D7.4 Social-economic assessment

The University of Edinburgh (UEDIN)

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[D7.4 Social and Socio-economic assessment]
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Abstract

The purpose of this document is to introduce the Socio-economic Cost of Energy (SCOE) model and present preliminary results for the FLOTANT project. The model is based on UEDIN's work on previous projects and uses various estimates and assumptions to provide a holistic analysis of the economic value that shall be returned to the European economy on deployment of the FLOTANT project. This report starts off with an introduction to the adopted methodology along with the assumptions and inputs used for the preliminary analysis. It then goes on to discuss the results produced from the model and concludes the findings of the analysis.

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2 Introduction

Within the FLOTANT project various innovations in the moorings, cables, and platform of a Floating Offshore Wind (FOW) system are investigated, to achieve an innovative, low cost, low weight and safe floating wind technology optimised for deep water wind sites. This document provides the results of the **socio-economic analysis** (performed in task 7.3) when the FLOTANT technology is deployed in Scotland and Canary Islands.

The **social-acceptance evaluation** conducted in parallel in task 7.3 was led by PLOCAN, where the broader social acceptance, project sustainability, knowledge sharing and educational opportunities in the two regions were evaluated. The social-acceptance evaluation is presented in a separate report thus is not covered here.

The contents of the report are organised as follows:

Section 3 provides a background of the FLOTANT socio-economic study which includes a brief overview of the analysis model and literature review.

Section 4 introduces the FLOTANT socio-economic analysis model, including the inputs and assumptions used for the analysis followed by the adopted methodology.

Section 5 presents the results of the socio-economic analysis.

Section ¡Error! No se encuentra el origen de la referencia. **summarises the results** and discusses the uncertainties.

3 Background

3.1 Socio-economic analysis model

This work can be described as a Socioeconomic Cost of Energy (SCOE) study, as it quantifies the socioeconomic benefits associated with the deployment of the FLOTANT technology.

Socio-economic assessment studies can be performed in several ways: analytical studies, Input-Output (IO) table-based studies and the Computable General Equilibrium (CGE) approach. For the FLOTANT socio-economic study, the Input-Output table-based approach has been adopted. The approach is based on the Scottish Government's Input-Output (IO) Methodology Guide [1] . It is built on previous studies conducted by the Policy & Innovation Group at The University of Edinburgh for projects (e.g. Open Sea Operating Experience to Reduce Wave Energy Costs (OPERA) project [2] [3], Tidal turbine Power Take-off Accelerator (TiPA) project [4]). For this SCOE analysis, GVA and jobs supported are employed as the metrics calculating the socio-economic effects of the deployment of the FLOTANT technology.

As stated in the Scottish Government's IO Methodology Guide [1], GVA is simply the sum of each company's outputs (sales) less inputs (purchases). It is made up of the difference between the value of goods and services produced and the cost of the raw materials and other inputs, which are used up in the production process – in this instance, all the activities involved in development and deployment of the FLOTANT technology. GVA is linked with Gross Domestic Product (GDP) according to Equation (1):

$$GVA = GDP + \text{subsidies on products} - \text{taxes on products} \quad (1)$$

In this study the activity related to the 600 MW FLOTANT wind farm is considered to be a 'demand shock' that describes the additional spend entering the regional economies where the FLOTANT technology is deployed i.e. West of Barra (Scotland) or Gran Canaria (Canary Islands).

Employment is the number of jobs supported throughout the deployment of the project and can be expressed in job years or full-time employment (FTE) values. Jobs supported can be measured as

- Direct - those employed by the project itself
- Indirect - those employed in supplying the inputs to the project
- Induced - those employed due to the increased spending of employees throughout the region's economy

Both the GVA and jobs supported models use an IO framework to account for the interdependence of industries within the economy. This analytical framework includes region specific Industry by Industry (IxI) IO tables to describe the sale and purchase relationships between producers and consumers within an economy [5]. These tables are used in the calculation of the employment and GVA effects and multipliers, which relate invested project spend to jobs supported and GVA. For this study, the GVA values are expressed in Euros while the job values are expressed in job years.

Based on the IO tables-based approach, the socio-economic impact of the FLOTANT project is represented through GVA generated and employment supported.

3.2 Literature review

Several developers and third parties have published the results of socio-economic analyses for offshore wind (OW) projects [6] [7] [8].

However, there exist very few reports that discuss the socio-economic benefits of FOW projects. Nevertheless, three relevant studies under the FOW sector were found that analyse the socio-economic benefits of the sector. The report by Crown Estate Scotland (CES) - Offshore Renewable Energy (ORE) Catapult, "The Macroeconomic Benefits of Floating Offshore Wind in the UK" from 2018, is one of the two reports that discusses the potential macroeconomic benefits arising from policy and investment support for the early stages of FOW deployment in the UK [9]. The report mentions three different scenarios, each with a deployment of 20GW, 15GW and 10GW, respectively. The socio-economic benefits (GVA and full time employment) derived under these scenarios are presented in Table 1 below.

Presented by the Friends of Floating Offshore Wind in 2018, "The Future's Floating" is another report that discusses the GVA of the FOW sector in the UK [10]. As an opportunity to establish strong policy commitment and to discuss establishing a suitable route to market for the FOW sector, the report demonstrates the discounted socio-economic GVA benefits associated with three hypothetical FOW project scenarios – pilot project (30 MW), pre-commercial project (96 MW) and commercial (750 MW) project. The report states that the three project scenarios would result in a GVA of £142.6m, £398m and £1.76bn, respectively, as seen in Table 1 below.

Another study analyses the economic impact of a 200 MW FOW farm in the Canary Islands in terms of regional and national gross value added (GVA) and employment [11]. The project shows around 0.680 €bn of GVA generated for Spain at national level including a regional contribution of 0.33 €bn to 0.25 €bn at Canary Islands. Table 1 below presents the GVA and employment benefits generated for Canary Islands on deployment of the 200 MW FOW project for a low leakage and high leakage scenario.

Table 1: Summary of FOW socio-economic studies

Reference	Deployment	Project Capacity	GVA	GVA/MW	Jobs
FOFOW, 2018 [10]	UK	30 MW	£142.6m	£4.73m	
		96 MW	£398m	£4.15m	-
		750 MW	£1.76bn	£2.35m	
CES-ORE Catapult, 2018 [9]	UK	20 GW	37 €bn	1.85 €m	17,000 FTE
		15 GW	20 €bn	1.33 €m	9,700 FTE
		10 GW	7.5 €bn	0.75 €m	3,600 FTE
Schallenberg-Rodriguez, 2021 [11]	Canary Islands	200 MW (low leakage)	0.33 €bn	1.67 €m	8,118
		200 MW (high leakage)	0.25 €bn	1.25 €m	5,558

4 Overview of the FLOTANT Socio-Economic Methodology

A high-level summary of the inputs to the models developed to evaluate the GVA, and jobs supported is given below.

4.1 High-level summary of required inputs and assumptions:

- Model: The FLOTANT SCOE study uses a model which estimates the GVA and jobs benefits to Scotland and the Canary Islands from the deployment of floating wind farm using the FLOTANT technology.
- Deployment scenarios: The deployment in the SCOE study is a 600MW FLOTANT project deployed within West of Barra (Scotland) and Gran Canaria (Canary Islands).
- System boundaries/ Case studies: The SCOE study uses two case studies, these are:
  i. FLOTANT WTS - Analysis conducted for the FLOTANT technology inclusive of the wind turbine system (WTS) i.e., it includes all components under a FOW project (wind turbine, export cable, anchor, plus FLOTANT innovation system).
  ii. FLOTANT IS - Analysis for the FLOTANT innovation system (IS) only and excludes the wind turbine system. The FLOTANT innovation system includes the components specifically developed for FLOTANT i.e. the mooring system, floating platform, and power transmission. The wind turbine, export cable and anchors (Constituting approximately 50% of the total CAPEX and OPEX costs) are not innovated within the FLOTANT project and are thus not considered under the FLOTANT IS.

- Project timeline: Defines the period from when the project is first deployed until the project is decommissioned. It is also the period within which the entire project investment is made. It includes the following phases within the project: development & consenting, construction, production & acquisition, installation & commissioning, operation & maintenance, decommissioning & disposal.
- Annual spend: Defines the spend that is invested throughout the project timeline annually. The total spend made throughout the project is calculated based on the per unit capital expenditure (CAPEX), operational expenditure (OPEX) and decommissioning expenditure (DECEX) over the project timeline. The spend is deflated to the year of the IO table for GVA and Jobs calculations.
- Sectorial breakdown: Identifies the industrial sectors that would be impacted by the investments made under this project.
- Leakage rate: Leakage rates give indication on where the components are manufactured. It reflects how much of spend in a sector is invested in the region of interest; a high leakage rate would indicate that a large amount of the sector spend is invested outside the region of interest while a low leakage rate indicates a high retention in the region.
- Discount rate: The discount rate used in this work reflects the social time preference of consumption[1]. A constant discount rate of 3.5% is applied to maintain consistency with the assumptions made under the FLOTANT LCOE model. The discounting of the spend is considered only for the GVA model and not for the jobs supported model.

4.2 Stepwise breakdown of the FLOTANT socio-economic method

The economic benefits are calculated by quantifying the gross spend invested in each relevant industry in the region of interest to develop, deploy, operate, and maintain the FLOTANT project. This industrial spend is then multiplied by the value that industry has to the economy (i.e., GVA effects and employment effects generated from the IO tables), to generate GVA benefits, and jobs supported, respectively [12]. A stepwise breakdown of the methodology adopted for the FLOTANT socio-economic analysis is given in Figure 1.

[1] defined as the value society attaches to present, as opposed to future, consumption

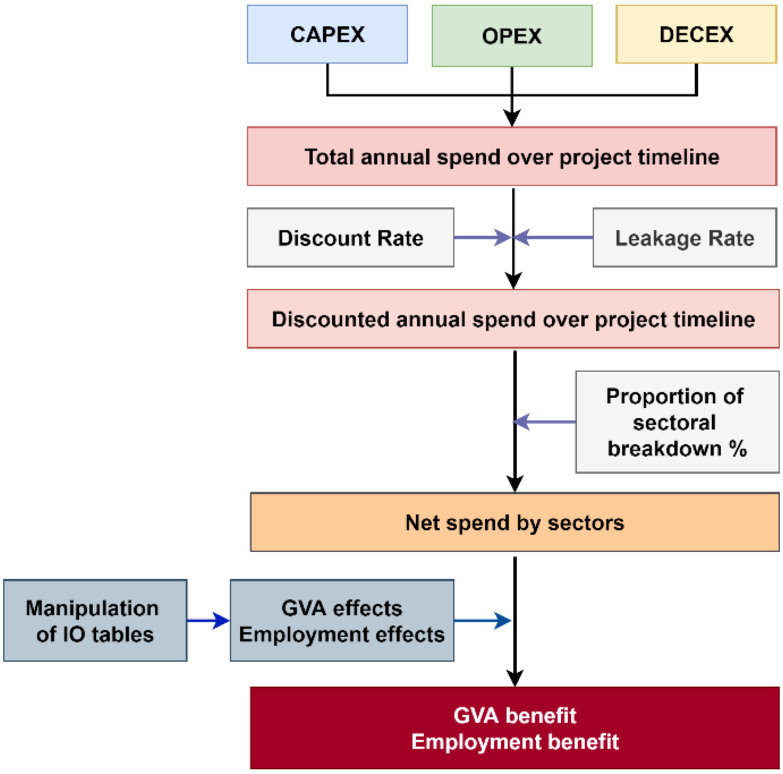

Figure 1 - Flowchart representation of GVA methodology

The methodology for conducting the FLOTANT GVA and jobs supported analysis can be broken down into the following steps:

- The total amount invested annually within our scope of analysis in terms of CAPEX, OPEX and DECEX spend under the FLOTANT project are calculated over the project timeline. The total CAPEX, OPEX and DECEX values are obtained by multiplying the per unit cost deployment by installed capacity in that year.
- The investment amount is deflated in nominal terms, so it is common to the year of the IO table referred for the region of interest i.e. all monetary values are in the same base year.
- The total gross spend is multiplied by (1-leakage rate) and discounted. The discount rates are applicable for the GVA analysis only and not for the jobs supported analysis. Leakage rates are an indication of where items are manufactured/sourced from and is different for various cost centres.
- The post leakage and discounted investment (undiscounted for jobs supported) is split in different cost centres and then allocated to the relevant industrial sector. This helps identify the industrial sectors impacted by the investments made under this project.
- This net investment amount by cost centre is finally multiplied by the GVA effects and employment effects (derived from the IO tables) [5]. This gives us the final disaggregated GVA, and jobs supported results of the FLOTANT project within the economy.

