Offshore Wind: Employment and value creation of EPCI exports in Norway

To cite this article: F Rocha Aponte *et al* 2021 *J. Phys.: Conf. Ser.* **2018** 012004

Offshore Wind: Employment and value creation of EPCI exports in Norway

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Abstract. The objective of this study is to investigate the value creation potential and the employment effects for the offshore wind engineering, procurement, construction and installation (EPCI) sector in Norway up to 2030 considering multiple scenarios. We perform our analysis using a macro-econometric input-output model that allows to observe how changes in one sector affects the remaining sectors of the economy. To highlight the uncertain nature of some of the outlooks and industry inputs for an emerging sector, several scenarios will be investigated. By providing information about net employment and value creation effects per sector, policy makers can implement appropriate measures to maximize the potential posed by the offshore wind industry. Furthermore, measures can be taken to mitigate any potential negative effects that the energy transition can have.

1. Introduction

The Norwegian offshore industry has, since the discovery of oil on the Norwegian continental shelf, experienced a tremendous development. Albeit large involvement of foreign companies in the early phases of exploration and field development in the 1960's and 1970's, the Norwegian industry quickly developed, and it is today considered as one of the world's leading actors within offshore development and engineering [1]. Raising awareness about climate change, reduced costs of renewable energy technology, combined with low oil and gas prices, renders an uncertain future for Norwegian companies that used to deliver products and services to the offshore Oil & Gas industry. The ambitious emission reduction targets and subsequent energy transition towards renewables required for achieving a climate-neutral economy is projected to fuel the deployment of largescale offshore wind plants [2]. The emerging offshore wind sector is thus perceived as a new opportunity as there are several synergies between Oil & Gas and Offshore wind farms, including transport, installation, operation, maintenance, and engineering design [3].

Although offshore wind deployment may also provide opportunities for other Norwegian sectors, this study is limited to assess the potential in employment and value creation derived from exports of engineering, procurement, construction, and installation (EPCI) products and services for the global offshore wind market. The paper is focused on the international part of the EPCI sector for three main reasons: 1) Norwegian EPCI businesses already provide exports to the offshore wind industry, generating 5.4 mill NOK in 2017 with 150 companies involved [4]. 2) For emerging sectors like offshore wind, there is presence of uncertainties with respect to what global market share Norwegian companies can take, as well as how much offshore wind will be deployed in the coming decade. Furthermore, it is not known exactly which products and services Norwegian companies will deliver, or to what extent these will be produced domestically or outsourced internationally. 3) Norway does not currently have an operative plan for a full developed offshore wind market in their continental shelf and therefore is not possible to know the incentives, limitations, and structure for the installation and production of offshore wind plants in the country. Therefore, focusing on the exports of EPCI products is a reasonable baseline to evaluate the potential of the sector for the upcoming decade. It is estimated that a EPCI contract can provide around 5 billion NOK per 1 GW of offshore wind farms [5], which constitutes a good opportunity for businesses with expertise on this area.

The purpose of this study is to quantify the value creation and employment potential in the Norwegian EPCI service sector as a supplier to the global offshore wind industry. As with all deployment of new technology, there exist some uncertainty regarding how fast the new market will grow, to what extent Norwegian companies will be competitive, and eventually how large accumulated market share Norwegian companies would gain. To mitigate against the uncertainty, we designed multiple growth scenarios, as well as different sectorial compositions of the delivered EPCI services. To assess these potentials, we use a macro-econometric input-output model (MEIONorway) that allows to observe how changes in one sector affects the remaining sectors of the economy, quantifying economic ripple effects.

Due to the relevance of the Oil & Gas industry for the Norwegian economy, it is of main concern to assess the potential of the offshore wind sector in providing employment and economic growth with respect to the transformation of the global energy systems that will shift investments from fossil fuels to renewables. The Oil & Gas sector is already suffering from job losses because of this shift [3]. It is not only the oil & gas industry directly that experiences losses, but also the domestic suppliers within Norway. Input-output models consider all inter-industry linkages in the economy and are therefore able to provide not only insights on direct employment effects, but also on indirect economy-wide implications. By providing information about direct, indirect, and induced employment effects, policy makers can implement appropriate measures to mitigate any potential negative effects that the energy transition can have on employment. Furthermore, measures can be taken to maximize the value creation potential posed by the offshore wind industry and at the same time identify the necessary employment skills for the new sector.

