EMPIRICAL STUDY OF FACTORS TO PROMOTE OCEAN ENERGY IN INDIA: DEVELOPING A SUGGESTIVE FRAMEWORK FOR OTEC POLICY IN INDIA

A Thesis Submitted to the

UPES

For the Award of

Doctor of Philosophy

in

Management (Power)

By

Sankhadeep Chakraborty

June 2024

SUPERVISOR (s)

Dr. Rajesh Gupta
Dr. Prasoom Dwivedi

UPES
UNIVERSITY OF TOMORROW

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School of Business
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Dehradun-248007: Uttarakhand

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DECLARATION

I declare that the thesis entitled "Empirical Study of Factors to Promote Ocean Energy in India: Developing a Suggestive Policy Framework for OTEC" has been prepared by me under the guidance of Dr. Rajesh Gupta, Professor, CCE, UPES, Dehradun, India, and Dr. Prasoom Dwivedi, Professor, Economics & International Business, School of Business, UPES, Dehradun, India. No part of the thesis has previously formed the basis for the award of any degree or fellowship.

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THESIS COMPLETION CERTIFICATE

I certify that Sankhadeep Chakraborty has prepared his thesis entitled "**Empirical Study of Factors to Promote Ocean Energy in India: Developing a Suggestive Framework for OTEC Policy in India**" for the award of a Ph.D. degree from the University under my guidance. In addition, he has carried out work at the CCE, UPES, Dehradun.

It is certified that the work has not been submitted anywhere else for the award of any other diploma or degree of this or any other University.

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Executive Summary

India's GDP is the fastest-growing economy in the world. As a result, energy demand is expected to rise to 4,000 TWh by 2030. As a result, this country needs to plan additional electricity generation capacity to meet its growing electricity demand. There is a need to augment annual capacity to 35,000 MW per year. Thus, it is vital for India to explore the RE generation mix to expand additional electricity generation resources.

The excessive focus on solar and wind stresses natural resources such as land and forest areas. In addition, the low Capacity Utilization Factor (CUF) of wind and solar and its intermittency will drive the country to maintain the baseload.

Recently, the Indian government has attempted the RE bucket diversification by getting approval from the cabinet for a Deep-ocean mission. The cabinet has approved OTEC for energy generation and fresh water from the ocean. Researchers have revealed that OTEC has the potential to become a competitive RET with various advantages over the other RETs, especially wind and solar. Based on available ocean resources in India and the techno-economic benefits of OTEC have encouraged the researchers of this study on the way forward for the development of OTEC in India.

This study attempts to help policymakers develop OE as a viable option for India to achieve its ambitious targets of adding 450 GW of RE by 2030. The study aimed to develop a practical policy framework to leverage its OE potential in India. The study has been planned in the following manner to achieve the objective of the study.

Analysis of the international experiences to identify and suggest necessary variables of RE policy to promote OE.

Understanding the viability gap funding needs to boost the OE sector with the help of a techno-economic analysis of OTEC.

Building insights for OE policy development with the help of an opinion survey of the stakeholders interested in the RE development of the country.

Developing a suggestive policy framework for OTEC development in India.

- The study consists of **eight chapters**. The first chapter is the **introduction** to the topic, including India's energy needs to sustain its current economic growth, the contribution of renewable energy to the electricity mix, the renewable energy scenario in the country, and the importance of policies to augment the development of renewable energy in the country. This chapter also mentions that India needs to tap into OE.
- The second chapter **reviews literature** which studies the global renewable energy scenario, OE development in the world, the present status of the OE sector in Europe with a focus on the UK and France, a brief on the Indian RE sector and policies to encourage the growth of growing RE in India. The chapter also includes the **Theoretical Premise** using Resource-based theory. It has covered OE as a valuable resource for exploiting the OE resource advantage to identify the research gap and define the problem statement. This chapter also highlights the gap in the literature on OE policy availability for India. Thus, identified variables are presented in this section.
- The third chapter deals with the **Ocean Economics Analysis** of setting up OTEC projects in India with or without value-added products.
- The fourth chapter explains the **research design**, and the rationale of the study, followed by the statement of the research problem, objectives of the study, research questions, scope of the study, research model and hypotheses, the research methodology, sampling process, Instrument design, questionnaire format, scale formation, Instrument reliability, Instrument validity, pilot testing,

data collection and operational definitions of variables found through literature survey and analytical tools used for the analysis of primary data.

- The fifth chapter explains the data analysis and discussion. The factor analysis reduced the 21 variables identified through the literature survey. It was administered as a questionnaire to 324 respondents into six factors, and then the logistic regression gave the log odds of growth of OE in India. The formulated research model is empirically validated, and consequent results are reported.
- SAP-LAP analysis of the UK and France is explained in the sixth chapter. Barriers, as discussed in the LR chapter, have been considered as situations. Further steps such as actor, process, learning, action, and performance have been analyzed with each barrier with the help of a literature review. In total, 66 points have been discussed, and this tool has helped to understand the nuts and bolts of the successful implementation of OE policy in the UK and France. Finally, a comparative analysis of the UK and France in the SAP-LAP paradigm (situation-actor-process-learning-action-performance) is provided.
- The seventh chapter explains the **Suggestive Policy Framework for OTEC in India**. In this chapter, a linkage framework is developed for each one of the factors identified based on the learning experience in France and the UK. Further, it was validated by an industry expert. UK experience for OE development was considered for the linkage framework for developing the proposed linkage framework for India. The methodology for choosing the policy framework of the leading countries was based on the following: Policy implementation, deployment of OE-based installed capacity after policy implementation, and at what cost can India afford?

- Finally, the eighth chapter gives the **conclusions and recommendations**. The bibliography is provided at the end as a reference.

This study has provided essential inputs and conceptualizes the framework for Ocean Energy development in India; if implemented, this framework will help harness renewable energy effectively and contribute significantly to the country's transition to net zero emission. Apart from this, the study has also filled the theoretical gap in understanding the role of policy in natural resource utilization for competitive advantage.

The recommendations have been given under significant heads, which are as follows,

- A nodal agency for faster approvals
- Grid connectivity for OE projects
- Long-term (at least ten years) policy goals must be established and communicated.
- Encourage R&D in OE
- Market and non-market incentives for OE
- Legally enforceable payment mechanism

The study introduced the country's policy pathways for natural resource development with the help of a linkage framework. This framework has developed pathways through actors, processes, actions, and performances. This framework has identified vital actors and processes, suggested the required actions, and estimated the expected performance.

ACKNOWLEDGMENT

Pursuing a doctoral degree has been one of the most formative experiences of my life, yet achieving this goal would not have been feasible without the encouragement and direction I got from many individuals. It is difficult to mention all the people who assisted in getting this done, and it is much more challenging to thank them properly for their contributions. Throughout this fantastic journey, many people have helped me in many ways and contributed to my thesis. I want to offer my most heartfelt gratitude to those people.

First, I want to offer my profound and heartfelt appreciation to my mentors, Dr Rajesh Gupta and Dr Prasoom Dwivedi. Both of you have been invaluable to me. Their direction and unwavering support have been invaluable to me during this entire research process and writing my thesis. I had the good fortune to profit from his extensive experience and insightful comments, which inspired me to put in extra effort because of the significance of his contributions. This important goal could not have been accomplished without his direction and the consistent input he provided.

Many thanks to the UPES, where I was granted permission to carry out the study that led to the completion of my PhD degree.

Furthermore, I would like to thank my Head, Dr V J Byra Reddy (Director-Quality Assurance & Accreditation, UPES), for his constant encouragement. The success of this endeavour is in large part due to his encouragement. When I needed help in school or life, he was always there to listen and guide me.

I also appreciate the advice of the School Research Committee members for their constructive comments and valuable suggestions, which enabled me to make necessary improvements in my work.

My sincere thanks also go to Dr Raju Ganesh Sunder, Dr Tarun Dhingra, Dr S.K Pokhriyal, Dr Anil Kumar, Dr T.B Raju, Dr P.C Bahuguna, Dr Saurabh Tiwary, Dr Atul Razdhan, Dr Mohammad Yaqoot, Dr Sunil Barthwal, Dr Prasoom Dwivedi, Prof. Atri Nautiyal and Dr K.K Pandey for always encouraging and motivating me to complete this research work.

I express my humble gratitude to all the farmers, wholesalers, commission agents, transporters, and experts who have contributed their valuable time and efforts to collect the necessary data for the study.

No thanks to my mom, dad, and late brother will ever be adequate for how their love inspired me to study hard and get my PhD. Thanks to their inspiration, I know I can achieve my goal, no matter how difficult the path may be. Without their faith and perseverance, this study would never have been conducted. Thanks to their love and understanding, my sister, brother-in-law have tremendously encouraged me. Both my parents-in-law's assistance was invaluable to me while I wrote this thesis, and I am eternally grateful to them. My two nephews Ivan and Jian deserve a lot of credit for keeping me motivated.

Finally, I'd like to express my gratitude to my wonderful wife, Roshni, and my daughter Erina who put up with my many questions and never complained about the lack of sleep. She has given up so much to bring me where I am today.

Thank You All…!!!

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CHAPTER 1 - INTRODUCTION

1.1 Background

India's current population is 1.40 billion, expected to grow to 1.51 billion by 2030(WPR, 2021). As per the International Monetary Fund (IMF)(2022), India's GDP in 2022 is expected to bounce back to 8.2%, reclaiming its status as the fastest-growing economy in the world. Population and GDP growths place massive demands on electricity consumption. Energy demand is expected to rise to 4,000 TWh by 2030 (MoP-GoI, 2020). As a result, this country needs to plan additional electricity generation capacity to meet its growing electricity demand. As of May 2022, India's total capacity for electricity supply is 402 GW(CEA, 2022), of which 28.11% is renewable energy (RE), 11.6% is hydroelectric, 1.68% is nuclear power, and the majority percentage at 58.6% is still represented by coal and gas-based power plants, as shown in Table 1-1.

Table 1-1 Power Generation Installed Capacity in India (CEA, 2022)

Fuel	MW	%
Coal	204,079.5	50.66%
Lignite	6,620.0	1.64%
Gas	24,879.2	6.18%
Diesel	509.7	0.13%
Nuclear	6,780.0	1.68%
Hydro	46,722.5	11.60%
Renewable	113,226.5	28.11%
Total	402,817.4	100.00%

RE capacity increased significantly in the last few years to 113 GW; however, it remains less than 30% (Table 1-1). As per the plan for additional capacity building, five times more RE capacity needs to be generated by 2030, i.e., 500 GW (CEA, 2018; GoI, 2016; MoP, 2020; NITI Aayog, 2019). That means an additional 386 GW of RE capacity must be installed in the country by

2030(Table 1-2). It needs an annual capacity augmentation of 48,250 MW or 927 MW per week to reach this gigantic target in the next eight years. Therefore, India must augment additional resources to boost the development of the RE generation mix.

Table 1-2 Renewable Energy Scenario against Potential in India (CRISIL; IIT-M, 2018; MNRE, 2021a; NITI Aayog, 2019)

System	Current Installed Capacity (GW)	Target for 2030 (GW)	Theoretical Potential (GW)	Untapped Potential (in %)
Wind	40.71	140	180	22.22%
Solar	56.95	350	360	16.67%
Biomass, Waste to Power	10.68	10	20	48.50%
Small Hydro	4.89		10	53.00%
Ocean	0	-	522.5	100.00%
OTEC*	0	-	450	100.00%
Tidal	0	-	12.5	100.00%
Wave	0	-	60	100.00%
Total	**113.23**	**500**	**1615**	**72.14%**

* Ocean Thermal Energy Conversion (OTEC)

1.2 Need for research

India plans to achieve 500 GW of RE by 2030, of which 350 GW will be solar, 140 GW will be wind, and 10 GW will be generated from other sources such as small hydro, biomass, waste to energy, and others (as per Table 1-2)(NITI Aayog, 2019). This implies India will heavily focus on solar and wind (490 GW) to meet its 2030 target. However, the generation of large-scale renewable power is land-intensive. Only 1 MW solar power plants in India require four to five acres of land (Chakraborty, Gupta, et al., 2018). According to a recent article titled "Renewable Energy and Land Use in India: A Vision to Facilitate Sustainable Development" by the Centre for Science Technology and Policy (CSTEP) and the Nature Conservancy (TNC), the RE target for 2022 (175 GW) is very land-intensive because it is estimated that India would require as much land area as the entirety of Himachal Pradesh or Chhattisgarh to meet its target, that is, between 55,000 and 125,000 sq km of the total land footprint. Considering the above estimation of generating 490 GW in solar and wind power, the land between 165,000 and 375,000 sq km, roughly 11% of the national land area or more than the area of Rajasthan, would be needed. Therefore, the availability of land could be the biggest constraint for this ambitious expansion program for the RE of the government.

Another significant challenge might be the Intermittency and Capacity Utilization Factor (CUF) of solar and wind power. As per Central Electricity Regulatory Commission’s (CERC) tariff regulations, the CUF of solar power varies between 19% and 25 %(CERC, 2019b), which is significantly low. As discussed above, Indian energy demand is expected to rise to 4,000 TWh by 2030 (MoP-GoI, 2020). However, RE's contribution is likely between 518 TWh (Palchak et al., 2019) and 887 TWh (CERC, 2019b). As per the former Chairman of the Atomic Energy Commission (AEC) of India, Anil Kakodkar, wind and solar cannot meet the baseload requirements in 2030 due to their intermittency(Kakodkar, 2020). Kakodkar and other researchers recommended that 50–52 % of the total electricity demand be maintained as the baseload in 2030(Bhat & Bachhiesl, 2017; Kakodkar, 2020). Accordingly, the baseload requirement of the country will be about 2,000 TWh. Low CUF coupled with solar and wind power intermittency has forced India to consider alternative RE sources to maintain the baseload (MoES, 2021).

Table 1-3 compares the levelised cost of energy (LCOE) of different energy technologies based on estimated capital costs. The energy technologies have been listed in three categories; conventional energy technologies, established RETs, and emerging RETs (OE). The per-unit levelised cost of ocean energy is approximately Rs.5/kWh, whereas the per-unit levelised cost of wind and solar is Rs.2.50–Rs.3/kWh. However, wind and solar energies have an additional cost of balancing, estimated at Rs.1.10/kWh(CEA, 2020). This makes the effective cost of wind and solar fall within Rs.3.50–4/kWh. Compared to this, the LCOE is still on the higher side. However, we must remember that at its inception during 2009–10, solar PV tariffs were approximately Rs.18/kWh(CERC, 2019a). With progressive policy and regulatory support, the investors started evincing interest in this matter. Consequently, the economies of scale led to a decline in solar tariff from Rs.18/kWh to around Rs. 2–2.50/kWh (The Hindu BusinessLine, 2020).

Table 1-3 Comparison of Levelised Cost of Energy (LCOE) of different technologies

(CEA, 2020)

Source of Generation	Capital Cost (in Lakhs)/ MW	LCOE (in Rs/ kWh)	Balancing Cost (in Rs/kWh)	Total Cost (in Rs/kWh)
	1	2	3	4 = (2) + (3)
Non-fossil Fueled Cogen Plant	452.8	3.5	0	3.5
Hydro	754.6	4.5	0	4.5
Wind	400	2.44	1.1	3.54
Solar	300	2.36	1.1	3.46
Ocean Energy	2,122.20	5.01	0	5.01

Proper policy and regulatory support are expected to bring in the desired economies of scale for ocean energy technology (OET), which, in turn, will lead to cost reduction and, eventually, grid parity for OE technology in the foreseeable future. Therefore, knowing the the ocean-economic aspects of OE in the Indian context that are favourable. The potential of OE should be leveraged to meet sustainable development objectives Table 1-4 represents that the potential of OE is between 229 GW and 372 GW(MNRE, 2021a; Ravindran & Abraham, 2002; Ravindran M & Abraham, 2002). Theoretically, it can be said that OE alone can support the required RE capacity of India in 2030. As per Kumar(2017), 116 GW of this capacity can be tapped from OE by 2030 (Chakraborty, Gupta, et al., 2018; Kumar, 2017). The CUF of the OE system is around 90–92%(Kempener & Neumann, 2014), which is significantly higher than RE systems such as solar and wind energy systems. Similarly, the plant life of OETs is 30–35 years. However, international experience has shown that there can be more than 50 years of plant life(Magagna & Uihlein, 2015b).

Table 1-4 Potential of OE in India

Source: (CRISIL; IIT-M, 2018; MNRE, 2021a)

OE technology	Min (in GW)	Max (in GW)
OTEC	180	300
Tidal	9	12.5
Wave	40	60
Total	229	372.5

Thus, OETs with non-intermittency, high CUF, no land requirement, and longer plant life can be RE policy alternatives and a solution to the baseload problem (Soudan, 2019). Let's assume OE provides around 1,400 TWh with 180 GW capacity by 2030. Therefore, it will provide approximately 35% of the total energy demand by 2030 and support around 71% of the baseload requirement (2000 TWh, as discussed above). In addition, OTEC has value-added advantages such as drinking water, seawater, air conditioning, etc. Therefore, the development of OE in India is the most appropriate strategy to achieve its RE targets and its sustainable development goals (SDGs).

1.3 Business problem

The lack of coupling ocean energy potential for harnessing RE in India leads to opportunity loss. The opportunity loss can be defined in terms of the following:

■ Tangible Opportunity Losses:

Tangible Opportunity Loss	=	{(Potential – Installed Capacity) x Cost per MW X Equity x (ROE- Treasury bill interest)}
Potential	=	229,000 MW [MNRE]
Current Installed Capacity	=	0 MW [CEA]
Equity	=	30% (assuming standard values from CERC)
ROE	=	16% (assuming standard values from CERC)
Avg. Treasury bill rate	=	7.55% (Avg. 1993-2019) (RBI website)
Cost per MW	=	$ 0.324 Million Per MW (IRENA)
Tangible Opportunity Loss	=	{(229,000-0)x0.324 x 0.30 x (0.16-0.0755)}/1,000
	=	$ 1.88 Billion/- p.a

■ Intangible Opportunity Losses:

- Low CUF
- Baseload management crisis (including backup of baseload for wind and solar)
- Intensive land requirement for solar and wind
- Intermittency
- Byproduct of OTEC
- Drinking water
- Sea water air conditioning
- Additional job opportunity

The above estimations indicate that India is preceding an annual revenue of approximately **$ 1.88 Billion annually** by not developing its unutilized OE potential.

1.4 Outline of the study

India has encouraged the growth of the OE sector to mitigate the risks associated with fossil fuels and enhance the share of renewable sources in the electricity mix. However, a comprehensive policy is needed to start and sustain the adoption of OE farms, as observed in several countries globally (the literature review section covers this in detail). At a fundamental level, what constitutes the essential elements of offshore wind energy policy needs to be known to draw up the entire architecture of this intervention.

The study aims to develop a suggestive policy framework for India's Ocean Energy (OTEC) development. This study has reviewed policies for OE development in eleven countries (Belgium, Denmark, France, Germany, Ireland, United Kingdom, Canada, USA, China, Japan, and the Republic of Korea). In addition, the data has been collected from RE stakeholders in India to understand the critical factors for OE development in India. Based on the learnings from eleven different countries and responses collected from Indian RE stakeholders, a policy framework for OE development in India has been proposed in this study.

This thesis does an exhaustive literature survey of the successful adoption of the OE sector by select countries in the world to identify the basic building blocks (variables) needed to encourage OE growth in those countries. The research model and hypotheses are formulated, keeping an eye on the study's objectives. Twenty-one such variables were identified; Statements are constructed and evaluated using a 5-point Likert scale and an itemised rating scale. A pilot study was conducted, the instrument's reliability was calculated using Cronbach Alpha and further validated, field survey responses were analysed using SPSS 21.0, and the proposed framework was validated. The collected data were subjected to factor analysis to determine the fundamental structure. Hypothesis testing is carried out by multivariate analytical techniques like logistic regression to empirically test the framework to predict the growth probability of India's OE sector. The results are presented in CHAPTER 5 – ANALYSIS & DISCUSSION of this document.

Further, based on the review of the 11 countries' policies, an SAP-LAP analysis, a methodological construct, was used to analyze the best practices of the benchmark countries. The researchers have taken the UK and France as benchmark countries to gather learnings for India. SAP-LAP and e-IRP tools were used to develop the policy framework for OE development in India.

1.5 Significance of the study

Due to heavy dependence on solar and wind, Indian policymakers face challenges in two ways 1) maintaining the baseload problem due to the intermittancy of solar wind and 2) the problem of land requirement. To meet these challenges, the Indian Government has included OTEC energy in the RE basket and is part of RPO compliance through the new renewable energy ministry.

The importance of the study for the researchers is to analyze the problem from a resource-based view theory perspective where the researchers have tried to explore the country's natural resource and their use for the country's development. Still, this study has also presented the policy framework that can help effectively and efficiently utilise OTEC. To achieve this objective, the researchers have analyzed the policies of benchmark countries (the UK and France) for OE development, identified the critical factors for OE development in India, ranked the essential actors and actions for a suggestive policy framework, and finally presented a policy framework for OE development in India.

This study has also done a techno-economic analysis of OTEC in India, which will provide significant inputs for decision-makers regarding the commercial viability of OTEC in India.

1.6 Organization of the report

The study consists of **eight chapters**. The first chapter introduces the topic, including India's energy requirements to sustain its current economic growth, the RE contribution to the electricity mix, the current state of RE in

India, and the role that government policy should play in encouraging its growth,. This chapter also discusses India's need to utilise OE.

The second chapter **reviews literature** which studies the global renewable energy scenario, OE development in the world, the present status of the OE sector in Europe with a focus on the UK and France, a brief on the Indian RE sector and policies to encourage the growth of growing RE in India. The chapter also includes the **Theoretical Premise** using Resource-based theory. It has covered OE as a valuable resource for exploiting the OE resource advantage to identify the research gap and define the problem statement. This chapter also highlights the gap in the literature on OE policy availability for India. Thus, identified variables are presented in this section.

The third chapter deals with the **Ocean Economics Analysis** of setting up OTEC projects in India with or without value-added products.

The fourth chapter explains the **research design**, and the rationale of the study, followed by the statement of the research problem, objectives of the study, research questions, scope of the study, research model and hypotheses, the research methodology, sampling process, Instrument design, questionnaire format, scale formation, Instrument reliability, Instrument validity, pilot testing, data collection and operational definitions of variables found through literature survey and analytical tools used for the analysis of primary data.

The fifth chapter explains the **data analysis and discussion**. The factor analysis reduced the 21 variables identified through the literature survey. It was administered as a questionnaire to 324 respondents into six factors, and then the logistic regression gave the log odds of growth of OE in India. The formulated research model is empirically validated, and consequent results are reported.

SAP-LAP analysis of the UK and France is explained in the sixth chapter. As discussed in the LR chapter, barriers have been considered as situations. Further steps such as actor, process, learning, action, and performance have been analyzed with each barrier with the help of a literature review. In total, 66 points have been discussed, and this tool has helped to understand the nuts and bolts of the successful implementation of OE policy in the UK and France. Finally, a comparative analysis of the UK and France in the SAP-LAP paradigm (situation-actor-process-learning-action-performance) is provided.

The seventh chapter explains the **Suggestive Policy Framework for OTEC in India**. In this chapter, a linkage framework is developed for each one of the factors identified based on the learning experience in France and the UK. Further, it was validated by an industry expert. UK experience for OE development was considered for the linkage framework for developing the proposed linkage framework for India. The methodology for choosing the policy framework of the leading countries was based on the following: Policy implementation, deployment of OE-based installed capacity after policy implementation, and at what cost can India afford?

Finally, the eighth chapter gives the **conclusions and recommendations**. The bibliography is provided at the end as a reference.

CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

In this chapter, the research themes are reviewed in detail. The first section of the chapter explains the themes identified and discusses the prominent studies. Then, the conceptual process of the research gap is discussed in the subsequent section of the chapter. Finally, the Research problem, questions, and objectives are drawn based on consolidated research gaps with the help of the funnel approach adopted and expanded by Miller, 2009).

2.2 Literature Review on Identified Themes

Two hundred thirty-three (233) research articles and journal papers, along with several government reports and other documents from India and the rest of the world, were reviewed for the research topic. The following topics and subthemes have been used to organise the literature review:.

- **Theme 1:** Global Policy Instruments for Promotion of RE, including Ocean Energy
- **Theme 2:** International practices with a focus on the US, UK and EU experience for the development of Ocean Energy
- **Theme 3:** Policy Instruments for the Promotion of RE in India
- **Theme 4:** Ocean Energy in India
- **Theme 5:** Studies based on “Resourced Based Theory.”

2.3 Justification of Identified Themes

- **Theme 1:** Global Policy Instruments for Promotion of RE, including Ocean Energy, provided an insight into the country's leading variables responsible for Ocean energy development.
- **Theme 2:** A complete comparative analysis of major countries (the US, UK, and EU) that have developed ocean energy. The purpose of this theme is to cover the learnings and experiences.

- **Theme 3:** Policy tools to promote RE growth in India: an in-depth analysis. It studied the market and non-market-based instruments implemented for RE development in the country.
- **Theme 4:** Potential, current status, and barriers to Ocean energy development in India.
- **Theme 5:** 45 papers were studied related to the Theory of Opportunity Loss, Theory of Competitive advantage, Theory of Comparative advantage, and Resource-based Theory (RBT). This study is based on a theoretical underpinning that natural resource needs to be taken as a strategic resource to achieve the goal of competitive advantage for a country. Therefore, RBT provides theoretical support to the idea of exploitation of Ocean Energy to achieve the purpose of sustainability with the self-sufficiency of the GoI.

2.4 Theme 1: Global Policy Instruments for Promotion of RE, including Ocean Energy

2.839 TW of renewable energy installed in the world. The contribution of renewable energy sources to the total energy consumption in the world remains significantly lower than fossil fuels (REN 21, 2022). Five nations account for nearly 60 per cent of the global installed capacity of renewable energy(RE) sources. China, the US, Brazil, India, and Germany(REN 21, 2022). The global renewable energy industry is expanding due to two main factors: supportive policies and clear goals for renewable energy production (REN21, 2016). Financial and political backing for renewable energy sources is essential at all levels, from the neighbourhood to the country. (Wüstenhagen et al., 2008; & Hohler et al., 2009) noted that, investment in renewable energy technology for power generation worldwide has recently surpassed investment in fossil fuel technologies, highlighting the sector's global potential. The expansion of certain renewable energy sources and technologies has been linked to the pursuit of certain policy goals, as has been shown in several studies (Onut et al., 2008; Komor and Bazilian, 2005 & Beccali et al., 2003)(Abazajian et al., 2022).

During the past two decades, policy assistance in industrialised nations has benefited several renewable energy sources.

Reduction in the cost of RETs, increase in solar and wind generation, geothermal energy, long-term policy commitment, easy access to finance, environmental and energy security issues in developed and developing countries, etc., are contributing to the growth of RE in the world (REN 21, 2022). Policymakers have been consistently focusing on RETs. It requires economic and public support on both local and regional levels and at the national level to succeed (Wüstenhagen et al., 2008; & Hohler et al., 2009). Either electricity generation or capacity installation are the focus of policy tools designed to promote the expansion of renewable energy sources.. (Vries et al., 2003) classified basic policy measures generally adopted by countries worldwide (refer to Figure 2-1). Many policy instruments worldwide support RE development, including OE which are classified into financial/Non-market based and market-based instruments.

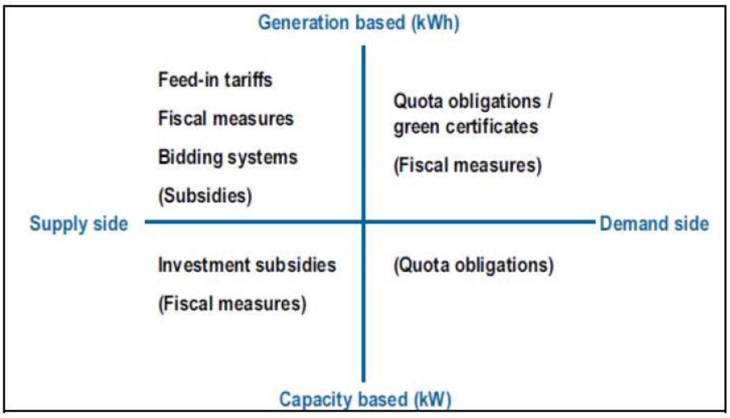


Figure 2-1 Typical Policy measures to promote renewable energy

Source: Vries et al., 2018

2.4.1 Financial /Non-market based Instruments for Promotion of RE: International Experience

Countries have utilised the following financial and non-market-based mechanisms to encourage RE sources:.

2.4.1.1 Tax Credit, Production Tax Credit (PTC), and Investment Tax Credit (ITC)

A tax credit, Production Tax Credit (PTC), and Investment Tax Credit (ITC) are essential tools to promote grid-connected RE facilities. Tax credit helps reduce tax liability based on project cost or output percentage. PTC is linked to the electrical output of grid-connected RE projects and helps minimize income tax liability(DSIRE, 2013). The investors who have invested in the RE projects qualify for ITC. Therefore, it helps in reducing the tax liability of eligible investors. It was implemented in the USA for the first time under the Energy Policy Act of 1992. A 10% tax credit was allowed to the investors under the act. Later on, it was expanded under the American Recovery and Reinvestment Act of 2009 (DSIRE, 2013).

2.4.1.2 Capital Subsidy, Rebates, and Grants

It is observed that Rebates and grants are generally given at the beginning of project operation in lump sum amounts. These incentives are based on system capacity and the cost of the system. Notably, these incentives are not contingent on electricity generation. Therefore, the Rebates and grants are not performance-based, so the developers are not incentivised to build efficient systems. (REN21, 2021).

2.4.1.3 Accelerated Depreciation

To reduce operating earnings and tax payments, investors can take advantage of Accelerated Depreciation (AD) when purchasing power generation gear and equipment that uses RE sources. In some countries, up to 30% AD of capital investment is permissible for RE equipment (for example, Canada and Japan)(VAMIL,2013).

2.4.1.4 Net metering

Net metering deals with the compensation to the project operators for producing more electricity than their consume. The onsite generators are compensated at the prevailing retail rate. It is a different method than an electricity sale contract. Under this method, the electricity bill is credited at the retail or wholesale level. (Mitchell et al., 2004).

2.4.1.5 Loan Guarantee

The US energy department has extensively used the loan guarantee for eligible RETs such as fuel cells, biodiesel, OE, wind, solar, etc. This tool aims to reduce the lender's risk when granting the loan. In addition, the federal government pledges to repay the principal and interest in case of default by the borrower(DSIRE, 2013).

2.4.1.6 Feed-in Tariff

To attract more investment in the RE sector, RE producers are offered long-term contracts based on generation cost in this policy process. The arrangements vary from technology to technology. RE generators (including farmers and homeowners) are reimbursed a cost-based price for supplying electricity to the grid. The rates are pre-defined based on multiple criteria and are subjected to review occasionally. Generation cost-based purchase process, grid connectivity guarantee, and generation-based long-term agreements are the essential requirements for a typical Feed-in-Tariff (FIT). It is one of the most popular mechanisms implemented in more than 50 countries worldwide (Gordon, 2020; IMF, 2020; KPMG, 2015; Lacal-Arantegui, 2019).

2.4.2 Market-based Instruments for Promotion of RE: International Experience

Various nations have employed the following market-based mechanisms to encourage the usage of RE sources:.

2.4.2.1 Auction/Tendering

The project developers agree to sell electricity at a pre-determined price under the Tendering / Auction /Tendering process. Literature reveals a range of approaches to implementing competitive strategies in terms of complexity, from RFP to muti round-the-clock auctions. For example, under RFP lowest bid is taken as a winner, while in the other approach, multiple winners are taken(Cunha et al., 2020).

2.4.2.2 Feed-in Premium(FIP)

Introduced in Spain in 1997, Feed-in Premium(FIP) charges a premium above the market price. Under this process, generated electricity is sold on a power exchange platform at the spot price, while RE producers are incentivized by providing a premium over the spot price. The premium may vary from time to time based on demand and supply conditions (Sijm, et al., 2021).

2.4.2.3 Tradable Renewable Energy Credits, viz., REC/ROC

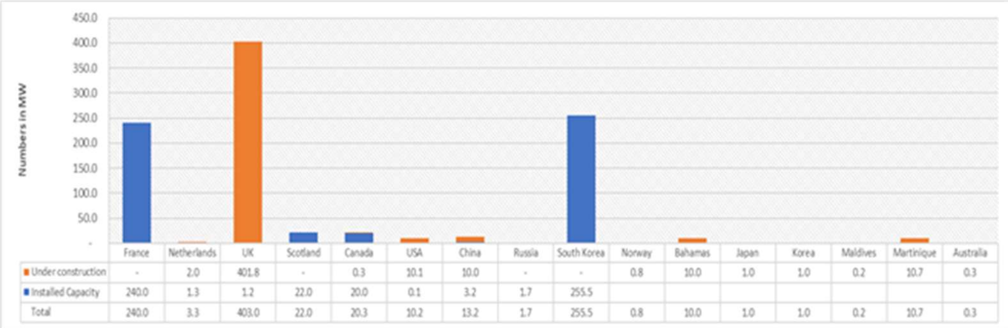
Renewable Energy Credits (REC) is a mechanism that separates environmental attributes from electricity. It is measured as the environmental attributes of one megawatt-hour (MWh) of electricity generation. It can be traded with the generated electricity component or as a commodity. Generally, RECs are used to demonstrate compliance with RE targets. Such tradable instruments were first developed in the USA in 1990 to comply with the state-level RPS policy (Rickerson et al., 2012). (Mitchell et al., 2020) analyzed that the generators encountered an added risk factor during the implementation of this approach.

2.4.2.4 Renewable Portfolio Standards and Quota Systems

Under this system, the utilities are instructed to procure the targeted amount of RE. The system also complies with distribution companies to procure a designated green component of their load through eligible RE sources(Char et al., 2021). Such a system of obligation on electricity generators and suppliers compliment the success of REC.

2.5 Theme 2: International practices with a focus on the US, UK, and EU experience in the development of Ocean Energy

Tidal, wave, ocean currents, and salinity gradient technologies are all included under the umbrella term of ocean energy (OE). The currently installed capacity and under-construction projects are depicted in Figure 2-2.



With multiple projects in the pipeline, the sector is witnessing encouraging signs. It is expected that by 2050, 188 GW capacity will be installed (EU-OEA, 2019).

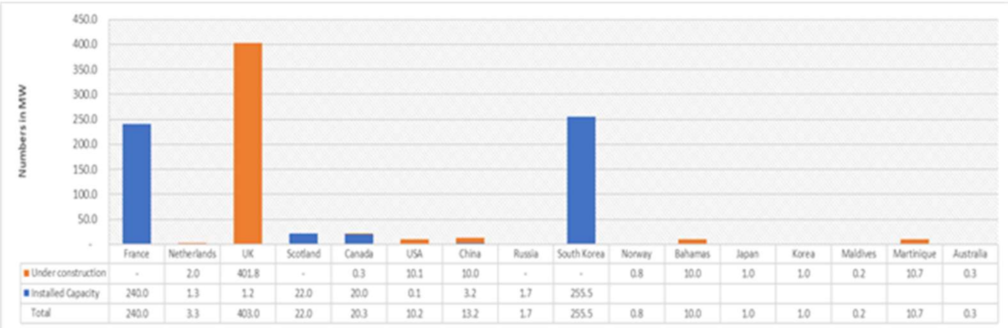


Figure 2-2 Ocean Energy Current Installed Capacity and Under-Construction Projects in Select Countries

When it comes to maritime energy capacity, Europe is well ahead of the rest of the world. Moreover, Ocean Energy's first European deployment took place in La Rance, France, and it has a 240 MW installed capacity and has produced an average of 600 GWh annually since 1966 without affecting climate change(Chakraborty, Dwivedi, Gupta, et al., 2021). It has been producing power from maritime energy farms for almost 50 years. Europe is leading with over 50% of the globally installed OE capacity(Magagna & Uihlein, 2015a). The policy implementation for OE development in various countries starting from 2000 in the UK, followed by other European countries, gave momentum to OE development. At present, eleven countries in Europe (Belgium, Denmark, France, Germany, Ireland, United Kingdom), the Americas (Canada, USA) and Asia (Japan, Republic of Korea, China) have implemented long-term policy, strategy, and targets for OE policies(Chakraborty, Dwivedi, et al., 2018). Given the similar support and policy enabling environment, Ocean energy capacity can reach 188 GW by 2050(EU-OEA, 2020) (**Figure 2-3**).

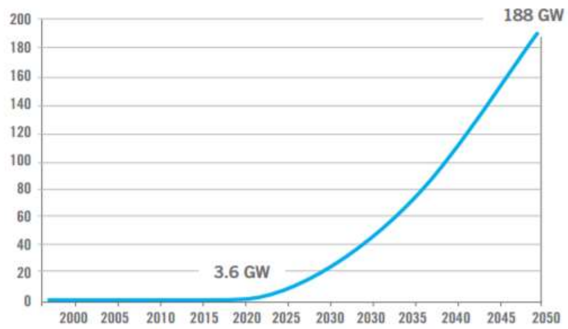


Figure 2-3 Projected Ocean Energy Installed Capacity
(EU-OEA, 2020)

To tap the OE potential, these countries have implemented various policy measures. Solangi et al.(2011)discovered that feed-in tariffs (FIT), renewable portfolio standards (RPS), and the quota system are being practised by various leading countries, which have assisted them in considerably speeding up the generation of RE (including OE). However, due to the cash flow assurance, fixed tariff systems such as FIT remain preferred for project developers with a low-risk appetite for new evolving technologies and developing markets. It is also observed from the literature that countries have tackled the financial and commercial aspects, as well as provision for maritime spatial planning, exclusive economic zone, open sea testing centres, dedicated research institutes, consent processes, and others, along with other known policy measures that play a key role in OE development.

Schmid(2012) emphasized that policies play a pivotal role in the RE growth of the country. Similarly, other authors, such as Pillai and Banerjee(2009) and Srinivasan et al.(2010), have also advocated that robust policy frameworks help RE growth.

Dalton and Ó Gallachóir(2010) and Swider et al. (2008) analyzed grid connectivity costs for onshore and offshore energy projects. They found that the number of grid connections for OE projects is almost double that of conventional RE projects. The studies concluded that higher support mechanisms and technological advancements would be necessary to bring down the grid connection cost of OE projects. Marczyk and DeMatteo(2010)and Prässler and Schaechtele(2012) found that supportive policies were significantly correlated with the expansion of RE projects like the OE sector. Several other researchers (Green & Vasilakos, 2011; Heptonstall et al., 2012; Levitt et al., 2011) all agree that good site conditions and forward-thinking, long-term, coherent policies are the most important factors in the expansion of OE projects.

