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Technical report

Employment impacts of 40 GW offshore wind in France by 2050

MINISTRY OF FOREIGN AFFAIRS IN DENMARK

QBIS | DENMARK

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INTRODUCTION

In March 2022, the French government and the French offshore industry signed the "Offshore Wind Energy Pact" aiming for a minimum volume of call for tenders of 2 GW offshore wind per year from 2025, and 20 GW allocated in 2030 with 18 GW in service in 2035 and 40 GW in service in 2050. The development of the Programmations pluriannuelles de l'énergie will set out the planning work to enable the achievement of these objectives.[1] So far, France has put 3.5 GW of offshore wind up for auction, whereof 500 MW is floating wind.[2]

By signing this pact, the French offshore wind industry has committed to 1) increasing the currently around 6,000-7,000 jobs to at least 20,000 direct and indirect jobs by 2035, 2) investing more than EUR 40 billion over the next 15 years, and 3) achieving 50% local content at the time of commissioning for each offshore wind project by 2035.[3]

The strong commitment by the French government combined with a clear timeline provides the industry and investors with the needed clarity on volumes to prepare themselves for the build-out, investments in plants and reduction in costs. The 50% local content requirements could however risk leading to higher costs and slowing down implementation if the local French labour markets cannot deliver the needed manpower at the right time in right amount and with the right qualifications, education, experience and training.

To prevent delays and cost increases due to labour market bottlenecks, assessments of the labour demand from offshore wind companies contracted to implement the 40 GW is therefore needed. Ideally, to provide helpful guidance in the preparations of the French labour markets, this information should be sufficiently detailed to indicate the labour demand measured in terms the number of job professions needed per year in the period 2025-2050.

[1] The French Government, see: https://www.ecologie.gouv.fr/sites/default/files/2022.03.14_pacte-eolien-mer.pdf
[2] WindEurope, see: https://windeurope.org/newsroom/news/france-commits-to-40-gw-offshore-wind-by-2050/
[3] The French Government, see: https://www.ecologie.gouv.fr/sites/default/files/2022.03.14_pacte-eolien-mer.pdf

EXECUTIVE SUMMARY

1.1.1 Study purpose and objectives

The purpose of the study is two-fold. First, to provide an assessment of the labour input likely to be provided by French-based companies and hence the employment benefits of the 40 GW offshore wind investments in France. Second, through facilitating high detailed assessments of labour inputs, to provide aid for avoiding labour market bottlenecks in terms of labour shortages and skill gaps and for preparing and implementing educational and training programmes to meet labour demand from the offshore wind industry.

This is particularly important with a target of 50% local content. If the offshore wind companies contracted to implement the 40 GW cannot source all of the required labour globally but are forced to source 50% locally in France, the local French labour markets need to be prepared and able to supply the required labour skills in the right amount at the right time. Otherwise, the 50% local content risk increase the costs of the 40 GW offshore wind and delay its commissioning.

The study aims to achieve its purposes by developing two offshore wind farm (OWF) models - one for fixed and one for floating foundation - capable of forecasting labour inputs (convertible to jobs) associated with offshore wind investments in France. To accommodate the purpose of providing aid for preparation of the French labour markets, the model assessments are broken down by job professions and further by year, lifecycle, main components and activities, and French-based and foreign companies.

1.1.2 Model pitfalls

Establishing such models entails various pitfalls capable of undermining the accurateness of the predictions. Some pitfalls can be addressed now while others will have to wait until more information becomes available. Factors such as inflation and global and domestic supply chain bottlenecks are both currently too uncertain and unpredictable to be addressed now and must wait.

Others, such as not correcting for productivity improvements reducing required labour input per GW, particularly for floating foundation and using national statistics multipliers for assessing direct jobs are addressed now based on QBIS (2020) and LCOE/CapEx/OpEx forecasts by leading industry players.

The study finds that ignoring productivity improvements and using national statistics multipliers risk overestimating job potentials significantly. In 2023-2050, not properly correcting for productivity improvements can risk inflating job numbers with by a factor 1.6 for fixed and 2.4 for floating, while using national statistics multipliers for assessing direct jobs risk inflating job numbers by a factor 1.4 for fixed (case Denmark).

1.1.3 Model configuration

The OWF models need to be configured for a number of variables. First, since main study objective is to assess employment impacts of French offshore wind investments, the models need a detailed configuration of labour input and further itemise this input on as many job professions as possible.

Based on IRENA (2018), it has been possible to configure the models for up to 40 different job professions.

Second, due to continued productivity improvements, MEUR/GW (CapEx/OpEx) is expected to continue to fall in the coming years, particularly for floating offshore wind. Since this reduction will impact labour input, the models need to take this into consideration. Based on Aegir (2023), NREL (2022) and US DOE (2021), the models assume MEUR/GW to fall by minus 1.6% CAGR for fixed OWF and minus 3.2% CAGR for floating OWF in 2023-2050.

Third, considering the expected continued cost reductions, the OWF models need a dynamic adaptation of assessed labour inputs reflecting the expected productivity improvements in the period 2023-2050. Based on QBIS (2020), Aegir (2023) and US DOE (2021), the models assume a reduction of 0.12 FTE/MW per year for fixed and 0.42 FTE/MW per year for floating.

Fourth, also considering expected continued cost reductions and their impact on labour input, the OWF models need to take into consideration the timing of the commissioning of offshore wind farms in France in the period 2023-2050. To accommodate this, the models use RTE (2023) to determine the timing of commissioning of OWF GW in 2011-2035.

Fifth, the French offshore industry has committed to have up to 50% local content in total project costs and creating 20,000 direct and indirect jobs by 2035. To test whether 50% local content would be a plausible configuration of the OWF models, an assessment of the current and future expected state of the French-based offshore wind production capabilities is carried out. Subject to conditions, this assessment indicates that 50% local content can be plausible.

1.1.4 Scenario for 40 GW by 2050

The time from contract award to commissioning is currently around nine years in France. Consequently, to capture full employment impacts of GW commissioned in 2023-2032, the forecast period of the OWF models should ideally go back to 2014. However, due to data limitations, it is only possible to go back to 2019 leaving five years unaccounted for.

In 2019-2075, subject to the above limitation, it is assessed that commissioning of 40 GW offshore wind by 2050 will be associated with a total labour input of around 436,000 FTE, whereof around 158,300 FTE are fixed, and around 277,700 FTE are floating. The distribution of FTE across time reveals the need for a massive build-up of labour supply up to around 2031, where labour supply for peaks with around 6,400 FTE/year for fixed and around 13,600 FTE/year for floating totalling around 20,000 FTE/year.

It is particularly production of wind turbines, balance of plant, and installation that require massive labour supply in the period up to 2031. As offshore wind farms are commissioned and start operating, also labour supply for O&M and decommissioning gradually build up and constitute the sole labour requirement from 2050-2075.

Adding second-tier contractors supplying products and services to the first-tier contractors, and assuming gradual build-up of local content to 50% in 2035 among all first-tier contractors regardless of whether French-based or foreign, the around 436,000 FTE are assessed to increase to around 675,500 FTE, whereof around 243,500 FTE are fixed, and around 432,000 FTE floating corresponding to a 36%-64% split between fixed and floating.

Further assuming a gradual build-up of first-tier French-based contractors to 50% in 2035, the total of around 675,500 direct and indirect FTE are split with around 446,800 FTE from French-based companies and 228,700 FTE yet to be determined. The 446,800 FTE supplied by French-based companies are further assessed to be distributed with around 158,500 FTE on fixed and around 288,300 FTE on floating.

Converting FTE to jobs is always difficult, but annualising it is a good approximation. In 2031, FTE supplied by French-based companies peaks with around 19,300, whereof around 6,200 FTE on fixed OWF and around 13,100 FTE on floating. This is assessed as the maximum number of jobs in French-based companies at any point in time in 2019-2075.

The OWF models calculate the assessed labour input for up to 40 job professions. Hence, they can be a tool for avoiding bottlenecks in terms of labour shortages and skill gaps and for preparing and implementing educational and training programmes to meet labour demand from the offshore wind industry. This is particularly important in a situation with 50% local content. If the offshore wind companies contracted to implement the 40 GW cannot source the required labour globally but forced to source 50% locally in France, the local French labour markets need to be prepared and able to supply the required labour skills in the right amount at the right time. Otherwise, the 50% local content risk increase the costs of the 40 GW offshore wind and delay its commissioning.

1.1.5 Summary table

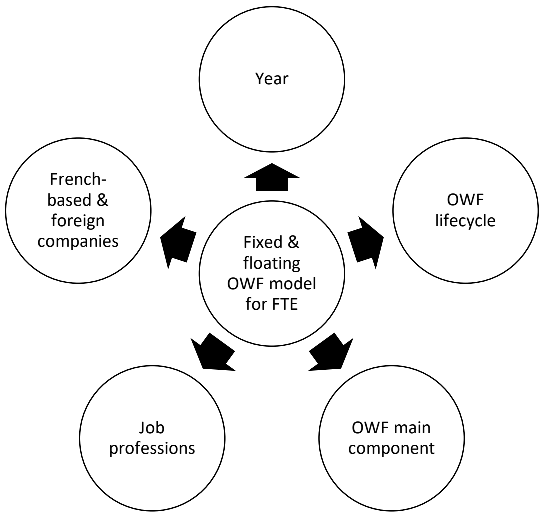
MODEL PITFALLS	**1** Ignoring productivity Improvements	**2** Using national statistics multipliers for direct jobs	**3** Local content target for French-based companies	**4** Global and domestic supply chain bottlenecks	**5** Inflation and lending costs
MODEL CONFIGURATION	**40** Models contain up to 40 job professions in their labour input predictions	**-1.6%/-3.2%** OWF cost reduction of -1.6% CAGR for fixed and -3.2% CAGR for floating	**0.12/0.42** Labour input reduction of 0.12 FTE/MW/year for fixed and 0.42 FTE/MW/year for floating	**18/22** Timing of commissioning follows RTE (2023) with 18 GW in 2035 and 22 GW in 2036-2050	**50%** Gradual build-up of local content to 50% from 2025 to 2035
SCENARIO FOR 40 GW BY 2050	**436,000 FTE** In 2019-2075, 436,000 FTE from 40 GW with 158,300 FTE fixed and 277,700 FTE floating	**675,500 FTE** Adding suppliers 675,500 FTE from 40 GW with 243,500 FTE fixed, and 432,000 FTE floating	**446,800 FTE** In 2019-2075, 446,800 FTE from French-based companies and 228,700 FTE to be determined	**36%/64%** In 2019-2075, labour input of 675,500 FTE is split with 36% fixed and 64% floating	**19,300 jobs** Max no jobs in French-based companies in a single year are assessed to around 19,300 in 2031

STUDY PURPOSE AND OBJECTIVES

The purpose of the study is two-fold. First, to provide an assessment of the labour input likely to be provided by French-based companies and hence the employment benefits of the 40 GW offshore wind investments in France. Secondly, by breaking assessed labour inputs down by job professions, year, fixed/floating foundation, lifecycles, components and activities, and French-based/foreign companies, the purpose is furthermore to provide aid for avoiding labour market bottlenecks in terms of labour shortages and skill gaps and for preparing and implementing educational and training programmes to meet labour demand from the offshore wind industry.

This is particularly important with a target of 50% local content. Thus, if the offshore wind companies contracted to implement the 40 GW cannot source all of the required labour globally but are forced to source 50% locally in France, the local French labour markets need to be prepared and able to supply the required labour skills in the right amount at the right time. Otherwise, the 50% local content risk increase the costs of the 40 GW offshore wind and delay its commissioning.

Figure 1.1: Targeted model break-down levels



To accommodate its purposes, the study has four objectives. First, to develop two offshore wind farm (OWF) models – one for fixed and one for floating foundation - capable of forecasting labour inputs (convertible to jobs), GDP and company revenue associated with offshore wind investments in France.

Second, to populate the two OWF models with forecasts and data sufficiently detailed to produce results broken down by year, the six OWF lifecycles, up to 150 OWF components and activities, up to 40 job professions, and, finally, French-based and foreign companies, cf. **Figure 1.1**. Hence, the OWF models are the basis of the study.

Third, to develop a first scenario for 40 GW by 2050 with particular emphasis on French-based jobs considering the French offshore industry's commitment to create 20,000 direct and indirect jobs and 50% local content in OWF project costs in 2035. The OWF models can accommodate several scenarios whereof 40 GW by 2050 is one. Fourth, to update and improve the OWF models whenever new and better forecasts and data become available. As such, the predictions of the OWF models are reflections of the data and forecasts available at any given time as well as applied assumptions.

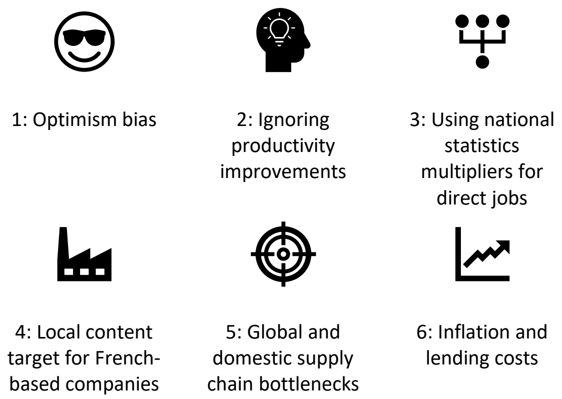
1 MODEL PITFALLS

1.1 AT LEAST SIX PITFALLS

Establishing models like the two OWF models with the desired capabilities of predicting detailed labour input for the next 25 years, and 50 years when including operation and maintenance and decommissioning, entails various pitfalls capable of undermining the accurateness of their predictions. Among the pitfalls are first of all optimism bias, notably the risk of a study being conducted without the results being sufficiently accurate and therefore misleading and potentially harmful.

To prevent this, it is the assessment that this study needs to consider and address other pitfalls given in terms of 2) ignoring productivity improvements, 3) using national statistics multipliers for assessing direct jobs from OWF investments, 4) potential delays and cost increases from local content target for French-based companies, 5) global and domestic supply chain bottlenecks and 6) inflation and rising lending costs, cf. **Figure 1.1**. Some of these pitfalls can be addressed in the current version of the study, while others must await the emerge of more information and market stabilisation.

Figure 1.1: Six model pitfalls



Source: QBIS

Thus, factors such as 5) global and domestic supply chain bottlenecks and 6) inflation and rising lending costs are assessed to be too uncertain and unpredictable at this point in time and must await potential market correction and stabilisation. But it is clear that rising costs of everything from turbines to labour and financing can render projects unviable, particularly if the prices for electricity are locked at too low levels. So, governments need to ensure that their procurement frameworks allow a return on investment and adequately take into account external factors such as inflation if they want their markets to remain competitive.

This is also a valid consideration for France. In addition, supply chain bottlenecks might negatively impact the commissioning of the 40 GW by 2050. In order to hit net zero goals and limit global warming, both the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA)[4] estimate offshore wind capacity will need to exceed 2,000 GW by 2050, up from 64 GW today (and 5 GW in 2012). This huge global expansion has the same time frame as the 40 GW in France and risks a fight over supplies and further upward price pressure. Both pitfall 5) global and domestic supply chain bottlenecks and pitfall 6) inflation and rising lending costs need to be monitored carefully and built into the OWF models when markets stabilise. The other pitfalls are addressed in this version of the study. Pitfall 2) and 3) below, and pitfall 4) throughput the study.

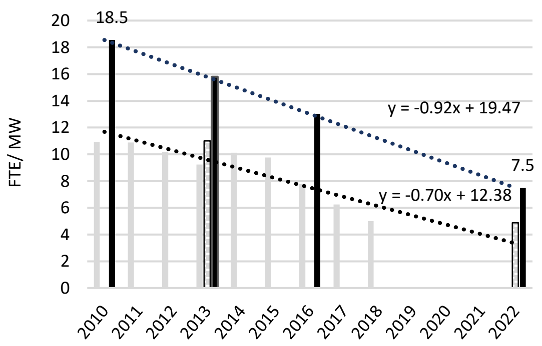
[4] See: https://www.irena.org/News/articles/2021/Jul/IRENA-Outlines-Action-Agenda-on-Offshore-Renewables-for-G20

1.2 Pitfall 2: Ignoring productivity improvements

The offshore wind industry has been characterised by significant productivity improvements that have increased the economic return measured as MW per Euro invested, but also reduced the labour needed per MW. Not correcting for this reduction will overestimate the employment associated with offshore wind investments.

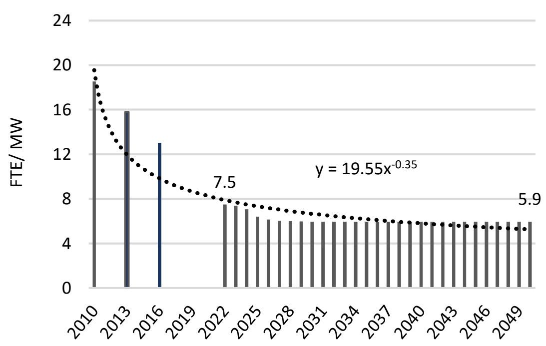
In QBIS (2020), direct labour input for a fixed foundation OWF is estimated to have been reduced by 0.7-0.9 FTE/MW per year in 2010-2022. From around 19.0 FTE/MW in 2010 to around 7.5 FTE/MW in 2022, cf. **Figure 1.2**. The estimation is based existing studies of the labour input associated with OWF investments as well as Wind Denmark's member survey of offshore wind turnover and employment in 2010, 2015 and 2020.

