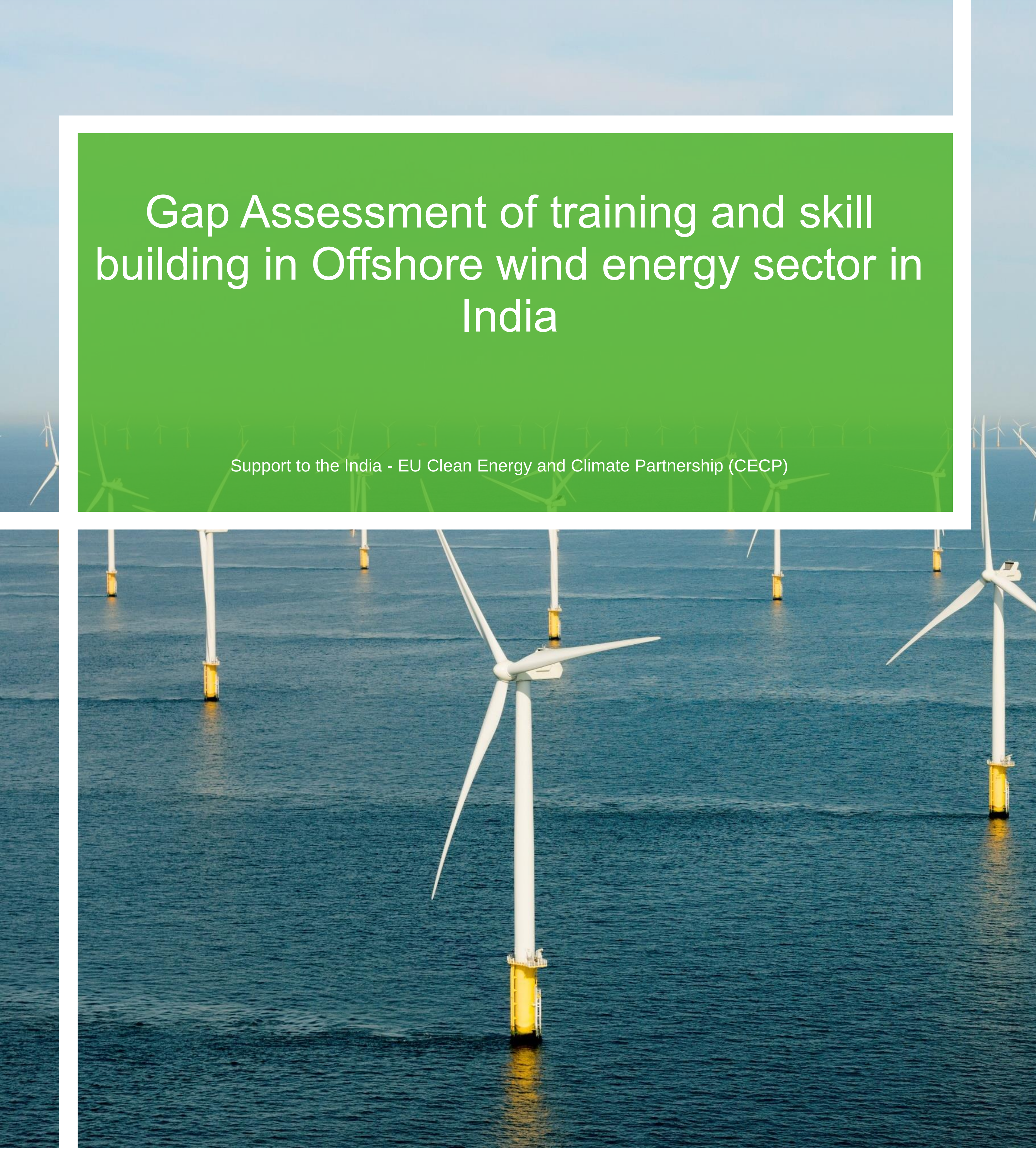
This project is funded by The European Union

EU-INDIA
CLEAN ENERGY & CLIMATE PARTNERSHIP

Gap Assessment of training and skill building in Offshore wind energy sector in India

Support to the India - EU Clean Energy and Climate Partnership (CECP)



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नवीन और नवीकरणीय ऊर्जा मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

सत्यमेव जयते

Dinesh Dayanand Jagdale
Joint Secretary

Foreword

With its expanding economy, urbanization and industrialization, India is projected to see a huge increase in its energy demand. The Government of India has made considerable progress to meet this increasing demand by successfully implementing a range of electricity sector reforms and strongly increasing deployment of renewable electricity.

Recently, in COP26, Honorable Prime Minister of India announced a target to achieve 500 GW of installed electricity capacity from non-fossil fuel sources by the year 2030. As of April 2022 India's installed renewable energy capacity stands at about 158 GW (including large Hydro), which is about 38 per cent of the country's total electricity installed capacity.

The Government of India is actively working towards adding offshore wind to the electricity mix and has set a target set of achieving offshore wind installations of 30 GW by 2030, This would require multi-disciplinary knowledge with participation from various institutions in developing a strong base for offshore wind development.

Offshore wind deployment has the potential to contribute towards economic growth and to create jobs across the entire value chain, including the planning phase, manufacturing, transportation, construction & installation, operations & maintenance and other allied areas. This however requires development of the necessary capabilities and need to expand skills to create a capable workforce. Training and skill development will be critical to realize India's offshore wind sector plans.

This report on "Gap Assessment of training and skill building for offshore wind", that has been produced under the EU-India Clean Energy and Climate Partnership (CECP), endeavors to take stock of the current situation with respect to the active institutions, available training, training requirements in the offshore wind industry and provide possible recommendations for strengthening the offshore skill-building ecosystem in India. This report identifies institutes for skill development in the European Union and India, different phases of skill development and provides recommendations for ensuring the required labour force for supporting an offshore wind sector in India.

Ministry of New and Renewable Energy (MNRE) hopes that various stakeholders will be benefited from these findings and take necessary steps to develop the required training and skill ecosystem, thus benefiting the offshore wind sector.

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1|6|2022

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ATS	Apprenticeship Training Scheme
BIS	Bureau of Indian Standards
BOISIET	Basic Offshore Safety Induction and Emergency Training
CAPEX	Capital Expenditure
CTV	Crew Transfer Vessel
DTU	Danish Technical University
EIA	Environment Impact Assessment
EU	European Union
FY	Financial Year
GW	Giga watt
GWO	Global Wind Organization
HSE	Health and Safety
ICOIS	Indian National Centre for Ocean Information Services
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
INDOFOS	Indian Ocean Forecasting System
IPP	Independent Power Producers
IRR	Internal Rate of Return
ISO	International Organization for Standardization
ITI	Industrial Training institute
MNRE	Ministry of New and Renewable Energy
MoU	Memorandum of Understanding
MP	MonoPile
MW	Megawatt
NIO	National Institute of Oceanography
NIWE	National Institute of Wind Energy
O&G	Oil and Gas
O&M	Operations and Maintenance
QP	Qualification Packs
R&D	Research and Development
ROV	Remotely Operated Vehicle
SCGJ	Skill Council for Green Jobs
SLDC	State Load Dispatch Centre
SNA	State Nodal Agency
SOV	Service Operation Vessel
TP	Transition Piece
WEP	Wind Energy Production
WMS	Wind monitoring station
WRA	Wind Resource Assessment
WTG	Wind Turbine Generator

Executive Summary

Executive Summary

The Ministry of New & Renewable Energy (MNRE) notified the National Offshore Wind Policy in October 2015, to realize the Offshore wind power potential in the country. To instill confidence in the wind industry, the government also declared a long-term target of 30 GW Offshore wind power capacity additions by 2030. In addition, the National Institute of Wind Energy (NIWE) has released an Expression of interest for 1 GW Offshore wind farm development in Gujarat.

Development of an Offshore wind sector in India will require local training and skill development programs. It is thus relevant to take stock of the current situation with respect to the active institutions, available training, key gaps, training requirements in the Offshore industry and provide possible recommendations for strengthening the Offshore skill-building ecosystem in India. This study will help to highlight the skills that are needed, which might either be available already or will have to be developed through possible collaboration with training facilities/institutes in the European Union (EU).

The broad objectives of the study include:

1 Assessment of the Key institutes active in Wind energy/ Offshore training programmes in India

3 Mapping of EU's technical expertise in training and capacity building

2 Identification of the gaps and needed skills in the Offshore wind sector value chain i.e. the development phase, construction phase, commissioning phase and operation phase

4 key recommendations to improve the Offshore wind sector skill base in India

The study shows that the following areas within the Offshore wind and training framework would require further consideration:

- Development of qualification packs (QPs) for Offshore wind
- Creation of knowledge portal
- Creation of tools/frameworks for financial institutions
- Institutional level capacity building of certain institutes
- Need of a development of Offshore wind standards
- Collaboration opportunities for certification
- Collaboration opportunities for R&D institutional development
- Development of concrete education and training courses at university level
- Leverage skills from Offshore oil and gas
- Share experiences gained during work and peer training
- Creation of conducive policy environment

INTRODUCTION

1. Introduction

1.1. Ascertaining the need for developing a strong skill base

The Offshore wind development in India will require multi-disciplinary knowledge with participation from institutions in developing a strong base for further development. The target of achieving Offshore installation of 30 GW by FY 2030[1], set by the government of India, will be difficult to achieve without focusing on holistic development of inherent capacities. The capacity enhancement needs to take place across segments such as strengthening of existing training facilities, development of new dedicated training institutions with certificated courses/ apprenticeship programs, designing of courses/training modules specific to target audiences, development of standardized guidelines/ protocols with respect to adoption of international standards for testing and finally creation of new qualification packs (QPs)/ course curriculums, which allows people to gain employment opportunities. The knowledge dissemination should involve the central and regional policy actors for on ground skill development monitoring and improved decision making.

It is crucial that the capacity building efforts are targeted across the entire value-chain of Offshore wind i.e. the planning phase, construction phase, commissioning phase and post-construction/ operations phase.

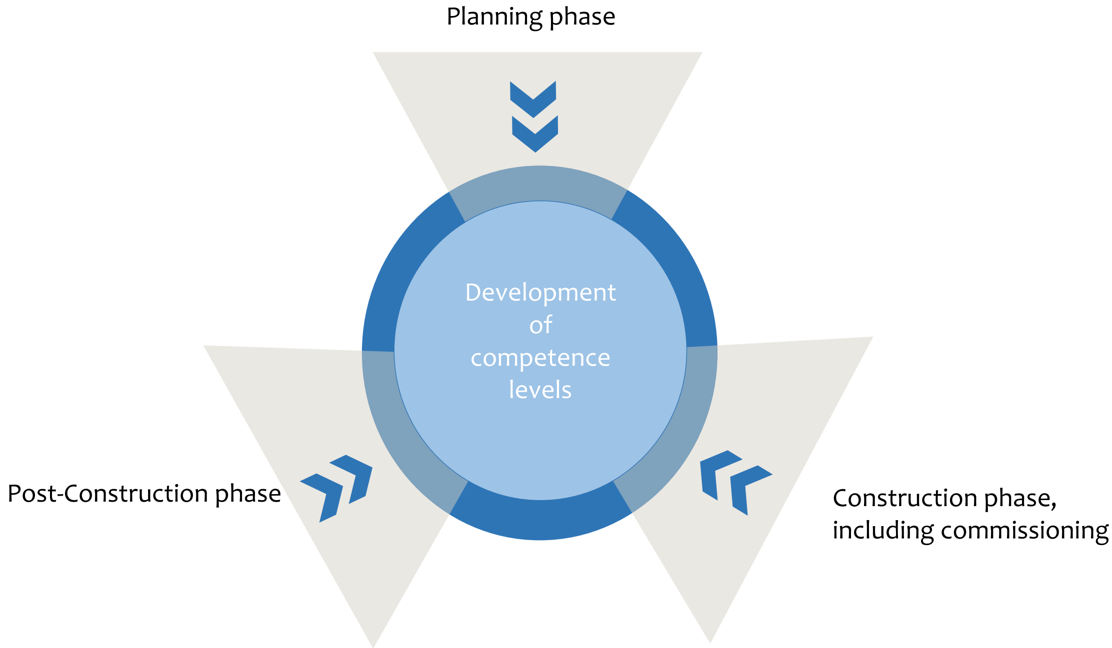


Figure 1: Various phases of development of an offshore wind project

The planning phase will involve energy assessments, Wind Resource Assessment (WRA) studies, geotechnical surveys, marine Environment Impact Assessment (EIA), bathymetric surveys, health and safety, permitting knowhow, stakeholder management, etc. During the construction (including commissioning) phase, skills relevant to technical design and engineering such as preparation of wind farm layout, Offshore cable routing, foundation design, foundation installation, turbine installation, Offshore substation design and installation, Offshore cable design and installations, procurement, financing, etc. will be required. Post the construction phase, the O&M will play a crucial role to ensure longevity of the Offshore plant and achieve the desired energy generation levels, which will require specialized skills. Much of these required skills do not overlap with the Onshore wind segment. Hence capacity building will be necessary.

[1] https://mnre.gov.in/wind/Offshore-wind/

KEY INSTITUTES

2. Key Institutes

As a first step towards the assessment of Offshore skill-building, this section covers major European and Indian institutes which have been established for wind energy training program development, deployment, and research. There are several government and private sector training providers active in the sector. The subsequent section provides examples of relevant Indian and European institutes.

2.1. Relevant Indian Institutes

In India, there are several public and private sector institutions which have been providing relevant technical training to both local and international target audience in Onshore wind technology. Additionally, there are various institutions which have proven track record in the field of marine and oceanic engineering, forecasting meteorological conditions. Currently, there is no single institute which provide trainings catering to Offshore wind industry needs. This section covers relevant Indian institutes which have training courses in Offshore area and in wind technology.

2.1.1. Government institutes

2.1.1.1. NIWE (National Institute of Wind Energy)

The National Institute of Wind Energy (NIWE) is a premier autonomous Research & Development institution under the Ministry of New and Renewable Energy, Govt. of India, catering to the growth of wind energy-based technologies in India. NIWE does undertake relevant activities for performance improvement of existing wind turbines, including Wind Resource Assessment, Wind Turbine Test and Measurement analysis (both for large/small wind turbine) for certification of Wind Turbines, wind power forecasting and supports information exchange through education and training. Tailor made training program on resource assessment to the industry

NIWE is has been designated as the nodal agency for implementing and facilitating Offshore projects in India, including capacity building efforts required for local skill development. As per the National Offshore Wind Policy, NIWE will undertake promotional activities such as organizing workshops & symposiums to bring awareness in the local wind turbine manufacturers and components manufacturers including potential investors to boost Offshore wind power development.

NIWE has contributed to training and capacity development for the Onshore wind segment in India from Oct 2004. Till now, it has provided 51 national trainings and 39 International training which covered theoretical knowledge on different aspects such as wind energy technologies, wind resource assessment, design-installation, and maintenance of wind turbines, testing, certifications, windfarm operation & maintenance, economics of wind farm as well as provided on-ground exposure with visits to wind [2]farm sites. The target audiences have included engineers, diploma holders, Industrial Training Institutes (ITIs), academic and R&D institutions, state Nodal Agencies (SNAs), consultants, Independent Power Producers (IPPs), suppliers, distributors and government organizations. The key topics included in the present training efforts have been highlighted below.