4.3 Inputs and assumptions

The FLOTANT socio-economic model represents the economic benefit offered to Scotland and Canary Islands, in terms of GVA and job-years supported, derived from the net spend invested in both the regions for a 600MW FLOTANT wind farm deployment. This, as explained before, considers the spend over the lifetime of FLOTANT's wind farm deployment, operation and decommission. Detailed input and assumptions are discussed more in detail below.

4.3.1 Deployment scenarios Project timeline and Annual Spend

The model considers the deployment of 600MW FLOTANT technology at West of Barra (Scotland) and Gran Canaria (Canary Islands). For the deployment scenarios used in this study the 600 MW wind farm is assumed to be commissioned in 3 deployment phases. The three phases are two 240 MW deployments followed by a 120 MW deployment, this is aligned with the LCOE model. The investment under each of these phases and their timelines are shown in Table 2.

Table 2: Investment timeline considerations for the large farm deployment case.

Phase I (240MW)	Investment
D&C	Year 0
P&A	Year 1 (70%) and year 2 (30%)
I&C	Year 1 = 8 months (40%) Year 2 = 12 months (60%)
O&M	Year 3-Year 27
D&D	Year 28 (70%) Year 29 (30%)
Phase II (240MW)	**Investment**
D&C	Year 1
P&A	Year 2 (22.5%), Year 3 (60%) and Year 4 (17.5%)
I&C	Year 3 = 12 months (70%) Year 4 = 8 months (30%)
O&M	Year 4 (4 months) - Y29 (8 months)
D&D	Year 29 (30%) Year 30 (70%)
Phases III (120MW)	**Investment**
D&C	Year 2
P&A	Year 4 (85%) and year 5 (15%)
I&C	Year 4 = 4 months (40%) Year 5 = 8 months (60%)
O&M	Year 5 (6 months) - Y30 (6 months)
D&D	Year 30 = 6 months (60%) Year 31 (40%)

The annual spend is the proportion of the total investment that is retained within the region's economy (this includes leakage effects – see section 4.3.4). A timeline of the annual spend retained within the Canary Islands economy for the 600 MW FLOTANT farm is shown in Figure 2. This illustrates how the majority of the spend occurs during the initial years, where the Production and Acquisition and Installation and Commissioning activities take place. A similar trend exists for the Scottish annual spend.

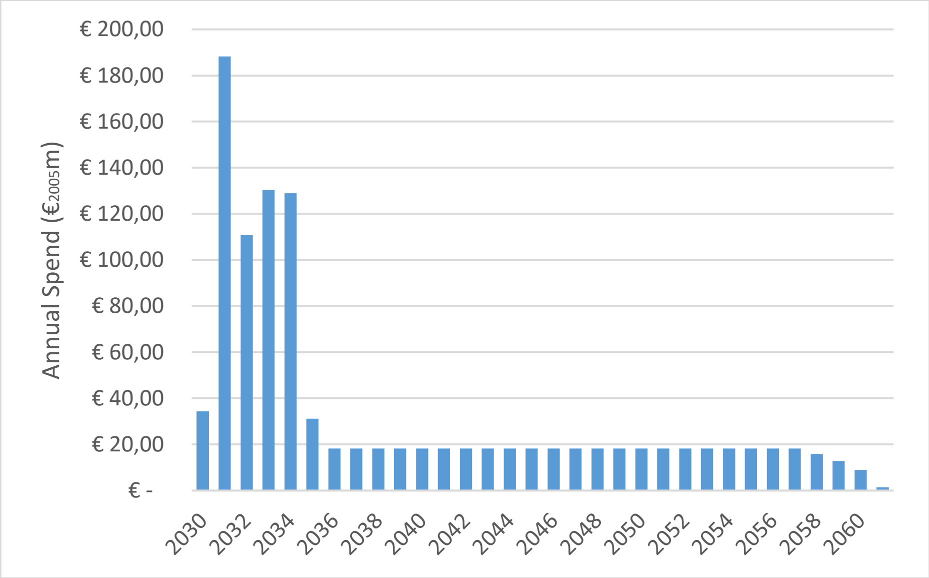

Figure 2: Breakdown of total undiscounted annual spend retained in the Canary Islands for FLOTANT WTS

4.3.2 Sectorial breakdown

A detailed cost breakdown of the various cost components under the FLOTANT project for the FLOTANT technology is obtained from the techno-economic assessment (D7.1) provided by COBRA. These cost components, along with their cost breakdown, are then allocated to specific sectors as per the Standard Industrial Classification (SIC) codes[2] (provided in Appendix A.I) [13]. Once the cost components are assigned their respective SIC sector, the percentage contribution of each sector towards CAPEX and OPEX and DECEX spend are calculated. Table 3: Sector allocation for FLOTANT technology cost components below provides a tabular representation of the final proportion of cost components contribution towards CAPEX and OPEX for FLOTANT technology.

Table 3: Sector allocation for FLOTANT technology cost components

SIC Codes		**CAPEX**	**OPEX**
H52	Warehousing and support activities for transportation	2.18%	-
H50	Water transport	12.84%	-
K65	Insurance, reinsurance and pension funding, except compulsory social security	1.94%	25.00%
K64	Financial service activities, except insurance and pension funding	11.16%	-
M71	Architectural and engineering activities; technical testing and analysis	13.85%	25.00%
E39	Remediation activities and other waste management services	0.75%	-

[2] SIC = Standard Industrial Classification of economic activities. It consists of an industry classification system to sort data according to the kind of economic activity it is related to.

C33	Repair and installation of machinery and equipment	-	50.00%
C28	Manufacture of machinery and equipment n.e.c.	25.75%	-
C27	Manufacture of electrical equipment	8.34%	-
C25	Manufacture of fabricated metal products, except machinery and equipment	21.22%	-
C23	Manufacture of other non-metallic mineral products	0.00%	-
C20	Manufacture of chemicals and chemical products	1.97%	-

4.3.3 Leakage Rates

Leakage reflects the investment made in the supply chain in the region of interest; a high leakage value would indicate that a large amount of the supply chain investment is made outside the region of interest while a low leakage rate indicates high retention within the region. Leakage has a significant effect on the estimated GVA generated in each region. Public data does not exist to estimate the baseline sectoral leakage rates in the Canary Islands, which is a major source of uncertainty in this study.

Three scenarios have been chosen to understand the sensitivity of the benefits depending on the variability in the strength of the domestic supply chain.

- Baseline leakage rate scenario: For the Scottish model, the baseline leakage rate (L) for every industry (i) is based on the below equation, where RUK_{imp} is imports from rest of UK, ROW_{imp} is imports from rest of the world, and TDU is total domestic use. The leakage rates dependent on the imports within the UK industries has been calculated based on the inputs from the 2014 Scottish IO table [14].

$$L_i = \frac{RUKimp_i + ROWimp_i}{TDU_i + RUKimp_i + ROWimp_i}, \tag{3}$$

  Unlike the Scottish model, a constant leakage rate of 54.2% is assumed for the baseline scenario for the Canary Islands model. This is because the inputs required for calculating the leakage rate are not available in the Canary Islands IO table. Thus, the rate is based on the overall import of good and services within Canary Islands and is taken from the Canary Islands Macroeconomic Table provided by the Instituto Canario De Estadastica [15]. For this reason the results from the Scottish and Canary Island scenarios cannot be directly compared.

- High leakage rate scenario: A high leakage scenario indicates weakness in the domestic supply chain and thus a heavy dependency on imports. The leakage rates for the scenario are similar to the 'minimum potential scenario for the UK supply chain sector' from the CES-ORE Catapult, report [9]. Based on this scenario, a pessimistic view is provided where it is assumed that both Scotland and Canary Islands have a similar supply chain structure and are market followers. This scenario represents a case, where low supply chain investment takes place.
- Low leakage rate scenario: Alternatively, a low leakage scenario indicates high retention of spend within the economy in question, due to strong domestic supply chain and thus less dependency on imports. Based on the 'maximum potential scenario for the UK supply chain sector' from the CES-ORE Catapult report, an optimistic view is provided. In this scenario, it is

assumed that both Scotland and Canary Islands have a similar supply chain structure and are market leaders in the sector. This scenario represents a case, where supply chain investment takes place now resulting in higher benefits from the studied deployments for the regional economies.

Table 4 below provides a breakdown of the assumed leakage rates for both regions by cost centres for the baseline and high/low leakage rate scenarios.

Table 4: Leakage rates adopted for Scotland and Canary Islands for all cost centres

SIC Code	Category of spending	Baseline Scotland [23]	Baseline Canary Islands [24]	Low Leakage [11]	High Leakage [11]
	Development and consenting				
M71	Project management	74%	54.2%	20%	61%
M71	Consenting services	74%	54.2%	20%	61%
M71	Surveys	74%	54.2%	20%	61%
K65	Insurance	70%	54.2%	20%	61%
K64	Margins and contingencies	67%	54.2%	25%	80%
	Construction				
K64	Construction supervision costs	67%	54.2%	20%	61%
M71	Engineering and consultancy/FEED	74%	54.2%	20%	61%
M71	Certification	74%	54.2%	20%	61%
	Production and Acquisition				
C27	Supervisory control and data acquisition (SCADA)	79%	54.2%	58%	89%
C25	Mooring spring	77%	54.2%	50%	85%
C25	Anchors	77%	54.2%	50%	85%
C28	Turbine	78%	54.2%	60%	90%
C25	Floating platform - Tower	77%	54.2%	20%	85%
C23	Floating platform - Base - concrete parts	70%	54.2%	20%	85%
C20	Floating platform - Base - plastic compartments	58%	54.2%	20%	85%
C27	Inter-array cable	79%	54.2%	58%	89%
C27	Export cable	79%	54.2%	58%	89%
C27	Substation (if floating)	79%	54.2%	20%	85%
	Installation and Commissioning				
H50	Support Services Infrastructure	65%	54.2%	25%	81%
H50	Offshore Logistics	65%	54.2%	25%	81%
H52	Port Charges	72%	54.2%	25%	81%
H50	Installation of components	65%	54.2%	25%	81%
M71	Commissioning and Testing	74%	54.2%	25%	80%
	Decommissioning and Disposal				
H50	Decommissioning	70%	54.2%	40%	85%
E39	Waste management	74%	54.2%	40%	85%

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H50	Site clearance	76%	54.2%	40%	85%
M71	Post monitoring	76%	54.2%	40%	85%
	Operation and Maintenance				
K65	Insurance	65%	54.2%	15%	62%
M71	Project management	72%	54.2%	15%	62%
H50	Vessel operations	65%	54.2%	15%	62%
C33	Maintenance service	74%	54.2%	15%	62%

4.3.4 GVA and employment effects

GVA effect indicates the impact on GVA from a unit change (or expansion) in output of an industry while an employment effect indicates the impact on employment from a unit change of output. GVA and employment effects are used to understand the impact on GVA and employment through a unit change or expansion in output. Two types of effects are typically used:

- Type I: Direct (Increase in output) + Indirect (Increase in output of supplier or supply chain)
- Type II: Direct + Indirect + Induced (Increase in output of other sectors due to increase in Direct and Indirect output)

In this analysis, Type II effects are used to assess GVA and employment effects.

$$(G_{eff})_j = \sum_i g_i L_{ij} \tag{2}$$

$(G_{eff})_j$ in equation (2) is the GVA effect for industry j [1]. g_i is the GVA of industry *i*, in the region of interest, divided by total output of the same industry ("total output at basic prices," or, "production at basic prices"). GVA is usually present in the IxI IO tables. *Lij* (Leakage rate) is the cell of the type II Leontief inverse matrix that corresponds with industries *i* and *j*.

$$(E_{eff})_j = \sum_i w_i L_{ij} \tag{3}$$

$(E_{eff})_j$ in equation (3) is the employment effect for industry *j* that is used to calculate job supported [1]. w_i is the Full Time Equivalent (FTE) employment for industry *i* divided by total output of the same industry ("total output at basic prices," or, "production at basic prices") and may have to be obtained from external sources if not readily available in the region-specific IO table. *Lij* (Leakage rate) is the cell of the type II Leontief inverse matrix that corresponds with industries i and j.