Figure 1.2: FTE/MW, CapEx, fixed, EU, OWF, 2010-2022



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), and Wind Denmark (2020).

Figure 1.3: FTE/MW, CapEx, fixed, EU/US OWF, 2010-2050



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023) and US DOE (2021).

It follows that not correcting for productivity improvements in the period 2010-2022 would have resulted in significant overestimations of the employment impact of offshore wind investments. The question is therefore whether offshore wind farms still will experience productivity improvements going forward and, if yes, to what extent they will influence the employment impacts of the 40 GW in France.

According to leading industry experts, more productivity improvement will follow. US DOE (2021), NREL (2022) and Aegir (2023) all predict cost reductions in offshore wind farms due to further productivity improvements and given the nature of these productivity improvements labour input per MW is also expected to fall, cf. section 2.3.

For EU/global OWF with fixed foundation, US DOE (2021) and Aegir (2023) predict reductions in LCOE corresponding to minus 2.5%-2.9% CAGR over the next 10-15 years. Since these cost reductions are driven by productivity improvements likely to reduce labour input per MW, these forecasts are also used for predicting labour input per MW resulting in a reduction from 7.5 FTE/MW in 2022 to 5.9 FTE/MW in 2050 and a growth rate of minus 1.61% CAGR, cf. **Figure 1.3**.

1.3 Pitfall 3: Using national statistics multipliers for direct jobs

Studies of labour impacts of offshore wind investments often use FTE multipliers derived from national statistics input-output (IO) tables for assessing direct labour impacts.[5] While national statistics' IO multipliers often can be useful for assessing indirect and induced labour impacts (as done in this study), at least three reservations apply to using these IO multipliers for assessing direct labour impacts.

Reservation 1: Mixed multipliers

National statistics IO tables seldom have offshore wind as a stand-alone industry. Therefore, the impacts of an OWF need to be assessed based on a combination of IO multipliers with as close as possible industry affiliation to the OWF components and activities. In Statistics Denmark's multipliers, the industry 280010 "Manufacture of engines, windmills and pumps" is the closest to production of wind turbines and balance of plant. However, since pumps (most Grundfos pumps) and engines are likely to require more labour input per produced unit than an OWF, applying this mixed multiplier risks overestimating impacts of an OWF.

Reservation 2: Import shares too low

Import shares of industries in the national statistics IO tables with close industry affiliation to the OWF components and activities are often lower than for an OWF. In Statistics Denmark's IO tables, the industry 280010 "Manufacture of engines, windmills and pumps" has an import share of around 30%, while the import share for a OWF built and operated on Danish soil is assessed to around 40%-45%. This higher import share will further overestimate labour impacts because a higher proportion of the products and services are assessed produced domestically.[6]

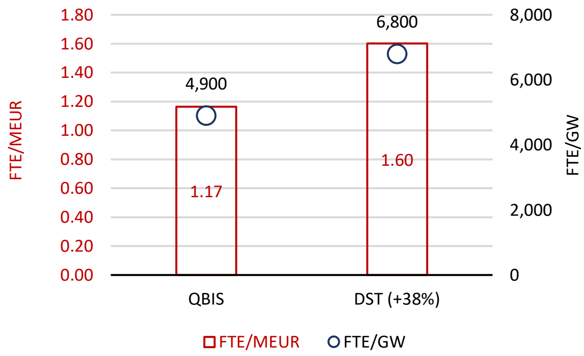
Reservation 3: Time lag

National statistics IO tables are at least 3-5 years old, which means that the latest productivity improvements in the offshore wind industry are not properly factored into the multipliers. Case in point. Assessing the labour impacts of an OWF in 2022 using 3-5 years old multipliers would mean using a multiplier of around 11.2 FTE/MW instead of 7.5 FTE/MW, cf. **Figure 1.2**, and in turn overestimating the labour impact by around 33%.

To illustrate the potential consequences of reservation 1-3 and the potential overestimation from using national statistics IO tables for assessing direct labour impacts from OWF, the labour impacts of a 1 GW OWF on European soil are assessed using QBIS (2020) multipliers and Statistics Denmark multipliers. In QBIS (2020), the CapEx+Opex of 1 GW OWF in Europe was estimated to around 4,225 MEUR and requiring around 9,430 FTE. This corresponds to a weighted average FTE multiplier of 2.23 FTE/MEUR.

[5] See e.g., AE (2019 and 2022) and KPMG (2023).
[6] QBIS (2020).

Figure 1.4: FTE/MEUR (multiplier) and FTE/GW, 2022



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), and Wind Denmark (2020).

As the Danish market share was assessed to max. 57% and 4,900 FTE/GW, the average direct FTE multiplier for Denmark is around 1.17 FTE/MEUR, cf. **Figure 1.4**. Statistics Denmark's latest version of the IO multiplier for the industry 280010 "Manufacture of engines, windmills and pumps" is from 2019 and has a value of around 1.60 FTE/MEUR, which imply around 6,800 FTE/GW. The difference in labour impact measured as FTE/GW between using the multipliers assessed by QBIS (2020) and Statistics Denmark corresponds to 38%, i.e., an overestimation in the potential labour input from offshore wind investments of 38%.

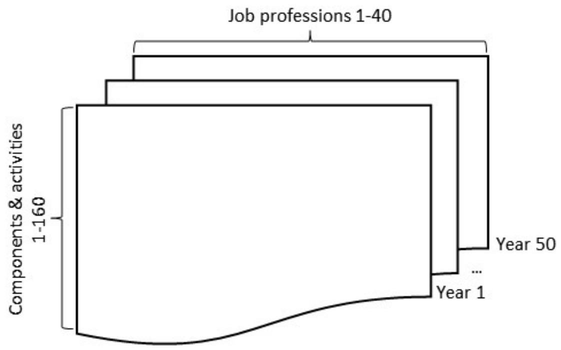
Using national statistics IO multipliers for assessing indirect labour impacts from companies supplying products and services to the first-tier offshore wind contractors such as Vestas, Siemens and GE Renewable Energy is assessed to be associated with a somewhat smaller risk of overestimating impacts than the direct IO multipliers.

Thus, the constant cost pressure exposed to first-tier OWF companies during the 20+ years driving productivity improvements will not necessarily trickle down to their suppliers to the same degree. For instance, steel suppliers will probably not have to reduce their prices because the first-tier OWF companies are building bigger wind turbines to reduce costs. Or first-time suppliers to first-tier OWF companies contacted due to local content requirements might not reduce their prices either.

Using national statistics IO multiplier for assessing induced labour impacts from spending of salaries by employees of the first-tier OWF companies and their second-tier suppliers is assessed as not overestimating impacts at all. Since these multipliers indicate the propensity to consume by the professions employed by the particular industries, they are the best available indicator for assessing the induced impacts.

2 MODEL CONFIGURATION

The OWF models for fixed and floating foundation are structured as up to 160 x 40 matrices with up to 160 costs of components and activities and around 40 job professions. Adding the nearly 50 years in the project period 2024-2075 results in a 160 x 40 x 50 matrix with a total of around 320,000 cells with assessed of labour inputs measured as FTE/MW per OWF model. Appendix A and B provides detailed insight into the costs of components and activities of the two OWF models.



The OWF models differ in the distribution of costs and FTE across the lifecycles reflecting differences between fixed and floating foundation, cf. **Figure 2.1** and **Figure 2.2**. Most significant are differences in wind turbines and balance of plant, where fixed foundation has higher costs for wind turbines than floating, while floating has higher costs for balance of plant than fixed foundation. But differences are also evident for installation, O&M and decommissioning.

This means different suppliers and labour inputs with different qualifications are required for the two types of foundation and that is important to consider in order for the industry and labour markets to be able to deliver the required inputs for the two types of offshore wind farms. This emphasises the importance of solid forecasts of the split between fixed and floating commissioned offshore wind in the 40 GW as well as the timing of commissioning measured per year.

Figure 2.1: MEUR/GW, CapEx-OpEx, fixed-floating, EU, 2022

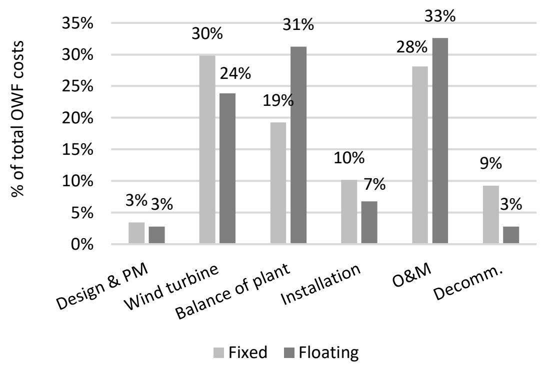
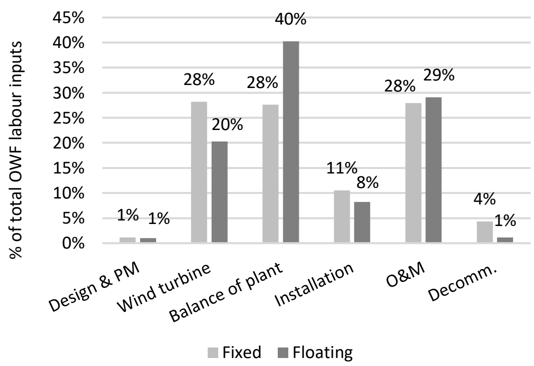


Figure 2.2: FTE/GW, CapEx-OpEx, fixed-floating, EU, 2022



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), NREL (2022), US DOE (2021) and Aegir (2023).

To adapt the OWF models to forecast detailed labour inputs for OWF in France in the period 2023-2075, they need to be configured for a number of variables. First, since main study objective is to assess employment impacts, the models need a detailed configuration of labour input and further itemise this input on as many job professions as possible.

Second, due to continued productivity improvements, MEUR/GW (CapEx/OpEx) is expected to continue to fall in the coming years, particularly for floating offshore wind. Since this reduction will impact labour input, the models need to take this into consideration. Third, considering the expected continued cost reductions, the OWF models need a dynamic adaptation of assessed labour inputs reflecting the expected productivity improvements in the period 2023-2050.

Fourth, also considering expected continued cost reductions and their impact on labour input, the OWF models need to take into consideration the timing of the commissioning of offshore wind in France in the period 2023-2050. The fifth and final variable to configure is the percentage of contracts expected to be allocated to French-based companies. This is a very important determinant for the potential number of jobs generated from the 40 GW. In the next sections, the configuration of each of these five variables in the OWF models are described in more detail.

2.1 FTE PER JOB PROFESSION, FIXED-FLOATING, 2022

The first variable to configure is job professions. Since the main study objective is to assess employment impacts of French offshore wind, the models need a detailed configuration of labour input and further itemise this input on as many job professions as possible.

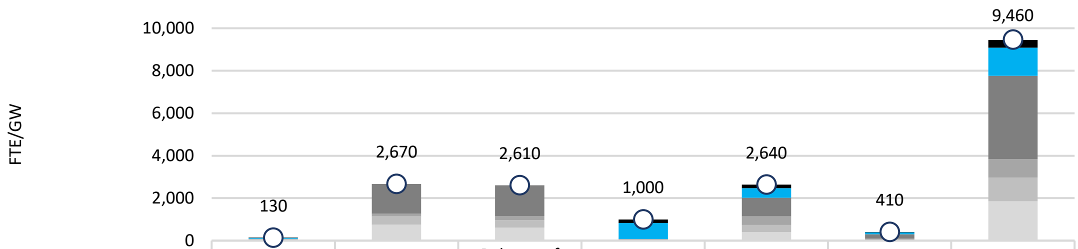
IRENA (2018) assesses labour input measured in terms of man-hours per job profession needed for development, production, installation, O&M and decommissioning of an 0.5 GW OWF reaching final investment decision (FID) in 2020 using 8 MW turbines, fixed foundation, located on 45m water depth, and with 40 km from OWF to O&M port. In comparison, the 1.0 GW OWF model with fixed foundation will reach FID in 2022 using 10 MW turbines, located on 30m water depth, and with 60 km from OWF to O&M port, while the 1.0 GW OWF model with floating foundation will reach FID in 2025 using 15 MW turbines, located in 100m water depth, and with 60 km distance from OWF to O&M port.

Considering these differences in design specifications, the IRENA (2018) mapping of labour inputs cannot be directly applied to the two 1.0 GW OWF models. Thus, given the differences in FID year, total GW, distance from OWF to O&M port and water depth, the number of man-hours in IRENA (2018), whether total or per main activity and component, are not applicable for either the 1.0 GW OWF with fixed or floating foundation.

However, assuming a fixed capital-labour ratio, the percentage distribution of job professions per Euro across components and activities can make the IRENA (2018) labour input mapping applicable to the two 1.0 GW OWFs without ignoring the differences in OWF specifications. A fixed capital-labour assumption implies that the production of a tower requires the same percentage welders per Euro regardless of whether the tower is for an 8 MW, 10 MW or 15 MW wind turbine. With this assumption, the FTE/MW will reduce with turbine size, while the extra welding acquired for making a 15 MW turbine instead of an 8 MW turbine will be incorporated.

Subject to this assumption, the IRENA (2018) mapping of around 40 job professions across 26 OWF components and activities can be applied to the two 1.0 GW OWF with fixed and floating foundation. In 2022, the total labour input is assessed to around 9,460 FTE/GW for fixed and around 20,750 FTE/GW for floating. To illustrate how these FTE are distributed across job professions using IRENA (2018), the around 40 job professions are, as a starting point, summarised in six broad job categories given in terms of operators, ship crews, workers and technicians, engineers, outdoor experts and indoor experts, cf. **Figure 2.3** and **Figure 2.4**.

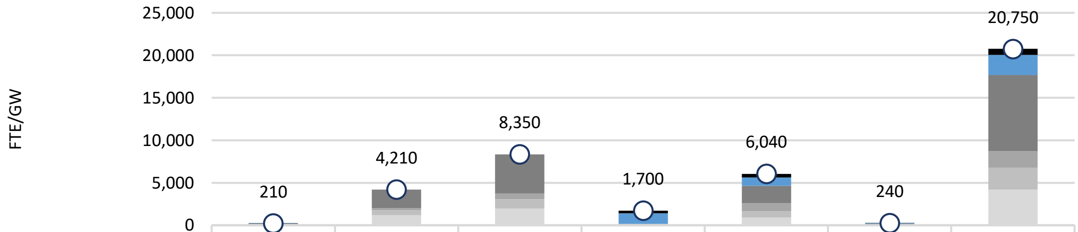
Figure 2.3: FTE per job profession, six categories, 1GW, fixed, 2022



	Design & PM	Wind turbine	Balance of plant	Installation	O&M	Decomm.	Total
Operators	3	0	0	161	176	19	360
Ship crews	33	0	0	753	440	97	1,320
Workers + technicians	2	1,399	1,442	3	880	198	3,920
Engineers	30	127	205	38	411	61	870
Outdoor experts	26	380	349	21	331	13	1,120
Indoor experts	36	760	612	20	402	23	1,850
Total	130	2,670	2,610	1,000	2,640	410	9,460

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), and Wind Denmark (2020).

Figure 2.4: FTE per job profession, six categories, 1GW, floating, 2022



	Design & PM	Wind turbine	Balance of plant	Installation	O&M	Decomm.	Total
Operators	4	0	0	289	403	11	710
Ship crews	53	0	0	1,262	1,007	57	2,380
Workers + technicians	4	2,209	4,614	5	2,013	116	8,960
Engineers	48	200	658	64	940	36	1,950
Outdoor experts	42	600	1,118	41	758	7	2,570
Indoor experts	57	1,200	1,958	40	921	13	4,190
Total	210	4,210	8,350	1,700	6,040	240	20,750

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), NREL (2022), US DOE (2021) and Aegir (2023).

Operators include drilling, crane, cable plough, trenching ROV and jetting system operators. Ship crews only includes ship crews. Workers and technicians include factory and civil workers and different types of technicians. Engineers include electric, telecommunication, computer, material, industrial, mechanical, naval and civil engineers. Outdoor experts include logistics, geotechnical, health & quality, safety, environmental, sociological, marine, biology, and fishing site security experts. Indoor experts include administrative, accounting, marketing, taxation, regulation & standardisation and financial experts. As a next step, the six job profession categories can be expanded to the 42 job categories for each of the OWF models providing further insight into the labour demand, cf. **Table 2.1** and **Table 2.2**.