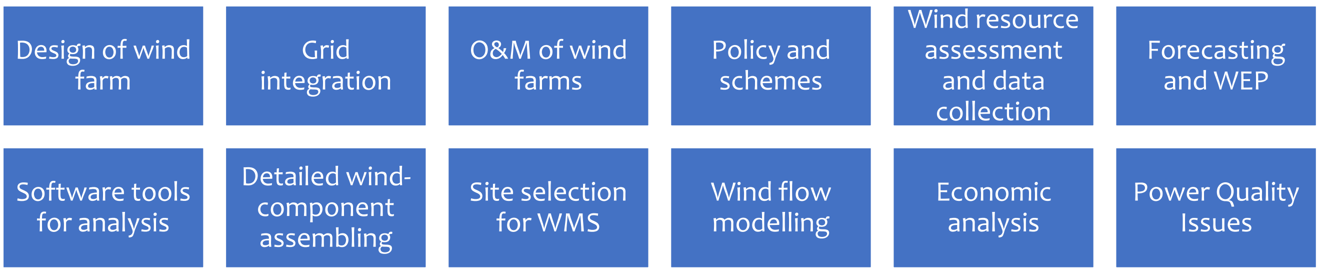


Figure 2: Key areas of wind training by NIWE

[2] https://niwe.res.in/department_itcs_ntc.php

NIWE currently provides following services with respect to Offshore wind:

- Wind measurements
- Oceanographic measurements (Wave, current, tidal)
- Geophysical and geotechnical services
- Rapid Environmental Impact Assessment study

With respect to Offshore wind training, NIWE currently only provides a small 'overview course[3]', as part of its 5-day training session. Apart from the national courses, NIWE has also successfully been running several international courses (39 in total till date[4]) for ASEAN as well as African countries. However, these trainings are restricted to only Onshore wind segment.

NIWE is working with Skill Council for Green Jobs (SCGJ) on various courses. It is also promoting skilling and reskilling of the people to develop a skilled workforce for the sector and expand the employment opportunities by collaborating with training providers and academia such as DTU. The R&D council of NIWE has prepared a course curriculum to offer AICTE approved 2-years master's degree course in wind energy, which can be implemented by various educational colleges and universities. Lastly, NIWE in partnership with Ministry of Skill Development and Entrepreneurship is also supporting Apprenticeship Training Scheme (ATS) to develop talented manpower in India.[5]

Hence, it can be said that NIWE has pioneered the skill development in Onshore wind sector in India. For Offshore wind sector development, it needs to develop more program which are currently limited to meeting only few planning phase requirements during project development. The knowledge dissemination then needs to take place across target audience through integration in various training programs at national and international level.

2.1.1.2. SCGJ (Skill Council for Green Jobs)

The Skill Council for Green Jobs (SCGJ) is a national level organization established by the Ministry of Skill Development and Entrepreneurship. It is an industry driven body that closely interacts with several relevant ministries such as the MNRE, Ministry of Environment, Forest & Climate Change, etc. and accordingly develops relevant skill sets needed for employment opportunities. SCGJ is acting as a bridge between the Government of India, State Governments, and industry for developing strategy & implementing programmes for Skills Development, correlated to Industry needs but also aligned to best International practices. Once the training needs are identified after discussions with stakeholders, SCGJ affiliates with training centers and universities to roll out these trainings.

The SCGJ has prepared the governing modules and operational standards for various programs in renewable energy skill development. Within the RE segment, the Skill Council for Green Jobs has not established training curriculum for securing a job in Offshore wind sector. There are '8' dedicated qualification packs (QPs) and model curriculums for Onshore wind, as indicated below.[6] These qualification packs give an indication of possible trainee qualification and course duration in similar QPs which may be released in future for Offshore wind sector. SCGJ maintains a list of Training institutions (both public and private sector) that are eligible to offer trainings through certified trainers. After a training has been imparted, independent assessment agencies empaneled by SCGJ conduct an evaluation of candidates and recommend certification for qualified candidates. The certifications are thereafter provided to the selected candidates by SCGJ.

Table 2.1: QPs for Onshore wind related jobs

Qualification Pack	Course Duration/Training Hours	Trainee Qualification	NSQF Level*[7]
Assistant Planning Engineer – Wind Power Plant SGJ/Q1201	200	ITI/Diploma (Electrical, Mechanical, Civil)	4
Site Surveyor-Wind Power Plant SGJ/Q1202	120	B.E. / B. Tech. (Electrical/ Mechanical/ Civil/ Electronics and Communication / Electrical and	6

[3] https://niwe.res.in/national_22.php
[4] https://niwe.res.in/department_itcs_itc.php
[5] https://niwe.res.in/department_ksm_apprenticeship_training.php
[6] http://sscgj.in/publications/qualification-pack-model-curriculum/
[7] * National Skill Qualification Framework (NSQF) provides levels to different kind of jobs from 1-10, depending on process, professional knowledge, professional skill, core skill and responsibility.

		Electronics/ Control & Instrumentation)	
Construction Technician (Mechanical) - Wind Power Plant SGJ/Q1401	200	12th pass preferred	4
Construction Technician (Civil) - Wind Power Plant SGJ/Q1402	200	12^{th} pass preferred	4
Construction Technician (Electrical) - Wind Power Plant SGJ/Q1403	200	12^{th} pass preferred	4
CMS Engineer- Wind Power Plant SGJ/Q1501	200	B. Tech (Electrical, Electronics)	5
O&M Mechanical Technician – Wind Power Plant SGJ/Q1502	200	12th pass preferred	4
O&M Electrical & Instrumentation Technician – Wind Power Plant SGJ/Q1503	200	12th pass preferred	4

With the current strength and market outreach of Skill Council, which has more than 500 certified trainers and presence across 24 centers Pan-India, the efforts need to be scaled up to cater to Offshore wind requirements and create more employment opportunities.

2.1.1.3. INCOIS (Indian National Centre for Ocean Information Services)

INCOIS is an autonomous body under the Ministry of Earth Science responsible for conducting research and modelling pertaining to oceanic phenomena. It also performs the role of forecasting oceanographic parameters (both surface and sub-surface) at different time scales and is thus crucial for Offshore industries. For this purpose, the institution has established an integrated Indian Ocean Forecasting System (INDOFOS)[8], capable of predicting the surface and subsurface features of the Indian Ocean reasonably well in advance (5 to 7 days presently). Some of the parameters which are constantly monitored include the following.

- Height, direction, and period (of both wind and waves and swell waves)
- Sea surface currents
- Sea surface temperature
- Mixed layer depth
- Depth of the 20-degree isotherm
- Astronomical tides
- Wind speed and direction

Figure 3: Parameters monitored by INDOFOS

All the above parameters are critical when it comes to the planning and conducting resource assessment wind studies for Offshore wind. The forecasts are generated by a suite of state-of-the art numerical models, which are customized to simulate and predict the Indian Ocean features accurately. The models used are WAVEWATCH III, MIKE, Regional Ocean Modeling System (ROMS) and General NOAA Oil Modeling Environment (GNOME). Atmospheric forecast products from different meteorological forecasting agencies (NCMRWF and ECMWF) are used for forcing these models in the forecast mode. Some of the day-ahead forecasting plots for wave height, direction of wind, wind speed etc. are shown below.[9]

[8] https://incois.gov.in/portal/osf/osf.jsp
[9] https://incois.gov.in/portal/osf/osfCoastal.jsp?region=coastal&area=tamilnadu&param=wind&ln=en

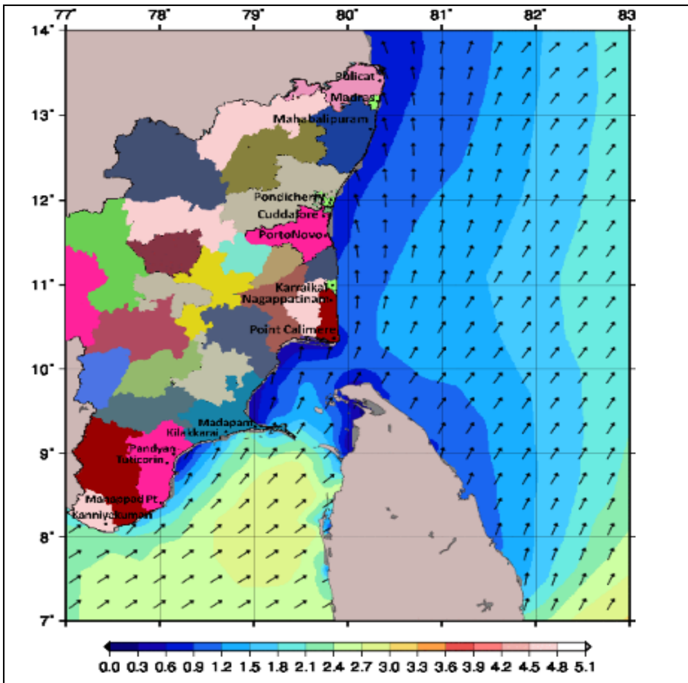


Figure 4: Wave height and direction forecast for Tamil Nadu

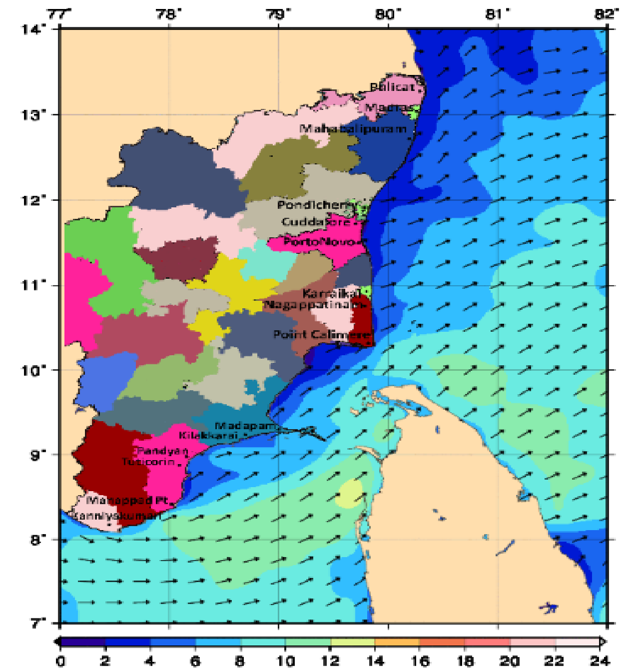


Figure 5: Wind speed forecast in Tamil Nadu

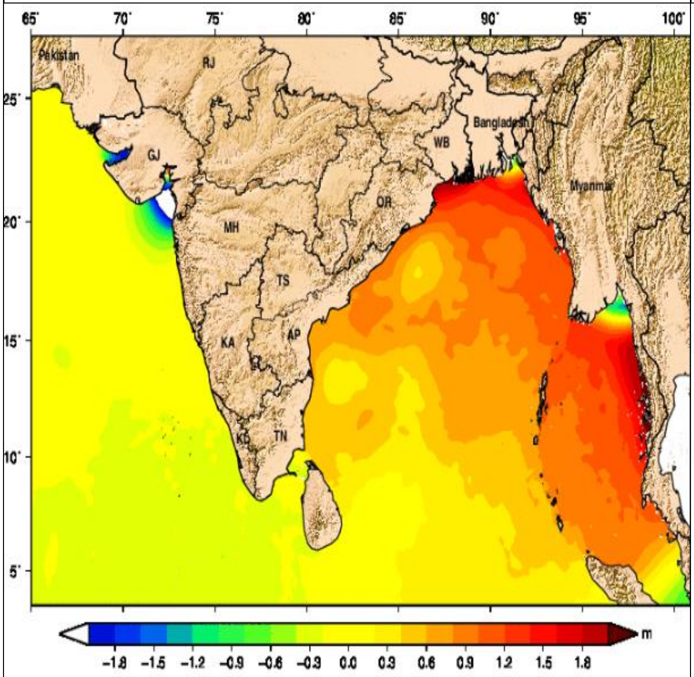


Figure 6: Sea surface height (in metres)

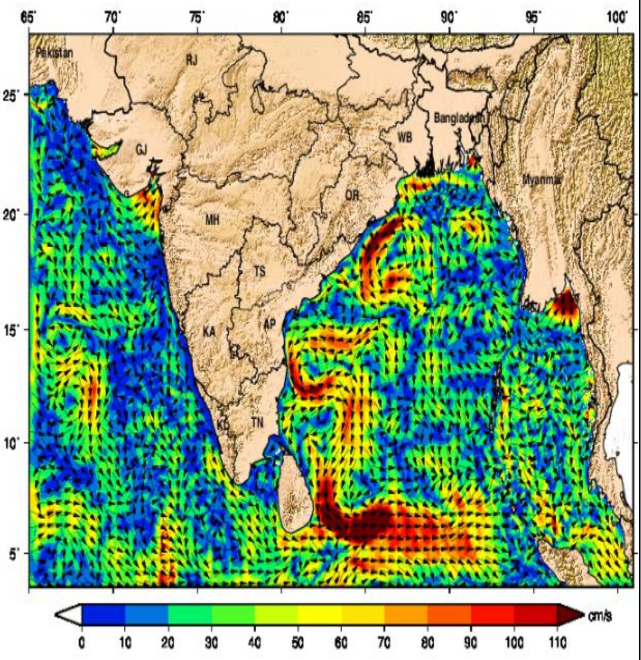
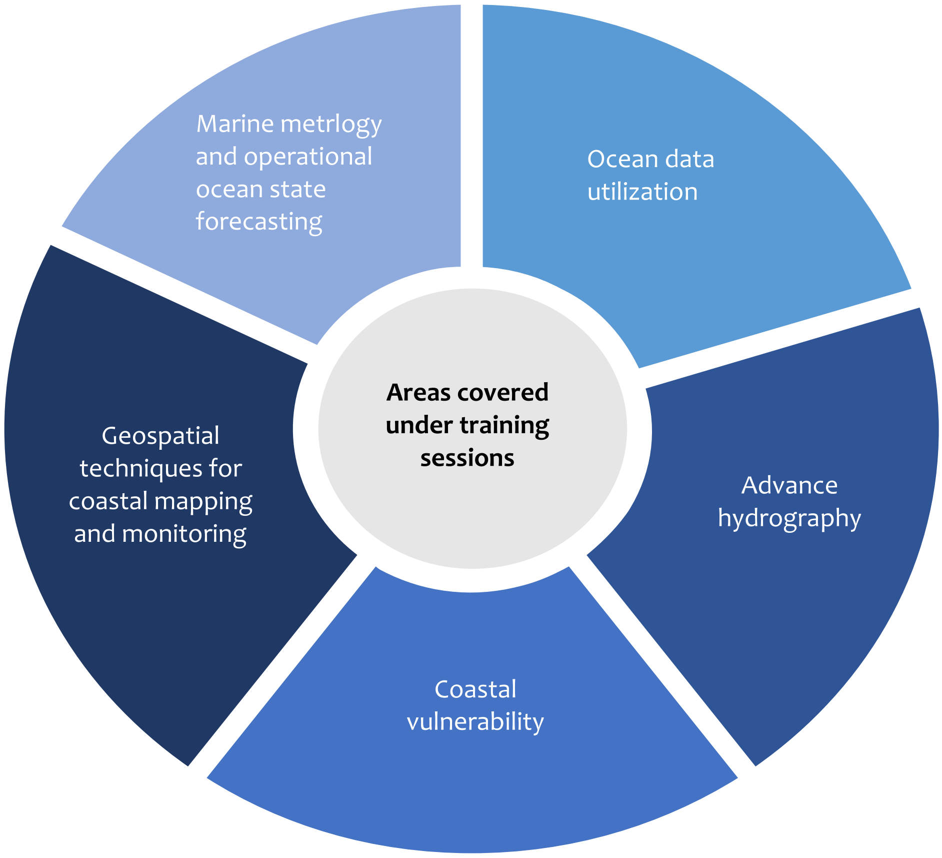


Figure 7: Wave current in cm/s

(Note: Arrows indicate direction of wave from North and color indicates the wave height in metres)

The International Training Centre for Operational Oceanography (ITCOocean), under the INCOIS provides the relevant trainings with respect to oceanography at national, regional, and global scales. It provides training on generation of data from oceans using in situ and satellite platforms, transmission of data to operational centre, data reception, data processing in real-time, usage of data in models and generation of forecasts and dissemination of the same to end users within the shortest possible time. The Intergovernmental Oceanographic Commission (IOC/UNESCO) also support ESSO-INCOIS for capacity building activities in the field of operational oceanography through ITCOocean.