The existing literature reiterates the hypothesis that a strong and committed policy landscape is a prerequisite for developing RE (including OE) (Marczyk & DeMatteo, 2010; Prässler & Schaechtele, 2012).In addition, the studies in the literature have also helped classify the numerous vital variables of policy actions for OE development in the country.

2.6 Theme 3: Policy Instruments for the Promotion of RE in India

India's renewable energy policy encompasses supply, utilization, and environmental objectives(Saidur et al., 2010). Although renewable energy generation in India has increased at a healthy pace of 21%, the overall generation capacity is still below par. At this time, India's CO_2 emissions are around one tonne per person per year. India is eager to invest in various forms of renewable energy to bring this number down (Sholapurkar & Mahajan, 2015).

India is continuously making improvements and establishing common objectives for adopting renewable energy (RE) per (UN, 2015) Sustainable Development(SDG) Goal 7, which seeks to provide universal access to affordable, reliable, sustainable, and modern energy. The three sub-objectives enumerated under energy are:

- Goal 7.1: Achieve universal access to energy services that are cheap, dependable, and up-to-date by 2030.
- Goal 7.2: By 2030, the proportion of the world's energy supply from renewable sources should have increased.
- Goal 7.3: Increase the pace of energy efficiency improvements worldwide by a factor of two by the year 2030.

To accomplish these goals would take significant work in the form of RE investments at the national and state levels (Azevedo et al., 2018; UN, 2015). The Government of India has developed many energy-related policies to guarantee the dependability and safety of the nation's energy supply over the long term, essential for India's continued socio-economic progress (Saidur et al., 2010). The Electricity Act 2003 replaced the Electricity Act 1910, the Electricity Supply Act 1948, and the Electricity Regulatory Commission Act 1998, and has been amended twice by the Electricity (Amendment) Act 2003 and the Electricity (Amendment) Act 2007. India is enthusiastic about putting resources into RE advancements(Sholapurkar & Mahajan, 2015). National Electricity Policy (NEP) was published in 2005, and it laid the foundation for prescribing the obligation for the purchase of renewable Power through Renewable Energy Certificates(REC)(CRISIL, 2015; Saidur et al., 2010). The objective is to propel the sector onto a solid commercial development path, allowing the States and the federal government to coordinate in concert. (Ministry of Power, 2019). One of these strategies' main and direct consequences is the drastic increase in RE generation energy mix from a low of 0% in 1990 to more than 21% in 2019. Some of the RE implementation policies are explained below. RE incentives in India at the Central and State level are summarized below.

2.6.1 Central Incentives for RE in India

Multiple incentives are initiated at the central level. These are summarized in Table **2**-**1**

Table 2-1 Central RE Incentives in India

(Mehra & Hossain, 2014; MNRE, 2019)

Incentive	Amount	Applicable for	Remarks
Incentives based on Generation (GBI) Scheme	• Rs. 0.5 per unit • Totalling Rs.6.25 Million each MW. • Yearly Rs.1.5 Million / MW (maximum)	• To be benefited from the Wind sector for 10 years. • For Solar projects similar GBI was offered for capacity up to 50 MW.	The plan was pulled back after the commencement of JNNSM.
Foreign Direct Investment (FDI)	100%	Wind power.	It implies that no prior regulatory endorsement required for international organizations intrigued to invest in India.
Accelerated Depreciation (AD)	80 % for apparatus on “written down value method”.	Wind power.	Improvement in cash flow for and net present value (NPV) for investors.
Capital Subsidy:	40 %	• Biomass, • Small hydro, • Off-grid solar PV	Applicable for joint liability groups (JLGs), self-help groups (SHGs), NGOs, farmer’s club through NABARD. Not available to public or private limited companies.
Income Tax Holiday:	For 10 years (projects commissioned before 31-Mar-13)	For all RE generation and distribution company	20% minimum alternative tax (MAT) applicable.
Customs Duty Exemption:	5%	For all RE projects.	
Excise Duty Exemption	100%	For RE project equipment	
Deduction in Taxable Income:	Exemption for revenue from Infrastructural capital fund or other banking organization under section 10(23G) of IT act.	For all RE projects	
Renewable Regulatory Fund (RRF)	Unscheduled Interchange (UI) will be compensated by state utility from an RRF if a RE generator fails obligation.	Wind and solar power projects.	
Renewable Energy Certificate (REC)	5-10% but defers from State to State.	Wind and solar power projects.	

Incentive	Amount	Applicable for	Remarks
Other Central Fiscal incentives - Direct taxes.	Income tax exclusion on incomes for 10 years under sec 80IA,	For all RE projects.	
Other Central Fiscal incentives - Indirect taxes	Custom duty concessions and excise duty exemptions for a) Special bearings b) Wind turbine controllers c) Supplies for fragments, and subfragments of blades. d) Gear Box	Wind power projects.	
R&D incentives	200% expenditure incurred for R&D can be appealed for IT deduction	Wind Power	

2.6.2 State Policy:

2.6.3 Renewable Purchase Obligation

26 SERCs detailed the mandatory procurement mandate outlined in Section 86, 1(e) of the Electricity Act of 2003 for acquiring a fixed amount of RE-based energy. Depending on the proximity of renewable resources and the amount of power delivered in those states, the RPO rate might be from 0.5 per cent to 10.2 percent. RPO obligation can be met through direct purchasing under respective agreements and tradable REC systems, generating revenue for RE initiatives(Chaurasiya et al., 2019; Kar & Sharma, 2015; Mehra & Hossain, 2014; Sharma et al., 2015). Table **2-2** below analyzes the impetuses of various states in India.

Table 2-2 Assessment of incentives of various states in India (CRISIL; IIT-M, 2018; Energy & Special, 2015; International Renewable Energy Agency, 2012)

State	**Wind Tariff (FIT) (Rs. /kWh)**		**Non-Solar RPO**
	Without AD	**With AD**	
Andhra Pradesh	4.70		4.75%
Tamil Nadu	4.16	3.70	9% for 2015-16
Rajasthan			
Jaisalmer, Jodhpur, Barmer districts	5.46	5.12	8.90% for
Rajasthan (Others)	5.73	5.38	2016-17
Maharashtra Wind power density (WPD)			
WPD >400 w/m2	4.17	3.92	
WPD 300-400 w/m2	4.45	4.18	8.5% for 2014-
WPD 250-300 w/m2	5.33	5.01	15
WPD 200-250 w/m2	6.06	5.70	
Karnataka	4.50		10% for 2014
Madhya Pradesh	5.92		6% for 2015-16
Gujarat	4.52	4.15	8.25%

2.6.4 Comparison of Policies for different RE Technology in India

Table 2-3 summarizes policies for different RE technologies in India.

Table 2-3 Comparison of Central Policy for different RE Technology in India (MNRE, 2019) (Mehra & Hossain, 2014).

RE Technology	Principal Market Incentives	Investment / Non-Market Incentives (eg. Subsidies, Accelerated Depreciation)	Legislation (e.g. CO2 emission)	Long Term Policy, Strategy & Targets	Open sea testing centers	Maritime Spatial Plan / Consent Procedure	R & D Support	Comments
Wind (onshore & offshore)	FIT varies from 4.11 to 6.58 Rs/ kWh, RPO	GBI, 100 % FDI, AD, 10 years Income Tax Holiday:		No long-term Policy Generation target of 60 GW by 2022	NO	No Maritime Spatial Plan / Consent Procedure. Draft Offshore Wind Energy Lease Rules	Generators for Wind Turbine through MNRE	States have separate FIT rates.
Solar (PV, rooftop, Floating)	For Solar PV FIT 7.05 Rs/kWh, For Solar Thermal FIT 12.05 Rs/kWh, RPO	100 % FDI, 10 years Income Tax Holiday	33-35% emissions decrease by 2030	No long-term Policy Generation target of 100 GW by 2022	No	No Maritime Spatial Plan / Consent Procedure for floating solar	Only through MNRE focus systems are, • Solar PV systems • Energy-efficient buildings employing RE perception. • Solar thermal for energy generation, industry, and urban purpose.	States have separate FIT rates

RE Technology	Principal Market Incentives	Investment / Non-Market Incentives (eg. Subsidies, Accelerated Depreciation)	Legislation (e.g. CO2 emission)	Long Term Policy, Strategy & Targets	Open sea testing centers	Maritime Spatial Plan / Consent Procedure	R & D Support	Comments
Biomass	The tariff varies from 2.80 to 5.50 / kWh,	100 % FDI, 10 years Income Tax Holiday		No long-term Policy Generation target of 10 GW by 2022	NA		Biomass integrated gasification combined cycle systems.	
Small Hydro (RE)	FIT based on capacity <5MW: 4.64 to 5.47 <25MW: 3.95 to 4.65 RPO	100 % FDI, 10 years Income Tax Holiday		No long-term Policy Generation target of 5 GW by 2022	NA		Only through MNRE	

2.7 Theme 4: Ocean Energy in India

India has a coastline of approximately 7500 kilometres spanning seven states and approximately 336 islands in the Bay of Bengal and the Arabian Sea. In Gujarat, the maximum and average tidal range has been reported between 11 to 8m and 6.77 to 5.23m, respectively (Sen et al., 2016). The Sundarbans, the Gangetic Delta in West Bengal, and the islands of Lakshadweep, Andaman & Nicobar have all been recognised by MNRE as promising OE resources. (MNRE, 2016). The Indian coast has all the ideal conditions for OTEC plants, such as 20^0C temperature difference throughout the year, an Exclusive Economic Zone (EEZ) with tropical water in an area of around 1.5 x 10^6 square kilometres with a power density of 0.2 MW/km^2 and Lakshadweep, Andaman & Nicobar Islands(Sen et al., 2016).

Table 2- shows OE's potential is between 229 GW and 372 GW(Chakraborty, Gupta, et al., 2018; CRISIL; IIT-M, 2018; MNRE, 2021a). Theoretically, it can be said that OE alone can support the required RE capacity of India in 2030. As per Kumar(2017), 116 GW of this capacity can be tapped from OE by 2030 (Chakraborty, Gupta, et al., 2018; Kumar, 2017). The CUF of the OE system is around 90–92%(Kempener & Neumann, 2014), which is significantly higher than RE systems such as solar and wind energy systems. Similarly, the plant life of OETs is 30–35 years. However, international experience has shown that there can be more than 50 years of plant life(Magagna & Uihlein, 2015b).

Table 2-4 Potential of OE in India

Source: (CRISIL; IIT-M, 2018; MNRE, 2021a)

OE technology	Min (in GW)	Max (in GW)
OTEC	180[1]	300
Tidal	9	12.5
Wave	40	60
Total	229	372.5

Researchers found that OETs with non-intermittency, high CUF, no land requirement, longer plant life can be an RE policy alternative and a solution to the baseload problem(Soudan, 2019). Therefore, the development of OE in India is the most appropriate strategy to achieve its RE targets and sustainable development goals (SDGs). Furthermore, the Indian Government has recently announced a Deep-ocean mission comprising six components dedicated to the energy and fresh water from the ocean(MoES, 2021). Moreover, the MNRE has also declared that all the forms of OE will be treated as RE (MNRE, 2021a). In addition, MNRE has categorized OE under renewable purchase obligations (RPO) compliance for different entities.

The studies in the literature do not display any empirically tested model of essential components of successful OE policies. The literature on OE policies for India has attempted to fill the gap in this study, for which 21 important variables for expanding this sector in the country have been uncovered.

2.8 Discussions on Variables Identified from the Literature Review

Based on the literature review of the policies implemented in leading countries, the following set of variables is the foundation of these countries' policy landscapes. These 21 identified variables have presented below in Table 2-4

Table 2-4 List of Variables Identified from the Literature Review

Sr. No.	Variables Definition
1.	**Long-term policy continuity** would be a prerequisite to increasing stakeholder confidence.
2.	Exemption from interest payments in the initial phase of the project (for the first five years) would reduce the risks for investors and improve developers' cash flow.
3.	**Cost of capital reduction through OE fund creation** can be done by policy instruments such as levying green cess on CO_2-emitting activities, including coal-fired projects.
4.	**RPO/REC legal compliance:** The RPO compliance authorized the Government to instruct distribution licensees to produce a minimum specified quantity of the requirement from RE.
5.	**Providing an attractive rate of interest for capital** would reduce the debt burden and debt servicing of developers.
6.	**Generation-based incentives (GBI)** is a mechanism that is over and above the FIT system. It gives bonus points to RE generators for injecting green energy back into the grid.
7.	**Declaring OE as a "priority sector"** would increase investment attractiveness and ease accessibility to funds.
8.	Research and development (R&D) support for the production of equipment components domestically in the country will directly impact capital cost reduction.
9.	**R&D organisations' focus on OE innovation and technology advancement** would be critical to their technological advancement and, thereby, commercial success.
10.	**Accelerated depreciation (AD)** is a faster rate of depreciation that is available for investors who invest in RE projects early in their useful lives.
11.	**HR training and skill development** would be vital for smooth labour-intensive OE projects (20–30 manpower/ MW).
12.	**Feed-in tariffs (FIT)** are the amount paid by the distribution companies to the RE developers for feeding each unit of power generated into the grid.
13.	**Related to potential OE sites, precise technical information,** including critical input factors such as temperature gradient, water depth, and wind speeds, among others, impacts the generation and, thereby, the project's profitability at a substantial level.
14.	**Developers'skill development for large-scale project execution** would be a prerequisite for successful project construction management and turnover.
15.	**Developing local manufacturing capability for the main equipment** would be critical to optimising production costs rather than importing them.
16.	**Development of the ancillary supply chain within the country** will help in the cost reduction of components. As a result, this will help in the enhanced adoption of OE in the country.
17.	**The readiness of skilled contractors** is needed for the successful construction of OE projects, as a shortage of competent contractors could delay construction and affect profitability.
18.	**Financial support through incentives** for developing OE projects in tax-related schemes, import duties exemptions, excise/customs duty waivers, and others can be initiated.
19.	**Flexibility in tariff calculation in alignment with technical factors** such as temperature gradient wind speed, water depth, and others would support the growth of a low capacity and testing platform.
20.	**One-stop-shop clearance** will enhance the ease of doing business by reducing the gestation period hurdle.
21.	**Grid connectivity from OE projects to an onshore transmission line** would be a critical factor in governing the successful implementation and operation of the OE project.

2.9 Theme 5 Studies based on Resourced Based Theory

2.9.1 Resource-based theory

This theory was associated with the scholars like Bernard and Ricardo in 1938 (Almarri & Gardiner, 2014; Coff, 1997, 1999; Conner, 1991; Habbershon & Williams, 1999; McWilliams & Siegel, 2011; Priem & Butler, 2001; Richard, 2000; Wan et al., 2011) Selznick's (1957) and Penrose in 1959, Pfeffer and Salancik in 1978 Rumelt in 1984 schools of thought are also considered essential contributions to this theory (Bryson et al., 2007; Conner, 1991; Nair et al., 2008). According to Barney, 1991, 2002 RBT theory identifies the resources of a firm or a nation as strategic assets which can help in seeking sustainable competitive advantages. The resources can be the assets, expertise, systems, information, etc., available with the firm or a nation that can be used as an advantage. Such resources are precious, unique, incomparable, and non-substitutable (Barney et al. 2011).

Almarria and Gardinera (2014) highlight the limitations such as construct validity, the scope of definition, and inappropriate description. Sanchez (2008) criticized Barney's conceptualizing of "strategically valuable resources" as conceptually deficient and logically problematic. He also criticized Barney's VRIO framework, which identified organizations' / nations' essential resources that can give a competitive advantage. This theory highlights the logical problems of the value dilemma, the tautology difficulty in identifying resources, and the lack of chain causation. Sanchez (2008) further criticised the theory's core proposition of sustained competitive advantage, which is flawed using the scientific method in Resource-Based View (RBV). However, Penrose (1950) proved that the absence of sufficient resources would hinder the growth of a nation /organization. He argued that a country or organisation may produce high economic value and fuel long-term expansion by being innovative with how it uses its resources. (Mahoney, 1995). (Mahoney, 2011) summarized that efficient and effective deployment of resources could also help achieve a nation's sustainable development. Therefore, the theory emphasizes the peculiarity of a nation’s or firm's internal resources as an advantage(Habbershon & Williams, 1999; Pablo et al., 2007).

2.9.2 OE as a valuable resource

As per (Mahoney, 1995) a nation must effectively utilize all its resources for sustainable and continuous growth. Therefore, resources represent a critical asset to a country(J. B. Barney et al., 2011)(J. B. Barney, 2002). However, a resource is considered strategically important only if it is precious, limited amongst all rivals, and non-imitable. With its renewable, non-intermittent nature, OE possesses a competitive advantage for India. Yet, despite its tremendous potential, OE has been overlooked by Indian policymakers.

Several researchers have acknowledged that OE is a strategic resource for India because of its availability, potential, technology access, diversity, etc. Additionally, (J. Barney, 1991)has also defined aid as valuable and able to present opportunities. OE is a valuable resource because it has the potential to meet 100% of India’s current energy requirements, and it can create opportunities for 450 GW of electricity generation and provide 10-11 value-added products, including drinking water, hydrogen, ocean minerals, etc. Therefore, to address energy security, drinking water, and hydrogen-powered future growth, OE presents a unique opportunity for India.

The core concept of RBT relates the strategic resource and competitive advantage. The theory suggests that a strategic resource can provide impetus for a competitive advantage. OE is a strategic resource because it has the potential to compete with the cost of electricity generation from fossil fuels. It has capacity utilization at par with conventional electricity generation technologies. It has the potential to deal with the baseload requirement due to the country's solar and wind penetration. This resource can also play a critical role in creating hydrogen energy through its value-added product. Researchers have also envisaged OE as a valuable substitute for solar and wind, especially when unavailable. OE is also inimitable because its availability cannot be created; it will be only nurtured if the potential is available.

2.9.3 Exploiting the OE resource advantage

Mahoney (1995) described that the mere presence of internal resources would not provide economic value to the nation. Still, the country has to create its ability to utilize its resource effectively and innovatively. Therefore, a definitive strategy and resource availability are also essential for the country. It is important to note that OE is also facing the constraints such as the high-cost absence of appropriate policy and framework. Therefore, resource availability complements purposeful policy action leading to successful use and management. Therefore, this research aims to develop a practical policy framework to leverage its OE potential in India(**Figure 2-4**).

Though literature argues that policy plays an important role in the efficient use of the natural resource in a nation's context, the approach to **how policy can help in the effective and efficient utilization of ocean energy (natural resources) has not been adequately discussed.**

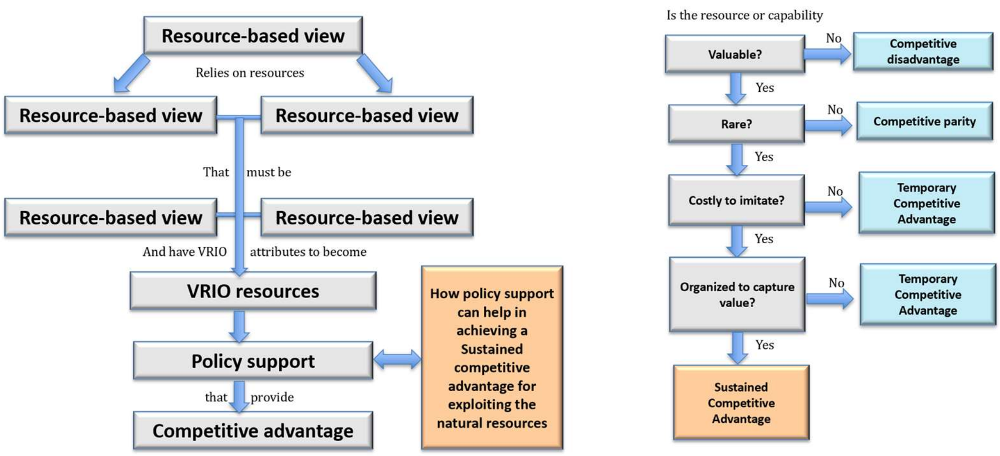


Figure 2-4 Projected Ocean Energy Installed Capacity

2.10 Identified Gaps in literature

Four research themes identified on review of the keywords point out the following research gaps from the structured literature review:

Theme 1: Global Policy Instruments for Promotion of RE, including Ocean Energy

- Factors that may enable Ocean energy w.r.t. Indian scenario are not discussed in the literature.
- Best international practices to develop Ocean energy in the Indian context are not discussed.
- A complete comparative analysis of the major countries which have utilized ocean energy for learnings w.r.t. Indian context lies out of the research.

Theme 2: International practices with a focus on European countries experience in development of Ocean energy

- International practices to develop OE are not discussed for Indian context.
- Consent procedures required to develop ocean energy w.r.t. Indian context is yet to be developed.
- Literature on maritime spatial planning w.r.t. Indian exclusive economic zone is not covered in literature.

Theme 3: Policy Instruments for Promotion of RE in India

- Applicability of variables w.r.t. Indian context or for Indian condition not discussed in in the literature.
- Non-technical barriers for development of OE in India are not discussed w.r.t. Indian context.
- Research does not specify the regulatory, policy aspects which are hurdle to develop OE in India.

Theme 4: Ocean energy in India

- Cost benefit analysis of OE considering benefits of byproducts of OE including electricity generation in India is yet to be conducted.

- MOES included energy from OTEC and water as a critical strategy under the Deep Ocean Mission and MNRE included OE as RE but there is no policy framework for OE in India.
- While MNRE, India plans to develop majority of 40% RE electricity generation from low-capacity factor (20%) RE sources, there is no study carried out whether OTEC with high potential and high CF (90%) can be developed in India considering hign intermittency.

These thematic gaps mentioned above were further reviewed and refined in the light of available literature. The refined gaps are as follows:

1. Applicability of variables for Indian context or Indian condition not discussed in the literature
2. The regulatory, policy aspects of Ocean Energy projects in developed countries are being planned with a long-term strategic plan, however, the same is yet to be developed for the Indian context.
3. The conceptual framework on how Ocean based energy sector evolved or evolving in developed countries are comprehensive but the same for India is left at the stage of identifying the problem.

2.11 Research gap

As discussed above, the study has identified thematic gaps which were narrowed down following the funnel approach suggested by "Creswell (1994)" and as adopted and expanded by Miller in 2009 to three main gaps and further narrowed down to the research gap, i.e., "**A comprehensive study could not be found which suggests a policy framework for the development of Ocean Energy (OTEC) in India"**.

2.12 Critical Analysis of Research Gaps

The literature review has analyzed the global status of OE development, Global Policy Instruments for the Promotion of RE, including OE, International practices focusing on European countries' experience with Ocean energy development, Policy Instruments for the Promotion of RE in India, and Ocean energy in India. In addition, it has identified essential variables responsible for OE development, including policy tools and incentives. It is evident from the literature that policy played a significant role in the development of OE. Therefore, the literature has also provided an exhaustive list of policy instruments, practices, barriers, etc., for promoting OE development.

It is also evident from the literature that India uses policy instruments extensively to promote RE in the country. Still, such initiatives are insufficient for developing OE in the country. Hence, there is a need for a dedicated policy framework for the development of OE in the country. For this purpose, this study attempts to answer questions such as critical policy factors and the linkages between actor, action, process, and performance based on the best practices.

The experts have criticized the OTEC energy system due to its capital intensity. But it is interesting to note that literature also suggests the potential of byproducts from this OTEC energy system; however, most of the documents in the literature have analyzed the viability of keeping electricity as a product only.

While every resource is critical to a country, internal resources would not provide economic value to the nation. Therefore, the government must be able to utilize its resources effectively and innovatively. Therefore, a definitive strategy and resource availability are also essential for the country. Furthermore, it is important to note that OE is also facing the constraints such as high costs and the absence of appropriate policy and framework. Therefore, deliberate policy action leading to practical use and management and resource availability complement each other. Therefore, this research is an effort to develop a sensible policy framework to leverage its OE potential in India.

2.13 Research problem

A research problem can be expressed as an issue or an area of concern in the literature or within current practices that need significant understanding and deliberate investigation (Britton, 1975). While it offers a vague proposition, it doesn't illustrate how to do something (McClelland et al, 1953). The research problem in our case is " **Lack of policy framework for effective and efficient utilization of ocean energy potential in India."**

2.14 Research questions

1. What are the significant factors for the ocean energy development in India?
2. How can policies help to remove the barriers?
3. What policy framework India should develop for ocean energy (OTEC) policy in India?

2.15 Research objectives

1. To identify significant factors for the ocean energy development in India
2. To analyze the role of policies in removing the barriers.
3. To develop a suggestive policy framework for OTEC policy in India

2.16 Summary

A literature landscape review is conducted on four different research subjects, as well as the underlying theory. 1) Global Policy Instruments for Promotion of RE including Ocean Energy, 2) International practices with focus on European countries experience for development of Ocean energy, 3) Policy Instruments for Promotion of RE in India, 4) Ocean energy in India, 5) Resource Based Theory.

The research gap is consolidated through the process of refining the research gap that is determined from the research themes. The funnel methodology proposed by Miller, 2009 is used to do this. In the beginning, there were a total of twelve research gaps, which were eventually narrowed down to the following three consolidated research gaps::

- Variables for the development of Ocean Energy discussed in the literature have not been tested as critical components for Ocean Energy development in India.

- Linkage between policy decisions for removal of barriers have not been discussed in the literature.
- Literature has indicated Ocean Energy as a RPO compliance but policy framework for guiding the Ocean Energy development in the country is unexplored

The theoretical premise gap for the present study is, ‘Though literature discusses that policy plays an important role in making the efficient use of the natural resource in a nations context, the approach of how policy can help in the effective and efficient utilization of ocean energy (natural resources) has not been adequately discussed.’.

The consolidated ‘Research Gap’ and ‘Theoretical Premise Gap’ led to formulating the ‘Research Problem’, ‘Research Question’ and ‘Research Objective’.

The derived Research Problem for the study is ‘Lack of scholarly attention to understanding pathways through which policy decisions affect Ocean Energy.’.

The critical analysis of theme-based Research Gap and purpose for present study frames following as Research Questions,

- What are the significant factors for ocean energy development in India?
- How can policies help to remove the barriers?
- What policy framework India should develop for ocean energy (OTEC) policy in India?

The Research Objectives corresponding to Research Questions are,

- To identify significant factors for the ocean energy development in India
- To analyze the role of policies in removing the barriers.
- To develop a suggestive policy framework for OTEC policy in India

The Research Question highlights the need for a mix of Quantitative and Qualitative Research Design.

The Research Designs and research methodologies for the present study are elaborated in the following chapters.

CHAPTER 3 –ECONOMIC ANALYSIS OF OTEC IN INDIA

3.1 Introduction

Two-thirds of Earth's surface is water. Thus, the seas gather solar energy and convert it into mechanical and thermal power. The tropical oceans absorb most of the sun's energy, almost 250 billion barrels of oil's worth. The planet can continue to function only if this energy is put to good use. By harnessing the sun's heat absorbed by saltwater, ocean thermal energy conversion (OTEC) can provide reliable power around the clock all year long(Kusuma, 2018). An OTEC system may create substantial electricity if there is a temperature difference of roughly 20°C between the warm surface water and the cold deep water. Therefore, the seas represent a potentially enormous renewable resource that might be used to generate several gigawatts of electricity. Some analysts have calculated that this capability might provide around 1013 TW of baseload electricity. The OTEC technique relies on nutrient-rich, cold, deep saltwater, which may be utilised to cultivate marine creatures and terrestrial plants. (Langer et al., 2020) said that the economic analysis of most energy systems has been limited to electricity generation only. This has also delayed the popularization of the OTEC energy system. Otherwise, it is a promising alternative energy source, especially for those economies like India, which depend heavily on imported fuel. OTEC systems in such economies can provide much-needed power, desalinated water, and various mineral and marine culture products(Kusuma, 2018).

Induced by these benefits, the Government of India (GoI) has included OTEC in the RE basket. The Ministry of New and Renewable Energy (MNRE) has recommended OE for RPO compliance. The Government has also envisaged value-added products (drinking water) and electricity generation (MNRE, 2021a). However, the capital cost of OTEC varies from \$1 M/MW to \$ 14 M/MW(Chakraborty, Dwivedi, Chatterjee, et al., 2021; Khan et al., 2017;

Langer et al., 2020). The high capital cost of this technology has been a cause of concern (Kusuma, 2018). This aspect has drawn the researchers' attention and motivated them to explore the financial viability of the OTEC system in India. The review of contemporary literature on techno-economic aspects of OTEC energy systems has revealed the need to include other revenue-generating applications in the economic analysis of OTEC. The researchers have emphasized that such research will promote emerging renewable technologies such as OTEC for commercial use.

This study involves a more profound economic analysis of OTEC with special reference to India. This study assumes the upscaling of a single OTEC plant at a specific site and applies different scenarios and sensitivity analyses to understand the technology development and economic interactions. In this context, three scenarios (involving 1 MW, 25 MW, and 50 MW) are taken to understand the project's impact on cost and various financial viability indicators.

The external natural condition, such as seawater temperature difference, influences the size and performance of an OTEC plant and its economics. This study assumes a temperature gradient of 20°C throughout the year.

The cost estimations are based on the latest sources, and state-of-the-art technology cost is taken for the study. Further, the data was validated by a scientist from the National Institute of Ocean Technology (NIOT), a research institute of GoI. Similarly, the operational performance of the pilot plant in India is also validated by NIOT.

OTEC is capital-intensive technology; therefore, it is important to understand technological learning and the assessment of cost reduction with plant scalability. This paper has delved into various cost components of OTEC power plants and undertaken a sensitivity analysis of costs concerning the size of the lant (having varying capacity).

The financial risk of the OTEC is another critical factor in the viability of the project. This risk originates from the choice of interest rate. Literature suggests that the interest rate should be transparent and considerate enough, keeping the OTEC technology in mind. Therefore, this paper assumes the interest rate per the Central Electricity Regulatory Commission (CERC) regulations for tariff calculation purposes(CERC, 2019c).

(Langer et al., 2020) mentioned that most of the economic analyses of OTEC plants are limited to electricity generation only, while other aspects of the financial and economic viability of the project are neglected. Therefore, this study builds on this literacy gap and includes the value of electricity generated and other revenue-generating applications for calculating the viability of an OTEC plant. It also extends the use of other tools beyond LCOE, such as VGF, NPV, IRR, and discounted payback period.

3.2 Working with different OTEC plants

The OTEC plant generates energy by using the difference in temperature between the warmer water at the ocean's top and the colder water farther down. Continuous power production requires a temperature gradient of at least 20^0C between the surface and deep ocean water. First, this system pumps warm water from the ocean surface through the boiler, producing steam. Next, the steam is introduced to the turbine, coupled with a generator to produce electricity. Finally, cold water from the deep ocean is pumped through the condenser to condense the steam to complete the cycle.

Two types of OTEC power plants, land-based and ocean-based, are found in the literature(Langer et al., 2020). However, experts suggest that ocean-based power plant is better than land-based ones as they argue that land-based ones are costlier than floating ones due to longer cold water pipe. On the other hand, land-based power plants have limitations in scaling their capacity (Khan et al., 2017). The ocean-based power plants can be designed in three cycles to generate electricity.

3.2.1 Open cycle

As per **Figure 3-1**, the warm water is pumped through a valve and flash evaporator, which rotates the turbine coupled with a generator to produce electricity. Then, the cold water pumped from the deep sea is used to condense the vapor through a condenser, and the pumped cold water is again released into the ocean.

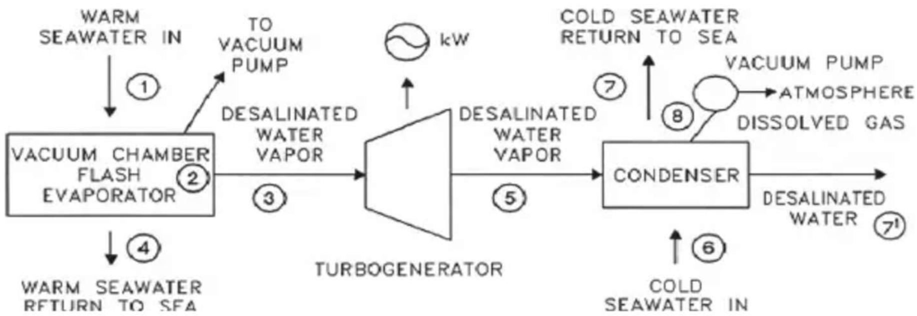


Figure 3-1 Flow diagram of a typical OC-OTEC

3.2.2 Closed cycle

As shown in **Figure 3-2**, the closed cycle uses ammonia as a working fluid to produce electricity. However, a low boiling temperature fluid helps steam generation faster than the open cycle. Hence, this is more efficient than the open cycle.

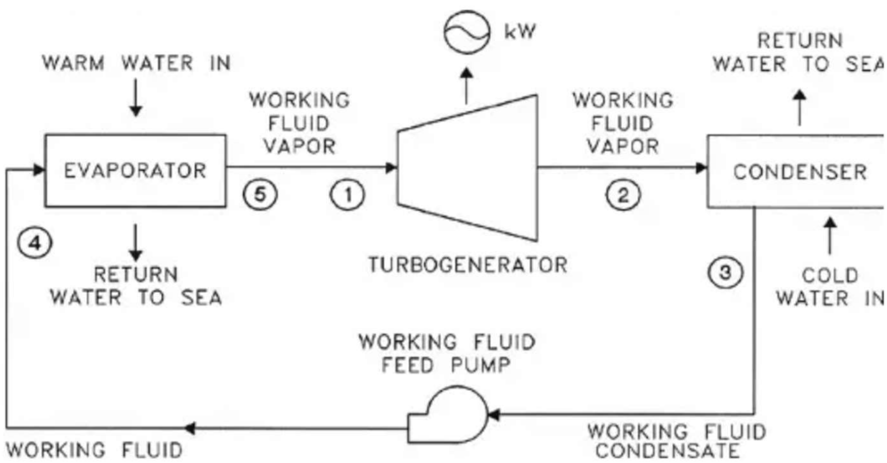


Figure 3-2 Flow sheet diagram of a typical CC-OTEC

3.2.3 Hybrid-cycle

This process combines the unique characteristics of both the open and the closed cycle. Warm water is used as a working fluid to generate steam, thus producing electricity, and desalinated water is produced through the steam condensed by cold water. This method also captures the hot water released into the sea (open and closed cycle) for producing the byproducts. A hybrid cycle increases thermal efficiency and reduces auxiliary power consumption compared to an open cycle. Therefore, the experts recommend a hybrid cycle from the viability perspective(Langer et al., 2020).

3.3 Methods, assumptions, Levelized costs, and results

3.4 Methods and Assumptions

This paper has used the financial norms specified in the CERC Regulations for tariff calculation purposes. The assumptions specific to the OTEC energy system have been discussed in detail in the next section. The information on electrical output, different cost components, their levels, and timings are needed to calculate the LCOE of the electricity generated during its project lifetime(CERC, 2019c). Thus, the study has reported comparable and reliable results to other RETs. Table 3-1 lists the critical cost components of the OTEC system (Vega, 1992).

Table 3-1 Major Compoenents of OTEC plant

Sr. No.	Cost Components
1	Heat Exchanger
2	Cold water pipe
3	Barge cost
4	Cost of mooring
5	Installation of Turbine

.

Table 3-2 Assumptions of OTEC parameters

S. No.	Assumption Head	Sub-Head	Sub-Head (2)	Unit	OCEAN Energy per MW (with new rates)	Reference
1	Power Generation	Capacity	Installed Power Generation Capacity	MW	1	(Kempener & Neumann, 2014)
			Capacity Utilization Factor	%	90%	
			Auxiliary Consumption	%	1%	(CERC, 2019c)
			Deration Factor	%	0.00%	(Kempener & Neumann, 2014)
			Useful Life	Years	30	
2	Project Cost	Capital Cost/MW	Power Plant Cost	Rs Lacs/MW	7200.00	Based on literature and expert review
3	Sources of Fund	Debt: Equity	Tariff Period	Years	30	(Kempener & Neumann, 2014)
			Debt	%	70%	(CERC, 2019
			Equity	%	30%	(CERC, 2019
			Total Debt Amount	Rs Lacs	5040.00	
			Total Equity Amount	Rs Lacs	2160.00	
		Debt Component	Loan Amount	Rs Lacs	5040.00	
			Moratorium Period	years	0	
			Repayment Period(incld. Moratorium)	years	13	(CERC, 2019
			Interest Rate	%	9.94%	(CERC, 2019
		Equity Component				
			Equity amount	Rs Lacs	2,160.00	
			Return on Equity for Project Life	% p.a	17.60%	(CERC, 2019
			Discount Rate		9.94%	(CERC, 2019
4	Financial Assumptions		Income Tax	%	17.472%	(CERC, 2019
		Depreciation				
			Depreciation Rate for the first 13 years	%	5.28%	(CERC, 2019
			Depreciation Rate 14th year onwards	%	1.26%	(CERC, 2019
			Years for 5.28% rate		13	(CERC, 2019
5	Working Capital	For Fixed Charges				
		O&M Charges		Months	1	(CERC, 2019
		Maintenance Spare	(% of O&M exepenses)		15%	(CERC, 2019
		Receivables for Debtors		Months	2	(CERC, 2019
		Interest on Working Capital		%	11.41%	(CERC, 2019
6	Operation & Maintenance	O&M Expenses (2019-20)		Rs Lacs	216.00	
		Total O&M Expenses Escalation		%	5.72%	(CERC, 2019
7	Generation and Sale Of Energy	Total No. of Hours		Hrs	8766	(CERC, 2019

Table 3-2 summarizes the essential assumptions to calculate the LCOE of OTEC technology. There are seven broad categories of assumptions: Po Generation, Project Cost, Sources of Fund, Financial Assumptions, Working Capital, Operation & Maintenance, Generation, and Sale of Energy.

For sensitivity analysis purposes, the study assumed the installed generation capacity of 1MW for the baseline scenario and conducted a sensitivity analysis for 50 MW and 100 MW. In addition, for the baseline scenario, the Capacity Utilization Factor (CUF), Auxiliary consumption, and valuable life are considered as 90%, 1% of the installed capacity, and 30 years respectively.