Table 2.1: FTE per job profession, 42 categories, 1GW, fixed, 2022

No	Job professions	Design & PM	Wind turbines	Balance of Plant	Instal-lation	O&M (25 years)	Decom.	Total
1	Administrative and accounting personnel	0	253	233	0	0	0	486
2	Administrative personnel	0	0	0	0	268	0	268
3	Cable ploug operators	0	0	0	18	0	0	18
4	Civil engineers (foundation experts)	3	0	0	0	0	0	3
5	Civil workers	0	0	0	0	440	0	440
6	Crane operators	0	0	0	74	88	19	181
7	Design and R&D engineers	0	0	30	0	0	0	30
8	Drilling system operators	3	0	0	42	0	0	45
9	Electric engineers	3	0	30	0	0	0	33
10	Electronic engineers	3	0	0	0	0	0	3
11	Energy, electric, electronic, mechanical, telecom and computer engineers	10	0	0	0	0	0	10
12	Environmental experts	0	0	0	0	67	0	67
13	Environmental and regulation experts	0	0	0	0	0	23	23
14	Environmental, sociological, marine/biology experts and fishers	3	0	0	0	0	0	3
15	Factory workers	0	1,399	1,442	0	0	0	2,841
16	Financial analysts	9	0	0	0	0	0	9
17	Geotechnical experts	5	0	0	0	0	0	5
18	Helicopter pilots	0	0	0	0	88	0	88
19	Industrial engineers	1	127	146	0	0	0	274
20	Industrial, mechanical and electric engineers	0	0	0	0	222	0	222
21	Industrial, mechanical, electric, electronic, naval and civil engineers	0	0	0	0	0	61	61
22	Jetting systems operators	0	0	0	9	0	0	9
23	Legal experts	0	0	0	0	134	0	134
24	Legal, energy regulation and taxation experts	20	0	0	0	0	0	20
25	Logistics experts	18	127	116	0	0	2	263
26	Marketing and sales personnel	0	253	233	0	0	0	486
27	Material engineers	3	0	0	0	0	0	3
28	Mechanical engineers	3	0	0	0	0	0	3
29	Naval engineers	3	0	0	0	44	0	47
30	Naval, electric and electronic engineers	0	0	0	38	0	0	38
31	Physicists and weather data experts	1	0	0	0	0	0	1
32	Quality, health and safety experts	0	253	233	21	0	0	507
33	Regulation and standardisation experts	0	127	30	0	0	0	156
34	Regulation experts	7	0	0	20	0	0	27
35	Safety experts	0	0	0	0	88	11	99
36	Ship crew	33	0	0	753	440	97	1,323
37	Site security and cleaning personnel	0	0	0	0	176	0	176
38	Taxation experts	0	127	116	0	0	0	243
39	Technicians	2	0	0	3	440	101	546
40	Telecommunication and computer engineers	0	0	0	0	145	0	145
41	Trenching ROV operators	0	0	0	18	0	0	18
42	Truck drivers	0	0	0	0	0	97	97
	Total	**131**	**2,666**	**2,608**	**996**	**2,640**	**410**	**9,451**

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), and Wind Denmark (2020).

Table 2.2: FTE per job profession, 42 categories, 1GW, floating, 2022

No	Job professions	Design & PM	Wind turbines	Balance of Plant	Instal-lation	O&M (25 years)	Decom.	Total
1	Administrative and accounting personnel	0	400	745	0	0	0	1,145
2	Administrative personnel	0	0	0	0	614	0	614
3	Cable ploug operators	0	0	0	24	0	0	24
4	Civil engineers (foundation experts)	5	0	0	0	0	0	5
5	Civil workers	0	0	0	0	1,007	0	1,007
6	Crane operators	0	0	0	146	201	11	359
7	Design and R&D engineers	0	0	95	0	0	0	95
8	Drilling system operators	4	0	0	83	0	0	87
9	Electric engineers	5	0	95	0	0	0	100
10	Electronic engineers	5	0	0	0	0	0	5
11	Energy, electric, electronic, mechanical, telecom and computer engineers	16	0	0	0	0	0	16
12	Environmental experts	0	0	0	0	153	0	153
13	Environmental and regulation experts	0	0	0	0	0	13	13
14	Environmental, sociological, marine/biology experts and fishers	4	0	0	0	0	0	4
15	Factory workers	0	2,209	4,614	0	0	0	6,823
16	Financial analysts	15	0	0	0	0	0	15
17	Geotechnical experts	8	0	0	0	0	0	8
18	Helicopter pilots	0	0	0	0	201	0	201
19	Industrial engineers	2	200	468	0	0	0	670
20	Industrial, mechanical and electric engineers	0	0	0	0	508	0	508
21	Industrial, mechanical, electric, electronic, naval and civil engineers	0	0	0	0	0	36	36
22	Jetting systems operators	0	0	0	12	0	0	12
23	Legal experts	0	0	0	0	307	0	307
24	Legal, energy regulation and taxation experts	32	0	0	0	0	0	32
25	Logistics experts	28	200	373	0	0	1	602
26	Marketing and sales personnel	0	400	745	0	0	0	1,145
27	Material engineers	5	0	0	0	0	0	5
28	Mechanical engineers	5	0	0	0	0	0	5
29	Naval engineers	4	0	0	0	101	0	105
30	Naval, electric and electronic engineers	0	0	0	64	0	0	64
31	Physicists and weather data experts	1	0	0	0	0	0	1
32	Quality, health and safety experts	0	400	745	41	0	0	1,186
33	Regulation and standardisation experts	0	200	95	0	0	0	295
34	Regulation experts	11	0	0	40	0	0	51
35	Safety experts	0	0	0	0	201	6	208
36	Ship crew	53	0	0	1,262	1,007	57	2,379
37	Site security and cleaning personnel	0	0	0	0	403	0	403
38	Taxation experts	0	200	373	0	0	0	573
39	Technicians	4	0	0	5	1,007	59	1,075
40	Telecommunication and computer engineers	0	0	0	0	331	0	331
41	Trenching ROV operators	0	0	0	23	0	0	23
42	Truck drivers	0	0	0	0	0	57	57
	Total	**208**	**4,210**	**8,348**	**1,702**	**6,041**	**241**	**20,750**

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), NREL (2022), US DOE (2021) and Aegir (2023)..

The OWF models can split the five lifecycles into a maximum of around 160 underlying components and activities providing even more detailed insight into the labour demand. In this capacity, the OWF models can be used as tools for avoiding bottlenecks on the French labour markets. This is particularly important with the 50% local content target for the 40 GW offshore wind. If the offshore wind companies contracted to implement the 40 GW cannot source all the required labour globally but are forced to source 50% locally in France, the local French labour markets need to be prepared and able to supply the required labour skills in the required amount at the right time. Otherwise, the 50% local content risk increases costs of the 40 GW offshore wind and delays its implementation.

2.2 MEUR/GW, FIXED-FLOATING, UP TO 2050

The second variable to be configured in the models are the costs of an OWF going forward. As mentioned, due to further productivity improvements (and excluding rising costs from inflation and supply chain constraints), costs of an OWF are expected to continue to fall. Since this will impact labour input, the models need to take this into consideration.

According to RTE (2022), France is expected to implement as much floating and fixed-bottom foundation OWF by 2050. This means that the costs of floating OWF is just as essential as for fixed OWF. Leading industry experts such as BVG Associates (BVGA), National Renewable Energy Laboratory (NREL), U.S Department of Energy (US DOE) and Aegir Insight Analysis (Aegir), all unanimously estimate costs of floating foundation to drop significantly within the coming years.

These experts estimate an around 60% drop in LCOE within the next 8-15 years, cf. **Figure 2.5**, which in turn will reduce the floating-fixed ratio to around between 1.3-1.6, down from up to 2.1 in 2023, cf. **Figure 2.6**.

Figure 2.5: LCOE index, floating, 2019-2035

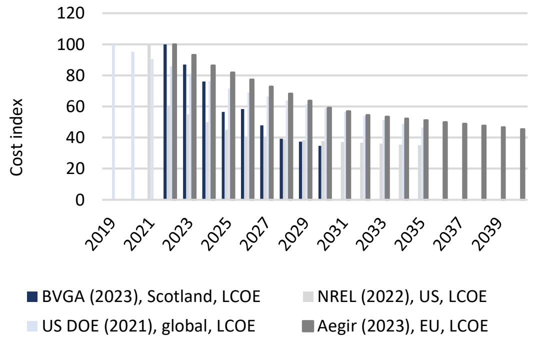
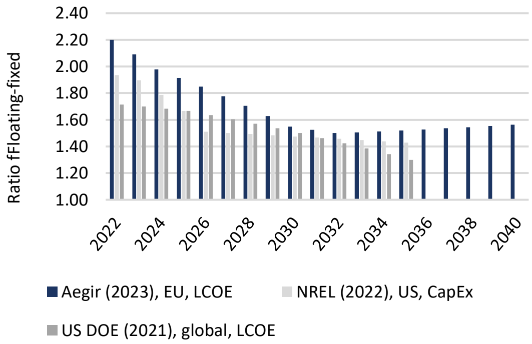


Figure 2.6: LCOE-CapEx ratios, floating-fixed, 2022-2040



Source: QBIS based on BVGA (2023), NREL (2022), US DOE (2021) and Aegir (2023).

Cost reductions will come with deployment. To cut down costs, OWF with floating foundation must be planned and built in such a way that allows a supply chain to be established, and industry to build factories that produce relevant components on a large scale. This will contribute to industrialisation and increased volume production. The commitment by the French government to build 20 GW floating OWF by 2050 is important for facilitating such a process.

For North Europe, Aegir (2023) estimates LCOE reductions of around 36% for fixed OWF and 55% for floating OWF by 2040 resulting in 32 EUR/MWh for fixed and 50 EUR/MWh for floating. Globally, US DOE (2021) estimates LCOE reductions of around 38% for fixed OWF and 54% for floating OWF by 2030 resulting in 50 USD/MWh for fixed and 65 USD/MWh for floating, cf. **Figure 2.7**.

In Compound Average Growth Rate (CAGR), Aegir (2023) estimates minus 2.5% for fixed OWF and minus 4.3% for floating OWF, while US DOE (2021) estimates minus 2.9% for fixed OWF and minus 4.7% for floating OWF. I.e., high degree of agreement in estimates for Northern Europe and globally.

In comparison, BVGA (2023) estimates minus 12.4% for floating OWF in Scotland, while NREL (2022) estimates minus 3.5% for floating OWF in the US.

Figure 2.7: LCOE, fixed-floating, EU-global, 2019-2040

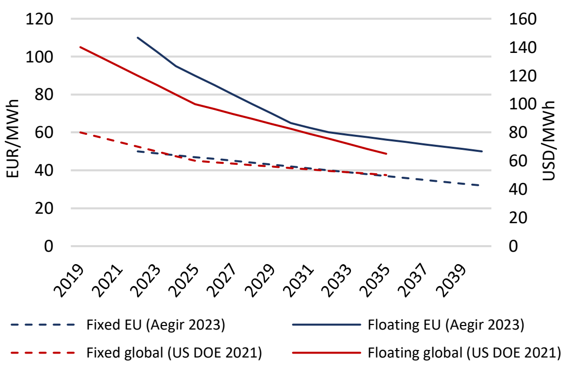
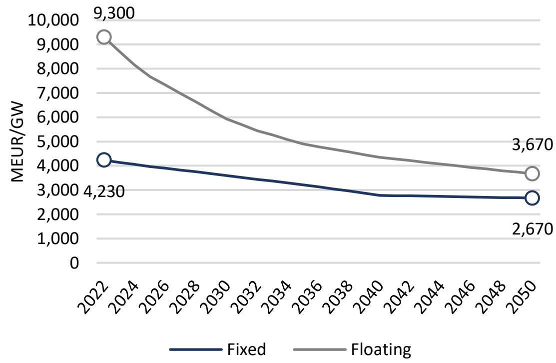


Figure 2.8: CapEx-OpEx, fixed-floating, EU, 2022-2050



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023) and US DOE (2021).

Since LCOE contains CapEx and OpEx and since Aegir (2023) and US DOE (2021) roughly corresponds, the LCOE estimates by Aegir (2023) for Northern Europe are used to forecast the CapEx and OpEx in the OWF models. For the period 2040-2050 not covered by Aegir (2023), the forecast assumes lower growth rate than for 2022-2040, resulting in a forecast for MEUR/GW of average minus 1.6% CAGR for fixed and minus 3.2% CAGR for floating in 2023-2050, cf. **Figure 2.8**.

2.3 FTE/GW, FIXED-FLOATING, UP TO 2050

The third variable to be configured in the OWF models is labour input per GW (FTE/GW) going forward. Considering the expected continued cost reductions, the OWF models need a dynamic adaptation of assessed labour inputs reflecting the expected productivity improvements in the period 2023-2050.

Figure 2.9: FTE/GW, CapEx-OpEx, fixed, EU, 2019-2050

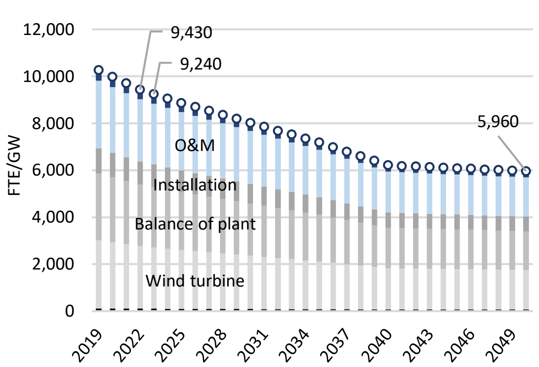
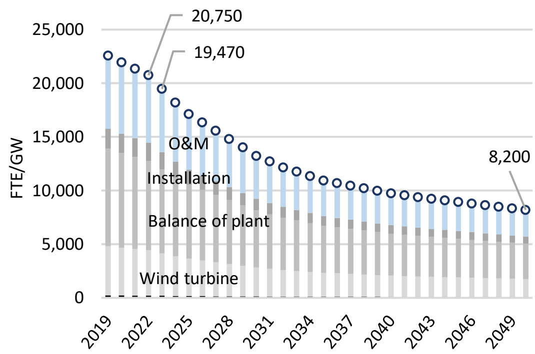


Figure 2.10: FTE/GW, CapEx-OpEx, floating, EU, 2019-2050



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020) and Aegir (2023) and US DOE (2021).

The LCOE forecasts by Aegir (2023) and US DOE (2021) are assessed as relevant indicators of how labour input is going to develop in the coming years. Thus, the future reductions in LCOE forecasted by these sources are driven by system engineering improvements such as upsizing of generator, larger rotor, higher hub weight, integrated turbined design, wind farm layout optimization, turbine reliability, wind farm supportability and maintainability, standardisation of interfaces, installation methods and grid connection. As many of these improvements implicitly will reduce labour input per GW, the LCOE forecasts are proxies for the future development in labour input per GW. On this basis, the LCOE forecasts are used to forecast the labour input per GW.

Table 2.3: FTE per job profession, 42 categories, 1GW, fixed, 2022-2050

	2022	2023	2024	2025	2047	2048	2049	2050
Total	**9,430**	**9,240**	**9,050**	**8,860**	**6,030**	**6,010**	**5,980**	**5,960**
Administrative and accounting personnel	485	475	466	456	310	309	308	307
Administrative personnel	268	262	257	251	171	171	170	169
Cable ploug operators	18	18	17	17	12	12	12	11
Civil engineers (foundation experts)	3	3	3	3	2	2	2	2
Civil workers	439	430	421	412	281	280	278	277
Crane operators	181	177	174	170	116	115	115	114
Design and R&D engineers	30	29	28	28	19	19	19	19
Drilling system operators	45	44	43	42	29	29	28	28
Electric engineers	33	32	32	31	21	21	21	21
Electronic engineers	3	3	3	3	2	2	2	2
Energy, electric, electronic, mechanical, telecom and computer engineers	10	10	10	9	6	6	6	6
Environmental experts	67	66	64	63	43	43	42	42
Environmental and regulation experts	23	22	22	21	14	14	14	14
Environmental, sociological, marine/biology experts and fishers	3	3	2	2	2	2	2	2
Factory workers	2,834	2,777	2,720	2,663	1,812	1,806	1,797	1,791
Financial analysts	9	9	9	9	6	6	6	6
Geotechnical experts	5	5	5	5	3	3	3	3
Helicopter pilots	88	86	84	83	56	56	56	56
Industrial engineers	273	268	262	257	175	174	173	173
Industrial, mechanical and electric engineers	222	217	213	208	142	141	141	140
Industrial, mechanical, electric, electronic, naval and civil engineers	61	60	58	57	39	39	39	38
Jetting systems operators	9	9	9	9	6	6	6	6
Legal experts	134	131	128	126	86	85	85	85
Legal, energy regulation and taxation experts	20	19	19	19	13	13	13	13
Logistics experts	262	257	252	246	168	167	166	166
Marketing and sales personnel	485	475	466	456	310	309	308	307
Material engineers	3	3	3	3	2	2	2	2
Mechanical engineers	3	3	3	3	2	2	2	2
Naval engineers	47	46	45	44	30	30	30	30
Naval, electric and electronic engineers	38	37	37	36	24	24	24	24
Physicists and weather data experts	1	1	1	1	0	0	0	0
Quality, health and safety experts	506	495	485	475	323	322	321	320
Regulation and standardisation experts	156	153	150	147	100	99	99	99
Regulation experts	27	26	26	25	17	17	17	17
Safety experts	99	97	95	93	63	63	63	62
Ship crew	1,320	1,294	1,267	1,241	844	842	837	835
Site security and cleaning personnel	176	172	169	165	112	112	111	111
Taxation experts	243	238	233	228	155	155	154	153
Technicians	545	534	523	512	348	347	345	344
Telecommunication and computer engineers	144	141	138	136	92	92	91	91
Trenching ROV operators	18	17	17	17	11	11	11	11
Truck drivers	97	95	93	91	62	62	61	61

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020) and Aegir (2023) and US DOE (2021).

On this basis, labour input for CapEx+OpEx is expected to reduce from 9.240 FTE/GW in 2023 to 5,960 FTE/GW in 2050 for OWF with fixed foundations, cf. **Figure 2.9**, and from 19,470 FTE/GW in 2023 to 8,200 FTE/GW in 2050 for OWF with floating foundation, cf. **Figure 2.10**. It follows that the employment impact of France's offshore investments will depend on the timing of the implementation in the period 2023-2050.