Currently, ITCOocean offers short-term certificate courses of duration up to three months. However, long-term courses of up to two years spread over four Semesters leading to a university Post-Graduate Degree/Diploma are also planned. Some of the areas in which the training sessions have been conducted include the following:



With the current technical and research strength, the institute can be pivotal in designing trainings especially in resource assessment and planning for Offshore wind sector.

2.1.1.4. NIO (National Institute of Oceanography)

The NIO, under Council of Scientific and Industrial Research (CSIR), is a multidisciplinary oceanographic research institute, with a specific focus on observing and understanding special characteristics of Indian ocean.

- The institute conducts bathymetry, seabed engineering and CRZ demarcation surveys for Offshore industry with international standards
- It has facilities and capabilities to collect long-term site-specific environmental data and evaluation of engineering design parameters for Offshore facilities
- It conducts detailed EIA inspection, numerical modelling, and underwater surveys

Additionally, the NIO-HRM[10] also undertakes numerous capacity building activities through seminars, workshops including tailor-made program for both national and international audience. This improves skill level with respect to oceanic phenomena also helps stakeholders in making informed policy decisions. Some of the major areas of training covered by the institute include Offshore industrial surveying and Oceanic observations for coastal zone management. NIO also provides fellowship opportunities on similar lines to young scientists and specialized training programmes for SAARC countries and IOR-ARC Countries.

2.1.1.5. IIT Chennai

The Department of Ocean Engineering, IIT Chennai has been providing training on several aspects related to Offshore to different industry players such as Oil and Natural Gas Corporation Ltd., Larsen & Toubro Ltd., Technip, etc. The training includes the following key courses:

[10] https://www.nio.org/human-resource/capacity-building

- Foundations for Offshore structures
- Design of Offshore structures
- Subsea engineering for O&G
- Advanced Marine Structures
- Installation of Offshore structures
- Material of fabrication of Offshore structures
- Numerical modelling of Offshore structures
- Ultimate strength analysis of Offshore structures

These courses are will also be useful for structure and foundation related studies in Offshore wind sector.

2.1.2. Key private training providers

There are multiple private players providing training programs within the area of wind energy. Some examples are:

- Elite Offshore Pvt Ltd[11].: The private agency is an ISO 9001:2015 Certified-Offshore, Marine and Industrial Trainer and undertakes specialized trainings in the field of Basic Offshore Safety Induction and Emergency Training (BOISIET). The training involves a 3-day practical exposure focusing on providing basic understanding and awareness on hazard management while working in Offshore industry. Some of the key aspects covered as part of the course include:
    - Principles of managing safety on Offshore
    - Main Offshore hazards and hazard effects/consequences; explain their associated risks, and how they are controlled
    - Potential environmental impact of Offshore installation operations
    - Report incidents, accidents and near misses on an Offshore installation
- Maersk[12]: The private agency has been delivering training on several facets covering Offshore O&G, maritime and safety, with presence in Mumbai and Chennai. The facilities have been accredited by International Well Control Forum (IWCF) and provide classroom training. Some of the training courses may be repurposed for use in Offshore wind sector as well.
- Sagar Offshore Maritime Academy Pvt. Ltd[13].: The institute is an ISO 9001:2008 certified company, approved by D.G. Shipping, GoI, providing number of course on Offshore and maritime related activities. The courses typically range from 1-5 days and include the latest aids for practical demonstration. Some of the key courses include:
    - Basic Offshore Safety Induction and Emergency Training
    - Offshore Crane Operator Safety Training
    - Offshore Anchor Handling and Towing
    - Offshore Installation Manager

2.1.3. Synergies with O&G sectors for training purpose

A noteworthy point in the development of Offshore wind sector is that there is a significant opportunity to tap the existing in-house potential in the country such as training ecosystem available in Onshore wind and Oil & Gas sector.

[11] https://eliteOffshore.com/bosiet-huet/
[12] https://www.maersktraining.com/category/our-locations/india/
[13] https://sagarOffshore.com/courses.html

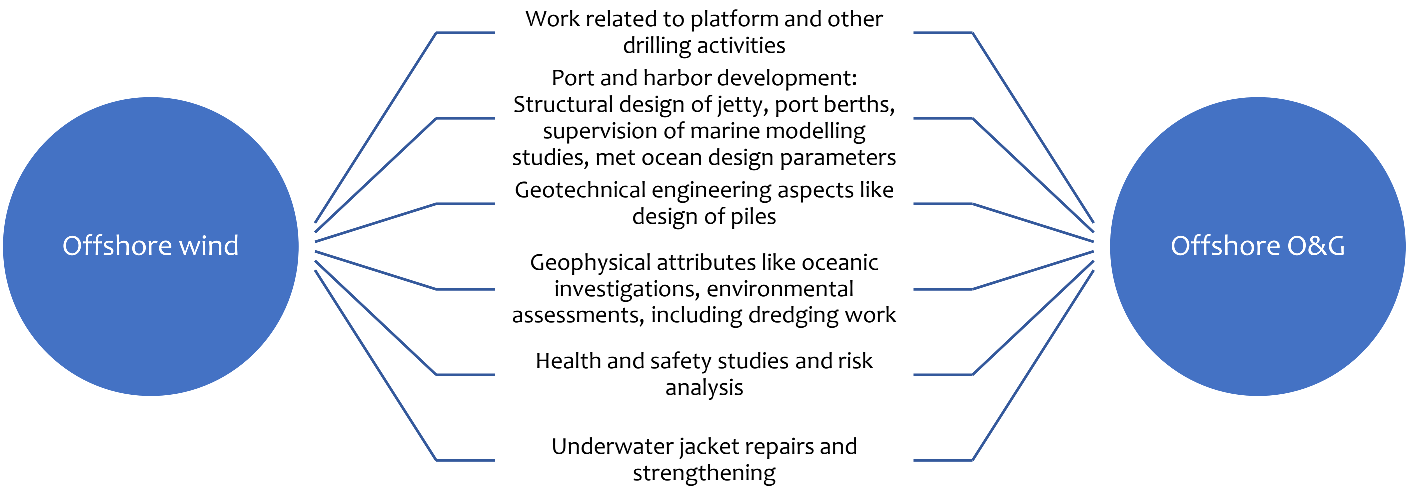


Figure 8: Mapping synergies between Offshore wind and Offshore O&G

There are several government players and private entities which have been a valuable part of development of Offshore Oil & Gas (O&G) in India and provide services related to high end technical, engineering and project execution capabilities across the Offshore project cycle.

In this regard, there may be several commonalities or overlaps, which can be harnessed to develop subsequent skills for Offshore wind. Some of the leading players in O&G include:

- ONGC (Oil and Natural Gas Corporation Limited): ONGC, a Maharatna Public sector undertaking, has been running several institutes which conduct extensive research work and provide relevant trainings related to Offshore segment. ONGC has also planned a significant portfolio of 10 GW renewable energy, with specific focus on developing Offshore wind projects. Some of the institutes and respective trainings include:
    - Institute of Drilling Technology[14] which provides basic and advanced courses involving drilling in Offshore rigs (directional drilling, drilling bit, safety in drilling, drilling complications, hydraulics, cement classification and additives). While the drilling techniques by themselves are not transferable to the offshore wind sector, the more general skills related to operating in offshore environments are relevant to offshore wind.
    - Institute of Engineering and Ocean Technology (IEOT)[15]: The Institute has developed expertise in core fields of Geotechnical Engineering, Structural Engineering, Risk & Reliability Engineering, Materials & Corrosion Engineering
- Players like Engineers India Limited (EIL), L&T Hydrocarbon[16] have developed numerous Offshore facilities for O&G clients, with complete range of Engineering, Procurement and Construction (EPC) services.

2.2. Relevant European institutes

In the EU, there are numerous universities, research institutes and private agencies which cover the area of wind energy. Most of the institutes focusing on Offshore wind energy are in Germany, the Netherlands, Belgium, and Denmark, which are the EU countries with the largest installed capacity of Offshore wind turbines. The subsequent sections provide examples of relevant institutes, which have a strong knowledge base within the topic of Offshore wind energy including universities, research institutes and private training providers.

[14] https://www.ongcindia.com/wps/wcm/connect/1b3d0b5f-27b9-4fd8-a561-10a20eff377c/calender2020.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE-1b3d0b5f-27b9-4fd8-a561-10a20eff377c-m-zIUTn
[15] https://www.ongcindia.com/wps/wcm/connect/en/about-ongc/core-business-expertise/applied-rd-training/
[16] https://www.lnthydrocarbon.com/our-businesses/Offshore/

2.2.1. Universities and research institutes

For most of the European universities' wind energy curriculum is included as separate courses in more general study programs such as mechanical engineering, civil engineering, and electrical engineering, while a few universities are offering dedicated MSc programs on wind energy for example the Technical University of Denmark[17] and Leibniz Universität Hannover[18]. The European Wind Energy Master's Program[19] is an example of a multi-national collaboration where four institutions (the Technical University of Denmark, TU Delft, NTNU (Norwegian University of Science and Technology) and the University of Oldenburg, jointly offer a MSc program including the option of specializing in Offshore engineering. Some universities also offer online courses and programs for example wind energy courses at TU Delft[20] and the Wind Energy Master Online Programme[21] offered by the Technical University of Denmark. The table below provides a list of EU universities which are dedicating efforts to the field of wind energy.

Table 2.2: Universities focusing on Offshore wind energy

University/Institute	Examples of Engineering and Technology - Grade	Webpage	Country
Ghent University	• Department of Civil Engineering • Department of Department of Structural engineering and Building Materials • Department of Electromechanical, Systems and Metal Engineering	https://www.ugent.be/en	Belgium
Vrije Universiteit Brussel	• Department of Mechanical Engineering • Department of Electric Engineering and Energy Technology • Department of Mechanics of Materials and Constructions	https://www.vub.be/	Belgium
Technical University of Denmark (DTU)	• Department of Chemical Engineering • Department of Civil Engineering • Department of Engineering in Offshore Wind Energy • Department of Informatics and Mathematical Modeling • Department of Physics • Department of Systems Biology • Structure	www.dtu.dk/English	Denmark
Aalborg University	• Faculty of Engineering and Science • Civil Engineering • Data Engineering • Engineering with Specialisation • Environmental Engineering • Environmental Management • International Technology Management • Mechatronic Control Engineering • Power Electronics and Drives • Software Systems Engineering • Sustainable Cities • Sustainable Energy Planning and Management	www.en.aau.dk	Denmark

[17] MSc in Wind Energy Engineering at DTU, link: https://www.dtu.dk/english/education/msc/programmes/wind_energy
[18] MSc in Wind Energy Engineering at Leibniz Universität Hannover, link: https://www.windenergie-master.de/en/start.html
[19] European Wind Energy Master, link: https://ewem.tudelft.nl/
[20] Online courses in Wind Energy at TU Delft, link: https://online-learning.tudelft.nl/aerospace-engineering/wind-energy/
[21] Wind Energy Master Online Programme at DTU, link: https://wem.dtu.dk/

Technical University of Munich	• Civil Engineering • Geotechnics • Mechanical Engineering • Electric and computer Engineering	https://www.tum.de/en/	Germany
Carl von Ossietzky University of Oldenburg	• Department of Engineering and Physics • Faculty of Computer Science, Economy and Law • School of Linguistics and Cultural Studies	https://uol.de/	Germany
Albert Ludwigs University of Freiburg	• Centre for Renewable Energy • Faculty of Engineering • Faculty of Forest and Environmental Sciences • Institute of Geosciences • Structure	www.uni-freiburg.de/	Germany
Leibniz Universität Hannover	• Civil Engineering • Electrical Engineering • Environmental Engineering • Power Engineering • Production and Logistics	https://www.uni-hannover.de/	Germany
Universität Bremen	• Power Electronics • Electrotechnic • Geophysics	https://www.uni-bremen.de/	Germany
Delft University of Technology, Netherlands	• Electrical Engineering, Mathematics and Computer Science • Industrial Design Engineering • Mechanical, Maritime and Materials Engineering • Structure • Technology, Policy and Management • Applied Sciences • Civil Engineering and Geosciences	home.tudelft.nl/en/	Netherlands
Universiteit Twente	• Electrical Engineering, Mathematics and Computer Science • Engineering Technology • Science and Technology • Single tier structure • Civil Engineering and Management • Construction Management and Engineering • Industrial Design Engineering • Mechanical Engineering • Sustainable Energy Technology	www.utwente.nl/en/	Netherlands

NTNU Norway	• Electric Power Engineering • Geotechnics • Globalisation and Sustainable Development • Marine Technology • Sustainable Energy	https://www.ntnu.edu/	Norway

A number of EU research institutes/centers are specialized in Offshore wind energy, for example: TNO (Netherlands Organisation for Applied Scientific Research), OWI-lab (On -and Offshore Wind Infrastructure Application Lab), Fraunhofer, DHI (Dansk Hydraulisk Institut), and MaREI (Research Centre for Energy, Climate and Marine). The table below displays an overview of organizations and research institutes focusing on Offshore wind energy.

Table 2.3: Research institutes focusing on Offshore wind energy

Type of organisation	Name of organisation	Webpage	Country
Research Institution for Manufacturing Engineering and Automation	Fraunhofer IWES	https://www.iwes.fraunhofer.de	Germany
Netherlands Organisation for Applied Scientific Research	TNO	https://www.tno.nl/en/	Netherlands
On -and Offshore Wind Infrastructure Application Lab	OWI-Lab	https://www.owi-lab.be/	Belgium
Danish Hydraulic Institute	DHI	https://www.dhigroup.com/	Denmark
Research Centre for Energy, Climate and Marine	MaREI	https://www.marei.ie/	Ireland
Renewable Energy Engineering and Management	University of Freiburg	https://uni-freiburg.de/	Germany
Environment, climate change, sustainability, infrastructure	Hochschule Bochum	https://www.hochschule-bochum.de/	Germany
Water and environmental	Forschungs Zentrum Küste	https://www.fzk.uni-hannover.de/	Netherlands
Norwegian Research Centre on Offshore Wind Energy	SINTEF	https://www.sintef.no	Norway
Swedish Wind Power Technology Centre	Chalmers University of Technology	https://www.chalmers.se	Sweden

2.2.2. Private training providers

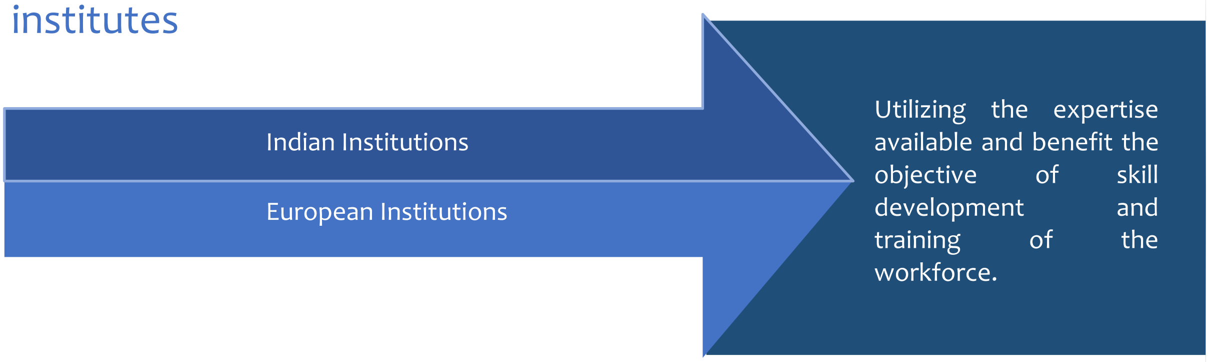
There are multiple private players providing training programs within wind energy. Some examples are provided in the following[22]:

- **Maersk:** Is a global company offering training relevant in the Offshore wind energy industry incl. located in the EU.
- **BFW:** Offers vocational education for example within Offshore wind energy.