As per IEA 2019, OTEC costs range between \$7.22 to \$ 13.9 million per MW. This cost is as low as Rs 150 million/MW in the middle east region(Chakraborty, Dwivedi, Chatterjee, et al., 2021; Khan et al., 2017; Langer et al., 2020). Such a wide variation in the capital cost is due to the difference in the conversion process of OTEC systems(Khan et al., 2017; Langer et al., 2020)and the additional capital expenditure incurred for extracting the value-added products(Banerjee et al., 2017; "Encycl. Sustain. Sci. Technol.," 2012; Fujita et al., 2012; Osorio et al., 2016). It means that the project cost only for electricity generation is \$7.22 million/MW, and there will be an additional capital cost if other value-added products are considered. Therefore, this study has considered the project cost of \$10 million /MW, including the capital cost for electricity generation, drinking water, and mineral product extraction(Langer et al., 2020). The assumptions are based on CERC RE Tariff Order 2019-20 (CERC, 2019c) for the analysis (refer to Table 3-2).

CERC decides on a fixed amount of O&M expenses and allows a 5.72% annual increase in O&M expenses as an escalation rate. In addition, 3% O&M is recommended in the literature for the OTEC system. Therefore, the study has assumed 3% of capital expenditure as O&M expenses and a 5.72% escalation rate per the CERC Regulations.

3.5 Calculation of Levelized Cost of Electricity (LCOE) Generation

LCOE is a ratio of the summation of the present value of costs and the present value of output. As per CERC RE Tariff Order 2019-20 (CERC, 2019c), LCOE calculations are done based on the Present Value (PV) method during the period(t) and life of the project(n) in years:

$$LC_D = \frac{PV(Costs)}{PV(Output)} = \frac{\sum_{t=0}^{n} C_t/(1+r)^t}{\sum_{t=0}^{n} O_t/(1+r)^t}$$

Where n = total no. of years of project life

t = time in years

r = discount rate

Ct= Total capital cost at t=0

Ot = Total output at t=0

The LCOE is calculated in two ways, i.e., 1) LCOE with byproducts and 2) LCOE without byproducts. The formula discussed above is LCOE without byproducts.

The methodology for LCOE with byproducts is as follows.

3.5.1 By-product's availability and their respective calculation

This study has considered the value of byproducts of potable water and chemicals such as (Hydrogen, Ammonia, Methanol, Conc. CO2, Urea, Excess NH_3, Soda ash, 50% O2 enriched air, shellfish, etc.).

3.5.1.1 Potable Water Availability

The minimum production of potable water from a 1 MW OTEC plant is

= (0.02 X 400 X 24 X 3600 m3 / day; for continuous plant operation

= 172,800 m3/day .

The cost of potable water is around INR 42/KL; the minimum annual return from this byproduct of potable water alone from a 1MW hybrid-OTEC could be,

= (42 X 172,800 X 365) / yr

= 32,450,000 / yr for 24 X 7 operations around the year

3.5.1.2 Production of concentrated CO_2

The minimum production of concentrated CO_2 from a 1 MW OTEC plant is,

= 218 kg / day; for continuous plant operation

The cost of CO_2 is around INR 10/kg; the minimum annual return from this byproduct of concentrated CO_2 alone from a 1MW OTEC plant could be,

= (218 X 10 X 365) / yr

= 794,700 / yr for 24 X 7 operations around the year.

3.5.1.3 Production of Hydrogen

The minimum production of hydrogen from a 1 MW OTEC plant is

= 354 kg / day; for continuous plant operation

The cost of Hydrogen is Rs 16/kg; the minimum annual return from this byproduct of hydrogen alone from a 1MW OTEC plant is estimated as,

= (354 X 16 X 365) / yr

= 2,067,500 / yr for 24 X 7 operations around the year.

3.5.1.4 Production of Ammonia

The minimum production of ammonia from a 1 MW OTEC plant is

= 6018 kg / day; for continuous plant operation

The cost of ammonia is around Rs 10/kg; the minimum annual return from this byproduct of ammonia alone from a 1MW OTEC plant is estimated as,

= (6018 X 10 X 365) / yr

= 21,967,100 / yr for 24 X 7 operations around the year.

3.5.1.5 Production of Methanol

The minimum production of Methanol from a 1 MW OTEC plant is

= 6018 kg / day; for continuous plant operation

The cost of Methanol is around Rs 10/kg; the minimum annual return from this byproduct of ammonia alone from a 1MW OTEC plant is estimated as,

= (6018 X 10 X 365) / yr

= 21,967,100 / yr for 24 X 7 operations around the year

3.5.1.6 Production of Urea

The minimum production of urea from a 1 MW OTEC plant is

= 297 kg / day; for continuous plant operation

The cost of urea is around Rs 10/kg; the minimum annual return from this byproduct of urea alone from a 1MW OTEC plant is estimated as,

= (297 X 10 X 365) / yr

= 1,083,685 / yr for 24 X 7 operations around the year

3.5.1.7 Production of Soda Ash

The minimum production of Soda ash from a 1 MW OTEC plant is

= 525 kg / day; for continuous plant operation

The cost of Soda ash is around Rs 10/kg; the minimum annual return from this byproduct of Soda ash alone from a 1MW OTEC plant is estimated as,

= (525 X 10 X 365) / yr

= 1,914,535 / yr for 24 X 7 operations around the year

3.5.1.8 Production of Excess NH_3

The minimum production of Excess NH_3 from a 1 MW OTEC plant is

= 5850 kg / day; for continuous plant operation

The cost of Excess NH_3 is around Rs 10/kg; the minimum annual return from this byproduct of Excess NH_3 alone from a 1MW OTEC plant is estimated as, = (5850 X 10 X 365) / yr

= 21,353,000 / yr for 24 X 7 operations around the year

3.5.1.9 Growth of Mariculture

The minimum production of shellfish from a 1 MW OTEC plant is

= 250,000 kg / year; for continuous plant operation

The cost of shellfish is Rs 50/kg; the minimum annual return from this byproduct alone from a 1MW OTEC plant is estimated as,

= (250,000 X 50) / yr

= 12,500,000 / yr

Table 3-3 below summarizes the yearly revenue of byproducts from an OTEC plant based on the abovementioned assumptions.

Table 3-3 Estimated byproduct's additional annual revenue from 1 MW OTEC plant

Byproducts	**Unit**	**Daily Production in Kg**	**Rate**	**Revenue/year**
Potable water	m3	2,117	42 /KG	32,450,544
50% O_2 enriched air	Kg	47	10 /Kg	172,187
Conc. CO2	Kg	218	10 /Kg	794,715
Hydrogen	Kg	354	16 /Kg	2,067,477
Ammonia	Kg	6,018	10 /Kg	21,967,160
Methanol	Kg	1,888	35 /Kg	24,120,733
Urea	Kg	297	10 /Kg	1,083,685
Soda ash	Kg	525	10 /Kg	1,914,535
Excess NH3	Kg	5,850	10 /Kg	21,353,084
Shellfish	Kg	68	50 /Kg	1,250,000
Total revenue/year (in Rs)				107,174,118
Total revenue/year (in USD)			Rs. 72/ USD	1,488,629

3.6 Results

The explanation of components of the Levelized Cost of the OTEC energy system and its byproducts are given in Table 3-3. This study is based on CERC Regulations for calculating the LCOE of the OTEC project. The total cost per unit includes fixed cost and variable cost per unit. The literature has not reported any variable cost for such technologies. Operating and Maintenance Expenses, Depreciation, Term Loan Interest, Working Capital Interest, and Return on Equity are all examples of fixed costs. Each component is calculated based on the Levelized cost approach.

Table 3-4 Levelised cost of OTEC output (Electricity generation and Value-added products)

Sr. No.	Variables	Electricity Generation	Value Added Products
1.	Total cost per unit	It is the sum of fixed cost per unit and variable cost per unit.	
2.	Fixed Cost Components	It includes O&M Expenses, Depreciation, Interest on term loans, Interest on Working Capital, and Return on Equity. The respective calculations and assumptions have been discussed in section 3.3.	
2.1	Electricity Generation	Units generated are calculated as follows = Installed capacity (in MW) X (CUF- Aux Consumption) X total no of hours in a year	
		= 1 X (0.90-0.01) X 8760 / 1000 = 7.80 MU	
2.2	O&M Expenses are calculated as,	3% of Capital cost	
		4.78	2.05
2.3	Depreciation	90% depreciation has been spread across the plant life. Depreciation for the first 13 years is calculated at 5.28% and 14th year onwards till the 30th year is considered at 1.26%. The remaining 10% is taken as salvage value.	
		3.95	1.70
2.4	Interest on the term loan	13 years repayment period on reducing balance.	
		2.9	1.24
2.5	Interest in Working Capital	11.41% of total working capital is considered for interest on working Capital as per the calculation below, = (O&M expense for 1 month + Receivables for 2 months + Maintenance Spare (15% of O&M expense) X 11.41%.	
		0.45	0.19
2.6	Return on Equity	30% of the capital cost is considered as equity amount. 17.6% of this amount is considered a Return on Equity for the project life cycle.	
		4.87	2.09
3.	Variable Cost	Since there is no fuel cost, so variable cost is taken as zero for the tariff calculation.	
4.	Levelized cost per unit (in Rs)	16.95	7.28
	Levelized cost per unit (in USD)	0.24	0.10

The Levelized Cost of the OTEC energy system, including its byproduct, is $ 0.24 and $ 0.10, respectively. Therefore, the total Levelized cost of a 1 MW OTEC energy system is $. 0.34 As per Table 3-4, the Levelized revenue from the 1MW OTEC plant is Rs. 17.73 per unit. At this stage, Rs 6.50 per unit is needed to make the project financially viable. Thus, the viability gap funding approach makes the project financially viable.

3.7 Viability Gap Funding

The viability gap funding (VGF) is based on the premise that the revenue from user charges is insufficient to recover the project's cost, including the sources of finance. In such situations, VGF is recommended as an essential tool through which the Government may contribute funding to make the project financially viable. The purpose of using VGF is to make economically infeasible projects financially viable.

This study assumes that the OTEC project can create more public benefits that may not be reflected in the user charges. The second reason can be keeping the user charges deliberately low to ensure the social acceptability of the project.

Researchers have used a two-pronged approach in this study. One is to compare the LCOE of different RETs and estimate the VGF for OTEC projects in India. As per Table 3-5, the standard approach has been used to calculate the LCOE as prescribed by CERC. LCOE of OTEC is more than other technologies (refer to Table 3-5). The literature shows that the LCOE of the 1 MW solar project was $ 0.25, which means that this project had a comparatively lower LCOE at its inception stage. It is argued that OTEC projects are economically viable if the other benefits are also clubbed with the output. Therefore, this study has calculated the Levelized cost and revenue of electricity generated and value-added products. As per the table below, the estimated VGF at the initial stage for a 1 MW OTEC project is $0.09 per kWh. Thus, it is proposed that VGF needs to be provided for a 1 MW planned capacity at the initial stage.

Table 3-5 Calculation of Viability Gap Funding for OTEC

Source of Generation	Capital Cost (in $M)/ MW	Levelized Cost of Energy (in $/ kWh)	Balancing cost (in $/kWh)	Levelized cost (in $/kWh)	Levelized Cost of Value-added product (in $/kWh)	Total Levelized Cost (in $/kWh)	Levelized Revenue of Electricity (in $/kWh)	Levelized Revenue of Value-added Product (in $/kWh)	Effective Total Cost (in $/kWh)	VGF $/kWh)
	1	**2**	**3**	**4 = (2) + (3)**	**5**	**6 = 4 +5**	**7**	**8**	**9= 7 + 8**	**10 = 6 - 9**
Offshore Wind	5.56	0.10	0.02	0.12		0.12				
1 MW OTEC	97.22	0.24	0.00	0.24	0.10	0.34	0.06(*)	0.19	0.25	0.09

(*) Reference (CERC, 2021)

This analysis is undertaken in two parts. In the first part, the LCOE of different energy systems is calculated. This analysis aims to understand the difference in LCOE with benchmark energy systems. The results show that the LCOE of the OTEC system is more than other RETs. The second part calculates the Levelized Cost of Value-Added Products (LCO_{VAP}). This analysis aims to evaluate the impact of value-added products on the overall cost. The following equation is used to calculate the VGF.

$$\text{Viability Gap Funding} = (LCO_E + LCO_{VAP}) - (Rev\text{-}O_E + Rev\text{-}O_{VAP})$$

Where LCO_E = Levelized Cost of Energy

LCO_{VAP} = Levelized Cost of Value-Added Products

$Rev\text{-}O_E$ = revenue from the sale of energy

$Rev\text{-}O_{VAP}$ = revenue from the sale of Value-Added Products

The following steps are used for determining the amount to calculate the VGF.

- Step 1: Capital Cost of the project (in \$) per MW.
- Step 2: Calculation of Levelized Cost of Energy (in \$/ kWh).
- Step 3: Balancing Cost (in \$/kWh)
- Step 4: Total Cost (in \$/kWh)
- Step 5: Levelized Cost of Value-added product (in \$/kWh)
- Step 6: Total Levelized Cost (in \$/kWh)
- Step 7: Levelized Revenue of Electricity (in \$/kWh)
- Step 8: Levelized Revenue of Value-added Product (in \$/kWh)
- Step 9: Effective Total Cost (in \$/kWh)
- Step 10: VGF \$/kWh)

The calculations of these steps are explained in section 3.3 above.

3.8 Scenario Analysis

The LCOE calculation of the 1 MW OTEC plant showed that the project needs viability gap funding of $ 0.09 per unit. Still, the analysis is based on the assumption that with the scaling up of the OTEC plant, there may not be any need for viability gap funding. The rationale of sensitivity analysis is to understand plant size's impact on OTEC projects' capital intensity. Therefore, it is used to measure the impact of capacity expansion on project cost, LCOE, Payback period, NPV, and IRR.

3.8.1 Project cost

Heat exchanger cost, cold water pipe cost, barge cost, mooring cost, turbine installation cost, etc. are all components of the total project cost. Thus, the impact of capacity expansion from 1 MW, 25 MW, to 50 MW on project cost is shown in Table 3-6 and **Figure 3-3**. It is observed that the total project cost per MW declines by 15.5% from 1 to 25 MW and by 18.4% from 25 to 50 MW, i.e., from 720 million to 607 million and to 496 million. This decline is due to a change in the contribution of different cost components in the total cost structure. For example, the decrease in per MW cost of Heat exchangers and cold-water pipes is due to the pipe diameter changing, but the length remains the same. However, as the share of the heat exchanger cost in the total cost structure is between 50 – 55% of the total cost, the decremental cost % is higher in the case of cold-water pipes. While barge size increases, manpower cost remains the same, reducing per MW cost. In the case of turbine installation, duration increases, but manpower remains the same, due to which more than a 10% decrease in cost per MW can be observed as we go for capacity expansion (Barberis et al., 2019; IEA-OES, 2019; Muralidharan, 2012; Ravindran M & Abraham, 2002; Vega, 1992).

Table 3-6 Per MW cost of different components in $ in M and %

Capacity (MW)	Cost of Heat Exchanger ($ in M)	Cold water pipe ($ in M)	Barge cost ($ in M)	Cost of mooring ($ in M)	Cost of installation of Turbine ($ in M)	Total cost ($ in M)
1	5.10	0.97	0.85	0.50	2.57	9.99
25	4.64	0.68	0.49	0.40	2.21	8.42
50	4.07	0.39	0.28	0.28	1.85	6.86

Capacity	Cost of Heat Exchanger	Cold water pipe	Barge cost	Cost of mooring	Cost of installation of Turbine	Total Cost
25	-8.9%	-30.2%	-41.4%	-19.4%	-13.9%	-15.6%
50	-12.3%	-42.6%	-41.9%	-30.3%	-16.2%	-18.4%

Capacity	Cost of Heat Exchanger	Cold water pipe	Barge cost	Cost of mooring	Cost of installation of Turbine	Total Cost
1	50.97%	9.80%	8.50%	5.03%	25.70%	100.00%
25	55.00%	8.10%	5.90%	4.80%	26.20%	100.00%
50	59.10%	5.70%	4.20%	4.10%	26.90%	100.00%
100	59.70%	5.40%	3.90%	3.90%	27.10%	100.00%
200	60.40%	4.90%	3.70%	3.50%	27.50%	100.00%

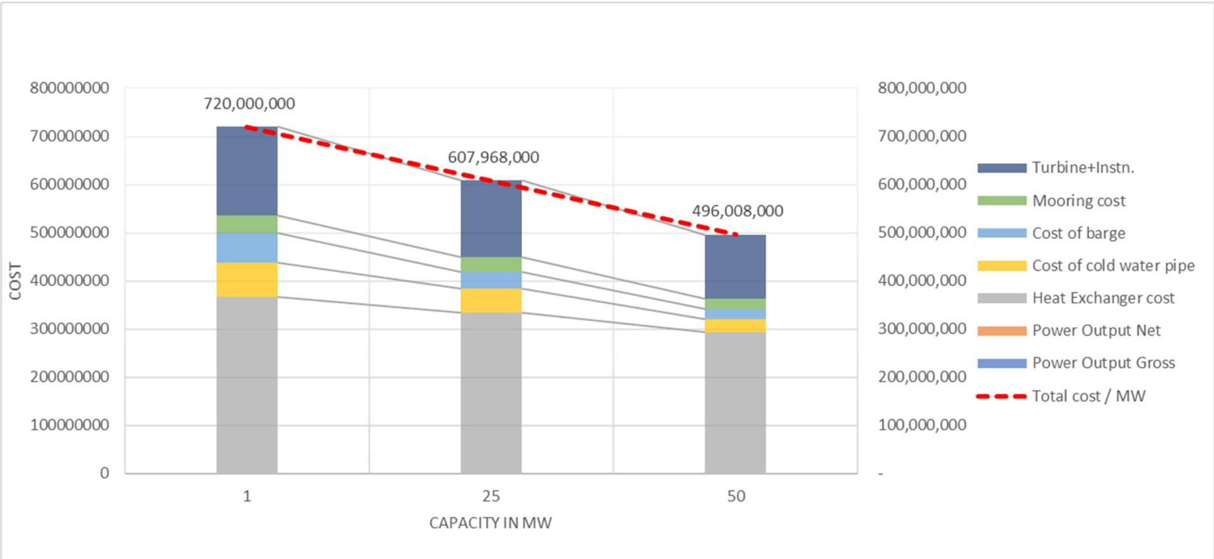


Figure 3-3 Incremental Cost Analysis (Assuming capacity expansion of the same facility)

Per MW cost analysis in terms of per MW – Impact on the cost component

3.8.2 NPV, IRR, and Payback period

The total annual cash flow with a discount factor is NPV. Therefore, the decision criteria for acceptance or rejection of the project are based on the comparison of discounted annual cash flow (DCF) with capital outlay (CO). If DCF is more than CO, accept the project and vice versa.

$$\text{NPV} = \sum_{T=1}^{EL} \frac{a_T}{(1+ir)^T} \tag{36}$$

L= Estimated life

t= no of years

DCF= discounted annual cash flow

i= interest rate

IRR is internal to the project, unlike other rates of return concepts. Technically it is the rate at which the sum of DCF is equal to zero. Generally, a higher IRR means more chances of undertaking the project. IRR can be calculated with the help of the formula given below.

$$\text{The value of IRR such that} \sum_{T=1}^{EL} \frac{a_T}{(1+IRR)^T} = 0 \tag{37}$$

L= Estimated life

t= no of years

DCF= discounted annual cash flow

irr= internal rate of return

This study used NPV, IRR, and discounted payback period to analyze India's investment sensitivity w.r.t. CERC tariff regulations. The NPV calculations are based on a discounting factor of 9.94% as per CERC regulations. The calculations are based on the scaling up capacities from 1 to 25 to 50 MW, and each capacity is further bifurcated into with or without byproducts. As per **Figure 3-4** below, the NPV is positive in higher-level capacities and negative only at the 1 MW capacity (without byproduct). The value of NPV increases with the increase in the project capacity. It is also observed that the rate of increase of NPV with byproduct projects is more than without byproducts.

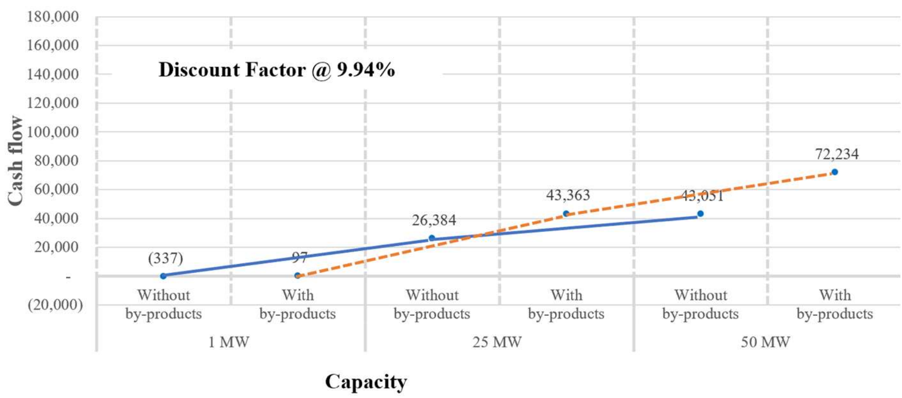


Figure 3-4 NPV Comparisons of OTEC projects in India with or without value-added products

As discussed in the literature, IRR is the most reliable method for evaluating the financial viability of a project. **Figure 3-5** below indicates that the IRRs are increasing with the plant capacities. Therefore, IRRs of planned capacities of value-added products are more than those without value-added products. As per the literature, the IRR of energy projects ranges between 8% and 12%. Thus, the IRR of all the OTEC projects falls within the 8 – 12% range. Hence, they are financially viable projects except for 1 MW capacity without byproducts, as the NPV is negative.

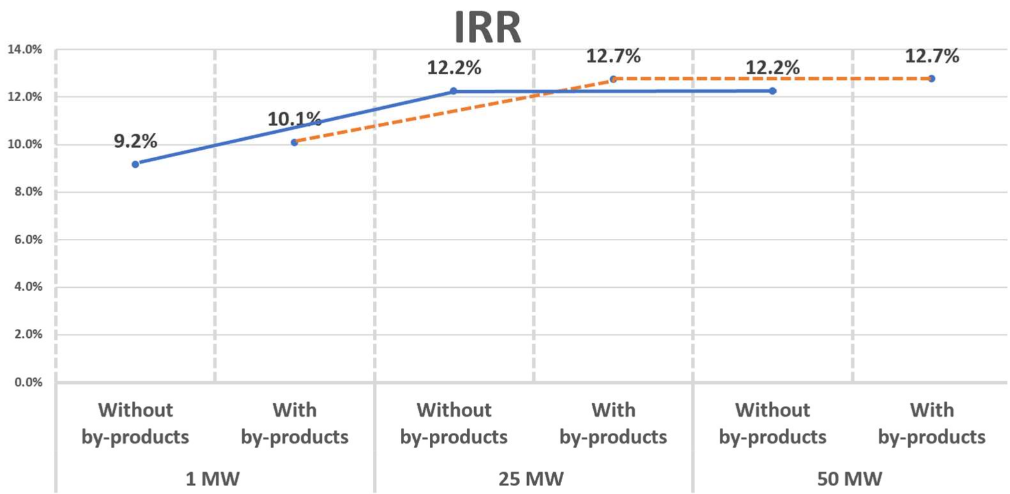


Figure 3-5 IRR comparisons of OTEC projects in India with or without value-added products

As per the literature, the DPP of an energy project ranges between 6 and 8 years. As per the calculations in **Figure 3-6** below, the DPP for 25 MW and 50 MW capacities is within 6 to 8 years. Therefore, this method also suggests more significant capacities. A comparison of financial viability results clearly shows that investing in a 1 MW capacity will not be advisable because NPV is negative and the payback period exceeds the industry benchmark in this capacity. Regarding 1 MW capacity, only IRR is within the industry benchmark range. If the NPV of the project is negative, relying on IRR only will not give the desired result. Experts also opined that capacities in the range of 1 MW have already been developed in India for demonstration purposes. Thus, it would be better for policymakers to encourage investments in more significant capacities.

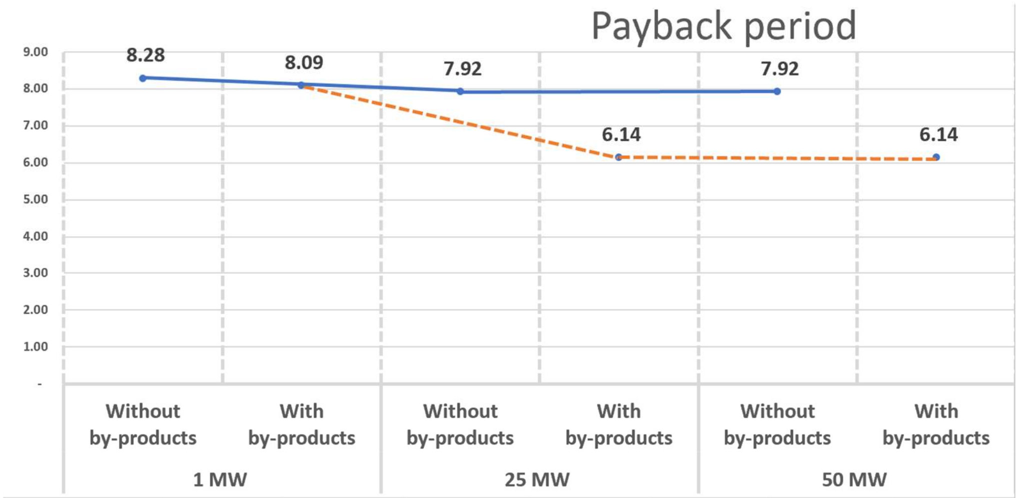


Figure 3-6 Payback period comparisons of OTEC projects in India with or without value-added products

3.9 Conclusion

A literature review was performed to understand the critical research gaps in OTEC economics. These gaps are a lack of in-depth economic analysis of OTEC, analyzing the external natural conditions, operating performance, financial risk, technological learnings, and, more importantly, the criticism that the studies are limited to inclusion of LCOE only for calculation purposes by ignoring the LCOE and revenue from the byproducts. Based on the research gaps identified in the literature, this paper has attempted to bridge the research gap as discussed above. c

The techno-economic aspects with and without byproducts for the basis of the sensitivity analysis of LCOE in twelve different scenarios in India. It considers three capacity levels (1 MW, 25 MW, and 50 MW), and each capacity level includes the sensitivity parameters such as Project Cost, LCOE, Payback period, NPV, and IRR.

The results are calculated by assuming the Hybrid cycle, CERC Regulations, and value-added products such as drinking water, production of oxygen, soda water, and Carbon di Oxide, Chemicals such as Soda ash, urea, Methanol, and hydrocarbons, H_2-type fuels, and NH_3, Agricultural products (mariculture proteins) and Sea Water Air Conditioning.

The estimated VGF at the initial stage for a 1 MW OTEC project is Rs 6.5 per kWh. Thus, it is recommended that the VGF at the initial stage can be provided for a 1 MW planned capacity. The larger capacities can be self-sustained because of a reduction in the cost components from 15% to 18% with the capacity expansion. Similarly, the other parameters, such as NPV, IRR, and discounted payback period, reflect improved financial performance with increased capacities. Therefore, the results have also proved that the OTEC energy systems would be economically viable with larger capacities and very competitive compared to other RETs.

In addition, experts opined that capacities in the range of 1 MW have already been developed in India for demonstration purposes. Thus, it can be concluded that it would be better for decision-makers to encourage investments in more significant capacities.

CHAPTER 4 - RESEARCH METHODOLOGY

4.1 Introduction

Research methods refer to using tools and techniques during the different steps of the research process to understand and ensure that the research output is relevant to the given problem. Research design is a strategy that integrates data collection, measurement, and analysis. Conclusive research and exploratory research are two broad research designs. This thesis has used these two research designs, meaning that the study used quantitative and qualitative data to analyze the problem. Conclusive research design (Quantitative) forms the core part of the work. In contrast, exploratory research (Qualitative) was used during the literature survey, developing the hypothesis, validating, finalizing the variables for the study, analyzing the best practices linkage framework, and ranking the action & performance and actor & process.

This chapter presents the rationale for the study, the problem statement, research questions, objectives, the data collection strategy, and the findings. Further, this chapter discusses the sampling process, survey administration, and statistical tools used for data analysis.

4.2 The rationale of the study

The current renewable energy development plan is land-intensive and beset with high intermittency, low capacity utilization factor, and the challenge of maintaining the baseload. This study is an attempt to identify a RE source which can solve the challenges of existing RE basket in India. In this context, the Indian cabinet decided to include energy from OTEC and water as a critical strategy under the Deep Ocean Mission, and MNRE included OE as RE, but there is no policy framework for OE in India. With the given background, this study is planned to explore various policy aspects of the OTEC development in the country.

4.3 Problem Statement

Although variables for the development of Ocean Energy are discussed in the literature, it has not been tested as critical components for Ocean Energy development in India. The literature has not discussed the linkage between policy decisions for removing barriers. Literature has indicated Ocean Energy as an RPO compliance, but there is a lack of scholarly attention for understanding pathways through which policy decisions affect the development of the Ocean Energy

4.4 Research questions

The following research questions are identified based on the gaps identified in the Literature review chapter:

1. What are the significant factors for ocean energy development in India?
2. How can policies help to remove the barriers?
3. What policy framework should India develop for ocean energy (OTEC) policy in India?

4.5 Research objectives

The following are the objectives of the research:

1. To identify significant factors for the ocean energy development in India
2. To analyze the role of policies in removing the barriers.
3. To develop a suggestive policy framework for OTEC policy in India

4.6 Scope of the study

The scope of the study is limited to India's geographical boundary. An extensive literature survey of the OE sector in the UK, France, and other countries is conducted to understand the OE policies adopted by these countries that helped the growth of this sector. Using the knowledge gained, a questionnaire survey is carried out in India to elicit the responses of Indian stakeholders on what could constitute supportive OE policies.

4.7 Research Design

The research design is vital because it connects theory and argument with the empirical data collected and research output. (Seem et al., 1988)(Churchill & Iacobucci, 2006; Churchill & Peter, 1984). In this thesis, the research process has been explained with the help of (Saunders et al., 2019) onion approach, which provides different layers and approaches used during research.

4.7.1 Understanding Research Process with Saunder's Approach

Figure 4-1summarises the different layers of the onion process, which are explained below.

4.7.1.1 Research Philosophy

The first and the most crucial layer of the process is Research philosophy. It influences the researcher's research plan (Saunders, M., Lewis, P., & Thornhill, 2012). It includes Positivism, critical realism, Post-modernism, Pragmatism, and Interpretivism. This research adopts an Interpretivism philosophical approach in which researchers have proven the hypothesis that the policy framework plays a vital role in using natural resources in the country. Therefore, this study has explored and prioritized the policy factors for developing Ocean Energy in India. These factors will play differently in different situations, and the target audience will interpret the research findings in the given context. It also means these findings will have various interpretations in different contexts/situations. To carry out research under this philosophy, we collected the data using questionnaires and interviews through survey techniques. The study collected quantitative and qualitative data and used a mixed-method approach. This data is cross-sectional because the data has been collected in a given snapshot. This research is inductive because the researcher has formulated a model(Creswell, 2003, 2008, 2012).

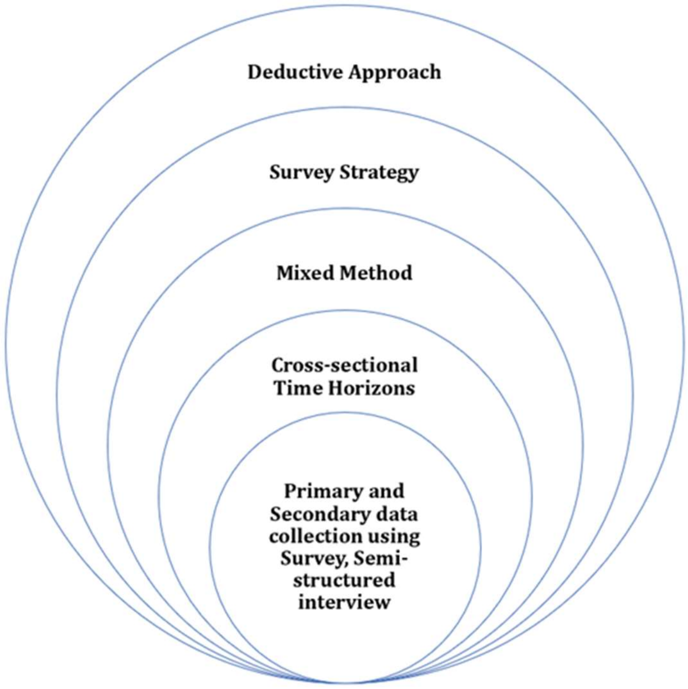


Figure 4-1 Research Onion Framework
(adopted from (Saunders et al., 2019)

4.7.1.2 Research Approach

This layer of the Research onion helps explain the researcher's research approach. Generally, the researchers either test a theory or hypothesis or build a theory or hypothesis. When a theory or hypothesis is tested, the approach is known as the "Deductive" approach; in other cases, it is known as the "inductive" approach. In this case, the researchers tested the hypothesis **"that a strong and committed policy landscape is a prerequisite for developing OE."** Therefore, the research approach is deductive.

4.7.1.3 Research Strategy, Choice, and Time Horizons

The following three layers of the approach define the core of the research onion. These are Research Strategy, Choice, and Time Horizons. As data were collected using questionnaires and interviews from a defined sample, a survey strategy was used for the research. In addition, the study has collected quantitative and qualitative data and used a mixed method approach (choice).

Finally, the study has taken Cross-sectional Time Horizons because the survey was conducted at a particular time and covered all the stakeholders through representative samples.

The research process to attain the objectives is outlined in Figure 4-2.

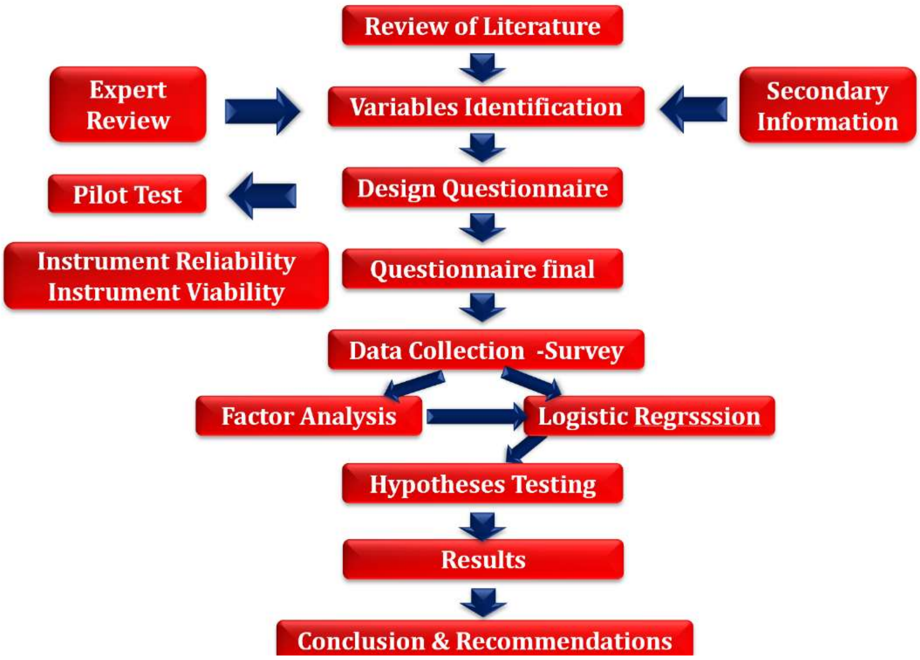


Figure 4-2 Flowchart of the Research Process

The research design and steps followed to accomplish the objectives are summarized below in Figures 4-3, Figure 4-4, Figure 4-5 and elaborated subsequently.

