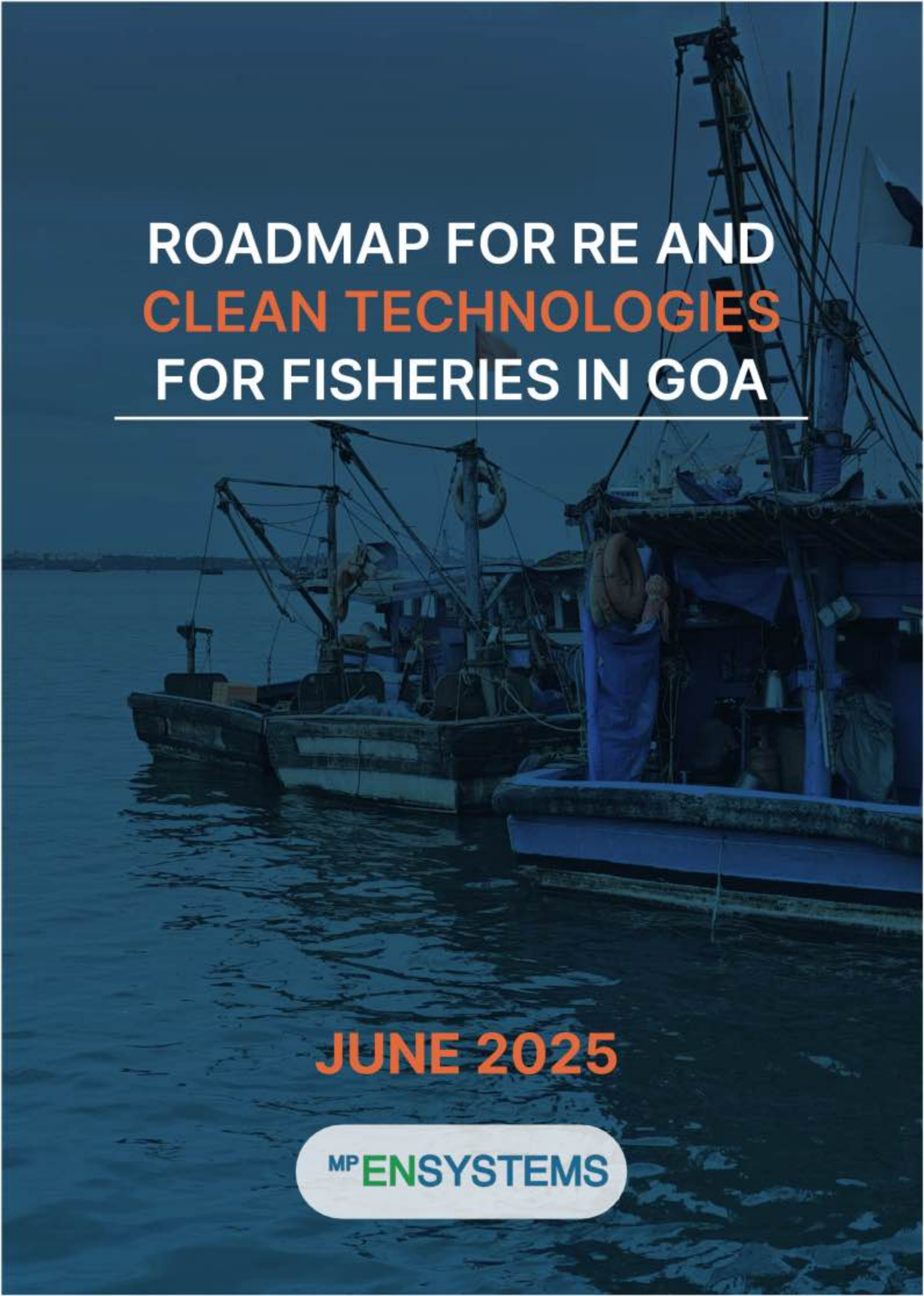


The background of the entire page is a photograph of several fishing boats on a body of water. The boats are wooden and have various rigging and equipment visible. The water is calm, and the sky is a clear blue. The overall tone of the image is serene and professional.

ROADMAP FOR RE AND CLEAN TECHNOLOGIES FOR FISHERIES IN GOA

JUNE 2025

MP **EN**SYSTEMS

ACKNOWLEDGEMENTS

We acknowledge the unwavering support received from Goa Energy Development Agency (GEDA), Department of Fisheries, South Goa Planning and Development Authority (SGPDA), Krishi Vigyan Kendra (KVK), Goa State Pollution Control Board (GSPCB), National Bank for Agriculture and Rural Development (NABARD), National Institute of Rural Development and Panchayati Raj (NIRD & PR) and Central Institute of Fisheries Technology (CIFT).

We would like to thank the value chain stakeholders of Goa fishermen cooperative societies, ice manufacturing plant owners, fish processing plant owners, and fishing folk, among others for sharing their valuable insights.

We would like to thank clean technology providers such as - New Leaf Dynamic Technologies, Sunrise CSP India, Mid-West Advanced Materials, Windstream Energy Technologies India, Datamatrix Infotech, Inficold, Pluss Advanced Technologies, and Ecozen Solutions for the enriching discussions which were essential for conducting our research and analysis.

This document and the inferences drawn reflect the views of the authors and not those of any other parties.

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CITATIONS

MP Ensystems Advisory Private Limited (2025). Goa's fisheries sector clean energy roadmap.





Shri Sohan Ashok Uskaikar
Director, Department of New and Renewable Energy, Goa

FOREWORD

Goa aims to implement renewable energy and energy efficiency measures in key sectors including tourism, transportation, industry, healthcare, agriculture, fisheries, and cooking, for attaining 100% renewable energy by 2050.

I am very happy that the Goa Energy Development Agency (GEDA) is leading the efforts to achieve this goal through on-the-ground planning and action. Given the critical role that fisheries play in Goa's socioeconomic well-being, prioritizing this sector is extremely relevant. GEDA's clean energy goals are positioned to meet the growth ambitions of Goa's fisheries department, which is continuing to spearhead various avenues of growth for the sector.

To this end, the Roadmap for Renewable Energy and Clean Technologies for Fisheries in Goa, by MP Ensystems Advisory Pvt. Ltd, will provide a phased, practical strategy for reducing emissions while enhancing energy efficiency across the fisheries value chain.

Shri Sohan Ashok Uskaikar
Director
Department of New and Renewable Energy, Goa





Shri Gauresh Ashok Pilgaonkar
Managing Director, Goa Energy Development Agency

FOREWORD

Goa is set to play a key role in India's Net Zero journey, with an ambitious goal to transition to 100% renewable energy across all sectors by 2050. Among these, fisheries a vital part of Goa's traditional livelihood and economy stands out as a sector ready for sustainable transformation.

Goa has long promoted responsible and sustainable fishing practices. The integration of clean technologies is the natural next step, aligning with the state's broader environmental vision and strengthening the resilience of the fisheries sector and its allied industries.

The Goa Energy Development Agency is pleased to support and guide the Roadmap for Renewable Energy and Clean Technologies for Fisheries in Goa, developed by MP Ensystems Advisory Pvt. Ltd. This initiative paves the way for cleantech adoption in fisheries and has the potential to inspire similar efforts across other sectors in Goa's economy.

Shri Gauresh Ashok Pilgaonkar
Managing Director
Goa Energy Development Agency





Shri Sanjeev Joglekar
Member Secretary, Goa Energy Development Agency

FOREWORD

Goa is committed to becoming India's first 100% renewable energy-powered state by 2050. The clean energy roadmap of the fisheries for the state of Goa, developed by MP Ensystems Advisory Pvt Ltd with support from the Shakti Sustainable Energy Foundation, offers a robust roadmap for clean tech adoption in the fisheries helping Goa achieve the 2050 vision.

Through extensive energy base-lining, complimented by consultation with value chain stakeholder and technology providers clean tech interventions and their impact has been identified. The report provides a clear, data-driven framework for Goa's clean energy transition in the fisheries sector.

As we move forward, this document will serve as a valuable guide for policy and investment decisions. We commend the team behind this work and encourage all stakeholders to engage with its findings in our collective pursuit of a greener, energy-secure Goa.

Shri Sanjeev Joglekar
Member Secretary
Goa Energy Development Agency





Dr. Shamila Monteiro
Director, Directorate of Fisheries, Goa

FOREWORD

Fisheries have been an essential thread in the socioeconomic fabric of Goa. It has been a prominent livelihood activity supporting over 12,000 fisher folks. The department has been active in implementing the Pradhan Mantri Matsya Sampada Yojana, facilitating the holistic development of the fisheries sector.

Renewable energy adoption through clean tech implementation has the potential to revolutionise the sector, with increasing economic and environmental costs of fossil fuels, RE development is key to the sector's growth. The department of fisheries in the past has collaborated with several governmental agencies to demonstrate the capabilities of such technologies, spreading awareness among fisherfolk.

The Directorate of Fisheries is proud to have facilitated the development of the Roadmap for Renewable Energy and Clean Technologies for Fisheries in Goa by MP Ensystems Advisory Pvt. Ltd. This important initiative promotes the integration of clean technologies within the fisheries sector, strengthening its sustainability and setting a strong example for similar transitions across other sectors in Goa's economy as part of the state's broader Net Zero vision.

Dr. Shamila Monteiro
Director
Directorate of Fisheries, Goa





Dr. Mahesh Patankar
Founder and MD, MP Ensystems Advisory Pvt Ltd

FOREWORD

India's fisheries sector plays a key role in food security, coastal livelihoods, and bolstering the blue economy. In Goa, fisheries support over 12,600 fisherfolk along its 104 km coastline but remain energy-intensive, consuming 2.56 – 3.04 lakh MWh annually and emitting up to 96,600 tonnes of CO₂e. The sector relies heavily on fossil fuels with an annual consumption of 16,000 kl of diesel and an annual ice usage of 8,04,436 tonnes. To enable a sustainable, low-carbon transition, MP Ensystems Advisory Pvt. Ltd. presents the Roadmap for Renewable Energy and Clean Technologies for Fisheries in Goa, aligned with the Goa Energy Development Agency's vision of 100% renewable energy by 2050.

This roadmap adopted a value chain approach informed by stakeholder consultations, identifying impactful clean technology interventions across the sub-systems- from marine fishing and aquaculture to processing and markets. Grounded in a detailed baseline energy assessment, the study presents a phased transition strategy that prioritizes energy conservation, efficiency, and renewable energy adoption. By mapping phase-wise (short, medium and long term) interventions and aligning them with existing policy frameworks and probable business models, the roadmap offers a clear and actionable pathway toward decarbonisation.

We are grateful to the Directorate of Fisheries, Goa, Co-operative societies, technology providers, and on-ground stakeholders for their valuable insights. We also acknowledge the knowledge support of Shakti Sustainable Energy Foundation in enabling this important work. We hope this roadmap will serve as both a guide and a catalyst for clean energy transition of fisheries sector—fostering livelihoods while contributing meaningfully to Goa's climate and energy goals

Dr Mahesh Patankar
Founder and MD
MP Ensystems Advisory Pvt Ltd



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LIST OF ABBREVIATIONS

CAA – Coastal Aquaculture Authority
CIFT – Central Institute of Fisheries Technology
CMFRI - Central Marine Fisheries Research Institute
CNG – Compressed Natural Gas
CRCFV - Climate Resilient Coastal Fishermen Villages
CS – Cold Storage
CST – Concentrated Solar Thermal
EC – Energy Conservation
EE - Energy Efficiency
EMS – Energy Management System
EV – Electric Vehicles
FaaS – Farming as a Service
FIDF - Fisheries and Aquaculture Infrastructure Development Fund
FFPO – Fish Farmer Producer Organisation
FRP – Fibre Reinforced Plastic
FSI – Fisheries Survey of India
GEDA – Goa Energy Development Agency
GHG – Greenhouse Gas
GSIDC - Goa State Infrastructure Development Corporation
GSPCB – Goa State Pollution Control Board
ha - hectare
ICAR - Indian Council of Agricultural Research
IIFPT - Indian Institute of Food Processing Technology
IoT – Internet of Things
kCal – kilo Calories
kl - Kilolitre
km - Kilometre
kW – Kilo Watt
kWh – Kilo Watt hour
JERC – Joint Electricity Regulatory Commission
LNG – Liquefied Natural Gas

LPG – Liquefied Petroleum Gas
MRF – Material Recovery Facility
MW – Mega Watt
MWh – Mega Watt hour
NABARD – National Bank for Agriculture and Rural Development
NIFTEM - National Institute for Food Technology Entrepreneurship and Management
NIRD & PR - National Institute of Rural Development & Panchayati Raj
OEM – Original Equipment Manufacturer
ODDP – One District One Product
PAY-G – Pay as You - Go
PCM – Phase Change Material
PMFME – Pradhan Mantri Formalisation of Micro Food Processing Enterprises
PM KUSUM – Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PMMSY - Pradhan Mantri Matsya Sampada Yojana
PM-MKSSY - Pradhan Mantri Matsya Kisan Samridhhi Sah-Yojana
PPP – Public Private Partnership
PV - Photo Voltaic
RAS – Recirculating Aquaculture System
R&D – Research and Development
RE – Renewable Energy
RESCO – Renewable Energy Service Company
RoI – Return on Investment
SGPDA - South Goa Planning and Development Authority
TES – Thermal Energy Storage
TPD – Tonnes Per Day
UHMWPE - Ultra-High Molecular Weight Polyethylene
WSA – Water Surface Area



EXECUTIVE SUMMARY

This roadmap for renewable energy (RE) and clean technologies for the fisheries sector in Goa is a comprehensive document showcasing the paths recommended for clean energy and technology diffusion in the sector. The roadmap focuses on the fisheries value chain categorised and analysed in the form of seven sub-systems i.e. marine fishing (vessels), landing centres (jetty), ice manufacturing, logistics, fish processing (export and waste), markets and aquaculture. Each of them experiences their own challenges and opportunities for RE uptake.

This study aims to develop actionable outcomes for the roadmap and aims to capture the following broadly:

1. Mapping the sector's potential renewable energy, energy efficiency, and energy conservation interventions to reduce fossil fuel dependence and limit GHG emissions in alignment with the Goa Energy Development Agency Clean energy roadmap. The mapping has been conducted through energy base-lining of the sector on a sub-system level and then recognize the RE, EE and EC interventions that align the gaps identified during the base-lining exercise.
2. Assessing the feasibility and impact on deployment of the clean tech solutions mapped during the study through primary and secondary research in 3 stages i.e. short (0-3 years), medium (3-5 years) and long term (more than 5 years)
3. Recommend broad policy suggestions and potential business models to promote the adoption of clean tech interventions, reduce the fisheries sector GHG footprint and optimise its operational efficiency.

The roadmap for its recommendations follows a mixed methodology, incorporating insights developed through extensive stakeholder consultations from a diverse group of stakeholders such as government officials, beneficiaries, technology providers, authorities of the co-operative societies and others to develop a deep understanding of the requirements of the value chain. This has been done through both online and offline field consultations. The secondary research has been pivotal in steering the consultations towards the cleantech domain. The study has attempted to be comprehensive by incorporating measures that promote energy efficiency and energy conservation to further optimise the cleantech adoption and aid in seize the low-hanging opportunities available to the beneficiaries. A 'Clean Technology Compendium' of the solutions presented in this study is shared in the Annexure of this report.

Finally, the study has identified various policies and programs that can readily prioritize and accelerate the cleantech and clean energy dissemination in the value chain. It also proposes several business models that cater to the specific challenges of cleantech uptake such as high capital costs, lack of awareness, rigid repayment structures and others.

The roadmap contains eight chapters excluding the references and annexure that cater to introduction of the Goa fisheries value chain, brief on the learnings from the energy base-lining exercise, introduction of mature and market-ready clean technology interventions, scenario-based cleantech update, policy, initiatives and programs, potential business models for cleantech deployment, GHG reduction potential scenarios, adoption time period (conclusion and way forward included) respectively.

For the instance, solar storage solutions can play a key role in the Pradhan Mantri Matsya Kisan Samridhi Sah-Yojana (PM-MKSSY) program support for microenterprises for improving fisheries value chain efficiency and promotes fish safety and quality assurance. Similarly, the Fisheries and Aquaculture Infrastructure Development Fund (FIDF) can play key role in bringing strong renewable interventions in infrastructure projects like jetties, vessels and processing units.



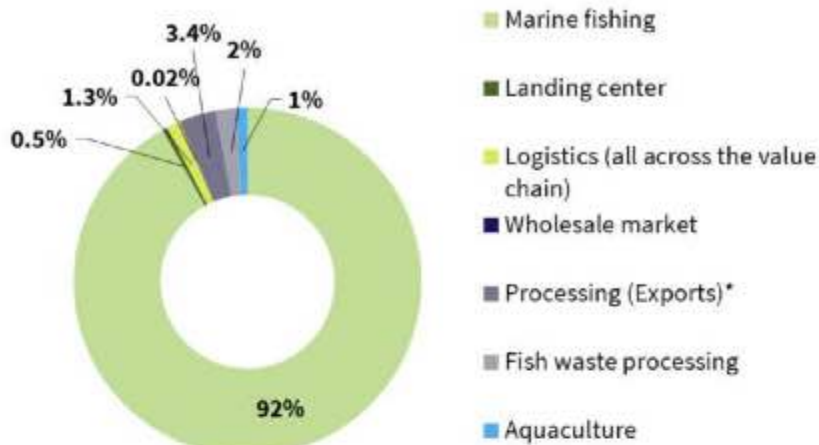


Figure 1: Share of different sub-systems' annual energy consumption

As per the base-lining exercise, the fisheries sector in Goa has an annual energy consumption to be around 256,000 – 303,800 MWh of energy annually for a catch of 128, 514 tonnes of fish. It has identified the marine fishing (vessels) sub-system as the highest energy consumption sub-systems with over 92% of the entire value chain, utilising over 235,219 – 282,322 MWh of energy utilised, with the major chunk coming out of fossil fuels. This consumption includes the ice manufactured for utilisation in vessels. The infographics provided below highlights the energy consumption on a sub-system basis.

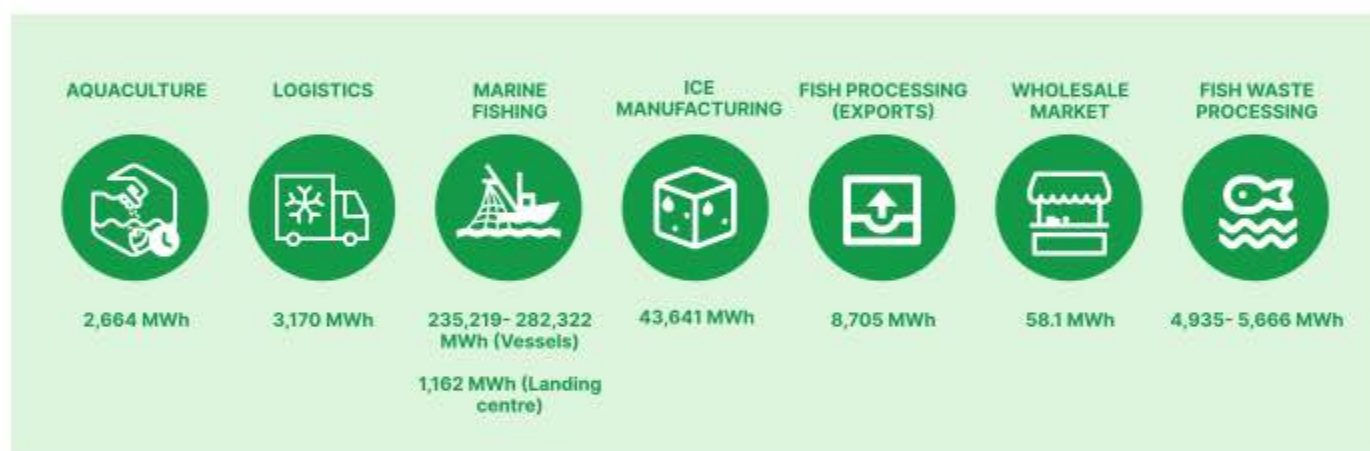


Figure 2: Annual energy consumption of the sub-systems

*The energy consumption in Ice manufacturing is included in the energy consumption of different sub-systems using ice

Parallel to the base-lining, the study has conducted multiple interactions with technology providers to gauge the opportunity of cleantech deployment in the sub-systems. Some of the prominent interventions realised through the interactions were IoT based sub-metering, PCM tabs, vessel design changes, solar-wind hybrid solutions, solar PV solutions and many more that are provided in the table below. The discussions were held around the scope of implementation, scalability and maturity of technology, capital expenditure, infrastructure required to deploy, challenges that can occur with installation, GHG emission reduction potential among other parameters to determine the overall viability and impact of a deployed technology. Based on these discussions, the technologies have been identified under short term (0-3 years), medium term (3-5 years) and long term (above 5 years) deployment scenarios, as represented above.



Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

AQUACULTURE 	SHORT TERM	1	
		0.9	• Energy-efficient motors/pumps • Solar pumps
		0.8	• IoT based sub-metering
		0.7	• Solar aerators • Solar-wind hybrid aerators • Solar-wind hybrid pumps
	MEDIUM TERM	0.6	• TES integrated cold storages • Solar cold storage
		0.5	• Solar-wind hybrid cold storage
		0.4	
	LONG TERM	0.3	• Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

MARINE FISHING (VESSELS) 	SHORT TERM	1	• Propulsion speed regulation • Insulated ice boxes for fish storage
		0.9	• Energy-efficient motors/pumps
		0.8	
		0.7	• Otter board (V-board) • Semi-pelagic trawl system • Turtle excluder device • Insulated ice boxes for fish
	MEDIUM TERM	0.6	• Fishing vessel design changes • LNG run boats • Solar PV or wind hybrid on vessels for ancillary consumption
		0.5	• TES boxes, tabs and pouches
		0.4	• Solar PV or wind-hybrid for refrigeration system
	LONG TERM	0.3	• TES-based chiller
		0.2	• Solar boats
		0.1	• Electric boats
		0	• Bio-diesel run boats

Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

LANDING CENTRES 	SHORT TERM	1	Insulated ice boxes for fish storage
		0.9	
		0.8	Energy-efficient motors/pumps
		0.7	- Solar PV rooftop ice plant - IoT based sub-metering
	MEDIUM TERM	0.6	- Solar PV or wind hybrid vessel battery recharging - Solar PV or wind hybrid on jetties for ancillary consumption - Solar cold storage
		0.5	- Solar wind hybrid cold storage - TES integrated cold storages - Solar wind hybrid ice plant - Solar-electric fish dryer - TES boxes, tabs and pouches - Biomass run ice-making machine
		0.4	
	LONG TERM	0.3	- Solar based and TES integrated fish dryer - Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

MARKETS 	SHORT TERM	1	Insulated ice boxes for fish storage
		0.9	
		0.8	
		0.7	- Solar PV rooftop ice plant - Solar vending machine for descaling, cutting and display
	MEDIUM TERM	0.6	Solar cold storage
		0.5	- Solar wind hybrid cold storage - Solar wind hybrid ice plant - TES boxes, tabs and pouches - Bio-energy production from fish waste - TES integrated cold storage
		0.4	
	LONG TERM	0.3	Solar based and TES integrated cold storage
		0.2	
		0.1	
		0	



Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

LOGISTICS 	SHORT TERM	1	• Insulated ice boxes for fish storage
		0.9	
		0.8	
		0.7	
	MEDIUM TERM	0.6	
		0.5	• TES boxes, tabs and pouches
		0.4	• TES based trucks • Reefer trucks (diesel-based)
		0.3	• Electric trucks (EV, no cold storage)
	LONG TERM	0.2	
		0.1	
		0	

ICE MANUFACTURING 	SHORT TERM	1	
		0.9	
		0.8	• Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
	MEDIUM TERM	0.6	• Solar wind hybrid cold storage • TES integrated cold storage
		0.5	
		0.4	
	LONG TERM	0.3	• Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

 PROCESSING (EXPORTS)	SHORT TERM	1	
		0.9	
		0.8	• FRP-based fan blades • Energy-efficient motors/pumps • Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
	MEDIUM TERM	0.6	• TES integrated cold storage • Solar wind hybrid cold storage
		0.5	
		0.4	
	LONG TERM	0.3	• Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

 PROCESSING (FISH MEAL)	SHORT TERM	1	
		0.9	
		0.8	• FRP-based fan blades • Energy-efficient motors/pumps • Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
	MEDIUM TERM	0.6	• Concentrating Solar Thermal (Steam generation) • Solar wind hybrid installation
		0.5	
		0.4	• Biomass based boiler
	LONG TERM	0.3	• Bio-diesel based boiler
		0.2	
		0.1	
		0	



The study also conducted a comprehensive policy analysis and coupled it with the discussion held with several value chain stakeholders to construct business models that cater to specific challenges faced by the deployment of cleantech. The study also delves into business model enablers on a sub-system level catering to fill the gaps in the current policy landscape, furthering the cleantech deployment. The potential business models for clean technology uptake in the sub-systems and their enablers have been listed below.

Table 2: Potential business models and enablers for sub-systems

Sub-system	Potential business model and enablers for clean tech uptake
Aquaculture	• Widening the scope of PM KUSUM under the ambit of the state policies and leveraging existing schemes for the adoption of solar pumps and aerators • Community supported technology adoption in farms through fish farmer associations • Government run pilot programs to demonstrate solar aerators, pumps and IoT based metering in farms
Marine fishing (Vessels)	• Demonstration of CIFT's green retrofittable technologies, such as LNG/LPG engines retrofitted on 10HP petrol motorised boats, small electric boats • Leveraging PMMSY to promote drag reducing vessel design changes for fuel savings and increased insulation to reduce ice consumption • Generating awareness on fuel saving practices during vessel propulsion • R&D support to stakeholders such as CMFRI, CIFT to develop usage of bio-diesel in boats
Landing centres	• PPP business model for developing green infrastructure • Entrepreneurship model for integrating bundle of RE/EE solutions for jetties • Subscription/rental models or PAYG models for collecting revenue from users of the infrastructure • Community based infrastructure development, managed/operated by local folk • Technology demonstration programs by government for TES tabs, biomass-based ice plants, solar drying units, solar ice plants
Markets	• Government-supported pilot programs for TES tabs, biomass ice plants and cold storages, solar drying units, solar ice plants, and cold storages • Community-driven RE based infrastructure development, operated and managed by local communities • Public-private partnership (PPP) model for RE/EE based public infrastructure development • Entrepreneurship model for bundling and implementing RE/EE solutions in markets • Subscription, rental, or PAYG models to generate revenue from infrastructure users • Leveraging Goa's initiative for developing cold storage and ice plant at Margao whole sale market

Sub-system	Potential business model and enablers for clean tech uptake
Ice manufacturing	• Entrepreneurship model supported by NFDB and PMMSY for integrated RE/EE based solutions for ice manufacturing plant • Solar roof-top installations through RESCO model supported by FIDF's credit guarantee • Demonstration pilot by government for selected ice manufacturing plants, to highlight benefits of IOT based sub-metering, EE motors and pumps and solarisation
Processing (Exports) and (Waste)	• State fisheries department schemes for subsidising plant and machinery of value addition enterprises can be leveraged for cleantech uptake. Availing Infrastructure subsidies under PMMSY. • Performance based grants to incentivise usage of IoT sub-metering. • RESCO model promotion through credit guarantee to facilitate solarisation.

The fisheries value chain in Goa is essential to the coastal state's economy and present unique set of challenges in its journey towards a sustainable green transition. It is crucial for the entire stakeholder ecosystem to work in tandem towards realisation of the cleantech uptake that provides immense GHG emission reduction potential. Policy support through specific business models for mature technologies with a competitive presence in the market can be the low hanging opportunities acting as a kick start to this transition, catalysing the demand for more greener solutions aiding the research and development and eventual absorption in the medium- and long-term period pivotal for sustainable and responsible fishing.







1.0 | INTRODUCTION



Figure 2: Locations of major jetties, cold storage and ice factories in Goa (MP Ensystems Research, 2024)

The coastal state of Goa contributes extensively to the blue economy of India. The state with a coastline of 104 kms sustains over 12,651 fisherfolk across the state (Directorate of fisheries, Government of Goa, 2024). The fisheries sector also feeds into the processing and fish meal industry of the state further consolidating its economic relevance. Fishing, fish processing and its ancillary services entail energy intensive activities, requiring about 2 MWh of energy for one tonne of fish catch (MP Ensystems Research, 2024).

This energy is primarily sourced from fossil fuels such as diesel, petrol and grid electricity, and thus contributing significant carbon footprint. This makes it imperative to explore and assess the opportunities and challenges for cleantech adoption in the fisheries sector promoting renewable energy uptake, energy efficiency and conservation measures to optimise the operational efficiency of the value chain.

Goa government's vision of transitioning the state towards 100% renewable energy by 2050 is captured in the Clean Energy Roadmap for the state by the Goa Energy Development Agency (GEDA, 2023). It has laid out the key objectives for the fisheries sector to transition towards cleaner practices. GEDA's roadmap can be considered as the first step calling for deeper assessment of the sector leading to this detailed study to identify mature and market-ready clean technologies that can be pivotal for greening the value chain.



The unique landscape of the fisheries sector encourages an approach promoting energy conservation efficiency and renewable energy uptake to address the value chain holistically.

The roadmap has been developed through a systems thinking approach, by viewing the value chain as an integration of several sub-systems that work in tandem, with value-added activities at each level. This approach has enabled the assessment at a granular level leading to discerning of various intervention areas.

Thus, the recommendations by the study aim to aid the decision making for prioritising cleantech adoption based on feasibility and impact in the value chain. For this purpose, clear articulation of business models leveraging existing policies and programs are presented for quick action. Furthermore, the study provides recommendations for policy reforms mitigating the challenges the sector face in reducing its GHG footprint.

The adoption of clean technologies in Goa's fisheries sector presents a transformative opportunity to align economic growth with sustainability. By addressing energy use and emissions through targeted interventions, the sector can significantly contribute to the state's renewable energy goals and green economy vision.

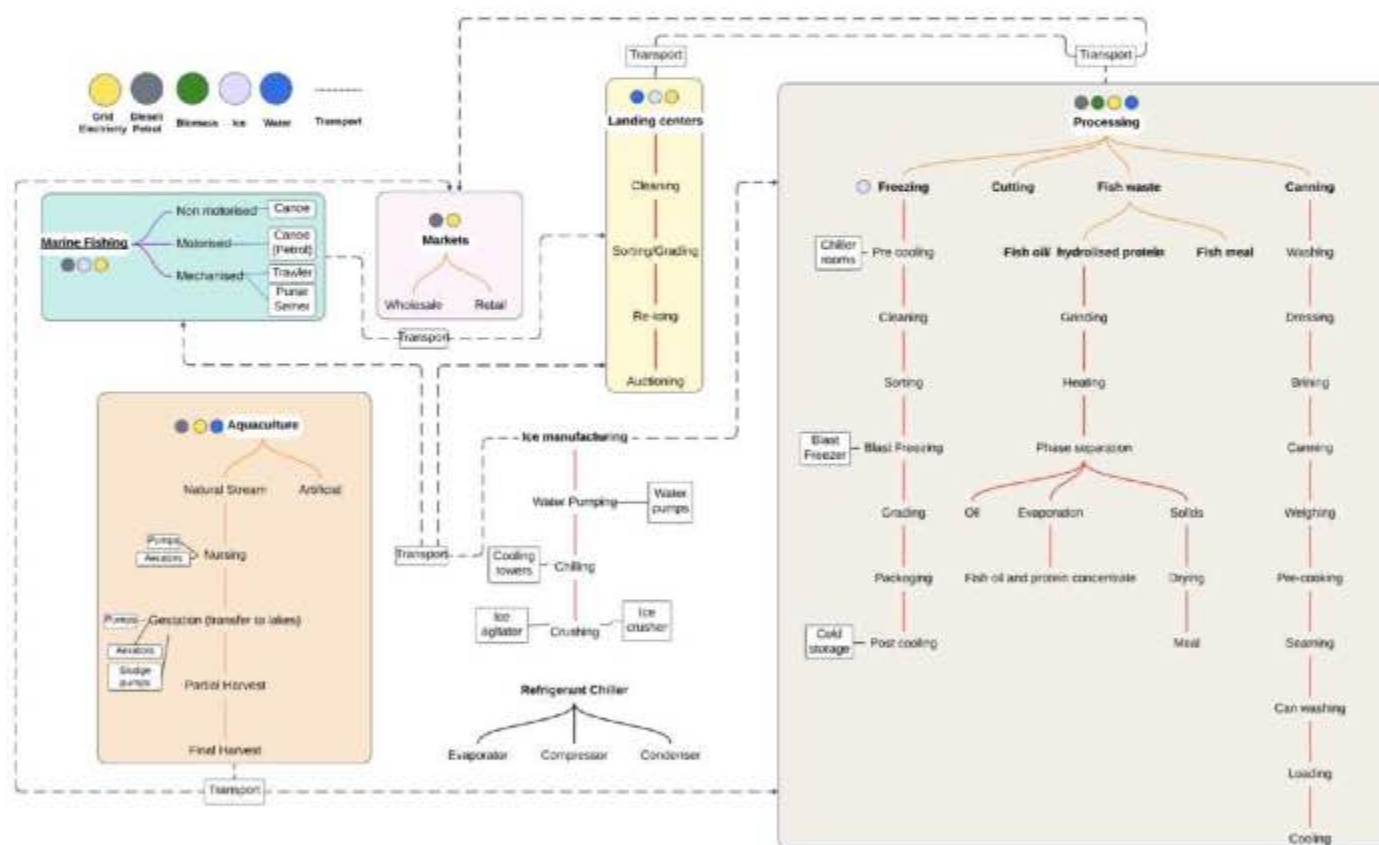


Figure 2: Mapping of Goa state fisheries system (MP Ensystems Research, 2024)



2.0 | LEARNINGS FROM THE BASELINE STUDY OF THE FISHERIES SECTOR IN GOA

The fisheries in Goa is an energy intensive sector with major energy consumption in vessels (due to diesel and ice use) and ice manufacturing industries. To address the complexity of the value chain in our baseline energy calculations, we have looked at the value-chain at sub-system level. The annual energy consumption has been calculated for each sub-system, to arrive at the overall energy use of the value chain. In few cases, the energy consumption has been captured in a range, based on the variations in data captured from different secondary sources and stakeholders¹. Through our base-lining study, we have arrived at the annual energy consumption of the sector to be 2,56,000 - 3,03,800 MWh, having a carbon footprint of 88,600 - 96,600 tonnes of CO₂ equivalent. The annual diesel consumption of the sector is 16,000 kl (GEDA, 2022).

The fisheries sector can be categorised into seven sub-systems, each playing a key role in the entire value chain. For our value chain baselining study, we have considered the following sub-systems-

Input sub-systems

- Marine fishing (Vessels and landing centres)
- Aquaculture

Value addition sub-systems

- Markets
- Fish processing (Exports)
- Fish processing (Fish meal)

Ancillary services sub-systems

- Ice manufacturing
- Logistics

MARINE FISHING

Marine fishing contributes to the highest energy consumption in the sector, contributing to 91-92% of the sector's annual energy consumption. The unpredictability of the fish catch leads to over-fishing (majorly by mechanised vessels) (Rossi. S, 2023) resulting in longer voyages and higher quantity of ice carried on vessels, even when the fish catch could be smaller.

Fishing vessels are major energy guzzlers in the sector, owing to their annual diesel usage of 15,265,043 litres and annual ice usage of 781,946 tonnes on voyages. Besides, ice is also used in the landing centres, for re-icing the catch before it is transported. The ice to fish ratio for re-icing the catch is 1:6, resulting in an annual ice consumption of 21,419 tonnes on landing centres.

The high ice demand in vessels and landing centres, leads to transportation of ice from ice-plants to the landing centres due to lack of ice plants on landing centres, resulting in further energy consumption in ice logistics to landing centres. Thus, the annual energy consumption in

- Vessels (ice and diesel) ranges between 235,219 to 282,322 MWh
- Landing centres (ice for re-icing) is 1,162 MWh.

With marine fishing attributing to an overall energy consumption of 236,381 to 283,484 MWh in a year, this sub-system is a key area for greening of the sector, with focus on optimising diesel use and ice use in vessels. Later in this report we present the scope of renewable energy integrated ice and cold storages on jetties, and thermal energy storage (TES) solutions like phase change materials (PCM) for fish storage boxes to reduce or replace the use of ice.



AQUACULTURE

The state of Goa has 27 active aquaculture farms (7 in North Goa, 20 in South Goa)² with a total aquaculture water surface area (WSA) of 60.93 ha. The major produce from Goa's aquaculture farms is prawn, while there is a growing number of fish farming. Aquaculture as a sector has high energy use, primarily owing to the continuous use of aerators contributing to approx. 77% of energy consumption in a farm (water pumps contributing to approx. 23% followed by sludge pumps having minuscule energy consumption).

During our energy base lining study of the aquaculture sub-system based on operations of the farms we visited in Goa, we arrived at annual energy consumption of a standard farm producing 1.5 tonne of fish per harvest cycle (90 days), covering an area of 0.3 ha, to be 5,824 kWh per tonne of fish produced. The overall annual energy consumption of the aquaculture in Goa is 2,664 MWh, which is high compared to the nascency of the sub-system. Thus, aquaculture provides avenues for renewable energy interventions in aerators and water pumps, to reduce the annual energy footprint.



MARKETS

The prime energy use in the markets is from the ice consumption for re-icing the catch before selling or distributing it through logistics. The ice ratio needed for re-icing depends highly on the length/duration of the haul. Long distance inter-state transportation of fish catches from markets requires higher quantity of ice in comparison to distribution of catch for Goa's local consumption. The ice to fish ratio for fish logistics within the state of Goa is 1:6.



In our energy base-lining study, we assessed the energy consumption in Goa's single wholesale market for fisheries (Magao wholesale market). The ice consumption in the wholesale market was found to be 1,071 tonnes, leading to an annual energy consumption of 58.1 MWh. Further, the logistics for transporting ice from nearby ice plants to the wholesale market contributes to diesel consumption and increased ice requirement (to tackle possible melting during transit to wholesale market). Thus, wholesale and retail markets provide avenues for optimising diesel use, primarily by establishing small-scale ice plants in markets, supported by renewable energy integration. Further, thermal energy storage solutions such as PCM integrated into fish storage boxes can be explored for optimising ice use, for both in markets, and transportation-distribution.



Energy use per tonne of fish
9 kWh



Annual energy consumption
in wholesale market
58.1 MWh

ICE MANUFACTURING

Ice manufacturing is the second highest energy consuming sub-system of the sector, contributing to 14-17% of the annual energy consumption in fisheries. The major energy guzzlers of the sub-system are compressors, emphasising the opportunities for retrofitting with energy-efficient compressors. Ice is manufactured by using cold brine solution (-12 degree Celsius) which freeze water cans into ice blocks, which are crushed before shipping. Ice manufacturers rely on grid electricity and conventional ammonia-based refrigerant (sub-zero temperatures) systems.

Ice-manufacturing is a crucial ancillary service for different sub-systems, majorly for preservation of fish catch in vessels, re-icing on jetties and wholesale market, thus contributing to an annual ice demand of 7,81,946 tonnes, 21,419 tonnes and 1,071 tonnes, respectively. Thus, the cumulative annual energy consumption in ice-manufacturing has been calculated to be 43,641 MWh, and offers several avenues for renewable energy integration.



Energy use per tonne of fish
54 kWh



Annual energy consumption
in ice manufacturing
43,641 MWh

LOGISTICS

Logistics is the backbone for distribution of fish and also ice in the sector. Currently, the inter-state fish distribution and ice logistics (within the state) comprises mainly of 1.4-tonne capacity insulated trucks (51%), followed by 6-tonne insulated trucks (46%) and 10-tonne insulated trucks (3%). The demand for logistics is primarily for transportation of:

- Fish from aquaculture to markets
- Fish waste from markets and jetties to fish-meal plants
- Fish catch and ice from jetties to wholesale markets and fish processing plants (export)
- Ice from ice plants to jetties and markets

The energy consumption of fisheries logistics in Goa is mainly due to the use of diesel, amounting to an annual consumption of 251,058 litres. The annual energy consumption of the logistics as a sub-system has been calculated to be 3,170,863 kWh and the energy use for plying one tonne of fish/ice to be 3.85 kWh. Thermal energy storage-based solutions can be explored for fish storage boxes and vehicles, to optimise the ice demand of logistics.