[22] See for example GWO's webpage for an overview of GWO training providers: https://www.globalwindsafety.org/trainingproviders/findttraningprovider

- **Global Wind Academy:** Offers a long range of GWO (Global Wind Organization) certified safety and technical courses including options of on-site training.
- Global Wind Academy **Danish Wind Power Academy:** Offers a long range of GWO certified courses including optimization of components.
- **Lucas-Nülle:** Provides training systems facilitating hands-on learning of technical topics also covering wind energy
- **Monsson, Renewable Energy School of Skills:** Offers GWO and BZEE certified wind energy training programs.
- **Vulcan Training and Consultancy:** Offers GWO certified safety training programs.

2.3. Potential partnership opportunities between Indian and European institutes



For example, NIWE can consider collaboration with the Technical University of Denmark or Leibniz Universität Hannover wherein degree courses such as MSc programs dedicated for wind energy are conducted. This can help workforce equip with skills for wind energy through such dedicated courses and increase the employment opportunities in the sector. Besides, collaboration can also be considered with The European Wind Energy Master’s Program, a multi-national collaboration where four institutions (the Technical University of Denmark, TU Delft, NTNU (Norwegian University of Science and Technology) and the University of Oldenburg, jointly offer a MSc program including the option of specializing in Offshore engineering.

Furthermore, a number of universities in Europe, as highlighted in Table 2.2, offer engineering courses in relevant fields of civil, electrical, mechanical, etc. which have a component focusing on wind energy, can be considered for such degree courses, or for including relevant subjects in the curriculum in India for specialized skill development.

NIWE may also consider exploring facilitates at research institutes/centers in EU, to assess the readiness of Indian institutes/centers and identify the scope for enhancement, if required. Besides, NIWE may also consider exchange programmes with these universities/institutes as part of the curriculum to help students/candidates avail firsthand experience of the facilities in the EU.

DEVELOPMENT PHASE

3. Development phase

In the development phase, the preparations and planning for the Offshore wind farm are carried out. The development phase involves pre-construction activities including a wide range of financial and technical preparations including analyses of wind and sea conditions and characteristics, site selection, supply chain studies, etc. Compared to the subsequent phases of construction, commissioning and operation, more tasks in the development phase are carried out as office work.

3.1. Employment in the development phase

The Offshore windfarm developments typically span over a multi-year long period covering aspects like financing, site identification, Offshore surveys and data collection, Pre- Front End Engineering & Design (FEED) and FEED study, port assessments, securing grid connection, completion of permits and consents processes, etc.

Prior to the consent applications, surveys and studies are needed to analyse the environmental impacts to develop an early wind farm design. These include meteorological and oceanographic studies, wildlife surveys, geotechnical and geophysical surveys, port studies, visual studies, economic studies, and Onshore studies.

Generally, these studies/surveys require degree-level qualifications in relevant disciplines such as environmental sciences, economics, engineering and project management, graphic designing. The following list provides an overview of the areas of expertise relevant in the development phase and the required qualifications for each area:

Site selection and project development	Environmental Impact Assessment and Wildlife surveys	Technical conceptual and feasibility studies and Wind farm layout	Financial feasibility studies
Degree in economics, master's degree in project management and technology	Degree or HND in biology, marine biology, or environmental monitoring	Master's degree in naval architecture, marine engineering, mechanical engineering, high voltage design, civil and design	Master's degree in economics, business administration

Engineering R&D and design	Tender support	Port studies	Geotechnical and geophysical surveys
Master's degree in physics, mathematics, electrical, mechanical, civil and design	Master's degree in law (L.L.M), Degree in mechanics, high voltage design, marine engineering	Degrees in naval architecture, marine engineering, environmental sciences, economics.	Degrees in environmental sciences. Master's degree in oceanography, hydrography, and geophysics

The direct and indirect employment depends on scale, location, maturity, supply chain and many other factors, but will typically require several man years of effort.

3.2. Skills needed

For the services within project design and development, the services are typically contracted to specialist within the Offshore wind or alternatively Onshore wind and Offshore operation companies.

Experience gained from Offshore wind projects is highly needed as a successful development process of an Offshore wind farm. These learnings can be leveraged from the industries of more mature markets such as Denmark, Netherlands, Germany, and the UK.

In addition to the experience, basic skills required during the development phase in the Offshore wind industry is the same as already being demanded in the Offshore sector and across the wider energy sector – both from Onshore wind and in the oil and gas sector. Some roles in Offshore wind sector development phase are as below:

Table 3.1: Mapping competency requirement

Core Area	Practical Competency Requirement	Basic Competency Requirement
Administration and planning	• Administration staff • Financiers • Project Managers • Data analytics • Logistic experts • Business managers • Commercial • Environmental experts • Planners • Supply chain management. • HSE Management • Legal experts • Surveyors • Assets Managers	• Managing and leadership • Planning • Organization skills • Interpersonal • Coordination
Site surveys	• Marine biology • Geophysics • Geotechnical • Hydrography • Oceanography • Mariners • Geographic's Information System	• Teamwork • Communicative • Working at sea
FEED study, tender material, and risk assessment	• Design and civil Engineering • Mechanical Engineering • Electrical Engineering • Marine Engineering • Proposal Engineering • Environment and Social study Engineers • Planners • Electronics and communication engineering • Instrumentation and control system engineering	• Teamwork • Communicative • Coordination • Strong problem –solving skills

3.2.1. Available in India

Indian institutes which provide training in Offshore domain are covered in the table below. The table also covers skill mapping with development phase and possible recommendations.

Table 3.2: Skills available in India – Development phase

Name of the Stakeholder /Institution	Offshore Wind projects: Skill Mapping **Development Phase**	Possible recommendations
NIWE	• Wind measurements • Oceanographic measurements (Wave, current, tidal) • Geophysical and geotechnical services	• Onshore Wind experience in providing training running apprenticeship programs and preparing curriculum for universities should be utilized in Offshore segment • Need to take a more central role for offshore wind sector capacity building • Need to build in more inherent capacities with respect to techno-commercial feasibility aspects such as technical design and installation, financial due-diligence, O&M issues in offshore wind sector, etc.
NSDC	• Currently not available	• Training courses/curriculum should be designed for Offshore, whereas similar dedicated attributes exist for Onshore wind • Qualification packs (QPs) or criteria should be established for Offshore • Need to develop in-house personnel and tie-ups for disseminating trainings related to Offshore
INCOIS	• Bathymetry • Marine meteorology and operational ocean state forecasting (Wind speed, direction, wave current, sea temperature, etc.) • Advanced Hydrography • Risk and hazard assessment	• Need to expand its horizon and include potential estimation studies (based on ocean parameters), including dedicated courses on Offshore EIA • Need to collaborate more with training agencies for sharing insights on oceanic parameters and assist in conducting techno-commercial feasibility studies
NIO	• Bathymetry, seabed engineering and CRZ demarcation surveys • Evaluation of engineering design parameters for Offshore facilities • Detailed EIA inspection • Numerical modelling and underwater surveys	• Need to build courses in Offshore wind aspects and include dedicated trainings
IIT Chennai	• Advanced marine structures • Numerical modelling of Offshore structures • Ultimate strength analysis of Offshore structures	• Need to develop courses in the field of EIA, marine engineering, and techno-commercial Offshore wind assessment studies.
National Institute of Ocean Technology (NIOT)	• Laboratories, integration bays for assembly and integration of large-scale deep ocean testing equipment and machinery like underwater mining machine, ocean observation buoys, unmanned underwater vehicles etc. • Acoustic test facility, hyperbaric test facility, etc. and water quality, marine biotechnology laboratories for in-house testing of underwater components and samples.	• Need to assess the impact such as EIA of development activities on the ocean ecosystem.

Name of the Stakeholder /Institution	Offshore Wind projects: Skill Mapping **Development Phase**	Possible recommendations
	• Test facility for research in the areas of low temperature thermal desalination and ocean thermal energy conversion. • Shallow water bathymetry	
National Centre for Sustainable Coastal Management (NCSCM)	• Soil / Sediment processing facility, Soil / sediment particle size distribution, Soil Moisture tension measurement, Soil / Sediment / Rock homogenization • In-situ current, tide, discharge, wave direction, sediment transport, solar irradiance, bathymetry and photo synthesis rate data	• Need to introduce training packages integrating coastal aspects with offshore wind installations.

3.2.2. Additional skills needed in India

During the development phase of an Offshore wind farm, there are many activities which support the Engineering, Procurement and Construction (EPC) and the developer/owner of projects. These include site surveys, unexploded ordnance (UXO) surveys and potential removal. Other offerings often required are the supply of survey & guard vessels, oil-clean up services, the supply of fuel, waste disposal and insurance.

Special designed vessels are used for geotechnical and geophysical surveys and smaller surveys vessels are used for Wildlife surveys.

Activities are primarily linked to generic Offshore requirements, including marine operations and logistics with a higher technician level. The list below covers certification/training requirement for various roles in development phase:

- Marine coordinator and ships agent: require no specific technical knowledge or qualifications
- Vessel master: The master needs certifications for Seafarers
- Vessel mate and deckhand: The deckhand requires the Seafarers basic training
- UXO (unexploded ordnance) diver: Qualifications in Explosive Ordnance Disposal (EOD), valid professional diver certificate

Health and Safety "HSE" practices during the lifetime of the Offshore wind farm are essential and highly rated within the industry as poor practices can lead to long-term adverse effects that could be detrimental to the organization. Some of those effects include, but are not limited to, customer dissatisfaction, delays in Schedule, long term disabilities, fatalities, low morale, decreased quality and increased cost. For supporting the project Management in setting and define the HSE Policy, standards, guidelines, responsibilities, and organization roles, HSE managers should join the project at the earliest stage.

This position will entail detailed planning and creating an overall HSE Plan and including it within the Project Management Plan. Large organizations normally have readily available safety plans, policies, and regulations included within their organization.

HSE Manager should be tailoring the HSE Plan to suit the project's needs, type, complexity, client requirements, country regulations, and so on. The overall HSE plan will be used for setting the guideline of each supplier during the tendering rounds.

Experienced HSE Manager/s who hold training and industry recognized qualification such as the NEBOSH Diploma (or equivalent) will be needed. The National Diploma course accredited by the National Examination Board in Occupational Safety (NEBOSH) is a degree-level health and safety qualification intended for those who wish to develop a career in health and safety as a manager, consultant, or advisor. Many universities accept this qualification as prior learning that meets their entry criteria for access to advanced MSc level courses.

Before registering for the National Diploma, it is advisable to first complete one of the following:

- NEBOSH National General Certificate
- NEBOSH National Certificate in Construction Health and Safety Institutes providing the NEBOSH

The Certificates and diplomas can be obtained widely at the National Diploma course accredited by the National Examination Board in Occupational Safety. NEBOSH[23] is a UK based organization, which is internationally acknowledged within the wind power industry. Training is provided throughout the world by certified trainers.

Table 3.3: Key certified institutions providing training

Provider	Contact
Focus on Training	http://www.focus-on-training.co.uk
Astutis	www.astutis.com
British Safety Council	www.britsafe.org
Lloyd's Register	www.lr.org
The Knowledge Academy	https://www.theknowledgeacademy.com

3.2.3. Relevant certification

No special wind energy related certification is required for the development phase other than normal professional standard certifications. The main workload during the development phase is planning from office locations. However, it is important during the development phase to be aware of certification needs in the construction and operation phases and to plan accordingly, for example when defining the HSE organization and roles (see Section 3.2.2). See information on certification needs in the construction and operation phases in section 4.3.2 and 5.4.3, respectively.

[23] https://www.nebosh.org.uk/about-nebosh/our-organisation/

CONSTRUCTION PHASE

4. Construction phase

The construction phase is the most important phase in project development, encompassing planning, execution, monitoring, commissioning, and closure phase of construction. During this phase the wind farm elements are manufactured, supplied, and installed at the wind farm site including cable connections to the electrical grid on shore. The key elements of an offshore wind farm comprise foundation, tower, turbine, cables, and substation, and the installation of the components relies on a skilled work force capable of operating offshore.

4.1. Direct employment related to the construction of the two upcoming Offshore wind farms

In this section, the local job creation opportunities related to the first 1 GW offshore wind projects in India are estimated based on information from the study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector*[24]. The study provides estimations of the number of jobs related to selected parts of the construction phase, which can be expected to result in local job creation.

The study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector* was published in 2019, where the offshore wind energy capacity in the Netherlands was around 1 GW with an expected addition of around 3,7 GW by 2023. Although the Dutch offshore wind power capacity was already at 1 GW at the publication time, the study can arguably provide basis for job creation figures related to the first projects in India, and indicate the supply chain elements, which can be expected to be the first to develop locally.

In the present study, the indications of job creation opportunities during the construction phase are based on two offshore wind projects with a total capacity of 1 GW, having an indicative of 83 turbines on the sites, which is based on an assumed power capacity of 12 MW per turbine. The employment related to one-off activities during the construction phase is assumed to fall in the following categories:

- Tower manufacturing and supply
- Foundation manufacturing and supply
- Foundation installation
- Turbine installation
- Array cable installation
- Installation support and logistic

Compared with the Dutch employment study mentioned above, tower manufacturing and supply has been added in order to represent existing Indian tower production capabilities from the onshore wind energy sector. The following elements of the construction phase is thereby not considered: turbine manufacturing and supply, foundation substation manufacturing and supply, cable manufacturing and supply, substation manufacturing and supply, export cable installation, substation foundation installation and substation installation.

The employment figures are based on the study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector* and experience and information from stakeholders active in the offshore wind industry and must be seen as an indication only due to various factors such as:

1. Product and process innovations (e.g. increase in single turbine capacity)
2. Economies of scale (e.g. larger wind farms require higher manpower but lower manpower/MW)
3. Learning curves (e.g. more efficient installation schedules, increase in operational excellence)

The assessment is based on the following two approaches:

[24] https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

- Bottom-up workload bringing in the insights of existing and forthcoming two Offshore wind farms for direct employment indications related to the number of WTGs
- Analysis of required competencies from the perspectives of functional competencies and basic competencies.

These approaches are suited to come up with direct employment figures and competencies to support plans for education and inflow of future employees to the offshore wind sector. The construction related aspect will focus on job-creation opportunities across 6 major areas as illustrated below.