Table 2.4: FTE per job profession, 42 categories, 1GW, floating, 2022-2050

	2022	2023	2024	2025	2047	2048	2049	2050
Total	**20,750**	**19,470**	**18,180**	**17,130**	**8,630**	**8,490**	**8,340**	**8,200**
Administrative and accounting personnel	1,145	1,075	1,004	946	476	469	460	453
Administrative personnel	614	576	538	507	255	251	247	243
Cable ploug operators	24	23	21	20	10	10	10	10
Civil engineers (foundation experts)	5	4	4	4	2	2	2	2
Civil workers	1,007	945	882	831	419	412	405	398
Crane operators	359	337	315	297	149	147	144	142
Design and R&D engineers	95	89	83	78	40	39	38	38
Drilling system operators	87	82	77	72	36	36	35	35
Electric engineers	100	94	88	83	42	41	40	40
Electronic engineers	5	5	5	4	2	2	2	2
Energy, electric, electronic, mechanical, telecom and computer engineers	16	15	14	13	7	7	6	6
Environmental experts	153	144	134	127	64	63	62	61
Environmental and regulation experts	13	12	12	11	6	5	5	5
Environmental, sociological, marine/biology experts and fishers	4	4	4	3	2	2	2	2
Factory workers	6,823	6,402	5,978	5,633	2,838	2,792	2,742	2,696
Financial analysts	15	14	13	12	6	6	6	6
Geotechnical experts	8	8	7	7	4	3	3	3
Helicopter pilots	201	189	176	166	84	82	81	80
Industrial engineers	670	628	587	553	278	274	269	265
Industrial, mechanical and electric engineers	508	477	445	420	211	208	204	201
Industrial, mechanical, electric, electronic, naval and civil engineers	36	34	31	30	15	15	14	14
Jetting systems operators	12	11	11	10	5	5	5	5
Legal experts	307	288	269	253	128	126	123	121
Legal, energy regulation and taxation experts	32	30	28	26	13	13	13	13
Logistics experts	602	565	528	497	250	246	242	238
Marketing and sales personnel	1,145	1,075	1,004	946	476	469	460	453
Material engineers	5	5	5	4	2	2	2	2
Mechanical engineers	5	5	5	4	2	2	2	2
Naval engineers	105	99	92	87	44	43	42	42
Naval, electric and electronic engineers	64	60	56	53	27	26	26	25
Physicists and weather data experts	1	1	1	1	0	0	0	0
Quality, health and safety experts	1,186	1,113	1,039	979	493	485	477	469
Regulation and standardisation experts	295	277	259	244	123	121	119	117
Regulation experts	51	48	45	42	21	21	21	20
Safety experts	208	195	182	172	86	85	84	82
Ship crew	2,379	2,232	2,084	1,964	989	973	956	940
Site security and cleaning personnel	403	378	353	333	168	165	162	159
Taxation experts	573	537	502	473	238	234	230	226
Technicians	1,075	1,008	942	887	447	440	432	425
Telecommunication and computer engineers	331	310	290	273	138	135	133	131
Trenching ROV operators	23	22	21	19	10	10	9	9
Truck drivers	57	53	50	47	24	23	23	22

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020) and Aegir (2023) and US DOE (2021).

Using IRENA (2018), the FTE/GW for 2022-2050 can further be broken down into around 40 job professions providing more insight to the planning and preparation of the French labour market for the commissioning of the 40 GW in France, cf. **Table 2.3** and **Table 2.4**.

2.4 Time of operation, fixed-floating, up to 2050

The fourth variable to be configured in the OWF models is the time for commissioning of the offshore wind. This is important because labour input per GW is expected to fall up to 2050 and because the implementation period from contract award to commissioning in France currently is around nine years. As offshore farms are built with the technology available at the time of contract award and not commissioning, it is important to thoroughly incorporate the timing of the offshore wind into the models.

The organisation responsible for planning and timing of offshore wind investments in France is Réseau de Transport d'Électricité (RTE). RTE (2023) predicts a total of 17.8 GW offshore wind to be in operation by 2035, whereof 11.0 GW are expected to be fixed and 6.8 GW are expected to be floating. By 2050, the target is a 50%-50% split between fixed and floating foundation and a total of 40 GW. In 2035-2050, the planning and timing is still pending and consequently, the remaining GW (40.0 GW minus 17.8 GW = 22.2 GW) is assumed to come into operation evenly distributed over the remaining of the remaining period with 0.6 GW/year fixed and 0.9 GW/year floating, cf., **Figure 2.11**, **Figure 2.12** and **Table 2.5**.

Figure 2.11: GW in operation, actual-expected, fixed, 2021-2050

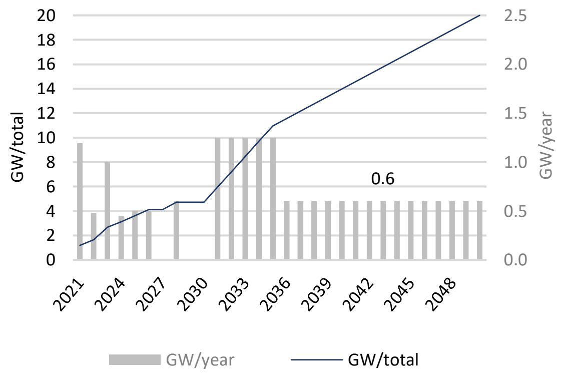
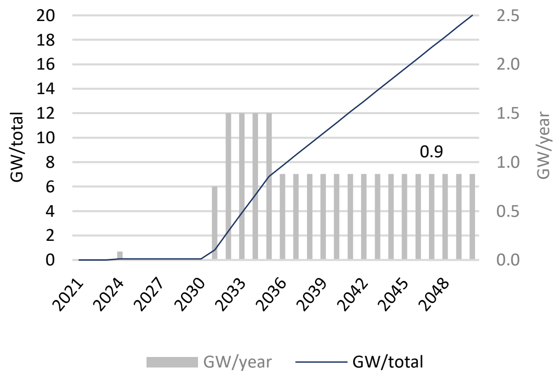


Figure 2.12: GW in operation, actual-expected, floating, 2021-2050



Source: QBIS based on RTE (2023).

Table 2.5: OWF, GW and operation year

Foundation	OWF	GW	Year	Foundation	OWF	GW	Year
Fixed	Base	1.19	2021	Floating	Faraman	0.03	2024
Fixed	St-Nazaire	0.48	2022	Floating	Leucate	0.03	2024
Fixed	St-Brieuc	0.50	2023	Floating	Gruissan	0.03	2024
Fixed	Fécamp	0.50	2023	Floating	Sud Bretagne	0.75	2031
Fixed	Courseulles	0.45	2024	Floating	Occitanie	0.75	2032
Fixed	Yeu Noirmoutier	0.50	2025	Floating	PACA	0.75	2032
Fixed	Dieppe Le Tréport	0.50	2026	Floating	TBD	1.50	2033
Fixed	Dunkerque	0.60	2028	Floating	TBD	1.50	2034
Fixed	Centre Mache 1	1.25	2031	Floating	TBD	1.50	2035
Fixed	Centre Mache 2	1.25	2032	Floating	To-come	13.17	2036-2050
Fixed	To-come	9.03	2034-2050				
Total		**20.00**				**20.00**	

Source: QBIS based on RTE (2023).

To achieve these targets, RTE (2023) assesses that it is necessary to reduce the time from contract award to commissioning by two years from 9 years to 7 years. Assuming this reduction will happen gradually over the project period, the OWF models are configured with a 8-years lag, where GW commissioned in year x has been designed in year x-8 with the technology available at that time including FTE/GW, cf. **Figure 2.13** and **Figure 2.14**.

Figure 2.13: GW in operation, actual-expected, fixed, 2019-2050

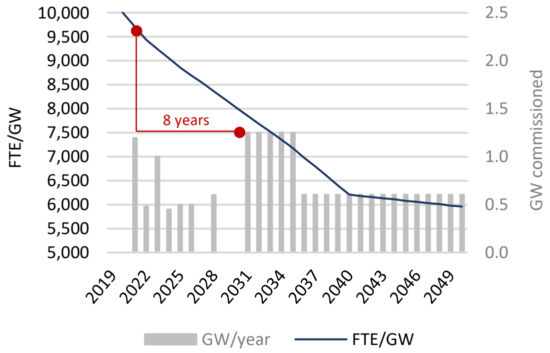
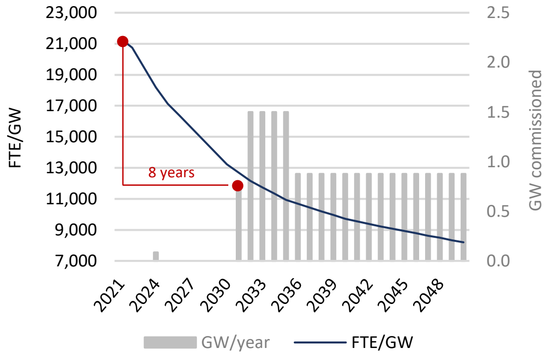


Figure 2.14: GW in operation, actual-expected, floating, 2021-2050



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023), US DOE (2021) and RTE (2023).

2.5 French-based input, up to 2050

The fifth and final variable to configure is the percentage of contracts expected to be allocated to French-based companies. This is a very important determinant for the potential number of jobs coming from the 40 GW.

The fifth and final variable to configure is the percentage of contracts expected to be allocated to French-based companies. This is a very important determinant for the potential number of jobs coming from the 40 GW.

As mentioned, according to the offshore wind pact (Pacte éolien en mer entre l'Etat et la filière), signed by the French government and the industry represented by the Renewable Energy Union (SER), France Energie Eolienne (FEE) and the Strategic Committee for New Energy Systems (CSF-NSE) in March 2022, the industry has committed to creating 20,000 direct and indirect jobs in France by 2035 and "by 2035 to achieve up to 50% local content in project costs, at the time of commissioning, for each offshore wind project".[7]

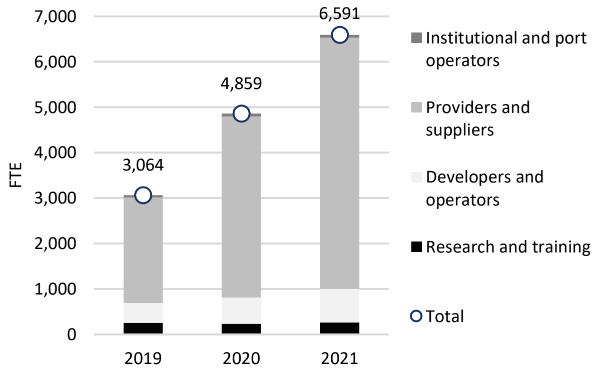
To test whether 50% local content would be a plausible configuration of the OWF models, an assessment of the current and future expected state of the French-based offshore wind production capabilities is carried out.

According to FEE (2022) and OEM (2022), the French offshore wind industry increased its FTE from around 3,100 FTE in 2019 to around 6,600 FTE in 2021 corresponding to a growth of 47% CAGR, cf.

[7] See: https://www.ecologie.gouv.fr/sites/default/files/2022.03.14_pacte-eolien-mer.pdf

Figure 2.15. To reach the target of 20,000 direct and indirect jobs in 2035, FTE need to grow with a CAGR of around 8%.

Figure 2.15: FTE, actual, total across supply chains



Source: QBIS based on FEE (2022) and OEM (2022).

Considering the further commitment by the French industry to invest a total EUR 40 billion by 2035 and the current investments in ports (Brest, La Nouvelle, Cherbourg, Le Havre, Saint-Nazaire and Marseilles-Fos) as well as existing production and assembly facilities, the objective of 20,000 direct and indirect jobs by 2035 seems plausible, cf. **Table 2.6**. Most jobs are expected to be created primarily in production, installation and O&M. Partly because these lifecycles require relatively most labour input per GW, and partly because of the current and future investments.

Table 2.6: Current activities and investments and expected jobs

Lifecycle	Activity	Company	Location	Jobs
Design & PM	Engineering, quality, purchasing, project management and service	GE Renewable Energy	Nantes	200
Wind turbine	Blades, nacelles and generators (Saint-Brieuc and Fécamp OWF)	Siemens	Le Havre	750
	Blades	GE Renewable Energy	Cherbourg	750
	80 nacelles for Saint-Nazaire	GE Renewable Energy	Montoir-de-Bregtagne	450
Balance of plant	Foundation, transition pieces and substations for Saint-Nazaire	Chantiers de l'Atlantique	Saint-Nazaire	280
Installation/O&M	Port of Brest		Brest	450
	Port-La Nouvelle		La Nouvelle	3,000
	Port of Cherbourg		Cherbourg	
	Port of Le Havre		Le Havre	
	Port of Saint-Nazaire		Saint-Nazaire	
	Port of Marseille-Fos		Marseille-Fos	

Source: QBIS based on FEE (2022) and OEM (2022).

With a gradual build-up of local content to 50% in 2035, the OWF models predicts up to around 20,000 FTE per year in French-based companies, cf. section 3.3. This indicates that the objectives of the offshore wind pact seem as a plausible.

3 SCENARIO FOR 40 GW BY 2050

3.1 DIRECT FTE, UP TO 2075

With the configuration of the OWF models completed, chapter 2, it is possible to provide an assessment of the labour input associated with commissioning of 40 GW by 2050 in France. It is important to emphasise that this assessment is based on the current configuration that should be evaluated whenever new information becomes available.

Thus, one of the objectives of the study is to update and improve the OWF models whenever new and better forecasts and data become available. As such, the assessments of the OWF models will always reflect the information available at any given time and the applied assumptions.

Since the configuration determines the model assessments, it needs constant awareness, cf. **Table 3.1**. Among others, the configuration for this first version of a scenario for 40 GW by 2050 includes 1) LCOE forecasts of minus 1.61% CAGR for fixed and minus 3.15% CAGR for floating in 2023-2050, an assumption that negative growth in LCOE equals negative growth in labour input (FTE/GW), labour input across job professions as IRENA (2018a) and costs distribution across components and activities as BVGA (2019) for fixed and BVGA (2023) for floating.

Table 3.1: Configuration, direct FTE, fixed-floating, 2019-2075

1)	LCOE, fixed, 2023-2050 = -1.61% CAGR
2)	LCOE, floating, 2023-2050 = -3.15% CAGR
3)	LCOE CAGR = FTE CAGR
4)	Job professions across components & activities for fixed foundation = IRENA (2018)
5)	Job professions required for 500 MW = 1 GW
6)	Fixed capital-labour ratio, 2022-2050
7)	Costs across components & activities for fixed foundation = BVGA (2019) and QBIS (2020)
8)	Costs across components & activities for floating foundation = BVGA (2023)
9)	Commissioning of GW as predicted by RTE (2023)
10)	Average implementation period, 2023-2050 = 8 years

Source: QBIS based on IRENA (2018a), BVGA (2019 and 2023), Aegir (2023), US DOE (2021) and RTE (2023).

In 2019-2075, 40 GW offshore wind by 2050 is estimated to be associated with a total of 436,000 FTE whereof 158,300 FTE fixed and 277,700 FTE floating, cf. **Figure 3.1**. FTE is not the same as jobs. To convert FTE to jobs, annualising FTE is considered a reasonable approximation. This suggests an average of 7,650 FTE per year in 2019-2075 with a peak of around 20,000 FTE in 2031, cf. **Figure 3.2**..

Figure 3.1: Direct FTE, fixed-floating, total, 2019-2075

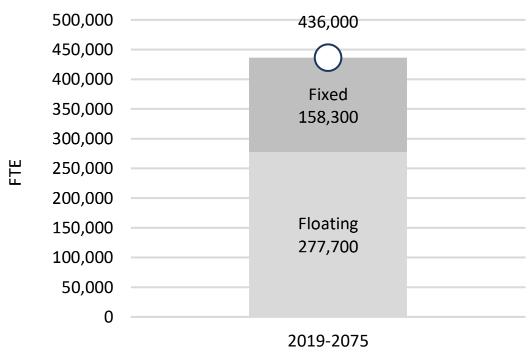
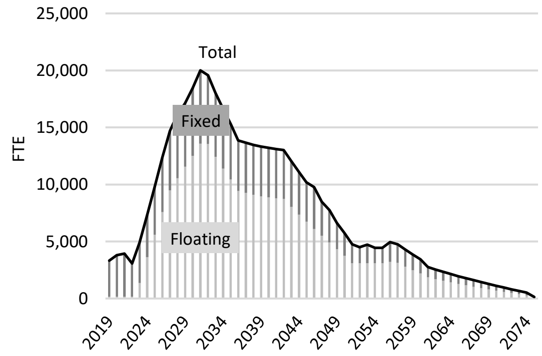


Figure 3.2: Direct FTE, fixed-floating, per year, 2019-2075



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023), US DOE (2021) and RTE (2023).

The distribution of FTE across lifecycles reveals the need for a massive build-up of labour supply up to around 2031, where fixed OWF peaks with around 6,400 FTE/year, cf. **Figure 3.3**, and floating peaks with around 13,600 FTE/year totalling around 20,000 FTE/year, cf. **Figure 3.4**.