Type II GVA and employment effects are obtained through the Leontief inverse of the 2014 Scottish and 2005 Canary Islands IO table, adapted to Industry-by-Industry (IxI) format [14] [16]. For both regions, the most recently updated IO table is taken.

For both regions, the spend is deflated to the year of the IO tables used so that all monetary values are in the same base year. Thus, for the Scotland model, the spend is deflated to year 2014 while for the Canary Islands model it is deflated to year 2005.

4.3.5 Summary of inputs and assumptions for the regional model

Table 5 below provides us with a summary of the inputs and assumptions used discussed in the previous sections.

Table 5: Summary of inputs and assumptions for the regional models

Inputs and Assumptions	Scotland deployment	Canary Islands deployment
Deployment scenarios (refer 4.3.1)	600MW farm deployed in West of Barra, Scotland	600MW farm deployed in Gran Canaria, Canary Islands
Technology lifetime	25 years	
Project timeline (see)	32 years (2030-2061)	
Case studies (refer 4.1)	FLOTANT WTS and FLOTANT IS	
Sectorial breakdown (refer 4.1)	Based on techno-economic assessment (D7.1)	
Discount rate (refer 4.1)	Constant 3.5% for GVA model and 0% for jobs supported model	
Leakage rate (refer 4.3.2)	Three scenarios: baseline, low leakage, and high leakage	
GVA & employment effects (refer 4.3.4)	Type II GVA and employment effects obtained from the Scottish 2014 IO table [14]	Type II GVA and employment effects obtained from the Canary Islands 2005 IO table [16]

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5 Results

The results from the FLOTANT socio-economic study West of Barra, Scottish deployment and Gran Canaria, Canary Islands deployment are discussed in this section. The economic benefit is assessed in the form of discounted Type II GVA, and undiscounted jobs supported within the regions. Type II GVA gives us the total of direct, indirect, and induced GVA while type II jobs give us a total of direct, indirect, and induced jobs supported.

Table 6 below shows a summary of the results obtained under a baseline leakage rate scenario. The Scottish benefits are presented in 2014 values while the Canary Islands benefits are presented in 2005 values. It should be noted that due to the leakage rate assumptions, these results cannot be directly compared (see section 4.3 for further details on leakage rate assumptions).

Table 6: Summary of type II results for FLOTANT technology under a baseline leakage rate scenario

	Scottish model (2014 values)		Canary Islands model (2005 values)	
	GVA(€m)	Job Years	GVA(€m)	Job Years
FLOTANT WTS	491	9,010	972	24,200
FLOTANT IS	276	4,950	508	13,400

The following sections discuss the socio-economic benefits for both case studies: FLOTANT WTS and FLOTANT IS.

5.1 Spend vs GVA generated

As seen in Figure 3 below, a Scottish deployment of the 600MW FLOTANT wind farm results in a total discounted spend (within the Scottish economy) of approximately 665 $€_{2014}$m and generates a total discounted GVA of approximately 491 $€_{2014}$m within the Scottish economy. Of the total GVA benefits, approximately over half (276 $€_{2014}$m) are generated directly. The overall GVA generated is less than the spend because the type II effects used in the calculation of the total spend has a value lesser than 1.

Considering the Innovation System (IS) only for a total discounted spend of 398 $€_{2014}$m the FLOTANT IS generates a total discounted GVA amount of approximately 276 $€_{2014}$m. Here, the GVA generated by the FLOTANT IS is comparatively lower than the WTS as it does not include the turbine system, export cable and the anchors.

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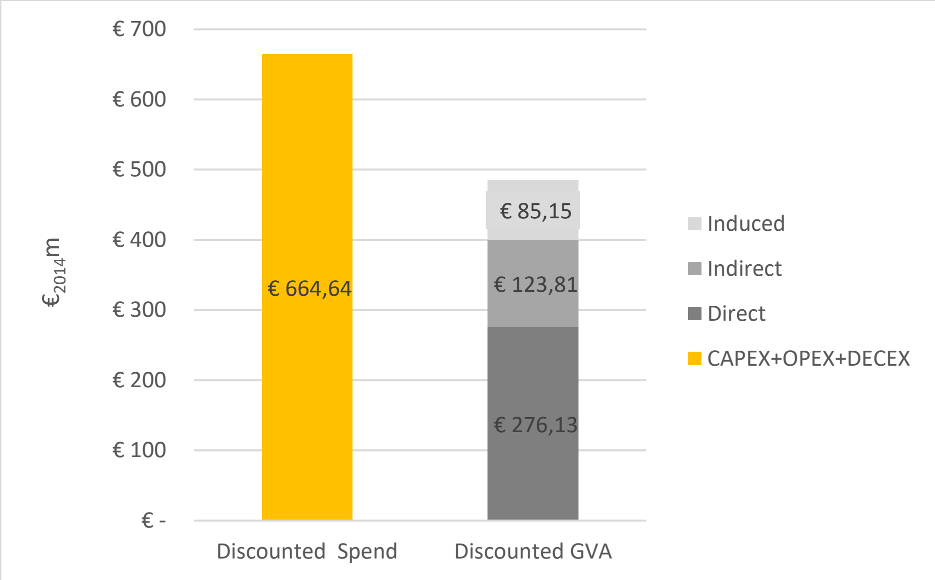

Figure 3: Total discounted spend and GVA retained within Scottish economy for FLOTANT WTS

Under Gran Canarian deployment, with a total discounted spend of approximately 823 $€_{2005}$m the FLOTANT WTS generates a total discounted GVA of approximately 972 $€_{2005}$m, seen in Figure 4. Of the total GVA benefits, under half (395 $€_{2005}$) is direct, while the majority is indirect and induced. The overall GVA generated is more than the spend because the type II effects used in the calculation of the total spend has a greater value than 1.

Under the innovation system, for a total discounted spend of 442 $€_{2005}$m the FLOTANT IS generates a total discounted GVA amount of approximately 508 $€_{2005}$m. Without the turbine system, export cable and the anchors, the FLOTANT IS generates comparatively lesser GVA benefits.

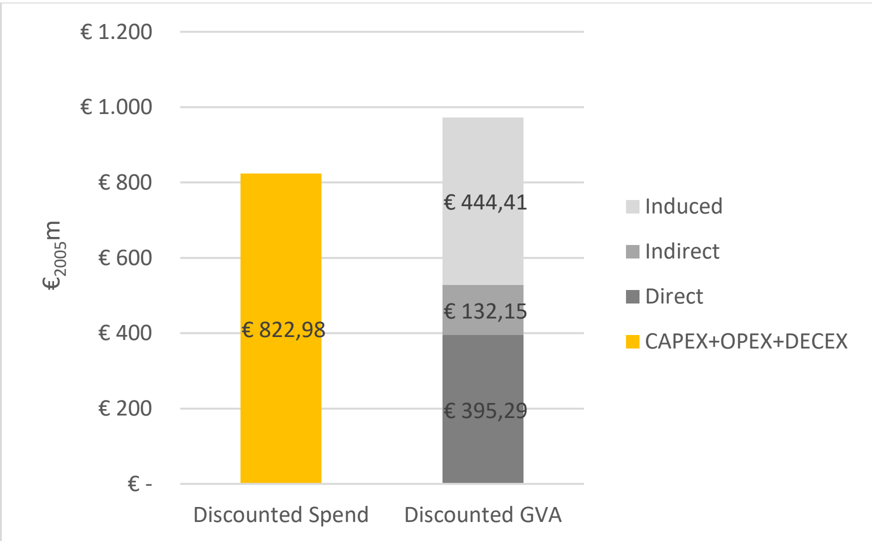

Figure 4: Total discounted spend and GVA retained within Canary Islands economy for FLOTANT WTS

5.2 Jobs supported

As seen in Figure 5 below the FLOTANT WTS is estimated to support over 9,000 undiscounted job years within the Scottish economy. Of the total jobs supported, the majority (4,855) are direct job-years. For the FLOTANT IS 4,955 undiscounted job years are supported in Scotland.

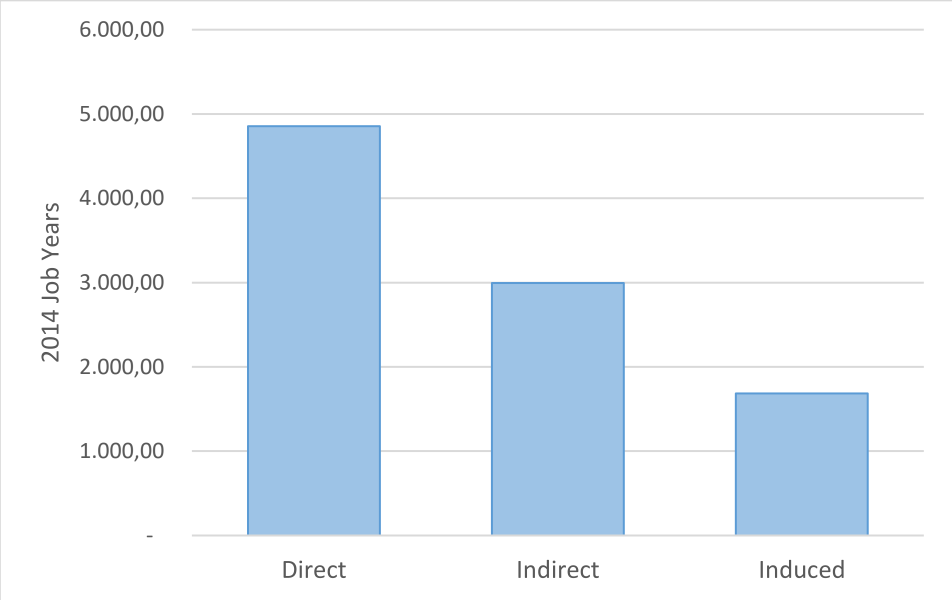

Figure 5: Undiscounted jobs supported within Scottish economy for FLOTANT WTS

Within Canary Islands the FLOTANT WTS supports 24,174 undiscounted job years, as seen in Figure 6 below. Of the total jobs supported, under half (9,890) are direct jobs, while the majority are indirect and induced jobs.

For the FLOTANT IS around 13,400 undiscounted job years are supported by the economy of Canary Islands.