1. Tower manufacturing and supply
2. Foundation manufacturing and supply
3. Foundation installation
4. Turbine installation
5. Inter array cable installation
6. Installation and commissioning support

The job figures related to these areas are presented in the succeeding sections. The presented figures represent only local job creation, while the execution of the tasks would involve additional work from international partners with relevant expertise, which is not accounted for here.

4.1.1. Tower manufacturing and supply

The estimations of job creation figures for the tower manufacturing and supply area are presented as person-years based on the following employee categories, which are active in this part of the construction phase:

Factory workers, engineers, planner, process operators, maintenance technicians, QA/QC professionals

These converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, the robustness of retrieved data from industry, product specifications and ongoing growth in process efficiencies such as production automation.

Direct employment for the manufacturing of one tower[25]:	1.5 person-years per tower
Cumulative direct employment for the project (83 Turbines)	124 person-years

4.1.2. Foundation manufacturing and supply

The estimations of job creation figures for the foundation manufacturing and supply area are presented as person-years based on the following employee categories, which are active in this part of the construction phase:

Factory workers, engineers, planner, process operators, maintenance technicians, QA/QC professionals

These converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, the robustness of retrieved data from industry, product specifications and ongoing growth in process efficiencies such as production automation.

Direct employment for the manufacturing of one monopile (MP)[26]:	1.5 person-years per MP
Cumulative direct employment for the project (83 Turbines):	124 person-years

Direct employment for the manufacturing of one transition piece (TP)[26]:	2 person-years per TP
Cumulative direct employment for the project (83 Turbines):	166 person-years

[25] Assumed to be the same workload per tower as the workload per monopile due to the similar structure of the components
[26] Based on https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

4.1.3. Foundation installation

The foundation installation workload is related to the installation of approximately 83 foundations MP+TP at Offshore wind farm(s). In the below table we have estimated the workload and employment for both scope of work for the installation of the MP and the TP. The complete crew onboard an installation vessel includes approximately 160 persons in total comprising primarily of:

Captain, Mate, Nurse, Facility manager, HSE officer, Engineers, Technicians, Electricians, Motormans, Storekeepers, Firemen, Superintendent's, Rigger, Cook, Steward, Laundrystaff, Handyman, Welder , Safety officer, Maritime Automation Engineer, Crane operators, Oiler, Heavy Lift crane operators, Crawler Crane operators, Scaffolding technicians, ROC technicians, Surveyors, Waste controller, Communication controllers, Environment specialist, lead project draughtsman, client representative

The estimations of job creation figures for the foundation installation area are presented as person-years based on the following employee categories, which are active in this part of the construction phase:

Marine crew, Offshore construction manager, drilling operators, superintendent, surveyor, technicians, riggers, engineers, lifting and crane staff, QC and HSE professionals, Electrician, Welder, painter, jacking engineer, Deckhand

These categories converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, robustness of retrieved data from industry, product and engineering specification, vessel, cranes capability, ongoing process efficiency and weather window.

Direct employment for the manufacturing of foundation (MP+TP)[26]:	0.25 person-years per MP 30 Marine crew per project
Cumulative direct employment for the project (83 Turbines):	Staff approximately 21 person-years Marine crew: 60 fixed for the 2 projects

4.1.4. Turbine installation

The turbine installation workload is related to the installation of approximately 83 turbines at project site(s). The complete crew onboard an installation vessel includes approximately 95 persons in total and include:

Captain, Installation Manager, Mate's, Medic, Facility Manager, HSE Officer, Engineers, Electricians, Technicians, Storekeepers, Superintendents, Riggers, Cook, Steward, Deckshand, Welder, Bosun, Oiler,Crane operators, Surveyors, Client representatives

In our estimations, we have included employee categories as:

Offshore construction manager, Superintendent, Surveyor, Lifting supervisors, QA and HSE professionals, Riggers, Site managers, Foreman, WTG technicians and engineers, riggers, master of marine crew, 1st officer, 2nd officer, Chief engineer, Chief mate, Electrician, Jacking engineer, Bosun, Deckhands, Stewards, Camp boss, Cook

These converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, the robustness of retrieved data from industry, product and engineering specification, vessel, cranes capability, ongoing process efficiency and weather window.

Direct employment for installation of the turbine[26]:	0.38 person-years per MP 30 Marine crew per project
Cumulative direct employment for the sites (83 Turbines):	Staff approximately 32 person-years Marine crew: 60 fixed for the 2 projects

4.1.5. Inter array cable installation

The inter array cable installation workload is related to the installation of approximately 83 turbines. In our estimations, we have included employee categories as:

Offshore construction manager, Superintendent, Welder, Deckhand, Crane operator, Cable operator, Deck foreman, Tower teams, ROV pilot, Captain of the Marine Crew, Chief mates, 2nd mate, Dynamic positioning operator, Survey, Chief engineer, 2nd engineer, Technician in the engine room, 3rd engineer, electrician, Cook, CCTV crew

These converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, the robustness of retrieved data from industry, product and engineering specification, vessel, cranes, capability, ongoing process efficiency and weather window.

Direct employment for installation of the array cables[26]:	0.39 person-years per foundation 28 Marine crew per project
Cumulative direct employment for the project (83 Turbines):	Staff approximately 32 person-years Marine crew: 56 fixed for the 2 projects

4.1.6. Installation Support

The turbine installation support workload is related to the installation of approximately 83 turbines at the project site. The estimations of job creation figures for the installation support area are presented as person-years based on the following vessel types and related employee categories:

- 2 CTV vessels
- 1 Supply vessel
- 1 Guard vessel
- 1 Multipurpose vessel (Crew members + Client representatives)
- Survey vessel (5)
- 1-Pre-layer grapnel run (Crew members + Surveyor + Client Rep)

Based on the list above, 75 Marine Crew Members are estimated per wind farm project, which convert into person-years based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, robustness of retrieved data from industry, product and engineering specification, vessel, cranes capability, ongoing process efficiency and weather window.

Direct employment for installation support[26]:	75 Marine crew per project
Cumulative direct employment for the sites (83 Turbines):	Marine crew: 150 fixed for the 2 projects

4.2. Overview of direct employment in India related to construction

The table below gives an overview of the estimated direct employment during the construction phase related to the Offshore wind farms presented in the above paragraphs.

Table 4.1: Overview of direct employment opportunities from construction of upcoming offshore wind projects in India

Wind farms packages under this survey	Cumulative one-off direct work	
	Person-years specialists	Person years Marine crew
Tower manufacturing and supply	124	-
Foundation (MP+TP) manufacturing and supply	290	-
Foundation installation	21	60

Turbine installation	32	60
Array cable installation	32	56
Installation and commissioning support	-	150

By summing the numbers in the table above, this study estimates that the cumulative one-off direct work potential during the construction phase of the first two wind farms in India amounts to around 825 person years. In order to give high-level employment insights, the total direct and indirect employment in the entire value chain for manufacturing and installation can be estimated at 10-20 times as many man years as the direct employment indicated above.

IRENA estimates[27] that an offshore wind project of 500 MW results in 2.1-million-person days considering the value chain from project planning to decommissioning over a project lifetime of 25 years. Out of the 2.1-million-person days, a share of 11 % is attributed to installation and grid connection and 59 % is attributed to manufacturing and procurement. If the categories installation and grid connection and manufacturing and procurement are considered to represent the construction phase, the workload of the construction phase is estimated by IRENA to be 14,700 person years per GW, assuming 200 person days per person year. The 14,700 person years per GW estimated by IRENA represents the entire workload in the supply chain related to installation and grid connection and manufacturing and procurement. This includes all tasks involved in the supply chain elements procurement, manufacturing, installation, and grid connection. On the other hand, the 825 person years/GW estimated in the present study covers only a part of the work related to tower manufacturing and supply, foundation manufacturing and supply, foundation installation, turbine installation, array cable installation, and installation support and logistic, which, based on the Dutch example, is expected to be carried out by a local work force. This comparison indicates that the total number of person years/GW related to construction of 1 GW of offshore wind could be up to 20 times the direct local employment, in round figures 15,000 person years, which can be realized as the Indian offshore wind energy supply chain and skill base develops.

4.3. Skills needed

More elaborations among industry parties and between industry and education institutes are required to work out competencies overviews, not only being relevant for the human capital activities within the coming Indian Offshore wind farms, but also for education and training institutes serving the sector. The employment related to one-off activities during the construction phase of wind farms has been categorized under different categories and key competencies have been mapped under the same:

1. Tower manufactory and supply
2. Foundation manufactory and supply
3. Foundation installation
4. Turbine installation
5. Array Cable Installation and termination
6. Installation support

Table 4.2: Mapping competency requirement[28]

Core Area	Practical Competency Requirement	Basic Competency Requirement
Tower manufacturing and supply	• Manufacturing Management • Production Automation • Metalworks • Paint and Coating • Electrical engineering • Logistic management • Quality control and inspection work • Safety training	• Managing and leadership • Coaching and teaching • Professionalism • Teamwork • Communicative • Interpersonal • Results driving • Reliability and dependable • Duty awareness

[27] Renewable Energy Benefits: Leveraging local capacity for offshore wind, IRENA, link: https://www.irena.org/publications/2018/May/Leveraging-Local-Capacity-for-Offshore-Wind
[28] Based on https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

Core Area	Practical Competency Requirement	Basic Competency Requirement
		• English speaking • Flexibility • Relevant Technical skills
Manufacturing foundations	• Manufacturing Management • Production Automation • Metal works • Paint and Coating • High Voltage and low voltage engineering • Electrical engineering • Logistic management • Quality control and inspection work • Safety training	• Managing and leadership • Coaching and teaching • Professionalism • Teamwork • Communicative • Interpretable • Results driving • Reliability and dependable • Duty awareness • English speaking • Flexibility
Foundation Installation	• Positioning the MP • Jacking up and down of the vessel • Lifting operations • Working at sea • Installation work on MP • Mounting the TP • GWO (safety training certificates) • Quality Control • HSE (Health and safety)	• Managing and leadership • Coaching and teaching • Professionalism • Teamwork • Communicative • Results driving • Reliability and dependable • Duty awareness • English speaking • Flexibility
Turbine Installation	• Managing and leadership • Jacking up and down of the vessel • Lifting operations • Installation of nacelle • Bolting to tower • Installation of Hub • Installation of blades • Termination of the electrical systems • Commissioning of various technical systems • GWO (safety training certificates) • Quality Control • HSE (Health and safety) • Working at sea	• Professionalism • Teamwork • Communicative • Results driving • Reliability and dependable • Duty awareness • English speaking • Flexibility
Array Cables	• Geotechnical and seismic work • Array cable positioning and laying • Array cable termination • Burial inspection • Commissioning and test of array cables • GWO (safety training certificates) • Quality Control • HSE (Health and safety) • Working at sea	• Managing and leadership • Professionalism • Teamwork • Communicative • Results driving • Reliability and dependable • Duty awareness • English speaking • Flexibility

Core Area	Practical Competency Requirement	Basic Competency Requirement
Installation Support	• Operational excellence for Offshore activities • Planning of operations • Coordination of vessel and Offshore operations • HSE (Health and safety) • Working at sea	• Professionalism • Teamwork • Communicative • Reliability and dependable • Duty awareness • Flexibility

4.3.1. Available in India

Indian institutes which provide training in the Offshore domain are covered in the table below. The table also covers skill mapping with construction phase and possible recommendations.

Table 4.3: Training available in India – Construction phase

Name of the Stakeholder /Institution	Offshore Wind projects: Skill Mapping - **Construction and Installation Phase**	Possible recommendations
NIWE	Currently not available	• Need to build in more inherent capacities with respect to construction aspects such as project management, site installations, risk, and mitigations etc.
NSDC	Currently not available	• Training courses/curriculum should be designed for Offshore, whereas similar dedicated attributes exist for Onshore wind
INCOIS	Currently not available	• Need to collaborate more with other training agencies to prepare material for construction challenges on part of ocean parameters and related studies
NIO	Currently not available	• No training on construction activities in offshore wind sector in line, need to develop the training material in line with current strength
IIT Chennai	• Installation and design of Offshore structures • Foundation of Offshore • Subsea engineering (although for O&G) • Material of fabrication of Offshore structures	• Need to include more civil and electrical works related training material

4.3.1. Additional skills needed in India

Health and Safety "HSE" practices[29] during construction are highly rated within the Offshore industry as poor practice can lead in long-term adverse effects that could be detrimental to the organization. Some of those effects are, but not limited to Customer dissatisfaction, delays in Schedule, long term disabilities, fatalities, low morale, decreased quality and increased cost.

Safety should not be taken lightly and be planned in detail during the planning phase by creating an HSE Plan and including it within the Project Management Plan. Large organizations normally have readily available safety plans, policies, and regulations included within their organization. HSE Manager should be tailoring the HSE Plan to suit the project's needs, type, complexity, client requirements, country regulations, and so on.

[29] See for example good practice guidelines by the Global Offshore Wind Health and Safety Organisation, link: https://www.gplusoffshorewind.com/work-programme/workstreams/guidelines

During risk planning, HSE risks are thoroughly evaluated, and their estimated impact is added to the contingency and management reserves depending on whether it is a known-unknown or unknown-unknown risk. For supporting the top management and the project Management HSE managers will join the project at the earliest stage.

- Health and safety "HSE" training for all staff will be needed locally

Experienced HSE Manager/s who hold training and industry recognized qualification such as the NEBOSH Diploma (or equivalent) will be needed during the project phases

The National Diploma course accredited by the National Examination Board in Occupational Safety (NEBOSH) is a degree-level health and safety qualification intended for those who wish to develop a career in health and safety as a manager, consultant, or advisor. Many universities accept this qualification as prior learning that meets their entry criteria for access to advanced MSc level courses.

Before registering for the National Diploma, it is advisable to first complete one of the following:

- NEBOSH National General Certificate
- NEBOSH National Certificate in Construction Health and Safety Institutes providing the NEBOSH

The Certificates and diplomas can be obtained widely at the National Diploma course accredited by the National Examination Board in Occupational Safety.

Table 4.4: Certified institutions providing training

Provider	Contact
Focus on Training	http://www.focus-on-training.co.uk
Astutis	www.astutis.com
British Safety Council	www.britsafe.org
Lloyd's Register	www.lr.org
The Knowledge Academy	https://www.theknowledgeacademy.com

GWO standards are created by the industry, for the industry. The members are globally leading turbine manufacturers and owners, representing a majority of installed wind energy capacity around the world. Together, they share risk information and expertise to create training standards that improve safety and build a competent workforce.

GWO module certificates for all work at height and work at sea is required for all workers and as the certificates are valid only for 2 years, there is an ongoing business in keeping all certificates updated for all workers on site.

GWO training facilities for all workers will need to be arranged and set up locally until then the training can only be obtained from several places around Europe. Few of the training facilities are mentioned below.