Input-output (IO) models have been used previously to assess the effects from deploying the offshore wind industry in national economies. For example, [6] use a multiregional IO model to assess the expansion of wind energy projects in the US finding positive spillovers through the economy of a value of 26 billion USD among 10 states with the biggest impact in sectors such as construction and financial services. In [7] the impact of offshore wind projects in the UK is studied by simulating the deployment of the sector in different zones of the country, their results point to substantial emission reductions from offshore wind as a supplier of energy and a cumulative increase of 30 bill. Pounds in the UK economy. In [8] an IO model is combined with computable general equilibrium (CGE) model to estimate the employment and value-added effects of offshore wind for Scotland, finding a total increase of 57,498 full time equivalents (FTE) as a result of offshore wind farms in Scotland. In [9] an IO model is used to assess the sustainability of wind energy in the US, finding that larger offshore wind farms produce 48% less greenhouse gases than onshore wind. The model used in this paper (MEIONorway) contributes to this literature by adding the possibility of assessing economic effects by simulating different scenarios via the "creation" and introduction of a new sector in the IO tables.

This paper is structured as follows: Section 2 describes the methodology of MEIONorway, the data, and the description of the different scenarios. In section 3, we show the results of our different scenarios. Finally, our concluding remarks are presented in section 4.

2. Methodology and Data

2.1. Input-Output model

Input-output (IO) models are a set of linear simultaneous equations that record the industrial linkages within an economy that in matrix form can be expressed as:

$$x = Ax + y \tag{1}$$

Where x is a vector of the output of each industry. A is a square matrix that shows the intermediate transactions in an economy, that is what one industry consumes from all other industries in the economy to produce its own output. Finally, *y* is a matrix of final demand consumption. Solving for *x* in equation 1 we have:

$$x = (I - A)^{-1}y \tag{2}$$

Where I is an identity matrix and $(I - A)^{-1}$ is the Leontief inverse matrix [10]. Equation 2 can be used to estimate the impacts on output that comes from changes in components of the final demand matrix, such as increases on investments or exports. By linking data on employment by industry to the model, it is possible to estimate employment effects that come about with changes in final demand (y). Let vector e denote employment intensities, with e_i being number of employees needed to produce one unit of output of industry *i*, with $\hat{e}$ indicating the diagonalized form of vector e. Then the change in total employment by industry ΔE is:

$$\Delta E = \hat{e}(I - A)^{-1}\Delta y \tag{3}$$

The macro-econometric input-output model for Norway (MEIONorway) combines a simple macro-econometric model with the Norwegian input-output table. The macro-econometric model consists of four equations: two for the exogenous variables government consumption and exports, and two equations linking the demand side variables household consumption expenditures, government expenditures, and investments to the production side GDP. In input-output models the production side GDP is the sum of all industries' value added. Investments (INV) grow with the GDP growth rate and household consumption expenditures per capita (HHCEpc) depends on the current and three previous years' per capita GDP (GDPpc):

$$INV_t = INV_{t-1}\frac{GDP_t}{GDP_{t-1}} \tag{4}$$

$$HHCEpc_t \sim f(GDPpc_t, GDPpc_{t-1}, GDPpc_{t-2}, GDPpc_{t-3}) \tag{5}$$

By endogenizing household expenditures, the model can in addition to direct and indirect economic effects, also capture induced effects through household earnings and spending. Value added (=GDP), household consumption expenditures and investments are endogenous. Government consumption expenditures (GCE) depend on population (POPU, based on UNDESA population prospects [11]), and exports (EXP) are growing with the global GDP (glGDP) growth rate from the OECD's Longview [12].

$$GCE_t \sim f(POPU_t) \tag{6}$$

$$EXP_t = EXP_{t-1}\frac{glGDP_t}{glGDP_{t-1}} \tag{7}$$

The equations for household and government consumption expenditures are estimated with ordinary least squares using annual data from 1970 to 2017 from the UN SNA [13]. Estimation results and related statistics are available from the authors upon request.

In the following, we analyze specifically the direct effects in the wind offshore EPCI sector, as well as the indirect effects on the other sectors of the economy.

2.2. Data

The model uses the input-output tables for Norway as published by Statistics Norway in the *ESA Questionnaire 1750* industry by industry tables from 2017 (last updated year) which shows industry by industry transactions at the aggregated level (65 industries). For the econometric estimation of household and consumption expenditures the UN SNA (System of National Accounts) main aggregates database [13] is utilized. Macroeconomic (global GDP growth) and demographic (population) variables up to 2030 are taken from the OECD's Longview [12] and the UNDESA population prospects [11]. Finally, for the evolution of the global offshore wind sector we use the projections of [14] and [15]. Data in the input-output tables is furtherly linked with sectoral employment as an additional socioeconomic indicator to measure the effects of EPCI exports to the global offshore wind market in more than purely monetary terms.