Figure 3.3: FTE, lifecycles, fixed, 2019-2075

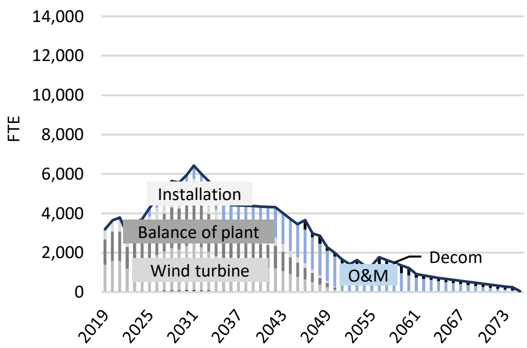
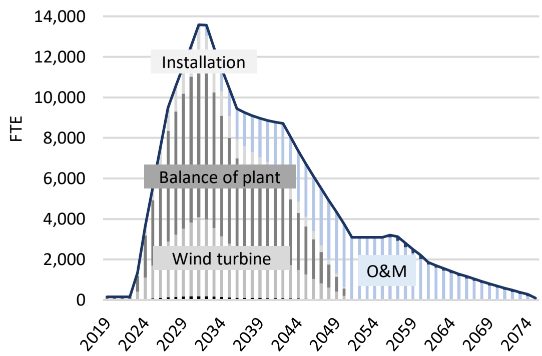


Figure 3.4: FTE, lifecycles, floating, 2019-2075



Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023), US DOE (2021) and RTE (2023).

Table 3.2 provides an illustration of how this labour input is broken down by job professions in the OWF models for fixed foundation. A similar break down is available for the OWF model with floating foundation.

It is particularly production of wind turbines and balance of plant as well as installation that require massive labour supply in the first part of the period. As offshore wind farms are commissioned and starts operating, also labour supply for O&M and decommissioning gradually build up and constitute the sole labour requirement from 2051-2075.

Floating OWF has a steeper build-up curve that fixed OWF, which means that securing the required labour supply will be more challenging not least considering that the production techniques for floating is less developed and hence is the knowledge of the types of required labour input.

Table 3.2: Direct FTE, job professions, fixed, 2022-2075

	2022	2023	2024	2025	=>	2031	=>	2048	2049	2050	2051-2075
Total	**2,914**	**3,545**	**3,693**	**4,254**		**6,421**		**2,855**	**2,272**	**1,997**	**22,593**
Design & PM	**46**	**55**	**57**	**65**		**98**		**14**	**10**	**5**	**0**
Ship crew	12	14	14	17		25		4	2	1	0
Legal, energy regulation and taxation experts	7	8	9	10		15		2	1	1	0
Energy, electric, electronic, mechanical, telecom and computer engineers	4	4	4	5		8		1	1	0	0
Financial analysts	3	4	4	5		7		1	1	0	0
Logistics experts	6	7	8	9		13		2	1	1	0
Geotechnical experts	2	2	2	3		4		1	0	0	0
Drilling system operators	1	1	1	1		2		0	0	0	0
Civil engineers (foundation experts)	1	1	1	1		2		0	0	0	0
Naval engineers	1	1	1	1		2		0	0	0	0
Environmental, sociological, marine/biology experts and fishers	1	1	1	1		2		0	0	0	0
Technicians	1	1	1	1		2		0	0	0	0
Physicists and weather data experts	0	0	0	0		0		0	0	0	0
Regulation experts	2	3	3	3		5		1	0	0	0
Electric engineers	1	1	1	2		3		0	0	0	0
Electronic engineers	1	1	1	2		3		0	0	0	0
Material engineers	1	1	1	2		3		0	0	0	0
Mechanical engineers	1	1	1	2		3		0	0	0	0
Industrial engineers	0	0	0	1		1		0	0	0	0
Wind turbine	**1,138**	**1,353**	**1,394**	**1,604**		**2,404**		**355**	**234**	**117**	0
Factory workers	597	710	731	842		1,261		186	123	61	0
Marketing and sales personnel	108	129	132	152		228		34	22	11	0
Administrative and accounting personnel	108	129	132	152		228		34	22	11	0
Quality, health, and safety experts	108	129	132	152		228		34	22	11	0
Industrial engineers	54	64	66	76		114		17	11	6	0
Logistics experts	54	64	66	76		114		17	11	6	0
Taxation experts	54	64	66	76		114		17	11	6	0
Regulation and standardisation experts	54	64	66	76		114		17	11	6	0
Balance of plant	**1,113**	**1,324**	**1,364**	**1,569**		**2,352**		**348**	**229**	**114**	**0**
Factory workers	615	732	754	867		1,300		192	127	63	0
Marketing and sales personnel	99	118	122	140		210		31	20	10	0
Administrative and accounting personnel	99	118	122	140		210		31	20	10	0
Quality, health and safety experts	99	118	122	140		210		31	20	10	0
Industrial engineers	62	74	76	88		132		19	13	6	0
Logistics experts	50	59	61	70		105		16	10	5	0
Taxation experts	50	59	61	70		105		16	10	5	0
Regulation and standardisation experts	13	15	16	18		27		4	3	1	0
Electric engineers	13	15	16	18		27		4	3	1	0
Design and R&D engineers	13	15	16	18		27		4	3	1	0
Installation	**425**	**506**	**521**	**599**		**898**		**133**	**88**	**44**	**0**
Ship crew	321	382	394	453		679		100	66	33	0
Crane operators	32	38	39	45		67		10	7	3	0
Drilling system operators	18	21	22	25		38		6	4	2	0
Naval, electric, and electronic engineers	16	19	20	23		35		5	3	2	0
Quality, health, and safety experts	9	10	11	12		19		3	2	1	0
Regulation experts	9	10	11	12		18		3	2	1	0
Cable plough operators	8	9	9	11		16		2	2	1	0
Trenching ROV operators	8	9	9	11		16		2	2	1	0
Jetting systems operators	4	5	5	5		8		1	1	0	0
Technicians	1	1	1	2		2		0	0	0	0

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023), US DOE (2021) and RTE (2023).

Table 3.2: Direct FTE, job professions, fixed, 2022-2075

	2022	2023	2024	2025	=>	2031	=>	2048	2049	2050	2051-2075
Total	**2,914**	**3,545**	**3,693**	**4,254**		**6,421**		**2,855**	**2,272**	**1,997**	**22,593**
O&M	**192**	**307**	**359**	**416**		**670**		**1,611**	**1,538**	**1,528**	**17,924**
Technicians	35	56	66	76		123		295	281	279	3,278
Civil workers	35	56	66	76		123		295	281	279	3,278
Ship crew	35	56	66	76		123		295	281	279	3,278
Administrative personnel	21	34	40	46		75		180	171	170	1,998
Industrial, mechanical, and electric engineers	7	11	13	15		25		59	56	56	656
Site security and cleaning personnel	14	22	26	30		49		118	113	112	1,312
Telecommunication and computer engineers	4	6	7	8		12		29	28	28	328
Legal experts	11	17	20	23		37		90	86	85	1,000
Helicopter pilots	7	11	13	15		25		59	56	56	656
Crane operators	7	11	13	15		25		59	56	56	656
Safety experts	7	11	13	15		25		59	56	56	656
Environmental experts	5	9	10	12		19		45	43	43	500
Naval engineers	4	6	7	8		12		29	28	28	328
Decommissioning	**0**	**0**	**0**	**0**		**0**		**394**	**174**	**189**	**4,669**
Technicians	0	0	0	0		0		97	43	47	1,149
Ship crew	0	0	0	0		0		93	41	45	1,102
Truck drivers	0	0	0	0		0		93	41	45	1,102
Industrial, mechanical, electric, electronic, naval, and civil engineers	0	0	0	0		0		59	26	28	694

Source: QBIS based on AE (2013), IRENA (2018), BVGA (2019 and 2023), Statistics Denmark's FTE multipliers, Wind Denmark's member survey, WindEurope (2019 and 2020), Wind Denmark (2020), Aegir (2023), US DOE (2021) and RTE (2023).

3.2 INDIRECT FTE, UP TO 2075

The labour input assessed in section 3.1 is the direct FTE, i.e., the labour input associated with the first-tier contractors such as Vestas, Siemens and GE Renewable Energy. The indirect labour input from second-tier contractors supplying products and services to the first-tier contractors can be determined using an input-output (IO) model of the French economy.

The publicly available IO table published by INSEE, the French national statistics office, covers 64 industries. However, upon request, it has been possible to obtain a 138-industry IO table from INSEE, otherwise used for internal purposes. Though the 138-industry IO table does not have an actual offshore wind industry or a general wind industry, it has closer industry affiliation to the components and activities of an OWF than the 64-industry IO table, cf. **Table C 1** in Appendix C. The challenge is to find the best match between the OWF components and the industries and the industries in the 138-industry IO table.

An OWF is made of lots of steel for the turbines and towers and fibreglass but also rather advanced electronics for e.g., the substations and transmission. Subject to this, industry 8 "Extractive industry support services" has been selected as the closest approximation to installation, O&M and decommissioning, industry 39 "Manufacture of metal parts for construction" has been selected as the closest approximation to balance of plant, industry 44 "Manufacture of electronic components and boards" as the closest approximation to substations, and industry 53 "Manufacture of general-purpose machinery and equipment" as the closest approximation to wind turbines, cf. **Table 3.3**.

Table 3.3: Assumptions and assessments, direct FTE, fixed-floating, 2019-2075

	INSEE (partly based on NACE)	OWF component & activities	Weight	FTE/MEUR
8	Extractive industry support services	Installation, O&M and decom	40%	0.55
39	Manufacture of metal parts for construction	Balance of plant	20%	4.35
44	Manufacture of electronic components and boards	Substations	10%	2.80
53	Manufacture of general-purpose machinery and equipment	Wind turbines	30%	4.00
	Weighted average			**2.58**

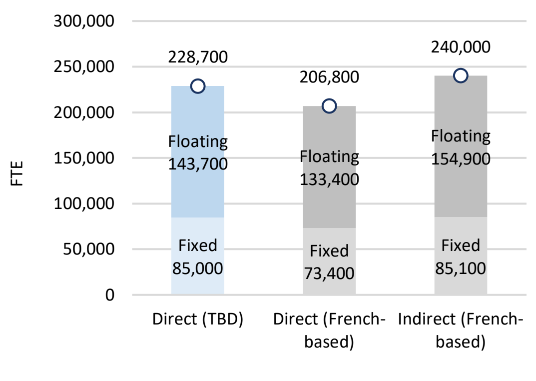
Source: QBIS based on INSEE and NACE.

Each of the multipliers from the chosen industries from the 138-industry IO table are weighted according to the cost shares for the lifecycle they are assessed to represent. The cost shares are assessed as the average cost shares of the lifecycles in the fixed and floating OWF models. This result in an average weighted multiplier of 2.58 FTE/MEUR, i.e., 2.58 full-time man-years per million EUR. In comparison, the weighted average FTE multiplier for the direct labour input from the first-tier contractors is assessed to 2.23 FTE/MEUR.

In the offshore wind pact (Pacte éolien en mer entre l'Etat et la filière) the French offshore wind industry has committed itself to achieving up to 50% local content by 2035 regardless of whether the project owner/operator is French-based or foreign.

It follows that 50% local content implies half of total contracted value going to French-based companies regardless of whether the first-tier contractors are French-based or foreign. In 2019-2075, assuming gradual build-up of local content to 50% in 2035, this suggests a total of around 240,000 indirect FTE from French-based suppliers contracted by the first-tier contractors, whereof around 85,100 FTE fixed and around 154,900 FTE floating, cf. **Figure 3.5**.

Figure 3.5: FTE, direct-indirect, fixed-floating, total, 2019-2075



Source: QBIS based on QBIS (2020), BVGA (2023), Aegir (2023), US DOE (2021), FEE (2022), RTE (2023) and INSEE 138-industry input-output table.

The question remaining is the percentage of French-based first-tier contractors. How many of the main OWF contracts will be awarded to French-based companies? At this moment, this is unknown, and an assumption needs to be applied. In this first version of the scenario, it is assumed that the percentage of first-tier contracts to French-based companies is identical to second-tier contracts and hence a gradual build-up to 50% in 2035. This suggests a total of around 206,800 direct FTE from French-based first-tier contractors, whereof around 73,400 FTE fixed and around 133,400 FTE floating, cf. **Figure 3.5**

This leaves around 228,700 direct FTE yet to be decided, where it currently is uncertain whether it will be French-based or foreign first-tier contractors that are awarded the OWF contracts. In total, the commissioning of the 40 GW in 2050 is assessed to be associated with around 675,500 FTE whereof around 446,800 FTE from French-based companies and around 228,700 FTE yet to be determined. Annualising the around 446,800 FTE from French-based companies indicates a peak of around 9,300 direct FTE/year and around 10,000 indirect FTE/year in the peak year in 2031. These around 19,300 FTE are the maximum number of jobs per year in French-based companies assessed to be associated with the 40 GW in 2050, cf. **Figure 3.6**.

Figure 3.6: FTE, direct-indirect, per year, 2019-2075

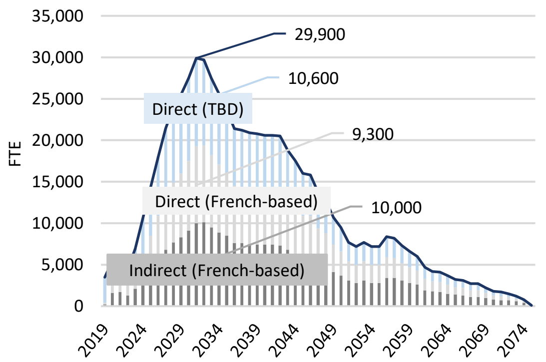
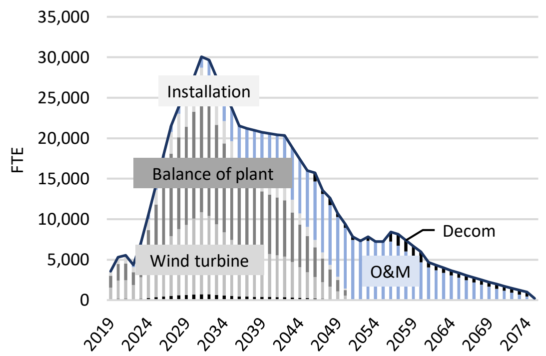


Figure 3.7: Direct-indirect FTE, lifecycles, 2019-2075



Source: QBIS based on QBIS (2020), BVGA (2023), Aegir (2023), US DOE (2021), FEE (2022), RTE (2023) and INSEE 138-industry input-output table.

Across lifecycles, the direct and indirect FTE shows a heavy build-up from around 5,000-6,000 FTE in 2023 and up to around 30,000 FTE in 2031, cf., **Figure 3.7**. Production of wind turbines and balance of plant as well as installation are driving the strong growth in FTE up to 2031, while O&M drives the growth in FTE in the remaining period. Across fixed and floating foundation, it is particularly floating that drives the growth in FTE, cf., **Figure 3.8** and **Figure 3.9**.

Figure 3.8: Direct & indirect FTE, fixed, 2019-2075

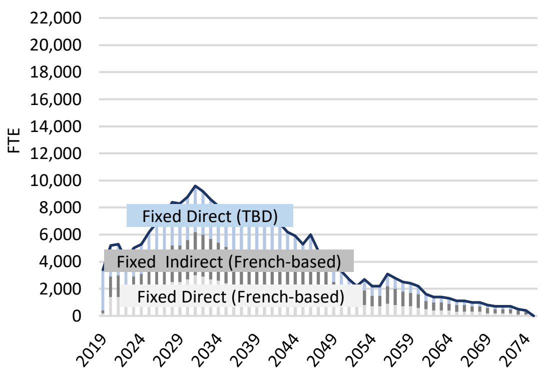
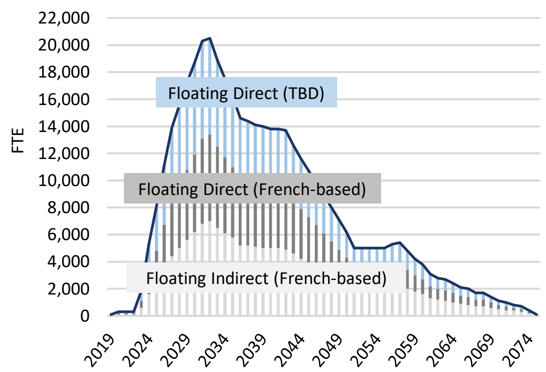


Figure 3.9: Direct & indirect FTE, floating, 2019-2075



Source: QBIS based on QBIS (2020), Aegir (2023), US DOE (2021), FEE (2022), RTE (2023) and INSEE 138-industry input-output table.

3.3 SUMMARY

In 2019-2075, a total of around 436,000 direct FTE are assessed to be associated with planning, producing, maintaining, operating and decommissioning 40 GW offshore wind in France. Across foundation types, around 158,300 direct FTE are assessed to be associated with fixed foundation, while around 277,700 direct FTE are assessed to be associated with floating foundation.

The distribution of FTE across OWF lifecycles reveals the need for a massive build-up of labour supply up to around 2031, where labour supply peaks with around 6,400 FTE/year for fixed and around 13,600 FTE/year for floating totalling around 20,000 FTE/year.

Adding second-tier contractors supplying products and services to the first-tier contractors, the around 436,000 FTE are assessed to increase to around 675,500 FTE, whereof around 243,500 FTE are assessed to be associated with fixed foundation, while around 432,000 FTE are assessed to be associated with floating foundation corresponding to 36%-64% split between fixed and floating foundation.