Table 4.5: Training facilities offering GWO certificates

Provider	Contact	Nationality
RelyOn Nutec	www.relyonnutec.com	Denmark
Global Wind Academy	www.globalwindacademy.com	Denmark
Deutsche WindGuard Offshore	https://www.windguard.com/	Germany
Deutsche Windtechnik	https://www.deutsche-windtechnik.com	Germany
FMTC Safety	www.fmtcsafety.com	The Netherlands
STC KNRM	www.stc-knrm.nl	The Netherlands

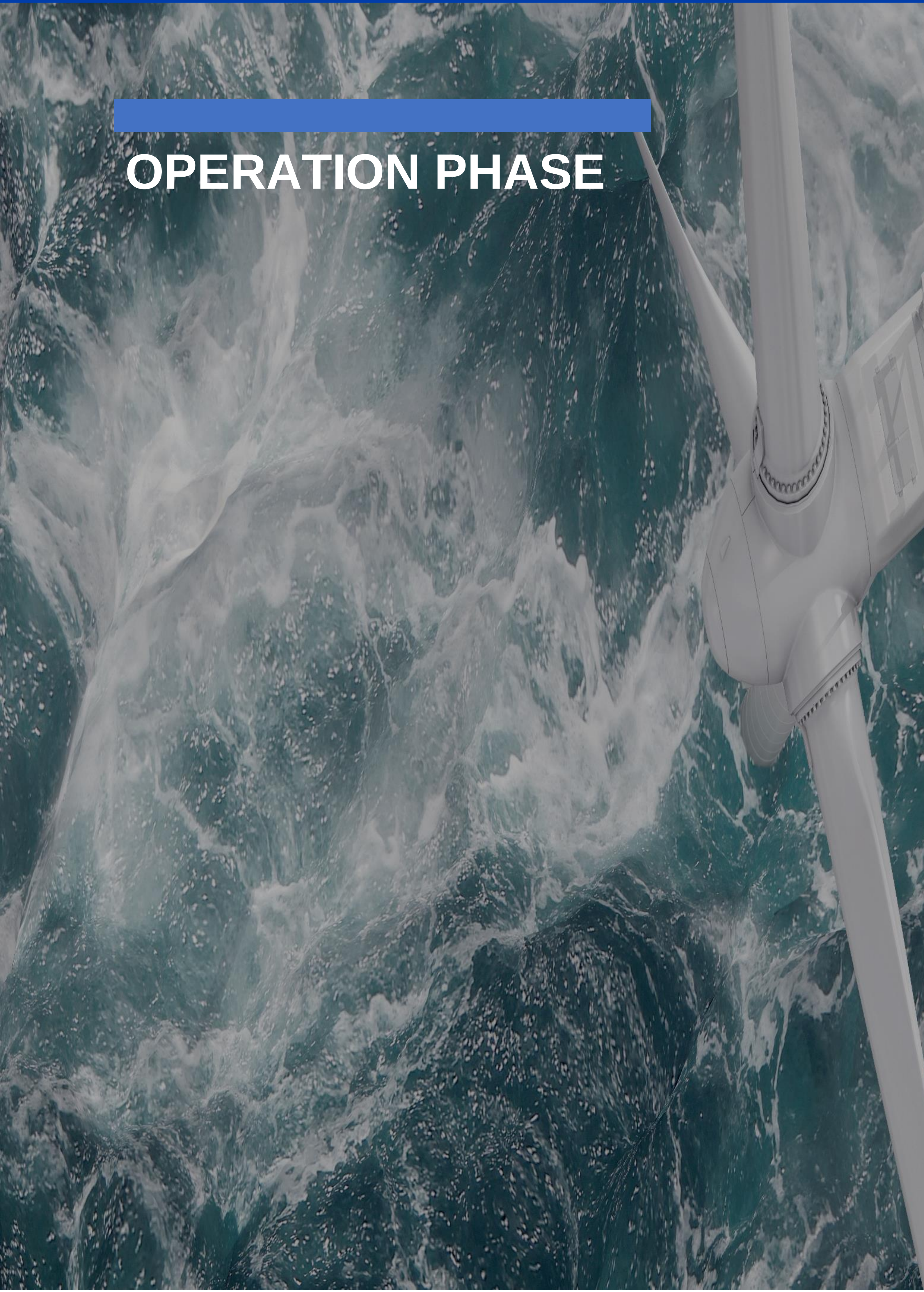
4.3.2. Relevant certification

To be certified, the GWO training facilities and operation must be audited by a certification body, which must comply with the GWO[30]. See description of GWO certifications in section 4.3.1.

[30] Link to GWO webpage for more information: https://www.globalwindsafety.org/

Setting up local organisations include facilities fit for purpose, hiring of administration staff and instructors who must follow the national legislation, applicable standards, and regulations in India for enabling consistent delivery of training and assessment in accordance with GWO Training Standard(s).

OPERATION PHASE



5. Operation phase

The operational phase indicates the period wherein a project in consideration is in operation after construction and commissioning is complete. The phase involves the tasks related to keeping the wind farm in operation for example maintenance and inspection of structures, turbines, cables, substation, etc.

5.1. Employment related to Operation and maintenance phase

In the following the local job creation opportunities related to the first 1 GW offshore wind projects in India are estimated based on information from the study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector*[31]. The study provides estimations of the number of jobs related to selected parts of the operation phase, which can be expected to result in local job creation.

The study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector* was published in 2019, where the offshore wind energy capacity in the Netherlands was around 1 GW with an expected addition of around 3,7 GW by 2023. Although the Dutch offshore wind power capacity was already at 1 GW at the publication time, the study can arguably provide basis for job creation figures related to the first projects in India, and indicate the supply chain elements, which can be expected to be the first to develop locally.

In the present study, the indications of job creation opportunities during the construction phase are based on two offshore wind projects with a total capacity of 1 GW, having an indicative of 83 turbines on the sites, which is based on an assumed power capacity of 12 MW per turbine.

Employment-related to recurring activities during the operations and maintenance of wind farms has been categorized under following key activities:

- Wind farm operations
- Turbine maintenance
- Structural inspection and maintenance
- Maintenance and service logistics

The following elements of the operation phase is thereby not considered: Array cable inspection, export cable inspection substation operations and maintenance, and maintenance and service logistics for substations.

The employment figures are based on the study *Employment analysis (2019-2023) of various fields of activities in the Dutch offshore wind sector* and on experience and information from stakeholders active in the Offshore wind industry and must be seen as an indication due to:

1. Product and process innovations (e.g. increase in single turbine capacity)
2. Economies of scale (e.g. larger wind farms)
3. Learning curves (e.g. more efficient installation schedules, increase in operational excellence)

In general, all employment related to the phase of operations and maintenance has a recurring character. Therefore, in this paragraph the direct employment indications are presented on an annually basis.

The job figures represent only local job creation, while the execution of the considered operation tasks would involve additional work from international partners with relevant expertise, which is not accounted for here.

5.1.1. Wind farm operations

The estimations for activities related to wind farm operations include the following employee categories:

- Commercial Operation Management

[31] https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

- Monitoring and Marine coordinators
- Technical specialists
- Data analysts / AI (Artificial Intelligence) data specialist
- Cyber security technical specialist
- Network Engineers
- Research scientists
- Administration
- HSE

All together, 11 Employees per wind farm project would be needed for this sub-category. These converted into person-years is based on 1500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included. Influencing factors could include employee categories, the robustness of retrieved data from industry, developments in economies of scale when multiple wind farms will be installed and monitored from one operation base in the future.

Direct employment for the operation of one wind farm[32]:	Approximately 11 persons per Offshore Wind Farm
Recurring direct employment per year for the operation of wind farms at two sites	Approximately 22 persons for the Fixed 2 projects

5.1.2. Turbine Maintenance

The estimations for activities related to turbine maintenance include the following employee categories:

- Technicians at various levels low-high
- Onshore staff back-office staffs

Recurring employment indication per turbine per year: 200 effective preventive maintenance hours by technicians, independent of geographical distance of the Offshore wind farm from the port and independent from the single turbine capacity. Experts from the Dutch Offshore wind industry show estimate of 1,200 productive hours per year per full time equivalent of 38 hours per week. These converted into person-years is based on 1,500 productive manufacturing hours per year per employee. No additional employment factors like seasoning and production shift are included.

Influencing factors could include robustness of retrieved data, CTV concept (e.g. daily CTV transit time per technician, shift duration, on-site working hours per turbine etch), economy when windfarm strategies are crossed from multiple wind farms and weather windows.

Direct employment for preventive maintenance of one WTG:	0.27 technician per WTG 0.12 Other staff per WTG
Cumulative direct employment for the project (83 Turbines)	Staff approximately 32 person-years

5.1.3. Structural inspection and maintenance

The estimations for activities related to structural inspection and maintenance include the following employee categories:

- Inspectors and technicians at various levels

Recurring employment indication per turbine per year: 1200 productive hours per year per full-time equivalent of 38 hours per week. No additional employment factors like seasoning and production shift are included.

[32] Based on https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

Influencing factors could include robustness of retrieved data, inspection and maintenance strategy and development over time, amount of work related to large scale maintenance projects economy when windfarm strategies are crossed from multiple wind farms and weather windows.

Direct employment per year for preventive maintenance of one WTG:	0.1 technician per WTG
Cumulative direct employment for the project (83 Turbines)	Staff approximately 8 person-years

5.1.4. Maintenance and service logistic

We have estimated that a standard Service Operation Vessel (SOV) operates with 15 crew members and standard Crew Transport Vessel (CTV) operates with 2 crew members on 12 hours shifts. These converted into person-years is based on 1500 productive manufacturing hours per year per employee.

Influencing factors could include robustness of retrieved data, economy when windfarm maintenance strategies are crossed and weather windows.

Direct employment per year for maintenance and logistics of one Offshore wind farm:	Approximately 15 persons per Offshore Wind Farm
Cumulative direct employment for the project (83 Turbines)	Approximately 30 persons for the two considered wind farms

5.2. Overview of direct employment in India related to operations and maintenance

The table below gives an overview of the direct employment related in the Offshore wind farms presented in the above paragraphs.

Table 5.1: Overview of direct employment opportunities from installation, operation and maintenance of upcoming offshore wind projects in India

Wind farms packages under this survey	**Cumulative one-off direct work**		Direct employment per year forward for the two wind farms Person years/year
	Person-years Specialist	Person years Marine crew	
Tower manufacturing and supply	124		
Foundation (MP+TP) manufacturing and supply	166		
Foundation installation	21	60	
Turbine installation	32	60	
Array cable installation	32	56	
Installation support		150	
Wind farm operations & maintenance			22 Management and admin
Turbine maintenance			32 Technicians and others
Structural inspection and maintenance			8
Maintenance and service logistics			30

Based on the above direct job opportunities offered by Offshore wind projects, it has been estimated that 793 person-years jobs are directly generated with 1GW of offshore wind installation. The table below reflects the potential of such job opportunities with installation of 30GW of offshore wind projects in India by the year 2030, in line with MNRE's target. While there will be one time job opportunities linked to installation and commissioning, there will be recurring job opportunities as well linked to operations and maintenance, which have been considered in the following assessment.

Table 5.2: Potential job opportunities with 30GW offshore wind target by 2030 in India

S. No.	Year of installation	Year wise capacity addition	Year wise total direct person years of jobs
1.	2022	1GW	793
2.	2023	2GW	1,678
3.	2024	3GW	2,655
4.	2026	4GW	3,724
5.	2027	5GW	4,885
6.	2028	5GW	5,345
7.	2029	5GW	5,805
8.	2030	5GW	6,265
9.	**Total**	**30GW**	**31,150**

Overview of direct employment indication in person-year and full-time equivalent for the two offshore wind sites. In order to give high-level employment insights, this study makes a pragmatic move by converting full-time equivalent figures into person-years figures based on a factor 1.

In total, this study estimates that the direct employment per year related to operation and maintenance of the first two wind farms in India amounts to around 90 person years/year. IRENA estimates[33] that an offshore wind project of 500 MW results in 2.1 million person days considering the value chain from project planning to decommissioning over a project lifetime of 25 years. Out of the 2.1 million person days, a share of 24 % is attributed to operation and maintenance, which corresponds to around 5,000 person years per GW assuming 200 person days per person year. Considering a project lifetime of 25 years, the present study estimates a workload of 2,200 person years/GW. The 5,000 person years/GW estimated by IRENA is representing the entire work load related to operation and maintenance, while the 2,200 person years/GW estimated in the present study covers only the part, which, based on the Dutch example, is expected to be carried out by a local work force. The 2,200 person years/GW does thereby include a potential for growth, which can be realized as the Indian offshore wind energy supply chain and skill base develops.

For comparison, the New Jersey offshore wind strategic plan[34] estimates that the development of 7.5 GW offshore wind projects results in 68,340 jobs from 2020 to 2035. The category of installation, maintenance, and repair occupations accounts for 12.8 %, and the category of transportation and material moving occupations accounts for 5.6 %. Comparing these two categories with the job creation numbers estimated for the construction and operation phase in the present study, the New Jersey offshore strategic plan estimates job creation equivalent of 1,677 person years/GW, while the present study estimates around 2,200 person years/GW[35].

5.3. Indirect employment

Indirect employment contains jobs outside of the Offshore wind energy sector and do include such as:

- Initial supply
- Spare part and repairs
- Transport service facilities and accommodation of construction/O&M personnel plus all related local services

These employment opportunities are part of the supply chain to the sector and should be counted into as employment within the Offshore wind industry. Due to the complexity and the fact that no high-quality information and data regarding indirect employment is available, this study has not elaborated on the size of the indirect employment regarding the packages under survey.

[33] Renewable Energy Benefits: Leveraging local capacity for offshore wind, IRENA, link: https://www.irena.org/publications/2018/May/Leveraging-Local-Capacity-for-Offshore-Wind
[34] https://www.nj.gov/bpu/pdf/Draft_NJ_OWSP_7-13-20_highres.pdf
[35] Estimated as the sum of the workload in the construction phase and operation phase, where the operation phase is considered over 15 years: 850 + 92 x 15 = 2,200 person years/GW (rounded)

5.4. Skills needed

In addition to the experience, base skillset required during the development phase in the Offshore wind industry is the same as already being demanded in the Onshore Wind sector. Some roles in Offshore wind sector development phase are as below:

1. Wind farm operation
2. Wind Turbine Maintenance
3. Structural inspection and maintenance
4. Maintenance and logistic services

Table 5.3: Mapping competency requirement[36]

Core Area	Practical Competency Requirement	Basic Competency Requirement
Wind farm operations	• Business management • Commercial and operational excellences • Technical operation management • Planning of operations • Data modelling and analysis • Optimizing of Energy output • Marine coordination of Offshore operations • Quality control • HSE (Health and safety) • Problem solving skills	• Management and leadership • Coaching • Professionalism • Technical problem solving • Reflectivity • Result-driven • Communicative • Duty awareness

[36] Based on https://www.topsectorenergie.nl/sites/default/files/uploads/Wind%20op%20Zee/Documenten/20190709%20OW%20Employment%20NL%20Report%20-%20final%20v1.2%20-%20online.pdf

Turbine maintenance	• Operations and maintenance protocols and guidelines • Maintenance standards • Data analysis • Quality control • GWO (safety training certificates) • HSE (Health and safety) • Inspect the exterior and physical integrity of towers, inspect, troubleshoot, or repair turbine equipment • Collect turbine data for testing or research and analysis. • Perform routine maintenance on wind turbines • Test electrical components and systems, as well as mechanical and hydraulic systems • Troubleshoot mechanical, hydraulic, or electrical malfunctions • Service underground transmission systems, wind field substations, or fiber optic sensing and control systems	• Flexibility • Coaching • Reliability and dependable • Teamwork • Coaching • Working at sea • Professionalism • Technical problem solving • Reflectivity • Result-driven • Duty awareness • Integrity
Structural inspection and maintenance	• Operations and maintenance protocols and guidelines • Maintenance standards • Data analysis • Quality control • GWO (safety training certificates) • HSE (Health and safety)	• Flexibility • Coaching • Reliability and dependable • Teamwork • Coaching • Working at sea • Professionalism • Technical problem solving • Reflectivity • Result-driven • Duty awareness • Integrity
Maintenance and logistics service	• Logistic management • International Offshore standards • Safe transfer of personnel and parts • Quality control • GWO (safety training certificates) • HSE (Health and safety)	• Flexibility • Reliability and dependable • Teamwork • Working at sea • Professionalism • Duty awareness

5.4.1. Available in India

Indian institutes which provide training in Offshore domain are covered in the table below. The table also covers skill mapping with operation phase and possible recommendations.