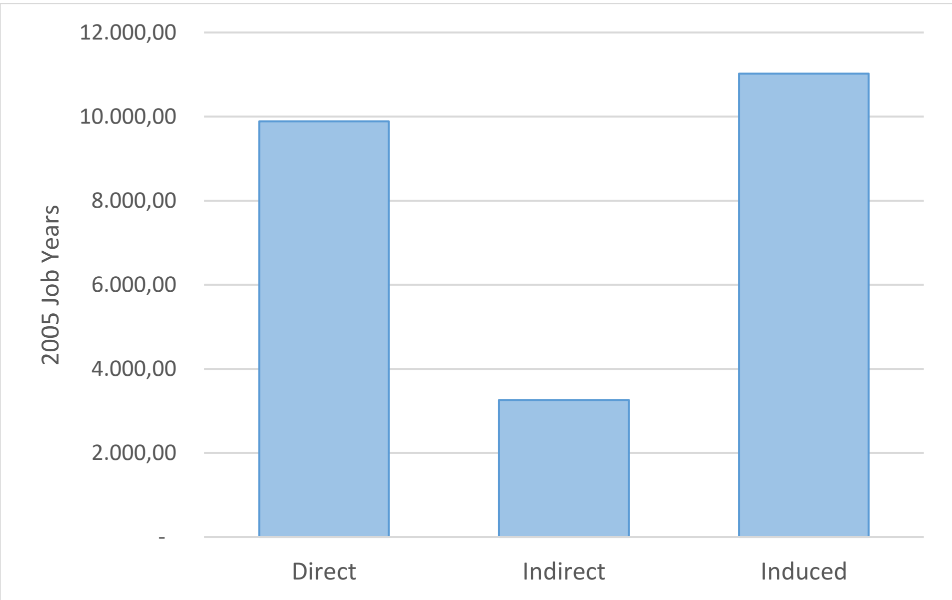

Figure 6: Undiscounted jobs supported within Canary Islands for FLOTANT WTS

An example of the distribution of the total undiscounted jobs supported within the Canary Islands from 2030-2061 for FLOTANT WTS is given in Figure 7. Similar to the spend it is seen that the job years peak in 2031, decreases gradually until 2036 and then remains fairly constant until 2061 when the project is finally decommissioned. A similar trend exists for the Scottish jobs supported.

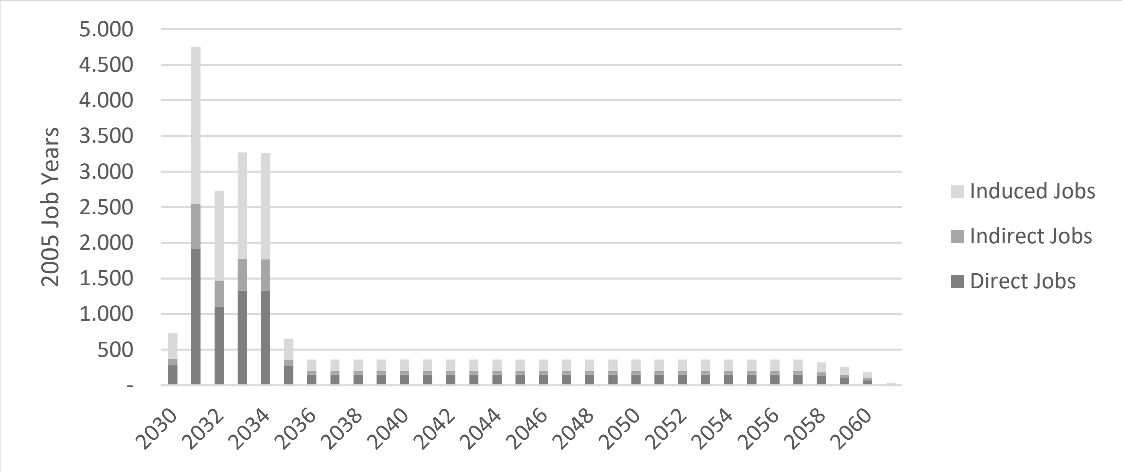

Figure 7: Breakdown of type II undiscounted annual jobs supported, within Canary Islands economy for FLOTANT WTS

5.3 GVA by category of spending

Figure 8 and Figure 9 provide a breakdown of the discounted GVA benefit to Scottish and Canary Islands economy by category of spending. Under FLOTANT WTS, the greatest GVA share is taken by the 'production and acquisition' category followed by 'operation and maintenance', these generate around 234 $€_{2014}$m and 160 $€_{2014}$m of Scottish GVA benefits, and 406 $€_{2005}$m and 353 $€_{2005}$m of Canary Islands benefits, respectively. The turbine component under the 'production and acquisition' centre that has the highest GVA contribution under both modelled deployments. While the 'operation and maintenance' is more labour intensive, the turbine component is highly cost intensive which contributes towards the high GVA share under the 'production and acquisition' system.

Considering the FLOTANT IS, both 'production and acquisition' and 'operation and maintenance' continue to retain the highest shares - generating around 148 $€_{2014}$m and 80 $€_{2014}$m of GVA, respectively, in the Scottish economy, and 225 $€_{2005}$m and 177 $€_{2005}$m in the Canary Islands.

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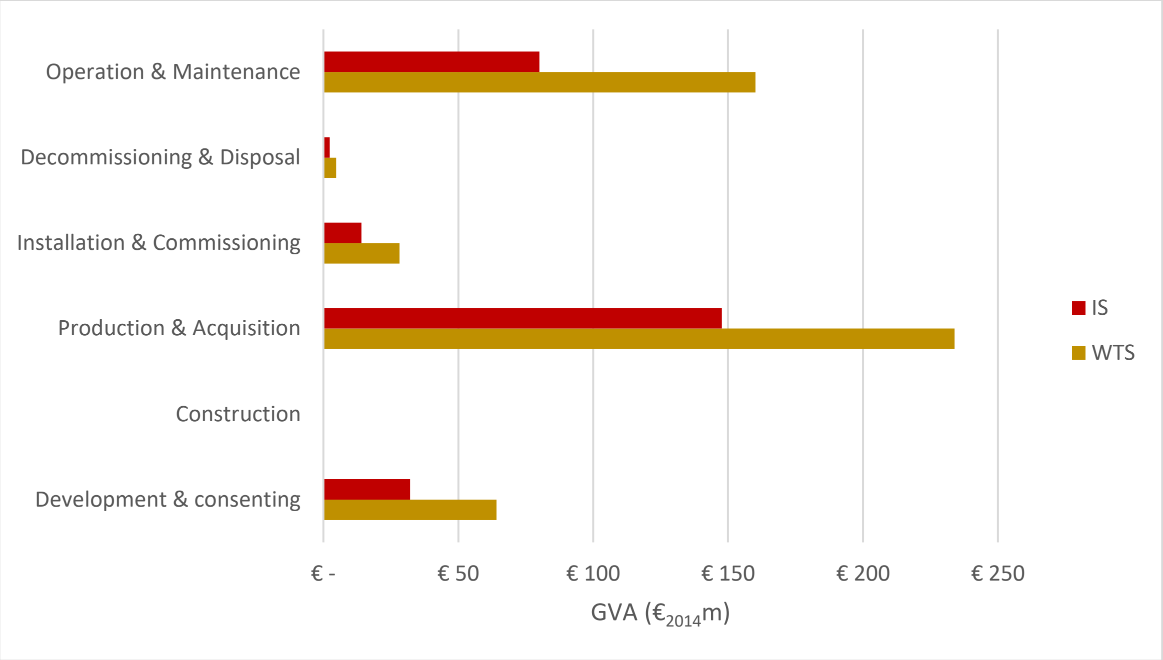

Figure 8: Discounted GVA by category of spending for FLOTANT WTS within Scottish economy

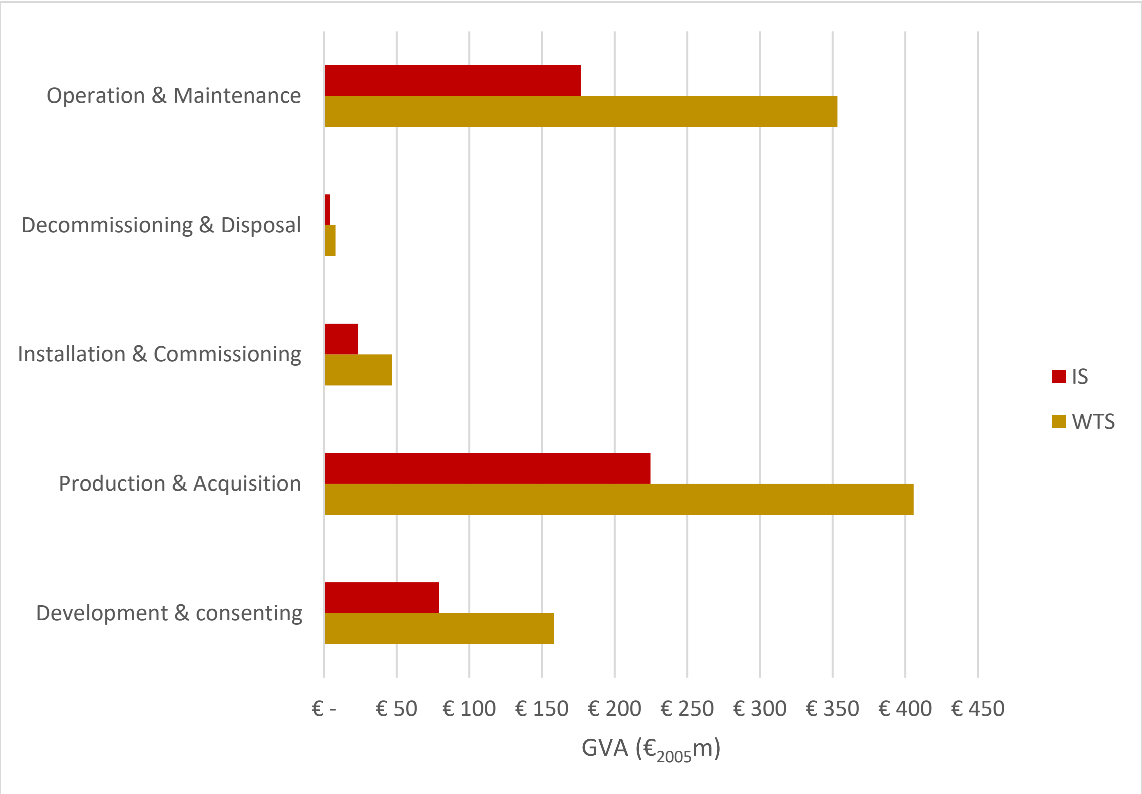

Figure 9: Discounted GVA by category of spending for FLOTANT WTS within Canary Islands

Figure 10 and Figure 11 below presents the different components under a 'production and acquisition' category for the FLOTANT WTS. The turbine is the largest individual contributor to the GVA generated in this category, generating approximately 63 $€_{2014}$m and 173 $€_{2005}$m of Scottish and Canary Islands GVA benefits. The bars for export cable, turbine and anchors are patterned to highlight that they are not included under the FLOTANT IS. Under the FLOTANT IS, without the turbine system components, it is the floating platform (tower and base) which has the highest GVA contribution of approximately 110 $€_{2014}$m and 165 $€_{2005}$m for Scotland and Canary Islands respectively.