4.7.2 Research Objectives 1

The research process for Research Objectives(RO)1, i.e., "to identify significant factors for the ocean energy development in India." This objective has been achieved in two parts. The first part deals with the Document Analysis, which was used to analyze policies of leading countries and explore essential variables for factor analysis to identify important factors for OE development in India. The second part of this objective deals with identifying and prioritizing the factors promoting OE policies in India using the Factor analysis technique

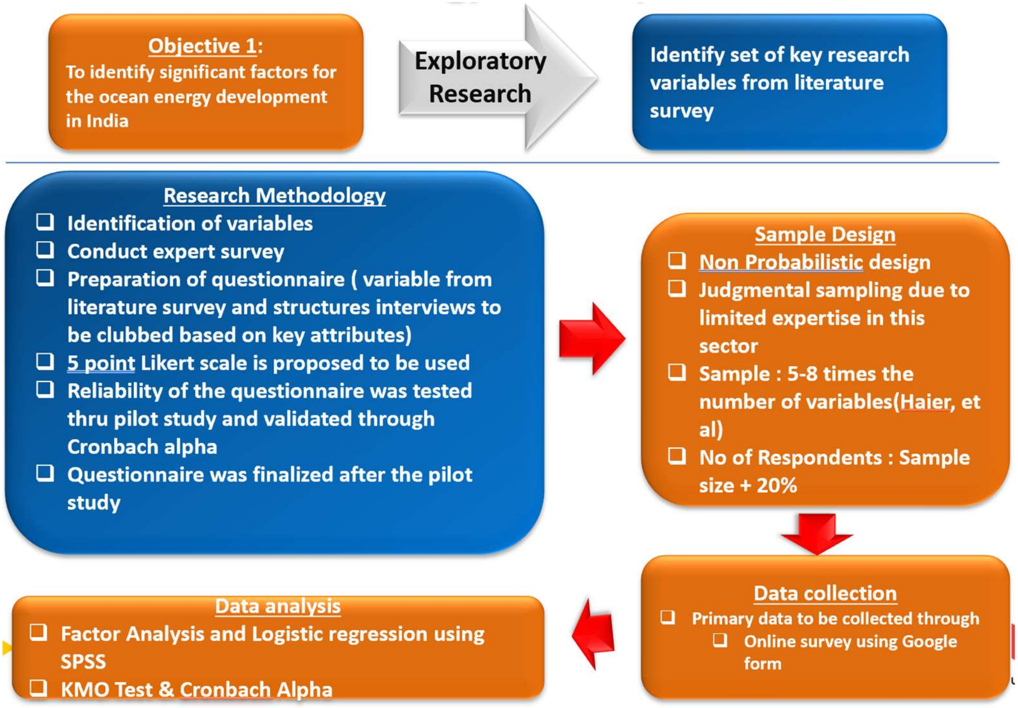


Figure 4-3 Research Methodology for Objective -1

Figure 4-4 Research Methodology for Objective -2

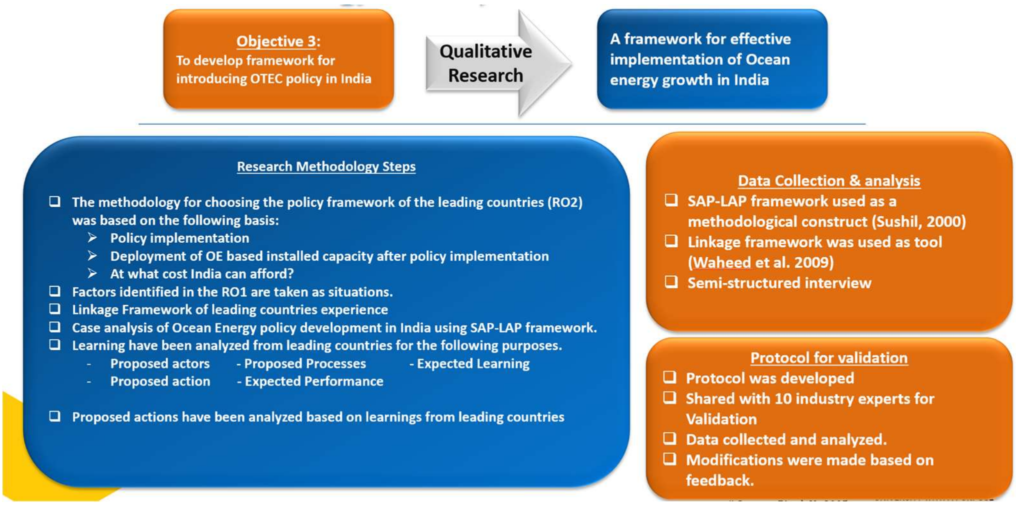


Figure 4-5 Research Methodology for Objective -3

4.7.2.1 Document Analysis of Ocean Energy policies of 11 leading countries

For this type of exhaustive research, applicable data is required from scholarly articles and grey literature on web-based reports and policy-related documents. To frame and analyze qualitative data related to policy initiatives and incentives, “Document analysis,” a recognized and tested qualitative data analysis methodology, is adopted (Alasseri et al., 2020; Bowen, 2009). A keyword search-based framework with a systematic literature review process is made to decide the keywords. During the initial review, 924 peer-reviewed articles were identified for the OE policies of eleven countries; namely the United Kingdom(UK), France, Belgium, Denmark, Germany, USA, Japan, China, Canada, Australia, and South Africa, New Zealand, and Korea. The countries were selected based on similar demography and expert opinion.

To perceive the appropriateness of the articles, a manual screening process is adopted to eliminate 758 papers. In this process, finally, 166 most suitable papers were selected for this research. Also. 68 grey literature, of which 44 technical reports and 14 based on official websites related to the environment, policy, and economic development, government sector, and private sector in the field of energy were referred. The assimilation of the data containing total of 214 documents, including review articles, policy and strategy documents including the timeline for obtaining various processes and procedures, were mapped as per countries and summarized under common parameters such as 1) Market incentives, 2) Long Term Policy, Strategy & Targets, 3) Marine spatial planning, Consent Procedure, 4) R & D Support, Public funding & Prototype Testing followed by a country-wise comparative analysis performed, and from this, an attempt has been made to explore international experience and learnings for India and recommends the best practices for India with an expectation to help various research organizations, government agencies, and policymakers around the world. The methodology is summarized in **Figure 4-6**.

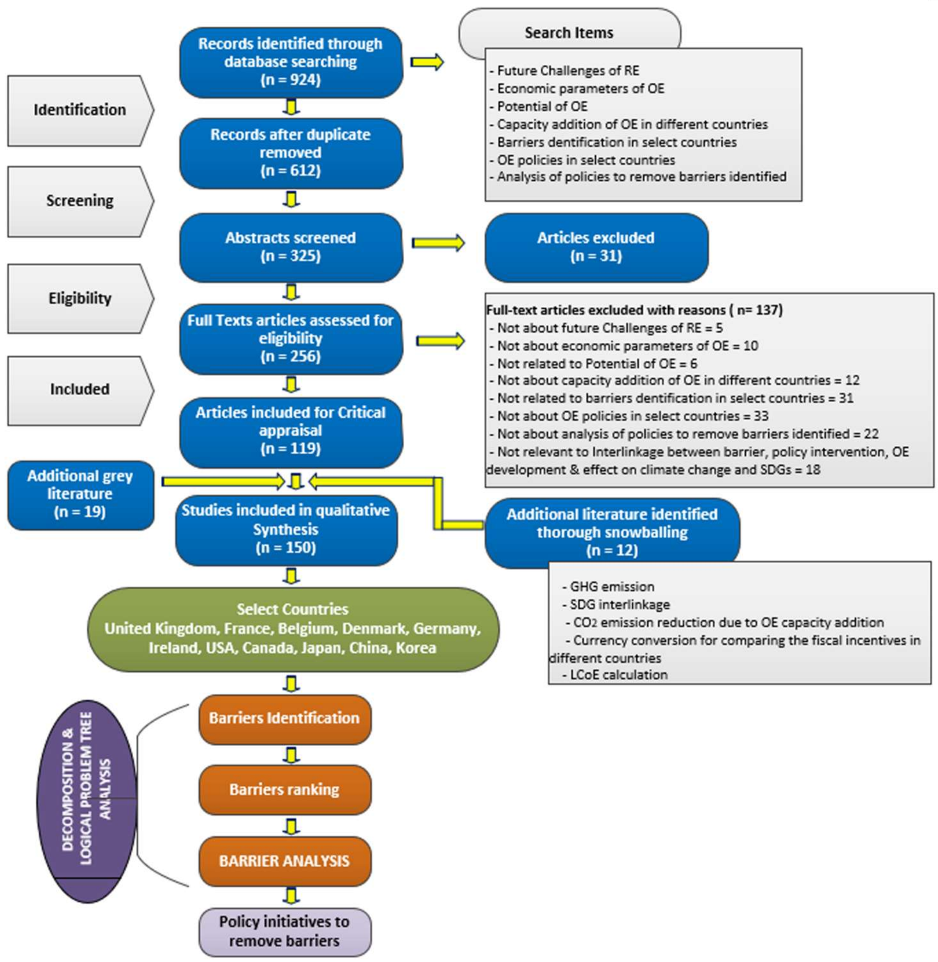


Figure 4-6 Document Analysis Process of Ocean Energy policies of 11 leading countries

4.7.2.2 Identification and Prioritization of Factors important for OE development in India

Conclusive research (descriptive research) has been chosen as a research methodology (RM) for RO1, as it supports analysis using statistical tools. It follows the procedure for an inquiry by employing closed-ended questionnaires as a survey tool; a quantitative RM is used to accumulate numeric data. Therefore, a quantitative approach to RM emerged as a suitable methodology for this RO, comprising the identification of variables through Document Analysis as discussed above, development of research models, instrument reliability, and validity, along with the statistical tools' application for the conclusion (Castka et al., 2001; Given, 2012; Judge et al., 2001; Swedberg, 2020). Stakeholder interest in OE development in India was gathered through a five-point Likert scale questionnaire, and results were analyzed using a weighted average method and factor analysis.

Table 4-1 explains the operational definitions of the variables identified from the literature. The inclusion of the operational definitions is to provide a better understanding and clarity about the variables identified.

Table 4-1 Variable operational definitions derived from a literature review

Sr. No.	Variables Definition
1.	**Long-term policy continuity** would be a prerequisite to increasing stakeholders' confidence.
2.	Exemption from interest payment in the initial phase of the project (for the first five years) would help reduce the risk of investors and improve developers' cash flow.
3.	**Cost of capital reduction through OE fund creation** can be done by policy instruments like levying green cess on CO2 emitted activities like coal-fired projects.
4.	**RPO/REC Legal Compliance:** RPO compliance authorizes the Government to instruct the distribution licensees to produce a minimum specified quantity of RE requirements.
5.	**Providing an attractive interest rate for capital –** would reduce the debt burden and debt servicing of developers.
6.	**Generation-based Incentives (GBI) -** It is a mechanism over and above the FIT system. It gives bonus points to the RE generators for injecting green energy into the grid.
7.	**Declaring OE as a "Priority sector –** would increase the investment attractiveness and ease accessibility of funds.
8.	R&D support for the production of equipment components domestically in the country –will directly impact the reduction of capital cost.
9.	R&D organizations focus on OE innovation and technology advancement: critical for technological advancement and commercial success.
10.	**Accelerated Depreciation (AD)** – a faster depreciation rate is available for investors who invest in RE projects.
11.	**HR training and skill development would be vital** for the smooth execution of labor-intensive OE projects (80 – 100 manpower/ MW).
12.	**Feed-in Tariffs (FIT) –** is the fixed price paid by the distribution companies to the RE developers for feeding each unit of power generated into the grid.
13.	**Precise technical information of potential OE sites –** Critical input factors like temperature gradient, water depth, wind speeds, etc., impact the generation and, thereby, the project's profitability and can substantially impact profitability.
14.	**Developers' skill development for large-scale project execution** would be a prerequisite for successful project construction management and turnover.
15.	**Developing local manufacturing capability for leading equipment –** would be critical to optimizing production cost rather than importing it.
16.	Developing the ancillary supply chain – Facilitation of growth of ancillary units within the country will help reduce components. As a result, it will help in the enhanced adoption of OE in the country.
17.	**Readiness of skilled contractors –** would be required for the successful construction of OE project as a shortage of competent contractors could delay construction and affect profitability.
18.	**Financial support through incentives** - for the development of OE project incentives in tax-related schemes, import duties exemptions, excise/customs duty waivers, etc., can be initiated.
19.	**Flexibility in tariff calculation aligned with technical factors –** such as depending on temperature gradient wind speed, water depth, etc. would support the growth of a low capacity and testing platform.
20.	**One-stop Shop clearance –** It will facilitate the investors/service providers by reducing the gestation period hurdle.
21.	**Grid connectivity from the OE project to the onshore transmission line –** would be a critical factor governing the successful implementation and operation of the OE project.

4.7.2.3 Hypothesis

Null Hypothesis H0: A strong and committed policy landscape is not a prerequisite for developing OE in India, i.e., capacity-building for research and skill development, promoting local content, economic tools for oe projects, financing mechanism, regulatory and fiscal incentives, and government support don't predict the growth of ocean energy in India.

Alternate Hypothesis H1: A strong and committed policy landscape is a prerequisite for developing OE in India, i.e., capacity-building for research and skill development, promoting local content, economic tools for oe projects, financing mechanism, regulatory and fiscal incentives, and government support predict the growth of ocean energy in India.

4.7.2.4 Use of Mean for Ranking the Variable

A ranking method was adopted based on the weighted scores to analyze the variables identified from the literature contributing to OE development (Ajagbe et al., 2014; Aramyan et al., 2007; Guritno et al., 2015; Negi & Anand, 2018; Ramanathan & Parthasarathy, 2014; Shehrawat, 2006; Singh, 2011). First, the significant variable was measured on a five-point Likert scale, ranging from strongly disagree—1, disagree—2, neutral—3, agree—4, and strongly agree—5, as shown in Table 4-2. Next, based on the degree of significance of stakeholders' responses, a total choice score (TCS) / weightage score for each variable and its percentage (%) in the overall weighted score was calculated. Then the TCS / weighted score so obtained for each variable was converted into weighted mean scores. At last, the variables were ranked based on their weighted mean scores (Shehrawat, 2006; Singh, 2011).

Table 4-2 *Assignment of Weightage*

Rating Scale	Degree of Significance	Assignment of Weight
1	Strongly agree	5
2	Agree	4
3	Neutral	3

Rating Scale	Degree of Significance	Assignment of Weight
4	Disagree	2
5	Strongly disagree	1

4.7.2.5 Sampling Procedures

4.7.2.5.1 Target Population

The survey was conducted with the organisation or individuals who showed a keen interest in exploiting the RE potential of the country. The target population included companies based in India.

4.7.2.5.2 Sampling Frame

The stakeholders interested in RE development and have been operating from India were found suitable for sampling.

4.7.2.5.3 Sampling Element and Sampling Unit

Executive decision-makers in organizations having experience of "less than 10 years," "10–20 years," and "more than 20 years" were considered as the sampling elements.

4.7.2.5.4 Sampling Technique

The data was collected using a proportional stratified sample. Stakeholders such as engineering, procurement, and construction (EPC) contractors, financial institutions, regulatory agencies, RE industry associations, academia, consultants, project developers, R&D institutions, policymakers, RE equipment manufacturers, independent power producers, and thought leaders in RE have been identified as the strata from the population. The breakup of the sample size has been illustrated in Table 4-3.

Table 4-3 ***Overall Sample Size***

Source	No.	% of	Sample
Government Senior Officers (Ministry of Power and MNRE) / Individual Experts	100	20%	20
NGOs	10	30%	3

Source	No.	% of	Sample
Electricity Regulators	30	40%	12
RE Generators*	600	40%	240
Financial Institutions	50	30%	15
Distribution Companies	70	30%	21
Load Dispatch Centers	30	30%	9
Power Exchanges	3	30%	1
RE Association/Individual	10	30%	3
Total	**903**		**324**

4.7.2.5.5 Sample Size

The sample size for the study was calculated using Yamane's method. (Joskow & Yamane, 1965). The formula is as follows:

$n= N/(1+N.e^2)$

Here,

n = sample size needed

N = size of the population

e = level of precision (.05 at 95% confidence level)

About 900 senior executives and professionals of the respective strata were identified as the target population for the survey. Researchers looked at the sample size from three different perspectives. First, a sample size of 166 was determined by taking N = 900 and e = 5% and using them in the equation mentioned above. Second, Malholtra and Dash(2016) recommended using eight respondents for each variable to conduct factor analysis. On this basis, a 168 sample size was determined for the survey; third, Siddiqui (2015)recommended that a sample size of 300 or more would be required for a good (factor) analysis.

On this basis, the researchers decided on a sample size of 324 to consider and distribute proportionately across the stakeholders on a pro-rata basis (Matsunaga, 2010; Siddiqui, 2015). Hence, the questionnaire was distributed to a sample of 450 respondents. Incomplete responses were also received, which were removed from the survey responses, and as a result, 324 questionnaires (72%) were found suitable to be taken to the next level (Malholtra & Dash, 2016).

4.7.2.6 Strategy for Instrument Design, Questionnaire Development, and Scale Development

The questionnaire served as a tool for collecting information. Each questionnaire contained 30 questions. The survey with two sections was administered: Section “A” included three items that inquired about the demographic data such as name, organization name, and management level; Section “B” consisted of a structured-undisguised questionnaire to be responded with 1–5 (Vagias, 2006).

A five-point Likert scale [strongly disagree (1) to strongly agree (5)] could be used by the respondents to present their perspectives through a Google Form. The questionnaire was formed with the help of the 21 variables identified in the literature (Sekaran, 2003). The questions were asked in the context where a variable would support the development of OE in the country.

4.7.2.7 Scale formation

In this research, the variables identified from the literature survey are converted into questions administered to the RE stakeholders in India. The participants were then asked to weigh in on whether they believed a given variable would promote or hinder ocean energy development. Since this is a one-dimensional activity, one of the uni-dimensional scaling methods needs to be chosen to develop the scales for the questionnaire. There are three such methods.

- Guttman or "Cumulative" Scaling
- Likert or "Summative" Scaling
- Thurstone or Equal-Appearing Interval Scaling

The Likert scale is predominantly used as it is easier to construct and administer. Likert is a widely used scaling technique if one is needed to test a hypothesis and is used for scoring purposes. Also, Likert is an interval scale where the distance between attributes is constant and can be interpreted and exploited using quantitative techniques like factor analysis and regression. The items that need to be rated as part of the thesis were generated from the literature survey (21 variables). Then a suitable rating (Likert 1-5 scale) of the items was developed as 1-5 scales are most suitable for logistic regression models. Finally, stakeholders' responses were analyzed using SPSS (v 22.0) software for further analysis (Cronbach, factor analysis, and logistic regression)

4.7.2.8 Pilot Testing

The scale, structure, and questions of the questionnaire were refined through pilot testing. (Creswell, 2003). The questionnaire was piloted with a representative sample of 46 RE stakeholders across the country. The purpose of the pilot testing was to make the questionnaire more concise and specific to achieve the study objective. A dummy table was developed to understand whether the responses aligned with the questions. This process made the questionnaire better and more reliable in terms of its substance. Stakeholder comments from the pilot survey informed the order of questions and the rephrasing of a few vague ones.

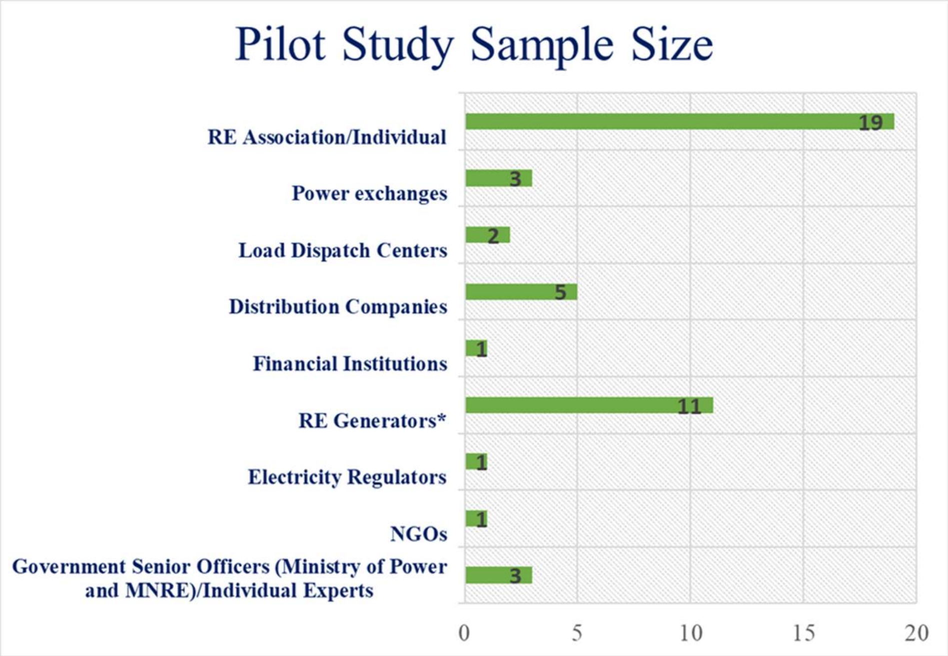


Figure 4-7 Pilot Study Proportionate Sample Size

4.7.2.9 Instrument reliability

The concept of reliability refers to the consistency in the respondents' responses during the survey. There are four methods to measure instrument reliability: Internal-consistency reliability, Test-retest reliability, Parallel-forms reliability, and Inter-rater reliability. This research makes use of an internal consistency approach.

4.7.2.10 Instrument validity

Instrument validity reflects the robustness of the survey design, which means that the questions asked in the instrument are right and understood by the respondents in the same spirit. It helps in ensuring sample representativeness and measurement accuracy. In this study, Face validity and Content validity were checked

4.7.2.11 Quantitative analytical tools used

This research has used a two-pronged approach for quantitative analysis. In the first approach, the number of variables was cut down to size using factor analysis., and in the second approach, the relationship between the dependent variable (growth of Ocean Energy) and independent variables (the factors identified in the first approach) was studied with the help of logistic regression technique (as shown in Figure 4-8).

In this research, the six factors that emerged from factor analysis were used as the independent variables, and the growth of OE (Growth/No growth) was used as the dichotomous dependent variables. The multivariate analysis factor analysis and logistic regression details are given in chapter -4 of this thesis. SPSS software was used for analysis.

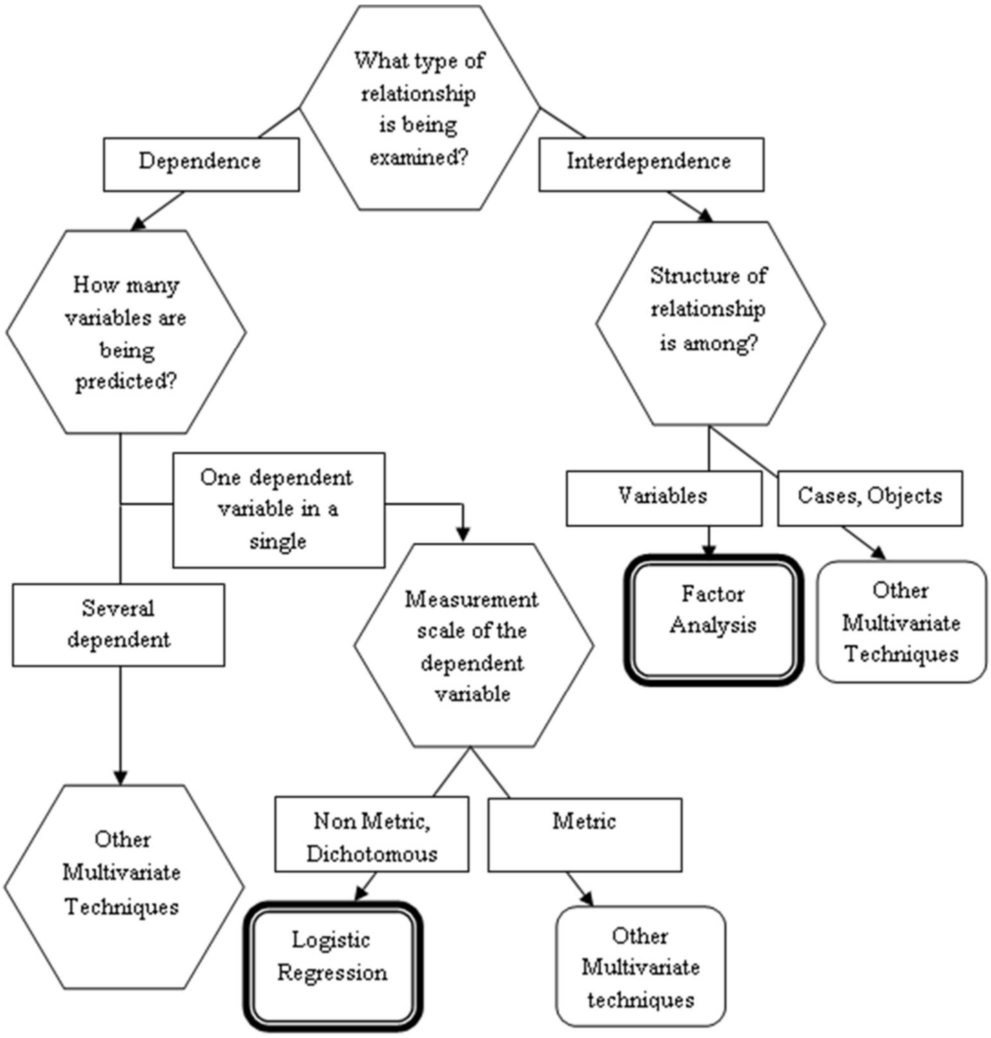


Figure 4-8 Flowchart for selecting a multivariate technique

4.7.3 Research Objectives 2

For RO 2, i.e., "to analyze the role of policies in removing the barriers," the researchers have used a two-pronged approach. The first step identifies barriers using Document Analysis in RO1 and analyzes using Decomposition and Logical Tree Analysis. In the second step, using Situation-Actor-Process(SAP) Learnings-Action-Performance(LAP), i.e., SAP-LAP analysis of leading countries, was performed. Experiences were analyzed in the form of Actors identified; Processes adopted, Learning experiences, Actions taken, and Performance achieved.

- Understanding Situation: In this category of SAP-LAP analysis, we have kept the situations that were a barrier to OE development growth. This study has considered the UK, France, and South Korea as leading countries in the OE field because these countries share more than 85% of the global installed capacity of OE systems. The researcher has identified 11 significant barriers to a situation with the help of LR. The leading countries faced these situations, which they addressed with their robust policy framework.
- Actors: This is the 2nd step in SAP-LAP analysis where the researchers have tried identifying the critical actors. This tool also defines actors' roles, responsibilities, and associated factors. The study has identified three significant actors who have played important part in breaking down roadblocks to OE growth.
- Process: This step in the SAP-LAP framework deals with the processes used to understand the probable solutions to identified situations. The processes in this step play their role in transforming the given situations by converting a set of inputs into outputs. As per literature, there can be different processes such as policy, customer interface, supply chain, and many more. (Suri & Sushil, 2012) recommend that one or more processes may be involved depending upon the situation to portray their key issues.

The “process” and “actor” interface explains policies, structures, and systems required for the sector's development.

The Interface between “situation” and “process” explains alternate methods for accommodating the reply to the fluctuating situations

- Learning: The SAP-LAP framework synthesizes the essential experiences from the research. These experiences can be generic and specific. The generic experiences are based on the experiences of the leading countries, which can be synthesized for the country’s willingness to implement. At the same time, specific issues deal with the problem areas and objectives to be accomplished.
- Action: Recommendations on how to better the situation will be made after studying best practises in developed nations.
- Performance: The performance assessment is done to justify the actions.

Researchers have used SAP-LAP analysis, as discussed above, to understand the learning experience of leading countries in the OE sector in the world. As discussed above, the researchers have reviewed 11 leading countries. The UK and France have been considered for SAP-LAP analysis as these countries represent about 65% of the global OE capacity. The following 11 barriers have been identified from the literature,

1. Lack of long-term visibility and dedicated Ocean Energy policy
2. High installation cost
3. Lack of financing mechanism
4. Inadequate Market incentives
5. Grid connection
6. Supply chain bottleneck
7. Lack of accurate data on OE potential sites (delay in Site Selection)
8. Lack of research and development (R&D) capabilities
9. Lack of experienced professionals

10. Public awareness and information barriers
11. Environmental barriers

In SAP-LAP analysis, these barriers have been considered as situations. Further steps such as actor, process, learning, action, and performance have been analyzed with each barrier with the help of a literature review. This analysis has 66 points that have been discussed, and this tool has helped in understanding the nuts and bolts of the successful implementation of OE policy in the UK and France.

4.7.4 Research Objectives 3

The methodology for choosing the policy framework of the leading countries was based on the following: policy implementation, deployment of OE-based installed capacity after policy implementation, and at what cost can India afford it?

In the Indian context, policymakers expect rapid growth and self-sufficiency in the sector in focus(MoES, 2021). Therefore, w.r.t. the development of OE, India should meet the policymakers' requirements. After comparing UK and France policy frameworks, it is observed that the UK's Framework is more aligned toward fast and rapid development. In contrast, the French framework has an orientation towards self-sufficiency. Therefore, the researchers have used a mixed approach for developing a proposed framework for the OE development in India. A mixed approach in this context means a mix of learnings from two leading countries, France and the UK. UK experiences tell the short term strategy while French experience is towards long term strategy. Similarly, this has proved the theoretical premise that the natural resource policy is also equally important. Moreover, it has also been proven that policy helps develop natural resources and ensures their efficient and effective utilization.

This study has brought all possible factors that could help harness OE energy in India. First, in RO1, an attempt was made to understand the variables identified based on the literature survey of select countries. Next, a questionnaire survey was conducted consisting of these variables. Then, the factors responsible were identified and validated.

In the next step in RO2, a SAP-LAP study was conducted to compare the contrast approaches taken by world powerhouses like the United Kingdom and France to foster the development of their OE industries so that lesson can be taken in the Indian context. Using SAP-LAP analysis, a linkage framework was developed in the Indian context.

Based on SAP-LAP analysis (of RO2) and e-IRP method, important actors and actions have been ranked concerning processes and performance. Therefore, the RO3 is a two-pronged approach. Part 1 discusses the results of efficient Interpretive Ranking Process (e-IRP) analysis, and part 2 presents the suggestive framework for OTEC policy in India.

During the research, it was realized that the government agencies and researchers had developed a various frameworks for RE development related to regulatory, operation, REC etc. (MNRE, 2021b; Reddy & Singh, 2020; Tarai & Kale, 2018)

Based on this experience, the researchers wanted to develop a holistic linkage framework (Waheed et al., 2009) that brings together analytical and intuitive approaches to systems by undertaking the actions linked with the performance.

The purpose of the Use of the SAP-LAP framework is to develop a specific model for OE development by using critical questioning and metric-based tools, which will be further taken as a learning process.

SAP-LAP framework provides the learning lessons supported by the case analysis. In this study, the objective is to develop a linkage framework to develop Ocean energy in India

We considered the factors from the factor analysis as the situation and proposed process, expected learning, proposed action and expected performance mapped for the Indian context.

The proposed linkage framework was validated by eight (8) experts and prioritised the actor, process, action and performances in the linkage framework. Based on this, the study conceptualizes a three-stage analysis framework to develop Ocean energy in India. This framework consists of essential factors responsible for OE development in the country, identifying important actors, analyzing actions to be taken for the OE development and suggesting processes for the effective implementations of the actions/decision taken by the policymakers and stakeholders. Von der Fehr and Millan (2001) suggest that the objective of the Governments in power sector development is to provide electricity to the country's people in a sustainable manner. Similarly, the objectives will remain the same in this case also. This framework is an outcome of intense research which involves a review of global OE policies, identification of essential factors for OTEC development in India, and analysis of best practices for OE development through SAP-LAP and e-IRP analysis. The framework for OE development in India divides the critical factors responsible for OE development into three levels setting up policy and institutional framework, developing a support system, and creating an enabling environment. Each level recommended the interventions in the form of actors, actions and processes.

Experts were again requested to review the results, which resonated with the study's research findings as per Yin (2003). Further, Triangulation has been attempted to enhance the quality of the study. For this purpose, the findings were vetted by experts from diverse backgrounds using an interview protocol. This step also aims to ensure the result's reliability (Yin, 2003).

The following steps were taken under the E-IRP method

- Identification of actions as ranking variables (alternatives) and process as reference variable (criterion). There are six (6) alternative and seventeen (17) reference variables.
- Defining the influence and impact of the process variable and establishing the contextual relationship between the alternative and criterion variable.
- In view of step 2, the binary and interpretive entries in the cross-interaction matrix were completed.
- Preparing dominance interaction matrix for each criterion variable and comparing alternative and reference variables.
- Analysis of the binary cross-interaction matrix, contrasting options i and j:
    - The possible mixture is: two criteria, one positive and one negative. If the interaction matrix includes an entry for 'i' with a value of '1' and a '0' for 'j,' then the i-j cell of interest should contain a value of '1'. In the case of a negative '0' input, the comparison of the implied dominance of i over j will take precedence.
    - In the appropriate dominant interaction matrix, considering the implication of "i" not being dominant over "j," enter "0" into the "i-j" cell, and repeat the process if required.
    - The interpretive matrix should be checked if both cell 'i' and 'j' are 1. In the appropriate dominant interaction matrix, the 'i-j' cell should be set to 0 if its meaning is the same as the 'i' cell. However, go to the following step if the values in cells i and j do not match..
- Experts should be consulted in the event that both the "i" and "j" columns contain a single item with separate meanings; in this case, a "1" should be entered into either the "i-j" or "j-i" cell, as illustrated in the exhibits.
- If more than two cells contain "1" values for criteria (such as "i," "j," and "k") that have different interpretations. After contrasting how I is interpreted with "j," evaluate how "j" works in tandem with "k." Given

that "i-j" and "j-k" are the two most important pairs of interactions, we must give "I" precedence over "k" and enter "1" into the "i-k" cell of the dominating interaction matrix..

- Carry out the same steps for each criterion's interpretative and transitive meanings. In general, there has to be (n X(n-1)/2). Combined data from every possible entry type in the dominant interaction matrix at hand. It is necessary to repeat the procedure for each additional criterion.
- Make the encompassing dominance matrix [D] by summing together the individual dominant interaction matrices [Di] according to Eq (1).

$$\boldsymbol{D} = \sum_{i} \boldsymbol{D}_{i} \qquad \textbf{Equation 1}$$

- The weighted sum of the dominating interaction matrices may be computed if there are weights (wi) associated with the different criteria (Sushil, 2017a) using Eq (2).

- $D = \sum_{i} w_i D_i$ Equation 2

- Finish the rankings by calculating the net dominance of each criterion.
- Compute the total number and percentage of each form of paired comparison. Noticeably, this procedure could transform the IRP to be more effective by dramatically lowering the proportion of interpretative comparisons.
    - There would be no undeclared dominance or subordination if the cross-interaction matrix was an identity matrix. If there is agreement on an interpretation, non-dominant connections may be implied. In this context, most forms of comparison would be interpretative and transitive.

CHAPTER 5 – ANALYSIS & DISCUSSION OF POLICY FACTORS FOR OE DEVELOPMENT

5.1 Results and Analysis

There will be three chapters (Chapters 5, 6, and 7) devoted to the examination and discussion of the obtained data. Data analysis for achieving objective(RO1) 1 is covered in Chapter 5.. This chapter aims to answer the questions of significant factors for ocean energy development in India. In this chapter, we examine the ranking of variables, factor analysis, and logistic regression analysis of the data obtained from the sample of RE stakeholders interested in RE development in India in order to find critical determinants for OE development in India. This chapter is discussed with the following points,

- Ranking of the Variables
- Grouping of Variables in Different Factors

5.2 Ranking of the Variables

Table 5-1 below illustrates the ranking of the variables contributing to India's OE development. These variables ranked based on the weighted average response of the stakeholders who showed keen interest in exploiting the RE potential in India. The purpose of ranking the variables was to highlight the important variables that needed to be tackled on a priority basis; however, it did not mean the low-ranking variables were not important for OE development. In this regard, grid connectivity from the OE project to the onshore transmission line, long-term policy continuity, provision of an attractive interest rate for capital, precise technical information about potential OE sites, GBI, and R&D support for the production of components of equipment domestically in the country have been identified as the top-six variables that need immediate attention while creating policies.

Table 5-1 Ranking of the Variables Contributing to OE Development in India

Variable	Scale					N	TCS	%	WMS	Rank
	1	2	3	4	5					
R&D support for the production of components of equipment domestically in the country	0	4	47	169	104	324	1345	5.0%	4.15	6
Precise technical information about potential OE sites	0	0	67	126	131	324	1360	5.1%	4.20	4
Developers' skill development for large-scale project execution	4	10	48	174	88	324	1304	4.8%	4.02	10
R&D organizations' focus on OE innovation and technological advancements	0	4	68	145	107	324	1327	4.9%	4.10	8
Development of the ancillary supply chain	7	18	42	179	78	324	1275	4.7%	3.94	13
RPO/REC legal compliance	8	15	48	144	109	324	1303	4.8%	4.02	11
Grid connectivity from OE projects to an onshore transmission line	0	4	20	124	176	324	1444	5.4%	4.46	1
Long-term policy continuity	6	5	30	136	147	324	1385	5.1%	4.27	2
FIT	9	5	76	171	63	324	1246	4.6%	3.85	15
GBI	0	9	34	173	108	324	1352	5.0%	4.17	5
Cost of capital reduction through OE fund creation	0	33	74	160	57	324	1213	4.5%	3.74	17
Exemption from interest payments in the initial phase of the project (for first five years)	0	33	100	99	92	324	1222	4.5%	3.77	16
Declaring OE as a "priority sector"	0	44	91	141	48	324	1165	4.3%	3.60	20
Provision of attractive interest rates for capital	0	0	57	136	131	324	1370	5.1%	4.23	3
Flexibility in tariff calculation in alignment with technical factors	4	29	88	154	49	324	1187	4.4%	3.66	18
Financial support through incentives	4	5	34	193	88	324	1328	4.9%	4.10	7
AD	0	10	75	171	68	324	1269	4.7%	3.92	14
HR training and skill development	19	74	98	109	24	324	1017	3.8%	3.14	21
Developing local manufacturing capability for main equipment	0	33	31	149	111	324	1310	4.9%	4.04	9
One-stop shop clearance	36	10	57	150	71	324	1182	4.4%	3.65	19
Readiness of skilled contractors	3	12	57	167	85	324	1291	4.8%	3.98	12

5.3 Factor Analysis

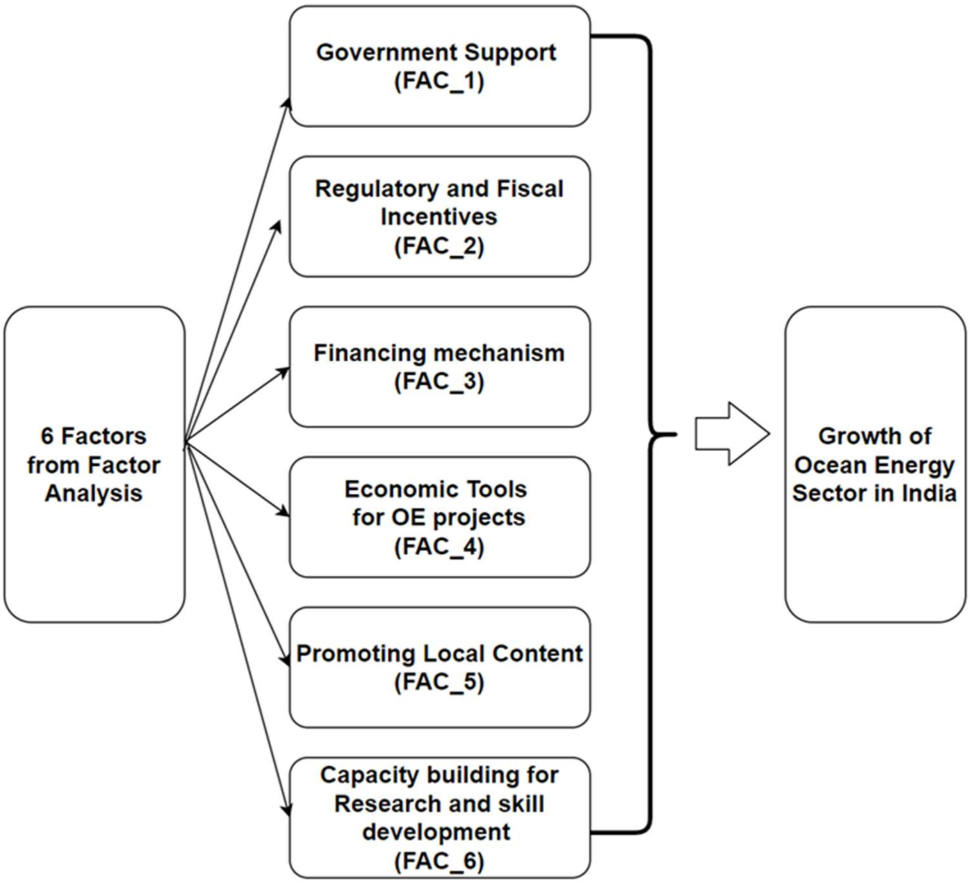


Figure 5-1 Factors to Promote Ocean Energy in India

5.4 Grouping of Variables in Different Factors

Figure 5-1 depicts the factors derived from the statistical analysis. The grouping of variables in different factors is explained below.