Energy use per tonne of fish/ice
3.85 kWh



Annual energy consumption
in logistics
3,170 MWh

FISH PROCESSING (EXPORTS)

The fish processing sector catering to exports contributes to 2.9% - 3.4% of the annual energy consumption in fisheries sector of Goa. These fish processing plants also process fish coming from other states before exporting, along with Goa's fish catch. For our calculations, we had focused on the fish caught in Goa, which attributes to 40% - 45% of the total fish processed in these plants.

The annual energy consumption in the fish processing (exports) sub-system has been calculated to be 8,705 MWh, with an energy footprint of 151 kWh per tonne of fish. These plants primarily use electricity and has large use of water and ice, where compressors in refrigeration systems (51% of total energy consumption) and blowers/fans (29% of total energy consumption) are the most energy intensive components. This gives rise to the need for energy efficient compressors. Keeping in mind the energy intensive operations in processing plants, it provides avenue for energy management system to optimise energy usage, to assess the quantum of energy consumed and make informed decisions. The ample rooftop space available in processing plants, are key opportunities for solarisation of the plants. The discussions later in the report explore, multiple green technological solutions that can be explored for tackling the high energy demand of fish processing plants.



Energy use per tonne of fish
151 kWh



Annual energy consumption
in fish processing
8,705 MWh

FISH PROCESSING (FISH MEAL)

The fish waste processing sub-system contributes to 1.6% - 1.9% of the total annual energy consumption of the sector. There is only one prominent fish waste processing plant in Goa. Boilers are the key source of energy consumption in these plants and are met using coal (76% - 82%), used for generating steam in processing activities. Grid electricity caters to the rest of the energy demand (18% -24%). The energy use for processing 1 tonne of fish waste has been calculated to be 725 - 833 kWh³.

The annual energy consumption in fish meal plant has been calculated to be 4,935 - 5,666 MWh, calculated using the fish waste generated from fish caught and processed in Goa. Our study has identified, biomass/bio diesel-based boilers, concentrated solar thermal solutions, solarisation of the plant, to be possible avenues for optimising the high coal and electricity consumption in fish waste plants.





Energy use per tonne of fish waste
725- 833 kWh



Annual energy consumption
in fish meal plant
4,935- 5,666 MWh

ENERGY DEMAND OF FISHERIES SUB-SYSTEMS – THE BIG PICTURE

Goa's fisheries sector is critical to the commercial and economically activities of the state. The sector consumes about 0.9% of the entire state's energy consumption (GEDA, 2023) and has the potential to integrate into the renewable sources of energy such as solar, wind, biomass, TES and others. As discussed above, marine fishing primarily using motorized and mechanized vessels is the key source of energy consumption in the sector, followed by ice manufacturing. The share of each-sub system in the overall energy consumption of the sector has been provided below, followed by a system map of the entire sector capturing the sub-system wise energy consumption and processes.

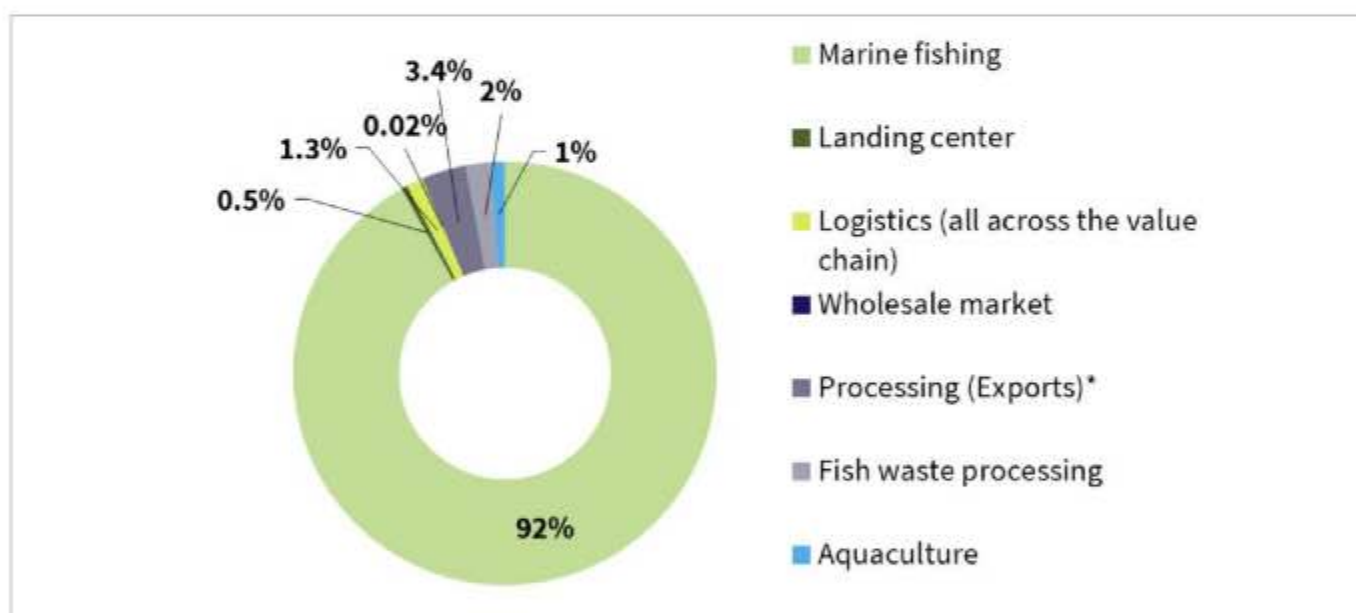
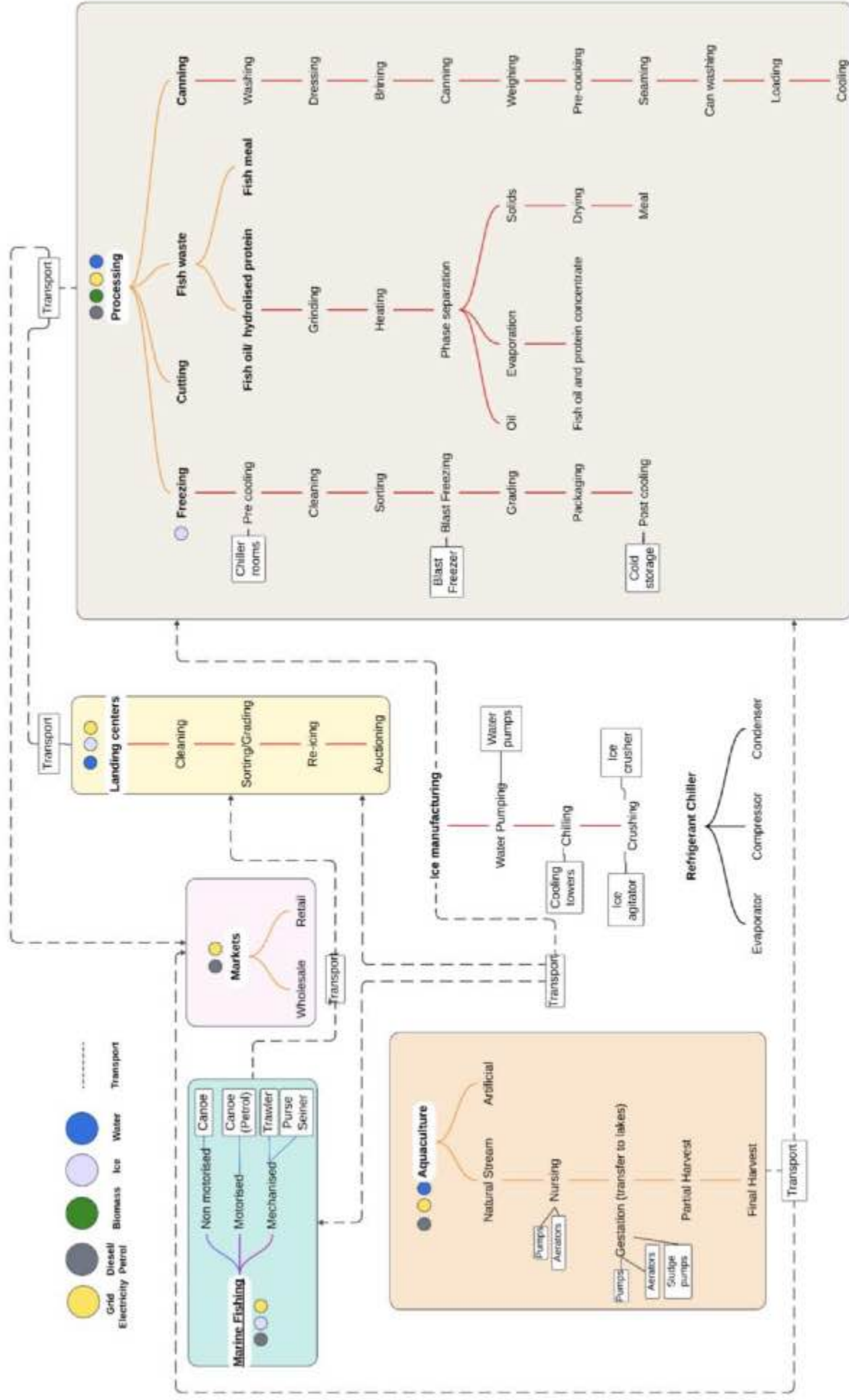


Figure 3: Energy consumption (%) in different sub-systems of the fisheries sector in Goa (MP Ensystems Research, 2024)

Figure 2: Mapping of Goa state fisheries system (MP Ensystems Research, 2025)





3.0 | CLEAN TECHNOLOGY INTERVENTIONS FOR STRONGER RENEWABLE ENERGY UPTAKE AND DECARBONISATION

The fisheries sector in the state of Goa offers a unique landscape for implementing renewable energy interventions.

Based on our baseline study propulsion, cooling and heating have been identified as the three major energy-intensive processes in the entire value chain: (i) The propulsion of mechanised and motorised vessels requires a significant amount of energy from fossil fuels such as diesel and petrol, (ii) the perishable nature of fish leads to a major need for ice to prolong its freshness, while ice manufacturing is an energy-intensive process, and, (iii) fish processing phases entails blast freezing or boiling/steam use, depending on the end products, such as frozen fish produce, mostly for exports and fish processing activities, including fish waste. They offer significant opportunities for renewable energy uptake optimised with energy conservation and efficiency measures enabling reduction in the energy footprint. Such a transition is complimentary to the current activities of the sector, leading to cleantech adoption with minimal disruptions.

Fisheries sub-systems have several avenue for adopting clean energy technologies. Although several of them require dedicated solutions, many cleantech solutions can have overlapping applications across the sub-systems.

Fishing vessels require customised interventions owing to the spatial and operational landscape of the sub-system, encouraging technology providers to stretch beyond the standard solutions widening the scope of clean technology applications. On the other hand, the fisheries sector has immense potential to replicate the efforts for clean energy adoption undertaken by the agriculture and the MSME sectors. Several technologies such as solarised pumps and cold storages, for instance, are readily deployed in other sectors and can be replicated with minor tweaks in the fisheries value chain.

IoT based energy management system (EMS) applications across the sector (particularly in ice manufacturing and processing centres) shall offer monitoring of energy use and machinery health and holds the key to short-term and long-term greening goals. Such EMS solutions offer, both energy and monetary savings usually with an under a year payback period (DESL, 2022). Monitoring also enables process optimisation through signalling efficiencies in the operations.

Based on the potential implementation approach/strategy the cleantech interventions can be classified into three:

- Retrofitted
- Replaced
- New addition



The table below distinguishes the solutions on two broad categories i.e., on the nature of the intervention, such as Energy conservation, Energy Efficiency, Renewable energy and Energy Management while also examining if these interventions are retrofittable (blue fill), or complete replacements (yellow fill) or new addition (green fill).

The techno-commercial details of the solutions discussed below are available in the 'Clean Technology Compendium' available in the Annexure of this report.

Table 3: Cleantech applications identified for sub-system levels (MP Ensystems Research, 2024)

Sub-systems & Clean technology interventions	Energy conservation	Energy efficient	Renewable energy	Energy management
AQUACULTURE	Solar-based and TES-integrated cold storage	Energy-efficient motors/pumps	Solar aerators Solar pumps Solar-wind hybrid pumps Solar-wind hybrid aerators Solar-wind hybrid cold storage Solar cold storage	IoT based sub-metering
MARINE FISHING (VESSELS)	Propulsion speed reduction TES-based chiller TES boxes, tabs and pouches Fishing vessel design changes Insulated ice boxes for fish storage	Otter board (V-board) Semi-pelagic trawl system Turtle excluder device Energy-efficient motors/pumps LNG run boats LPG run boats	Solar boats Solar-wind hybrid technology on vessels for ancillary consumption Bio-diesel run boats Solar PV or wind-hybrid refrigeration system Electric boats	

Sub-systems & Clean technology interventions	Energy conservation	Energy efficient	Renewable energy	Energy management
LANDING CENTRES	Solar-based and TES-integrated cold storage TES boxes, tabs and pouches Insulated ice boxes for fish storage Solar-based and TES-integrated dryer	Energy-efficient motors/pumps	Solar wind hybrid cold storage Solar wind hybrid ice plant Solar PV rooftop ice plant Solar PV/ wind hybrid-based vessel battery recharging Solar-wind hybrid technology on jetties for ancillary consumption Solar fish dryer Biomass run ice-making machine	IoT based sub-metering
MARKETS	TES boxes, tabs and pouches Insulated ice boxes for fish storage Solar-TES hybrid cold storage		Solar wind hybrid cold storage Bio-energy production from fish waste Biomass run ice-making machine Biomass run cold storage Solar vending machine for descaling, cutting and display	
LOGISTICS	TES based trucks TES boxes, tabs and pouches Insulated ice boxes for fish storage	Reefer trucks (diesel-based)	Electric trucks (EV, no cold storage)	



Sub-systems & Clean technology interventions	Energy conservation	Energy efficient	Renewable energy	Energy management
ICE MANUFACTURING	Solar-based and TES-integrated cold storage TES integrated cold storage	Energy-efficient compressors	Biomass run ice-making machine Solar wind hybrid cold storage	IoT based sub-metering
FISH PROCESSING (EXPORTS)	Solar-based and TES-integrated cold storage	FRP-based fan blades Energy-efficient motors/pumps	Solar wind hybrid cold storage Biomass run ice-making machine	
LOGISTICS	TES integrated cold storages	Energy-efficient compressors	Solar wind hybrid installation Solar PV installation Concentrating Solar Thermal (Steam generation) Biomass/biodiesel-based boilers	

The fisheries value chain offers significant opportunities to offer cleantech solutions leveraging various available renewable resources. These solutions either deploy energy conservation, energy efficiency, energy monitoring measures and/or utilise renewable resources of energy reducing fossil fuel dependence directly or indirectly.

3.1 SOLAR PV, SOLAR PV-WIND HYBRID AND CONCENTRATED SOLAR THERMAL APPLICATIONS

The fisheries sector readily offers various avenues for easy integration of solar PV systems. Some these include cold storages, aerators, pumps, ice-manufacturing and fish processing plants, fish dryers among others. These are highly viable for solar PV-wind hybrid integration for ensuring longer RE access.

Small and marginal fishers are exposed to distress selling due to unavailability of temperature-controlled storage as reported by the stakeholders in Goa. Solar PV-based and TES-integrated cold storages have greater potential to mitigate this challenge. With subsidies available under government initiatives such as PMMSY for up to 40% of unit/project cost, their uptake can be scaled quickly (refer Annexure 10.5 for technology details). Such RE-based storage systems are well established in the agriculture sector across the country with over 1400 solar cold storages operational across the country (Ministry of New and Renewable Energy, 2025). Considering the robustness and market presence of these solutions, their adoption is a low-hanging opportunity.

RE interventions for generating steam in activities such as canning and in food processing is already being adopted, with greater use of concentrated solar thermal (CST) solutions in the country. With the capability to scale up the quantum steam productions from 5kg/hour to 400kg/hour and more the solution has versatile application and its modularity can be leveraged across diverse requirements of adopters (Refer Annexure 10.7). This mature technology is primarily replacing coal-based or grid-connected boilers. It utilises the reflective properties of a mirror, reflecting and concentrating solar radiation to a receiver with multiple mirrors, generating thermal energy which is then used for multiple purposes such as steam or electricity generation. CST solutions with systems that have molten salt thermal storage technology embedded offer energy services post solar hours (sunrisecsp.com, 2022).

Electric and solar based fishing boats are being tested in various parts of the country particularly in inland water ecosystems with optimistic results (CIFT, n.d.), and is positioned to become a bellwether for decarbonizing initiatives in the fisheries sector. While the prototypes show promising results, the solutions are likely to be realized over a medium to long-term period. However, there is a visible trend in deploying solar PV systems onboard or using solar-charged batteries for ancillary services in fishing vessels. Leveraging such awareness and increasing acceptance among stakeholders can be important in furthering public policy for promotion of clean technologies and act as a key adoption catalyst.

3.2 IOT SYSTEMS FOR RESOURCE EFFICIENCY AND DECISION MAKING

Considering the energy demand of fisheries value chain, particularly fossil fuels, it makes the sector highly susceptible to energy costs and fuel price instability. Energy efficiency is a necessary complementary measure to optimise clean energy adoption, making the returns on these interventions attractive to end-users. Hence opportunities for the actors to understand energy-use inefficiencies is critical. The study found that there were virtually no IoT installations used by stakeholders across the value chain to monitor energy usage in the sub-systems. Marginal capital expenditure in relation to potential savings and optimisation offered by modular IoT systems make a compelling case for wide scale adoption however it requires an awareness-based fillip (refer Annexure 10.6 for technology details).



Data from IoT based submetering would enable processing units, for instance, to be motivated to replace dated motors, pumps and compressors, with newer and more efficient variants. Such energy efficient interventions have proven to have quick returns, as they can lead to significant energy savings, optimise resource utilisation and compliment decision making in improving operational efficiency.

3.3 THERMAL ENERGY STORAGE (TES) APPLICATIONS

Storage of renewable energy in thermal storage solutions extends the time for energy utilisation beyond the generation hours. Latent heat is stored in thermal energy batteries (as ice, chilled water or in phase-change materials), and are used for a wide array of cooling services. These solutions are increasingly playing a key role in food production/processing systems with attention to reducing spoilage and used across various cold-chain solutions. (Sindhu & Kulloli, 2023). The recent guidelines for benchmarking solar cold storages by the Ministry of New and Renewable Energy has also promoted the integration of TES to further acknowledging their effectiveness (Ministry of New and Renewable Energy, 2025). By integrating renewable energy TES-based solutions offer versatile applications as an essential cleantech intervention in storing and transport of fish in temperature-controlled environments. Thermal energy storage systems offer modular solutions enabling easier adoption across the value chain, in the form of TES boxes, tabs, pouches, and TES based trucks. TES based trucks with relatively shorter payback periods and coupled with low operational costs make them a viable alternate to conventional diesel reefer trucks (Refer Annexure 10.9 for technology details). TES interventions offer more than 5 years+ lifespan and 2000+ recharging cycles such that the RoIs justify the slightly higher initial capital expenditure and become financially viable with longer usage. (Refer Annexure 10.10 for technology details). The use of TES interventions in vessels can complement ice usage for the storage of catch.