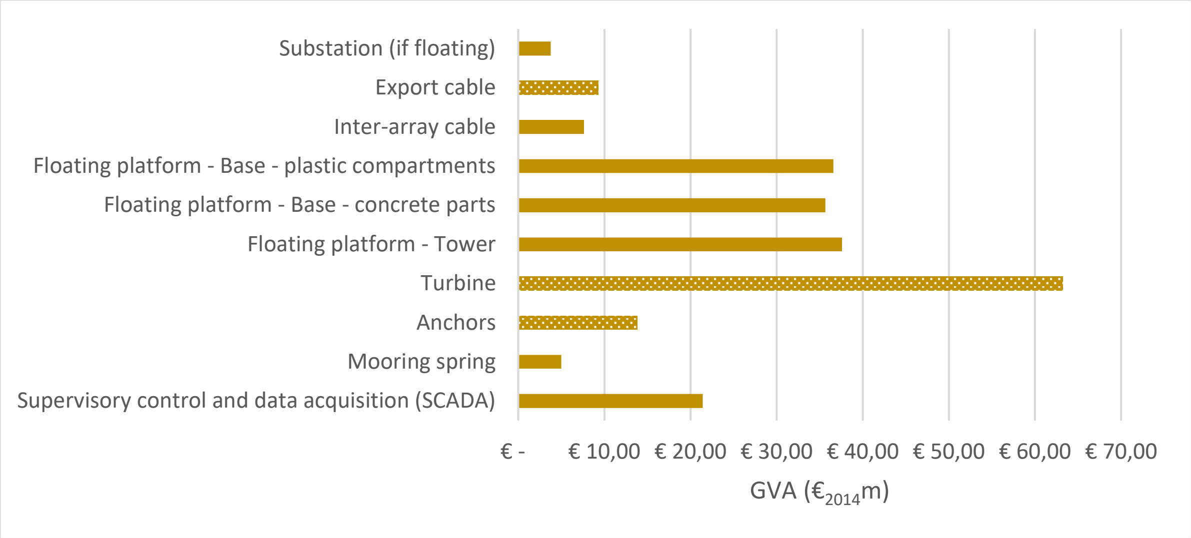

Figure 10: Discounted GVA for Production and Acquisition system for FLOTANT WTS within Scottish economy

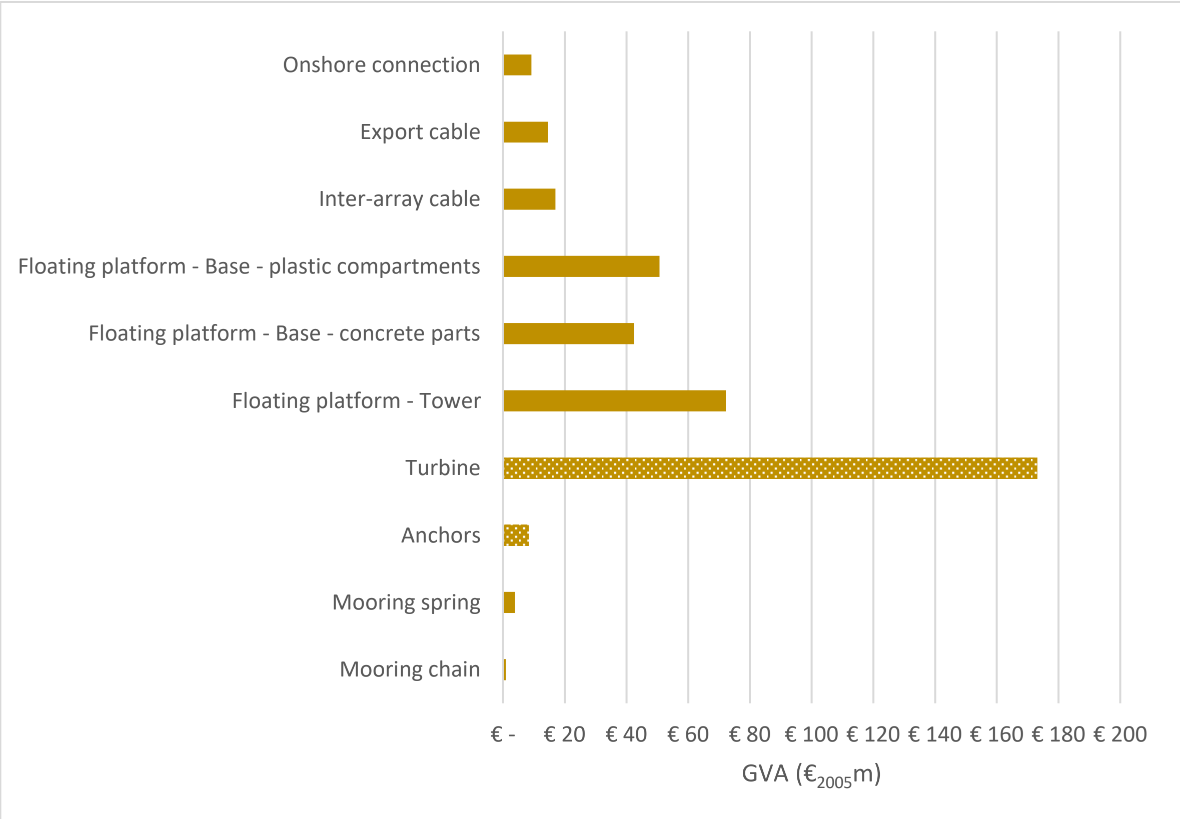

Figure 11: Discounted GVA for Production and Acquisition system for FLOTANT technology within Canary Islands

5.4 Jobs supported by category of spending

Similar to GVA generated, the 'production and acquisition' centre supports the maximum Scottish and Canary Islands job years followed by 'operations and maintenance' centre for FLOTANT technology. For FLOTANT WTS, it can be seen in Figure 12 and Figure 13 below that 'production and acquisition' centre supports the largest number of job years in both regions for FLOTANT technology. The 'operations and maintenance' also supports a large proportion of the total job years in both regions.

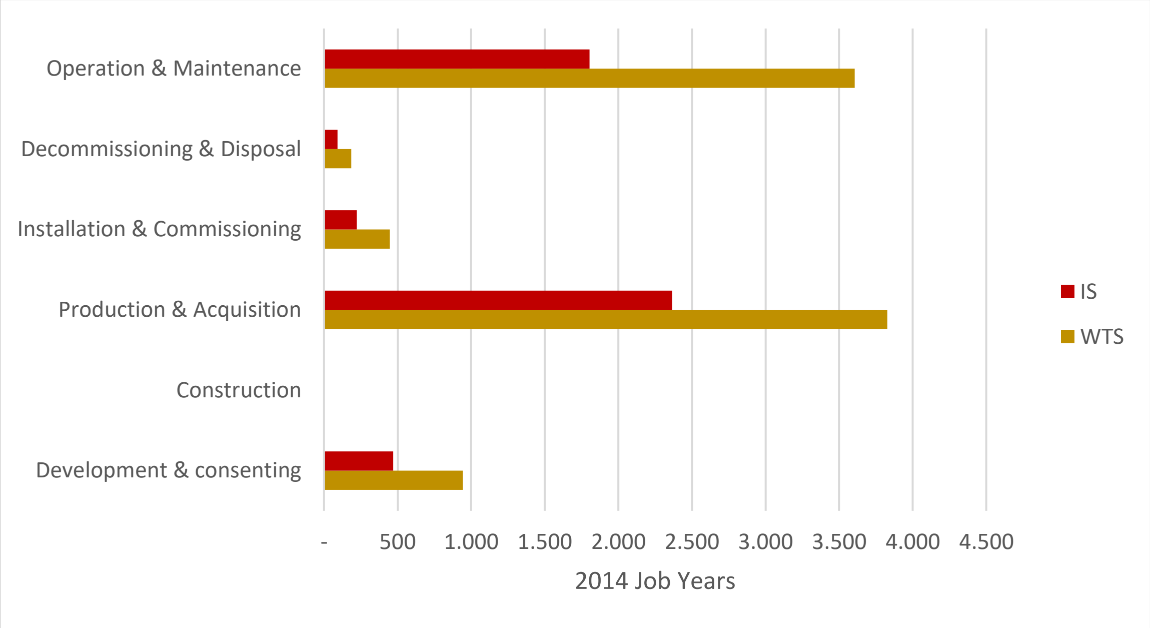

Figure 12: Undiscounted job years supported by category of spending for FLOTANT technology within Scottish economy

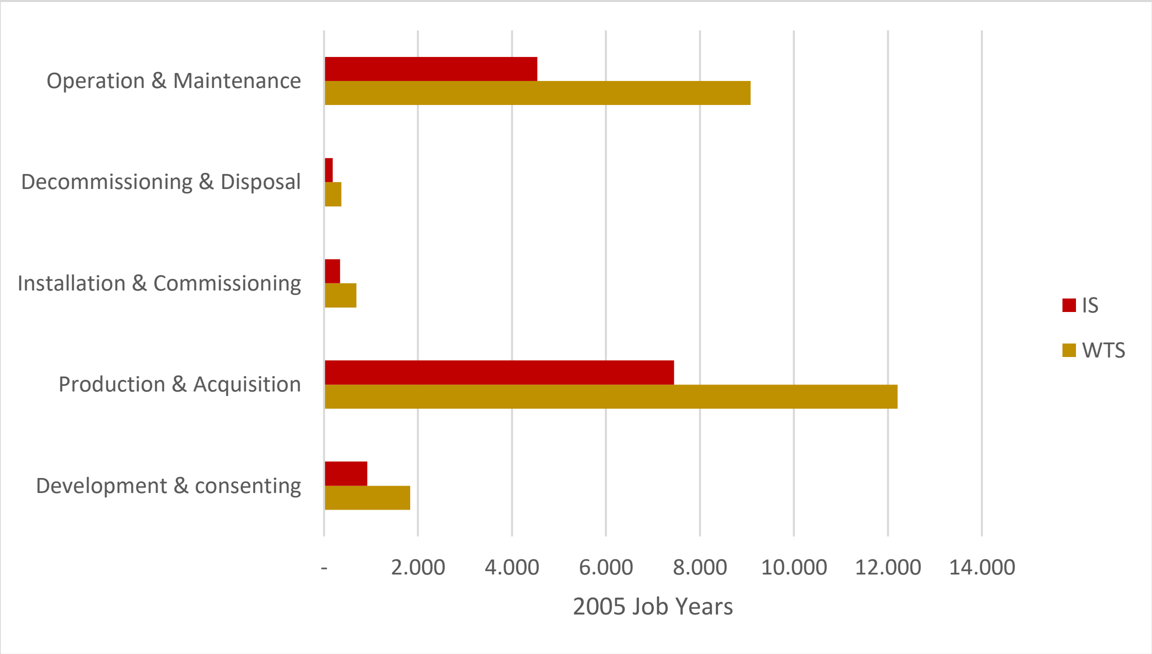

Figure 13: Undiscounted job years supported by category of spending for FLOTANT technology within Canary Islands

Under the production and acquisition system, the turbine system alone supports the largest individual share of job years for both the regions. In its absence, it is the floating platform component (Base concrete parts + tower) that supports the largest share of jobs – 1,311 (596 for Base and 715 for Tower) and 3,336 (972 for Base and 3,144 for Tower) job years for Scotland and Canary Islands, respectively.

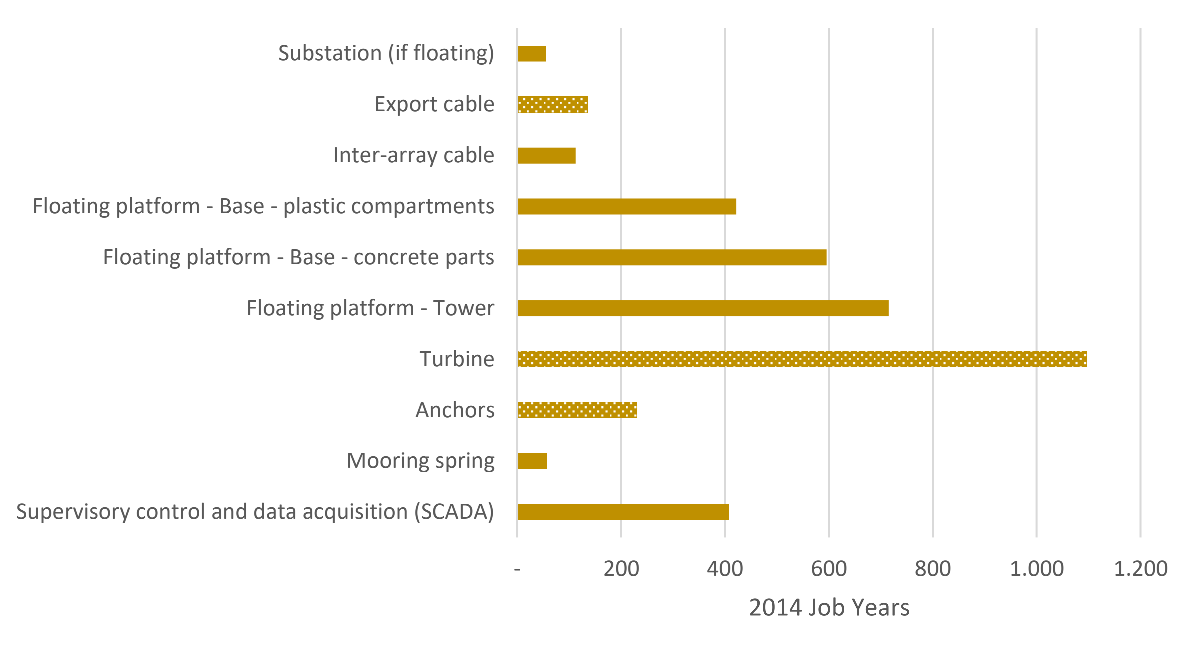

Figure 14: Undiscounted job years supported for Production and Acquisition system for FLOTANT technology within Scottish economy