Assuming a gradual build-up of local content to 50% in 2035 among all first-tier contractors regardless of whether French-based or foreign as well as a gradual build-up of first-tier French-based contractors to 50% in 2035, the total of around 675,500 direct and indirect FTE are split with around 446,800 FTE from French-based companies and 228,700 FTE yet to be determined. The 446,800 FTE supplied by French-based companies are further assessed to be distributed with around 158,500 FTE on fixed and around 288,300 FTE on floating.

The maximum number of direct and indirect jobs in French-based companies associated with the 40 GW in 2050 is assessed to around 19,300 in 2031. In the build-up period 2019-2035, the average number of direct and indirect jobs in French-based companies are assessed to around 2,800 per year, while it decreases to around 1,960 per year for the entire period 2019-2075 including O&M and decommissioning.

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APPENDIX A: OWF MODEL COSTS FOR FIXED FOUNDATION 2022

	1 GW OWF fixed foundation, 2022	**MEUR/GW**
	Total	**4,225.6**

Design and development	**1**	**Design and development**	**MEUR/GW**
		Total	**144.6**
	1.1	**Development and consenting services**	**60.2**
	1.1.1	Environmental Impact Assessments (EIA)	9.6
	1.1.2	Site selection	
	1.1.3	Project development	
	1.1.4	Financial feasibility	
	1.1.5	Access to grid connection	
	1.2	**Environmental surveys**	**4.8**
	1.2.1	Benthic environmental surveys	0.5
	1.2.2	Fish and shellfish surveys	0.5
	1.2.3	Ornithological environmental surveys	1.2
	1.2.4	Marine mammal environmental surveys	1.2
	1.2.4.1	Offshore ornithological and mammal surveying vessels and craft	
	1.2.5	Onshore environmental surveys	0.7
	1.3	**Resource and metocean assessment**	**4.8**
	1.3.1	Structure	3.6
	1.3.2	Sensors	0.8
	1.3.3	Maintenance	0.4
	1.4	**Geological and hydrographical surveys**	**4.8**
	1.4.1	Geophysical surveys	0.8
	1.4.1.1	Geophysical survey vessels	
	1.4.2	Geotechnical surveys	3.0
	1.4.2.1	Geotechnical survey vessels	
	1.4.3	Hydrographic surveys	1.0
	1.5	**Engineering and consultancy**	4.8
	1.5.1	Engineering design	
	1.6	**Identification of specifications and raw materials**	
	1.7	**Logistics management**	

Wind turbines	**2**	**Wind turbines**	**MEUR/GW**
		Total	**1,259.9**
	2.1	**Nacelle total**	**961.4**
	2.1	Nacelle	481.9
	2.1.1	Bedplate	24.1
	2.1.2	Main bearing	24.1
	2.1.3	Main shaft	24.1
	2.1.4	Gearbox	84.3
	2.1.5	Generator	120.5
	2.1.6	Power take-off	84.3
	2.1.7	Control system	30.1
	2.1.8	Yaw system	20.5
	2.1.9	Yaw bearing	8.4
	2.1.10	Nacelle auxiliary systems	8.4

	2.1.11	Nacelle cover	12.0
	2.1.12	Small engineering components	30.1
	2.1.13	Structural fasteners	8.4
	2.1.14	Condition monitoring system	
	2.2	**Rotor**	**227.7**
	2.2.1	Blades	156.6
	2.2.1.1	Structural composite materials	
	2.2.1.2	Blade root	
	2.2.1.3	Environmental protection	
	2.2.2	Hub casting	18.1
	2.2.3	Blade bearings	24.1
	2.2.4	Pitch system	12.0
	2.2.4.1	Hydraulic pitch system	
	2.2.4.2	Electronic pitch system	
	2.2.5	Spinner	2.4
	2.2.6	Rotor auxillary systems	4.8
	2.2.6	Fabriucated steel components	9.6
	2.3	**Tower**	**80.7**
	2.3.1	Steel	72.3
	2.3.2	Tower internals	8.4
	2.3.2.1	Personel access and survival equipment	
	2.3.2.2	Tuned damper	
	2.3.2.3	Electrical system	
	2.3.2.4	Tower internal lighting	
	2.3.2.5	Coatings	

Balance of plant	**3**	**Balance of Plant**	**MEUR/GW**
		Total	**813.0**
	3.1	**Cables**	**198.1**
	3.1.1	Export cables	148.3
	3.1.1.1	Cable core	33.0
	3.1.1.2	Cable outer	105.0
	3.1.1.3	Cable assessories	5.0
	3.1.1.4	Cable jointing and testing	5.0
	3.1.2	Array cables	43.6
	3.1.3	Cable protection	6.2
	3.2	**Turbine foundation**	**285.6**
	3.2.0	Design	
	3.2.1	Monopile	180.4
	3.2.2	Jacket	
	3.2.3	Transition piece	120.5
	3.2.3.1	Crew access system and work platform	40.0
	3.2.3.2	Internal platforms	
	3.2.3.2	Davit crane	5.0
	3.2.3.4	J-tubes, I-tube or monopile entry point	
	3.2.4	Corrosion protection - monopiles	35.0
	3.2.4	Corrosion protection - jackets	
	3.2.5	Scour protection	10.0
	3.3	**Offshore substation**	**120.4**
	3.3.1	Electrical system	6.0
	3.3.1.1	HVAC system	36.1
	3.3.1.2	HVDC system	

	3.3.2	Facilities	56.2
	3.3.2	Structure	21.7
	3.4	**Onshore substation**	44.8
	3.4.1	Buildings, access and security	44.8
	3.5	**Operational base**	6.8
	3.6	**Other costs**	210.0
	3.6.1	Site investigation (not in development phase)	170.0
	3.6.2	Insurance & Other items	40.0

Installation & grid connection	**4**	**Installation & grid connection**	**MEUR/GW**
		Total	**428.9**
	4.1	**Foundation installation**	**107.7**
	4.1.1	Foundation installation vessels	40.0
	4.1.1.1	Foundation handling equipment	25.0
	4.1.1.2	Foundation installation equipment	30.0
	4.1.1.3	Sea fastenings	12.7
	4.2	**Offshore substations installation**	**26.1**
	4.2.1.	Substation installation vessel	10.0
	4.3	**Onshore substation construction**	**27.6**
	4.4	**Onshore export cable installation**	**13.0**
	4.5	**Offshore cable installation**	**172.3**
	4.5.1	Cable laying vessel	61.2
	4.5.1.1	ROV	
	4.5.1.2	Cable-handling equipment	3.1
	4.5.2	Cable burial	16.0
	4.5.2.1	Cable burial vessel	64.6
	4.5.2.2	Cable plough	3.4
	4.5.2.3	Trenching ROV	6.8
	4.5.2.4	Vertical injector and jetting sled	6.1
	4.5.3	Cable pull-in	6.0
	4.5.4	Electrical testing and termination	5.2
	4.6	**Turbine installation**	**62.6**
	4.6.1	Turbine installation vessel	46.7
	4.6.1.1	Turbine handling equipment and sea fastening	15.0
	4.6.2	Commissioning	
	4.7	Construction port	5.0
	4.8	**Offshore logistics - Installation**	**14.6**
	4.8.1	Sea-based support	14.0
	4.8.2	Marine coordination	
	4.8.3	Weather forecasting and metocean data	

Operation and maintenance	**5**	**Operation & maintenance**	**MEUR/GW**
		Total	**1,225.7**
	5.1	**Operations**	**395.8**
	5.1.1	Training	10.9
	5.1.2	Onshore logistics	13.7
	5.1.3	Offshore logistics	
	5.1.3.1	Crew tranfer vessels (CTV)	91.8
	5.1.3.2	Service operations vessels (SOV)	3.6
	5.1.3.3	Turbine access systems	

	5.1.3.4	Helicopters	
	5.1.4	Health and safety inspections	12.0
	5.1.4.1	Health and safety equipment	4.5
	5.1.5	Administrative personel	153.2
	5.2	**Maintenance and service**	**791.7**
	5.2.1	Turbine maintenance and service	522.5
	5.2.1.1	Blade inspection and repair	
	5.2.1.1.1	Unmanned aerial vehicle	
	5.2.1.2	Main component refurbishment, replacement and repair	
	5.2.1.2.1	Large component repair vessel	
	5.2.2	Balance of plant maintenance and service	260.0
	5.2.2.1	Foundation inspection and repair	
	5.2.2.1.1	Remotely operated vehicle (ROV)	
	5.2.2.1.2	Autonomous underwater vehicle	
	5.2.2.2	Cable inspection and repair	
	5.2.2.3	Scour monitoring and management	9.0
	5.2.2.4	Substation maintenance and service	
	5.3	**Other O&M costs**	**38.2**
	5.3.1	OEM WTG monitoring and technical support	22.5
	5.3.2	Turbine Electricity consumptions	8.6
	5.3.3	Wind & Weather Monitoring	0.6
	5.3.4	Fees leases, taxes and insurance	6.5

Decom	**6**	**Decommissioning**	**MEUR/GW**
		Total	**391.6**
	6.1	**Turbine decommissioning**	**54.2**
	6.2	**Foundation decommissioning**	**90.4**
	6.3	**Cable decommissioning**	**168.7**
	6.4	**Substation decommissioning**	**78.3**
	6.5	**Decommissioning port**	**5.0**

APPENDIX B: OWF MODEL COSTS FOR FLOATING FOUNDATION 2022

	1 GW OWF floating foundation, 2022	MEUR/GW
	Total	**9,296.2**

	1.0	**Development and project management**	**MEUR/GW**
Design and PM		**Total**	**256.1**
	1.1	**Development and consenting services**	**116.1**
	1.1.1	Environmental impact assessments	17.1
	1.1.2	Development activities and other consenting services	99.0
	1.2	Environmental surveys	15.0
	1.2.1	Offshore species and habitat surveys	12.0
	1.2.2	Onshore environmental surveys	1.9
	1.2.3	**Human impact studies**	**1.2**
	1.3	Resource and metocean assessment	11.3
	1.3.1	Structure	5.6
	1.3.2	Sensors	4.6
	1.3.3	Maintenance	1.1
	1.4	Geological and hydrographical surveys	15.0
	1.4.1	Geophysical surveys	4.1
	1.4.2	**Geotechnical surveys**	**8.0**
	1.4.3	Hydrographic surveys	3.1
	1.5	Engineering and consultancy	15.0
	1.6	Project management	76.8

	2.0	**Wind turbines**	**MEUR/GW**
Wind turbines		**Total**	**2,219.5**
	2.1	**Nacelle total**	**1,297.5**
	2.1	Nacelle	650.4
	2.1.1	Bedplate	32.5
	2.1.2	Main bearing	32.5
	2.1.3	Main shaft	32.5
	2.1.4	Gearbox	113.8
	2.1.5	Generator	162.6
	2.1.6	Power take-off	113.8
	2.1.7	Control system	40.6
	2.1.8	Yaw system	27.6
	2.1.9	Yaw bearing	11.4
	2.1.10	Nacelle auxiliary systems	11.4
	2.1.11	Nacelle cover	16.3
	2.1.12	Small engineering components	40.6
	2.1.13	Structural fasteners	11.4
	2.1.14	Condition monitoring system	
	2.2	**Rotor**	**631.7**
	2.2.1	Blades	434.5
	2.2.1.1	Structural composite materials	
	2.2.1.2	Blade root	
	2.2.1.3	Environmental protection	
	2.2.2	Hub casting	50.1

	2.2.3	Blade bearings	66.8
	2.2.4	Pitch system	33.4
	2.2.4.1	Hydraulic pitch system	
	2.2.4.2	Electronic pitch system	
	2.2.5	Spinner	6.7
	2.2.6	Rotor auxiliary systems	13.4
	2.2.6	Fabricated steel components	26.7
	2.3	**Tower**	**358.5**
	2.3.1	Steel	321.1
	2.3.2	Tower internals	37.5
	2.3.2.1	Personal access and survival equipment	
	2.3.2.2	Tuned damper	
	2.3.2.3	Electrical system	
	2.3.2.4	Tower internal lighting	
	2.3.2.5	Coatings	

	3.0	**Balance of plant**	**MEUR/GW**
Balance of plant		**Total**	**2,902.4**
	3.1	**Array cable**	**121.2**
	3.2	**Export cable**	**341.5**
	3.3	**Cable accessories**	**75.1**
	3.3.1	Interface	15.2
	3.3.2	Cable protection	29.0
	3.3.3	Buoyancy	9.4
	3.3.4	Connectors and joints	22.2
	3.4	**Floating substructure**	**1,639.0**
	3.4.1	Structure	1,348.8
	3.4.2	Secondary steel	114.4
	3.4.3	Systems	99.0
	3.4.4	Corrosion protection	82.0
	3.5	**Mooring systems**	**307.3**
	3.5.1	Anchor systems	64.9
	3.5.2	Mooring lines and chains	187.8
	3.5.3	Jewellery	32.4
	3.5.4	Topside connection	11.4
	3.5.5	Installation aids	5.3
	3.6	**Offshore substation**	**256.1**
	3.6.1	HVAC electrical system	76.8
	3.6.2	Auxiliary systems	12.8
	3.6.3	Topside structure	119.5
	3.6.4	Foundation	46.1
	3.7	**Onshore substation**	**140.0**
	3.7.1	Electrical system	97.3
	3.7.2	Buildings, access and security	41.0

	4.0	**Installation and commissioning**	**MEUR/GW**
Installation		**Total**	**631.7**
	4.1	**Inbound transport**	**14.9**
	4.2	**Offshore cable installation**	**239.0**
	4.2.1	Export cable installation	78.5
	4.2.2	Array cable installation	126.3

	4.2.3	Cable pull-in	18.8
	4.2.4	Electrical testing and termination	16.6
	4.3	**Mooring and anchoring pre-installation**	**116.1**
	4.4	**Floating substructure - turbine assembly**	**116.1**
	4.4.1	Heavy lifting and moving equipment	47.8
	4.4.2	Technician services	8.0
	4.4.3	Marshalling port	51.2
	4.4.4	Other	8.4
	4.5	**Floating substructure - turbine installation**	**90.5**
	4.6	**Offshore substation installation**	**41.0**
	4.7	**Onshore export cable installation**	**9.7**
	4.8	**Offshore logistics**	**3.8**
	4.8.1	Sea-based support	2.4
	4.8.2	Marine coordination	0.8
	4.8.3	Weather forecasting and metocean data	0.3
	4.8.4	Marine safety and rescue	0.3

	5.0	**Operations and maintenance**	**MEUR/GW**
O&M		**Total**	**3,030.5**
	5.1	**Operations**	**1,024.4**
	5.1.1	Operations control centre	51.2
	5.1.2	Training	102.4
	5.1.3	Onshore logistics	51.2
	5.1.4	Technical resource (onshore and offshore)	256.1
	5.1.5	Admin and support staff (onshore)	307.3
	5.1.6	Insurance	256.1
	5.2	**Maintenance**	**1,878.0**
	5.2.1	Turbine maintenance	1,323.2
	5.2.2	Balance of plant maintenance	554.9
	5.2.3	Statutory inspections	19.2
	5.3	**Offshore logistics and vessels**	**93.9**
	5.4	**O&M port**	**17.1**

	6.0	**Decommissioning**	**MEUR/GW**
Decom		**Total**	**256.1**
	6.1	**Floating substructure - turbine decommissioning**	**18.9**
	6.2	**Mooring and anchoring decommissioning**	**68.3**
	6.3	**Cable decommissioning**	**124.6**
	6.4	**Substation decommissioning**	**44.4**

APPENDIX C: INPUT-OUTPUT MODEL FOR FRANCE

The indirect labour input from companies supplying products and services to the first-tier offshore wind contractors such as Vestas, Siemens and GE Renewable Energy can be determined using an input-output (IO) table of the French economy.

An IO table is an integral part of modern-day national accounts and thus widely available. Its main purpose is to study the interindustry dependency in an economy. Thus, an IO table describes how the output of one industry is at the same time either an input in the production of other industries in the economy or a delivery to final use by households, by government, through investments or through exports.

In this capacity, an IO table can be used to study how a supplier contract from the first-tier offshore companies will impact the level of economic activity in each industry of the economy taking these inter-industry interdependencies into account.

In France, the publicly available IO table published by INSEE, the French national statistics office, covers 64 industries. However, upon request, it has been possible to obtain a 138-industry IO table from INSEE, otherwise used for internal purposes. Though the 138-industry IO table does not have an actual offshore wind industry or a general wind industry, it has closer industry approximation to the offshore wind farm components and activities than the 64-industry IO table.

Offshore wind farms are made of lots of steel for the turbines and towers and fibreglass but also rather advanced electronics for e.g., the substations and transmission. The challenge is to find the best match between the OWF components and the industries in the 138-industry IO table.

Subject to this consideration, industry 8 “Extractive industry support services” has been selected as the closest approximation to installation, O&M and decommissioning, industry 39 “Manufacture of metal parts for construction” has been selected as the closest approximation to balance of plant, industry 44 “Manufacture of electronic components and boards“ as the closest approximation to substations, and industry 53 “Manufacture of general-purpose machinery and equipment” as the closest approximation to wind turbines, cf. light blue rows in **Table C 1**.