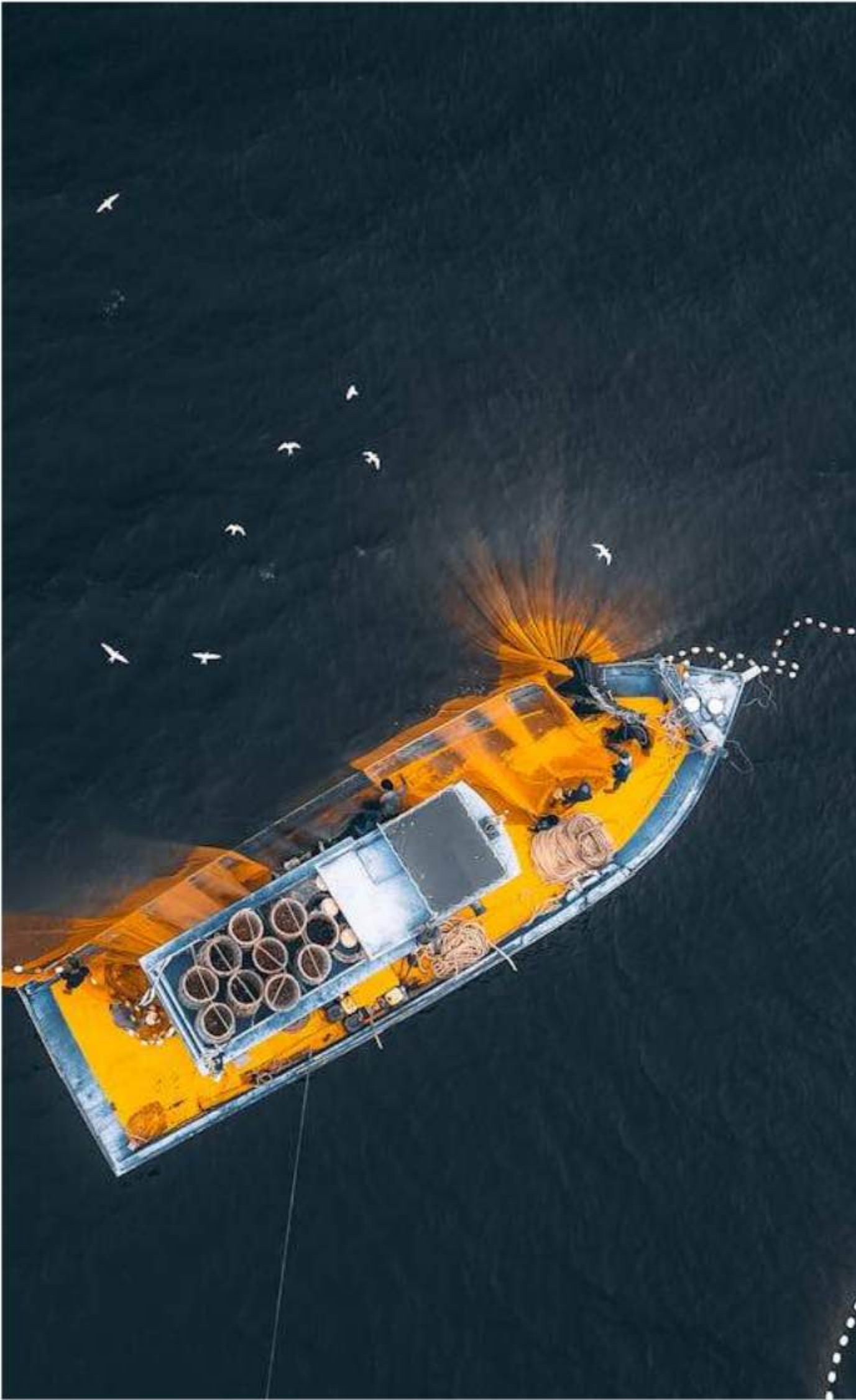
3.4 INTERVENTIONS IN MARINE FISHING

Mechanised and motorised marine fishing is the most energy intensive activity in the fisheries, accounting for over 90% of the value chain's energy consumption dependent on fossil fuels. Spatial constraints and operational environment make most renewable interventions challenging. Some of the ongoing R&D by the Central Institute of Fisheries Technology (CIFT, n.d.) entail exercises and experiments to optimise fuel consumption in vessels. Certain practices such as propulsion speed reduction/capping, vessel design changes focused on reducing drag can have a considerable impact on the fuel consumption. Interventions such as installation of otter V boards in trawlers (a retrofitable solution) can be adopted on a large scale, due to low costs and shorter payback periods. Some of these are already recommended by the PMMSY scheme.

Alternate fuels such as LNG/LPG have also been pilot-tested by CIFT against diesel and/or petrol run boats through engine retrofiting. The solutions have lower carbon (20-25% lower) and sulphur dioxide (90-95%) emissions and can be strong stop gap measure before solar based boats become the norm (MP Ensystems Research, 2024). They also offer more than 30% operational savings due to reduction in fuel costs leading to a less than 4-month payback period mitigating initial capital expenditure concerns and increasing fisherfolk revenue through reduced costs (Refer Annexure 10.8 for technology details).

3.5 BIO-ENERGY APPLICATIONS

The main source of bio-energy is biomass abundantly available in the state and is a relatively cleaner source of energy that has potential applications in the fisheries sector. One key candidate is fish waste, often a key cause for environmental pollution, can be used for producing bio-diesel, positioned as a key substitute for diesel via bio-diesel blending. Bio-diesel blended run boats is a crucial medium-term intervention that reduced the GHG emissions, however requires R&D in engine design for mainstream adoption.



4.0 | STRATEGIZING CLEAN TECHNOLOGY UPTAKE IN THE VALUE CHAIN

The clean technologies identified through our study is categorised as solutions for energy conservation, energy efficiency, renewable energy and energy management for their application identified in each sub-system, as shown in table-1. In order to reap the benefits of technology adoption, the technology transitions proposed here to be smooth. Keeping this in mind, we have further categorised the technological interventions for each sub-system, based on their probable adoption timeline, as show in table-2.

In this section, we have examined how the curated list of clean technologies can be effectively adopted in the value-chain. Depending upon how well these solutions meet each sub-system's operations and needs, the assessment examines if they can be adopted in a shorter time frame. To this end, the following criteria has been considered, i.e., if they have

- relatively less installation cost
- easy availability in the market
- policy/subsidy support for their uptake
- easier deployment (needs no complex ancillary infrastructure)
- high scalability of sizes and capacity (based on specific needs of a sub-system)
- stakeholder awareness, particularly of the sub-system

The adoption of clean technologies in the fisheries sector's value chain depends on factors like installation costs, market availability, infrastructure requirements, scalability, subsidies, and awareness. Energy-efficient motors/pumps, for instance, are considered a short-term intervention due to their low costs, ease of use, and market availability. While a technology might have applications across sub-systems, our study found that technology uptake varies by the sub-system, so we've categorized interventions by feasibility and timeline, evaluating them based on parameters like cost, scalability, and infrastructure needs, and assigning scores (1-5) to determine their viability.

Any technology's adoption in the value chain is highly governed by the above criteria. For an instance, energy efficient motors/pumps have considerably low installation costs compared to other clean technology interventions system. They possess easy market availability, lack of dependence on ancillary infrastructure, easy scalability owing to their modularity. Although, there are no dedicated subsidies for their adoption, the value chain players have decent awareness about them. Keeping in mind all these criteria, energy efficient motors/pumps have been evaluated to be short term interventions for the different sub-systems of the sector.

- **TECHNOLOGY COST:** The investment cost and operational expenditure involved in deploying a technology in the sub-system, impacts the feasibility of the technology for that sub-system. The technologies have been assigned relative scoring (1-5) dependent on the cost of their installation, where 1 indicates very low cost, 2 indicates low cost, 3 indicates moderate cost, 4 indicates high cost and 5 indicates very high cost of installation in the considered sub-system. The technology cost scoring has been assigned in a relative manner, keeping in mind the installation cost of other clean technology solutions for the considered sub-system.
- **TECHNOLOGY MATURITY:** The commercial availability of technology is a key factor, in understanding the possibility of its adoption in a sub-system. Hence, assessing the technology's market availability, is an important aspect for determining its feasibility. The technologies have been assigned relative scoring (1-5) dependent on their maturity, where 1 indicates still under R&D, 2 indicates prototypes are being tested, 3 indicates ready for commercialisation, 4 indicates already commercialised and 5 indicates high market availability.
- **TECHNOLOGY POLICY SUPPORT:** The available government support in the form of subsidies and policies is a strong impetus for the uptake of any technology in the sub-system. The technologies have been assigned relative scoring (1-5) dependent on the available support, where 1 indicates very less available support, and 5 indicates very high available support for up take in the sub-system under consideration. The technology policy support scoring has been assigned in a relative manner, keeping in mind the available support for other clean technology solutions for the considered sub-system, where dedicated policy support or subsidy has been assigned the highest score.
- **EASE OF TECHNOLOGY DEPLOYMENT:** The need for additional ancillary infrastructure to support technology deployment, impacts its ease of deployment in the sub-system. The technologies have been assigned relative scoring (1-5) dependent on the available support, where 1 indicates very easy to deploy, and 5 indicates very difficult to deploy based on the need for additional infrastructure for deployment in the particular sub-system. The technology deployment scoring has been assigned in a relative manner, keeping in mind the infrastructure needs for deploying other clean technology solutions in the considered sub-system
- **TECHNOLOGY SCALABILITY:** The robustness of any technology is dependent on the potential of scaling it to different sizes and capacity based on the needs and specifications of the considered sub-system. The technologies have been assigned relative scoring (1-5) dependent on their scalability, where 1 indicates very less scalable, and 5 indicates very highly scalable based on its modularity and ability to be scaled according to operations of the considered sub-system.
- **PUBLIC AWARENESS FOR TECHNOLOGY UPTAKE:** The awareness of the stakeholders of a sub-system regarding the benefits of adopting a technology, becomes crucial for its uptake in the sub-system. The technologies have been assigned relative scoring (1-5) dependent on public awareness about their benefits, where 1 indicates very less awareness, and 5 indicates very high awareness of the stakeholders of the considered sub-system regarding benefits of the uptake. The technology awareness scoring has been assigned in a relative manner, keeping in mind the awareness of the stakeholders regarding benefits of the other technical interventions.

The technological interventions have been rated on a Likert Scale⁴ of 1 to 5 for each parameter captured above, based on our field understanding and key stakeholder opinions. The overall feasibility score for each technological intervention has been normalised to arrive at the final score for each technology ranging from 0 to 1.

Based on their normalised feasibility score, the technologies have been mapped as short term, medium term and long-term interventions for the respective sub-systems. Short term, medium-term and long-term refers to the proposed timeline for the uptake of these technologies. The higher the feasibility score, the shorter the time period in which it can be up taken in the sub-system. Short term refers the readiness and availability of the technology for immediate uptake in the value chain over period of 0-3 years, while medium-term indicates uptake over 3-5 years, and long-term solutions are expected to be more prevalent in the markets over a period of more than 5 years.



Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

AQUACULTURE 	SHORT TERM	1	
		0.9	• Energy-efficient motors/pumps • Solar pumps
		0.8	• IoT based sub-metering
		0.7	• Solar aerators • Solar-wind hybrid aerators • Solar-wind hybrid pumps
	MEDIUM TERM	0.6	• TES integrated cold storages • Solar cold storage
		0.5	• Solar-wind hybrid cold storage
		0.4	
	LONG TERM	0.3	• Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

MARINE FISHING (VESSELS) 	SHORT TERM	1	• Propulsion speed regulation • Insulated ice boxes for fish storage
		0.9	• Energy-efficient motors/pumps
		0.8	
		0.7	• Otter board (V-board) • Semi-pelagic trawl system • Turtle excluder device • Insulated ice boxes for fish
	MEDIUM TERM	0.6	• Fishing vessel design changes • LNG run boats • Solar PV or wind hybrid on vessels for ancillary consumption
		0.5	• TES boxes, tabs and pouches
		0.4	• Solar PV or wind-hybrid for refrigeration system
	LONG TERM	0.3	• TES-based chiller
		0.2	• Solar boats
		0.1	• Electric boats
		0	• Bio-diesel run boats

Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

LANDING CENTRES 	SHORT TERM	1	Insulated ice boxes for fish storage
		0.9	
		0.8	Energy-efficient motors/pumps
		0.7	- Solar PV rooftop ice plant - IoT based sub-metering
	MEDIUM TERM	0.6	- Solar PV or wind hybrid vessel battery recharging - Solar PV or wind hybrid on jetties for ancillary consumption - Solar cold storage
		0.5	- Solar wind hybrid cold storage - TES integrated cold storages - Solar wind hybrid ice plant - Solar-electric fish dryer - TES boxes, tabs and pouches - Biomass run ice-making machine
		0.4	
		0.3	- Solar based and TES integrated fish dryer - Solar-based and TES-integrated cold storage
	LONG TERM	0.2	
		0.1	
		0	

MARKETS 	SHORT TERM	1	Insulated ice boxes for fish storage
		0.9	
		0.8	
		0.7	- Solar PV rooftop ice plant - Solar vending machine for descaling, cutting and display
	MEDIUM TERM	0.6	Solar cold storage
		0.5	- Solar wind hybrid cold storage - Solar wind hybrid ice plant - TES boxes, tabs and pouches - Bio-energy production from fish waste - TES integrated cold storages
		0.4	
		0.3	Solar based and TES integrated cold storage
	LONG TERM	0.2	
		0.1	
		0	



Table 1: Adoption timeline classification of technologies based on feasibility (MP Ensystems Research, 2025)

LOGISTICS 	SHORT TERM	1	• Insulated ice boxes for fish storage
		0.9	
		0.8	
		0.7	
	MEDIUM TERM	0.6	
		0.5	• TES boxes, tabs and pouches
		0.4	• TES based trucks • Reefer trucks (diesel-based)
		0.3	• Electric trucks (EV, no cold storage)
	LONG TERM	0.2	
		0.1	
		0	

ICE MANUFACTURING 	SHORT TERM	1	
		0.9	
		0.8	• Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
	MEDIUM TERM	0.6	• Solar wind hybrid cold storage • TES integrated cold storages
		0.5	
		0.4	
	LONG TERM	0.3	• Solar-based and TES-integrated cold storage
		0.2	
		0.1	
		0	

PROCESSING (EXPORTS) 	SHORT TERM	1	
		0.9	
		0.8	• FRP-based fan blades • Energy-efficient motors/pumps • Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
		0.6	• TES integrated cold storages • Solar wind hybrid cold storage
	MEDIUM TERM	0.5	
		0.4	
		0.3	• Solar-based and TES-integrated cold storage
	LONG TERM	0.2	
		0.1	
		0	
		0	

PROCESSING (FISH MEAL) 	SHORT TERM	1	
		0.9	
		0.8	• FRP-based fan blades • Energy-efficient motors/pumps • Energy-efficient compressors • IoT based sub-metering
		0.7	• Solar PV installation
		0.6	• Concentrating Solar Thermal (Steam generation) • Solar wind hybrid installation
	MEDIUM TERM	0.5	
		0.4	• Biomass based boilers
		0.3	• Biodiesel based boilers
	LONG TERM	0.2	
		0.1	
		0	
		0	

The technological interventions for each sub-system have been classified into short-term, medium-term and long-term and captured in the table below, where their colours are indicative of their feasibility scores.

As represented above, the feasibility of any technological intervention is contextual to its deployment in a sub-system. The feasibility of a technology depends highly on the key energy consuming components along with the needed and existing infrastructure of the sub-system. The technology interventions mapped above under short term, medium term and long-term solutions have been discussed below.



4.1 POLICY ATTENTION FOR ENERGY EFFICIENT TECHNOLOGIES CAN CREATE WIDER RECEPTION

Energy efficient solutions are a low hanging opportunity for reducing the energy and emission footprint of the sub-systems. They have been evaluated to be one of the most feasible interventions applicable to the entire value chain owing to its robust performance, strong dissemination in markets, easy replacement, and scalability with strong awareness among stakeholders. The transition of existing motors and pumps used in aquaculture, landing centres, ice manufacturing plants, fish processing industries, into energy efficient ones, thus can be a short-term step towards greening of the fisheries sub-systems. Similarly, energy efficient compressors for ice manufacturing industries and fish processing (exports), can be up taken as short-term opportunities. For instance, FRP based fan blades can reduce energy consumption in fish processing plants (exports and wastes) and can be up taken under the short-term plan. The PM-MKSSY initiative launched as an extension of the existing PMMSY scheme, has focus on energy efficient operations of the fisheries sector, and thus energy efficient solutions can receive higher support. To accelerate the adoption of these short-term interventions, more dedicated policies and subsidies can play a key role.

4.2 RENEWABLE ENERGY SOLUTIONS SHOULD BE CENTRAL TO ALL NEW INFRASTRUCTURE PROJECTS FOR FISHERIES

Under the PM-MKSSY several avenues offer for wider renewable energy deployment and impact the energy use of the sector. To this end, the needed infrastructure development in the sub-systems of the sector, can be integrated with RE based technologies. Solar PV and solar wind-hybrid installations can have varying feasibility across the sub-systems based on their intervention area and the sub-system under consideration.

Solar/wind-hybrid pumps and aerators are low hanging opportunities for greening the aquaculture sector, owing to their low cost, market availability and ease of deployment. Such off-grid solutions are of key relevance as aquaculture farms benefit from subsidised electricity tariffs offered for the agriculture sector in Goa (JERC,2024). Solar pumps can receive support from KUSUM component B subsidy, under the agriculture connection mandate, in addition to the PMMSY subsidy for pumps and aerators. As the sector is poised to grow rapidly, with large number of aerators continuously operated, the opportunity for greening them is large. Thus, solar and hybrid aerators and pumps can be short-term technological interventions for aquaculture.

Solar/wind-hybrid cold storages can be a probable solution for markets, landing centres and aquaculture to reduce distress selling. Even though solar/wind-hybrid cold storages are easy to deploy, they have been evaluated to be medium-term solution for the different sub-systems, due to its high cost, lack of dedicated support, less market availability for fisheries sector along with high ease of deployment. Similarly, solar PV/ wind hybrid ice plants can be probable medium-term solutions for landing centres and markets. Solar PV/ wind-hybrid installation in fish processing plants (exports and waste) and ice manufacturing can be suitable short-term interventions owing to the availability of space for such installations. Concentrated solar thermal solutions, use in fish processing plants (exports and waste), for reducing dependencies on grid and fossil fuels, can be up taken in the medium time period.

Solar PV or solar wind-hybrid solutions can also be installed in fishing vessels for ancillary consumption and refrigeration system, to reduce the diesel consumption and ice loss, respectively. Both of these interventions can be up taken in the sub-system in the medium time frame. Solar PV/wind hybrid installation on jetties for battery charging and other ancillary consumption can be medium-term interventions, for reducing the electricity consumption on jetties and can be adopted faster with the help of targeted policy/subsidy support. Solar vending machine for descaling, cutting, display and storage of fish can be a suitable intervention for markets, which can be adopted in the short-term period owing to their moderate cost, available policy support, ease of deployment and scalability.



4.3 ENERGY MANAGEMENT SOLUTIONS IMPORTANT FOR INFORMED DECISION MAKING

Energy management solutions can help optimise the energy consumption across the sector, through efficient monitoring of the existing energy use. IoT based sub-meters are crucial for energy monitoring of the processes, especially in sub-systems with high energy consumption. The sub-meters are easily available in the market, affordable, can enjoy support under the ambit of energy efficiency and has moderate awareness among the stakeholder players. Based on their area of intervention, sub-meters can be scaled to different sizes with different potential energy savings. Thus, IoT based sub-metering has been evaluated to be highly feasible across all the sub-systems, bringing them under the scope of short-term technology uptake.

4.4 INVESTMENTS FOR ENERGY CONSERVATION SOLUTIONS WILL IMPROVE REVENUES

Energy conservation interventions can help in optimising the electricity consumption and ice usage in different processes of the sector, thus creating avenues for improving revenue margins, through efficient use of ice and electricity.

Insulated ice boxes for fish storage, are low hanging opportunities in jetties, markets and fish logistics, which to optimise ice loss, thus reducing the energy footprint of ice-manufacturing. These boxes are being provided by government to few retail markets and jetties like Vasco fishing market. Further, their low costs, market availability, scalability and public awareness, makes them highly feasible for adoption in the sector.

TES retrofitted storage boxes for fishing vessels, landing centres, markets, fish carrying vehicles have been evaluated to be probable solutions for medium-term uptake. TES integrated grid connected cold storages can be explored as a medium-term solution for aquaculture, landing centres, markets, ice manufacturing industries, fish processing (exports) plants to optimise electricity consumption. However, TES integrated solar based cold storages can be up taken in a longer term owing to their higher cost of installation, lesser technology maturity, more difficulty in deployment, less scalability and less stakeholder awareness. Thus, TES integrated cold storages can be up taken in the medium-term and greening of the cold storages can be further enhanced by solarisation of the TES integrated cold storages in the longer term. Similarly, TES integrated solar based fish dryers can also be a long-term solution for landing centres to couple the benefits of solarisation and energy conservation in the long run.