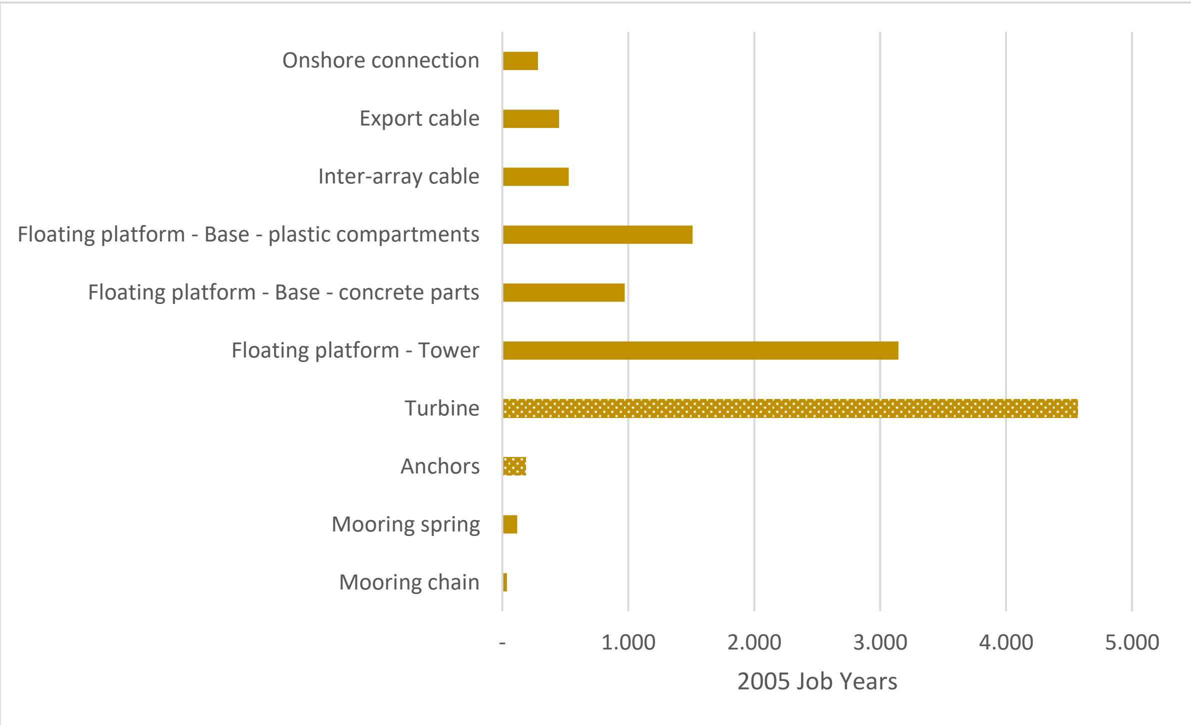

Figure 15 - Undiscounted job years supported for Production and Acquisition system for FLOTANT technology within Canary Islands

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5.5 Sectorial breakdown of GVA and jobs supported

A breakdown of the spend and GVA generated for sectors influenced by the deployment of FLOTANT WTS in West of Barra, Scotland and Gran Canaria, Canary Islands is provided below in Figure 16 and Figure 17.

For Scotland, 'water transport' has the highest associated GVA followed closely by 'manufacture of machinery and equipment n.e.c'. The turbine, which is the most expensive component, contributes to the 'Manufacture of machinery and equipment n.e.c' sector.

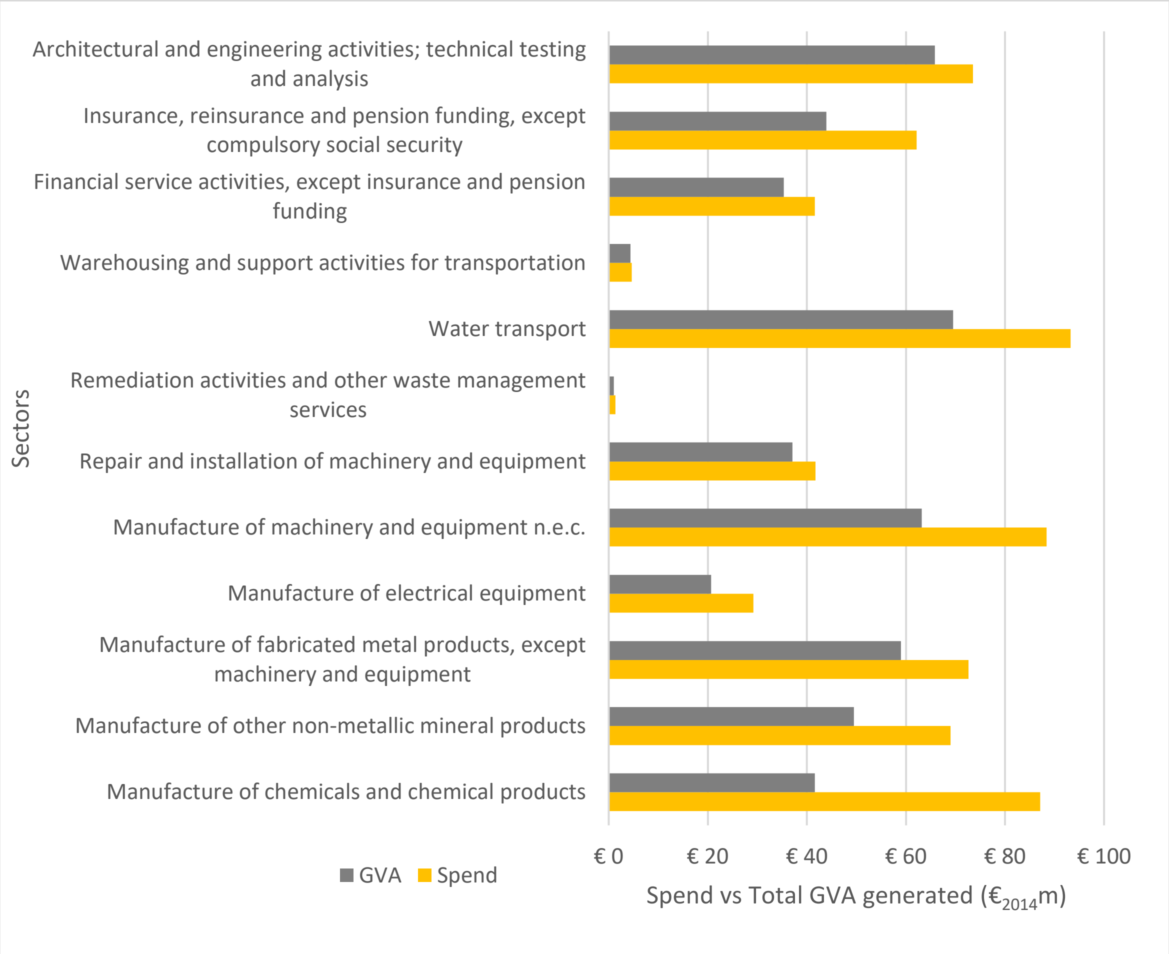

Figure 16: Discounted spend vs total GVA generated for various sectors for FLOTANT technology within Scottish economy

For Canary Islands, 'architectural and engineering activities; technical testing and analysis' has the highest associated GVA followed by 'manufacture of machinery and equipment n.e.c'. 'Architectural and engineering activities; technical testing and analysis' has major contributions from cost sectors under 'installation and commissioning', 'operation and maintenance' and 'decommissioning and disposal'. The turbine which is the most expensive component contributes to the 'Manufacture of machinery and equipment n.e.c' sector.

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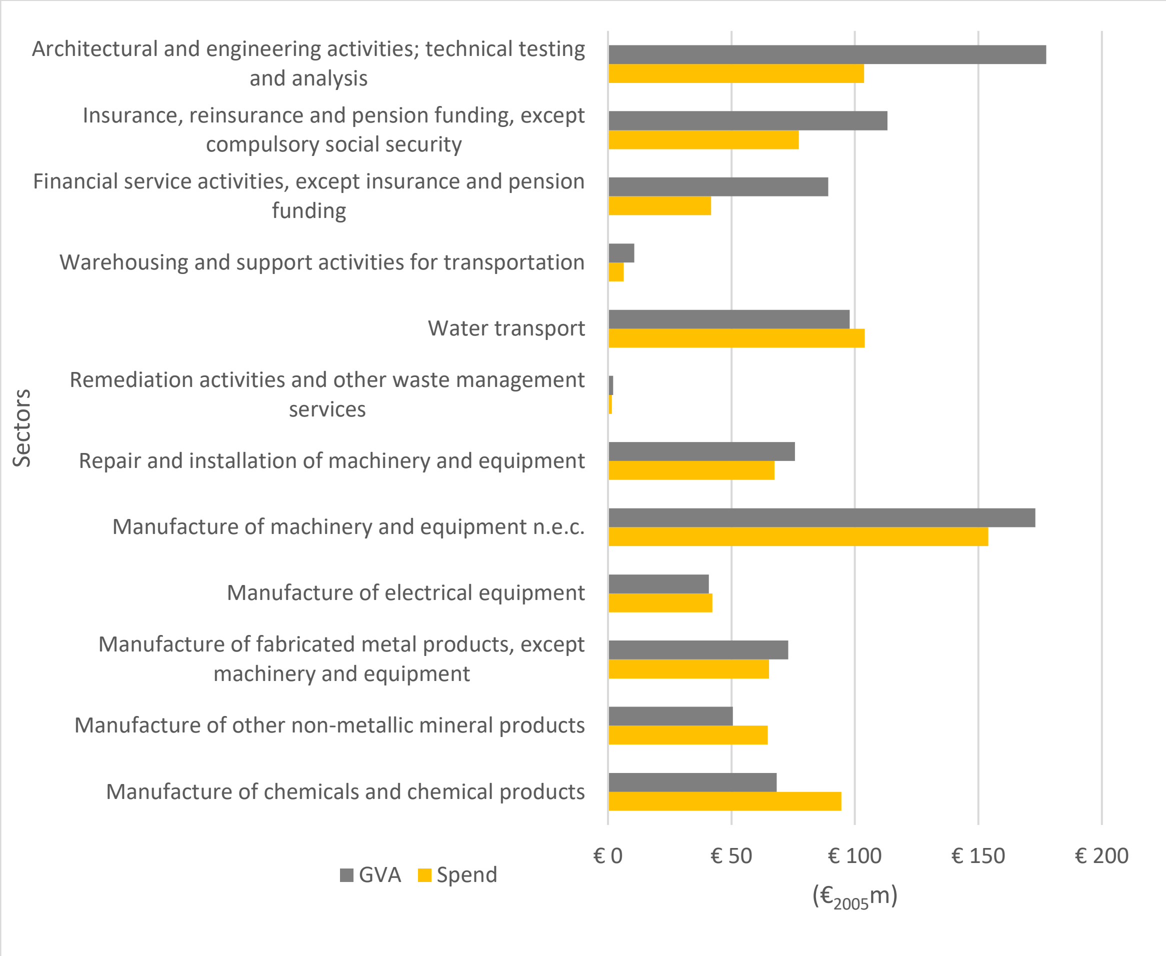

Figure 17: Discounted spend vs total GVA generated for various sectors for FLOTANT technology within Canary Islands

Figure 18 and Figure 19 presents the sectorial breakdown for undiscounted jobs supported from the deployment of the FLOTANT technology in West of Barra, Scotland and Gran Canaria, Canary Islands. The jobs supported for various sectors follow a similar trend like GVA generated but there are some differences seen. This difference in sectorial breakdown of GVA and jobs supported is due to the difference between the GVA and job effects used in the two locations.