5.4.1 Government Support (FAC_1)

The variables one-stop-shop clearance and grid connectivity from OE projects to an onshore transmission line are grouped into this factor. This factor is unique in the Indian context, which indicates the need for local content support at the entire value chain of OE projects.

5.4.2 Regulatory and Fiscal Incentives (FAC_2)

The variables such as RPO/REC legal compliance, GBI, FIT, and long-term policy continuity are grouped in this factor.

The variables of this factor are important in the literature for the development of OE in different countries. Similarly, the stakeholders interested in the promotion of RE in India have also given due importance to these variables (as per Table 4-3).

5.4.3 Financing Mechanism (FAC_3)

The variables including cost of capital reduction through OE fund creation, exemption from interest payments in the initial phase of the project (for the first five years), declaring OE as a “priority sector, and provision of attractive interest rates for capital have been grouped. The variables of this factor indicate the need for a dedicated financing mechanism for OE development.

5.4.4 Economic Tools for OE Projects (FAC_4)

The variables such as flexibility in tariff calculation in alignment with technical factors, financial support through incentives, and AD are grouped in this factor. The variables in this factor are important to make this project economically viable.

5.4.5 Promoting Local Content (FAC_5)

The variables such as the development of the ancillary supply chain and development of local manufacturing capability for main equipment are grouped in this factor. This factor is unique in the Indian context, indicating the need for support of local content at the entire value chain of OE projects.

5.4.6 Capacity Building for Research and Skill Development (FAC_6)

The stakeholders keen to develop RE in the country have shown concern for the capacity building for research and skill development. Here, a support system means that ancillary units should develop OE in the country. Ancillary units are for components such as gearbox, pipes, undersea cables, etc.

The variables such as R&D support for the production of components of equipment domestically in the country, precise technical information about potential OE sites, developers' skill development for large-scale project execution, HR training and skill development, the readiness of skilled contractors, and R&D organizations' focus on OE innovation and technology advancement are grouped in this factor.

5.5 Summarized results of Factor Analysis

As discussed above, the factor analysis highlights government support (FAC_1), regulatory and fiscal incentives (FAC_2), financing mechanism (FAC_3), economic tools for OE projects (FAC_4), promoting local content (FAC_5), and capacity building for research and skill development (FAC_6) as the critical factors that are important in promoting OE development in India. The analysis of the rank of the variables and grouping of factors revealed that four out of the top ten rank variables were grouped in the factor called capability development for R&D, skill, and support system. This implies that the stakeholders are the most concerned about this factor, which means that the government should assign top priority to the factor related to developing enabling a nurturing environment for R&D and skill development in the country. Apart from this, the spread of the top ten-ranked variables has been seen in all the factors, which signifies the justification of the identified factors.

As evident from Table 8, among the variables in FAC_1, evacuation infrastructure has emerged as the most prominent enabler for OE development. The transmission cost for the evacuation of OE is almost twice (Dalton & Ó Gallachóir, 2010; Das, 2018; Swider et al., 2008) the normal cost of transmission of energy from conventional sources, and therefore, it acts as a constraint to OE development. Pertinently, there were similar concerns in the context of solar and wind energy as well. Given the low CUF of solar energy [around 19% during the initial phase of 2010 and currently around 25%], the effective transmission charge for evacuating solar energy turned out to be almost three to four times the transmission charge applicable for conventional generators, with a plant load factor (PLF) of 85%. India came up with a waiver scheme of inter-state transmission charges and losses to address this constraint, and this has helped the growth of wind and solar power significantly. Therefore, compared to wind and solar energy, the impact of transmission charges for OE is likely to be less. Consequently, it can be considered for socialization in line with the policy of wavering transmission charges and losses for wind and solar energy, at least for a pre-determined target capacity to start with.

The following important variable emerging out of the survey undertaken in this study is the continuity of policies on a long-term basis (FAC_2). Policy certainty and continuity are often considered an essential enablers for any new and emerging technology, especially for a capital-intensive technology like OE. Any policy support extended to OE should be announced upfront, ensuring investors that their costs would be recovered within at least ten years. For example, in the UK, the policy certainty for renewable obligation certificate (ROC) was announced in 2002, with a certainty of continuing the scheme for 15 years (Ofgem, 2017). India also needs a robust policy framework for OE, and there needs to be a certainty of its continuation for a longer time.

In terms of policy support, or for that matter, fiscal and financial support, the survey has highlighted the need for support mechanisms (FAC_1, FAC_2, FAC_3, and FAC_4) such as GBIs, priority sector lending benefits, interest payment moratorium, zero import duty, excise duty waiver, AD benefits, single-window clearance, and others. Therefore, it is prescribed that these measures be put together in the form of a policy document that guarantees continuity of the support mechanisms (fiscal, financial, and others) for at least ten years.

Alongside policy support, regulatory interventions are also highly desirable, as is evident from the survey results. Demand-side support in the form of renewable purchase obligation (RPO) (FAC_2), including renewable energy certificate (REC) as an instrument for the fulfilment of RPO, has played an important role in promoting the new and emerging RE technologies. There are many instances across the world where such regulatory interventions have been tried with adequate success. In India too, we have an RPO mechanism in place (Electricity Act, 2003). As a matter of policy, RPO support in the future should be extended only to the new and emerging technologies. Technologies for wind and solar energy have already matured and achieved grid parity in terms of cost and, therefore, do not require RPO support anymore. Policy prescription is to move from the "RPO for all RE" regime to "RPO for new and emerging RE technologies" such as OE.

The FIT mechanism (FAC_2) as supply-side support is an equally important part of the regulatory intervention. Based on estimated capital costs, a comparison has been made regarding COE of different RE technologies, pr It is evident that the per-unit levelised cost of OE is in the range of Rs.5/kWh. In contrast, the per-unit levelised cost of wind and solar is Rs.2.50–3/kWh. However, a balancing cost results in a range of Rs.3.50–4.04/kWh for the effective cost of wind and solar. Compared to this, the levelised cost of OE is still on the higher side. However, we must remember that at its inception during 2009–10, solar PV tariffs were approximately Rs.18/kWh (CERC, 2019a). With progressive policy and regulatory support, the investors started evincing interest in this matter. Consequently, the economies of scale led to a decline in the solar tariff from Rs.18/kWh to around Rs. 2–2.50/kWh. It is expected that proper policy and regulatory support will also bring in the desired economies of scale for OET, which, in turn, will lead to cost reduction and, eventually, grid parity for OET in the foreseeable future.

In addition, the survey has also highlighted factors (also discussed above) such as R&D facilities, accurate data on OE, facilitation of research institutions and capacity building, encouragement of expert EPC contractors as important facilitators (FAC_6), and the variables of FAC_5 that would be desirable for the growth of OE resources.

5.6 Logistic regression

An odds ratio's natural logarithm – logit – is a fundamental mathematical concept applicable to logistic regression. The 2-2 contingency table is a simple example of logistic regression. Logit drive can be explained with a simple example from a 2-2 contingency table (Peng et al., 2002). In this study, the distribution of a dichotomous outcome variable (growth of OE) is paired with categorical predictor independent variables (capacity building for research and skill development, regulatory and fiscal incentives, government support, financing mechanism, economic tools, and promoting local content). Study data are included in **Table 5-7** . A test of independence applied using chi-square produces an odds ratio of 92.53%, suggesting that the predictor variable is more likely to be recommended for OE growth.

In this study, quantitative methods such as factor analysis and logistic regression were used. The factor analysis aimed to understand the variables' core structure and categorize the variables into factors. The second method was utilized to understand the probability of the development of OE in India. For analysis, the researchers used SPSS V 22.0 software. The survey was conducted with 324 RE stakeholders in India. The study used a close-ended questionnaire with a 5-point Likert scale. About 21 variables identified from the literature survey were reduced to smaller related factors using factor analysis

Table 5-2 Scores of KMO and Bartlett test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin (KMO)	Measure of Sampling Adequacy.	.753
	Approx. Chi-Square	1802.695
Bartlett's Test of Sphericity	Df	210
	Sig.	.000

Both Kaiser-Meyer-Olkin (KMO) and Bartlett test of sphericity is necessary to proceed for factor analysis. The KMO test assesses the sampling adequacy, while the Bartlett test of sphericity measures the statistical significance of the association of variables used for factor analysis. In this study, the value of the KMO test is 0.753, as shown in Table 5-2, which is higher than 0.5 and qualifies for factor analysis because the KMO test recommends that the value of the tests should be more than 0.5 to prove the sample adequacy(Peng et al., 2002).

As can be shown in Table 5-2, the p value for the Bartlett test is significantly lower than.05. The results indicate that the null hypothesis is rejected, as there is a significant correlation between the variables. For this reason, factor analysis should be used (Peng et al., 2002). The percentage of variation explained by each factor (out of a total of 21) is shown in Table 5-3. Six factors accounted for over 60% of the total variance in the twenty-one variables. According to Table 5-3 , the first component accounts for 17.7% of the variance, the second for 13.9%, the third for 8.89%, the fourth for 8.04%, the fifth for 5.7%, and the sixth for 4.81%. The six components share the variance evenly thanks to the varimax rotation.

Table 5-4, shows that there is a substantial loading on only one component for each variable.

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Table 5-3 Six factors explain the total variance.

Total Variance Explained									
Component	**Initial Eigenvalues**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**
1	3.720	17.713	17.713	3.720	17.713	17.713	3.373	16.063	16.063
2	2.929	13.947	31.660	2.929	13.947	31.660	2.410	11.478	27.541
3	1.867	8.892	40.552	1.867	8.892	40.552	2.314	11.020	38.561
4	1.690	8.048	48.601	1.690	8.048	48.601	1.781	8.482	47.043
5	1.197	5.702	54.303	1.197	5.702	54.303	1.282	6.104	53.148
6	1.011	4.816	59.119	1.011	4.816	59.119	1.254	5.971	59.119
7	.971	4.622	63.740						
8	.864	4.113	67.854						
9	.802	3.817	71.671						
10	.760	3.618	75.289						
11	.709	3.378	78.667						
12	.669	3.186	81.853						
13	.593	2.824	84.677						
14	.536	2.553	87.230						
15	.500	2.380	89.610						
16	.471	2.245	91.855						
17	.446	2.124	93.978						
18	.360	1.714	95.692						
19	.335	1.595	97.287						
20	.305	1.454	98.741						
21	.264	1.259	100.000						

Extraction Method: Principal Component Analysis.

Table 5-4 Specifics of how certain elements depend on other variables

Variable	Rotated component matrix[a]					
	Component/factors					
	1	2	3	4	5	6
R&D support for the production of components of equipment domestically in the country.	0.771					
Precise technical information of potential OE sites	0.767					
Developers' skill development for large scale project execution	0.751					
HR training and skill development	0.663					
Readiness of skilled contractors	0.499					
R&D organizations focus on OE innovation and technology advancement	0.711					
RPO/REC Legal Compliance		0.648				
Feed-in Tariffs (FIT)		0.597				
Generation based Incentives (GBI)		0.558				
Long term policy continuity		0.527				
One-stop Shop clearance			0.770			
Grid connectivity from the OE project to the onshore transmission line			0.555			
Cost of capital reduction through OE fund creation				0.772		
Exemption from interest payment in the initial phase of the project (for the first five years)				0.763		
Declaring OE as "Priority sector."				0.551		
Providing an attractive rate of interest for capital				0.532		
Flexibility in tariff calculation aligned with technical factors					0.814	
Financial support through incentives					0.567	
Accelerated Depreciation (AD)					0.550	
Developing of ancillary supply chain						0.809
Developing local manufacturing capability for main equipment						0.551

The investigation revealed six variables summarised and labelled in Table 5-5.

Table 5-5 Table displaying the factors upon which each variable loads

Factor code	Factor name	Factor loadings of independent variables
(FAC_1)	Capacity building for research and skill development	R&D support for the production of components of equipment domestically in the country.
		Precise technical information of potential OE sites
		Developers' skill development for large scale project execution
		HR training and skill development
		Readiness of skilled contractors
		R&D organizations focus on OE innovation and technology advancement
(FAC_2)	Regulatory and Fiscal Incentives	RPO/REC Legal Compliance
		Feed-in Tariffs (FIT)
		Generation based Incentives (GBI)
		Long term policy continuity
(FAC_3)	Government Support	One-stop Shop clearance
		Grid connectivity from the OE project to an onshore transmission line
(FAC_4)	Financing mechanism	Cost of capital reduction through OE fund creation
		Exemption from interest payment in the initial phase of the project (for the first five years)
		Declaring OE as "Priority sector"
		Providing an attractive rate of interest for capital

Factor code	Factor name	Factor loadings of independent variables
(FAC_5)	Economic Tools	Flexibility in tariff calculation aligned with technical factors
		Financial support through incentives
		Accelerated Depreciation (AD)
(FAC_6)	Promoting Local Content	Developing of ancillary supply chain
		Developing local manufacturing capability for main equipment

Analysis of the correlation between independent and dependent variables is the goal of logistic regression.. Dependent and independent variables are dichotomous and the metric or categorical, respectively. The growth of OE is the dependent variable (DV), and the six factors that emerged from the factor analysis are the independent variables in this study.

As shown in Table 5-6 the regression model in the study has considered all the inputs; thus, there is no missing case. Table 5-7 presents a model with no predictors, the first model in the output, and a null model. In the 'Variables in the equation' table, the constant gives the unconditional log chances of development (i.e., growth = 1).

Table 5-6 Summary of the processing of the case, which has no blanks

Case processing summary			
Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	324	100.0
	Missing Cases	0	.0
	Total	324	100.0
Unselected Cases		0	.0
Total		324	100.0
Dependent variable encoding			
Original		**Internal value**	
No growth		0	

Growth	1

a. To find out how many examples there are while considering weight, see the key..

Table 5-7 Null model with no predictors

Block 0: Beginning Block

Classification Table[a,b]

	Observed		Predicted		
			growth of ocean energy in India (dependent)		**Percentage Correct**
			0	**1**	
	Growth of ocean energy in	0	0	28	.0
Step 0	India (dependent)	1	0	296	100.0
	Overall Percentage				91.4

Variables in the equation

	B	SE Wald	df	Sig	Exp(B)
Step 0 Constant	2.358	.198 142.249	1	.000	10.571

a. Constant is included in the model.

b. The cut value is .500

The -2 Log-likelihood, the Cox and Snell R-squared, and the Nagelkerke R-squared tests are also summarised. Nagelkerke's R^2 of 0.891 demonstrated a robust correlation between the two processes.The results of the Lagrange multiplier test are shown in Table 5-8**.** The model fits significantly with predictors, as indicated by a chi-square value of 9.978 and a p-value of less than 0.0005. It also briefly summarises the -2 Log-likelihood, Cox and Snell, and Nagelkerke R Square tests' findings. Nagelkerke's R2 of 0.891 demonstrated a robust correlation between the two processes.

Table 5-10 indicate The estimated change in model fit resulting from the addition of the variables is indicated in the score column in the table.

The other two columns, degrees of freedom and 'p values,' present the estimated change for the model. Factors 1 and 3, as given in Table 5-9, are expected to significantly improve the model fit.

Table 5-9 Factors 1 and 3 have a significant role in the expansion of OE.

Variables not in the equation					
			Score	**df**	**Sig.**
Step 0	Variables	Factor 1: Capacity building for research and skill development	4.579	1	.032
		Factor 2: Regulatory and Fiscal Incentives	.013	1	.910
		Factor 3: Government Support	3.889	1	.049
		Factor 4: Financing mechanism	.803	1	.370
		Factor 5: Economic Tools	.300	1	.584
		Factor 6: Promoting Local Content	.601	1	.438
	Overall Statistics		10.184	6	.117

The outcomes of these omnibus examinations are summarised in Table **5-10**. The model fits significantly with predictors, as indicated by a chi-square value of 9.978 and a p-value of less than 0.0005. It also briefly summarises the -2 Log-likelihood, Cox and Snell, and Nagelkerke R Square tests' findings. Nagelkerke's R2 of 0.891 demonstrated a robust correlation between the two processes.

Table 5-10 When compared to a model using simply constants, the addition of predictors has a considerable effect

Block 1: Method

Omnibus Tests of Model Coefficients				
		Chi-square	Df	Sig.
Step 1	Step	9.978	6	000
	Block	9.978	6	000
	Model	9.978	6	000

Model Summary			
Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square

1	180.648[a]	.030	.068

Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	6.889	8	.549

a. Estimation ended at iteration number six because parameter estimates shifted by less than .001 at each iteration.

Hosmer and Lemeshow examine the null hypothesis that the observed values fit perfectly with the model. In order to calculate the chi-square results, the observed and expected frequencies are compared. The results show that the chi-square statistic is not significant, indicating that the data adequately explain the model.very well.

Table **5-11** explains "the cut value" for the "yes" category (see column 1 as "yes" and column "0" as "No" category of responses in the table) is 100%. This implies that the RE stakeholders believe in the growth of OE in India. Similarly, the percentage accuracy in classification (PAC) in this study is 91.4% by adding the independent variables (see the "Percentage Correct" column in the "1" row of the observed categories à specificity). Therefore, about 100% of participants who had an interest in RE development were also predicted by the model to have considered the growth of OE development in India, which comes under sensitivity. On the other hand, the specificity of participants is 0% in this study (see the "Percentage Correct" column in the "0" row of the observed categories à specificity). Therefore, the positive predictive value is also 91.4%, which means that 91.4% correctly predicted that the growth of OE development in India is possible, whereas the negative predictive value is zero.

Table 5-11 Classification table with 'b' coefficients listed below.

Classification Table[a]

Observed		Predicted		
		growth of ocean energy in India(dependent)		Percentage Correct
		.00	1.00	
Step 1	.00	0	28	.0

growth of ocean energy in India(dependent)	1.00	0	296	100.0
Overall Percentage				91.4

A binary logistic regression analysis was conducted to determine whether all the factors derived through Factor Analysis predict the growth of ocean energy in India (Table 5-12). The result of interest was India's increased use of ocean energy. Possible variables included capacity building for research and skill development, regulatory and fiscal incentives, government support, financing mechanisms, economic instruments, and local content promotion. The Hosmer-Lemeshow goodness of fit was not statistically significant ($p=0.549>0.05$), indicating that the model was specified accurately. Moreover, the -2 log-likelihood equals 180,648, and the Nagelkerke R^2 equals 068. The model determined that the IVs (regulatory and fiscal incentives, financing mechanism, economic instruments, and promoting local content) are insignificant ($p>0.05$). Nonetheless, the IVs (capacity building for research and talent development) and government support were substantial.

Controlling for local content promotion, economic tools, financing mechanisms, capacity building for research and skill development, government support, regulatory, fiscal incentives, and the predictor variable [government support] contributed to the model in the logistic regression analysis. The undersized B = (.399)], SE=(.199) Wald =(4.017), and $p<0.05$. The estimated odds ratio favoured an increase of nearly 49% (Exp[B] = [1.49], 95% CI [1.009, 2.201]) for every one-unit increase of government support.

Table 5-12 Variables in the Equation

		B	SE.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
								Lower	Upper
Step 1[b]	Capacity building for Research and skill development	.394	.184	4.585	1	.032	1.482	1.034	2.125
	Regulatory and Fiscal Incentives	.011	.209	.003	1	.958	1.011	.671	1.522
	Government Support	.399	.199	4.017	1	.045	1.490	1.009	2.201
	Financing mechanism	.184	.198	.869	1	.351	1.202	.816	1.771
	Economic Tools	.101	.199	.259	1	.611	1.107	.749	1.636
	Promoting Local Content	.180	.205	.770	1	.380	1.197	.801	1.787
	Constant	2.518	.225	124.872	1	.000	12.401		

[a]. The cut value is .500

[b]. Variable(s) entered in step 1:

-2 Log likelihood = 180.648; omnibus tests of model coefficients ($x^2 = 9.978$, df = 6, and P = 0.000); Hosmer and Lemeshow test ($x^2 = 6.889$, df = 8, and P = 0.549); pseudo R^2 = 6.8%; and overall percentage of growth of ocean energy in India is 91%.

Source: Field survey, 2021.

The B weights represent the combination of explanatory variables that best predicts the log probabilities. The inverse of the logarithmic function is the exponential function, also known as antilogarithm. Therefore, exponential log odds convert log odds back into odds. The odds ratio (p) is another name for log odds. Thus, the probability ratio is as follows::

Odd ratio (p) = odds / (1 + odds) (Steve Strand, Stuart Cadwallader, 2013)

Exp (2.518) = 12.401 / (1+ 12.401) = 92.53 %

Thus, the odds of success of OE development are around 92.53%.

Capacity building for research and skill development (FAC_1), regulatory and fiscal incentives (FAC_2), government support (FAC_3), financing mechanism (FAC_4), economic tools (FAC_5), and promoting local content (FAC_6) are the resultant factors. The purpose of using the logistic regression coefficient is to know the role of the independent variable in determining the dependent variable(OE sector growth).

The Indian OE sector growth derived from the logistic regression equation is as follows:

Log(p/(1-p)) = 2.518+ 0.394*F1+ 0.011*F2 + 0.399*F3 + 0.184*F4 + 0.101*F5 + 0.180*F6

The Indian OE sector growth probability is as follows:

e^(2.518+ 0.394*F1 + 0.011*F2 + 0.399*F3 + 0.184*F4 + 0.101*F5 + 0.180*F6)

= --

1 + e^(2.518+ 0.294*F1 + 0.011*F2 + 0.399*F3 + 0.184*F4 + 0.101*F5 + 0.180*F6)

The independent factors such as capacity building for research and skill development (FAC_1), regulatory and fiscal incentives (FAC_2), government support (FAC_3), financing mechanism (FAC_4), economic tools (FAC_5), and promoting local content (FAC_6) show the comparative importance of numerous factors in the expansion of India's OE sector. This was tested with a logistic regression tool considering the independent factors identified as predictors and the growth of OE in India as a dependent variable.

5.7 Concluding remarks

This chapter has not only answered the first research question but also provided key policy factors and prioritized them to help the policymakers in decision-making. Further, these doctors are used to develop a linkage framework for OE development in India. Finally, these factors are taken as situations in the SAP-LAP framework analysis in Chapter 7. The objective of this is to visualize the linkage framework of each one of the factors identified in terms of actors and processes.

CHAPTER 6 – MAPPING THE LEARNING EXPERIENCE OF FRANCE AND THE UK IN OCEAN ENERGY DEVELOPMENT: A SAP-LAP ANALYSIS

This chapter aimed to review and analyze the OE policies of leading countries, i.e., the UK and France, to understand the best practices to be treated as a learning experience for a proposed policy framework for OE development in India. SAP-LAP analysis tool is used for the study purpose. As discussed in the LR chapter, barriers have been considered as situations. Further steps such as actor, process, learning, action, and performance are analyzed with each barrier with the help of a literature review. This analysis has 66 points that are discussed, and this tool has helped us understand the nuts and bolts of the successful implementation of OE policy in the UK and France.

The following barriers are identified in CHAPTER 2 - LITERATURE REVIEW by reviewing various policy documents and reports of 11 countries.

- High installation cost
- Lack of financing mechanism
- Inadequate Market incentives
- Lack of long-term visibility and dedicated Ocean Energy policy
- Grid connection
- Supply chain bottleneck
- Lack of accurate data on OE potential sites (delay in Site Selection)
- Lack of research and development (R&D) capabilities
- Lack of experienced professionals
- Public awareness and information barriers
- Environmental barriers

The following section discusses how these barriers were addressed for OE development in the UK and France.

6.1 Lack of long-term visibility and dedicated Ocean Energy policy

With the review of OE polices of eleven countries, it is found out that Government of these countries lack long-term vision as well as commitment for its implementation. Hence, the study has taken the barrier as a situation to understand how leading countries France and the UK have tried to deal with it. A case study tool Sap-LAP analysis helped us in understanding two successful cases of OE implementation in France and the UK.

6.1.1 SAP LAP analysis of the UK

UK policy such as National Renewable Energy Action Plan (NREAP), Section 36 of the Electricity Act 1989, UK Renewable Energy Roadmap of UK ensured OE policy focus and continuity through policy tools such as introduction of the UK ocean energy road map, setting up the targets for the OE development, the introduction of a sunset clause, detailed resource assessment, Incentives for 25 years, etc., are the specific measures under the policy and implemented by a dedicated institution the Department of Energy & Climate Change (DECC) for the policy implementation purpose(Chakraborty, Dwivedi, Gupta, et al., 2021; Chowdhury et al., 2020).

These features helped this sector to grow, gave assurance of support to the investor, reduced the risk of future cash flow, and benefits continuation, reducing uncertainty in several European countries, including the UK.

Through these policy measures, the Government of the UK attracted companies to enter the OE equipment manufacturing and supply chain. In addition, the policies motivated the investors to invest in the entire value chain of OE. However, essential and critical facilities such as port and equipment assembly require heavy investment. Therefore, the suppliers need consistent policy and government support to leverage the business opportunities and return on investment. This will further attract more suppliers, as a result, will increase competition and drive down the cost.

6.1.2 SAP LAP analysis in France

Government of France set up Environment and Energy Management Agency (ADEME) as an actor to implement various policies and decisions to develop the OE in the country.

Governments of France implemented policies and plans as processes such as the National Renewable Energy Action Plan (NREAP), Section 36 of the Electricity Act 1989, Integrated National Energy And Climate Plan, Article 20 of the ordinance n° 2016–2017 (Chowdhury et al., 2020). Introduction of NREAP, setting up the targets for the OE development, detailed resource assessment, Incentives for 20 years, etc., are the specific measures taken by ADEME.

The French Government attracted companies to enter the OE equipment manufacturing supply chain through these policy measures, providing the certainty needed to invest in the entire value chain of OE.

ADEME was established in 1992 by the Government of France to assist in effectively implementing policies introduced by the Government to promote new energy sources. It also provides financial support to the projects aligned with its plan. Furthermore, ADEME provides advisory services to the decision-making bodies in the country. It develops tools and methods suitable for the stakeholders' requirements. ADEME is a pool of expert advisors that significantly supports developing these projects.

Based on these policy measures, France target to generate 6 GW of OE by 2030(IEA-OES, 2019).

The SAP-LAP matrix of UK and France of Situation 1 is summarised below.

6.2 High installation cost

Various researchers have discussed the high installation cost of OE projects as a major barrier to OE development. Similarly, the various stakeholders interested in the RE development of India have suggested the initial cost as an important challenge in the development of OE in the country in the survey conducted by the researchers of this study. Thus, the high installation cost is taken to carry out SAP-LAP analysis of leading UK and French countries. This analysis aims to know the strategies these countries adopted to tackle the problem of high capital costs.

6.2.1 SAP LAP analysis of the UK

Governments of the UK implemented processes such as the National Renewable Energy Action Plan (NREAP), Section 36 of the Electricity Act 1989, UK Renewable Energy Roadmap (Chowdhury et al., 2020). These policies developed capacity augmentation, backward integration, and industry collaboration processes. For this purpose, institutions were set up, such as the UK Research Institute (UKRI) and Offshore Renewable Energy Hub(ORE), in 2011. The purpose of UKRI and ORE was to capacity augmentation, creating dedicated space in the shipyard for OE assembly and interfacing with multiple agencies, respectively.

The following processes/ measures were undertaken to promote OE in UK.

- Ocean energy road map.
- Setting up the targets.
- Introduction of the sunset clause.

As a result of the creation of policies, institutional setup and processes, all these measures have helped reduce the upfront installation cost, contributing to better cash flow management of the investors.

Actions such as introducing specific OE development plans, creating a dedicated area in a shipyard for OE assembly, and interfacing with multiple agencies have helped reduce the cost to \$ 111 / MWh compared to the global benchmark of \$ 150 / MWh. This has also resulted in rapid capacity addition, reduced cost, and value-added products leveraging the value-added by-products such as drinking water, HVAC etc.

6.2.2 SAP LAP analysis in France

Compared to the UK, French Government has not implemented any policy measures to reduce the high installation cost. Rather, the French Government has focused on economies of large scale, which means that the Government has relied more on setting up larger installation capacities for a single project. The largest OE project in France is observed to be 220 MW (Chowdhury et al., 2020).

The French Government relied more on sound economic principles than on providing support to develop the industry. Instead, the Government focused on providing enabling support to develop the sector, which will be discussed in the following situation analysis.

As per Article 4 of the European Union Directive 2009/28/EC, the Government of France implemented processes such as the National action plan to promote renewable energies and the Energy Transition for Green Growth Act of 2015. These policies developed procedures for capacity augmentation, backward integration, and industry collaboration. For this purpose, the Environment and Energy Management Agency (ADEME), in collaboration with the French Ministry for Environment, Energy and the Sea, **Public Investment Bank (BPI), and National Research Agency (ANR),** set up a public agency. These institutes aimed to support stakeholders with a keen interest in OE development and policymakers with analysis, information, and financial support, including research, development, and demonstration of OETs.

Introduction of France's ocean energy road map, setting up the targets for the OE development, etc., are the specific measures ADEME took for policy implementation. In addition, the steps such as minimum local content requirements, incentivizing the contract awards, criteria to provide subsidies, etc., make this sector attractive for the stakeholders. These measures have resulted in manufacturing equipment locally and, in turn, supported the cost reduction.

As a result of the creation of policies, institutional setup, and processes, all these measures have helped reduce the upfront installation cost, contributing to better investors’ cash flow management.

All these policy institutional and implementation measures have helped reduce the cost to 0.15 c EUR/kWh.

6.3 Lack of financing mechanism

Various researchers (Dalton & Ó Gallachóir, 2010; Das, 2018; Green & Vasilakos, 2011; Heptonstall et al., 2012; Levitt et al., 2011; Marczyk & DeMatteo, 2010; Pillai & Banerjee, 2009; Prässler & Schaechtele, 2012; Schmid, 2012; Srinivasan et al., 2010; Swider et al., 2008) have observed that lack of financing mechanism to be one of the major barriers to the OE development. Similarly, the various stakeholders interested in the RE development of India have suggested financing mechanisms as an important challenge in the development of OE in the country in the survey conducted by the researchers of this study. Thus, the lack of financing mechanism is a situation to carry out SAP-LAP analysis of leading countries, the UK and France. This analysis aims to know the strategies these countries adopted to tackle the situation.

Here, the financing mechanism refers to incentives like zero import duty, excise duty waiver, customs duty waiver, and tax-related instruments for setting up OE projects available for other conventional RETs. Non-availability of these financing mechanisms resulted in high-risk perception by financial institutions, and thereby, OE projects are financed at a high interest rate. To tackle the situation, measures taken by the governments of the respective countries in dealing with these situations are described below,

6.3.1 SAP LAP analysis of the UK

In this situation, the government played a crucial role in removing challenges to support finance for OE projects. With the help of institutional set up like Green Investment Bank (GIB), the Government of the UK has created a fund to finance OE projects. GIB was created in 2012, the UK government is the only stakeholder in this bank, and this bank was set up to invest in offshore, waste and bioenergy projects. GIB has supported the financing of the OE projects in two ways 1) to support the projects in the pipeline and 2) to support the operational projects by financing the projects and providing liquidity to the developers to invest in new OE projects.

Further, GIB established its subsidiary, UK Green Investment Bank Financial Services Limited; this subsidiary aims to attract capital investment for the UK's OE sector. This is the first kind of set-up in the world to set up OE projects. This subsidiary also enabled the developers to reduce the finance cost by reducing their stakes. This will further help the developers to invest in new projects. In addition, the UK government has set up financing institutions to bridge the financing needs by creating OE funds and government-backed financial institutes to finance OE projects. GIB has invested €8.2bn in 8 OE projects in the UK with an expected capacity of 2.9 GW.

6.3.2 SAP LAP analysis in France

In this situation, the government was crucial in removing the barriers to OE projects' finance. With the help of an institutional setup like the **Public Investment Bank (BPI)**, the Government of France has created a fund to finance OE projects. In addition, ADEME, the financing arm in France, introduced measures such as zero-interest rate loans, higher loan volumes, and a new range of funds to support the energy transition.

Following are the learnings, 1) Create OE Fund to finance OE projects, 2) creation of government-backed financial institutes to finance OE projects, and 3) securing public funding. These have enabled the developers to reduce the finance cost by getting finance at a lower interest rate.

As a result of all these initiatives to innovate and support R&D, ANR and the government body for innovative research and development set up "Institutes for the Energy Transition" dedicated to OE projects inducing around €10 million of leveraged financing.

6.4 Inadequate Market incentives

Inadequate market incentives comprise inadequate fiscal incentives and insufficient government grants and subsidies. The measures taken by the governments of the respective countries in dealing with these situations are described below,

6.4.1 SAP LAP analysis of the UK

The UK policymakers have been classifying RE technologies according to their economic feasibility. In place of the ROC auction system, which had previously applied to OE technology, a new system called Contract for Difference (CfD) auctions were implemented. The market incentive mechanism for the deployment of new RE producing capabilities shifted from the ROC to the CfD between 2014 and 2017. All three strategies were available to investors over the three years. In 2019, the OE project strike price was established at £305/MWh(DECC, 2013). The UK Government has recognised OE as one of the most promising new technologies by setting its strike price at the top of Figure 6-1.

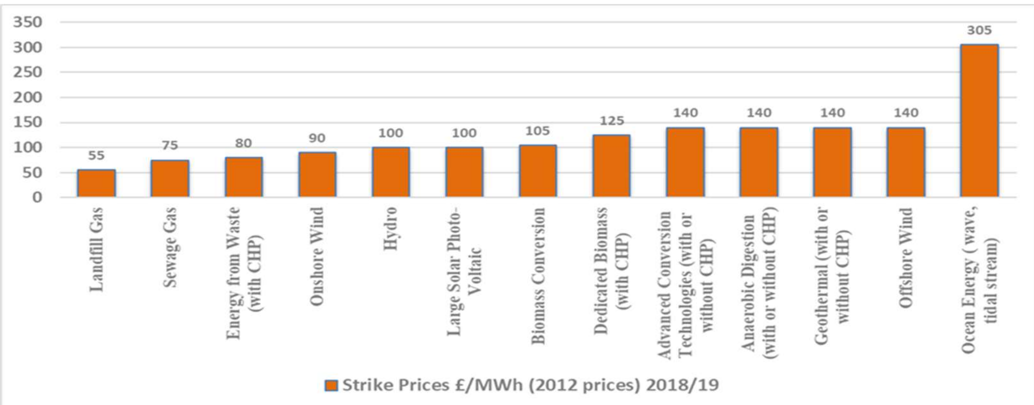

Figure 6-1 Renewable Energy Strike Price comparison
(DECC, 2013)

Table 6-1 : Levelised cost comparison of various RETs in the UK

Technology	Capital Cost / MW			
	MIN	MAX	FIT ($ /MWh)	Remarks
Offshore Wind	1,610,000	3,990,000	154.7	First 10 years
TIDAL	1,400,000	3,000,000	178.5	20 years
Wave	1,400,000	3,000,000	178.5	20 years
OTEC	1,400,000	3,000,000	178.5	20 years

Policymakers have incentivised new technologies by assigning them greater strike prices than other technologies in the same category, as seen in Table 6-1. Conversely, the UK Government has chosen to progressively lower the strike price as the technology's capacity increases.

The initial commercialization of maritime energy arrays and the scaling up of devices is supported by a £18 million fund, which is one example of the non-market incentives (EOEA, 2020). There are two categories of accelerated depreciation rates that have been planned for: regular and premium. In contrast to the standard rate of 18% applied to depreciating equipment and machinery, a special rate of 8% is applied to assets such as building amenities and other long-lived investments. The first year's capital type R&D investment has been provided as an R&D allowance, on top of the other non-market incentives outlined. Similarly, in the first year, businesses could deduct 100% of the cost of capital expenditures made on energy and water efficiency solutions(KPMG, 2015).

6.4.2 SAP LAP analysis in France

France has implemented market and non-market incentives to tackle the situation. The principal market incentive for OETs is 0.15 c EUR/kWh under the FIT mechanism(NREAP, 2011).

(Uihlein & Magagna, 2016) report that the FIT ($205/MWh) and reimbursable loans have helped fund two projects. The two high-energy tidal zones are chosen based on their cost per megawatt-hour (MWh) (Dincer, 2000). Higher FITs are assigned to OETs as a market incentive, as seen in Table 6-2. While this incentive is in place for the first ten years of offshore wind (the nearest developing technology), it is in place for the first twenty years of OETs.

Table 6-2 Emerging technologies Feed-in-Tariff comparison

(Ministère de l'Ecologie, 2010)

Technology	FIT (c EUR/kWh)	Remarks
Offshore Wind	13	For the first ten years. Between 3 – 13 for the next ten years, depending on site.
TIDAL	15	20 years
Wave	15	20 years
OTEC	15	20 years

In France the development and installation of RETs have been promoted through various policy incentives and schemes. Accelerated depreciation, tax credit, capital subsidy, grant rebate etc., are some of the important and popular measures for promoting RE in the country (KPMG, 2015).

6.5 Grid connection

Dalton and Ó Gallachóir(2010) and Swider et al.,(2008) mentioned that higher level of grid connectivity costs offshore energy projects is a critical barrier to OE. They mentioned that Grid connections comprise of grid planning, grid permitting, and grid operation. The measures taken by the Government of the respective countries in dealing with these situations are described as below,

6.5.1 SAP LAP analysis of UK

The Office of Gas and Electricity Markets(OfGem) is the regulator which looks after the monopoly companies that operates the gas and electricity companies, Transmission System Operator(TSO), offshore transmission operator (OFTO) and Crown Estate (Government) etc. are the actors involved in addressing the grid connection as a barrier.

Grid permits involve technical studies, review of options, and filing for permits and acquiring them. Generally, the developer performs core functions such as Power Purchase Agreement(PPA), on-time project completions, securing eligibility to enter the auction round, transmission system development.