Table C 1: The industries in the 138-industry INSEE IO table, 2019

1	A01Z	Cultivation and animal production, hunting and related services
2	A02Z	Silviculture and logging
3	A03Z	Fishing and aquaculture
4	B05Z	Coal and lignite mining
5	B06Z	extraction of hydrocarbons
6	B07Z	Metal ore mining
7	B08Z	Other extractive industries
8	B09Z	Extractive industry support services
9	C10A	Process and preserve meat and meat-based product preparation
10	C10B	Process and preserve fish, crustaceans and molluscs
11	C10C	Processing and preservation of fruits and vegetables
12	C10D	Manufacture of vegetable and animal oils and fats
13	C10E	Manufacture of dairy products

Table C 1: The industries in the 138-industry INSEE IO table, 2019

14	C10F	Grain processing - manufacture of starch products
15	C10G	Manufacture of bakery-pastry and pasta products
16	C10H	Manufacture of other food products
17	C10K	Manufacture of animal feed
18	C11Z	Beverage manufacturing
19	C12Z	Manufacture of tobacco products
20	C13Z	Textile manufacturing
21	C14Z	clothing industry
22	C15Z	Leather and footwear industry
23	C16Z	Woodwork - fab art wood cork (sf mbles) - basketwork and esparto
24	C17A	Manufacture of pulp, paper and cardboard
25	C17B	Manufacture of paper or cardboard articles
26	C18Z	Printing and reproduction of records
27	C19Z	Coking and refining
28	C20A	Fab prod chemical base, nitrogen, fertilizer, plastics and synthetic rubber
29	C20B	Manufacture of soaps, cleaning products and perfumes
30	C20C	Fab aut chemicals and artificial or synthetic fibres
31	C21Z	Pharmaceutical industry
32	C22A	Manufacture of rubber products
33	C22B	Manufacture of plastic products
34	C23A	Manufacture of glass and glassware
35	C23B	Manufacture of other non-metallic mineral products excluding glass
36	C24A	Iron and steel industry and first transformation of steel
37	C24B	Production of precious metals and other non-ferrous metals
38	C24C	Foundry
39	C25A	Manufacture of metal parts for construction
40	C25B	Fab tank, tank and metal container - steam generator fab
41	C25C	Manufacture of arms and ammunition
42	C25D	Forging, metal processing, machining
43	C25E	Fab cutlery, tools, hardware and other metal works
44	C26A	Manufacture of electronic components and boards
45	C26B	Manufacture of computers and peripheral equipment
46	C26C	Manufacture of communication equipment
47	C26D	Consumer Electronics Manufacturing
48	C26E	Fab instrument and apparatus for measurement, testing and navigation - watchmaking
49	C26F	Fab radiation equipment medic electromedicine and electrotherapist
50	C26G	Fab optical and photo equipment - fab magnetic and optical supports
51	C27A	Manufacture of household appliances
52	C27B	Manufacture of other electrical equipment
53	C28A	Manufacture of general-purpose machinery and equipment
54	C28B	Manufacture of agricultural and forestry machinery
55	C28C	Manufacture of metal forming machines and machine tools
56	C28D	Manufacture of other specific purpose machines
57	C29A	Motor vehicle construction - fab bodies and trailers
58	C29B	Manufacture of automotive equipment
59	C30A	Shipbuilding
60	C30B	Construction of locomotives and other railway rolling stock
61	C30C	Aircraft and space construction
62	C30D	Construction of military combat vehicles
63	C30E	Manufacture of transport equipment n c a
64	C31Z	furniture manufacturing
65	C32A	Fab artic jewellery, jewellery and the like and musical instruments
66	C32B	Manufacture of instruments and supplies for medical and dental use
67	C32C	Fab art sports, games and toys and other manufacturing activities
68	C33Z	Repair and installation of machinery and equipment
69	D35A	Generation, transmission and distribution of electricity

Table C 1: The industries in the 138-industry INSEE IO table, 2019

70	D35B	Gas, steam and air conditioning production and distribution
71	E36Z	Collection, treatment and distribution of water
72	E37Z	Wastewater collection and treatment
73	E38Z	Collection, treatment and disposal of waste - recovery
74	E39Z	Remediation and other waste management services
75	F41A	Real estate development
76	F41B	Construction of residential and non-residential buildings
77	F42Z	civil engineering
78	F43Z	Specialized construction work
79	G45Z	Sale and repair of automobiles and motorcycles
80	G46Z	Wholesale trade, except of motor vehicles and motorcycles
81	G47Z	Comm retail, sf automobiles and motorcycles
82	H49A	Rail transport
83	H49B	Other land passenger transport
84	H49C	Freight and pipeline road transport
85	H50Z	Water transport
86	H51Z	Air transport
87	H52Z	Warehousing and ancillary transport services
88	H53Z	Post and courier activities
89	I55Z	Accommodation
90	I56Z	Restoration
91	J58Z	Editing
92	J59Z	Prod films cinema video and prog TV- sound recording and musical ed
93	J60Z	Programming and broadcasting
94	J61Z	Telecommunications
95	J62Z	Programming, consulting and other computer activities
96	J63Z	information services
97	K64H	Financial services activities, excluding insured and cash withdrawn (excluding FISIM)
98	K64S	Financial services activities, excluding insured and retiring funds (SIFIM)
99	K65Z	Assurance
100	K66Z	Activities auxiliary to financial services and insurance
101	L68A	Real estate property merchant act and real estate act on behalf of third parties
102	L68I	Rental and operation of real estate (imp rents)
103	L68R	Rental and operation of real estate (actual rents)
104	M69Z	Legal and accounting activities
105	M70Z	Head office activities - management consultancy
106	M71Z	Activ architecture and engineering - control and technical analysis
107	M72M	Scientific research and development (commodity)
108	M72N	Scientific research and development (non-commercial)
109	M73Z	Advertising and market research
110	M74Z	Other professional, scientific and technical activities
111	M75Z	Veterinary activities
112	N77Z	Rental and leasing activities
113	N78Z	employment related activities
114	N79Z	Active travel agencies, tour operators, reservation services and related activities
115	N80Z	Investigations and security
116	N81Z	Services related to buildings and landscaping
117	N82Z	Administrative and other business support activities
118	O84Z	Public administration and defence - compulsory social security
119	P85M	Education (merchant)
120	P85N	Education (non-market)
121	Q86M	Activities for human health (market)
122	Q86N	Activities for human health (non-market)
123	Q87M	Medico-social and social accommodation (commercial)
124	Q87N	Medico-social and social accommodation (non-commercial)
125	Q88M	Social action without accommodation (market)

Table C 1: The industries in the 138-industry INSEE IO table, 2019

126	Q88N	Social action without accommodation (non-market)
127	R90M	Creative, artistic and performing activities (market)
128	R90N	Creative, artistic and performing activities (non-market)
129	R91M	Libraries, archives, museums and other cultural activities (merchants)
130	R91N	Libraries, archives, museums and other act cult (non-market)
131	R92Z	Organization of games of chance and money
132	R93M	Sporting, recreational and leisure activities (market)
133	R93N	Sporting, recreational and leisure activities (non-market)
134	S94M	Activities of associative (market) organizations
135	S94N	Activities of associative organizations (non-profit)
136	S95Z	Repair of computers and personal and household goods
137	S96Z	Other personal services
138	T97Z	Activities of households as employers of domestic staff

Source: INSEE.

The 2019 IO table for France was used for calculating the production, GDP and FTE multipliers using the Leontief Inverse Matrix. The Leontief Inverse Matrix (LIM) represents the amount of gross output from sector i that is produced to satisfy a unit of final demand y from sector j. Subject to **Table C 2**, the LIM is given by the following:

Equation (1): $$x = (I - A)^{-1} f$$

where *x* are production values (output), cf. x in **Table C 2**. *I* is a unit matrix with ones on the diagonal and zeros in all other cells. *A* is the matrix of supplies between industries, cf. *I-by-I* in **Table C 2**, divided by total output in each industry, cf. *TO* in **Table C 2**.

Table C 2*:* Structure of the 138-industry IO table for France, 2019

	Symmetric industry-by-industry IO table	Intermediate demand			Final expenditure				
		Industry 1	...	Industry 138	Domestic demand	Export (cross border)	Territorial correction	Total expendi-ture	Total
1	Industry 1	*I-by-I*			*dd*			*f*	*x*
...	...								
138	Industry 138								
139	Imports								
140	Taxes less subsidies on products								
141	Territorial correction								
142	Inputs and final demand, purchasers prices								
143	GVA								
144	- Salaries								
145	- Taxes on production D.29								
146	- Subsidies on production D.39								
147	- Gross operating surplus								
148	Total output	*TO*							
149	Employment	*h*							

GDP (expenditure approach) -
GDP (output approach) +

Source: QBIS based on 138-industry IO table from INSEE.

Finally, $(I\text{-}A)^{-1}$ is multiplied by total final use given as the sum of domestic demand, export and territorial correction, cf. *f* in **Table C 2**. The LIM says that when the final use vector *f* is multiplied by the inverted matrix $(I\text{-}A)^{-1}$, you get exactly the output vector *x*. This means that the inverted matrix includes not only the direct effects in the industry itself, but also all the derived effects on production in other industries.

When a company has to produce more products, it requires a large input from other domestic industries or import. It requires electricity and water from the utility sectors, but also various other production inputs and all these side effects or indirect effects are contained in the inverted matrix.

The LIM can be extended to also include the induced impacts given in terms of production and GDP accruing from spending of salaries of private households. This extended model is given by the following:

Equation (2): $$x_E = (I - A^E)^{-1} f$$

where inverted matrix, *A* is expanded to also include the domestic demand, cf. *dd* in **Table C 2**. Finally, the LIM can be extended to include the employment impacts measured in terms of Full Time Equivalents (FTEs) in connection with the direct, indirect and induced production and GDP impacts. These employment impacts are calculated by the following:

Equation (3): $$h = (h/x_E)(I - A^E)^{-1} f$$

where *h* is a vector of employed per industry, cf. *h* in **Table C 2**, and (h/x_E) is a vector of employment coefficients that is multiplied by the inverted matrix with the expanded A^E. The multipliers are demand driven. This implies an ability to quantify what happens to the production when demand given in terms of the elements of the *f* vector change. It is a simple response behaviour with the following limitations:

- No dynamic effects. All multiplier effects happen within the year of the IO table. No behavioural changes.
- No technological changes. The technology is fixed within the year of the IO table.
- The multipliers show average effects and do not consider marginal effects may be different.
- The multipliers do not consider that the effects of changes in the variables may be different depending on the type of final use that is counted on. There are only average effects.
- The multipliers do not consider potential existence of excess capacity in the economy.
- The multipliers do not consider changes in returns to scale and generates same result relatively regardless of the size of the change in demand.

If any of the above limitations is a consideration, more sophisticated models such as general equilibrium models or a macro-econometric models should be applied. However, despite its simplicity and obvious limitations, the IO tables and the associated multipliers provide general answers to what happens in the economy when demand changes. And they excel in being relatively easy operationalizable, at least compared to general equilibrium models or macro-econometric models.

Subject to the above considerations and limitations, the assessed production, GDP and FTE multipliers for the 2019 IO table for France are presented in **Table C 3**. To compare with other countries, the corresponding multipliers for Brazil, Nigeria, Liberia, Morocco, Oman, Saudi Arabia and South Korea are also presented, cf. the bottom rows in **Table C 3**.

Table C 3: Production, GDP, and FTE multipliers for France, 138-industries, 2019

		Production multipliers				GDP multipliers				FTE multipliers				Other	
No	Industry code	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Type I	Type II
1	A01Z	2.39	1.00	0.83	0.56	1.02	0.41	0.33	0.29	18.41	9.93	4.89	3.59	1.49	1.85
2	A02Z	2.62	1.00	0.84	0.78	1.28	0.49	0.39	0.40	14.06	4.62	4.46	4.98	1.97	3.04
3	A03Z	2.55	1.00	0.70	0.85	1.08	0.35	0.30	0.43	17.11	8.24	3.46	5.41	1.42	2.07
4	B05Z	1.20	1.00	-0.12	0.33	0.49	0.38	-0.06	0.17	4.62	3.22	-0.69	2.10	0.79	1.44
5	B06Z	2.17	1.00	0.46	0.70	0.96	0.38	0.22	0.36	10.28	3.22	2.58	4.48	1.80	3.20
6	B07Z	2.32	1.00	0.57	0.75	1.02	0.38	0.25	0.39	11.39	3.22	3.38	4.80	2.05	3.54
7	B08Z	2.68	1.00	0.82	0.86	1.19	0.38	0.36	0.44	13.06	3.22	4.36	5.48	2.36	4.06
8	B09Z	1.48	1.00	0.04	0.45	0.64	0.38	0.03	0.23	6.62	3.22	0.55	2.85	1.17	2.06
9	C10A	3.09	1.00	1.25	0.84	1.24	0.29	0.52	0.43	17.93	3.71	8.89	5.34	3.40	4.84
10	C10B	2.86	1.00	1.01	0.85	1.15	0.29	0.43	0.44	14.69	3.71	5.56	5.42	2.50	3.96
11	C10C	2.92	1.00	1.07	0.84	1.19	0.29	0.47	0.43	16.20	3.71	7.12	5.38	2.92	4.37
12	C10D	3.15	1.00	1.30	0.85	1.27	0.29	0.54	0.44	18.48	3.71	9.34	5.43	3.52	4.99
13	C10E	3.07	1.00	1.24	0.84	1.23	0.29	0.51	0.43	17.48	3.71	8.43	5.34	3.28	4.72
14	C10F	3.09	1.00	1.27	0.83	1.24	0.29	0.52	0.42	18.04	3.71	9.07	5.27	3.45	4.87
15	C10G	2.49	1.00	0.76	0.73	0.99	0.29	0.33	0.37	12.58	3.71	4.21	4.66	2.14	3.39
16	C10H	2.87	1.00	1.04	0.83	1.15	0.29	0.44	0.42	15.33	3.71	6.33	5.29	2.71	4.14
17	C10K	3.07	1.00	1.20	0.88	1.23	0.29	0.50	0.45	16.55	3.71	7.27	5.58	2.96	4.47
18	C11Z	2.71	1.00	0.93	0.78	1.08	0.29	0.39	0.40	13.97	3.71	5.29	4.97	2.43	3.77
19	C12Z	3.06	1.00	1.08	0.98	1.29	0.29	0.50	0.50	16.31	3.71	6.36	6.24	2.72	4.40
20	C13Z	2.60	1.00	0.72	0.88	1.11	0.34	0.32	0.45	15.88	5.89	4.38	5.61	1.75	2.70
21	C14Z	2.47	1.00	0.62	0.86	1.06	0.34	0.28	0.44	15.26	5.89	3.91	5.46	1.66	2.59
22	C15Z	2.33	1.00	0.54	0.80	0.99	0.34	0.24	0.41	14.44	5.89	3.47	5.08	1.59	2.45
23	C16Z	3.02	1.00	1.03	0.99	1.26	0.29	0.46	0.51	17.23	5.28	5.64	6.31	2.07	3.27
24	C17A	2.93	1.00	1.03	0.90	1.16	0.27	0.43	0.46	13.64	3.39	4.53	5.72	2.34	4.03
25	C17B	2.59	1.00	0.77	0.82	1.03	0.27	0.34	0.42	12.73	3.39	4.11	5.23	2.21	3.76
26	C18Z	2.68	1.00	0.67	1.01	1.25	0.44	0.30	0.51	17.62	7.53	3.68	6.41	1.49	2.34
27	C19Z	1.70	1.00	0.43	0.28	0.38	0.05	0.18	0.14	4.07	0.25	2.06	1.76	9.16	16.11
28	C20A	2.33	1.00	0.71	0.62	0.91	0.32	0.28	0.32	8.70	1.74	3.00	3.96	2.72	4.99
29	C20B	2.30	1.00	0.64	0.66	0.94	0.32	0.28	0.34	9.54	1.74	3.57	4.23	3.05	5.48
30	C20C	2.29	1.00	0.65	0.64	0.92	0.32	0.28	0.33	9.02	1.74	3.19	4.09	2.83	5.18
31	C21Z	2.17	1.00	0.54	0.63	1.02	0.45	0.25	0.32	8.71	1.71	2.98	4.02	2.75	5.11
32	C22A	2.17	1.00	0.40	0.77	0.96	0.39	0.18	0.39	12.54	5.00	2.65	4.89	1.53	2.51
33	C22B	2.52	1.00	0.63	0.89	1.12	0.39	0.28	0.46	14.07	5.00	3.40	5.67	1.68	2.81
34	C23A	2.63	1.00	0.81	0.83	1.12	0.34	0.35	0.42	13.41	4.00	4.15	5.26	2.04	3.35
35	C23B	2.86	1.00	0.95	0.92	1.23	0.34	0.42	0.47	14.95	4.00	5.11	5.85	2.28	3.74
36	C24A	2.79	1.00	1.00	0.79	0.98	0.15	0.42	0.41	12.30	2.44	4.80	5.06	2.97	5.05
37	C24B	2.67	1.00	0.91	0.76	0.94	0.15	0.39	0.39	11.57	2.44	4.29	4.84	2.76	4.75
38	C24C	2.54	1.00	0.82	0.72	0.88	0.15	0.36	0.37	11.21	2.44	4.19	4.59	2.72	4.60
39	C25A	2.75	1.00	0.75	1.00	1.22	0.39	0.32	0.51	16.56	5.83	4.35	6.38	1.75	2.84
40	C25B	2.80	1.00	0.77	1.02	1.24	0.39	0.33	0.52	16.75	5.83	4.40	6.52	1.75	2.87
41	C25C	2.43	1.00	0.53	0.90	1.09	0.39	0.25	0.46	14.91	5.83	3.36	5.72	1.58	2.56
42	C25D	2.67	1.00	0.70	0.97	1.19	0.39	0.30	0.50	16.00	5.83	3.99	6.19	1.68	2.75
43	C25E	2.62	1.00	0.67	0.95	1.16	0.39	0.29	0.49	15.58	5.83	3.71	6.05	1.64	2.67
44	C26A	2.29	1.00	0.51	0.78	1.09	0.47	0.23	0.40	10.79	3.05	2.80	4.95	1.92	3.54
45	C26B	2.57	1.00	0.67	0.90	1.25	0.47	0.32	0.46	12.64	3.05	3.83	5.76	2.26	4.15