TES based chillers for fishing vessels can be long term solution for optimising the ice use in vessels especially in case of long trips. Their very high cost, lack of market availability, less available support, lack of scalability and public awareness, make them feasible in the long term. TES based fish logistic vehicles can be explored for optimising the ice use in long inter-state hauls.

4.5 FISHING VESSEL DESIGN INTERVENTIONS CENTRAL FOR CLEAN ENERGY TRANSITION

Keeping in mind the challenges of installing RE-based systems on vessels future vessel design are expected to accommodate such needs. While new battery-operated vessels with sufficient torque⁵ are now available in India, this study has not been able to establish their commercialization status. However, these boats have onboard renewable charging installations indicating a new generation of electrified boats that will be available in medium to long term. However, retrofits of existing vessels and improving operational efficiency are easy to adopt. Propulsion speed reduction, otter board (V-board), semi-pelagic trawl system, and turtle excluder are such solutions for enhancing energy efficiency in vessels. Their low cost, market availability, ease of deployment, and high scalability makes them very feasible.



With higher policy support and public awareness, their uptake can be further upscaled in the sub-systems. Design changes in fishing vessels can further enhance their efficiency, making them ideal for medium-term uptake owing to their comparatively higher cost and deployment needs. Fuel changes in fishing vessels shall be a key step in reducing the emissions arising from high diesel consumption of the sub-system, like transitioning to LNG run boats, bio-diesel run boats, solar boats and electric boats. However, unlike LNG run boats, the other interventions have high cost, less technology maturity and awareness, lack of substantial policy support, deployment and scalability challenges. Thus, LNG boats can be medium-term solution for fishing vessels, however solar, bio diesel and electric boats can be up taken in the long-term scenario.

4.6 BIO ENERGY WILL BE KEY IN OPTIMISING DIESEL AND ELECTRICITY USE

Bio energy-based solutions like biomass and biodiesel provides potential avenues for optimising grid dependency and diesel consumption of the sector. Biomass and biodiesel-based solutions for the sub-systems can help reduce the carbon footprint of the sector, however they cannot be up taken in the short-term period, owing to their high cost, lack of market availability, scalability issues. With increased policy and infrastructure support, development of the supply chain, enhanced public awareness, these solutions can be more easily and quickly adopted in the sector. Biomass based boilers are medium-term solution for fish waste processing, however biodiesel-based boilers come can be long-term solutions due to lesser scalability, higher cost, and need for R&D to tackle clogging of boilers. Biomass run ice making machines can be small scale, medium-term solutions for landing centres and ice manufacturing plants to reduce the carbon footprint of ice consumption. The fish waste generated in the markets can be utilised to produce bio-energy, which can contribute to electricity production. This can be a medium-term intervention for retail markets, for judicious utilisation of the fish which would have otherwise gone for waste. With higher policy support and awareness, this initiative can be up taken in a shorter time frame.



5.0 | CURRENT POLICIES, PROGRAMS AND FINANCING FOR ACCELERATING TECHNOLOGY UPTAKE

Several policies and program initiatives of the Central and State government of Goa offer avenues for bolstering the green transition of the fisheries sector and can benefit from available subsidies.

The following table aims at capturing the key policies, programs and initiatives in the state of Goa, for promotion of sustainability in the fisheries value chain.

Initiative	Description	Supporting policy/ nodal department	Recommendations
Climate Resilient Coastal Fishermen Villages (CRCFV): Arambol and Cakra Distribution of fund- 100% central funding 70% for infra development and 30% for economic activities	Fund of INR 2 crores has been allocated per village. Focus on: • Development of essential fisheries infrastructure and facilities like drying yards, processing centres, jetties, markets, ice plants cold storage units and emergency rescue facilities. • Creation of sustainable livelihood opportunities- seaweed farming, artificial reefs, sea ranching, ornamental fish farming and aquaculture activities, green fuels, safety and security measures for fishermen • Insurance, livelihood and nutritional support, Kissan Credit Cards. • In Arambol, there has been support for key initiatives like fish market, toilet block, high mast, solar lighting, emergency rescue facilities, ice making machine, solar fish dryer, weather station, stock enhancement through sea ranching. • In Cakra, there has been support for upgradation of facilities and high mast and solar shrimp dryer at Oxdel jetty.	PMMSY NFDB- Nodal agency Target- 100 coastal villages as Climate Resilient Fishermen Villages	The funds for CRCFVs can be leveraged for RE integration in the villages. Technologies such as solar dryers, solar-wind hybrid interventions in cold storages, jetties and ice plants can be listed under the infra development fund.

Initiative	Description	Supporting policy/ nodal department	Recommendations
Cuncolim Industrial Estate: Treated water from fish units reused for watering 5,000 trees and for processes in steel plants.	The treated water from the fish units' Effluent Treatment Plant (ETP) is transported to steel plants, preventing discharge of approx. 700KLD, which would have caused ground water and nearby water bodies contamination.	Goa State Pollution Control Board (GSPCB)	Such initiatives can be explored for fish meal plants, which can reduce the pollution challenges that local communities face. This will boost sustainability of fish meal plants which cater to the value addition and reduction in fish produce waste
Margao Wholesale market: Proposed cold storage, fish testing laboratory and ice flake machines	The project was supposed to be completed in 2020; However, the project stalled mid-way and was restarted in 2022. It focused on development of cold storage for storing surplus fish preventing distress selling. The market already houses an ice flake producing machine and fish testing laboratory. Goa State Infrastructure Development Corporation (GSIDC)	South Goa Planning and Development Authority (SGPDA)	Solar cold storage and solar ice plant for crushed ice can be installed under the initiative
Aqua Goa Mega Fish Festival	CM Pramod Sawant urged youth to explore employment opportunities in fisheries sector, and reap benefits of PMMSY scheme	Ministry of Animal Husbandry and Veterinary Services Directorate of Fisheries	There can be more such awareness programs targeted at employment opportunities and support provided by PMMSY, focused on green technologies for the sector like solar fish dryer, etc.
Matsya Vahini, Eco-Friendly Movable Fish Kiosk launched by CM	It features electric, eco-friendly kiosks designed to ensure hygienic and efficient fish handling, improve the overall fish distribution network.	Department of Fisheries	This initiative can be explored for greening the fish selling



Initiative	Description	Supporting policy/ nodal department	Recommendations
	The components included in a kiosk: Solar Panels (300 watt), announcement speakers, refrigerated compartments (0 to 4°C for fresh fish and -18°C for frozen products, GPS tracking, lithium-ion batteries coupled with electric motor, display case).	PMMSY- 100% central funding	operations in markets and beaches. Further, it can prevent distress selling due to lack of freezing avenues at markets.
Prawn hatchery at Benaolim to be revived by Fisheries department in consultation with CMFRI	Multi-hatchery is proposed for a 5-hectare plot at Benaolim including creation of nursery tank, algal section, hatchery building unit, laboratory. The focus is on boosting prawn production and reviving hatchery's aquaculture sector. The objective is economic development for the local development and supporting sustainable fisheries practices. Tender has been drafted by Fisheries Department, yet to be approved.	Department of Fisheries CMFRI	The prawn hatchery can offer a platform for supporting R&D in aquaculture. Pilots for energy management and other technology interventions can be carried out in the hatchery, to be replicated in the State.
Goa government's plans for 1550 MW of RE in next 5 years.	The target is to generate 1400 MW from solar power, 150 MW from wind and other RE sources like biogas, hydro, waste to energy projects. The focus will be on roof top solar on government buildings, floating solar project on water bodies. For this initiative, 7,350 crores have been sought from the Finance Commission.	Government of Goa	This initiative can be explored for RE based technology deployment in the fisheries value chain.

5.2 PRADHAN MANTRI MATSYA KISAN SAMRIDDHI SAH YOJANA (PM-MKSSY)

In extension of the Pradhan Mantri Matsya Sampada Yojana, a sub-scheme known as PM-MKSSY has been launched by the central government that has performance-based grants allocation to the beneficiaries in the fisheries sector (Department of fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, 2025) to avail the grant the beneficiary would have to achieve pre-determined targets and upon the verification of the achievement the funds would be transferred. Details of the sub-scheme are present below.

FUND OUTLAY	
Total Investment Budget (2023-27):	INR 6,000 crore
Government of India Share:	INR 3,000 crore
Private share fund:	INR 3,000 crore

Broad aims and objectives:

- Gradual formalisation of the unorganised fisheries sector including creation of work based digital identities of fish workers for improved service delivery.
- Incentivise fisheries and aquaculture micro enterprises in the fisheries sector to establish supply chains of safe fish and fishery products including creation and maintenance of jobs through performance grants.

Key measurable outputs/ outcomes targeted at the end of scheme duration

- 1,700 cluster and product-specific business plans for fisheries sector value-chains for achieving improved efficiency.
- 8 million tonnes of carbon dioxide equivalent reduction in net greenhouse (GHG) emissions over the lifetime of project interventions.

Performance grant disbursement for Component 2 (supporting fisheries and microenterprises to improve fisheries sector value chains efficiencies) and 3 (for adoption and expansion of fish product safety and quality assurance systems by fisheries and aquaculture micro and small enterprises

• Aims and Objectives of the component

- i. Addressing the weaknesses of the value chains to increase efficiency and productivity.
- ii. Promoting decarbonization, improved energy efficiency and use of renewable energy in the value chains.
- iii. Enhancing climate resilience, improved hygiene and waste/pollution management.

• Activities and areas of operations covered

- i. Cold storages, retail vending kiosks.
- ii. Upgradation and renovation of infrastructure facilities related to fish production, processing, storage, transportation, and marketing to ensure hygienic handling and storage and production of safe fish.
- iii. Transport and distribution network and equipment including cold/refrigerated transport and cold storage.
- iv. Adoption of sustainable processing and packaging technologies for fish products.
- v. Financial assistance under component 2 and component 3 of the Sub-scheme will be provided in form of performance grant against achievement of a set of predetermined benchmarks.



PERFORMANCE GRANT	ELIGIBLE ENTITY
25% of total investment or 35 lakhs whichever is lower	Fisheries and Aquaculture microenterprises including individuals (General category)
25% of total investment or 45 lakhs whichever is lower	Fisheries and Aquaculture microenterprises including individuals (SC, ST women owned enterprises)
35% of total investment or 200 lakhs whichever is lower	Village level organisation's and federations of SHGs, FFPOs and Cooperatives

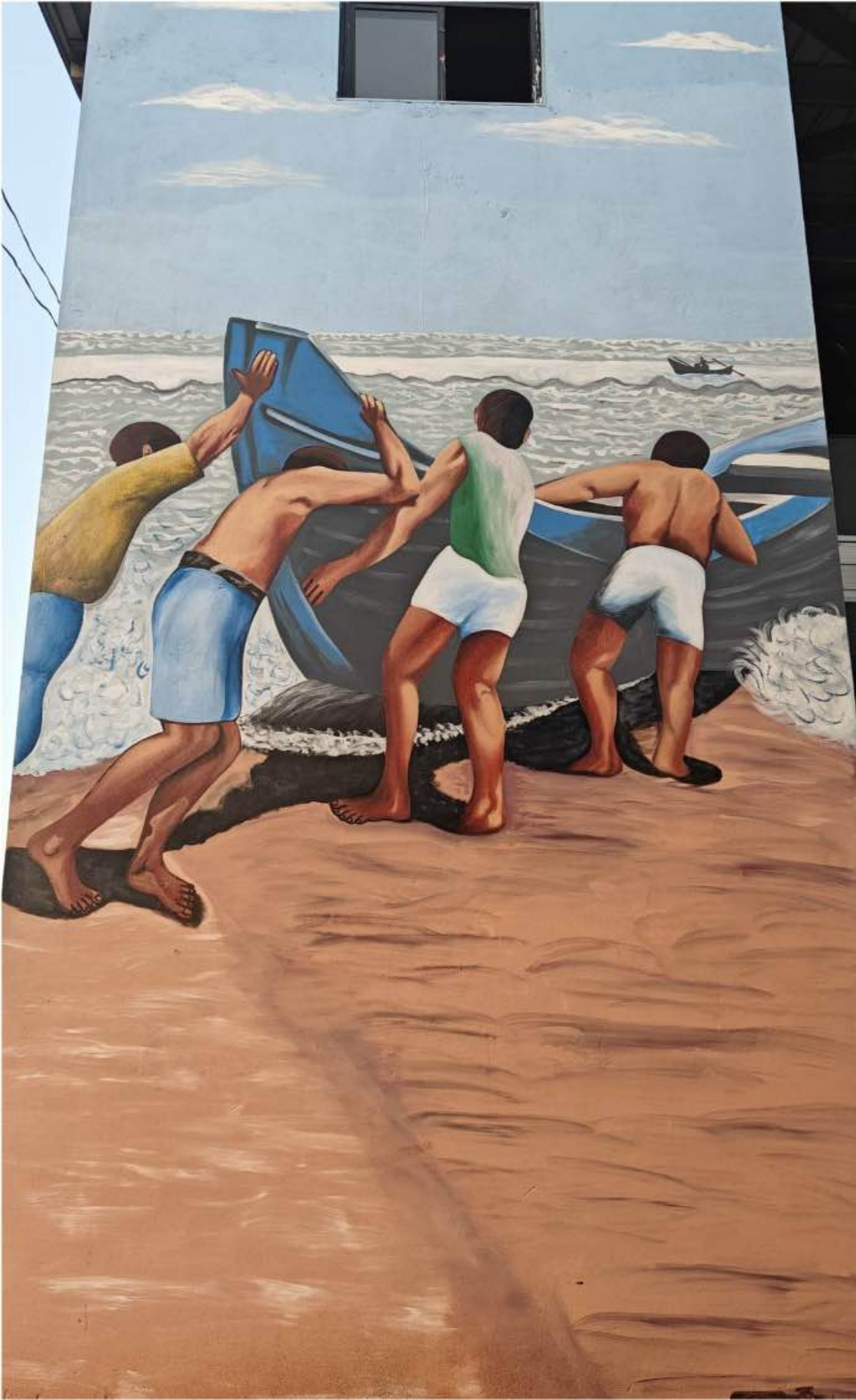
5.3 BROAD POLICY RECOMMENDATIONS TO ENHANCE CLEANTECH UPTAKE IN VALUE CHAINS

The study exploring clean energy opportunities for Goa's fisheries sector has identified the need for strong policy interventions that will strengthen the opportunities and address hurdles towards a strong cleantech adoption in the sector. Addressing both becomes imperative for framing robust recommendations for the strengthening the ecosystem through cleantech interventions. The recommendations below have been suggested appreciating the nuances of the Goa's unique context of the fisheries value chain. They aim to minimise the challenges and catalyse cleantech adoption impacting the overall energy and GHG footprint of the sector.

- Various policies currently offer subsidies and support for technology upgradation and infrastructure for improving the sector's yield and performance. Inclusion of renewable energy, energy efficiency and energy conservation promoting technologies under eligible entities for subsidies, viability gap funding, infrastructure development funding (solar ice plants, solar cold storage). Short term interventions such as IoT based sub-metering, solar PV installation, energy efficient motors/pumps can be prioritised in allocating subsidy, paving way for higher capital expenditure on other interventions as short-term solution would have demonstrated adoption benefits.
- PM-MKSSY program has prioritized supporting microenterprises to improve fisheries value chains efficiencies and the adoption and expansion of fish and fishery product safety and quality assurance, as priority components. This study thus offers strong insights demonstrating how cleantech solutions can meet these objectives while catering to a broad array of stakeholders. The techno-commercial compendium of technologies provides further insights (see Annexure 10). It can be leveraged for the uptake of the cleantech interventions assessed in this study.
- Wide-scale promotion of formalisation of the fisheries stakeholders to avail services and scheme benefits can be taken up similar to PM-MKSSY, with hand holding support considering socio-economic profile of the demographic.
- The Fisheries and Aquaculture Infrastructure Development Fund (FIDF) supports the establishment of fishing harbours, and landing centres, construction of ice plants, cold storage, fish transport facilities, integrated cold chain, development of modern fish markets, development of aquaculture farming – offering extensive avenues for policy programs to prioritize cleantech solutions.
- Centrally sponsored schemes can incorporate GHG emission reduction as a performance metric to determine states share of grants, loans and funds. Leveraging co-operative federalism and a healthy competition among states can catalyse the cleantech uptake in the sector.

- Motorisation of non-motorised vessels can prioritise adoption of relatively cleaner fuels such as LPG and LNG in smaller vessels. Pilots demonstrating fuel-based cost savings can fill the uncertainties against LNG based vessels.
- Otter V board replacements can be promoted and subsidised based on their significant drag reducing capabilities and relatively cheaper costs. GHG (tonnes) reduction potential (10%)– 150 – 285 | (25%) 375 – 713 | (50%) 750 – 1,425. FIDF can be leveraged for such interventions
- TOD tariffs can be optimised to maximise solarisation opportunities and electricity consumption during solar hours.
- Various departments working on diverse aspects of the fisheries value chain such as Fisheries department, CIFT, FSI, CMFRI can work in tandem to ensure R&D and practical application are in sync with each other. For instance, Tamil Nadu fisheries provide information on fishing zones thereby reducing the need for marine exploration hence reducing fuel consumption per trip.
- Fuel subsidies can be partially diverted to adopt cleaner and efficient engines. Engine retrofitting exercises conducted in Kerala can be replicated to Goa.
- Fishing vessel designs reducing overall drag without compromising on fish catching capacity, providing UHMWPE twines can be a low-hanging opportunity to explore.
- Sub – metering can be incentivised through subsidies, awareness campaigns, adoption by public department offices and pilot projects considering its potential GHG reducing impact across various sub-systems.
- Policies such as PM-KUSUM's scope can be expanded to promote solarisation of aquaculture farms.
 - a. Solar aerators and solar pumps adoption have the potential to reduce GHG emissions (tonnes) by for aerators - 1,433 (10% uptake) | 3,582 (25% uptake) | 7,164 (50% uptake).
 - b. For pumps - 43 (10% uptake) | 107 (25% uptake) | 215 (50% uptake)
- Similar to the lines of PM-MKSSY performance-based grants, additional grants to beneficiaries can be provided for RE, EE and EC uptake.
- Exporters should be incentivised to cut down on emissions to open closed export markets that demand sustainable and responsible fishing activities. MPEDA as an export promotion authority can initiate the process through awareness campaigns, pilot projects, allocation of grants and subsidies to early adopters.
- Research and development funds to be allotted to make bio-fuels feasible for blending in vessels.





6.0 BUSINESS MODELS FOR CLEANTECH UPTAKE IN FISHERIES IN GOA

6.1 BUSINESS MODEL SCOPE AND IMPLEMENTATION

I. CATALYSING SOLAR PV SOLUTIONS IN AQUACULTURE THROUGH FIDF, STATE SCHEMES AND PM KUSUM

Scope: Goa presently hosts 27 operational aquaculture farms⁶, covering a combined water spread area of approximately 61 hectares. With the sector poised for further expansion, there exists an opportunity to deploy clean technologies for greening the operations in the farms.

Application: With the rise in aquaculture activities in Goa, energy consumption will increase, straining the grid and raising concerns for GEDA, especially as aquaculture farmers benefit from agriculture allied tariffs. Solarisation of pumps and aerators is crucial to manage this growing energy demand.

Opportunities in existing policy frameworks and financing:

PM KUSUM: The Government of India subsidy⁷ for solarization of agricultural pumps and feeders can be extended for pumps and equipment used in aquaculture, thereby helping to lower the capital cost of solarization. In the purview of KUSUM deployment by the state, aquaculture can be included to incentivise solar energy use. To this end, small-sized solar pumps, solar aerators and solarization of aquaculture feeders can be brought into its ambit. This is strongly aligned with the state's objective to achieve lowest energy footprint in the country and aims to deploy 38,000 solar pumps by 2050⁸.

FIDF: Under the Fisheries infrastructure development fund (FIDF), the development of aquaculture is an eligible investment activity for which a maximum 80% loan on the total project cost be utilised for installation of solar pumps and aerators, with interest subvention and credit guarantee⁹.

Avenues in state schemes¹⁰: The Directorate of Fisheries, Goa offers a 50% subsidy for purchase of farm equipment for brackish water and freshwater aquaculture farms¹¹. Under these schemes the financial viability of the uptake of solar pumps and aerators can be increased.

Targeted impact: The additional subsidy support will aid in easing the penetration of solar pumps and solarization of aerators in aquaculture farming and thus reducing energy footprint.