Table 5.4: Training available in India – Operation phase

Name of the Stakeholder /Institution	Offshore Wind projects: Skill Mapping - **Post-Construction Phase**	Possible recommendations
NIWE	Currently not available	• Need to build in more inherent capacities and technical courses on project operations, issues, challenges, maintenance
NSDC	Currently not available	• Need to design training courses/curriculum designed for Offshore, whereas similar dedicated attributes exist for Onshore wind • Need to develop in-house personnel and tie-ups for disseminating trainings related to Offshore in O&M activities
INCOIS	Currently not available	• Need to collaborate more with training agencies for sharing insights on oceanic parameters and its impact on operations and maintenance of Offshore wind plant, support in material preparation
NIO	Currently not available	• No training on construction activities in offshore wind sector in line, need to develop the training material in line with current strength
IIT Chennai	Currently not available	• Institute needs to develop inherent capacities and training material in the field of project operations & maintenances, risks and mitigation

5.4.2. Additional skills needed in India

For turbine maintenance: Experienced climb and rope access experts will be needed. As turbines are becoming electronically sophisticated, the need of personnel who hold strong electrical / control and instrumentation skillset will be needed during the operation phase.

IRATA is an acronym for the Industrial Rope Access Trade Association. It is an initiative of several leading companies within the Offshore oil and gas industry, who use the industrial rope access techniques, to provide a safe working environment for the industry.

The IRATA level 3 course is addressed to rope access technicians with more than one year of experience and 1000 hours as IRATA level 2 technician. The IRATA level 3 course qualifies you as a supervisor of vertical work equipment, rescue in very complex situations, rescue procedures and risk analysis in vertical jobs. Currently there is a great demand for IRATA levels 3 technicians to work around the globe.

The IRATA certifications level 1-3 is a combination of training and experiences and will be required for all special work at height. IRATA training facilities can be certified locally and can also be obtained many places around Europe.

Table 5.5: Key training facilities offering IRATA certification

Provider	Contact	Nationality
Altitude Above All Training	https://www.aboveall.dk/	DK
RT9	https://rt9.dk/	DK
Skylotec	https://www.skylotec.com/	Germany
Vertex Training Solutions	https://vertextrainingsolutions.com	Germany
Ascent Safety	https://ascent.nl/	The Netherlands
Height Safety Expert	https://heightsafetyexpert.com	The Netherlands

Maintaining the turbine foundation: Specialists with professional diver skills will be required.

Analytic and technical staff for supervisory control and data acquisition (SCADA) monitoring: 24/7 monitoring and occasional remote manual intervention, requiring several dedicated personnel per wind farm who can also analyzed in-depth off site for condition monitoring purposes will be required.

Health and Safety "HSE" practices will continuously be in focus during the operation phase as accident will not be tolerated, safety will be taken seriously in all operations and overall tailored HSE Plan from the management should be followed for the whole organisations

HSE Manager are providing risk planning and audits for all operations, HSE risks are thoroughly evaluated and their estimated impact is added to the contingency and management reserves depending on whether it is a known-unknown or unknown-unknown risk.

For supporting the top management and the project Management HSE manager will be a part of the management group during the lifetime of the windfarm.

- Health and safety "HSE" training for all staff will be provided continuously locally

  Experienced HSE Manager/s who hold training and industry recognized qualification such as the NEBOSH Diploma (or equivalent) will be needed during operation of the wind farm.

The National Diploma course accredited by the National Examination Board in Occupational Safety (NEBOSH) is a degree-level health and safety qualification intended for those who wish to develop a career in health and safety as a manager, consultant, or advisor.

More detail on HSE such as NEBOSH certificates and certificate/ Diploma providers can be viewed in section 4.3.1

GWO standards are created by the industry, for the industry. The members are globally leading turbine manufacturers and owners, representing most of the installed wind energy capacity around the world. Together, they share risk information and expertise to create training standards that improve safety and build a competent workforce.

More details on GWO such as training facilities can be viewed in section 4.3.1

5.4.3. Relevant certification

To be certified, the GWO training facilities and operation must be audited by a certification body, which must comply with the GWO Requirements for Certification Bodies[37]. See description of GWO certifications in section 4.3.1.

Setting up local organisations include facilities fit for purpose, hiring of administration staff and instructors who must follow the national legislation, applicable standards and regulations in India for enabling consistent delivery of training and assessment in accordance with GWO Training Standard(s).

IRATA Level 1-3 certification will be required for the rope access personnel used for the maintenance of the structure and blades[38]. See description of IRATA in section 5.4.2.

To be certified, IRATA training provider facilities and operation must be audited by a certification body, which must comply with the IRATA requirements for Certification Bodies. Setting up local organisations include establishing facilities fit for purpose, hiring of administration staff and instructors who must follow the national legislation, applicable standards, and regulations in India for enabling consistent delivery of training and assessment in accordance with IRATA Training Standard(s).

37 Link to GWO webpage for more information: https://www.globalwindsafety.org/
38 Link to IRATA webpage for more information: https://www.irata.org/

CONCLUSION AND RECOMMENDATIONS

6. Conclusion and recommendations

Training and skill development will be critical to realize India's ambitious Offshore sector plans. This study highlights the key skills that are needed for an Offshore wind sector development in India and assessed the available skills in India, active institutes that have a role to play, key gaps in existing training curriculum, major EU institutes active in Offshore wind training and key recommendations.

Introductory competencies overviews, created for the most relevant work packages, illustrate that a substantial amount of the employment in the offshore wind industry is related to the mid to higher level of wind technicians. Also, a substantial number of professionals working in the industry can be linked to the lower technical level especially for factory workers during the foundation construction and delivery and marine crew on the vessels.

Although India announced its Offshore wind policy in 2015, till now no single institution has emerged as a central agency, having all kinds of skillsets to cater to Offshore requirements in the near future. Individually, many of the institutions have partial capacities comprising of Onshore wind, marine segments, environmental and safety etc. In general, some of the existing education programs in Onshore Wind/ Oil & Gas sectors in India should be able to support and serve the Offshore wind sector with changes. Additionally, there is a need for specialized courses/trainings to be organized in cooperation between Indian institutes and EU education institutes.

Recommendations have been developed for the Indian Offshore markets across 11 areas, which can lead to creation of a favorable market for the Offshore wind skill industry, backed by conducive institutional framework and policy instruments.

Some of the key improvement needs in Offshore wind sector skills/ training ecosystem in India are:

Figure 9: Key improvement needs in Offshore wind sector skills/ training ecosystem in India

Therefore, it is essential to take stock of the current situation and accordingly plug these gaps, by empowering institutions to expand their horizon.

Key recommendations

Building upon the areas of intervention analyzed in the previous section at the institutional level, the next step lies in assessing how best to tackle the situation. In this context, the following key measures can be taken up to improve the Offshore skill base in India.

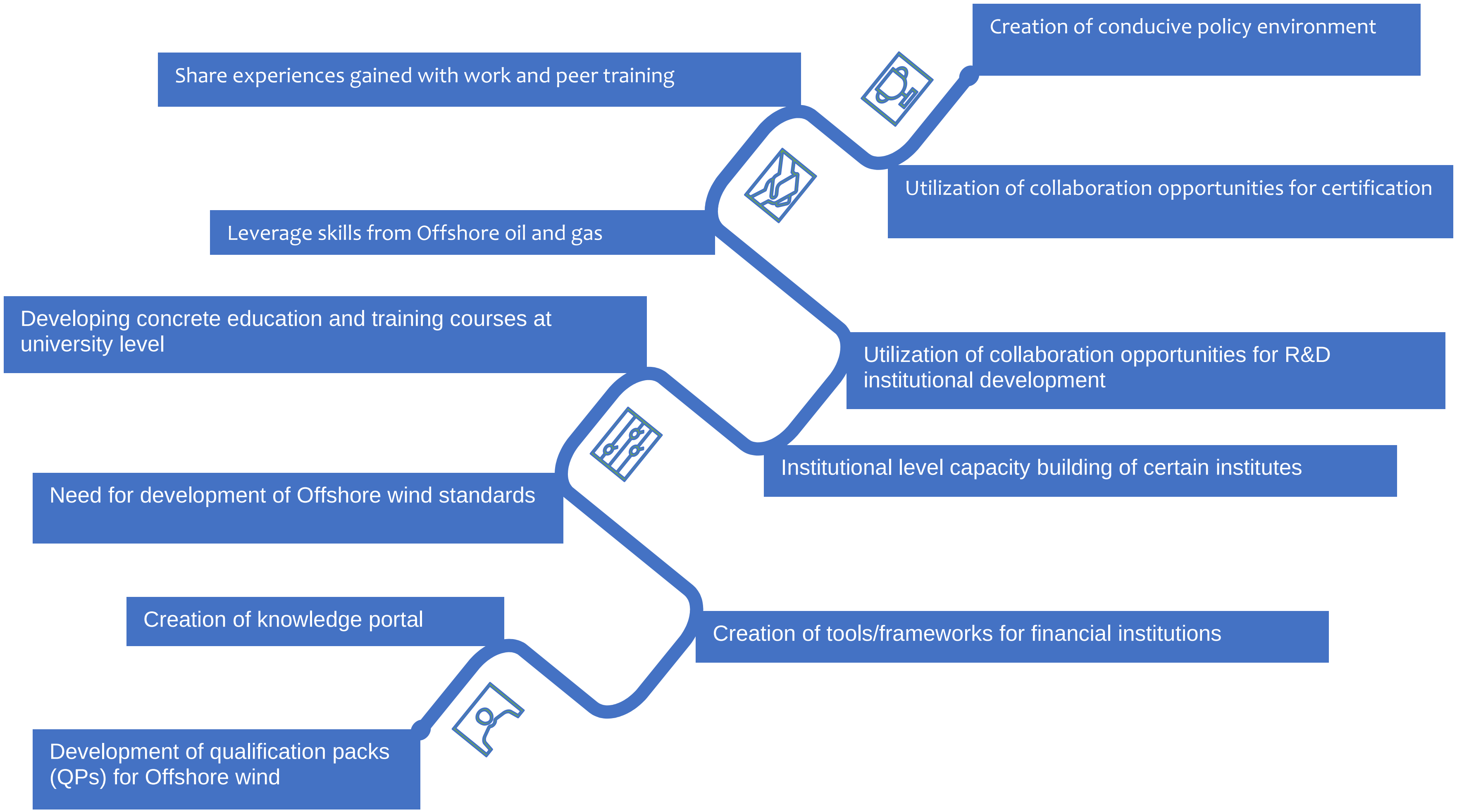


Figure 10: Key action areas for enhancing Offshore skill development framework

1. Developing qualification packs (QPs) for Offshore wind

In India, the government is focused on creating more employment opportunities across all sectors to tackle unemployment levels. In this context, Offshore wind segment can play a critical role, considering the ongoing and anticipated future demand for this segment in India. The Skill Council for Green Jobs (SCGJ) has developed comprehensive qualification packs and associated model curriculum for every RE technology, barring Offshore wind.

These occupational standards for Offshore wind segment need to be developed for audience with different qualifications such as technicians, diploma holders, engineers (mechanical/electrical/environment/marine) and others. For example, for an Offshore plant engineer (electrical), the following course curriculum may be needed to get employment opportunities.

Table 6.1: Draft curriculum for onsite plant engineer (electrical)

S. No	Module	Key learnings	Theory (Hours)	Practical (Hours)
1	Offshore wind resource assessment course	• Offshore wind site assessment • Analyzing oceanic parameters-data assessment • Met-mast data collection • Potential assessment • Conduct site and field surveys • Assist in preparing project plan • MSP (Marine Spatial Planning) ○ **Offshore wind farm planning** ▪ Wind resource assessment and measurements ▪ Design conditions e.g. extreme wind, typhoons etc. ▪ Environmental impact assessment ▪ Construction and logistics ▪ Grid connection and cabling ▪ Costs CAPEX, OPEX, LCoE ▪ Support mechanisms o Feed-in tariff/Feed –in Premium/CFD(Contract for Difference) o Tendering (economic part) o Green certificates	40	8
2	Basic Electrical Course	• Identify position of Offshore WTG, substation, transmission line, transformers, etc. • Identify accessibility of the site i.e., its connectivity to various transport mechanisms including rail, road, connecting roads etc. • Assess grid availability for power evacuation including nearest substation and transmission line capacity • Identify the relevant grid authority • Check the feasibility of point of power evacuation • Introduction to the offshore wind technology (wind turbines, foundation & fixed /floating concept, etc.,)	40	8
3	Detailed Plant Design Course	• Preparation of wind farm layout • Analyzing AEP and generation parameters • Offshore cable routing • Foundation design • Foundation installation • Turbine installation • Offshore substation design and installation, • Offshore cable design and installations, etc. • Onshore power evacuations and interconnection • Key aspects in O&M Offshore	120	24

Curriculums for other positions for Offshore wind, along with minimum qualifications will also need to be developed. Similarly, the associated QPs[39] will need to be consolidated to meet the required skill levels (core+ generic+ professional), along with performance criteria for evaluations.

Once the documentation is done, accordingly the trainers and affiliated training centers will need to be identified and capacities will need to be developed, across regional centers of Skill Council to take up future trainings related to Offshore and develop an 'Offshore training calendar'

2. Creation of knowledge portal for Offshore wind

At present there is no knowledge portal or online repository which provides relevant information catering to Offshore wind development in India. The knowledge portal should target the interests of all relevant stakeholders and project itself as a platform of learning and getting acquainted with the happenings and key developments taking place in India with respect to Offshore wind. The contents of the knowledge portal must be designed in such a manner that the people can relate to the information being shared, from designing of basic level to complex curriculums. Some of the integral components of the portal include:

- Offshore basic course: A generic description of the Offshore wind technology encompassing working principle, benefits over other technologies such as Onshore, technology types and key stakeholders involved in the value chain in India. This would act as a more user-friendly platform and make people aware about Offshore wind in a much more conventional manner

- Offshore supply chain: This can include information about the different component of the value chain-at pre/during and post construction phases of Offshore wind. The portal must include information about the various supply chain players in each segment, both nationally as well internationally covering their contact details (phone number, email-id, website link)

- Latest technology trends: Such particulars can be of immense importance as it will provide a perfect platform to C&I players, including project developers to make themselves aware about latest advancements taking place in the country globally. The R&D institutions/universities in India can share information about their findings, technical expertise and major areas of research work pertaining to Offshore. Hence the portal would help in creating more networking and collaborating opportunities and subsequently bridging the gap between industry requirements and supply. Case studies on some of the unique and innovative Offshore wind plants and their performance, specifications and key benefits can also be shared to map key success factors and replication potential.

- Project financing attributes: This is perhaps one of the most indispensable information which needs to be highlighted and made much more transparent, considering the nascency of the sector. The details of key financial institutions/ government agencies engaged in providing soft loans along with interest rates should be clearly specified. Successful bank-funded case studies can be highlighted providing financial details in terms of total investment cost, subsidies, cost for fuel replaced, and other specific investment cost can be shared. Additionally, international case highlights involving innovative funding mechanism/financial model and lessons learnt can also be emphasized.