2.2.1 The EPCI sector. Norway has already a well-structured supply chain, human capital, and know how related to offshore projects from the oil & gas industry that can be transferred to the offshore wind industry [16]. A good example of these interindustry transfer/innovation from Oil & Gas to offshore wind is the development of the Hywind project by Equinor [17]. Moreover, the EPCI category includes products and services linked to the planning, development, and construction of the wind farms, which will be of main interest in the early stages of a growing industry.

As the EPCI sector for offshore wind does not exists in the IO tables, it is necessary to create an EPCI sector that reflects the flows of inputs and outputs through the Norwegian economy. To do so, first we need to specify the products and services provided; a typical EPCI contract covers products and services such as development studies, project management, turbine supply and installation, foundation supply and installation, and array cables supply and installation [5]. Second, as the Norwegian input-output table shows industry transactions at the aggregated level (64 industries) we identify the sectors that include most of the products and services mentioned above. Such sectors are Architectural and engineering services, technical testing, and analysis services, and Construction and Construction works. As offshore wind projects require different combinations of products and services directly related to the characteristics of the wind farm (distance to coast, deep of the ocean, size of the turbines, type of foundation, among others) we used the different combinations showed in table 1 to evaluate the economic gains in employment creation and value added and, as such, have a broader perspective on the possibilities for the sector.

Table 1: Structure of the Sector Compositions that will be used in the scenarios[a].

Architectural and engineering services, technical testing, and analysis services	**Construction and Construction Works**
75%	25%
70%	30%
60%	40%
50%	50%

[a] The different shares are used for sensitivity analysis to evaluate differences in sectoral structures to value-added and employment creation.

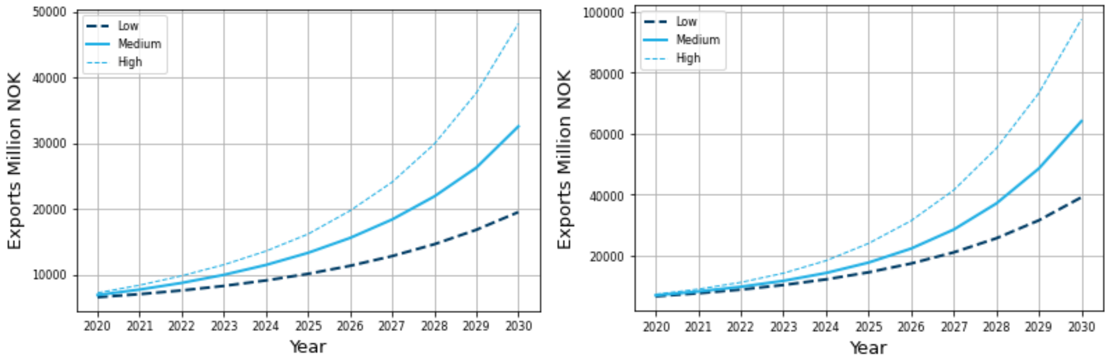
2.2.2 Scenarios. The benefits of the offshore wind market to the Norwegian economy are dependent on how the global market will evolve in the future; it is expected that, by 2030, there will be a total installed capacity of 431 GW of offshore wind globally if the current policies and regulations are maintained [14, 18]. However, to reach the global warming goal of 1.5 degrees in 2050, the offshore wind sector will require a more ambitious growth with the need for total installed capacity of 931GW by 2030 [14, 15]. To reach this level, investments of about 1300 – 4500 billion EUR will be required between 2020 and 2050, making the supply of services and products industry to grow from 22 billion euros in 2020 to 70-150 billion euros in 2050 [19]. Based on these projections, we calculate the value of exports for the EPCI Norwegian sector up to 2030 by considering six scenarios as displayed on table 2.

Table 2: Scenarios for the EPCI exports for offshore wind.