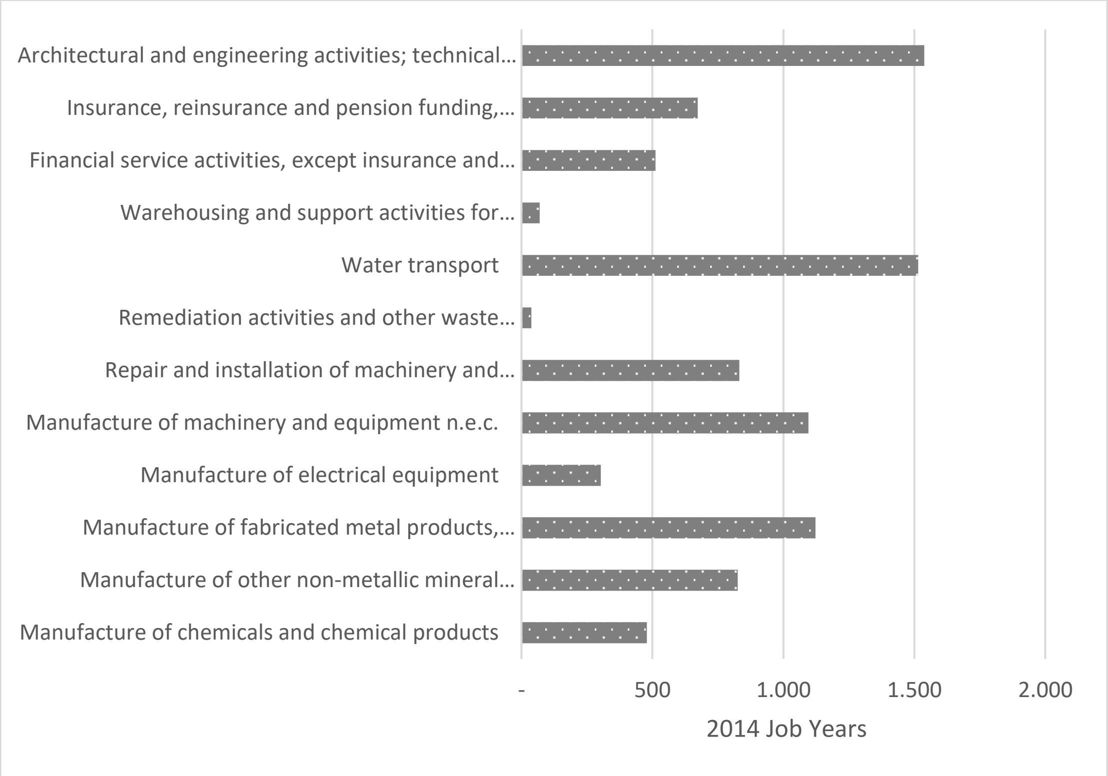

Figure 18: Undiscounted jobs supported for various sectors for FLOTANT technology within Scottish economy

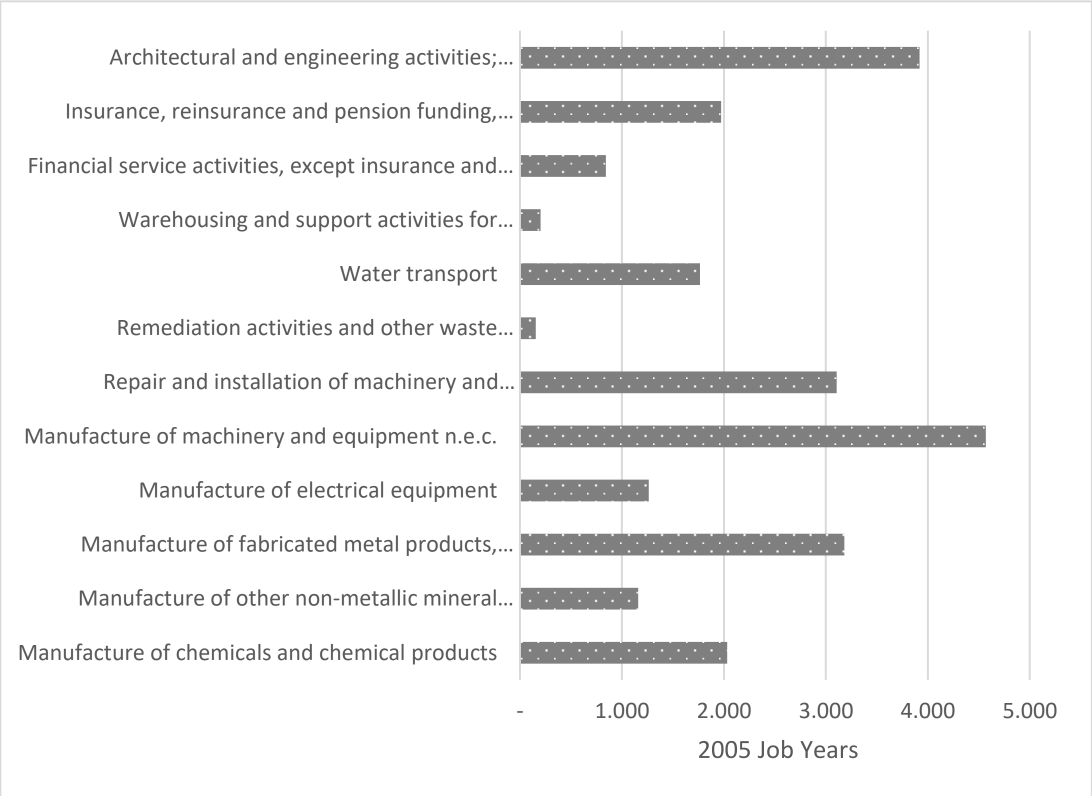

Figure 19: Undiscounted jobs supported for various sectors for FLOTANT technology within Canary Islands

5.6 Sensitivity studies

This section presents sensitivity analysis of GVA and jobs supported base on the three scenarios below:

i. Baseline leakage rate

ii. Low leakage rate

iii. High leakage rate

Detail leakage rates for each of the scenarios are given in Table 3.

5.6.1 Sensitivity of GVA benefit towards leakage rates

Figure 20 and Figure 21 presents the sensitivity of GVA results for the three variable leakage rate scenarios – baseline, low leakage, and high leakage for the FLOTANT WTS. It is seen that the values are highly sensitive to the leakage rate factors. As expected, the high leakage rates generate the lowest GVA since most of the GVA is leaked outside of the economy (this represents a weak local supply chain). On the other hand, low leakage rates generate the highest share of GVA, representing a strong supply chain. The baseline scenario for Scotland is dependent on the 2014 IO table and generates similar results as the high leakage rates indicating a greater need for investing in the Scottish FOW supply chain. Unlike the Scotland model, the baseline scenario for Canary Islands uses a constant leakage rate of 54.2%. For Canary Islands the baseline scenario generates comparatively higher GVA benefits that the Scottish results.

For the baseline and low leakage rates scenarios, 'Production and Acquisition' category has the highest share of GVA while for the high leakage rate scenario, 'operation and maintenance' which is more labor intensive is the biggest contributor.

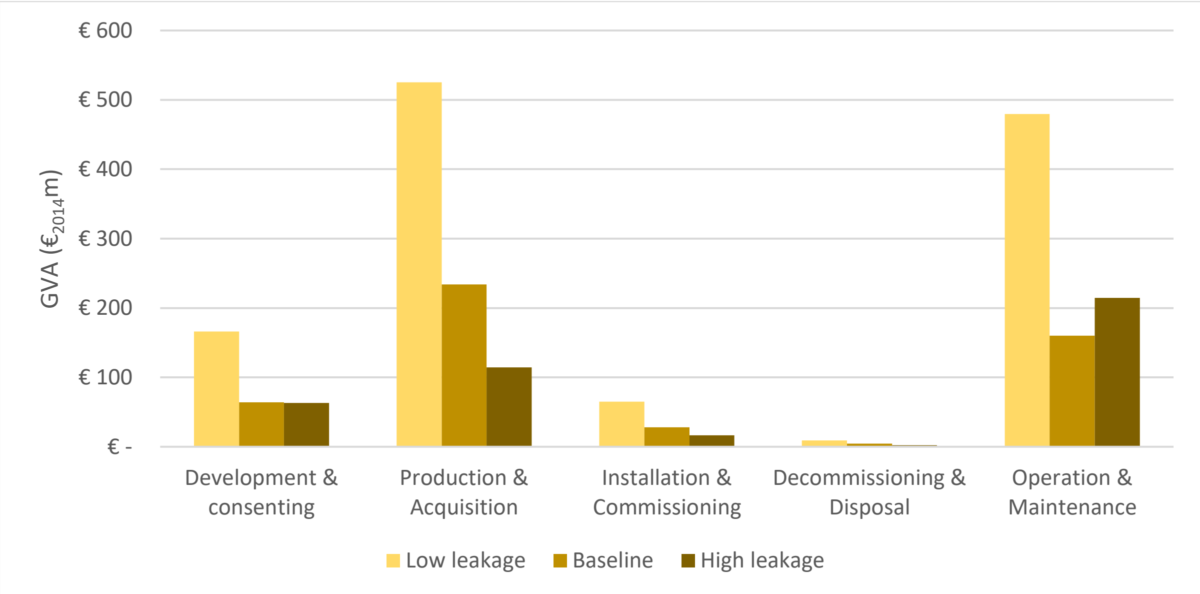

Figure 20: Sensitivity of GVA benefits towards leakage rate for FLOTANT WTS within Scottish economy

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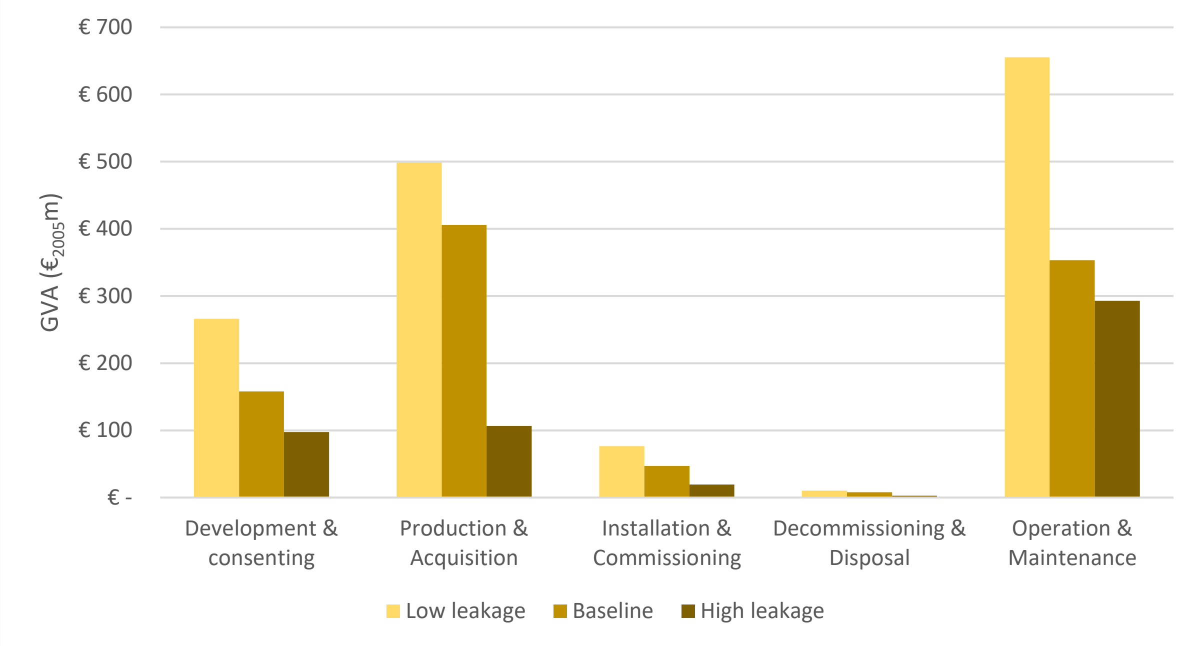

Figure 21: Sensitivity of GVA benefits towards leakage rate for FLOTANT WTS within Canary Islands

The sensitivity of GVA generated towards variable leakage rates for the innovation system FLOTANT IS are provided below in Figure 22 and Figure 23. The FLOTANT IS follows a similar trend as the FLOTANT WTS for both locations.