OfGem introduced an offshore transmission operator (OFTO). Under this provision, the developer has to transfer the assets to the OFTO. As a result, these independent operators can deliver on time and within budget. Similarly, the function of zone identification is done by the Government (Crown Estate).

Following are the learnings from UK 1) Zoning approach to site identification, consent, site investigation, 2) One-stop-shop created for faster approval, 3) collaboration with TSO(such as OFTO) for O&M brings experts to manage the grid and reduces investors' debt.

Actions taken by Government for faster Zone identification, site survey, Consenting and grid construction by the Investors and by policy provision to transfer Grid ownership to TSO for operation and maintenance has not only improved coordination between the Government, developers and independent bodies, it also promoted innovation in technology development and helped to reduce the risk and cost for all stakeholders. As a result of these policy measures, 8 OE projects are connected to the grid. These measures have also successfully reduced grid connectivity costs for about \$50 million to \$60 million for 1 GW of OE projects.

6.5.2 SAP LAP analysis in France

The French Environment and Energy Management(ADEME) is the regulator that provides businesses, local authorities and communities, and government agencies with the knowledge and consulting services necessary to establish and consolidate in addressing the grid connection as a barrier.

Government undertakes site identification, initial site surveying, and grid permitting. The developer must furnish full consent for grid connection, application, design and construction, including a detailed site investigation.

Following are the learnings from the Government perspective 1) fulfils the goal of decoupling the energy sector., 2) increased competition for asset management can reduce consumer prices, 3) increased cost transparency for customers, 4) the third party may not be adequately capitalised to address risks associated with pricey assets

Action taken are discussed below, 1) establishment of ADEME in 1992 by the Government as nodal agency, 2) providing support for grid connection was one of the functions of ADEME.

Due to the measures taken, France could scale up OE projects to more than 200 MW capacity and as result of economies of scale, the electricity cost has reduced by half with current cost being €0.12/kWh.

6.6 Supply chain bottleneck

Supply of equipment , port availability, availability of cables and ancillary equipment for OE installation etc. are some of the supply chain factors that make the OE project development which are more complex and extensive compared to other RETs (Dalton & Ó Gallachóir, 2010; Das, 2018; Heptonstall et al., 2012; Levitt et al., 2011; Marczyk & DeMatteo, 2010; Pillai & Banerjee, 2009; Prässler & Schaechtele, 2012; Schmid, 2012; Srinivasan et al., 2010; Swider et al., 2008).Lack of supply chain affect in terms of installation and maintenance of devices, delay in time schedule and ultimately it results in terms of higher project cost. To resolve the barriers, supply chain policies introduced by various Government aimed at prioritizing disposition, cost optimization, and sectoral growth and thereby addressing the supply chain bottleneck are described below,

6.6.1 SAP LAP analysis of the UK

Turbine rating, project size etc., are some factors that make the OE project development more complex and extensive compared to other RETs. To resolve the barriers, supply chain policies introduced by the **UK government** aimed at prioritizing disposition, cost optimization, and sectoral growth. Although there are other important actors such as private players, Investors, Insurance companies etc however, this study is limiting to the UK Government only.

Grants, low-interest loans, and local content requirements are some key policy measures to mitigate the gaps in the local market. The government has pushed substantial investment in port infrastructure, which has attracted private sector investment for transforming ports into fabrication facility centres, resulting in the establishment of OE supply chain clusters. UK Government has taken the following measures to improve the UK suppliers' involvement, such as increasing local content to 50% and introducing a regional growth fund of £20m to develop RE sector capability

Following are the learnings from the UK, 1) attracted inward investment and staging of nearby manufacturing facilities, 2) minimum local content requirements have incentivised contract awards, 3) Grants and low-interest loans to boost the supply chain.

By these policy initiatives, the government has encouraged local entrepreneurs and inventors, other industries, and new market prospects, as well as created an interface between industry participants.

All these measures have improved the supply chain intervention, by improving the market scale and visibility, infrastructure investment, business innovation and support etc. As a result, major OEM like Siemens has invested in Hull for manufacturing of equipment due to high disposition and a robust forward pipeline in the UK.

6.6.2 SAP LAP analysis in France

The **French Government(actor)** introduced local content requirement provision under NREAP to tackle the supply chain bottleneck. The government has assigned significant weightage to local content requirements in its tender evaluation process.

Following are the learnings from France, 1) it attracted inward investment and staging of nearby manufacturing facilities, 2) minimum local content requirements have incentivised contract awards, 3) Grants and low-interest loans to boost the supply chain.

In the tender evaluation process, the local content requirement was given 40% weightage along with 40% weightage to price and 20% weightage to environmental assessment. Due to the measures taken, the OE project has been successfully grid-connected. Further, through these policy measures, the Government has attracted local businesses and innovators, synergies.

French strategy has attracted new factories and port enhancements. As a result, Alstom built factories in Cherbourg and Saint-Nazaire, while Adwen is building at Le Havre and Rouen. The local supply chain development is also exporting Alstom equipment to the US. Thereby highlighting the export opportunities.

6.7 Lack of accurate data on OE potential sites (delay in Site Selection)

As the power output from an OE project heavily depends on accurate data on temperature gradient, wind speed, seabed conditions, and water depth, the non-availability of accurate data inputs not only delays site selection but also impacts the financial attractiveness of the project. The measures taken by the governments of the respective countries in dealing with providing accurate data on OE potential sites are described below,

6.7.1 SAP LAP analysis of the UK

In this situation, the Government played a vital role in removing challenges for providing accurate data on OE potential sites.

A dedicated institution (The Crown Estate) was created in the UK to perform essential functions such as identifying sites for OE project development. For example, developing criteria for selecting the sites based on site characteristics and constraints. This institution also performs the governance allocations of selected sites to the developer. The institution provides the sites on a lease, and the lease term for such a project is negotiable with the developer.

Following are the learnings from the UK, 1) Faster Zone Identification, 2) Faster site identification and site investigation, 3) Data collection center.

Following are the actions, 1) Government identifies the sites, 2) Bids are submitted by the developer for the exclusivity of a zone, 3) The data collected becomes the basis for project negotiation.

All these measures have resulted in better visibility and data accuracy.

6.7.2 SAP LAP analysis in France

The French Government has created a permitting and licensing procedure for the project developers to develop the projects. Therefore, the French Government and the developers are the main actors in this situation.

The permissions are categorized into regional and departmental levels, and the developers must request them from the respective heads. The developers must comply with the Government guidelines related to territorial waters, environmental effects, maritime safety and the use of maritime territories, Exclusive Economic Zone (EEZ). The developers must acquire a special permit in case of setting up a project in the EEZ. It is observed during the document analysis the developer needs to obtain three main licenses, such as

- Ministry of Energy granted the license for power generation.
- Access to restricted sea zone to the Concessionaires.
- Approvals are given under the French water act.

Local construction permits for coastal construction and land-based infrastructure, stakeholders management by organizing frequent meetings between the stakeholders, time taken to license a project is estimated at 14 months, two years for EIA, feasibility studies take three months.

The key learnings from France are, reducing the number of licenses, reduction in number of permits, reduction in number of steps involved, and reduction in number of days from date of application of consent to Project start

Timebound process were set up for consent process such as application for public maritime domain consent which require 14 months. Three step procedure has been defined clearly identifying the documents and the interfaces require in each step.

All these measures have resulted in better visibility and data accuracy. As a result one of the biggest capacity OE project has been in successful operation in France.

6.8 Lack of research and development (R&D) capabilities

There is a huge cost involved in the OE project development due to lack of research and development (R&D) capabilities. It comprise of limited availability of infrastructure, facilities, the latest technology, and other technical factors. The measures taken by the governments of the respective countries in dealing with these situations are described below,

6.8.1 SAP LAP analysis of the UK

Technological R&D is the key to driving down the cost of OE projects in challenging site conditions. The Government along with Research institute and Investors played a major role to develop the R&D capabilities in the country.

Government used various processes such as technology push and pull mechanisms to de-risk the OE projects, such as funding to research centres, academic institutions and engaging the private sector, provided the continuous stimulus for technological advancement in this sector. In addition, an interface was developed to provide information to the companies and investors regarding markets, grants, a network of technology centres etc. A multi-government and institutional collaboration have also been practised to promote OE. This collaboration includes government institutions, academic institutions, private investors and many more.

The Learning from UK are 1) funding support for Research and development (R&D), 2) Creating a multiple R&D institutions, 3) Industry collaboration, 4) exclusive OE parks development etc

Action taken by UK Government along with other actors are research push with considerable funding support, market pull initiatives, engaging the private sector, and Collaboration between different government bodies for promoting RE, providing grants for RET development, dealing with specialising in manufacturing research activities and Institutions engaged in manufacturing advisory services.

Through these measures the Government was successful in creating infrastructure for OE investment along with facilities for state of the art research with the latest technology. A dedicated program like the GROW initiative also helped in product and service development. As a result of these policy measures, 4 GW capacity of OE projects are connected to the grid. These measures have also successfully reduced grid connectivity costs for about $50 million to $60 million for 1 GW of OE projects.

6.8.2 SAP LAP analysis in France

Various Government interventions have been done to promote R&D innovations in OE. In collaboration with ANR, the ‘Institute for the Energy Transition’ under the France Energies Marines provides support for R&D projects. A €68M fund was approved for R&D initiatives on OE (Bahaj, 2011; Rodwell et al., 2014; Uihlein and Magagna, 2016). In addition, dedicated Research institutes such as Environment and Energy Agency (ADEME) and the

National Research Agency (ANR). (Blazquez et al., 2018; Dincer, 2000; Trouillet et al., 2011).

Government of France set up long-term grants, established specialized institutions, developed a wide range of relevant stakeholders (such as private companies, Research institutions and higher education institutes (HEI) etc.), introduced research tax credit, and set test centres. In addition, set up investment for the future (PIA) fund and Eco-technologies fund. Types of grants created were simple Grants, reimbursable subsidies, venture capital special purpose vehicle(SPV), and venture capital.

Learning from France are Higher degree of funding support for research and development (R&D), Creating a web of institutions, Industry collaboration, Exclusive OE parks development.

Following actions were taken to promote OE 1) One institution was set up Nodal body, 2) multiple institutions were set up to support R&D, 3) multiple institutions were set up to facilitate test centre, 4) multiple types of funds were set up to facilitate R&D funding, 5) multiple grants were awarded.

Due to the measures taken, France could scale up OE projects to more than 200 MW capacity and as result of economies of scale, the electricity cost has reduced by half with current cost being €0.12/kWh.

6.9 Lack of experienced professionals

Skilled workers and facilities are needed to install and maintain OE project including under water cables and anchors. Specialized cable laying services for the power connecting cable and underwater divers are required for equipment deployment and maintenance at site. Lack of experienced labours are in short supply and may not be accessible all the time. The measures taken by UK and France to overcome the resources are summarised below.

6.9.1 SAP LAP analysis of the UK

Public support can be generated towards creating skilled manpower by mobilising educational institutions and training centres to tackle high-risk offshore activities. In this regard, RenewableUK, an industry body, has set up a dedicated institution called National Maritime Training Centre (NMTC) to channelise more significant industry-specific training in the OE sector.

Through interface with education and research institute and interface with cross functional organization UK government has increased resource pool for OE projects.

The learning from UK are 1) supplementary education and training provided for,

- Individuals who are already employed in the renewable energy industry, in order to cover talent gaps or enhance their abilities.
- Individuals with pertinent skills from other industries, to provide them with the specialised skills and knowledge necessary to operate in OE or
- Recent alumni of less specialised programmes that qualify them for employment in OE;;

Through these measures more than 1,00,000 skilled work force has been developed in the UK. With the current training plan this work force number is expected to rise to 2,00,000 by 2030.

6.9.2 SAP LAP analysis in France

Similar institutions have also been set up for vocational training under the Ministry for National Education. In addition, regional governments and several professional bodies, such as The Commission Nationale de la Certification Professionnelle (CNCP), are also involved in the skill development initiatives. Several industry players like Schneider Electric collaborated with the Power Sector Skill Council to establish and support training centres. Further, the West Atlantic Marine Energy Community (WEAMEC) was set up in collaboration with Centrale Nantes, a public-funded engineering institute in France, along with the University of Nantes etc.

This collaborative effort provided a wide range of training courses in OE. In addition, they have created training programs for employees from operator to engineer level.

The ley learning would be supplementary education and training provided for existing RE professionals to uplift their skills and to plug the gaps; professionals working in similar sectors like offshore rigs, offshore wind etc., to provide them with skill upliftment training and specialised courses designed for fresh graduates. Apert from that multiple networks of stakeholders were developed for educational skill development. The training programs were created for different levels of skill sets, for example, from operators to engineers.

Actions taken to address the issues were 1) multiple levels of collaboration were set up and 2) private-public partnership system was created.

As a result of all these measures multiple training courses were set up for OE training, multiple persons were trained, and multiple persons were trained.

6.10 Public awareness and information barriers

UK OE implementation has been observed to be hindered by public ignorance.

Inadequate knowledge of environmental and economic benefits, inadequate understanding of OETs, uncertainties about the financial viability of OET installation projects, and public opposition due to seascape impacts, environmental damage, and local community consultation concerns are the most frequently observed issues in the UK. National interest groups, grassroots organisations, political leaders, citizens, and sometimes environmental groups oppose OE project plans(Jianjun and Chen, 2014).

6.10.1 SAP LAP analysis of the UK

To help deal with this, the Consultation procedure is kicked off after the application has been checked. The Marine Case Management System (MCMS) is the primary tool, while other consultees may be contacted through email as needed.

The Marine and Coastal Access Act of 2009 specifies who must be consulted on a project before it can move forward. Moreover, consultation addresses public opinion before final approval to remove disinformation, dearth of knowledge, and not-in-my-backyard (NIMBY) syndrome about OETs(Clément, McCullen, et al. 2002).

ORE Catapult and the Crown Estate also facilitate industry-wide cooperation and the exchange of information to maximise the effect of research initiatives, raise public awareness, and expand mutually beneficial relationships, all of which contribute to an increased rate of innovation.

The Crown Estate or ORE Catapult also facilitate industry-wide cooperation and the exchange of information to maximise the effect of research initiatives, raise public awareness, and expand mutually beneficial relationships, all of which contribute to an increased rate of innovation.

Information centres are set up to improve public awareness and comprehension of information about the benefits and potential of the RET, O&M expenses, funding sources, etc.

The learning from this are 1) the extended activity of MMO was to create public awareness and share information, 2) online interface in the form of a Marine Case Management System (MCMS) to develop communication with the community and stakeholders, and 3) highlighting the NIMBY syndrome. This behavioural syndrome should also be addressed, 4) statutory consultation, and 5) establishment of information centres to improve public awareness.

Promotional materials, websites, technical resources for planners and potential investors, and articles in the public press are all examples of state and government-initiated actions that might help address these issues (Clément, McCullen, et al. 2002). These initiatives would raise public awareness of the technology, leading to more potential investors.

6.10.2 SAP LAP analysis in France

The Government of France has entrusted ADEME with creating public awareness among the public community. Accordingly, ADEME created Energy Information Spaces to provide information for general interest. In addition, it has developed a partnership with local bodies, institutions and associations.

In this regard conference on OE was organized to deliver common strategies for ensuring ocean energy development by 2030. In addition, many promotional materials were distributed under government initiatives, websites were developed, and technical information was provided for public awareness.

Learning from the process is summarised below: 1) The extended activity of ADEME was to create public awareness and share information, 2) Statutory consultation, and 3) Establishment of information centres to improve public awareness.

The following are the action taken: 1) The extended activity of ADEME was to create public awareness and share information, 2) Statutory consultation, and 3) Establishment of information centers to improve public awareness.

Performance achieved are 1) Existing capacity and plan, 2) Number of the awareness program, 3) Interface with the public. and 4) Templates for public consultation

6.11 Environmental barriers

Environmental problems are the ultimate obstacle. These include OE project construction and deployment implications for local flora and wildlife, fisheries, and pollution (oil spillage). These acute problems require public awareness and the involvement of local fisheries and local people to convince them that OE projects don't hurt the environment. Finally, the measures taken by UK and France to address public concerns are summarised below.

6.11.1 SAP LAP analysis of UK

Marine Spatial Planning (MSP) in the UK is governed by the UK Marine and Coastal Access Act 2009. It entails the promoters of OE projects acquiring permission from the Marine Management Organization (MMO) (Leary & Esteban, 2009). The Crown Estate(TCE) owns the offshore region up to 12 nautical miles. Also, a centralised location for acquiring mandatory approval from the Maritime Management Organization has been established as a one-stop shop (MMO). The Marine Scotland Licensing Operations Team, often known as MS-LOT, is a government-approved organisation in Scotland that is in charge of handing out maritime licences (O'Hagan et al., 2016). To obtain all the clearances for consent, a 3-year timeline has been set. After obtaining all the requisite permits, developers must apply for a full lease agreement.

The Environmental Impact Assessment (EIA) European Regulation expressly address ocean energy projects and specifies project types, process, and evaluation substance. Annex I projects require EIA, but Annex II do not. National authorities decide if an EIA is needed based on environmental impacts. Ocean energy activities in most member nations require EIAs. EIA is case-by-case. According to EIA Regulations 2000, proposals are assessed based on size, type, and location. The Maritime Management Organisation (MMO) or the applicant decides if an EIA is needed.

Learning from the UK is a creation of a Maritime Spacial Plan and a dedicated Consent procedure and Environmental Clearances procedure.

Setting up a One-stop shop for Consent procedures and Environmental Clearances procedure has helped the UK deal with environmental issues.

To avoid delays in environmental clearance, loss of investors, cost overrun, UK ocean energy projects, the DECC created a Strategic Environmental Assessment (SEA). Any plan or project in England or the UK must comply with the 2004 SEA Regulations. SEA respects these guidelines. (UK). This SEA will assess the environmental impacts of an offshore oil, gas, wind and gas storage leasing plan/programme. Examine plan/programme choices and potential spatial interactions with other sea users. Advise the UK government on draught planning. Allow stakeholder and public involvement.

In order to identify and assess the environmental and socio-economic consequences of deploying an OTEC plant off the coast of India, it is necessary to keep an eye on the major parameters summarised in **Table 6-3** (Rivera et al., 2020).

Table 6-3 Primary factors for EIA monitoring

	Abiotic	Biotic	Social
OTEC	Discharge Plumes Pollutants Noise Electromagnetic fields	Marine commercial resources Specific interface with infrastructure Cetaceans' presence	Landscape changes Welfare before and after Public opinion/acceptance & Cost-benefit balance

As a result of all these initiatives, 8 OE projects in the UK with an expected capacity of 2.9 GW have received environmental clearances.

6.11.2 SAP LAP analysis in France

The environmental implications of OE projects are unique to the location, layout, and architecture employed, as well as the technologies that are implemented. By virtue of the fact that they will be physically present in the sea, the structures connected with OE will, in the same vein as any other buildings that are installed offshore, have an effect on the surrounding ecosystem.

The French Ministry of the Sea (Ministère de la Mer) is the national authority in charge of the general planning of maritime space and is responsible for the implementation of that planning. The Ministry is specifically tasked with the following tasks are strategic planning at the national level, interaction with the National Committee for the Sea and Shorelines, a body comprised of national representatives of stakeholders, and notifying the European Commission of strategic plans.

Licensing takes multiple phases throughout OE project start-up. Administrative (regional council, municipalities) and specialised public bodies support the agricultural initiative (such as the Environmental Authority). State-developer communication was competitive. The government introduced the envelope permission. This authorization simplified the law. This permission allows OE developers to request authority to include ranges for project variables (e.g., number of turbines, power of each turbine) for which environmental implications have been considered in the EIA, allowing the use of modern technology without delays. After the 2014 European Directive, France has simplified Marine Spatial Planning in parallel to this simplified consenting process (MSP).

Learning from France are as follows, the extended activity of ADEME was to create public awareness and share information and establishment of information centers for improve public awareness.

Action taken by France to develop OE was through creating public awareness and share information and by establishment of information centers for improve public awareness.

Due to the measures taken, France could scale up OE projects to more than 200 MW capacity and as result of economies of scale, the electricity cost has reduced by half with current cost being €0.12/kWh.

6.12 Discussion and analysis

This section aims to review and analyze the OE policies of leading countries, i.e., the UK and France, to understand the policy solutions for removing barriers to develop OE in different countries. Therefore, this study has used document analysis as a tool, situation-actor-process (SAP)-learning-action-performance (LAP) (SAP-LAP) linkages framework as a methodological construct (Sushil, 2009, 2011). This study has considered barriers as a situation and indicates necessary actions, required processes, and institution building from the standpoint of OE development in different countries. This study has also evaluated the learnings and the performance of OE development in the UK and France.

6.12.1 Situations

The situation in an SAP-LAP methodological construct answers the question “what” for existing processes or systems. It means that what are those situations which have been affecting the intended targets of the decision-makers. In this study, the situation has been defined as a barrier external and internal to the policy environment that influenced the OE development process. High installation costs and environmental barriers are external, and the rest are internal barriers for the policymakers. As discussed above, the identified barriers are generic, hence will be common in both countries. The table below has summarized the situations, and their explanations with references.

Table 6-4 List of barriers(situations) to OE development

Code	Situations	Explanation	Applicable for
S1	High installation cost	High installation costs include high upfront costs, shipyard and maintenance, and cables and mooring.	UK, France
S2	Lack of financing mechanism	High interest rates and the belief of high risk by financial institutions are components of the insufficient financing mechanism.	UK, France
S3	Inadequate Market incentives	Inadequate market incentives comprise inadequate fiscal incentives and insufficient govt grants and subsidies.	UK, France
S4	Lack of long-term visibility and dedicated Ocean Energy policy	Lack of government commitments and the inability to see the big picture are two aspects of the lack of long-term visibility and focused ocean energy strategy.	UK, France
S5	Grid connection	Grid connections comprise grid planning, grid permitting, and grid operation.	UK, France
S6	Supply chain bottleneck	Supply chain bottleneck includes the lack of spare parts, cables, mooring systems, etc., hinders the efforts to leverage the OE potential	UK, France
S7	Lack of accurate data on OE potential sites (delay in Site Selection)	This situation includes the accurate data such as temperature gradient, wind speed, seabed conditions, and water depth The non-availability of accurate data inputs not only delays site selection but also impacts the financial attractiveness of the project.	UK, France
S8	Lack of research and development (R&D) capabilities	Lack of research and development (R&D) capabilities comprise limited availability of infrastructure, facilities, the latest technology, and other technical factors.	UK, France
S9	Lack of experienced professionals	OE requires a skilled professional to execute projects in challenging offshore conditions.	UK, France
S10	Public awareness and information barriers	This situation would include a gap in knowledge about economic and environmental benefits, lack of information available with the local community, ecological damage, etc. As a result, OE projects are being opposed by various stakeholders such as individual citizens, local groups and organizations, some environmental enthusiasts, etc. (Jianjun and Chen, 2014).	UK, France
S11	Environmental barriers	The site, layout, architecture, and technology employed in OE projects all have a role in determining the environmental implications of the project. By virtue of the fact that they are physically present in the sea, the structures connected with OE will, in the same vein as other buildings installed offshore, have an effect on the surrounding ecosystem.	UK, France

6.12.2 Actor

Actors in SAP-LAP analysis deal with the question “Who.” This means that all are responsible actors for handling the situation. The actors of OE policy development in the UK and France are Government, the Developer, and Third Party/Transmission Systems Operator (TSO). Literarture reveal that the Government is a critical actor in all situations to remove the barriers. In comparison, other actors like developers and TSO are also contributing along with the Government in the OE development. It also shows that the majority of the OE development depends on internal actors to the Government while very few actors are external to the Government.

Table 6-5 List of actors for OE development in the UK and France

Code	Actors	Applicable for
A1	Government	UK, France
A2	Developer	UK, France
A3	Third-party / TSO	UK, France
A4	Academic Institutions	UK
A5	Research Centers	UK
A6	Private Institutions	UK

6.12.3 Process

The first two phases establish a connection between the actor and the situation. Next, these phases address the "what" and "how" questions. Finally, the third step transforms the input into the desired output. However, literature has mentioned various processes related to supply chain, customer interface, performance management, etc. Therefore, the researchers have used the policy process in this study. This process helps involve multiple government institutions, developing solutions for complex and interconnected policy issues. It also helps provide policymakers solutions during uncertainties. As per (Shiffman, 2017), the policy process consists of four distinct steps: prioritisation, planning, action, and assessment, but this study has taken policy process as a type of process for understanding the best practices in the benchmark countries for OE development.

The researchers have identified the National Renewable Energy Action Plan (NREAP), Section 36 of the Electricity Act 1989, UK Renewable Energy Roadmap, Section 66 of the Marine and Coastal Access Act 2009, The Future of Marine Renewables in the UK, and National Renewable Energy Action Plan (NREAP), Section 36 of the Electricity Act 1989, Integrated National Energy And Climate Plan, Article 20 of the ordinance n° 2016–2017 in France (Chowdhury et al., 2020) as significant policies for OE development with the help of document analysis.

Table 6-6 has mapped multiple policy options to provide solutions per the policy's agenda. This study has reported twenty-two policy options that are interfacing with each other. These policy options represent a variety of solutions related to capacity building, Government-industry-society interlinkage, project funding, fiscal benefits, dedicated economic zones, project award, backward and forward linkage, and so on.

Table 6-6 List of processes for OE development in the UK and France

UK			France		
Code	**Process**		**Code**	**Process**	
P1u	Capacity augmentation		P1f	Capacity augmentation	
P2u	Industry collaboration		P2f	Grants and low-interest loans	
P3u	Institution set up		P3f	Policy process	
P4u	Stage-gate funding		P4f	Linkage between Government, education, research institute and market players.	
P5u	Dedicated ocean energy fund.		P5f	International competitive bidding	
P6u	Policy process		P6f	Consenting	
P7u	Exemption of Climate Change Levy for buyers		P7f	Linkage between Government, education, research institute and market players.	
P8u	Lease payment for sites		P8f	Linkage between Government, education, research institute and market players.	
P9u	Application fee and guarantee provision		P9f	Institution set up	
P10u	Exclusive economic zone set up		P10f	Public collaboration	
P11u	Consenting		P11f	Consultation	
P12u	Approval		P12f	Environmental impact assessment	
P13u	Local content requirement		P13f	Consenting	
P14u	Grants and low-interest loans				
P17u	International competitive bidding				
P18u	Set up of Test Centre				
P19u	Linkage between Government, education, research institute and market players.				
P20u	Public collaboration				
P21u	Environmental impact assessment				

6.12.4 Learning

The combination and interface of analysis of Situation-Actor-Process advances to Learning-Action-Performance (LAP). After assessing the situations, actors, and processes learning about the critical policy implementations are also important. As per SAP analysis, different actors and processes have been identified, which were introduced as per the agenda setting to tackle the barriers to OE development. The learning step in the SAP-LAP analysis explains "why" UK and France adopted the policy processes. These learnings illustrate an action point to remove the barriers (situations) identified for OE development.

Table 6-7 explains the learnings categorized into cost reduction, financing mechanism, market incentives, long-term visibility, grid connection, supply chain, accurate data, research and development (R&D) capabilities, experienced professionals, public awareness, and environmental issues. The learnings from the document analysis of policies for OE development in the UK and France can be summarised as an umbrella policy covering both external and internal barriers. These policies have not only helped reduce the installation cost but also provided due importance to the forward and backward linkages for the OE development. Furthermore, these policies have also considered short-run and long-run OE development.

Table 6-7 List of learnings for OE development from the UK and France

UK			FRANCE		
Code	**Learning**		**Code**	**Learning**	
L1u	Rapid capacity addition and reduced cost		L1f	Rapid capacity addition and reduced cost	
L2u	Value added by-products		L2f	sound economic principles	
L3u	Dedicated space in shipyards		L3f	Enabling environment	
L4u	Interface with the cross-functional organization.		L4f	OE Fund	
L5u	OE Fund		L5f	Dedicated financial institution.	
L6u	Fund allocation for specific distinctive technologies, R&D guidance at different stages of technology difference such as concept. Prototype testing and commercialization.		L6f	The long-term outlook of OE development	
L7u	Sprinter Incentive for Early Finish		L7f	Unbundling the project activities	
L8u	Reductions in sales, energy, CO2, VAT, or other taxes		L8f	Greater transparency	
L9u	Multiple institutions on one platform		L9f	The hybrid approach has reduced the risk of mitigating expensive assets.	
L10u	Long-term visibility		L10f	Attracted inward investment and staging of nearby manufacturing facilities.	
L11u	Policy commitment		L11f	Minimum local content requirements have incentivised contract awards.	
L12u	Manufacturing Hub		L12f	Grants and low-interest loans to boost supply chain.	
L13u	Zoning approach to site identification, consent, site investigation.		L13f	Strong compliance with Government rules & policies.	
L14u	Lease for zone is secured through a competitive process.		L14f	Reduced number of licenses	
L15u	Collaboration with TSO for O&M brings experts to manage grid and reduces debt of Investors.		L15f	Reduced project permitting time	
L16u	Attracted local businesses and innovators, collaborations with related industries to support market opportunity communications, and brokering between industry players.		L16f	Funding support for research and development (R&D)	
L17u	Faster site identification, and site investigation.		L17f	Creation of web of institutions	
L18u	Excellent collaboration		L18f	Industry collaboration	
L19u	Policy support		L19f	Exclusive OE parks development	
L20u	Set up of test centers and open sea demonstration center reduced production cost.		L20f	Development of specialised knowledge	
L21u	Development of specialised knowledge		L21f	Public awareness as an extended activity by a dedicated instituition	
L22u	Research and development (R&D)		L22f	Statutory consultation	
L23u	Industry collaboration		L23f	Establishment of information centers for improve public awareness.	
L24u	Maritime Spatial Plan		L24f	Benefits of Maritime Spatial Plan	
L25u	Consent procedure		L25f	Benefits of Consent procedure	
L26u	Environmental Clearances		L26f	Benefits of Environmental Clearances	

6.12.5 Action

Researchers can find answers to critical questions such as the situations, who the actors are, how the process should be implemented, and why processes should be implemented with the SAP-LAP framework. In this stage, we asked questions like "when" and "where" things should be done(Suri & Sushil, 2012). The policy implementation has led to the OE development in UK and France. The study has identified, with the help of a detailed literature review, the critical actions, which include target setting, Government-backed FI, fiscal support, integrated national energy and climate plan, market incentive, non-market incentives, dedicated institution, enabling environment, data creation, a fund set up, capacity building, West Atlantic marine energy community (WEAMEC), European regional development fund, creation of energy information spaces, set up of environmental authority, introduction of a roadmap, sunset clause, shift from ROC trading certificate to auction mechanism, dedicated fund, special status, financing support, public awareness, maritime spatial plan.

As per **Table 6-8**, the actions ACu1, ACu2, ACu5, and ACf1, ACf2, ACf5 have set the OE development's playing field. ACu3, ACu4, ACu7, ACu10, ACu11, ACu12, and ACf3, ACf4, ACf7, ACf8, ACf9, ACf10, ACf12, ACf15 have supported the investors and players to reduce the cost of the setting of the power plant. The actions such as ACu6, ACu8, ACu9, ACu14, ACu15, and ACf6, ACf11, ACf14, ACf16, ACf17 have indicated the backward linkages which give long-term sustainability to the OE development.

Table 6-8 List of actions for OE development from the UK and France

UK		**France**	
Code	**Action**	**Code**	**Action**
ACu1	Introduction of Roadmap	ACf1	Introduction of Roadmap
ACu2	Target setting	ACf2	Target setting
ACu3	Government backed FI	ACf3	Government backed FI
ACu4	Fiscal support	ACf4	Fiscal support
ACu5	National Renewable Energy Action Plan (NREAP)	ACf5	National Renewable Energy Action Plan (NREAP)
ACu6	Dedicated instituition	ACf6	Integrated National Energy And Climate Plan
ACu7	Shift from ROC trading certificate to Auction mechanism	ACf7	Market Incentive
ACu8	Dedicated fund	ACf8	Non-market incentives
ACu9	Special status	ACf9	Dedicated instituition
ACu10	Sunset Clause	ACf10	Enabling environment
ACu11	Enabling environment	ACf11	Data creation
ACu12	Financing support	ACf12	Fund set up
ACu13	Capacity building	ACf13	Capacity building
ACu14	Public awareness	ACf14	West Atlantic Marine Energy Community (WEAMEC) (Public awareness)
ACu15	Maritime Spatial Plan	ACf15	European Regional Development Fund
		ACf16	Creation of energy information spaces
		ACf17	Set up of environmental authority (Name)

6.12.6 Performance

This step of SAP-LAP analysis answers the question of what has been achieved for the intended target. The performance objective for the OE development has been reported in the literature regarding project cost, cash flow, value-added products, supply chain, capacity addition, market and non-market incentives, infrastructure development, institutional building, policy stability, and facilitation for industry players and stakeholders. These are also performance indicators of the policies implemented in the OE development. As discussed above, the significant barriers have been considered a situation in SAP-LAP analysis. These barriers are generic and applicable to all countries that intend to leverage their OE potential. Therefore, the policies were also aimed at tackling those barriers.

The effectiveness of policy implementation has been seen in terms of capacity addition and planned capacity. The combined OE capacity in France and the UK represents 64% (2 GW in the UK and 0.8 GW in France) of the global OE capacity. The challenge of high installation cost was met through various tools and fiscal incentives such as feed-in tariffs (FIT), Contracts for Difference (CfD). The market incentives such as FIT and CfD (30% more than other energy systems) and the sale of value-added products have also contributed to reducing the burden of high installation costs. Establishing specialized financing mechanisms and dedicated funds has also emerged as an essential strategy to reduce the installation cost. These measures have also addressed the lack of financing mechanisms and inadequate market incentive barriers. In addition, policy decisions such as the sunset clause, the applicability of policies for 20 years, the roadmap for OE and space for OE in the RE policy landscape have helped mitigate the challenges due to the lack of long-term visibility.

The OE development policies in France and UK have also encouraged the integration of value chain stakeholders to tackle the supply chain bottlenecks in the OE project development. In this regard, policy created a space for integrating the equipment manufacturers for providing equipment at the project site. These supply chains have been developed in the catchment area of the project. This policy has helped develop the local content market and mobilized investment in the supply chain and critical infrastructure. The policies have also facilitated competition in the market, synergies with other industries, and enabled arrangements between industry players.

The policies of France and the UK have created a scope for new institutions such as ADEME and DECC, respectively. Although these initiations are also known as one-stop-shop solutions in the literature, these institutions are established to enable backwards and forward integration and coordination for OE development. In this regard, these intuitions have also taken responsibility for identifying the zones and developing sites for reliable data collection for developing the commercially viable project site.

These dedicated institutions have also contributed to developing knowledge by creating a network of academic industry and public organizations. Financing support was also provided for R&D activities and created a network of experienced professionals from similar industries to extend their expertise for OE development. Similarly, these institutions have also played an important role in creating public awareness and sharing information with stakeholders. ADEME and DECC faced a not-in-my-backyard syndrome(NIMBY) related to OE project development. They dealt with it efficiently by setting up the consultation process, collaboration, and information sharing with the stakeholders.

The OE project development has the most serious environmental concerns these institutions have tackled through Marine Spatial Planning (MSP). Researchers found out from the literature that this particular task was delivered in the UK with a de-centralized approach, while in France, it was done centrally by the Ministry of the Sea (Ministère de la Mer). While in the UK, multiple institutions such as MMO, MSLOT, and The Crown Estate (TCE). The major functions of these institutional set-ups are issuing licenses for operating in an offshore area and marine operations and conducting environmental impact assessment(EIA).

After comparing UK and France policy frameworks, it is observed that the UK's Framework is more aligned toward fast and rapid development. In contrast, the French framework has an orientation towards self-sufficiency. Therefore, the researchers have used a mixed approach to develop a proposed framework for OE development in India

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Table 6-9 List of performance for OE development from the UK and France

UK		France	
Code	**Performance**	**Code**	**Performance**
PEu1	Reduction in Levelized Cost of Energy (LCoE)	PEf1	Reduction in Levelized Cost of Energy (LCoE)
PEu2	Enhanced Cash flow	PEf2	Enhanced Cash flow
PEu3	Reduced of upfront installation cost	PEf3	Reduced of upfront installation cost
PEu4	Value added products	PEf4	Set up of Public Investment Bank (BPI)
PEu5	OE equipment manufacturing and supply chain investment	PEf5	Expected capacity of 6 GW
PEu6	The clarity for new products, services and facilities	PEf6	Expected capacity of 6 GW by 2030
PEu7	Investment in critical enabling infrastructures	PEf7	FIT of 0.15 c EUR/kWh
PEu8	Long term visibility with sustainability	PEf8	Applicable for 20 years
PEu9	Consistent policy leads to competitive market	PEf9	Non- market instruments
		PEf10	Generating capacity of 500 GWh/year
		PEf11	Major exporter to other countries.
		PEf12	Attracted local businesses and innovators.
		PEf13	Synergies with other industries.
		PEf14	Facilitating brokering between industry players.

CHAPTER 7 – SUGGESTIVE FRAMEWORK FOR OTEC POLICY DEVELOPMENT IN INDIA

7.1 Justification for choosing the policy framework

Some of the observations from the policy framework analysis from France and the UK are as follows:

- FIT is the only market incentive in France, while market incentives such as the capital grants scheme, ROC system, and CfD were implemented in the UK.
- Non-market incentives in the UK were accelerated depreciation, dedicated fund enhanced capital allowance, and France invested heavily in R&D., so financial support is capacity building in OE.
- Money spent on OE development was more focused on attracting investors. Therefore, the focus of the UK policy was to support OE development in a faster mode in the short run.
- The UK followed a zoning approach to site identification with options to increase the zone for capacity augmentation. This has attracted developers looking to capitalize on the economies of scale.
- The French Govt case focused on creating the enabling environment for developing the OE sector. For this purpose, GoF has created a simple institutional framework where one institution is ADEME. This institution aims to provide support and an enabling environment for various stakeholders. In addition, the government has also emphasized the R&D of OE sector technology and business development.
- The UK has focused more on Financial and market incentives to make the project viable, which seems relatively a strategy to develop the market in the short run. However, the policies are effective as per the trend analysis of the growth of projects after policy implementation.

- France has heavily emphasized local content requirements. Because of this, the development of an ancillary supply chain and local manufacturing capability for main equipment.

With this long-term strategy, France is a self-sufficient country in terms of technology and knowledge of OE and a prominent exporter of OE technology (OETs) to the world.