CONTEXT	Scenario Name	Market share of the Norwegian EPCI sector in the global market
Current policies and regulations	Low	6%
	Medium	10%
	High	15%
1.5 C Goal	Low 1.5	6%
	Medium 1.5	10%
	High 1.5	15%

The low scenario considers that Norwegian industry keeps the current market share is a conservative estimate as the Norwegian market share is expected to increase [20]. Especially, our high scenario of 15% of total market is lower than previous studies [16, 17] on the sector as new competitors will come and the market will be more competitive, which previous studies have not considered. Therefore, it is assumed that once the market grows it will become harder to obtain bigger shares of the market, even if the market gets bigger, which is reflected in our high scenario of 15%. Figure 1 shows our calculations of the export value for the EPCI Norwegian sector for the global offshore wind market.

Figure 1: Projected export values of EPCI to the global offshore market for the current policies (left) and 1.5 C goal (right).



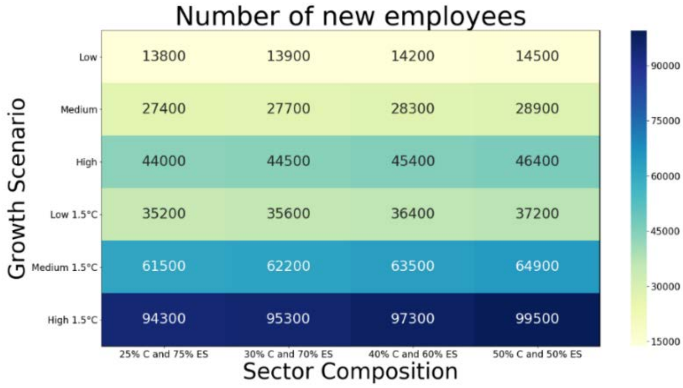
3. Results

We have used all combinations of sector compositions from table 1 and growth scenarios from table 2 (24 combinations) to calculate the effects with MEIONorway in order to assess how uncertainties influence the outcomes on value-added and employment in the Norwegian economy. In this section we present first the direct effects of such combinations followed by the indirect effects through linkages within other industries.

3.1. Direct Effects

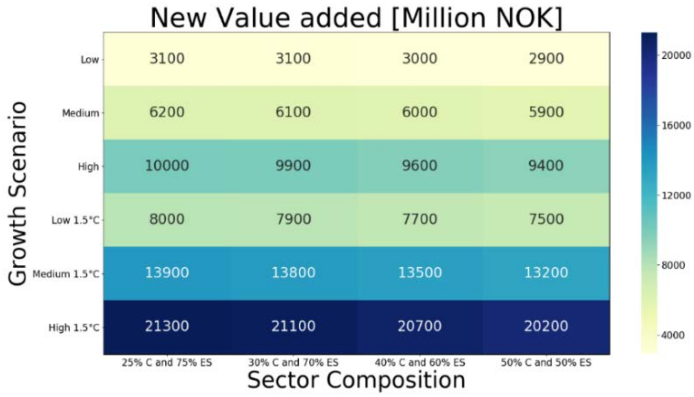
In all the considered scenarios, the sector shows promising effects in employment creation, going from 13.800 new direct employments between 2020 and 2030 for the lowest scenario to 99.500 direct employments on the most optimistic scenario. Figure 2 shows the estimations for direct employment for all the scenarios. The results show that, in average, employment creation per year varies from 1.400 to 9.950.

Figure 2: Estimated direct number of new employees expected by year 2030 for all combinations of growth scenarios and sector compositions.



Our analysis shows that as more products and services are exported related to the construction sector, more employment is created in the Norwegian economy. On the other side, value-added creation is higher when the sector has a bigger share of engineering services as it can be seen in figure 3. Construction services contribute more to employment creation while engineering services provide higher value-added. Value-added creation from the sector goes from 2.900 mill NOK to 21.300 mill NOK for the period 2020-2030. In the lowest scenario, both employment and value-added grow in average 11% per year while in the most optimistic scenario an average yearly growth rate of 30% is found.

Figure 3: Estimated direct increase in value added expected by year 2030 for all combinations of growth scenarios and sector compositions.