- Technical training dashboards: The portal must reflect the training schedule for the year and should present key highlights/learnings after completion of every successful training programme. This would involve a consolidation of all the upcoming training session from both government and private agencies on a single platform, including process of registration, target audience and key details of the session.

3. Creation of tools and frameworks for financial institutions/bankers

Considering the fact that Offshore wind is an emerging technology, the banks and financial institutions will be hesitant in providing loans for a sector, which has no precedents for success in India. Also, the upfront CAPEX requirement in case of Offshore will be much higher than Onshore wind, and hence financing of such projects might pose a challenge.

Availability of a standardized financial model to estimate cash flows, savings, IRR and other financial parameters is the need of the hour. However, such an initiative can only be made successful if training on financial modelling and other economic aspects is imparted from experts in the field. It is also very essential to organize bankers' trainings from time

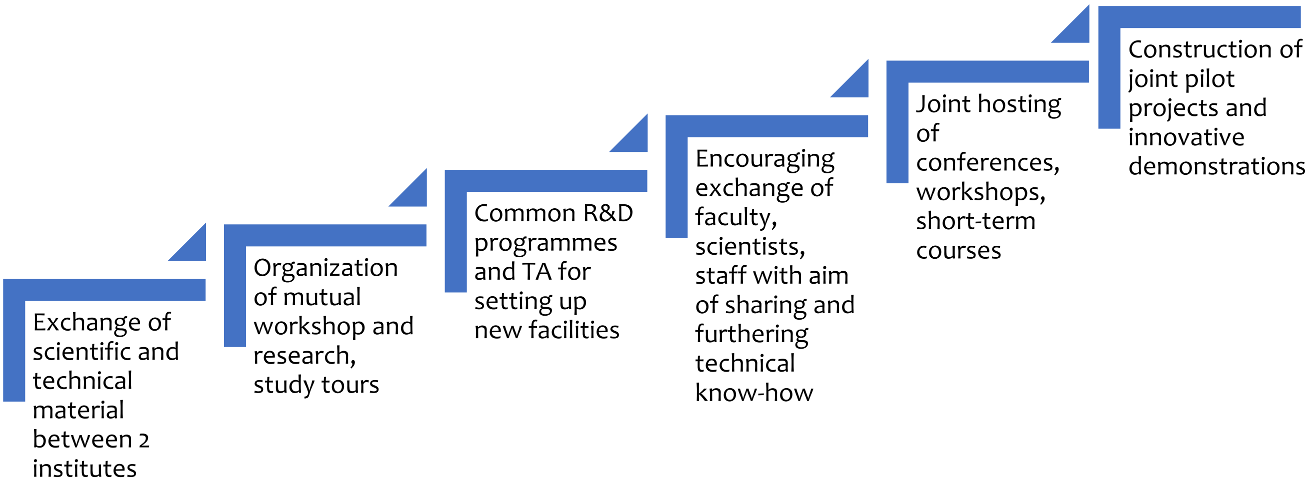
[39] http://sscgj.in/wp-content/uploads/2019/03/SGJ_Q1201_Assistant-Planning-Engineer-Wind-Power-Plant-v1.pdf :QP for Onshore wind engineer

to time as they are not willing to take the risk to provide loans for newer technologies. By creating a standardized financial model, it will provide more visibility to the financial institutions and improve the situation of lending.

4. Institutional level capacity building of certain key institutes

NIWE has been appointed as the nodal agency for successful capacity building for Offshore wind in India and hence, the progress in the skill building segment is not possible without providing handholding support to NIWE. NIWE has been particularly active in Onshore wind segments but lacks similar expertise in the Offshore domain. Hence, these inherent capacities need to be developed with support from international agencies.

International collaboration and strategic partnerships in today’s market are quintessential aspects for any training institute to be visualized as one of the ‘training centers of excellence’ existing in the country. The exposure provides an excellent opportunity for mutual growth and knowledge transfer through collaboration initiatives like workshops and research study tours. The key activities which are essential components of a successful knowledge exchange programme have been enlisted below.



As discussed in preceding sections as well, there is a need to develop a comprehensive training programme dedicated to only Offshore wind for NIWE specifically. This involves assessing training requirements, getting on board subject matter experts, designing a learning module, and finally developing a training, monitoring, and evaluation framework for certification process. The emphasis should be on both theoretical and practical concepts. Major aspects of designing new training curriculum are -

Designing new training curicullum	Designing course contents as per industrial needs & best practices covering basics to advanced courses
	Framing eligibility criteria/target audiences
	Course fees
	Duration
	Certification process
	Infrastructural and logsitics requirement (if any)

Dhanushkodi National Offshore Wind Test Centre

National Institute of Wind Energy (NIWE) plans to setup Asia-Pacific's first offshore turbine testing facility in Dhanudhkodi, Tamil Nadu, India. The facility is expected to be ready by the year 2024. The facility would house two turbines of 8MW capacity each, enabling advanced R&D tests. The center can be the state-of-the-art facility for the entire region for accurate offshore wind assessment. The center can analyze the facilities available at prominent test centers such as one set up by Østerild, which is close to the coast with high wind density. Since 2012, the Test Centre has been operational with seven test sites for prototype wind turbines and up to 250 meters in tip height. In 2018, the Centre was expanded with additional two sites, making it possible to test wind turbines up to 330 meters high in seven of the nine test sites. The test center houses following facilities (reference - https://windenergy.dtu.dk/english/research-infrastructure/research-facilities) :

- **Materials lab:** The lab offers composite processing techniques, preparation of test specimens, accredited mechanical testing to meet industrial standards, X-ray computed tomography, electron microscopy, plasma treatment and surface chemistry, sensor instrumentation, and signal analysis.
- **Poul La Cour Tunnel:** The largest university-owned wind tunnel in the world. It has been designed specifically for aerodynamic and aeroacoustic testing of airfoils and rotors. It is a closed-return tunnel with maximum flow speeds of up to 378km/h, similar to three-time hurricane strength.
- **Large Scale Facility:** The 1560 m^2 test hall has three stands capable of testing up to 50-meter blades. Advanced structural tests and loading of turbine blades provide accurate data about strength, reliability and fatigue.
- **BladeLab:** The BladeLab provides the possibility to produce larger composite structures under controlled conditions.
- **Windscanner:** Detailed measurements of the wind flow in the atmosphere are essential to optimize wind turbine design and siting.
- **Risø Research Turbines:** The wind turbine is used for experiments and tests of meteorological equipment, structural and electric measurements and verifications of models of calculations.

5. Need of Offshore wind standards

The development and delivery of standards is important for driving the industrialization of Offshore renewable energy. Appropriate standards create a foundation for growth based upon recognized benchmarks of quality and promote competitiveness by reducing barriers to international trade. There are many opportunities for collaboration in the area of standards. A commonly held view in discussions with the industry was that the Offshore wind industry should get standards under control as soon as possible, because the process of standardization is still ongoing in the oil and gas industry and it is causing problems and additional expense. A survey of the Offshore renewable energy industry reveals that 185 standards and guideline type documents are actively being used, some of these standards are from the following organizations:

- American Society of Mechanical Engineers (ASME)
- DNV/GL
- EMEC
- EN (Euro Norm standard)
- IEC
- IEEE (Institute of Electrical and Electronic Engineers)
- ISO
- Renewable UK

In India, currently there are well defined technology standards and certification schemes existing for Onshore wind technologies (such as the Type Approval Scheme, developed by NIWE in support with RISO National Laboratory, Denmark) but when it comes to Offshore there is no sort of framework available which the project developers needs to comply with. A national framework for Offshore wind project regulation is intrinsically linked to the country's unique meteorological, ocean, and lake (met-ocean) conditions. Hence, there is need for NIWE and Bureau of Indian Standards

(BIS) to collaborate with international agencies/ sector experts, which can assist in development of necessary standards compatible with Indian geographical conditions. Critical areas of standard development include[40]:

- Safety
- Site condition
- Design evaluation of wind turbines, blades, and support structures
- Manufacturing
- Transportation
- Installation, commissioning, and certification
- Operations and maintenance

Not only does the establishment of quality infrastructure (standardization, testing and certification) restore the faith of the beneficiary but also effectively translates into promotion of quality components being manufactured in the country as per local conditions. European certification agencies use IEC standards in Europe (IEC 2001, 2005, 2010a, 2010b) for certifying Offshore wind turbines. The replication of those standards with relevant modifications viable for Indian markets needs to be assessed.

6. Utilization of collaboration opportunities for certification

There are currently not enough agencies in India offering certification, which map industrial requirements and skills needed for Offshore wind market. Institutions in India are primarily engaged in certifications related to health and safety, environmental aspects and oceanic phenomena, however when it comes to having dedicated technical certified courses on 'design and engineering', a gap is evident.

Besides developing capacities of Indian agencies engaged in Onshore wind development, there is tremendous opportunity for international players to themselves be part of this institutional framework and be labelled as 'Technology Skill Partner' and offer certified courses, which make personnel industry ready for job. Global skill development agencies can sign MoU for technical collaboration with State Government/MNRE/NIWE/Skill Council for organization of certification courses with practical experiences (field visits). For example, Vestas has developed partnership with Skill council for Green Jobs for skill building in new avenues in wind in India, including development of Qualification packs, resulting in job creation of 100+ people[41]. RWE Renewable GmbH has also supported skilling by transferring its learnings through organizing training programs in universities.

7. Utilization of collaboration opportunities for R&D institutional development

There are various central level agencies, such as IIT Chennai, ICOIS (Indian National Centre for Ocean Information Services), etc. which are engaged in R&D related activities involving material science, Offshore wind structures, forecasting and numerical modelling studies.

There is need to develop capacities in the R&D space, especially in terms of reducing the costing of an Offshore plant to make it financially viable for Indian markets. It is anticipated that the current cost of generation for Offshore could be well beyond INR 10/unit, which is very high in comparison to the other competing RE technologies. Hence, research efforts targeted to reduce CAPEX of Offshore plants, through improved design and material choice need to be undertaken. There is a need of technology transfer from developed market to the Indian context, so that state of art research work and studies can be carried out here.

8. Development of concrete education and training courses at university level

Developing concrete Offshore wind education programs at university level is critical to ensure that the Offshore wind industry skill development grows at the grass root level. There are certain programs/courses which can be adopted/modified in India, which include:

- Vocational program levels
- Bachelor and master programs of universities
- Associate degree programs of universities

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[40] https://www.nrel.gov/docs/fy14osti/60573.pdf
[41] https://www.vestas.in/~/media/india/vestas%20india%20fact%20sheet_v9.pdf

Vocational programme (levels from low-medium)	Bachelor programmes related to Offshore wind energy sector	Master programmes related to Offshore wind energy sector
• Electrical engineering • Mechanical engineering • Industrial engineering/All-round operational technician • Maritime officer • Safety Engineer	• Civil engineering • Electrical engineering • Maritime officer • Maritime technology • Mechanical engineering • Ocean technology • Applied mathematics • Aviation/Aerospace • Coast and sea management or Ocean engineering • Industrial/business management • Informatics • Energy Engineering • Logistics engineering • Water management	• Civil engineering • Electrical engineering • Maritime officer • Maritime Piloting • Maritime technology • Marine innovations • Mechanical engineering • Industrial management • Business management • Informatics • Shipping and transport

In this regard, certain European technical universities have also been running several educational programs focusing on Offshore with success. These programs have been presented below:

Bachelor programmes related to Offshore wind energy sector: Civil technology, Electrical engineering, Maritime technologym Mechanical engineering,Aerospace engineering, Business administration, Data science, Mathematics, Informatics, Software engineering, Soil, water and atmosphere, Environmental sciences

Masters programmes related to Offshore wind energy sector: Civil Engineering, Business Management, Electrical Engineering, Energy Science, Marine Technology, Aerospace Engineering, Mechanical Engineering, Offshore and Dredging Engineering, Sustainable Energy System Management, Sustainable Energy Technology, Water Technology, Business Administration,Applied Mathematics, Applied Physics, Artificial Intelligence, Data Science, Informatics, Management, Physics, Software Engineering

At the level of each work package and scope of work, there are universities in Europe which have been offering appropriate education programs for students who want to work within the Offshore wind energy. There is a need to offer certain subjects within these disciplines, to enable students to gain insights into Offshore wind and to prepare them better for job opportunities in this field. Transfer, exchange programs etc. are of utility and can also be explored between Indian and EU academic institutes. With regards to specific job roles and competencies, there is room for specialistic courses to be developed and organized in India in cooperation between educational institutes and the experienced industry.

Broadly speaking, the following areas can be important for Offshore wind industry in the context of training courses development:

- Develop a human capital plan to secure students and professionals to the Offshore wind sector by raising awareness of the Offshore wind sector careers among the public and indicate career pathways within the sector and express the future needs of education and training in the sector.
- Seek for opportunities to involve students in the sector as early as possible during their education by offering of internship/apprenticeship programs with real-life assignments.
- Invest in industry-driven applied research supporting the industry and enabling different curriculum developments plans.
- Allow Doctorate students to select topics related to Offshore wind. Joint PhDs and interaction with Offshore industry shall be facilitated to increase skillset and expose students to Offshore wind.

- Align together with the educational institutes who will facilitate what special courses and trainings that are needed.

9. Leverage skills from Offshore oil and gas segment

As covered previously in paragraph 2.1.3, some of the technologies developed for Offshore oil and gas, are relevant to the Offshore wind industry. A large part of this technology is directly available through existing companies, especially for the design and development, where most of the learning has been incorporated into standardized engineering practice. The technologies developed for Offshore construction vessels, dynamic positioning systems, saturation diving, Remotely Operated Vehicle, heave compensated winches and cranes, etc. are all available, either in existing vessels or as components, which are available commercially, and can be incorporated into new Offshore wind vessels. The supply chain which supports the day-to-day operation of the Offshore oil and gas industry has readily transferable to support the Offshore wind industry in Europe and must be able to do the same in India. Safety related skill set is yet another area, which has high level of overlap between the 2 sectors.

Many of the skills between the oil and gas and renewables sectors are highly transferable, indicating there is much opportunity for sector mobility within energy. Oil and gas professionals in Europe are showing a strong interest to work in the renewables industry. There are still some very specific, niche skill sets, such as drilling, fluid science and process engineering, for example in the Oil and gas industry which are not required in renewables and are not always transferable, but work in maintenance, electrical engineering and Offshore operations are directly transferable to the Offshore wind industry.

Hence, the Indian Offshore wind industry would need to collaborate with Offshore O&G training institutes to develop skill sets, cashing in on the mutual synergies.

10. Share experiences gained by work and peer training

During the relatively short history in the Offshore wind industry, peer to peer learning has shown to be a powerful development tool that breaks through some common barriers to skill-building. While classroom education and training, experiential learning, and on-the-job application of skills are regularly used as learning mechanisms, sending employees to work on single days of intense training from an outside expert is assumed to be much more fruitful for the new workers. Due to this, experienced Offshore wind employees from Europe are often being used as experts and supervisors to learn and transfer new skills to the inexperienced workers in new markets around the globe.

11. Creation of conducive policy environment

The training and skill development aspect can be strengthened further, by developing enabling policy and regulatory instruments that are well aligned with overall development of Offshore industry. This can include the following key areas:

- Make predictable and long-lasting plans for Offshore wind energy in India.
- Facilitate employment and competencies studies that support human capital and education strategies in Offshore wind.
- Facilitate employment and competencies studies on indirect employment and export-related employment in Offshore wind.
- Facilitate investigations that could define the Indian educational capacities needed considering the future development in India and abroad.
- Focus on the Offshore wind sector in the upcoming years and beyond. It is recommended to update this report yearly.