In the Indian context, policymakers expect rapid growth and self-sufficiency in the sector in focus(MoES, 2021). Therefore, regarding the development of OE, India should meet the policymakers' requirements. After comparing UK and France policy frameworks, it is observed that the UK's Framework is more aligned toward fast and rapid development. In contrast, the French framework has an orientation towards self-sufficiency. Therefore, the researchers have used a mixed approach to develop a proposed framework for OE development in India.

7.2 Suggestive Policy Framework for OTEC Development in India :

Summarising the entire research process before introducing the suggestive policy framework is important.

This study has brought all possible factors that could help harness OE energy in India. First, an attempt was made to understand the variables identified based on the literature survey of select countries. Next, a questionnaire survey was conducted consisting of these variables. Then, the factors responsible were identified and validated, as illustrated in **Figure 7-1**

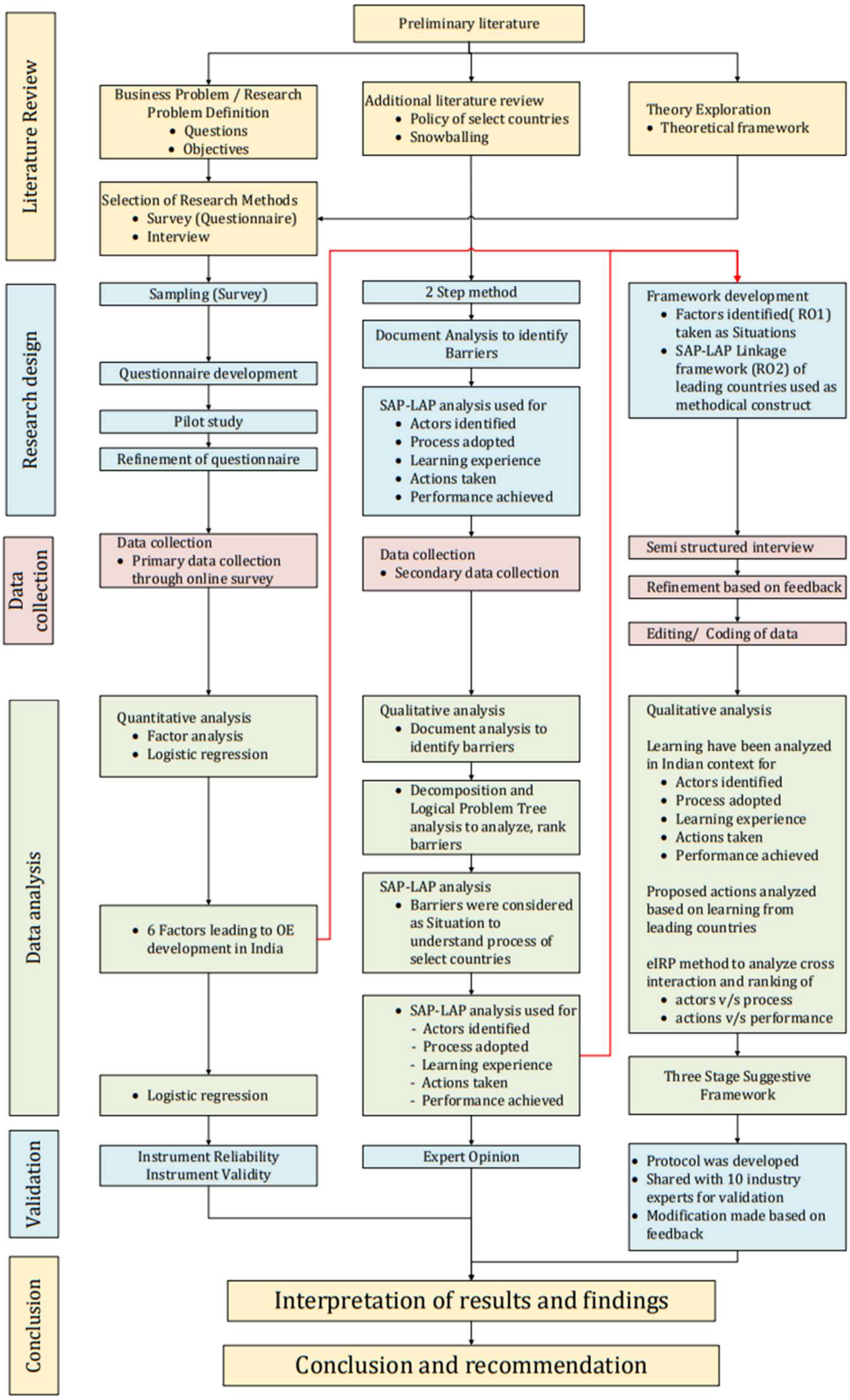

Figure 7-1 Research Process Flow Chart

Finally, a SAP-LAP study was carried out to examine the policies implemented by world powerhouses like the United Kingdom and France to foster the development of their respective ocean energy sectors and to find the practises that may be integrated into the Indian context.. During the analysis, a linkage framework was developed in the Indian context. Based on SAP-LAP analysis and eIRP method, important actors and actions have been ranked concerning processes and performance. Therefore, this section is presented in two parts. Part 1 discusses the results of efficient Interpretive Ranking Process (eIRP) analysis, and part 2 presents the suggestive framework for OTEC policy in India.

7.2.1 Part I – Results of eIRP analysis

7.2.1.1 Computational Analysis

This study determines the Action vs Performance cross-interaction matrix and Actor vs Process. The existence of a relationship has been represented with the help of binary coding. A "1" in this code indicates a connection exists, whereas a "0" indicates no connection exists. **Error! Reference source not found.** outlines the cross and corresponding interpretive matrix of Actor vs Process. Similarly, 8.5Appendix E presents the cross and corresponding interpretive matrix of Action vs Performance. Further, a pairwise comparison between ranked variables and the interpretation matrix was performed. In this study, the actors Government (A1), Developer (A2), Third-party / TSO (A3), Academic Institutions (A4), Research Centres (A5), Private Institutions (A6), and processes Capacity augmentation (P1), Industry collaboration (P2), institution set up (P3), Stage-gate funding (P4), Dedicated ocean energy fund. (P5), Policy process (P6), Exemption of Climate Change Levy for buyers (P7), Lease payment for sites (P8), Exclusive economic zone set up (P9), Consenting (P10), Grants and low-interest loans (P11), International competitive bidding (P12), Set up of Test Centre (P13), Linkage between Government, education, research institute, and market players. (P14), Public collaboration (P15), Environmental impact assessment (P16), and Consultation (P17) are considered for further analysis. Similarly, actions Introduction of Roadmap (A*1), Target setting (A*2), Sunset Clause (A*3), Government backed FI (A*4), National Renewable Energy Action Plan (NREAP) (A*5), Dedicated instituition (A*6), Shift from ROC trading certificate to Auction mechanism (A*7), Supply chain development (A*8), Dedicated fund (A*9), Special status (A*10), Fiscal support (A*11), Enabling environment (A*12), Collaboration with industry players (A*13), Public awareness (A*14), Maritime Spatial Plan (A*15), Data creation (A*16), Creation of energy information spaces (A*17) and performance such as Reduction in Levelized Cost of Energy (LCoE) (P*1), Enhanced Cash flow (P*2), Reduced of upfront installation cost (P*3), Value added products (P*4), OE equipment manufacturing and supply chain investment (P*5), Investment in critical enabling infrastructures (P*7), Consistent policy lead to competitive market (P*8), Dedicated investment bank for OE development (P*9), Large planned capacity addition (P*10), Attractive market & non-market instrument (P*11), Major exporter to other countries. (P*12), Attracted local businesses and innovators. (P*13), Synergies with other industries. (P*14).

The interaction between these alternatives variables, (A, A*,P, P*) with the help of the Cross-interaction matrix (CIM) and interpretive matrix is done in this study(**Error! Reference source not found.**). Further, these interactions are compared pairwise for the reference variable for example Processes P1–P17 are contrasted between the Government (A1) and the Developer (A2). 8.5Appendix J present the nature of dominance as per the step 4 methodology. According to the results of the dominance study(**Table 7-1**, 8.5Appendix F and 8.5Appendix H), implicit dominance (ID) (47.7%), is significantly higher than non-implicit dominance (31.6%), which comes in second place. The fluctuation in this dominance varied from 2.6 to 12.9%, while the interpretative dominance was rated third with 18.71% of the total. After then, the e-IRP technique is used to determine the actor's position in the rankings. A measure of both net and modified dominance values was applied to rank the candidates effectively. The methodology followed to determine the final dominance index. The sequence of the actors that contributed to the formation of the OE in India was determined to be as follows: A1, A2, A5, A4, A3, and A6(**Table 7-3**).

Analysing the preponderance of actions over performances follows a similar computational technique, detailed in 8.5Appendix E. **Table 7-2**, 8.5Appendix I, and **Error! Reference source not found.**. present the results of the examination of the dominance relationship. There are 17 pair comparisons for each performance area and a total of 238 paired comparisons based on the findings of actions vs performance dominance. **Table 7-4** displays the results of a dominance analysis, with interpretative dominance at 48.7% and non-implicit dominance at 45.1%.

Each action's dominance index has been calculated and is shown in **Table 7-4**. The dominance index ranks the proposed actions from highest to lowest. Based on the data presented in **Table 7-4**, and 8.5Appendix I, the following ranking order is determined: A*1, A*2, A*5, A*4, A*3, and A*6.

Table 7-1 Interaction analysis of actor's vs processes interactions

	Implicit dominance	Implicit non-dominance	Interpretive dominance	Transitive dominance	Total comparison	% Interpretive comparison
P1	5	5	0	0	10	6.45%
P2	10	6	4	0	20	12.90%
P3	6	5	4	0	15	9.68%
P4	5	5	0	0	10	6.45%
P5	5	5	0	0	10	6.45%
P6	5	5	0	0	10	6.45%
P7	0	0	0	0	0	0.00%
P8	1	1	0	0	2	1.29%
P9	3	1	0	0	4	2.58%
P10	3	1	0	0	4	2.58%
P11	5	5	0	0	10	6.45%
P12	3	0	3	0	6	3.87%
P13	5	0	5	0	10	6.45%
P14	6	3	8	3	20	12.90%
P15	5	0	5	0	10	6.45%
P16	2	2	0	0	4	2.58%
P17	5	5	0	0	10	6.45%
Total	74	49	29	3	155	100%
%	47.74%	31.61%	18.71%	1.94%	100%	

Table 7-2 Interaction analysis of action's vs performances interactions

	Implicit dominance	Implicit non-dominance	Interpretive dominance	Transitive dominance	Total comparison	% Interpretive comparison
P1	60	72	6	0	138	8.04%
P2	15	15	0	0	30	1.75%
P3	66	72	0	0	138	8.04%
P4	62	77	14	0	153	8.91%
P5	59	55	12	0	126	7.34%
P6	0	0	0	0	0	0.00%
P7	64	52	14	0	130	7.57%
P8	64	53	13	0	130	7.57%
P9	66	52	12	0	130	7.57%
P10	77	49	13	4	143	8.33%
P11	80	52	15	3	150	8.74%
P12	42	45	0	0	87	5.07%
P13	136	136	0	0	272	15.84%
P14	45	45	0	0	90	5.24%
Total	836	775	99	7	1717	171700%
%	49%	45%	6%	0%	100%	

7.2.1.2 Actor Versus Process

Researchers used the effective IRP approach to place the following performers in order: Government (A1), Developer (A2), Research Centres (A5), Academic institutions (A4) , Third party / TSO (A3) , Private Institutions (A6) are important decision makers for developing OE in India. (Chakraborty, Dwivedi, Chatterjee, et al., 2021) have analyzed that OE development in India could be accelerated by implementing a dedicated OE policy in India. Parallel to this, institutional set-up, Exclusive Economic Zone (EEZ) and backward linkages are also vital for developing OE policy in India. Recently, the GoI has approved OE for electricity generation and drinking water. From the analysis Capacity augmentation (P1), Industry collaboration (P2), institution set up (P3), Stage-gate funding (P4), Dedicated Ocean energy fund. (P5), Policy process (P6), Exemption of Climate Change Levy for buyers (P7), Lease payment for sites (P8), Exclusive economic zone set up (P9), Consenting (P10), Grants and low-interest loans (P11), International competitive bidding (P12), Set up of Test Centre (P13), Linkage between Government, education, research institute and market players. (P14), Public collaboration (P15), Environmental impact assessment (P16), Consultation (P17) are found out to be critical processes for the development of OE in India. Linkage between Government, education, research institute and market players. (P14) are identified as an important factor in the expansion of OE in the country.

7.2.1.3 Actions Versus Performance

The study uses the effective IRP approach to rank the acts in the following order: Introduction of Roadmap (A*1), Target setting (A*2), Sunset Clause (A*3), Government backed FI (A*4), National Renewable Energy Action Plan (NREAP) (A*5), Dedicated institution (A*6), Shift from tariff support to auction mechanism (A*7), Supply chain development (A*8), Dedicated fund (A*9), Special status (A*10), Fiscal support (A*11), Enabling environment (A*12), Collaboration with industry players (A*13), Public awareness (A*14), Maritime Spatial Plan (A*15), Data creation (A*16), and Creation of energy information spaces (A*17)are important actions for OE development. Further, institutional set-up, Exclusive Economic Zone (EEZ) and backward linkages are also vital for developing OE policy in India. Recently, the GoI has approved OE for electricity generation and drinking water. From the analysis, Reduction in Levelized Cost of Energy (LCoE) (P*1), Enhanced Cash flow (P*2), Reduced upfront installation cost (P*3), Value added products (P*4), OE equipment manufacturing and supply chain investment (P*5), Investment in critical enabling infrastructures (P*7), Consistent policy lead to competitive market (P*8), Dedicated investment bank for OE development (P*9), Large planned capacity addition (P*10), Attractive market & non-market instrument (P*11), Major exporter to other countries. (P*12), Attracted local businesses and innovators. (P*13), Synergies with other industries. (P*14). are found to be critical performances for the development of OE in India—the linkage between Government, education, research institute and market players. (P14) is found to be one of the critical enablers for developing OE in India.

Table 7-3 Dominance index and ranking of actors

	A1	A2	A3	A4	A5	A6	D	Net dominance value (D-B)	Adjusted net dominance (AND)	Dominance index	Rank
A1	-	16	14	13	12	11	66	49	63	58.3%	1
A2	4	-	4	3	3	3	17	-5	9	8.3%	2
A3	4	2	-	0	0	1	7	-13	1	0.9%	5
A4	3	2	1	-	0	1	7	-10	4	3.7%	4
A5	3	2	1	1	-	1	8	-7	7	6.5%	3
A6	3	0	0	0	0	-	3	-14	0	0.0%	6
B	17	22	20	17	15	17	108				

Table 7-4 Dominance index and ranking of actions

	A1	A2	A3	A4	A5	A6	D	Net dominance value (D-B)	Adjusted net dominance (AND)	Dominance index	Rank
A1	-	8	11	11	12	12	54	50	86	48.3%	1
A2	0	-	5	5	5	5	20	0	36	20.2%	3
A3	2	6	-	10	8	9	35	2	38	21.3%	2
A4	2	3	5	-	9	11	30	-6	30	16.9%	4
A5	0	1	6	7	-	12	26	-10	26	14.6%	5
A6	0	2	6	3	2	-	13	-36	0	0.0%	6
B	4	20	33	36	36	49	178				

7.2.2 Part II - Suggestive Framework for OTEC policy in India

Based on SAP-LAP analysis, ranking of actor, process, action and performance and interaction of industry experts, the study conceptualizes **three-stage analysis framework** to develop OTEC in India. This framework consists of important factors responsible for OTEC development in the country, identifying important actors, analyzing actions to be taken for the OTEC development, and suggesting processes to effectively implement the actions / decisions taken by the policy makers' stakeholders. Von der Fehr and Millan (2001) suggest that the objective of the Governments concerning power sector development is to provide electricity to the country's people sustainably. Similarly, the objectives will remain the same in this case also. This framework is an outcome of intense research which involves a review of global OTEC policies, identification of important factors for OTEC development in India, and analysis of best practices for OTEC development through SAP-LAP and e-IRP analysis. The framework for OTEC development in India proposes three levels Setting up policy and institutional framework, Developing support system, and Creating enabling environment. Each level recommends the interventions through actors, actions and processes as discussed in e-IRP analysis. The suggestive framework is explained below.

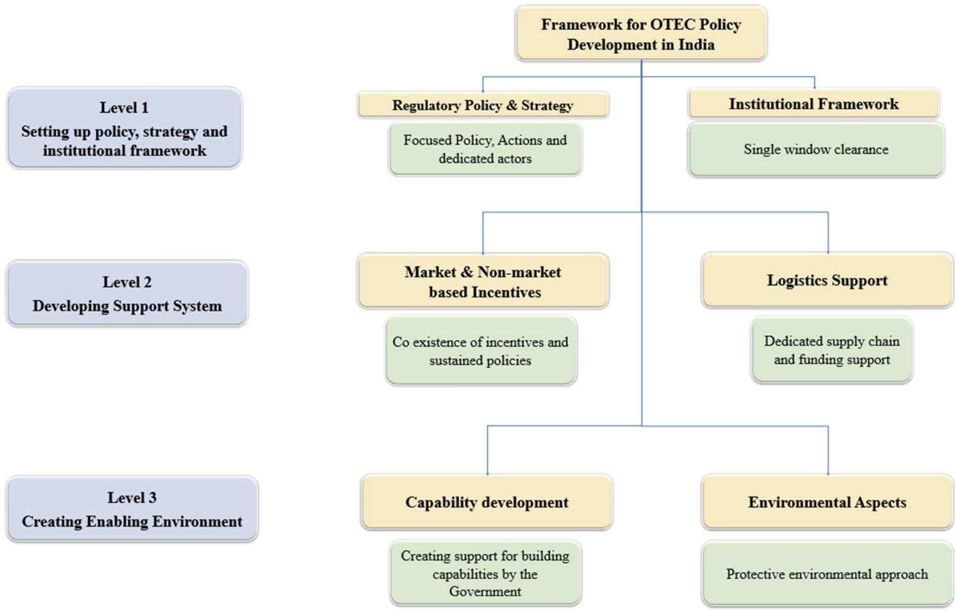

Figure 7-2 Framework for OTEC Policy Development in India

7.2.2.1 Level 1: Setting up policy, strategy and institutional framework

This level comprises regulatory policy, strategy, and institutional framework. It will influence the critical factors such as Economic Tools, Financing mechanisms, Government Support, Regulatory and Fiscal Incentives, and Promoting Local Content.

7.2.2.1.1 Regulatory Policy & Strategy

The country should have a robust regulatory policy and strategy framework for OTEC development.

It is learnt from the Linkage Framework that the regulatory policies and strategies in the UK such as the NREAP, Section 36 of the Electricity Act 1989, UK Renewable Energy Roadmap, Section 66 of the Marine and Coastal Access Act 2009, and institutions set up such as DECC, OfGem for policy implementation, etc. were the critical strategies for the OTEC development. Through these policy measures, the Government of the UK attracted companies to enter the OTEC equipment manufacturing and associated services to develop the overall ecosystem with a long-term view to increase competition and reduce cost. Long-term visibility refers to the clarity of the government's commitment to developing OE to the investors and other stakeholders.

Recently, the cabinet approved the Deep-ocean mission in India. The approval note comprises 6 points toward the deep ocean development, which 5th point being dedicated to the energy and fresh water from the ocean. It is also interesting to note that OTEC is the technology of choice for the Indian government.

The Linkage Framework demonstrates that nations with long-term policy continuity and a concentrated focus on OTEC projects outperform those with "Traffic signal"-style'start-wait-stop-start' initiatives. Long-term policy stability gives investors confidence that the government will continue to back the industry, lowering the sector's financial risk. The UK is one of several European nations where investment has halted to benefit uncertainty. Learning from leading countries, the Government of India may set up a dedicated policy for OTEC, including a roadmap under the mission.

Introduction of the OTEC road map, setting up the targets, introducing sunset clause, detailed resource assessment, Incentives for the long term, etc., are the specific measures that can be taken for the policy implementation.

By implementing these policy measures, the Indian Government will be able to expand the likelihood of private businesses establishing a presence in the original equipment manufacturing and supply chain. This will provide firms the confidence to spend money on new equipment, inventory, and services. Due to the high upfront costs and long construction times of critical enabling infrastructures like ports, factories, and ships, suppliers need to be confident that the market will provide enough opportunities for repeat business over long periods of time to justify the investment. In addition, consistent and large deployment volumes provide more vendors a reasonable slice of the market, therefore fostering healthy competition that drives down prices.

7.2.2.1.2 Institutional Framework

When referring to a set of formal organisational structures, regulations, and informal norms for the provision of services, the phrase "institutional framework" is typically used. Such a framework is a precondition for successfully implementing any mission, such as the Deep Ocean mission of Govt. of India and therefore needs to be considered in particular. The literature review of select countries noted that OTEC projects in the deep ocean require the coordination of multiple authorities for consent. MSP, site survey, grid connection, etc., at a different level. This could jeopardize the project timeline and adversely impact the stakeholders' cash flow. In this context, an institutional framework outlining the responsibilities of every institution engaged in different project activities (IEES 2020). Institutional frameworks differ from nation to nation, but regardless of the particular form, it is vital to have conversation and coordinating channels. A balance must be struck between a completely integrated strategy, in which certain concerns may be overlooked owing to a lack of experience or interest, and a sectoral approach, in which separate policies are implemented without coordination (GWP 2020).

Based on what has happened in other nations, OTEC project developers in India will need to contact many ministries or departments to secure approval. (refer to **Figure 7-3**). Developers who have already put a lot of money into the OTEC project can't afford any delays in the commissioning of the projects due to such bureaucratic red tape. It would be unreasonable to expect a project developer to go through the hassle of securing all of these permits and licences from various government entities. The Ministry of New and Renewable Energy (MNRE) in India should establish a nodal agency to coordinate all OTEC project approvals and consent with other relevant ministries and government agencies, as has been done in the UK. This means that there has to be a centralised clearinghouse for OTEC projects inside the Ministry of New and Renewable Energy. This coordinating body shall coordinate with relevant parties to secure the required permits. Before accepting bids to install in the

OTEC energy technology park, MNRE should determine a sizable area of the ocean that has already been cleared for use.

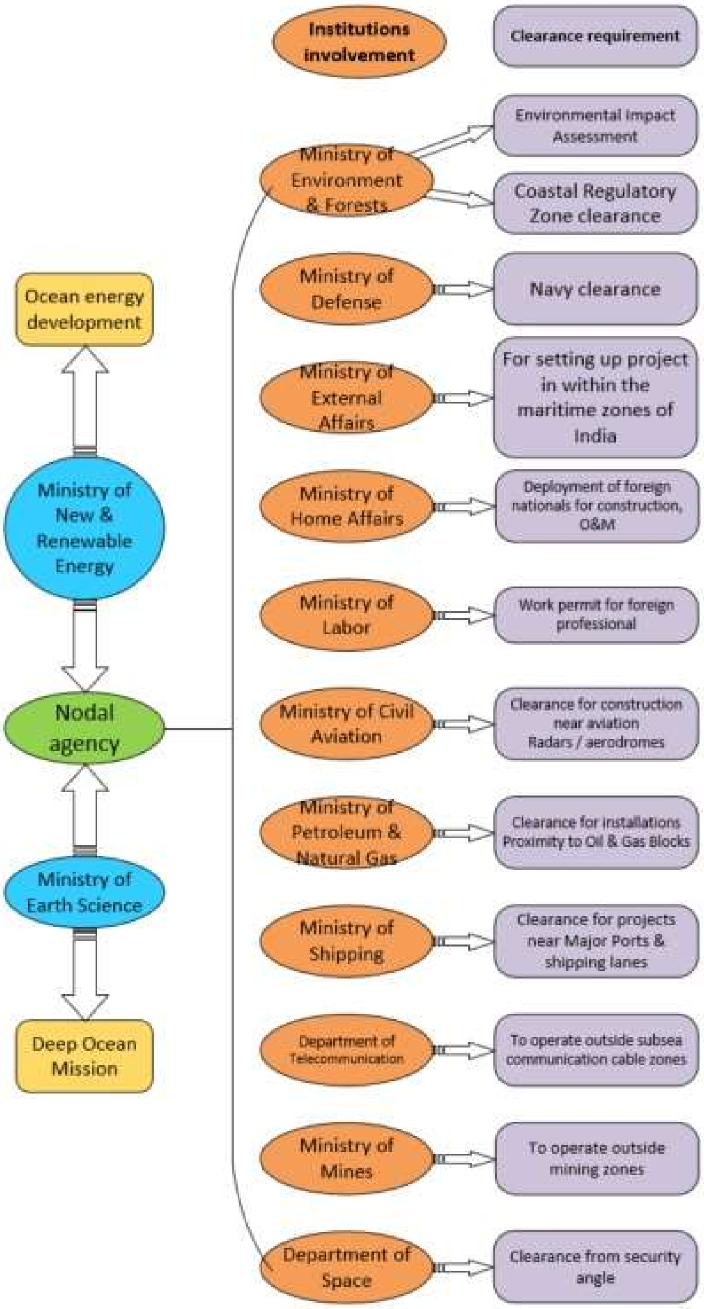

Figure 7-3 Probable Institutions engagement for OTEC development in India

7.2.2.2 Level 2: Developing Support System

This level comprises market & non-market incentives and logistics support. Like level 1, level 2 will also impact all the factors identified as discussed above.

7.2.2.2.1 Market & Non-market incentives

Market and non-market incentives comprise fiscal incentives, govt grants and subsidies. The measures taken by the government of the respective countries in dealing with these situations are described below,

The government must introduce various market and non-market incentives and policy processes to promote efficient technologies. The MNRE has just stated that OTEC would be acknowledged as RE. In addition, the ministry has classified ocean-based energy sources as non-solar renewable purchase obligations (RPO) that various businesses must meet(MoES, 2021).

From the experience of leading countries, the co-existence of REC and FIT, higher Tariff in the first ten years, support for commercialisation and scale-up, accelerated depreciation and support for energy and water-efficient technologies could go a long way to develop this technology in India.

These measures will attract investors to manufacturing, supply chain, new facilities, products, and services. Hence, a sustained business environment and thereby help set up a Competitive market and reduces cost due to policy commitment.

7.2.2.2.2 Logistics Support

Development of OTEC projects needs more broad and intricate supply networks than wind and solar PV. Increasing project scale and turbine rating impose stricter constraints on project logistics, facilities, and components, posing difficulties for offshore building techniques. The government can resolve these issues by introducing a supply chain policy and creating funding support to prioritise deployment, cost reduction, and industrial benefits. Supply chain policy, Grants and low-interest loans, and local content requirements can mitigate the gaps in the domestic supply chain.

Promoting local manufacturing through minimum local content requirements and grants and low-interest loans can help attract Investors to the manufacturing facility.

The government needs to act on prioritising cost reduction and industrial benefits and provision of local content as these go a long way towards establishing a solid Government & Industry interface, an opportunity for local businesses and innovators, increasing local content, and funds to help small and medium-sized enterprises enter the offshore renewable energy market.

7.2.2.3 Level 3: Creating Enabling Environment

This level comprises an enabling environment and environmental aspects. Level 3 will also impact all the factors identified as discussed above.

7.2.2.3.1 Enabling Environment

Research and development (R&D) capabilities can be described as availability of infrastructure, facilities, the latest technology, and other technical factors. The measures taken by the Government of the respective countries in dealing with these situations are described below. A range of Government interventions has been envisaged for OTEC development in the country to stimulate R&D activities.

- Considerable public funding must be committed towards academic institutions and research centres. The government's market pull initiatives will help in engaging the private sector.
- Market pull initiatives include market research, financial aid, individualised attention, close customer interface, and access to the technology centre network.
- Setting up the institutional framework for promoting the OTEC development such as a specialized training institution to provide funding support, advanced manufacturing research centre and advisory services.

- The establishment of a special fund to assist SMEs in participating in OTEC initiatives.
- Developing and providing support for building testing facilities for validating performance and improving designs before commercialization.
- At least in the first year, non-market incentives in the form of a hundred percent capital-nature R&D investment.

It is expected that the initiatives for building the R&D capabilities for the OTEC will help create dedicated support for R&D, making the network of institutions such as research institutions, Government and Private sectors etc. Furthermore, collaboration with industry will also help in technology commercialization, construction of projects, providing workforce to the industry etc.

Based on the experience from the leading countries, the government will have to provide research push through considerable funding support, market pull initiatives, engaging the private sector, a collaboration between different government bodies for promoting OTEC, providing grants for RET development, dealing specialising in manufacturing research activities, institutions involved in manufacturing advisory services, providing support for R&D expenditure. It is envisaged that these measures will provide infrastructure, facilities, the latest technologies, various business value chains, testing centres and capital support for R&D expenditure for developing OTEC in India.

In addition, the existing policy framework can also be used to develop OTEC in India. Specifically, the ‘Make in India’ policy of the Central Government already have a policy framework in place which can support the development of the OTEC, since this policy permits full Foreign Direct Investment (FDI) for RE projects through the provision of investment that can be attracted towards building R&D capabilities in the country. This policy also supports innovation and R&D with its start-up India initiatives. The existing ecosystem will help foster entrepreneurship and promote innovation in developing the R&D capabilities of the OTEC in India.

OTEC comprises sophisticated but risky offshore activities, which require personnel with a very high level of expertise. Thus, public funding may be directed towards educational institutions and specialised training centres catering to OTEC and other businesses closely associated with it.

A Marine Training Centre (with Government support) network must be set up to interface with education, research institute, and cross-functional organisation (within and between the project).

Those already working in the renewable energy industry who want to address knowledge gaps or further their careers by acquiring the specialised skills and information necessary to operate in OTEC. The knowledge gained is meant to augment the education and training of recent graduates of less specialist programmes who are seeking employment in OTEC.

The goal is establishing stable regulatory regimes in India to support the sector. Because of this, businesses will be able to put more money into education, retraining, and innovation. Another goal is to help companies that have transferable capabilities into the OTEC market, which will result in establishing a network of institutions for skill development. In this regard National Institute of Ocean Technology (NIOT) was established by the Ministry of Earth and Science; GoI was established to develop world-class technology, applications, knowledge base and institutional capabilities for sustainable utilization of ocean resources which can be leveraged to train professionals.

It has come to everyone's attention that one of the major obstacles to implementing OTEC in India is the lack of public awareness. Inadequate knowledge regarding both environmental and economic benefits, inadequate understanding of OETs, concerns about the lack of engagement with local populations and uncertainty about the projects' financial feasibility are two of the most prominent obstacles to the installation of OETs. Other challenges include their potential effects on the surrounding seascape and the environment.. Proposals for OTEC projects are frequently criticised by private residents, political leaders, national interest groups, grassroots organisations, and sometimes environmental groups. (Jianjun and Chen, 2014).

To mitigate this situation, the Consultation process can be initiated through the online portal by the Government / Marine Authority. Ministry of Earth Sciences (MoES) is an institution leading the Deep Ocean Mission of the Government of India, which is recently approved by the cabinet on 16-Jun-2021. Under this mission, the government has allotted INR 4,077 crore for the deep ocean mission(MoES, 2021).

The Indian government can create a specialized institution as a supporting arm of MoES to facilitate the deep ocean development, which will also take care of energy and fresh water from the ocean using OTEC under the mission

The extended activity of the Marine Authority would be to create public awareness and share information, an online interface to develop communication with the community and stakeholders, addressing the NIMBY syndrome, statutory consultation and setting up of information centres.

Possible solutions to these problems include distributing promotional materials, creating websites, and publishing articles in the public press to boost the technology's visibility. State and government initiatives could also be utilised to overcome these challenges. Raising awareness among the general population is essential if this new emerging technology will have any chance of becoming more widespread.

7.2.2.3.2 Environmental Aspects

The environmental implications of OTEC projects are highly dependent on the project's location, its layout, the architecture employed, and the technologies used. Because the structures linked with OTEC will be physically present in the sea, these structures will have environmental effects analogous to those of other offshore constructions. Negative environmental impacts can be avoided or mitigated by careful site selection and meticulous planning (which includes structural design, materials utilised, building procedures, and operating needs). OTEC may seem harmless since it does not involve the regular release of chemical pollutants or burning, but it really has far-reaching consequences on coastal processes, marine life, air and water quality, the visual environment, and geology, albeit to a lower extent. Also, the layout of the OTEC complex has caused several environmental problems that are one-of-a-kind. Before putting one of these into operation on a wide basis, considerable research is required. It is helpful to analyse these consequences in depth to ensure that they do not provide a prospective environmental hurdle, even though it is possible that they do not now appear to affect investment decisions in this technology. The following is a summary of some of the particular initiatives that India can intend to take, based on the experience gained from leading countries:

- Marine spatial plan
- Streamlined licencing regime
- Consent Procedure
- Support for site development

Because an offshore OTEC plant must rely on the transfer of electrical power via maritime cables, this might lead to disruptions in the natural environment and drive up the establishment's initial capital costs. Installing cables can cause physical changes to the habitat, which might have a short-term impact on the ecosystem. This can also result in the resuspension of sediments and the emission of electromagnetic fields. As a result, a monitoring method is suggested based on the experiences of leading countries. **Table 7-5** on the most important things to keep an eye on before, during, and after the installation of an OTEC plant. to detect and evaluate the environmental and socio-economic repercussions that it would cause off the coast of India. (Rivera et al., 2020).

Table 7-5 Primary factors for EIA monitoring adopted from (Rivera et al., 2020)

	Abiotic	Biotic	Social
OTEC	Discharge Plumes Pollutants Noise Electromagnetic fields	Marine commercial resources Specific interface with infrastructure Cetaceans' presence	Landscape changes Welfare before and after Public opinion/acceptance & Cost-benefit balance

CHAPTER 8– CONCLUSIONS & RECOMMENDATIONS

This chapter presents conclusion of the study, showing the need for framework developed for OTEC policy in India. It also discusses the findings, limitation of the study, recommendations, and future study direction. Like any other research work, this study has highlighted its contribution to knowledge. Therefore this chapter briefly discusses the important policy factors leading to its development, identification of important actors, processes, actions and performance based on experience and learning from leading countries. Finally, based on the factors identified, important stakeholders, processes etc. a linkage framework is developed which is further leading to development three stage policy framework for OTEC development in India.

8.1 Conclusions

As a policy choice, Ocean Energy (OE) has not got its due space in India despite the vast potential available in the country. International experience shows that the right policy intervention can help harness this technology and aid the ambition of going green. OE is a costly technology due to its high capital requirements and costly evacuation process, which often come in the way of developing this technology. However, there are inherent advantages of this resource, e.g., higher levels of Capacity Utilization Factor (CUF), less requirement of land, less variability, and benefits in the form of by-products like potable water, seawater air conditioning (SWAC), hydrogen, ammonia, methanol, concentrated CO_2, urea, NH_3, soda ash; Oxygen enriched air, and shellfish, etc., which can make this technology cost-competitive against other emerging technologies like offshore wind. It is only in the recent past (June 2021) that India announced the Deep Ocean Mission. This study has developed a suggestive framework for OTEC policy development in India based on an intensive analysis of the OTEC policy of twenty-one countries' essential factors for the development in India and the linkage framework. This study will support policymakers in developing OTEC as a suitable option for India to accomplish its ambitious goal of adding 450 GW of Renewable Energy by 2030. It has also drawn on international experience to suggest the essential ingredients of RE policymaking to boost OTEC. Reliance only on wind and solar sources might not be prudent for India, as constraints such as their intermittency, inability to provide baseload capacity support, high balancing cost, and substantial land requirements might derail the progress. There is an urgent need for diversification, and OTEC provides a viable alternative. The right kind of policy support is essential for this.

By employing SAP-LAP analysis, the learning experience of leading countries UK and France are mapped, which has provided various barriers and challenges in the development of OTEC, the critical variables for OE policy development, and the Linkage framework developed between the actors, processes, learnings, action, and performance to remove the barriers for OE development. The study has identified six(6) actors, seventeen (17) processes, thirteen (13) learnings, seventeen (17) actions, and thirteen (13) performances.

Further, this study was extended to understand the policy development for OTEC in the Indian context. The techno-economic analysis in the study has analyzed the financial and economic viability of the OTEC projects, including electricity generation and other revenue-generating applications. The results suggest that if OTEC plants are developed with larger capacity and other revenue-generating applications, then OTEC can compete with other RETs. This has raised the question of policy support for OTEC development in the country. Therefore, this study extends the use of Factor Analysis to identify critical factors for policy development.

As a result, six factors for the policy intervention (based on variables explored from the policy reviews of twenty-one countries) have been identified: government support, capacity-building for research and skill development, financing mechanisms, economical tools for OTEC projects, promotion of local content, regulatory and fiscal incentives. Policymakers could help overcome high evacuation costs through the socialization of such costs. Similar dispensation has already been extended to wind and solar by waiver of inter-

State transmission charges and losses. This has helped the growth of these resources. For investor confidence, policy certainty and continuity in terms of financial and fiscal support are needed. There should be a clear roadmap and policy assurance regarding the specific support (like capital subsidy, generation-based incentive, performance-linked incentive, tax relief, etc.) and the period for which such support is extended. Priority sector lending for OTEC can substantially reduce cost because the loan component constitutes about 70-80% of the total project cost. Equally important is regulatory support in the form of a demand-side framework (Renewable Purchase Obligation or RPO), supply-side intervention (Feed-In Tariff), and technical support through R&D and proper resource assessment. RPO creates demand, and FIT gives long-term certainty of cost recovery for the developers. These instruments have been used in several markets globally to encourage RE, especially in the initial phase of developing an RE technology. R&D support is critical for a breakthrough in technological advancement and eventually leads to cost reduction and acceptability. A robust policy around these factors would go a long way in helping India attain sustainable development goals.

Although all the factors identified are essential for the competitive advantage, it is also important to understand which factor should be focused on more by the policy makers. Therefore, the study has also evaluated the priority of the factor by using a logistic regression model. The stakeholders have given top priority to capacity development and skill development. While second and third priority was given to Regulatory and Fiscal Incentives Government Support, and so on.