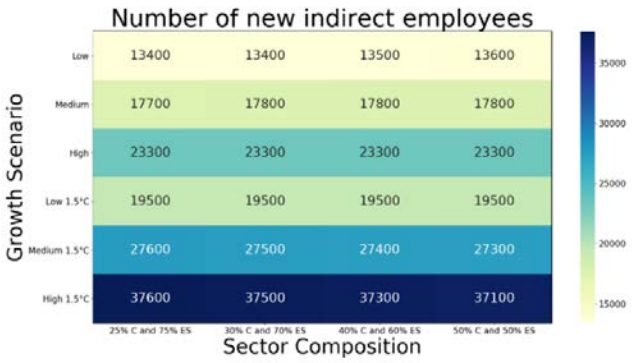


It should be noted that our estimations of the industry potential ranges from the most conservative scenario to the most optimistic one. As a result of this, the employment and value creation results cover a large interval. Our results are in line with previous studies on the potential of the supply chain export sector of the offshore wind sector for the Norwegian economy. Even though the growth rates in the scenarios are lower than previous studies, our labor and value-added estimates are higher as they consider both floating and fixed structures and therefore absolute investments are larger than those in [16, 17]. For instance, the estimations of [16] for the floating offshore wind sector alone, calculate a potential in employment creation and value-added of 15.700 and 14 billion NOK respectively which lies inside our interval estimations.

3.2. Indirect effects

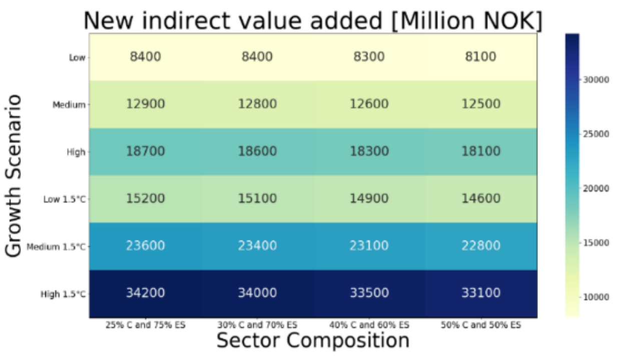
In addition to the direct employment and direct value added, the increase in exports will lead to several indirect effects in the Norwegian economy. The total indirect effects with respect to employment can be seen in figure 4 for all the growth scenarios and sector compositions. Similarly, Figure 5 shows the indirect and induced value added for all scenarios. Our results show that, in average, for every new direct job in the EPCI export sector there will be 0,6 new jobs in the rest of the economy.

Figure 4: Estimated indirect number of new employees expected by year 2030 for all combinations of growth scenarios and sector compositions.



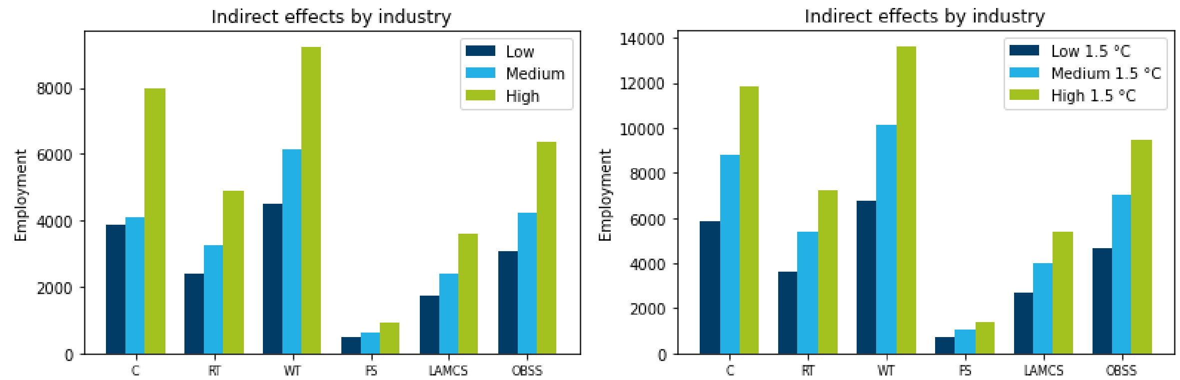
For added value, our results show an indirect effect that ranges from 8.400 mill NOK to 34.200 mill NOK in all the other sectors of the economy with the biggest impact on the following sectors: Construction, Real estate activities, wholesale trade, computer programming services, financial services, and mining and quarrying. It is interesting to note the indirect potential on computer programming services, which points out positive linkages toward sectors with high skilled employment.

Figure 5: Estimated indirect increase in value added expected by year 2030 for all combinations of growth scenarios and sector compositions.