II. LEVERAGE EXISTING INFRASTRUCTURE SUBSIDIES FOR CLEAN TECHNOLOGY DEPLOYMENT VIA PUBLIC-PRIVATE PARTNERSHIPS

Scope: Goa has 7 jetties, 29 ramp-based landing centres and one wholesale market at Margao. Infrastructure development in the wholesale market has been proposed by Goa State Infrastructure Development Corporation (GSIDC) and South Goa Planning and Development Authority (SGPDA), including cold storage, ice plant and fish testing laboratory. RE based cold storages and ice plants can be explored under this initiative.

The success of Swachh Bharat Abhiyan's initiative as a public-private partnership (PPP) in establishing Material Recovery Facilities (MRFs)¹² highlights the potential of similar models for greening fisheries infrastructure, where the government invests in infrastructure and technology providers manage facilities, sharing service revenues with government under concession agreements.

Application: This business model can be leveraged for developing and greening of infrastructure on landing centres and markets, like ice plants, cold storages and ancillary infrastructure for cold chain transport and vessels.

Opportunities in existing policy frameworks and financing:

Avenues in state schemes¹³: Panchayats or Municipal councils can leverage the current directorate of fisheries, Goa scheme on assistance for construction of fish markets up to 5 lakhs to develop fish market infrastructure. Private players can then be invited to operate and maintain the markets on a revenue sharing model generating additional income.

PMMSY: Centrally sponsored scheme component under the PMMSY can be leveraged for 100% sponsored modernisation of fishing harbours, the participation of private players can be based on a on the efficient utilisation of the infrastructure and quantitative targets of emission reduction.

FIDF: Concessionary loans¹⁴ provided under the FIDF scheme can be leveraged by the government entity to avail patient capital, it also aids the private players to provide longer breakeven points reducing risks for both the parties.

Targeted impact: The sharing of costs and responsibilities between the government and private player can increase the efficiency of operations and reduce the investment costs.

III. INTEGRATED VALUE CHAIN SERVICES FOR FISHERIES THROUGH ENTREPRENEURSHIP MODELS AND RESCOS

Scope: Clean energy solutions for the fisheries sector, covering production, processing, and logistics, can be bundled into packages based on similar requirements. Fisheries entrepreneurs can adopt this model, where business integrators develop and maintain infrastructure in exchange for a performance fee, following agreed-upon terms. This model can be adapted from existing Renewable Energy Service Company (RESCO) models used in solar rooftop projects.

Application: These business models can support rooftop solar and wind-hybrid systems across the value chain, including RE-based cold storages, dryers, ice plants on jetties and markets, and freezing infrastructure like TES tabs for vessels and transport.

Opportunities in existing policy frameworks and financing:

Entrepreneurial models under PMMSY¹⁵, supported by NFDB, enable bundling of policy sub-components and rolling out as business ventures for enhanced outcomes. While current focus is on post-harvest infrastructure including cold chain and marketing, clean technology interventions can also be integrated within PMMSY guidelines.

Avenues in state schemes¹⁶: Under the directorate of fisheries financial assistance to take up value addition to seafood scheme of Goa, entrepreneurs are supported with a subsidy of up to 5 lakhs for setting up or renovation a unit involved in seafood value addition, it further provides assistance of up to 2 lakhs for purchasing equipment for such units.¹⁷

Targeted impact:

- The entrepreneurship model will help reduce the financial burden of plant owners and users in RE/EE uptake.
- With the maintenance and operation responsibility being entrusted upon the technology providers/OEMs, the upkeep and operations of new technologies become smoother.
- This can be an avenue for supporting local livelihood and capacity building.
- Commercialisation of technologies can be supported by integrating them under one umbrella.
- The end-to-end deployment of solutions will provide opportunity for maximising outputs wherever possible by achieving economies of scale, as recommended by NFDB.

IV. RENTAL OR SUBSCRIPTION MODELS FOR CLEAN TECHNOLOGY ADOPTION IN THE VALUE CHAIN

Scope: Technology adoption in the fisheries value chain can be promoted through rental or subscription-based models, enabling steady revenue generation. Solutions may be offered by technology providers under entrepreneurship or PPP models (as described above) with fixed plans¹⁸. If the infrastructure is developed and operated solely by the government, rentals or subscriptions can be provided at concessional rates to encourage wider access.

Application: Subscription and rental models can be applied to processing, ice manufacturing, aquaculture farms, and green infrastructure on jetties and markets, including ice plants, cold storages, dryers, and TES tabs for storage, vessels, and cold chain transport. Such models have been explored under Farming as a Service (FaaS)¹⁹ for agriculture sector and can be explored for fisheries.

Opportunities in existing policy frameworks and financing:

Avenues in state schemes: The directorate of fisheries, Goa's financial assistance to take up value addition to seafood scheme as mentioned above can be leveraged.

FIDF: The eligible infrastructure such as ice plants, cold storages, development of landing centres can be developed on concessional loan basis, supporting lower subscription and rental rates for users.

PMSSY: The subsidy provided under the scheme for eligible infrastructure such as ice plants, cold storages can be utilised by private players investing capital expenditure reducing upfront costs by up to 40% thereby reducing subscription and rental rates.

Targeted impact:

- Revenue risks associated with uncertainty in market and usage can be combatted through subscription based or rental plans.
- Enhances the access to newer technologies for low-income groups.
- Reduces the upfront cost for value-chain players, aiding in smooth RE/EE transition of the sub-systems.

V. PAY-AS-YOU-GO (PAYG) PROGRAMS

Scope: Pay As You Go (PAYG) programs can support clean technology adoption in public infrastructure projects, with users paying based on usage tracked by PAYG meters. If the infrastructure is government owned and operated, the rates can be subsidized for wider adoption. These models, successful in Farming as a Service (FaaS) for agriculture, can be applied to the fisheries sector.

17. The subsidy is capped at 50% of the total project cost



FaaS offers agricultural services on-demand, where users pay per use or subscribe to access specific services²⁰. These include farm management solutions, production assistance and market access.

Application: The PAYG models can be leveraged in roof top solarisation projects and for infrastructure on jetties and markets accessible to community like solar dryers, ice plants, cold storages and blast freezers for TES tabs (for cold chain transport, vessels and storage).

Opportunities in existing policy frameworks and financing:

Avenues in state schemes: The directorate of fisheries, Goa's financial assistance to take up value addition to seafood scheme as mentioned above can be leveraged.

PMMSY: The subsidy provided for infrastructure development can be utilised to reduce risk of capital expenditure, this can also be passed on to the end users in the form of concessional tariffs.

FIDF: The loan provided at concessional interest rates with a longer repayment period can aid in realisation of viable break even points for capital expenditure investors at a low tariff rate.

Targeted impact:

- Encourages smooth adoption especially for small fishermen and businesses
- Creates a continuous revenue stream for the investors
- Enables users to pay on usage basis, reducing the capital expenditure burden
- Enables micro, medium and small industries to participate in solarisation of their plants

VI. COMMUNITY BASED INFRASTRUCTURE DEVELOPMENT SUPPORTED BY FISH PRODUCER COOPERATIVES AND BOAT OWNERS' ASSOCIATIONS

Scope: Community-based infrastructure development can drive an inclusive and sustainable transition in fisheries, with Fish Farmer Producer Organizations (FFPOs) and boat owners' associations investing in RE/EE solutions for jetties and markets. Local communities will manage operations and maintenance, fostering greater participation. Similar to agriculture, clean energy interventions can be explored for fisheries, where marginalized shrimp farmers can form associations to facilitate technology adoption and enhance bargaining power through collective marketing.

Application: Community-supported solar dryers, cold storage, ice plants, solar/wind-hybrid installations, and freezers for TES tabs can be developed at landing centres and jetties. In aquaculture farms, fish farmer associations can adopt solar aerators, pumps, and IoT-based sub-metering to enhance efficiency.

Opportunities in existing policy frameworks and financing:

PM-MKSSY intends to address the inherent weaknesses of the sector through identified financial and technological intervention. Its performance-based grants can serve as catalyst to improve efficiencies in the value chain. To this scope market-proven clean technologies can be introduced. Financing avenues: Small Farmers' Agribusiness Consortium (SFAC/NABARD) for aquaculture, private Agri-tech, credit guarantee scheme for fisheries via NABARD's NABSanrakshan route.²¹

Under the PMKSSY, there is a strong incentive for fish farmers to adopt the model of FFPOs, enabling the value chain organisation and formalisation. FFPOs shall enable a safer (risk shared) model for technology adoption.

Targeted impact:

- Reduces the financial risks of technology adoption by cost sharing
- Increases capacity building and livelihood opportunities through engagement of local folk

- Smoothens technology uptake in individual farms through aggregated need
- Enhances bargaining power and market linkage for marginalised fish farmers

VII. GREENING OF VESSELS – POLICY AND PROGRAM

A. Encourage retrofitting of existing fishing boats with interventions such as Otter board (V-board), Semi-pelagic trawl system, battery storage solution.

Scope: Marine fishing accounts for over 70% of energy consumption in the fisheries value chain, primarily driven by fossil fuels (MP Ensystems Research, 2024). The Department of Fisheries, Goa, can collaborate with the Central Institute of Fisheries Technology (CIFT) to launch pilot projects that raise awareness and promote the adoption of cleaner alternatives.

Application: Pilot demonstrations can target marine fishing stakeholders, with voluntary participants and early adopters testing green technologies on their vessels to build community confidence.

Policy Framework and Financing: Under the PMMSY, CIFT can access funding through centrally sponsored schemes for innovative technology demonstrations, supporting the deployment of green upgrades in fishing vessels.

Targeted Impact: Government-funded pilots can drive the adoption of CIFT-developed technologies, produced by approved vendors, leading to reduced emissions and improved efficiency in marine fishing operations.

B. The Department of Fisheries can launch a targeted vessel modernisation program aligned with clean energy goals.

Scope: Vessel modernisation focused on changes leading to a reduction in drag can lead to fuel savings²², such design changes can be implemented for all sizes of vessels.

Application: The marine fishing sub-system stakeholders can be the targeted beneficiaries; the design changes can be implemented on vessels of voluntary participants/early adopters to increase community confidence.

Opportunities in existing policy frameworks and financing:

The component of PMMSY centrally sponsored components specifically the acquisition of deep-sea fishing vessels and upgradation of existing fishing vessels for export competency can be utilised for vessel modernisation focusing on clean energy uptake. (Ministry of Fisheries, Animal Husbandry and Dairying, 2020)

Targeted impact: Such interventions can lead to direct reduction of fuel consumption leading to reduced levels of emissions in the marine fishing sub-system.

VIII. ROOFTOP SOLAR PV ADOPTION INCENTIVE FOR MSME UNDER FISHERIES

Scope: Solarisation of solar PV can be catalysed for MSMEs through introduction of the RESCO model for solar rooftop and ground mounted installations under a partial credit guarantee scheme cover similar to the FIDF credit guarantee.

Under the RESCO model, contracting of rooftop and or land where solar PV is to be installed for a mutually agreed period is fixed between the RESCO and user. Thereafter the RESCO is responsible to deploy the required capital expenditure for the installation of the solar PV system which cannot exceed the sanctioned load and is capped at 500kW in Goa under the net metering regulations.



Application: The model can be adopted by ice manufactures, processing plants, cold storages.

Opportunities in existing policy frameworks and financing:

The FIDF credit guarantee can be extended to RESCOs to make the market more attractive, it can be a partial Credit Guarantee that only ensure the default risk for the first 5 years.

Targeted impact:

The user gets a flat tariff rate (generally lower than the discom industrial tariff rates) to be paid based on the generation of the solar units. The model essentially divides the risk between both the parties, the RESCO secures a fixed stream of constant and uniform revenue whereas the final user receives a steady supply of cheap and green energy. This would enable a shift from grid electricity.

IX. TECHNOLOGY DEMONSTRATION AND VENDOR EMPANELMENT PROGRAMS

Scope: These pilots can be taken up over 12-month period with focus on priority areas such as costs, energy consumption, and emissions. Technology vendors will be shortlisted and empanelled by NFDB based on criteria to prevent cost escalation. The benefits observed will be documented to guide future technology adoption in the value chain.

Application: Pilot projects can showcase RE/EE infrastructure on jetties and markets, including solar drying units, biomass/solar cold storages and ice plants, TES tabs for vessels and transport, and freezing infrastructure for tabs. Solar PV can be demonstrated for processing industries and ice factories, while solar aerators and pumps for aquaculture can also be piloted. Additionally, IoT-based meters across the value chain, using rental/PAYG models, can be demonstrated.

Opportunities in existing policy frameworks and financing:

The empanelled technology providers under the PMMSY can avail financing to demonstrate novel green technologies under the centrally sponsored schemes supporting innovative technology demonstrations promoting adoption through pilot projects.

Targeted impact:

- The empanelment of vendors will aid in keeping the prices in check for availing subsidies.
- Government supported pilot demonstrations will make the value chain players aware about the merits of the clean energy transition.
- The gradual transition will reduce the risks associated with high capital investment at one go.
- The pilot projects will also enhance confidence of the financing institutes in investing in such technology adoption projects.

The different business models identified above has been mapped for the sub-systems of the Goa's fisheries sector. The scope of adoption of clean technologies in the sub systems along with the relevant business models have been captured in the table below.

Table 4: Scope of business models in sub-systems

Sub-system	Business models	Scope of implementation
Aquaculture	- Widening the scope of PM KUSUM under the ambit of the state policies and leveraging existing schemes for the adoption of solar pumps and aerators. - Community supported technology adoption in farms through fish farmer associations. - Government run pilot programs to demonstrate solar aerators, pumps and IOT based metering in farms	Aquaculture in Goa, with an energy consumption of 5,824 kWh per tonne, will face an increased energy footprint with growth of aquaculture business in the state. - Solarising aerators (77% of energy use) and pumps (23% of energy use) is crucial, but high capex for their adoption across all farms—₹7.62 crore for 2 HP aerators and ₹1.52 crore for 5 HP pumps—leads to long ROIs of 20 and 13 years. - This calls for innovative business models to reduce upfront costs and share financial risks. - Low-capex measures, such as energy-efficient motors and pumps, can be adopted directly due to their short payback periods. - Additionally, deploying IoT-based sub-meters to track energy use could enhance efficiency, requiring ₹13.5 lakh in capital with a shorter ROI of 5 years.
Marine fishing (Vessels)	- Demonstration of CIFT's green retrofittable technologies, such as LNG/LPG engines retrofitted on 10HP petrol motorised boats, small electric boats. - Leveraging PMMSY to promote drag reducing vessel design changes for fuel savings and increased insulation to reduce ice consumption - Generating awareness on fuel saving practices during vessel propulsion. - R&D support to stakeholders such as CMFRI, CIFT to develop usage of bio-diesel in boats.	- Energy utilisation in the value chain (Marine Fishing): 235,219 -282,322 MWh - Potential impact on GHG emissions due to various cleantech interventions: a. Propulsion speed reduction: 1,624 – 2,769 tonnes (10% uptake), 3,972 – 1,179 tonnes (25% uptake), 7,944- 13,845 tonnes (50% uptake) b. Fishing vessel design changes. (Low drag trawl): 150 – 285 tonnes (10% uptake), 375- 712 tonnes (25% uptake), 750 – 1,425 tonnes (50% uptake) c. TES boxes, tabs and pouches: 1,108 tonnes (10% uptake), 2,771 tonnes (25% uptake), 5,542 tonnes (50% uptake) d. LPG run boats: 122- 153 tonnes (10% uptake), 306 – 765 tonnes (25% uptake), 612 – 765 tonnes (50% uptake) e. Solar boats: 4,045 – 5,034 tonnes (10% uptake), 10,113 – 12,584 tonnes (25% uptake), 20,226 - 25,168 tonnes (50% uptake)



Sub-system	Business models	Scope of implementation
Landing centres	• PPP business model for developing green infrastructure • Entrepreneurship model for integrating bundle of RE/EE solutions for jetties • Subscription/rental models or PAYG models for collecting revenue from users of the infrastructure • Community based infrastructure development, managed/operated by local folk. • Technology demonstration programs by government for TES tabs, biomass-based ice plants, solar drying units, solar ice plants.	Landing centres consume 1,162 MWh annually for re-icing the catch for fish logistics. To reduce the energy use and ice logistics, RE supported ice plants can be set up on jetties. • Solar PV installation to meet entire re-icing demand requires ₹37.56 crores and offers a 6-year ROI, while solar-wind hybrid costs ₹60.03 crores with a 9-year ROI. This demands for innovative business models to combat the high capital expenditure. • Alternatively, small capacity biomass-based ice plants (10 TPD) with ₹36 lakh capital expenditure and 2-year ROI can be set up. • Additionally, adopting TES-based tabs and blast freezers for fish transport can replace 21,419 tonnes of ice, requiring ₹4.88 crores in capital expenditure and offering a 2-year payback.
Markets	• Government-supported pilot programs for TES tabs, biomass ice plants and cold storages, solar drying units, solar ice plants, and cold storages. • Community-driven RE based infrastructure development, operated and managed by local communities • Public-private partnership (PPP) model for RE/EE based public infrastructure development • Entrepreneurship model for bundling and implementing RE/EE solutions in markets • Subscription, rental, or PAYG models to generate revenue from infrastructure users • Leveraging Goa's initiative for developing cold storage and ice plant at Margao whole sale market	Margao wholesale market consumes 1,071 tonnes of ice (for re-icing catch) annually, using 58.1 MWh of energy. RE-powered ice plants, TES solutions, and RE-based cold storages can reduce energy consumption and mitigate distress selling. • Solar PV installations for meeting entire ice demand, requires a capital expenditure of ₹1,878,012, with a payback of 5 years. Similarly, wind-hybrid installation will need ₹3,001,528 as capital expenditure, with a payback of 8 years. The high capital expenditure, needs to be met through RESCO model or entrepreneurship models. • Small scale biomass run ice plant (10 TPD), will need a capital expenditure of ₹1,200,000 and have an ROI of 2 years. • For replacing the ice used for re-icing, TES tabs can be deployed along with the needed blast freezers. This will need a capital expenditure of ₹2,440,582, offering a 2-year payback.
Ice manufacturing	• Entrepreneurship model supported by NFDB and PMMSY for integrated RE/EE based solutions for ice manufacturing plant	Ice manufacturing accounts for 14-17% of the sector's energy use, consuming 43,641 MWh annually for meeting the sector's ice demand of 8,04,436 tonnes. This highlights an opportunity for RE/EE integration to reduce carbon emissions and optimize energy consumption.

Sub-system	Business models	Scope of implementation
	- Solar roof-top installations through RESCO model supported by FIDF's credit guarantee - Demonstration pilot by government for selected ice manufacturing plants, to highlight benefits of IOT based sub-metering, EE motors and pumps and solarisation	100% solarisation of the ice plants through rooftop PV installation, can incur a capex of ₹1,410,644,331, with a payback of 6 years. Similarly, wind-hybrid installation can cost ₹2,254,558,399 with a long ROI of 10 years. To ease this RE transition, the mentioned innovative models need to be explored. - Additionally, IOT based sub-metering requiring a capex of ₹7,500,000 with a payback of 1.1 years, can be low-hanging opportunity for optimising energy use. - Low-capex measures, such as energy-efficient motors and pumps, can be adopted directly due to their short payback periods.
Processing (Exports) and (Waste)	- State fisheries department schemes for subsidising plant and machinery of value addition enterprises can be leveraged for cleantech uptake. Availing Infrastructure subsidies under PMMSY. - Performance based grants to incentivise usage of IoT sub-metering. - RESCO model promotion through credit guarantee to facilitate solarisation.	- Energy utilisation in the value chain (Exports): 8,705 MWh - Energy utilisation in the value chain (Waste): 4,935 – 5,666 MWh - Potential impact on GHG emissions due to various cleantech interventions: a. Exports: 617 tonnes (10% uptake), 1542 tonnes (25% uptake), 3,083 tonnes (50% uptake) b. Waste: 345 – 397 tonnes (10% uptake), 1,234- 992 tonnes (25% uptake), 1727 - 1,983 (50% uptake) - Exports a. 100% uptake of basic IOT sub-metering would provide operational savings of up to INR 1,33,872 on a capital cost of INR 2,100,00 with an ROI of 1.6 years b. 100% uptake of Solar PV installation would provide operational savings of up to INR 44,395,750 on a capital cost of INR 2,81,375,321 with an ROI of 6 years c. 100% uptake of Solar-wind hybrid installation would provide operational savings of up to INR 44,395,750 on a capital cost of INR 449,707,328 with an ROI of 10 years - Waste processing a. 100% uptake of basic IOT sub-metering would provide operational savings of up to INR 866,975 on a capital cost of INR 600,000 with an ROI of 0.7 years b. 100% uptake of Solar PV installation would provide operational savings of up to INR 28,899,150 on a capital cost of INR 183,159,596 with an ROI of 6 years c. 100% uptake of Solar-wind hybrid installation would provide operational savings of up to INR 28,899,150 on a capital cost of INR 292,734,31 with an ROI of 10 years



6.2 BUSINESS MODEL ENABLERS

To drive the adoption of clean technologies across the fisheries value chain, enabling business models with a supportive ecosystem is essential. This environment should promote the diffusion of innovations and address challenges associated with technology reforms. Key enablers include:



IOT-BASED ENERGY MONITORING

Performance grants from Goa's electricity departments can incentivize the use of IoT systems for real-time energy monitoring. These enable data-driven decisions that optimize energy use and generate savings, which can further catalyse the emergences of various business models that will drive the clean technology adoption.