With the help of the steps discussed above, the study has given a suggestive framework by using SAP-LAP analysis and e-IRP method. The study has ranked the actors with the help of the e-IRP method in the following order Government, Developer, Research Centers, Academic Institutions, Third party / TSO, and Private Institutions are an essential decision makers for developing OTEC in India. The stakeholders have also suggested the critical policy processes which can support the need for institutional setup, Exclusive

Economic Zone (EEZ), backward linkages, Capacity augmentation, Industry collaboration, institution set up, Stage-gate funding, Dedicated Ocean energy fund, Policy process, Exemption of Climate Change Levy for buyers, Lease payment for sites, Exclusive economic zone set up, Consenting, Grants and low-interest loans, International competitive bidding, Set up of Test Centre, Linkage between Government, education, research institute and market players, Public collaboration, Environmental impact assessment, and Consultation, etc. The linkage between Government, education, research institute, and market players are found to be one of the critical enablers for the development of OTEC in India.

Based on the above analysis, the study conceptualizes three-stage analysis frameworks to develop OTEC in India. This framework consists of essential factors responsible for OTEC development in the country, identifying important actors, analyzing actions to be taken for the OTEC development, and suggesting processes for the practical implementations of the actions/decision taken by the policy makers, stakeholders, etc. The framework for OTEC development in India divides the critical factors responsible for OTEC development into three levels Setting up policy and institutional framework, Developing a support system, and Creating enabling environment. Each level recommended the interventions in the form of actors, actions and processes.

This study has provided essential inputs and conceptualizes the framework for the Ocean Energy development in India if implemented; then this framework will help to harness renewable energy effectively and will contribute in a big way to the country's transition to net zero emission. Apart from this, the study has also filled the theoretical gap in understanding the role of policy in natural resource utilization for competitive advantage.

This study is also a basis for a number of researchers, such as setting up an efficient value chain of market players, linking the buyers and sellers' market for electricity generation for value-added products, technology transfer, aligning the benefits for hydrogen energy generation, and many more.

8.2 Limitations

Research is focused only on OTEC. It means that the other technologies in Ocean Energy family has npt been considered. The study's results are based on information gathered from the stakeholders in India who are interested in the growth of RE. Therefore, the factor analysis results followed by logistic regression, SAP-LAP, and eIRP analysis are obtained from Indian geography. Thus the results cannot be inferred for other geographies. OTEC is at a very initial stage in India. With time, the learning curve for the survey stakeholders may give importance to other factors about the OTEC in India. Thus, the survey results may be different after incorporating the learning curve because the survey is perception based.

This study has not considered carbon credit concession. Thus, the overall NPV and IRR are calculated without the carbon credit valuation.

This research data used for ocean economic analysis in the study has been taken from official sources available in a limited manner.

8.3 Directions for Future Research

Detailed research can be carried out to explore the viability, investment risks/incentives and policy imperatives to develop OTEC to meet India's energy needs by RE.

As the OE sector in India is evolving, quantification of each factor in the logistic regression equation can be further explored and incorporated into the equation to further asses the probability of growth in subsequent studies.

The techno-economic analysis is done at an elementary level. India's OE potential spread across a 7500 km sea shore area from Gujarat to Kanyakumari to Bengal. A detailed study can be carried out for each of the feasibility areas. A deeper sensitivity analysis can be conducted to arrive at the feasibility analysis of OE in India that mimics the exact site conditions, factoring in different configurations available in the market etc

Research on the possibilities of technology transfer of various plants and equipment associated with OTEC should be considered.

Future researchers should study various business models associated with the entire value chain of the OTEC business.

This study has not taken the quantification of carbon credit as a part of the study. However, future research can consider the implications of carbon credit on project viability.

8.4 Recommendations

The following are some suggestions for fostering the development of OTEC in India.

India should establish a nodal organisation, led by the MNRE and the MoES, to serve as the central clearinghouse for all OTEC project approvals and to coordinate with other government departments as needed. Developers that have already invested much in OTEC projects may not be able to afford additional delays in the projects' commissioning due to onerous regulations.

Thus, this study proposes a nodal agency which will liase with eleven ministries and departments such as the Ministry of Environment & Forest for environmental impact assessment and coastal regulatory zone clearance, the Ministry of Defence for navy clearance, the Ministry of External Affairs for setting up a project in the maritime zone in India, the Ministry of Home Affairs for the deployment of foreign nationals for construction and O&M, the Ministry of Labor for work permit for foreign professional, the Ministry of Civil Aviation for clearance for construction near aviation radars, the Ministry of Petroleum & Natural Gas for clearance for installation proximity to oil & gas blocks, Ministry of shipping for clearance for projects near major ports and shipping lanes, the Ministry of Mines to operate outside mining zone, the Department of Telecommunications to operate outside subsea communication cable zones, the Department of Space for clearance from security angle has to be contacted in order for OTEC project developers to receive approval (refer to **Figure 8-1**).

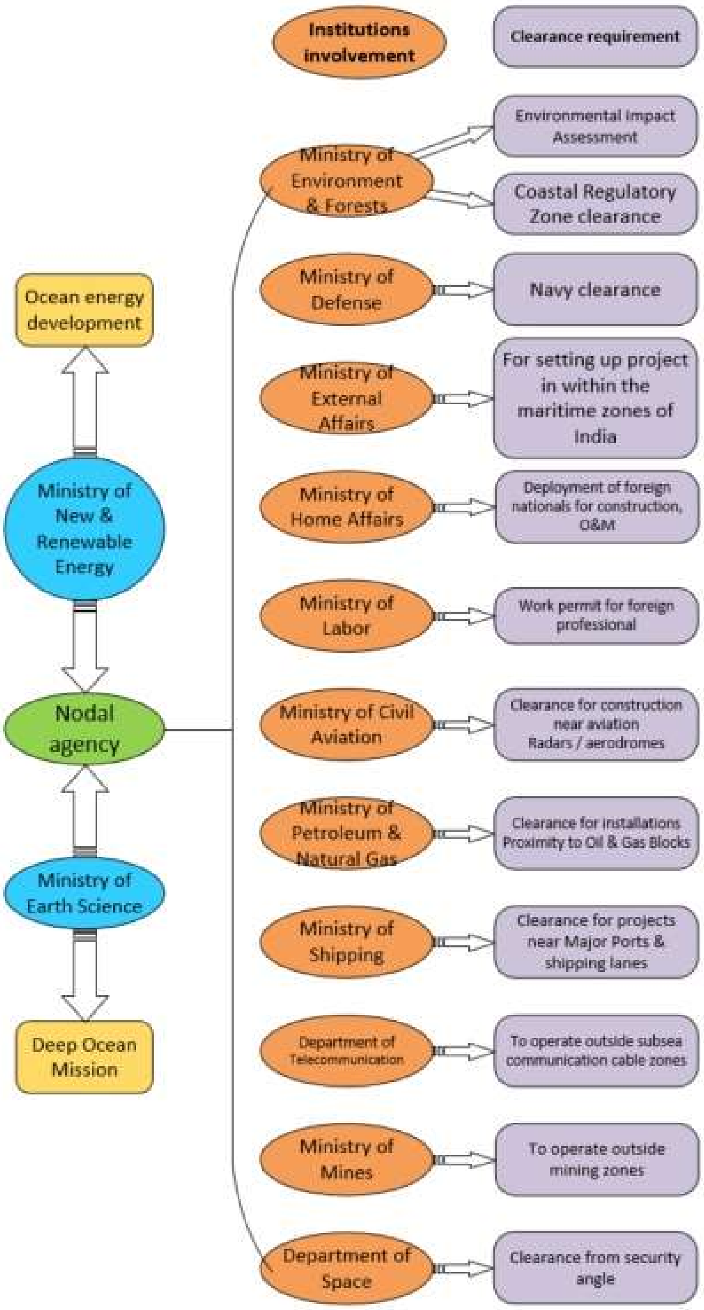

Figure 8-1 Interface of Ministry & institutions for OTEC development

Encourage data sharing among stakeholders on temperature gradient and potential: With reference to the results of the e-IRP analysis, the experts have recommended that the industry collaboration, Institution set up, Exclusive economic zone set up, Set up of Test Centre, linkage between Government, education, research institute and market players etc. are the practices through which the data collection centre, site identification centre can be developed and a strong interface between them can encourage the exchange of important information on temperature gradient, depth of sea, wind flow and potential at the site. The nodal agencies can develop a platform with the help of NIOT, the National Institute of Wind Energy (NIWE), and research centers and academic institutions which can collect and share data on temperature gradient and potential at sea to determine OTEC's true potential. Estimating the power production of these projects, which determines the cash flows and the project's feasibility, relies heavily on temperature gradient and potential. Since the power generated by these fluctuates in proportion to the cube of the wind speeds, even small errors in calculating the wind speeds can have a significant impact on the actual power generated. This is why precise wind speed forecasting is essential..

Grid connectivity: Experts warn that inadequate evacuation infrastructure is a major roadblock for OE initiatives. Also, OTEC projects have to pay a lot for transmission infrastructure since installing sub-sea cabling necessitates a high level of engineering expertise. For instance, the cost of grid connection in onshore wind farms, as a percentage of total costs, is 2-9%, while the cost of grid connection for these projects as a percentage of overall project costs is 15-30%. Therefore, based on expert opinion through e-IRP analysis, it is recommended that Zoning approach and One stop shop, Collaboration with TSO, Institution building, Backward & Forward Integration can help the actors such as Government, Developer and Third party / TSO to develop evacuation infrastructure. It is also recommended that the cost involved can be generated through the practices such as slight increase in tariff, exemption of Climate Change Levy (if applicable), lease payment for sites, exclusive economic zone set up, Consenting.

Create and disseminate a 10-year or longer policy vision: With reference to the results of the e-IRP analysis, the experts have recommended that policy development should focus on installation cost, financing mechanism, market incentives, long-term visibility and dedicated Ocean Energy policy, Grid connection, supply chain development, ensuring accurate data on OE potential sites, building R&D capabilities, developing experienced professionals, public awareness and information sharing, and Environmental protection. The experts have also recommended that the policy developed should be able to communicate with different stakeholders such as Government, education, institute, research centers, market players. collaboration with public and consultants.

In addition to the published research findings, additional research has shown that countries with focused policies for OTEC projects and countries with "Traffic signal" type of start-wait-stop-start policy measures have seen greater growth in this sector. Investment risk is mitigated when investors know the government will continue to back the industry over the long term through stable policy.

Encourage R&D in this sector: Concerning the results of the e-IRP analysis, the experts have recommended that the R&D should be supported through grants/subsidies for demonstration projects to reduce production costs. In addition, collaboration with Government agencies, R&D centres and other stakeholders. The policymakers should also focus on building linkages between Government, education, research institute and market players.

India should support R&D initiatives to hasten education, lower component costs, create a knowledge base, cultivate expertise in OTEC projects, and bring manufacture of key components back home. For every extra MW of capability, OTEC would need an additional 20 resources. Therefore, India will require around 1 million educated and competent human resources if it is to achieve its goal of harnessing 50,000 MW of OTEC in the coming years.

To promote skill development in RE, India has begun positively by establishing NIOT under MoES, NIWE, and CWET (Centre for Wind Energy Technology) under MNRE. To hasten the expansion of the OTEC sector in India, it is necessary to invest in R&D to domesticate the manufacture of components presently imported at exorbitant costs and establish auxiliary facilities to support the sector. The cost of establishing OTEC in numerous

European nations, for instance, has been decreased because to localization of manufacturing. So, to get the same results, India has to strengthen its research and development capacity.

Market and non-market incentives for OTEC: Concerning the results of the e-IRP analysis, the experts have recommended that OTEC to become established as an alternative channel for power generation, India would require a larger incentive (higher Feed Tariff relative to another renewable) at least in the early few years. Market and non-market incentives are closely intervened with policy processes; for example, special capital grants can be given through policy provision to facilitate OE projects in the initial phase. In addition to this dedicated OE policy, Sprinter Incentive for Early Finish, Public investment, loans, or grants, Accelerated Depreciation, Sunset clause, Ocean energy targets, Detailed resource assessment, etc., be considered.

The experts have brought out the recommendation given below during the interviews.

Payment procedure that can be enforced by law: Due to the lack of a legally enforceable payment mechanism, wind farm developers in India have faced considerable delays in getting payments from the state distribution companies/electricity boards that purchase the power generated by these facilities. The delay has devastated the financial flow and working capital of the project's developers. The whole feasibility of an OTEC project might be jeopardised if the money is not released on time, as these projects require significantly more cash than other RE projects. Most of India's distribution firms are in terrible financial shape, severely limiting their ability to make on-time payments. If the state power boards or distribution firms default or are late in paying the project developers, the developers have little recourse. Therefore, the project developers must be given adequate legal protections to ensure they get their funding on schedule from the SEBs. The lack of a legally binding payment system will provide project developers with the required protection and escalation mechanism for issue resolution in the case of extreme accounts receivable delays.

India has the resources necessary to propel OE's rapid expansion, including the necessary technology, market, potential, and funding. We need a solid policy structure.

8.5 Contribution to Theory

Many people now acknowledge the importance and value of the Resource-based Theory(J. Barney, 1991; J. B. Barney, 2002). This strategic resource fits neatly into the framework of the theory because of its central tenet of using natural resources to attain a predetermined end.(Mahoney, 1995; Nair et al., 2008; Region, 2020). However, though literature discusses that policy plays an essential role in the efficient use of natural resources in a nation's context, the approach to how policy can help in the effective and efficient utilization of ocean energy (natural resources) has not been adequately discussed. Although natural resources are critical in achieving competitive advantage, they are not enough alone to sustain it. In this regard, literature discusses that policy is essential in efficiently using natural resources in a nation's context.

This research is an attempt to explore critical factors that should be integral to the policy framework to harness natural resources to create a competitive advantage.

- Capacity building for research and skill development: This is a critical factor for developing natural resources in the country. It refers to the R&D support for developing technology, gathering critical technical information, training human resources, and building industry and academic institutions' value chain and network.
- Regulatory and Fiscal Incentives: Since it is established from the literature, developing a natural resource in the country has been capital intensive and hence unviable for individuals to use. Therefore, the study

has indicated that the Government will have to play a key role in the resource development and create a mechanism to provide financial support to create a market for the resource.

- Government Support: The Government should prioritise the factors related to developing, enabling a nurturing environment for R&D and skill development, financing for developing indigenous technology, attracting value chain stakeholders and value chain market etc., in the country.

The study introduced the country's policy pathways for natural resource development with the help of a linkage framework. This framework has developed pathways through actors and processes, actions and performance. This framework has identified vital actors and processes, suggested the required actions, and estimated the expected performance.

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Appendices

Appendix A. Survey Questionnaire

Sl. No.	Survey	Duration of Survey
1	Pilot Survey	Jan 2020
2	Survey	Apr – May 2020

Thank you for taking the time to answer a set of questions on the Ocean energy (OE) sector in India. There are no right "or wrong" answers to these questions. You are requested to provide data on a ratio scale which means the options will give relatively better choices(Strongly disagree < Disagree < Neither Agree or Disagree < Agree < Strongly Agree). Also, your exact identity will not be captured. So please feel free to respond to the best of your belief and conviction. The data collected are meant for academic/research (under the aegis of the University of Petroleum & Energy Studies (UPES), Dehradun) purpose and aimed at eliciting views of stakeholders on the factors to promote Ocean energy (OE) in India.

Questions may be answered by signing (√) in the boxes against each such question.

No.	Issues/Factors	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
1	India has good potential to grow the **Ocean energy (OE)** sector in the country					
2	For Ocean energy sector to take-off, **comprehensive OE policies** must be initiated by the Government of India					
3	Currently, technology and capability are available to harness the OE in India					
4	**Capital and funds** are available to develop the OE sector in India.					
5	**India has to eventually tap OE to satisfy** the ever-growing demand for electricity in the country.					

No.	Issues/Factors	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
6	**Feed-in tariffs** are an absolute must to grow the OE sector in India.					
7	**Accelerated depreciation** has to be offered to grow the Indian OE sector.					
8	**Generation based incentives (GBI)** must be offered to grow the OE sector in India.					
9	**Legally binding Renewable purchase obligation (RPO/REC)** is an essential prerequisite to see the growth of the OE sector in India.					
10	**Faster approvals (like Single window clearance mechanisms)** are an absolute must‘ to grow the OE sector.					
11	**Sustainability of policy environment, on OE, for a longer-term (say 10 years or more)** is very important to accelerate the growth of the OE sector.					
12	**Construction of transmission infrastructure** to evacuate power from OE farms in the seas is an important prerequisite for growing the OE sector.					
13	**Extending financial incentives** (like subsidies, moratorium on interest payment, zero duty on imports, excise duty waiver) for OE projects is a must.					
14	**Tariff determination on different factors such as water temperature, wind speeds, and not based on zones,** is an essential pre-requisite for the growth of the OE sector					

No.	Issues/Factors	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
15	**Capability, Expertise, and availability of EPC contractors for commissioning of the OE projects** will be a determining factor in the growth of the OE sector in India					
16	**Manufacture and availability of OE components (main equipment/gearbox),** locally, will be very important to grow the OE sector in India					
17	**Growth of ancillary units** is key to grow the OE sector in India					
18	**Superior program execution skills and capabilities available** for execution of projects is critical to grow the OE sector in India					
19	**Research institutions to build accurate data on OE potential sites** (seawater temperature gradient and Bathymetric data) is critical to grow the OE sector in India					
20	**Institutions focusing on Skills development and training of the human capital, needed to work on OE projects**, will be needed to grow the OE sector					
21	**R&D investments to localize production of expensive equipment, to bring the overall costs down,** will be crucial to grow the OE sector in India					
22	**Availability of capital at attractive rates of interest, similar to what is extended to priority sector projects, is an absolute must'** to grow the OE sector in India					

No.	Issues/Factors	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
23	**Moratorium on interest payments for the first 5 years of the project go-live,** is needed to grow the OE sector in India					
24	**Creation of an OE fund, from cess, levied on carbon emissions or a Government backed guarantee to reduce the cost of capital,** will be needed to grow the OE sector					
25	**Access to funds (from financial institutions) is not a problem** to set up the OE project in India.					
26	**Declaring the OE sector as a priority sector for lending** will help in the growth of OE in India					
27	**The OE sector can still grow in India** without dedicated policies for the sector.					
28	**It's still premature to talk about OE in India.** Time has not come yet to tap the OE in India.					
29	**OE policies adopted successfully by select developed and European countries (The USA, the UK etc.)** can be used as a reference by India for bringing out its own Ocean energy policy.					
30	**I/my company will not consider investments in the OE sector in India** until dedicated OE policies are put in place in India.					

Appendix B. SAP-LAP Protocol for Inquiry

SAP–LAP	Questions
Situations	▪ What is the current status of OTEC development in India? ▪ What are the different initiatives adopted to promote OTEC in India? ▪ What are the present issues hindering the growth of this sector?
Actors	▪ Who are the key actors in the development of OTEC in India?
Processes	▪ What are the key processes adopted to promote OTEC in India?
Learning	▪ What are the challenges with respect to the current situation? ▪ What are the challenges with respect to various policies for OTEC development in India? ▪ What are the challenges faced by various actors in developing OTEC in India?
Actions	▪ What are the actions that need to be taken to address the challenges and issues impeding OTEC development in the country?
Performance	▪ How are these proposed actions going to affect the current scenario of OTEC development in India? ▪ What will be the potential impact of these actions on key influencers or actors of OTEC development in India? ▪ What will be the potential impact on various processes of OTEC development in India?

Appendix C. Opinion Survey for Framework

Dear Sir,

As you are aware India has recorded remarkable economic growth during the last decade. Access to reliable and affordable electricity is one of the major inputs to economic growth and development. To maintain the accelerated economic development, coupled with huge population growth with the increased use of per capita electricity consumption, India needs to increase its installed capacity to 1650 GW in 2050 from 360 GW at present. The last 10 years' growth in renewable energy in India is remarkable, however, the majority of the contribution is from wind and solar-based renewable energy sources, and there has been no contribution from the ocean energy sector (OTEC/ tidal/wave/salinity gradient) as yet. India has about 7500km long coastline with estuaries and gulfs to harness this energy of about 229,000 MW. India needs a policy framework to encourage the development of ocean energy farms. To accelerate the growth of their ocean energy sector, several countries, most notably the USA, Japan, Korea, and the European Countries, have implemented effective ocean energy policies.

It is in this context that a set of questions for the interview have been prepared (as shown below). These questions are meant for academic/research (under the aegis of the University of Petroleum & Energy Studies (UPES), Dehradun) purpose and aimed at eliciting views of stakeholders on the factors to promote Ocean energy (OE) in India.

We would appreciate if you could spare some time out of your schedule to answer the questionnaire and send them back to this email ID at an early date.

Regards,

1. Questionnaire

These questionnaires are meant for academic/research purposes and aimed at eliciting views of stakeholders on developing a suggestive framework for OTEC policy in India.

Questions:

1. What according to you are the reasons (Government specific) for delay in implementation of Ocean Energy (OTEC) policy in India?
2. In your opinion, what will be the critical factors affecting OTEC growth in India?
3. What would you suggest initiating the comprehensive OTEC policies in India?
4. What are your observations regarding the capabilities, availability of manpower, and expertise for executing of the OTEC projects in India?
5. What measures would you recommend for developing evacuation infrastructure and trained manpower and technology etc. for the OTEC sector in India?
6. What would you suggest for financing the OTEC project?
7. What are your opinions and related experience on OTEC projects planned/started in India?
8. What enabling environment to do you wish to visualize for the development of OTEC in India?

Appendix D. Cross-interaction matrix (CIM) of actor versus process relationship

		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
		Cross-interaction matrix (CIM)																
Government (A1)	A1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Developer (A2)	A2	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Third party / TSO (A3)	A3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Academic Instituitions (A4)	A4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Research Centres (A5)	A5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Private Instituitions (A6)	A6	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Interpretive matrix																	
Government (A1)	A1	Facilitate capacity augmentation through government policies.	Promote industry collaboration through better Government, Inductry interface.	Setting up instituitions to drive the OE growth	Facilitate technology development value chain from lab scale to commercialization level.	Creating funding support committed to OE development	Strong policy support can help in OE development	NA	Lease payment for site can develop confidence among industry players	Establishment of EEZ can support in minimizing the project	Consenting procedure can promote zoning approach	Introduction of non market incentives helps in minimising cost and maximising cash flow	Benchmarking with international standard attracts competent stakeholders	Providing support to the test centres can make technology development fast	Facilitating interface between Government, academia, research centre and market	Promotion of awareness with public	Setting up of compliance of EIA can develop the sector effectively	Creation of statuatory platform for public awareness can develop public awareness

Developer (A2)	A2		Promototion of Industry collaboration can support the devlopers											Collaboration facilitation between the Government and the developers can support in setting up of the test centre				
Third party / TSO (A3)	A3		Industry collaboration can facilitate the transmission operation															
Academic Instituitions (A4)	A4		Industry collaboration with academic can help in technology and capacity development															
Research Centres (A5)	A5		Industry collaboration with research centre can help in technology development															

Private Instituitions (A6)	A 6		Industry collaboration with private instituitions can promote faster backward integration															

Appendix E. Cross-interaction matrix (CIM) of actions versus performance

		P*1	P*2	P*3	P*4	P*5	P*6	P*7	P*8	P*9	P*10	P*11	P*12	P*13	P*14
	Binary matrix														
Introduction of Roadmap	A*1	0	0	0	0	0	0	1	0	1	0	0	0	0	
Setting up the Target	A*2	1	1	1	0	0	0	1	0	1	0	0	0	0	
Establishment of Government backed FI	A*3	0	0	1	0	0	0	1	0	1	0	0	0	0	0
Use of fiscal support	A*4	1	0	1	0	0	1	0	0	1	0	0	0	0	0
Adoption of National Renewable Energy Action Plan (NREAP)	A*5	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Integrated National Energy And Climate Plan	A*6	0	0	1	0	0	1	0	1	1	0	0	0	0	0
Use of market incentive	A*7	1	0	1	0	0	0	0	0	1	0	0	0	0	0
Introduction of non-market incentives	A*8	0	0	0	1	1	0	0	0	1	0	1	1	0	0
Development of Dedicated instituition	A*9	0	0	1	0	0	1	0	1	1	0	0	0	0	0
Adoption of enabling environment	A*10	0	1	1	0	0	0	1	0	1	0	0	0	0	0
Improvement in data creation	A*11	1	0	1	0	0	0	0	0	1	0	0	0	0	0

Establishment of dedicated fund set up	A*12	0	0	0	0	1	1	1	0	1	0	0	1	1	1
Promotion of capacity building	A*13	0	1	0	0	1	1	0	0	1	0	0	1	1	1
Building institute for public awareness	A*14	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Development of dedicated Fund	A*15	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Creation of energy information spaces	A*16	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Establishmen t of environment al authority	A*17	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Introduction of Roadmap	A1						Roadmap can facilitate long term visibility		Long term visibility can support to the efficient market		Roadmap for OE developmen t can help in large capacity addition				
Setting up the Target	A2	Target setting facilitates reduction in long term cost					Target setting for OE can facilitate long term visibility				Long term targets can giive better clarity to the investors				
Establishment of Government backed FI	A3						Special provision for long term visibility can facilitate certainty in decisions				Long term visibility can reduce the risk perception and hence will help in rapid caapcity addition	Long term visibility can make the instruments more effective.			

Use of fiscal support	A4	Provide capital support hence reduced cost		Green Investment Bank and Public Investment Bank are the specialised instituitions for OE project funding			Dedicated Fis can develop confidence of the investors	Provision of Fis can attract the investors attention		Establisgment of specialised financing instituitions can devlop the market	Dedicated and speialised funding instituitions can boost the caapcity addition	Implementation of instruments is possible through Government backed FI.			
Adoption of National Renewable Energy Action Plan (NREAP)	A5						Action plan can provide clarity to investors				Dedicated action plan for OE development can mobilise the reseources for large caapcity addition				
Integrated National Energy And Climate Plan	A6						Specialised instituitions can support better to the eco system	Creation of specialised instituitions can facilitate the coordination hence promote the investment environment		1/1	Creation of committed instituitions can develop a better coordination among the stakeholders and hence can speed up the capacity addition				1/1
Use of market incentive	A7	Promotion of efficient market incentives devlops commecial viability	Regulatory support for tariff can help in earning better cash flow				Efficient market mechanism can boost the investors confidence		Market development trajectory can be achieved through consistent policy	1/1	Market development can direct the large capacity addition	Introduction of efficient market practices can make the instruments more effective			
Introduction of non-market incentives	A8				Support to extend supply chain can create support for	Facilitates backward integration and investment in supply chain	1/1				The integration of backward and forward supply chain can facilitate the large caapcity addition			The integration of backward and forward supply chain can attract local	

					additional income									business and innovators	
Development of Dedicated instituition	A9		Facilitates to reduce capital acquisiotion cost	Dedicated fuding has helped to cover high capital expenditure and reduced rate of interest.			1/1	1/1			Creation of financing support can attract more investors for capacity addition.	Integration of dedicated fuding with market and non-market incentives can make the projects more economically and commercially viable.			
Adoption of enabling environment	A10		Can attract the investors	Declaring OE as a "priority sector" would increase investment attractiveness and ease accessibility to funds			1/1		Providing special stattsu to OE can provide accessability and attractiveness to the investors	Creation of financing support can attract more investors for capacity addition.	Declaring OE as a "priority sector" can increase investment attractiveness and ease accessibility to funds	Declaring OE as a "priority sector" can increase investment attractiveness and ease accessibility to funds			Instituitional engagement with public can reduce the NIMBY syndrome and hence can facilitate capacity addition
Improvement in data creation	A11	Promotion of efficient non market incentives devlops commecial viability	Facilitates enhanced cash flow through non cash expenses	Fiscal support such as grants and tax incentives rduced upfront installation cost			Non market incentives can help in managing the high installation cost		Fiscal support such as grants and tax incentives can reduce upfront installation cost	Integration of dedicated fuding with market and non-market incentives can make the projects more economically and commercially viable.	Fiscal support such as grants and tax incentives can reduce upfront installation cost	Fiscal support such as grants and tax incentives can reduce upfront installation cost			
Establishment of dedicated fund set up	A12					Instituitional set up can facilitate the enabling environment	1/1	1/1			One stop shop solutions can facilitate the equipment manufacturing and supply chain development		Support environment can facilitate the equipment manufacturing and supply chain development	Support environment can facilitate the equipment manufacturing and supply chain development	Support environment can facilitate the equipment manufacturing and supply chain development

Promotion of capacity building	A13					Facilitates the market developmen t oppertuniti es for the indirectly associated inductry palyers	1/1	1/1			Better Government-industry collaboration can reduce OEMs risk and can facilitate the OE operators		Support environment can facilitate the equipment manufacturi ng and supply chain development	Better Government-industry collaboration can reduce OEMs risk and can facilitate the OE operators	Better Government-industry collaboration can reduce OEMs risk and can facilitate the OE operators
Building institute for public awareness	A14						1/1				Instituitiona l engagement with public can reduce the NIMBY syndrome and hence can facilitate capacity addition				
Development of dedicated Fund	A15						1/1				MSP directive frameowrk can provide guidelines to the developers and hence will promote the capacity addition.				
Creation of energy information spaces	A16						1/1				Committed efforts to create infrastructu re will give better clarity to the developers				
Establishmen t of environment al authority	A17						1/1				The instituition set up for OE developmen t can create better awareness among community				

Appendix F. Different types of dominance interactions (actor vs processes

	Implicit dominance	Implicit non-dominance	Interpretive dominance	Transitive dominance	Total comparison	% Interpretive comparison
P1	5	5	0	0	10	6.45%
P2	10	6	4	0	20	12.90%
P3	6	5	4	0	15	9.68%
P4	5	5	0	0	10	6.45%
P5	5	5	0	0	10	6.45%
P6	5	5	0	0	10	6.45%
P7	0	0	0	0	0	0.00%
P8	1	1	0	0	2	1.29%
P9	3	1	0	0	4	2.58%
P10	3	1	0	0	4	2.58%
P11	5	5	0	0	10	6.45%
P12	3	0	3	0	6	3.87%
P13	5	0	5	0	10	6.45%
P14	6	3	8	3	20	12.90%
P15	5	0	5	0	10	6.45%
P16	2	2	0	0	4	2.58%
P17	5	5	0	0	10	6.45%
Total	74	49	29	3	155	100%
%	47.74%	31.61%	18.71%	1.94%	100%	

Appendix G. Different types of dominance interactions (actions vs performance)

	Implicit dominance	Implicit non-dominance	Interpretive dominance	Transitive dominance	Total comparison	% Interpretive comparison
P1	60	72	6	0	138	8.04%
P2	15	15	0	0	30	1.75%
P3	66	72	0	0	138	8.04%
P4	62	77	14	0	153	8.91%
P5	59	55	12	0	126	7.34%
P6	0	0	0	0	0	0.00%
P7	64	52	14	0	130	7.57%
P8	64	53	13	0	130	7.57%
P9	66	52	12	0	130	7.57%
P10	77	49	13	4	143	8.33%
P11	80	52	15	3	150	8.74%
P12	42	45	0	0	87	5.07%
P13	136	136	0	0	272	15.84%
P14	45	45	0	0	90	5.24%
Total	836	775	99	7	1717	100%
%	49%	45%	6%	0%	100%	

Appendix H. Dominance index—ranking of actors w.r.t. processes

	A1	A2	A3	A4	A5	A6	D	Net dominance value (D-B)	Adjusted net dominance (AND)	Dominance index	Rank
A1	-	16	14	13	12	11	66	49	63	58.3%	1
A2	4	-	4	3	3	3	17	-5	9	8.3%	2
A3	4	2	-	0	0	1	7	-13	1	0.9%	5
A4	3	2	1	-	0	1	7	-10	4	3.7%	4
A5	3	2	1	1	-	1	8	-7	7	6.5%	3
A6	3	0	0	0	0	-	3	-14	0	0.0%	6
B	17	22	20	17	15	17	108				

Appendix I. Dominance index—ranking of actions w.r.t. performance

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	D	Net dominance value (D-B)	Adjusted net dominance (AND)	Dominance index	Rank
A1	-	8	11	11	12	12	6	11	11	11	11	12	9	8	5	3	3	144	140	217	23.0%	1
A2	0	-	5	5	5	5	6	6	7	7	7	7	1	1	1	3	1	67	40	117	12.4%	4
A3	2	6	-	10	8	9	9	9	9	8	9	9	2	1	1	1	1	94	56	133	14.1%	3
A4	2	3	5	-	9	11	5	9	12	9	12	11	2	2	1	2	2	97	36	113	12.0%	5
A5	0	1	6	7	-	12	4	11	11	11	11	12	12	9	4	2	2	115	71	148	15.7%	2
A6	0	2	6	3	2	-	1	4	6	6	4	11	3	8	3	2	2	63	19	96	10.2%	6
A7	0	1	3	2	2	5	-	3	5	4	4	3	3	3	1	1	1	41	-23	54	5.7%	13
A8	0	2	2	3	0	5	0	-	8	1	1	2	8	1	1	1	1	36	4	81	8.6%	9
A9	0	3	3	7	0	7	3	5	-	11	10	11	2	1	1	1	1	66	-9	68	7.2%	10
A10	0	3	3	8	0	5	0	7	0	-	10	11	10	10	3	4	4	78	5	82	8.7%	8
A11	0	3	3	7	7	5	4	9	8	8	-	11	2	1	1	1	1	71	6	83	8.8%	7
A12	0	3	2	8	7	0	0	9	7	0	0	-	3	2	1	2	2	46	-22	55	5.8%	12
A13	0	0	0	1	0	0	0	3	0	0	0	0	-	2	1	2	2	11	-77	0	0.0%	17

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	D	Net dominance value (D-B)	Adjusted net dominance (AND)	Dominance index	Rank
A14	0	0	0	0	3	0	0	0	0	0	0	0	0	-	1	2	2	8	-40	37	3.9%	16
A15	0	0	0	0	1	0	0	0	0	0	0	0	0	0	-	1	1	3	-38	39	4.1%	15
A16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	2	2	-18	59	6.3%	11
A17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	0	-25	52	5.5%	14
B	4	27	38	61	44	64	32	75	73	65	68	88	48	41	20	25	25	942				

Appendix J. Pair-wise dominance of actors for different processes

P1

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

P2

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	1	1	1	1
A3	0	0	-	-	-	1
A4	0	1	1	-	-	1
A5	0	1	1	-	-	1
A6	0	-	-	-	-	-

P3

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	1	1	1	1
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	1	-	-
A6	0	-	-	-	-	-

P4

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

P5

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

P6

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

P7

	A1	A2	A3	A4	A5	A6
A1	-	-	-	-	-	-
A2	-	-	-	-	-	-
A3	-	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P8

	A1	A2	A3	A4	A5	A6
A1	-	1	-	-	-	-
A2	0	-	-	-	-	-
A3	-	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P9

A1 A2 A3 A4 A5 A6

A1	-	1	1	1	-	-
A2	0	-	-	-	-	-
A3	-	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P10

	A1	A2	A3	A4	A5	A6
A1	-	1	-	1	1	-
A2	0	-	-	-	-	-
A3	-	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P11

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

P12

	A1	A2	A3	A4	A5	A6
A1	-	1	1	-	-	-
A2	1	-	1	-	-	-
A3	1	1	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P13

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1

A2	1	-	-	-	-	-
A3	1	-	-	-	-	-
A4	1	-	-	-	-	-
A5	1	-	-	-	-	-
A6	1	-	-	-	-	-

P14

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	1	-	1	1	1	1
A3	1	1	-	0	-	-
A4	1	1	0	-	-	-
A5	1	1	-	-	-	-
A6	1	0	-	-	-	-

P15

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	1	-	-	-	-	-
A3	1	-	-	-	-	-
A4	1	-	-	-	-	-
A5	1	-	-	-	-	-
A6	1	-	-	-	-	-

P16

	A1	A2	A3	A4	A5	A6
A1	-	1	1	-	-	-
A2	0	-	-	-	-	-
A3	0	-	-	-	-	-
A4	-	-	-	-	-	-
A5	-	-	-	-	-	-
A6	-	-	-	-	-	-

P17

	A1	A2	A3	A4	A5	A6
A1	-	1	1	1	1	1
A2	0	-	-	-	-	-

A3	0	-	-	-	-	-
A4	0	-	-	-	-	-
A5	0	-	-	-	-	-
A6	0	-	-	-	-	-

Brief Profile of Research Scholar

Sankhadeep is an experienced and highly skilled adviser in low carbon and sustainability energy solutions, who has been working on an extensive range of energy projects over the last 16 years, from concept through to construction.

With significant experience leading and directing major complex and business-critical projects, he brings compelling strategic insight and understanding of the policy and regulatory environment.

Currently based in Thailand, he is working in the Energy Advisory business for GE-FieldCore in Southeast Asia and Australia. Passionate about shaping a net-zero future, he helps government, cities and organizations make that transition to a green economy by advising on integrated renewable energy solutions including solar, onshore and offshore wind, solar PV, batteries, district heating and cooling and heat pumps.

He is also prolific speaker and have presented my research papers in several forums such as ICOE Cherbourg, France, IEEE, University of Petroleum & Eenergy Studies, India, Central Board of Irrigation & Power (India), Government of India forums etc.

Recently his research paper was published in the prestigious "Energy Policy" a The Australian Business Deans Council's (ABDC) indexed journal.

He is also a guest editiorial of Renewable and Sustainable Energy Reviews (Elsevier) and working on a special issue on United Nations Framework Convention on Climate Change ('UNFCCC') COP 26 targets

Publications Details

S. No	Title	List of Authors	Journal Title	Published Digital Link
1	An Overview of Ocean Energy Policies Across the World	Chakraborty, Sankhadeep Dwivedi, Prasoom Gupta, Rajesh	Water and Energy International	https://www.researchgate.net/publication/354402799_An_Overview_of_Ocean_Energy_Policies_Across_the_World
2	Need for Ocean Energy Policies in India for Future Power Requirements	Chakraborty, Sankhadeep Gupta, Rajesh Dwivedi, Prasoom	International Journal of Management Studies	https://www.researchgate.net/publication/322799375_Need_for_Ocean_Energy_Policies_in_India_for_Future_Power_Requirements
3	Review of Global Ocean energy Policies in view of lessons for India	Chakraborty, Sankhadeep Dwivedi, Prasoom Gupta, Rajesh	International Conference on Ocean Energy (ICOE), France	https://www.researchgate.net/publication/354248563_Review_of_Global_Ocean_energy_Policies_in_view_of_lessons_for_India
4	Factors to Promote Ocean Energy in India	Chakraborty, Sankhadeep Dwivedi, Prasoom Chatterjee, Sushanta K Gupta, Rajesh	Energy Policy	https://www.sciencedirect.com/science/article/pii/S0301421521005061?dgcid=author
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