation_Transport_v3_final_gs06062011.pdf
- IIASA. (n.d.). International Institute for Applied Systems Analysis. Retrieved from <http://www.iiasa.ac.at/web/home/research/researchPrograms/Energy/MESSAGE.en.html>
- India, G. o. (2017). 5th Census of Minor Irrigation Scheme Report. New Delhi: Ministry of Water Resources, River Development and Ganga Rejuvenation Minor Irrigation (Statistics Wing). Retrieved from <http://164.100.229.38/sites/default/files/5th-MICensusReport.pdf>
- MoPNG. (2020). IPNG Statistics 2019-20. New Delhi: MoPNG. Retrieved 03 24, 2022, from <https://mopng.gov.in/files/TableManagements/IPNG-2019-20.pdf>
- NIWE. (2019). India's Wind Potential Atlas at 120m agl. Chennai: MINISTRY OF NEW AND RENEWABLE ENERGY, GOVERNMENT OF INDIA. Retrieved 03 21, 2022, from https://niwe.res.in/assets/Docu/India's_Wind_Potential_Atlas_at_120m_agl.pdf
- NRSA. (2003). Wastelands Atlas of India. Hyderabad: NRSA. Retrieved 03 21, 2022, from <https://dolr.gov.in/sites/default/files/Goa.pdf>

Railways, K. (2020). Annual Report 2019-20. Goa: Konkan Railways. Retrieved 3 24, 2022, from <https://konkanrailway.com/uploads/pdfs/KRCLAR2019-20-Englsih.pdf>

RPG-21. (2017). STATE LEVEL COMMITTEE FOR REGIONAL PLAN FOR GOA -2021. Department of

Town and Country Planning. Goa: Government of Goa. Retrieved 03 08, 2022, from [https://www.indiawaterportal.org/sites/default/files/iwp2/Regional_plan_for_Goa Interim report by the task force Government of Goa 2008_.pdf](https://www.indiawaterportal.org/sites/default/files/iwp2/Regional_plan_for_Goa_Interim_report_by_the_task_force_Government_of_Goa_2008_.pdf)

(2020). SAPCC. Retrieved from <https://gsbb.goa.gov.in/wp-content/uploads/2020/12/Draft-Goa%20SAPCC-for-public-inputs.pdf>

Vikas Mendi, J. K. (2022). Evaluation of tidal stream energy at major tidal inlets of Goa, India. Panjim: ISH Journal of Hydraulic Engineering. doi:10.1080/09715010.2019.1692313

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