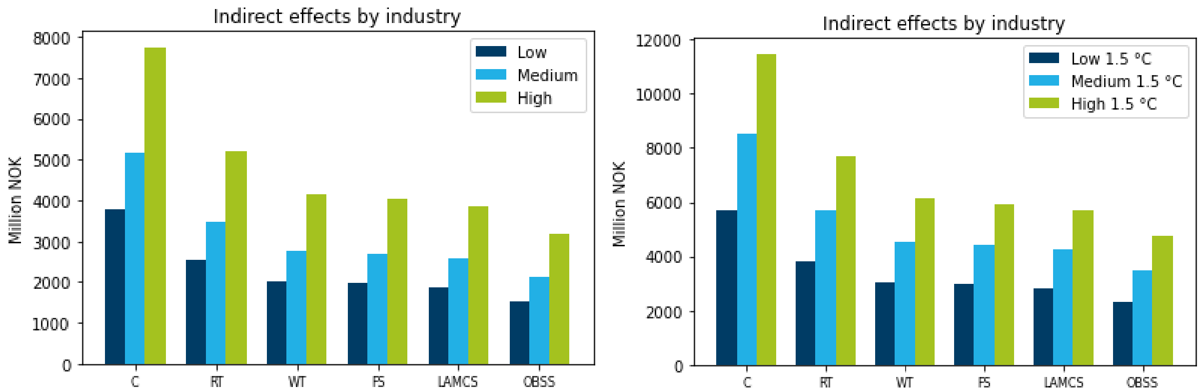
The indirect employment effect is stronger in the sectors of construction, wholesale trade, other business support services, legal and accounting services, and management consulting services as showed in Figure 6. In figure 7 we show the sectors with the biggest indirect and induced effects in value added for all scenarios, by comparing the values of figures 6 and 7 we found that the growth in employment on these industries is higher than the growth of value added because of the indirect and induced effects of exports of EPCI products/services to the global offshore market.

Figure 6: Estimated indirect employment effects in main industries for the current policies(left) and 1.5 C goal scenarios(right).



Notes: C =Construction and construction works, RT= Retail trade, WT=Wholesale trade, FS=Financial services, LAMCS= legal, accounting, and management consulting services, OBSS=Other business support services

Figure 7: Estimated indirect value added effects in main industries for the current policies(left) and 1.5 C goal scenarios(right).



Notes: C =Construction and construction works, RT= Retail trade, WT=Wholesale trade, FS=Financial services, LAMCS= legal, accounting, and management consulting services, OBSS=Other business support services

4. Concluding Remarks

This paper has studied the potential in employment and value-added creation for the Norwegian economy that comes from the increase in exports of EPCI products and services to the global offshore wind market for the period 2020-2030. The focus on this segment of the supply chain relies on the advantage that the Norwegian industry possess from the offshore Oil & Gas industry. The results point out that significant increases in employment and value added on the Norwegian economy can come from the EPCI exports. The sector has the potential to create between 1.400 and 9.950 new direct jobs per year if the international market grows as expected. Each additional direct job can incentivize, in average, to the creation of 0,6 new jobs in the rest of the economy with the biggest impact on crucial sectors such as construction, wholesale trade, and financial services. Similarly, value-added potential is big, created both directly and through linkage effects with the rest of the economy. Exports of the Norwegian EPCI sector can generate, in average, 1.210 mill NOK in value-added per year to the economy.

The linkages between the offshore wind sector and the rest of the economy may serve to counteract the job losses and value added foregone because of the phase out in fossil fuels production. Particularly, many of the new jobs in engineering, construction, and installation for offshore wind projects could be filled with labour previously employed in the Oil & Gas sector [3]. According to [21] worldwide job losses in Oil & Gas summed up to 440.000 in the period 2015-2016 because of lower prices and shrinking demand; by 2050 global job losses in Oil & Gas are estimated to reach around 7.4 million jobs lost that can be counteracted with the 20 million jobs that may be created in global offshore wind [22]. However, to fully maximize the value creation and employment potential, active policies are required on leveraging the existing expertise in connected industries (direct and indirect) supporting the transition of workers from one sector to another and on training and education on the skills that the offshore wind sector requires [3]. It is also required that the Norwegian EPCI-industry is able to take a substantial market-share internationally with a focus on the European market as the leader for the next decade [23].

Further work is required to analyse the full potential of the offshore wind sector in Norway, this includes a more detailed analysis on all the products and services that the industry can export globally with a focus on the markets where Norway can have a competitive advantage and what policies, incentives, and cooperation are necessary to gain market shares. Additionally, there is a need for further analysis of the offshore wind sector on its construction and operation segments inside Norway, including additional parameters in the analysis such as environmental and sustainability indicators to assess the contribution of the sector to the Sustainable Development Goals.

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