Table C3: Production, GDP, and FTE multipliers for France, 138-industries, 2019 (continued)

		Production multipliers				GDP multipliers				FTE multipliers				Other	
No	Industry code	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Type I	Type II
46	C26C	2.23	1.00	0.47	0.76	1.08	0.47	0.22	0.39	10.61	3.05	2.69	4.87	1.88	3.48
47	C26D	1.59	1.00	0.06	0.53	0.77	0.47	0.04	0.27	6.99	3.05	0.56	3.38	1.18	2.29
48	C26E	2.28	1.00	0.50	0.78	1.10	0.47	0.23	0.40	10.91	3.05	2.87	5.00	1.94	3.58
49	C26F	2.48	1.00	0.63	0.85	1.19	0.47	0.28	0.44	12.03	3.05	3.54	5.44	2.16	3.95
50	C26G	1.68	1.00	0.12	0.56	0.81	0.47	0.06	0.29	7.47	3.05	0.85	3.58	1.28	2.45
51	C27A	2.48	1.00	0.63	0.86	1.06	0.34	0.28	0.44	13.01	3.81	3.75	5.45	1.99	3.42
52	C27B	2.43	1.00	0.60	0.84	1.04	0.34	0.27	0.43	12.74	3.81	3.61	5.32	1.95	3.34
53	C28A	2.57	1.00	0.71	0.86	1.07	0.32	0.31	0.44	13.30	3.75	4.05	5.50	2.08	3.54
54	C28B	2.70	1.00	0.79	0.91	1.13	0.32	0.35	0.46	13.96	3.75	4.42	5.78	2.18	3.72
55	C28C	2.40	1.00	0.60	0.80	0.99	0.32	0.27	0.41	12.41	3.75	3.53	5.12	1.94	3.31
56	C28D	2.59	1.00	0.72	0.87	1.08	0.32	0.32	0.45	13.38	3.75	4.08	5.55	2.09	3.56
57	C29A	2.49	1.00	0.81	0.68	0.90	0.20	0.35	0.35	10.62	1.54	4.72	4.36	4.07	6.91
58	C29B	2.34	1.00	0.71	0.62	0.82	0.20	0.31	0.32	9.48	1.54	3.97	3.97	3.58	6.17
59	C30A	2.29	1.00	0.69	0.60	0.85	0.25	0.29	0.31	8.26	1.03	3.42	3.80	4.31	7.98
60	C30B	2.63	1.00	0.89	0.74	1.02	0.25	0.39	0.38	10.48	1.03	4.72	4.72	5.56	10.12
61	C30C	2.02	1.00	0.50	0.51	0.73	0.25	0.22	0.26	6.92	1.03	2.61	3.28	3.52	6.69
62	C30D	2.22	1.00	0.65	0.57	0.81	0.25	0.27	0.29	7.92	1.03	3.24	3.64	4.13	7.65
63	C30E	2.29	1.00	0.67	0.62	0.86	0.25	0.29	0.32	8.96	1.03	3.95	3.98	4.81	8.66
64	C31Z	2.75	1.00	0.73	1.02	1.29	0.45	0.31	0.52	17.71	7.00	4.19	6.52	1.60	2.53
65	C32A	2.48	1.00	0.53	0.94	1.18	0.45	0.25	0.48	16.25	7.00	3.24	6.00	1.46	2.32
66	C32B	2.35	1.00	0.46	0.89	1.12	0.45	0.22	0.45	15.36	7.00	2.69	5.67	1.38	2.19
67	C32C	2.56	1.00	0.59	0.97	1.22	0.45	0.27	0.50	16.65	7.00	3.45	6.20	1.49	2.38
68	C33Z	2.68	1.00	0.65	1.03	1.22	0.40	0.28	0.53	14.79	4.57	3.64	6.58	1.80	3.24
69	D35A	2.90	1.00	1.27	0.62	1.09	0.31	0.46	0.32	8.20	1.07	3.18	3.96	3.98	7.69
70	D35B	1.91	1.00	0.51	0.41	0.72	0.31	0.20	0.21	5.35	1.07	1.69	2.59	2.59	5.02
71	E36Z	2.69	1.00	0.84	0.85	1.25	0.42	0.39	0.43	11.78	1.92	4.47	5.38	3.32	6.12
72	E37Z	2.05	1.00	0.27	0.79	1.00	0.47	0.13	0.40	10.13	3.50	1.63	5.01	1.47	2.90
73	E38Z	3.05	1.00	0.88	1.17	1.48	0.47	0.41	0.60	15.99	3.50	5.04	7.45	2.44	4.57
74	E39Z	3.18	1.00	0.97	1.20	1.52	0.47	0.44	0.62	16.21	3.50	5.05	7.67	2.45	4.64
75	F41A	2.42	1.00	0.57	0.85	1.10	0.40	0.27	0.43	14.72	5.74	3.57	5.41	1.62	2.56
76	F41B	3.34	1.00	1.16	1.18	1.51	0.40	0.51	0.60	20.27	5.74	7.01	7.53	2.22	3.53
77	F42Z	3.09	1.00	1.00	1.09	1.40	0.40	0.44	0.56	18.57	5.74	5.89	6.95	2.03	3.24
78	F43Z	2.75	1.00	0.78	0.97	1.24	0.40	0.35	0.50	16.58	5.74	4.66	6.18	1.81	2.89
79	G45Z	2.54	1.00	0.48	1.06	1.36	0.59	0.22	0.54	19.16	9.65	2.76	6.75	1.29	1.98
80	G46Z	2.85	1.00	0.82	1.03	1.35	0.43	0.40	0.53	15.90	4.79	4.54	6.56	1.95	3.32
81	G47Z	2.76	1.00	0.62	1.14	1.44	0.56	0.30	0.58	24.06	13.33	3.48	7.24	1.26	1.80
82	H49A	3.12	1.00	0.93	1.19	1.52	0.48	0.44	0.61	20.55	8.52	4.45	7.58	1.52	2.41
83	H49B	2.60	1.00	0.56	1.04	1.28	0.48	0.27	0.53	18.60	8.52	3.47	6.62	1.41	2.18
84	H49C	2.77	1.00	0.66	1.11	1.36	0.48	0.32	0.57	20.08	8.52	4.50	7.07	1.53	2.36
85	H50Z	3.10	1.00	1.27	0.83	1.06	0.04	0.59	0.42	12.89	0.82	6.80	5.27	9.24	15.63
86	H51Z	2.60	1.00	0.69	0.91	1.14	0.37	0.30	0.47	12.62	2.93	3.89	5.80	2.33	4.30
87	H52Z	2.61	1.00	0.72	0.88	1.29	0.48	0.35	0.45	13.39	3.75	4.01	5.63	2.07	3.57
88	H53Z	3.06	1.00	0.46	1.60	1.69	0.63	0.24	0.82	32.84	19.04	3.62	10.19	1.19	1.73
89	I55Z	2.75	1.00	0.72	1.03	1.35	0.52	0.30	0.53	20.86	10.38	3.91	6.57	1.38	2.01
90	I56Z	2.76	1.00	0.73	1.03	1.36	0.52	0.31	0.53	20.91	10.38	3.97	6.56	1.38	2.01

Table C3: Production, GDP, and FTE multipliers for France, 138-industries, 2019 (continued)

		Production multipliers				GDP multipliers				FTE multipliers				Other	
No	Industry code	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Type I	Type II
91	J58Z	2.71	1.00	0.65	1.06	1.37	0.53	0.30	0.54	13.89	3.84	3.31	6.74	1.86	3.62
92	J59Z	2.67	1.00	0.75	0.91	1.23	0.43	0.33	0.47	13.03	3.44	3.78	5.81	2.10	3.79
93	J60Z	2.85	1.00	0.88	0.96	1.31	0.43	0.39	0.49	13.98	3.44	4.40	6.14	2.28	4.07
94	J61Z	2.55	1.00	0.79	0.76	1.20	0.45	0.37	0.39	10.54	1.94	3.77	4.82	2.94	5.42
95	J62Z	2.75	1.00	0.55	1.20	1.48	0.58	0.28	0.61	15.91	5.29	2.96	7.66	1.56	3.01
96	J63Z	3.09	1.00	0.77	1.32	1.64	0.58	0.38	0.68	17.84	5.29	4.11	8.43	1.78	3.37
97	K64H	2.90	1.00	0.85	1.05	1.38	0.43	0.41	0.54	14.12	3.42	4.01	6.69	2.17	4.13
98	K64S	2.84	1.00	0.81	1.03	1.35	0.43	0.39	0.52	13.80	3.42	3.84	6.54	2.12	4.04
99	K65Z	3.36	1.00	1.32	1.04	1.28	0.15	0.60	0.53	15.36	2.67	6.09	6.60	3.28	5.74
100	K66Z	2.83	1.00	0.79	1.05	1.35	0.45	0.37	0.54	14.68	4.14	3.87	6.67	1.93	3.54
101	L68A	2.07	1.00	0.52	0.55	1.25	0.70	0.27	0.28	5.96	0.00	2.47	3.48		
102	L68I	1.16	1.00	0.10	0.06	1.01	0.94	0.05	0.03	2.97	2.12	0.46	0.40	1.22	1.40
103	L68R	1.92	1.00	0.43	0.49	1.16	0.70	0.21	0.25	5.07	0.00	1.95	3.11		
104	M69Z	2.44	1.00	0.45	0.99	1.17	0.45	0.22	0.51	13.15	4.50	2.32	6.33	1.52	2.92
105	M70Z	3.39	1.00	1.03	1.36	1.63	0.45	0.49	0.69	18.32	4.50	5.17	8.64	2.15	4.07
106	M71Z	2.89	1.00	0.69	1.20	1.45	0.50	0.34	0.61	17.58	6.10	3.84	7.63	1.63	2.88
107	M72M	3.05	1.00	0.85	1.20	1.56	0.53	0.41	0.61	19.06	6.87	4.54	7.65	1.66	2.77
108	M72N	2.22	1.00	0.32	0.89	1.14	0.53	0.15	0.46	14.50	6.87	1.95	5.68	1.28	2.11
109	M73Z	2.97	1.00	0.76	1.21	1.43	0.45	0.36	0.62	20.12	7.82	4.61	7.69	1.59	2.57
110	M74Z	2.81	1.00	0.78	1.03	1.37	0.46	0.38	0.53	17.58	6.76	4.23	6.59	1.63	2.60
111	M75Z	2.28	1.00	0.44	0.85	1.10	0.46	0.21	0.43	14.74	6.76	2.59	5.39	1.38	2.18
112	N77Z	2.27	1.00	0.63	0.64	1.18	0.54	0.31	0.33	9.99	2.23	3.70	4.06	2.66	4.48
113	N78Z	2.96	1.00	0.16	1.80	1.89	0.88	0.08	0.92	34.67	21.95	1.25	11.47	1.06	1.58
114	N79Z	3.27	1.00	1.11	1.16	1.40	0.31	0.49	0.60	21.55	7.08	7.05	7.42	2.00	3.04
115	N80Z	2.50	1.00	0.44	1.06	1.24	0.49	0.21	0.54	20.41	10.78	2.87	6.76	1.27	1.89
116	N81Z	2.67	1.00	0.55	1.12	1.34	0.49	0.28	0.58	21.45	10.78	3.50	7.17	1.32	1.99
117	N82Z	3.16	1.00	0.86	1.29	1.58	0.49	0.43	0.66	23.94	10.78	4.91	8.25	1.46	2.22
118	O84Z	2.66	1.00	0.34	1.32	1.56	0.73	0.16	0.67	22.70	12.29	2.00	8.41	1.16	1.85
119	P85M	3.36	1.00	0.55	1.81	2.00	0.81	0.27	0.92	29.15	14.24	3.40	11.51	1.24	2.05
120	P85N	2.76	1.00	0.19	1.57	1.70	0.81	0.09	0.80	25.39	14.24	1.16	9.99	1.08	1.78
121	Q86M	2.45	1.00	0.36	1.09	1.45	0.71	0.19	0.56	20.75	11.44	2.39	6.92	1.21	1.81
122	Q86N	2.29	1.00	0.27	1.02	1.36	0.71	0.13	0.52	19.53	11.44	1.61	6.48	1.14	1.71
123	Q87M	3.01	1.00	0.30	1.71	1.82	0.80	0.15	0.87	35.65	22.82	1.93	10.90	1.08	1.56
124	Q87N	3.03	1.00	0.33	1.70	1.83	0.80	0.16	0.87	35.59	22.82	1.92	10.84	1.08	1.56
125	Q88M	2.89	1.00	0.22	1.67	1.78	0.80	0.12	0.86	35.11	22.82	1.63	10.65	1.07	1.54
126	Q88N	2.79	1.00	0.17	1.62	1.72	0.80	0.08	0.83	34.25	22.82	1.07	10.35	1.05	1.50
127	R90M	3.00	1.00	0.71	1.29	1.59	0.57	0.36	0.66	23.28	10.12	4.97	8.19	1.49	2.30
128	R90N	2.51	1.00	0.44	1.07	1.32	0.57	0.20	0.55	19.44	10.12	2.49	6.83	1.25	1.92
129	R91M	2.66	1.00	0.53	1.13	1.40	0.57	0.26	0.58	20.08	10.12	2.78	7.17	1.27	1.98
130	R91N	2.38	1.00	0.34	1.04	1.27	0.57	0.17	0.53	19.03	10.12	2.29	6.62	1.23	1.88
131	R92Z	2.92	1.00	0.69	1.23	1.54	0.57	0.34	0.63	22.21	10.12	4.22	7.86	1.42	2.19
132	R93M	2.90	1.00	0.71	1.19	1.48	0.55	0.32	0.61	22.85	11.27	3.99	7.58	1.35	2.03
133	R93N	2.47	1.00	0.44	1.03	1.28	0.55	0.20	0.53	20.16	11.27	2.31	6.59	1.20	1.79
134	S94M	3.12	1.00	0.58	1.54	1.66	0.61	0.26	0.79	30.41	17.37	3.20	9.84	1.18	1.75
135	S94N	3.02	1.00	0.50	1.52	1.63	0.61	0.24	0.78	29.90	17.37	2.87	9.66	1.17	1.72

Table C3: Production, GDP, and FTE multipliers for France, 138-industries, 2019 (continued)

		Production multipliers				GDP multipliers				FTE multipliers				Other	
No	Industry code	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Total	Direct	Indirect	Induced	Type I	Type II
136	S95Z	2.52	1.00	0.50	1.02	1.27	0.51	0.23	0.52	16.77	7.38	2.88	6.51	1.39	2.27
137	S96Z	2.38	1.00	0.45	0.93	1.37	0.66	0.23	0.48	28.83	19.98	2.92	5.93	1.15	1.44
138	T97Z	7.64	1.00	0.00	6.64	4.40	1.00	0.00	3.40	42.97	0.68	0.00	42.30	1.00	63.30
France		**2.63**	**1.00**	**0.66**	**0.97**	**1.30**	**0.50**	**0.30**	**0.50**	**16**	**7**	**4**	**6**	**1.9**	**3.2**
Brazil		**2.80**	**1.00**	**0.62**	**1.18**	**1.37**	**0.50**	**0.26**	**0.61**	**68**	**30**	**17**	**21**	**6.4**	**11.3**
Nigeria		**2.46**	**1.00**	**0.64**	**0.81**	**1.35**	**0.54**	**0.36**	**0.45**	**835**	**81**	**44**	**710**	**3.4**	**61.8**
Liberia		**1.82**	**1.00**	**0.61**	**0.21**	**0.73**	**0.45**	**0.21**	**0.07**	**674**	**396**	**189**	**89**	**2.5**	**3.2**
Morocco		**2.33**	**1.00**	**0.29**	**1.34**	**0.38**	**0.17**	**0.08**	**0.12**	**46**	**21**	**10**	**15**	**1.1**	**1.9**
Oman		**2.20**	**1.00**	**0.46**	**0.73**	**0.97**	**0.55**	**0.22**	**0.20**	**56**	**40**	**7**	**8**	**1.9**	**2.9**
Saudi Arabia		**3.21**	**1.00**	**0.52**	**1.69**	**1.93**	**0.59**	**0.41**	**0.93**	**33**	**5**	**7**	**19**	**2.1**	**5.5**
South Korea		**1.84**	**1.00**	**0.75**	**0.33**	**0.86**	**0.41**	**0.30**	**0.15**	**9**	**4**	**3**	**2**	**1.2**	**1.5**

Source: QBIS based on INSEE and previous QBIS studies.