GOVERNMENT SCHEMES AND SUBSIDIES

Central schemes like PMMSY reduce capital risks in clean technology infrastructure through subsidies. These can also support models such as subscription, rental, or pay-as-you-go, easing short-term financial pressures and enabling affordable tariffs.



RESCO MODEL FOR SOLARISATION

Solar projects, though capital-intensive, can be financed through the RESCO model, which offers developers predictable revenue streams and end users cheap and green electricity. To offset investment risks especially in the seasonal fisheries sector credit guarantees under FIDF can be extended to RESCO developers.



DEMONSTRATION PROJECTS

Market awareness for novel technologies can be boosted through pilot demonstrations, supported by centrally sponsored schemes under PMMSY. Offering these technologies at concessional rates can incentivize early adopters.



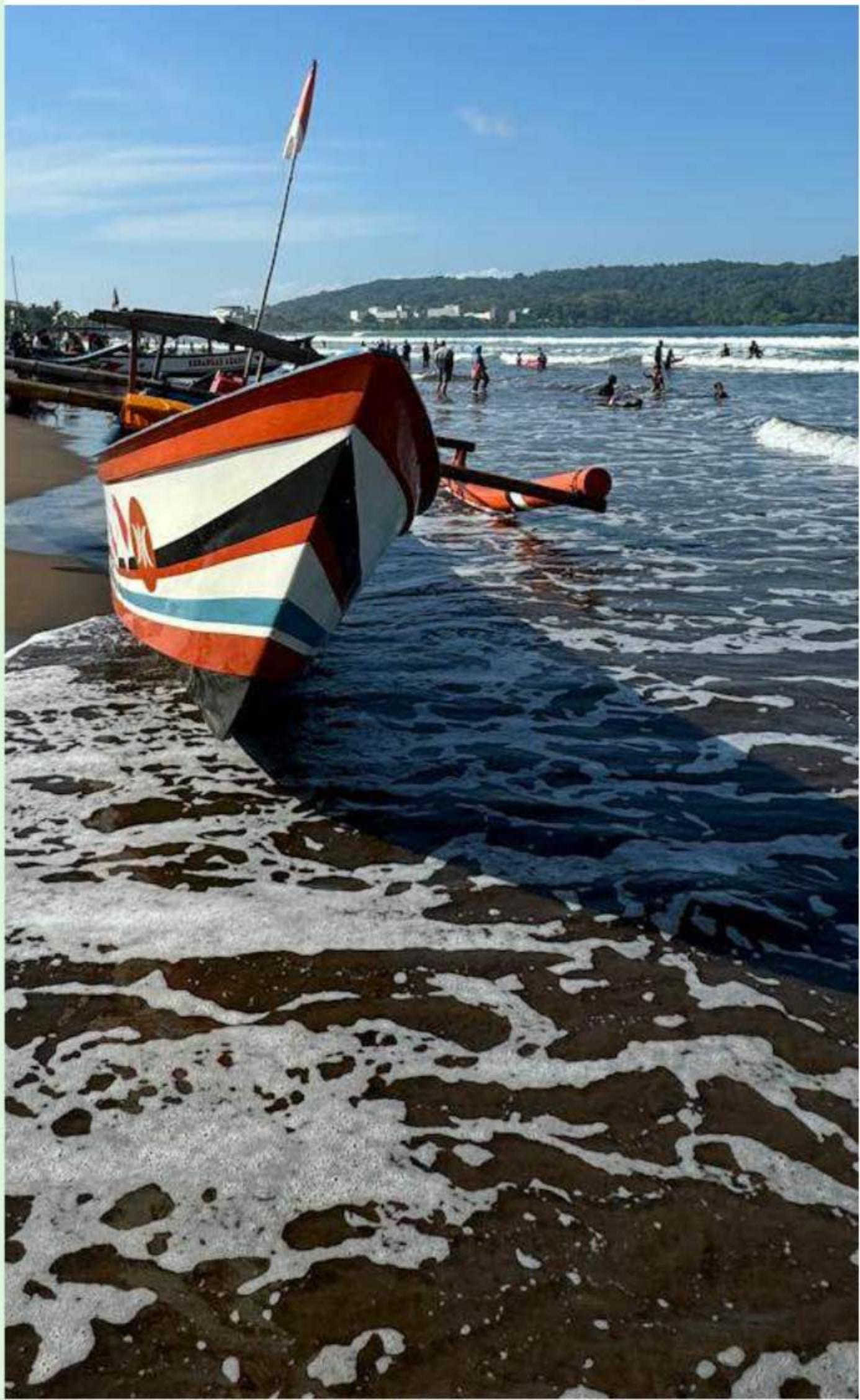
ACCESS TO PATIENT CAPITAL

Long-term, low-interest financing under FIDF can reduce the financial burden of clean tech adoption for ice plants, processing units, and related enterprises.



ROLE OF COOPERATIVES

Cooperatives enhance bargaining power, pool resources, share risks, and formalize value chain players. Their scalable nature makes them effective platforms for rapid tech adoption. Enhanced grants under PM MKSSY performance-based components can support cooperative development.



7.0 | GHG REDUCTION POTENTIAL SCENARIOS FOR TECHNOLOGY INTERVENTION

To assess the potential impact of the clean energy interventions in the fisheries value chain, the table below provides the GHG reduction potential (tonnes CO₂) based on 3 scenarios on a sub-system level. We examine a 10%, 25% and 50% implementation rate to the baseline scenario. For instance, the calculations below offer an understanding of how much GHG reduction in aquaculture is possible if 10%, 25% and 50% of all aerators currently deployed are solarised.

For fuel replacement scenarios, such as replacing diesel with solar, the GHG emission factor of the particular fuel has been taken (Central Pollution Control Board, n.d.), while the emission factor of grid electricity is taken into consideration for other renewable energy-based interventions (Central Electricity Authority, 2023). Owing to limited information for all the interventions the scenarios are only made for the interventions mentioned below.

Table 5: GHG Emission reduction potential of various cleantech interventions across sub-systems (MP Ensystems Research, 2025)

Sub-system	Strategy/ Technology	Details	GHG reduction potential according to uptake scenarios (tonnes CO ₂)			Challenges
			10%	25%	50%	
Aquaculture	Solar aerators	Solar PV installed on the aerators to generate electricity	1,433	3,582	7,164	Higher upfront costs, intermittency issues
	Solar pumps	Solar PV based electricity generation for water pumps	43	107	215	Intermittency issues, High Upfront costs

Sub-system	Strategy/ Technology	Details	GHG reduction potential according to uptake scenarios (tonnes CO2)			Challenges
			10%	25%	50%	
Marine fishing	Propulsion speed regulation ²³	Reduction in speeds of the vessels to save engine fuel consumption	1,624- 2,769	3972- 1,179	7,944- 13,845	Difficult to monitor and implement
	Fishing vessel design changes. Example (Low drag trawl)	An optimized design of trawl coupled with fabrication using new generation material Ultra High Molecular Weight Polyethylene (UHMWPE) twines	150- 285	375- 713	750 – 1,425	High upfront costs, small number of suppliers
	Otter board (V-board)	A pair of otter boards (trawl doors) are required for the horizontal opening of the trawl net. The V- board reduces otter board drag to reduce fuel consumption	150 – 285	375 – 713	750 - 1,425	Poor adoption due to weak supply chain
	TES boxes, tabs and pouches	Thermal energy storage-based boxes, tabs and pouches store thermal energy increasing the ice melting time, maintains fish preserving temperatures and reduces ice consumption	1,108	2,771	5,542	High capital costs, permanent infrastructure required for charging, more expensive than ice (compensated through reusing cycles)
	LPG run boats	Retrofittable kits to replace diesel and petrol as vessel fuel has reduces carbon and sulphur emissions	122 - 153	306 – 765	612 – 765	Cannot be retrofitted on big engines, currently only retrofitted on 9.9 HP engines, need more R&D

23. Propulsion speed regulation is a fuel conservation techniques that leads to reduced consumption at lower speeds



Sub-system	Strategy/ Technology	Details	GHG reduction potential according to uptake scenarios (tonnes CO ₂)			Challenges
			10%	25%	50%	
	Solar boats	Boats running on Solar PV modules on the boat replacing fossil fuels	4,045.13 – 5,033.54	10,112.83 – 12,583.85	20,225.66 – 25,167.70	Poor public perception, still in R&D for marine environment, has solar intermittency issues, requires battery storage
Landing centres	Solar PV rooftop ice plant	Rooftop Solarisation for the ice manufacturing plant to shift load from grid electricity during solar hours under a net metering system can also include a battery storage to reduce intermittency	81.34	203.35	406.70	Solar intermittency issues, ice plants flat load would require a larger system to be installed
	TES boxes, tabs and pouches	Thermal energy storage-based boxes, tabs and pouches store thermal energy increasing the ice melting time, maintains fish preserving temperatures and reduces ice consumption	50.97	127.44	254.89	High capital costs, permanent infrastructure required for charging, more expensive than ice (compensated through reusing cycles)
Markets	Solar PV rooftop ice plant	Rooftop Solarisation for the ice manufacturing plant to shift load from grid electricity during solar hours under a net metering system can also include a battery storage to reduce intermittency	4.07	10.17	20.34	Solar intermittency issues, ice plants flat load would require a larger system to be installed

Sub-system	Strategy/ Technology	Details	GHG reduction potential according to uptake scenarios (tonnes CO2)			Challenges
			10%	25%	50%	
	TES boxes, tabs and pouches	Thermal energy storage-based boxes, tabs and pouches store thermal energy increasing the ice melting time, maintains fish preserving temperatures and reduces ice consumption	2.57	6.40	12.82	High capital costs, permanent infrastructure required for charging, more expensive than ice (compensated through reusing cycles)
Ice manufacturing	Solar PV installation	Rooftop Solarisation for the ice plant to shift load from grid electricity during solar hours under a net metering system can also include a battery storage to reduce intermittency	3,054.93	7,637.32	15,274.63	Solar intermittency issues, ice plants flat load would require a larger system to be installed
Fish Processing (Exports)	FRP-based fan blades	Fibre reinforced plastic based fan blades replacing metal blades reducing weight of the fan decreasing load on motor i.e. reduced energy consumption	7.26	18.16	36.32	Minimal energy savings leads to ignorance towards intervention
	Solar PV installation	Rooftop Solarisation for the fish waste plant to shift load from grid electricity during solar hours under a net metering system can also include a battery storage to reduce intermittency	609.35	1,523.38	3,046.77	Solar intermittency issues, need battery storage, can be restricted due to limited rooftop space, high upfront costs



Sub-system	Strategy/ Technology	Details	GHG reduction potential according to uptake scenarios (tonnes CO2)			Challenges
			10%	25%	50%	
Fish processing (Waste)	Solar PV installation	Rooftop Solarisation for the fish waste plant to shift load from grid electricity during solar hours under a net metering system can also include a battery storage to reduce intermittency	345.47 – 396.65	1,233.80 – 991.63	1,727.32 – 1,983.27	Solar intermittency issues, need battery storage, can be restricted due to limited rooftop space, high upfront costs



8.0 | SUMMARY OF STAKEHOLDER CONSULTATION

The event, "Technology interventions for greening the fisheries sector" was organized as a part of the ongoing study to create a clean energy roadmap for the state's fisheries sector on behalf of the Goa energy development agency (GEDA). The event was held in Panaji, under aegis of GEDA, on 28th February 2025. The event leveraged MP Ensystems "RE-Connect" platform, a broader effort to convene diverse stakeholders to discover the RE and EE potentials and opportunities and accelerate the uptake of market-ready technological interventions that enable greening of the value chains of the Indian economy. The following section captures the insights from the stakeholder consultations.

PANEL 1: THERMAL ENERGY STORAGE SOLUTIONS AND ENERGY EFFICIENCY MEASURES FOR STRENGTHENING RENEWABLE ENERGY UPTAKE IN FISHERIES.

The session panelists engaged in the discussion on thermal energy storage solutions to complement ice usage, role of IoT based energy management systems to improve energy efficiency, and applications of solar PV hybrid in the various sub-systems in the sector. Composition of panel one was as follows:

Key insights of the panel discussion are highlighted below:

- Success and learnings of renewable energy-based cold chain solutions deployed in the Agri sectors are important to the fisheries, as capacity building programs, remote monitoring of the Agri sector solutions have strong replication potential
- Business models like rent (contract-based rentals) and operate (provider-run systems, pay-per-use) are promising in reduction/removal of capital costs.
- Solar cold storages have 60% subsidies but need full utilization for financial viability.
- Demonstration projects are necessary to generate awareness. Standards of energy efficiency can further reduce energy usage further optimising operational costs. Upgrade outdated equipment to energy-efficient standards. Wind and solar with batteries offer reliable energy for fisheries.
- The RE transition phase requires strong energy efficiency support and IOT based energy management systems can support this staggered approach for widespread adoption. Low-hanging opportunities such as basic sub-metering, and further customised granularity as per the need of the consumer can be achieved. AI and deep analytics have revolutionised the sector.
- Ancillary services in a marine fishing boat can be the first steps to introduce renewable sources of energy such as solar and wind minimising the utilisation of diesel-based generators., Electric boats can be another intervention that can have re based charging infrastructure on jetties to ensure emission reduction.



PANEL 2: SYNERGISING CLEAN ENERGY SOLUTIONS FOR FISHERIES - EMERGING BUSINESS MODELS

The session focused on synergising RE sources for reducing intermittency challenges and optimising usage, biomass as an abundant renewable source available to be tapped for energy generation, ice manufacturing and steam generation in the fisheries sector. It also focused on energy efficiency interventions in the vessels, considering their highest use of energy in the value chain primarily based on fossil fuels such as diesel and petrol.

Key insights of the panel discussion are highlighted below:

- Biomass is abundant but underutilized due to decentralized production, unorganized procurement, and adulteration risks. Organised aggregation and standardization are crucial for increased adoption.
- Beyond solar PV and wind hybrids, sources like concentrated solar power and biomass can manufacture ice. Lithium sulphate batteries and swappable solutions serve as transitional backups. Community awareness is essential for adoption.
- Metal V-form double-slotted otter boards in trawlers last 5 times longer than traditional ones and reduce fuel use. Retrofitting diesel and petrol vessels to use LPG lowers carbon and sulfur emissions, costing ₹1.2 lakhs and ₹25,000, with ROIs of 2–3 and 6–7 months, respectively.
- Addressing issues with open sun drying—high labor, sun dependence, hygiene, and spoilage—is key for solar fish dryer adoption. Solar electric dryers ensure uniform drying, reduced spoilage, and usability during monsoons. They save labor, improve shelf life, and retain nutrition. Pilots and demonstrations are essential for uptake.
- A solar-powered refrigerated fish vending kiosk with a 450W PV panel can store 30kg of fish, preserving freshness, reducing distress sales, and extending catch life.
- The panel discussions were followed by special remarks from Mohammad Khan, Senior Consultant, Centre for Innovations and Appropriate Technologies & Skills and Jobs (CIATSJ), National Institute of Rural Development & Panchayati Raj (NIRD&PR). He emphasised on down-sizing and simplifying available technologies for affordable and smoother uptake by the fishing folk supported through awareness programs.



9.0 | CONCLUSION AND WAY FORWARD

The base-lining study of the energy use in fisheries sector of Goa, highlighted the need for clean technology and energy efficient interventions across the value chain. With an overall energy footprint of 2,56,000 - 3,03,800 MWh the sector has a carbon footprint of 88,600 - 96,600 tonnes of CO₂ equivalent and annual diesel consumption of 16,000 kl. Based on the baseline energy consumption across the sub systems, the greening needs and suitable technology interventions have been identified under energy conservation, energy efficiency, renewable energy and energy management solutions. These solutions can either be retrofitted into existing systems, need replacement of existing technologies or can be a new addition to the existing operations of the sub-systems.

In order to ease the adoption of these clean technologies in the sub-systems, there is need for phase wise transition of the sector, based on the feasibility of the technologies. The technologies which are highly feasible and can be immediately up taken should be targeted under short term plan (0-3 years), solutions which cannot be up taken immediately can be adopted under mid-term (3-5 years) and long term (beyond 5 years) plans based on their feasibility. Through our study, also supported by strong field work activities, we identified short-term, mid-term and long-term solutions for the different sub-systems across the value chain.

Our study identified energy efficient measures like energy efficient motors/pumps, IoT based sub-metering, FRP based fans, energy efficient compressors, otter board (V-board), semi-pelagic trawl system in vessels, turtle excluder devices to be low-hanging opportunities across the sub-systems. RE based technologies like solar/wind-hybrid aerators, solar/wind-hybrid pumps, solar PV roof-top installation, solar vending machines can also be explored for immediate uptake. Propulsion speed reduction in vessels and insulated ice boxes for fish storage have been identified as short-term interventions for energy conservation in the sector.

RE based solutions like solar/wind-hybrid cold storages and ice plants, solar/wind-hybrid installation for ancillary consumption, refrigeration on vessels, and vessel battery re-charging, solar-electric fish dryer, concentrated solar thermal (steam generation), biomass-based boilers and ice making machines have been identified as mid-term technological solutions across the sub-systems. TES based solutions like TES integrated cold storages, TES based trucks, TES boxes, tabs and pouches can be substantial interventions to up taken under the mid-term phase. Further, fishing vessel design changes, LNG boats, bio energy production from fish waste in markets and reefer (diesel run) trucks can also be explored under the ambit of mid-term solutions.



In order to optimise the diesel consumption in fishing vessels, fuel changes like solar boats, bio-diesel run boats and electric boats shall be crucial, however they shall be more feasible for under long-term adoption scenario. Similarly, TES based solutions like TES based chillers, solar based and TES integrated fish dryer and cold storages along with biodiesel-based boilers, can be adopted in the sector under the long-term period.

Impact has been a crucial aspect in technology recommendations, our study has undertaken a potential GHG reduction impact calculation for several of the listed technologies at a sub-systems level at a 10%, 25% and 50% uptake potential, it has been pivotal to prioritise recommended technologies. Interventions such as IoT smart sub-metering, otter V boards, solar aerators, solar pumps have come out as most impactful interventions.

To smoothen the uptake of clean technology interventions in the value chain, there is need for targeted subsidies, viability gap funding and infrastructure development funds. The distribution of funds should incorporate GHG emission reduction as a performance metric and additional grants should be made available to beneficiaries for RE, EE and EC uptake. The solarisation of value chain should be escalated through dedicated subsidies for solar aerators and pumps adoption in aquaculture, setting up of TOD tariffs, dedicated funds for construction of solar ice plants and cold storages. In technological transition of fishing vessels, focus should be given to efficient and cleaner technologies like LPG/LNG for small fishing vessels, otter V board adoption, fishing vessel design changes for drag reduction, adoption of efficient engines. R&D funds should be dedicated to emerging clean technologies like bio-diesel blending for vessels and boilers, solar based TES supported cold storage, among others. IoT based sub-metering has low hanging opportunities across the value chain and needs to be supported by subsidies and pilot projects. To implement these programs and policies efficiently, there is need for different concerned departments to come together and work under one umbrella followed by necessary awareness programs and hand-holding support for the fisheries stakeholders.

Efficient business models are key to scaling clean technologies in fisheries. Subsidies like PM KUSUM, FIDF, and state schemes can support solar solutions in aquaculture. PPPs and entrepreneurship models can drive infrastructure development and integrated tech adoption, while community-led models ease capital burdens and boost local participation. Rental, subscription, and pay-as-you-go (PAYG) models offer sustainable avenues for consistent income generation and wider technology access. Targeted R&D is essential for vessel greening, while RESCO models can facilitate rooftop solar adoption in processing and ice-manufacturing units, together driving decarbonisation across the value chain. To accelerate and phase the adoption of technologies across the value chain, customised demonstration programs should be developed to showcase the benefits of the transition to the stakeholders.

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11. ANNEXURE: CLEAN TECHNOLOGY COMPENDIUM

This technology compendium has been collated as a part of an ongoing study for accelerating the uptake of clean energy interventions in the Goa's fisheries sector. This exercise is conducted under the ambit of Goa Energy Development Agency's "Clean Energy Roadmap" for the state. The information sheets contain technical and financial details of the cleantech interventions. It aims to present the diverse opportunities available for the stakeholders to consider in their transition for greening the fisheries value chain. It is also positioned to generate awareness about the implementable solutions enabling renewable energy transition.

11.1 SOLAR-WIND HYBRID SOLUTIONS

Solar-wind hybrid solutions	
About the technology	
Areas of application: Marine fishing, Jetty, manufacturing, fish processing	
Replaced/Upgraded technology: Small Vertical Axis Wind Turbines of Savonius Model	
Features	Product specification
Type (solar, solar-wind hybrid, etc)	Solar PV-wind hybrid module (1.5 kW) (basic model)
Grid connectivity (off-grid or on-grid)	Both off grid and on-grid
Max power output (solar) (kW)	1kW
No. of solar panels	2 No
No. of cells per panel (solar)	144
Max power output (wind) (W)	500 watts
Wind speed range (cut-in)	2.5 m/sec
Wind speed range (cut-out)	17.5 m/sec
Life span (years)	20 years
Maintenance cycle	Regular maintenance of solar panels and other electrical connections
Area required for installation (sq. m)	Approx 5 sq. m shadow free and obstruction free area
Costs and available support	
Cost and savings parameter	Solar wind hybrid module
Capital cost	Rs 2,00,000/-
Operational cost	Rs 0
Maintenance cost	Rs 4,000/-
Operational savings	100%
ROI (in years)	3.5 years
Available subsidies (Govt. programs):	
Benefits	
Potential energy savings: up to 90%	
Potential GHG emissions savings: 100%	
Other benefits: also, no damage for life around the plant	



11.2 BIOMASS ICE-MACHINE

Biomass-based ice-making machine		
About the technology		
Areas of application: Ice manufacturing plants, Jetties, Fish processing plants		
Scope of retrofitting: No		
Working of the technology: Off-grid and compressor-less refrigeration cycle (Adsorption refrigeration cycle)		
Technical specifications		
	Ice Flake	Ice Block
Machine/plant Dimensions (m X m):	4 M X 3 M	5 M X 4.5 M
Rated power (HP):	1.1 (single phase)	1.1 (single phase)
Ice making capacity (24 hours) (tonnes)	1 tonne (40 – 45 kg per hour)	1 tonne (17 – 21 hours) 45 slabs of 22 kg each
Compressor size (HP)	Equivalent to 14 kW / 4 TR / 48,000 BTU compressor	
Biomass required (kg/hour)	10 – 12	
Biomass form (Pellets, slab, blocks others)	Shredded and pelletized for automatic operations Block for manual feeding	
Calorific range of ideal biomass (kCal/kg)	3,000 – 4,500	
Available subsidies (Govt. programs)	• Pradhan Mantri Matsya Sampada Yojana (PMMSY) • Aquaculture Infrastructure Development Fund (FIDF)	
Benefits, challenges and needed support		
Benefits: • Cost of making ice is reduced by 50% • Use natural refrigerant as per National Action Cooling Plan having zero ODP and zero GWP • No requirements of 3 phase grid power or diesel generator • IoT enabled – Can monitor the system over web platform • Enhanced hygienic production • No requirement of crusher which is diesel powered	Challenges in uptake: Linking to biomass value chain	Needed support (policy and infrastructure): • Viability gap support to make it affordable • Policies incorporating special benefits for alternate technology
Potential Energy Savings		
9 kW per hour of energy savings for each installation		
GHG emission reduction potential		
57 tonnes per annum for each installation		

11.3 BIOMASS-BASED COLD STORAGE

Biomass based cold storage	
About the technology	
Areas of application: Markets, Fish processing plants, Ice manufacturing plants.	
Replaced/upgraded technology: Yes	
Scope of retrofitting: Yes, with any cold room of up to 20 MT storage capacity	
Working of the technology: Adsorption Refrigeration Technology (compressor-less)	
Technical specifications	
Features	Biomass based cold storage (Fish)
Capacity (MT)	5
Size (m X m):	• 3.6×3.2 (cold room dimensions) • 300 ft² area for 20 MT cold room installation including refrigeration unit
Refrigeration (TR)	4
Temperature range	-2 degree C and above
Temperature retention (hours)	No thermal backup required
Backup (grid connected)	Only for auxiliary power source
Biomass required (kg/hour)	6 – 8
Biomass form (Pellets, slab, blocks others)	Shredded and pelletized for automatic operations
Maintenance cost:	INR 20,000 per annum
Operational savings:	Above INR 20,000 per month
ROI (in years):	1 year
Available subsidies (Govt. programs):	MIDH, PMFME, AIF, PMMSY
Benefits	
Potential energy savings	
7.5 kW per hour of energy savings for each installation	
Potential GHG emission reduction	
40 tonnes per annum for each installation	
Other benefits: • Cost of cooling is reduced by 70% • Use natural refrigerant as per National Action Cooling Plan having zero ODP and zero GWP • No requirements of 3 phase grid power or diesel generator • IoT enabled with live camera streaming • Multipurpose applications (Can be use for ripening, storage) • 20% of capacity (i.e. 5 MT) daily loading capacity	



11.4 BIOMASS-BASED DRYER

Biomass-based fish dryer	
About the technology	
Areas of application: Fish drying	
Scope of retrofitting: Yes	
Working of the technology: Hot air-drying using Biomass Powered Hot Water Generator	
Technical specifications	
Capacity (tonnes):	0.1
Rated power (HP):	0.1
Size (m X m)	3.2×3.2 (insulated room dimension)
Operational temperature (deg. Celsius):	40 – 70
Reqd. drying time (hours):	12 – 15
Biomass required (kg/hour)	5 - 6
Biomass form (Pellets, slab, blocks others)	• Shredded and pelletized for automatic operations • Block for manual feeding
Calorific range of ideal biomass (kCal/kg)	3,000 – 4,500
Moisture content of biomass (%)	5 - 20
Fines (%)	1
Diameter of biomass (mm)	12 (automatic feeding)
Length of biomass (mm)	6 – 18 (automatic feeding)
Source of biomass:	Raw Farm residue/agriculture waste: Jackfruit, mango, arecanut, pineapple, coconut, kokum, banana, cashewnut, pulses farms residue
	Processing Waste: Pellets (MSW, Rice husk, bamboo), cashew, almond & groundnut Shells, shredded coconut, Bamboo chips.
Grid connectivity:	Not required
Type of back up:	Inverter
Back-up (hours):	10
Maintenance cycle:	Annual
Lifespan (years):	20
Costs and available support	
Costs and savings	Biomass based fish dryer
Capital cost	3,55,000
Operational cost	INR 4,000 per month
Operational savings	INR 25,000 per month
Maintenance cost	INR 20,000 per annum
ROI (years)	1 year

Benefits, challenges and needed support		
Benefits	Challenges in uptake	Needed support (policy/ subsidy/infrastructure)
Reduced drying time: 15 hours Vs 72 hours compared to solar dryer	Linking to biomass value chain	

11.5 COLD STORAGE

Cold storage						
About the technology						
Costs and available support (assumed 8 hours of power outage in a day)						
	TES based cold storage			Solar cold storage		
Capacity (MT)	5 MT	10 MT	20 MT	5 MT	10 MT	20 MT
Capital cost:	13.5 L	20.4 L	30 L	22 L	32 L	55 L
Capital cost of traditional system:	9.5 L	13.2 L	19.L	9.5 L	13.2 L	19.L
Operational cost per year:	0.8 L	1.5 L	2.8 L	0.8 L	1.5 L	2.8 L
Maintenance cost per year:	10,000	15,000	20,000	10,000	15,000	20,000
Operational savings per year:	2.8 L	5.0 L	8.8 L	2.8 L	5.0 L	8.8 L
Potential increase in revenue due to reduced losses per						
year (200 INR/kg fish, 10% utilization & 10% loss reduction):	36.5 L	73 L	146 L	36.5 L	73 L	146 L
ROI (in years):	1	1	1	1	1	1
Available subsidies (Govt. programs): Pradhan Mantri Matsya Sampada Yojana Subsidy of 40% of the unit/project cost for General category and 60 % for SC/ST/Women category - North Eastern & Himalayan state: 90 % central and 10 % state share - Other states: 60% central and 40% state share. - UTs (with legislature and without legislature): 100 % central share			Cost norms - Cold storage of 10 MT capacity: 40 Lakhs - Cold storage of 20 MT capacity: 80 Lakhs - Cold storage of 30 MT Capacity: 120 Lakhs			
Benefits						
Potential energy savings Potential GHG emission reduction: 500 to 1000 litres of diesel per year Other benefits: Store ice blocks in the same cold storage, no reliance on diesel, no diesel pilferage						
Areas of application: Perishable commodities such as fruits, vegetables, fish, meat, etc.						
Replaced technology: TES cold storage eliminates diesel & solar further reduces electricity consumption						
Scope of retrofitting: PUF panel room can be utilized provided it has adequate thickness						
Working of the technology: Solar or electricity generates cooling which is stored in TES for later usage						



Technical specifications						
Features	TES based cold storage (Sample specifications but can be modified as per client)			TES based cold storage (Sample specifications as per MNRE guidelines but can be modified as per client)		
	5 MT	10 MT	20 MT	5 MT	10 MT	20 MT
Capacity (MT)	1.5-2.5 TR	2.5 TR	4.75 TR	2.5 TR	4.5-4.75 TR	8.3 TR
Refrigeration TR	0.8 L					
Temperature range	-4 to 4 °C			-4 to 4 °C		
Temperature retention (hours)	24 hours			48 hours		
Grid requirement (hrs)	10 to 15 hours / day			4 to 6 hours / day on rainy season		
Electric rating (kW)	4 kW	8 kW	15 kW	4 kW	7 kW	15 kW
Solar capacity (kW)	NA			8 kWp	15.6 kWp	26 kWp
TES quantity (kg)	150 MJ	245 MJ	440 MJ	245 MJ	440 MJ	800 MJ
	765 kg	1250 kg	2244 kg	1250 kg	2244 kg	4081 kg
Type of insulation:	120 mm PUF			120 mm PUF		
Lifespan (years):	More than 20 years			More than 20 years		

11.6 VIRTUAL METERING SOLUTIONS

Energy management systems – Sub-metering			
About the technology			
Areas of application: Optimize Energy & Water Usage through sub-metering			
Product specification			
Features	Basic Energy Management System Unit Level	Performance management of critical utilities	Sustainable water management
Dashboard availability:	Yes	Yes	Yes
Parameters monitored:	- Power, Head, Flow - Performance of connected equipment	Integrated Performance Management of Utilities, such as HVACR, Pumping & Water Treatments Sys, Other Electrical Utilities	Integrated Water-Energy & Asset Management Platform
Smartphone compatibility:	Yes	Yes	Yes
Component or system failure alert:	Yes	Yes	Yes
Report creation:	Yes	Yes	Yes

Costs and available support			
Cost factors	Basic Energy Management System Unit Level	Performance management of Major Utilities (HVACR, Pumps etc.)	Sustainable water management
Capital Expenditure	INR 50,000 to 300,000	INR 3 Lakhs to 15 Lakhs	INR 3-5 Lakhs
Operational expenditure	Rs 3,000 - 5,000	Rs 10,000 - 20,000	INR 2,000 - 5,000
Maintenance cost	Can be remotely supported	Can be remotely supported	Can be remotely supported
Operational savings	2-3%	10-15%	10-20%
ROI (in years)	18 months	18 months	2-3 years
Available subsidies (Govt. programs):			
Benefits			
Basic Energy Management System Unit Level	Performance management of critical utilities	Sustainable water management	
Potential Energy Savings: 3 to 5% Energy Cost Reduction	Potential Energy Savings: 10 to 15%	Potential Energy Savings: 10-20% Potential GHG Emissions: As per the above	
Potential GHG Emissions: As per the above	Potential GHG Emissions: As per the above		

11.7 CONCENTRATED SOLAR THERMAL SOLUTION

Concentrated Solar Thermal		
About the technology		
Areas of application: Heating/ Cooling		
Scope of retrofitting: Possible		
Working of the technology: Using the reflective properties of mirror, concentrating sunrays to a point (receiver) to generate thermal energy.		
System specification		
Type of CST: Parabolic Dish Concentrator		
Concentration ratio:	Scheffler Concentrator: 300 Suns	Big dish Concentrator: >2000 Suns
Grid connectivity: Not required as can be run on PV		
Dish type	Scheffler Dish	Big dish
Size of dishes/troughs:	16 m ²	500 m ² .
No. of glass panels in a dish/ trough	Small segments: 200	380 Solar mirror panels of 1 m ² each
Max power output (solar):	5 KWthp	> 400 KWthp
Working temperature:	500-degree Center in Focus	Around 2000 degree Celsius in Focus



Quantum of steam production:	5 kg/hour	400 kg/hour (peak)
*Peak depends on DNI and will vary based on Temperature and pressure		
Steam pressure:	10-12 kg/cm2	up to 160 Kg/cm2
Thermal storage material: Pressurized Hot Water/ Steam Accumulator- looking for TES as option		
Thermal storage capacity: 1 -2 hours		
Area required for installation:	3m x 3m shadow free	25m x 25m shadow free
Costs and available support		
Capex (Per dish)	INR 3.5 lakhs	INR 2.5 crores
Opex: Negligible		
Maintenance cost: Negligible		
Operational savings: Varies		
ROI (in years): Varies based on fuel used		
Available subsidies (Govt. programs): None		
Benefits		
Potential Energy Savings: Will vary with size of Project		
Potential GHG Savings: Will vary with size of project		

11.8 LNG/LPG/CNG BOAT

CIFT LNG/LPG/CNG Boat	
About the technology: Alternate fuels usage to reduce emissions from diesel and petrol through retrofitted engine changes	
Areas of application: Use for dol-netting and gill netting in marine waters	
Possibility of retrofiting: Yes	
Working of the technology: LPG retrofitted in the 9.9 HP Petrol boats	
Boat Specifications	
Engine size	9.9 HP Petrol Boats and 20 HP Diesel Engines
Fuel type	LPG
Range	40 Knots
Speed:	4-6 knot
Overall length:	26 feet
Capacity	1.5 tonnes
Ancillary features (size of storage, type of insulation, engine ignition battery details)	No storage for the fish inside the boat, only on the deck
Scalability	Yes
Maintenance cycle	4 months
Costs and available support: One time subsidy may be provided from the State Govt for retrofiting	

Capex:	Govt may provide subsidy for the one-time retrofitting	
Opex:	No plan for subsidy from the Govt Side	
Maintenance cost	10-15 % of recurring cost	
Operational savings:	More than 30 %	
ROI (in years):	3.4 months for gill netting	
Available subsidies (Govt. programs):	Under discussion	
CIFT Profile		
Market readiness:	Procurement in Goa: Not Now	Contact Details
Years:	Presence in Goa: No Procurement	
No. of projects:	method: Through State Fisheries	Name: Dr Shravan Kumar Sharma
Capacity of projects (MW):	department Maharashtra/ ICAR-	Phone:
Deployment locations:	CIFT	Email:
Mumbai	Post-installation support: From	shravansharmacofsn@gmail.com
	BPCL Mumbai	

11.9 THERMAL ENERGY STORAGE SOLUTION APPLICATIONS IN LOGISTICS

Thermal Energy Storage in perishable transport		
About the technology		
Areas of application: Raw Meat & Sea food, Fresh Vegetables, Dairy, Chocolates, Frozen Food/ice cream		
Replaced/upgraded technology: Conventional Refer diesel driven trucks		
Scope of retrofitting: Yes		
Technical specifications		
TES based transport		
Size (feet): 10 ft		
Capacity (tonnes):		
TES plates (size and no)	For chilled: 3 Nos	For frozen: 7 Nos
Temperature range	For chilled: 2 to 8 degrees	For frozen: -18 degrees
Temperature retention duration (hours)	For chilled: 12 -14 hours	For frozen: 12 -14 hours
Lifespan (years): 8		
No. of charging cycles: 3,000		
Charging requirements		
Charging hours: 6-8 hours		
Energy consumption for one full charge (kWh): 12-15 units		
Costs and available support		
Offered technology		



Costs and savings	TES based vehicle	TES retrofitted vehicle
Capital cost (lakhs)	3.00	1.5
Operational cost (lakhs)	4.50	5.3
Operational savings (lakhs)	1.5	
Maintenance cost (lakhs)	0.2	0.2
ROI (years)	1.8	
Benefits		
Potential energy savings, GHG emission reduction potential and other benefits: Fossil-fuel free refrigeration with thermos tab active solution, Low operational cost savings up to 40% and higher annual savings, Low maintenance due to no moving parts, Provides carefree transportation in case of vehicle or refrigeration system breakdown. No air/ noise pollution while running		

11.10 THERMAL ENERGY STORAGE SOLUTION BOXES, TABLETS (TABS) AND POUCHES

Thermal Energy Storage boxes, tablets (tabs) and pouches
About the technology
Areas of application: Logistics, Marine fishing
Replaced/Upgraded technology: Conventional Refer diesel driven trucks, Ice and Dry Ice
Technical specifications
TES tabs/pouches/boxes
Temperature range: +75 to -75 degrees
Temperature retention duration: Up to 96/120 hours
TES tab size (millilitres): 270 ml /600 ml / 1200ml/1500ml – custom sizes can be done with MOQs
TES tab dimensions (mm X mm X mm): 185 × 90 × 20 /191 × 122 × 35 / 295 × 235 × 31/ 300 × 210 × 35
TES box size (no. and size of TES tabs used): 75lt / 6 Nos
TES box dimensions (mm X mm X mm): 600 × 400 × 320 mm
TES pouch size (milliliters): 70 ml/100 ml/200 ml /320 ml/ 450 ml
TES pouch dimensions (m X m): 95 × 157/ 125 × 157mm/ 190×157×11mm
Lifespan (years): up to 5 years (boxes) and 2 years for tabs
No. of charging cycles: 2000 cycles (6+ years)
Charging requirements
Blast freezer size (no. of TES tabs): 144, 210, 280, 600 (as per 600 ml pads) ,800 tabs
Blast freezer volume (litres): 219, 430, 543, 800, 1235 litres
Rated power (HP) 415 V 3phase 5-Ghz - 2.6 units per hour (3kVA to 10 kVA connection required)
Charging time (hours): 9-10 hours

Costs and available support				
Replaced technology- (Ice/ ice boxes)	Offered technology (TES tabs/ pouch/ boxes)			
	Costs and savings	TES tab	TES pouch	TES box
Capital cost:	Capital cost:	INR 250	INR 5	INR 2,000-10,000
Operational cost:	Operational cost:	INR 3.5 (including freezing) x 5 (INR 16.5/box)	Depends upon size but similar to tabs	Nil
Maintenance cost:	Operational savings:	34%	30-40%	-
	Maintenance cost:			
	ROI (years)			
Benefits				
Potential energy savings: 30-40%				
GHG emission reduction potential: Depending upon alternate fuel used				
Other benefits: Reusable solution with lower cost of operations				
Other benefits: Fossil-fuel free refrigeration with Tab and boxes Low operational cost savings up to 40% and higher annual savings Low maintenance due to no moving parts. Reduced need for refer trucks Green technology with no air and noise pollution while running Easily scalable solution. Reusable solution				