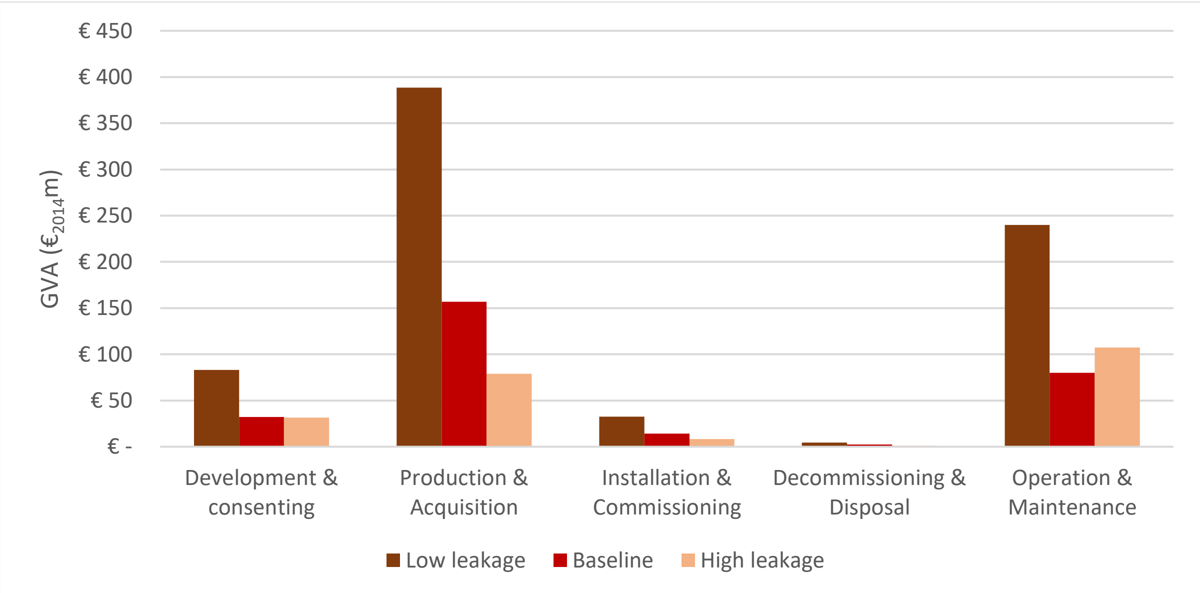

Figure 22: Sensitivity of GVA benefits towards leakage rate for FLOTANT IS within Scottish economy

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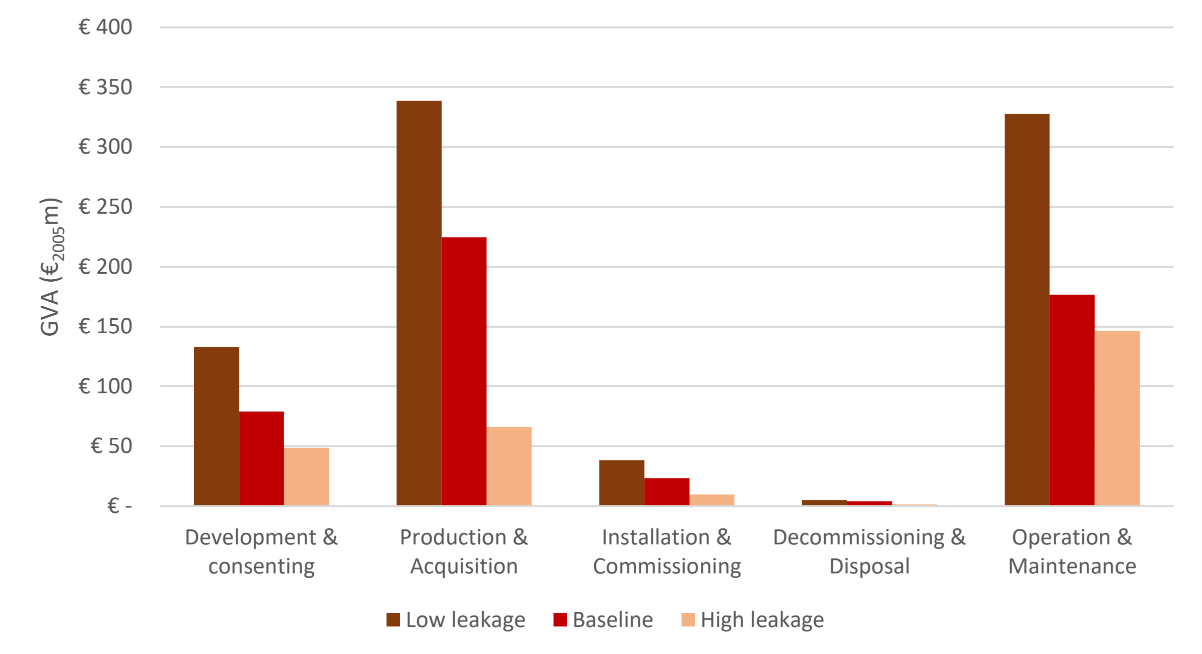

Figure 23: Sensitivity of GVA benefits towards leakage rate for FLOTANT IS within Canary Islands

5.6.2 Sensitivity of jobs supported towards leakage rates

Figure 24 and Figure 25 presents the sensitivity of jobs supported towards the three variable leakage rate scenarios – baseline, low leakage, and high leakage for the FLOTANT WTS and FLOTANT IS within the Scottish economy. Similar to the sensitivity of the GVA benefits, it is seen that the jobs supported are equally sensitive to the leakage rate factors. For both case studies, higher leakage rates along with the baseline scenario supports lower job years while lower leakage rates generate higher job years. For the baseline and low leakage rate scenarios, 'Production and Acquisition' category has the highest share of jobs supported while for the high leakage rate scenario, 'operation and maintenance' which is more labor intensive is the biggest contributor.

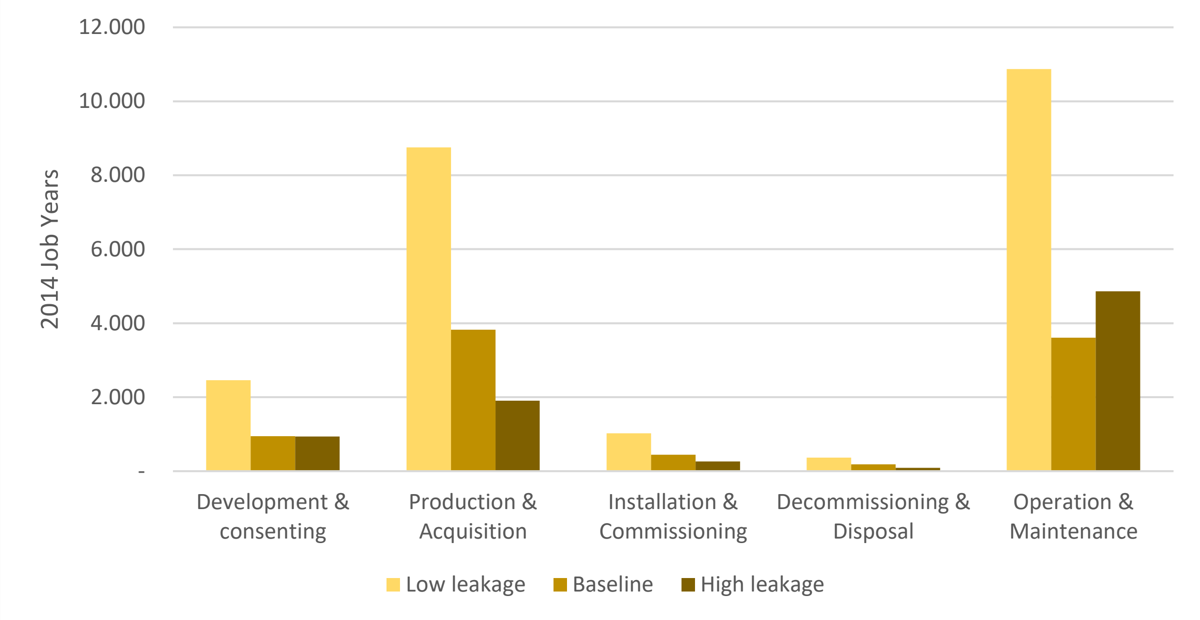

Figure 24: Sensitivity of jobs supported towards leakage rate for FLOTANT WTS within Scottish economy

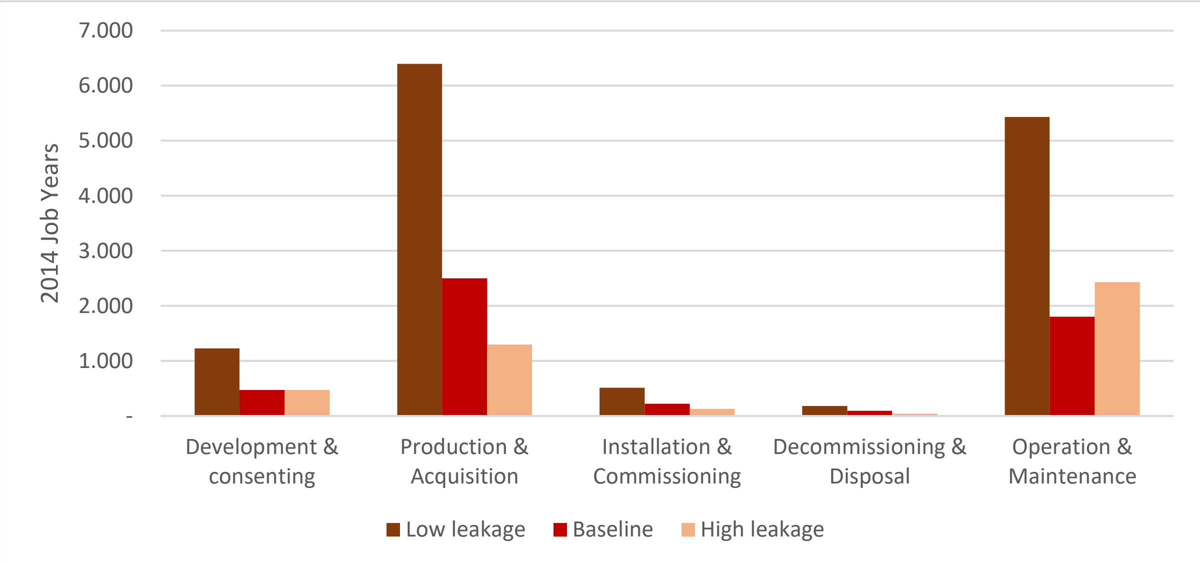

Figure 25: Sensitivity of jobs supported towards leakage rate for FLOTANT IS within Scottish economy

The sensitivity of jobs supported towards the three variable leakage rate scenarios – baseline, low leakage, and high leakage for the FLOTANT WTS and FLOTANT IS within Canary Islands are presented in Figure 26 and Figure 27 below. Similar to the sensitivity of the GVA benefits, it is seen that the jobs supported are equally sensitive to the leakage rate factors and follows a similar trend. For both case studies, higher leakage rates support lower job years while lower leakage rates generate higher job years. For the baseline and low leakage rate scenarios, 'Production and Acquisition' category has the highest share of jobs supported while for the high leakage rate scenario, 'operation and maintenance' has the biggest contributor.

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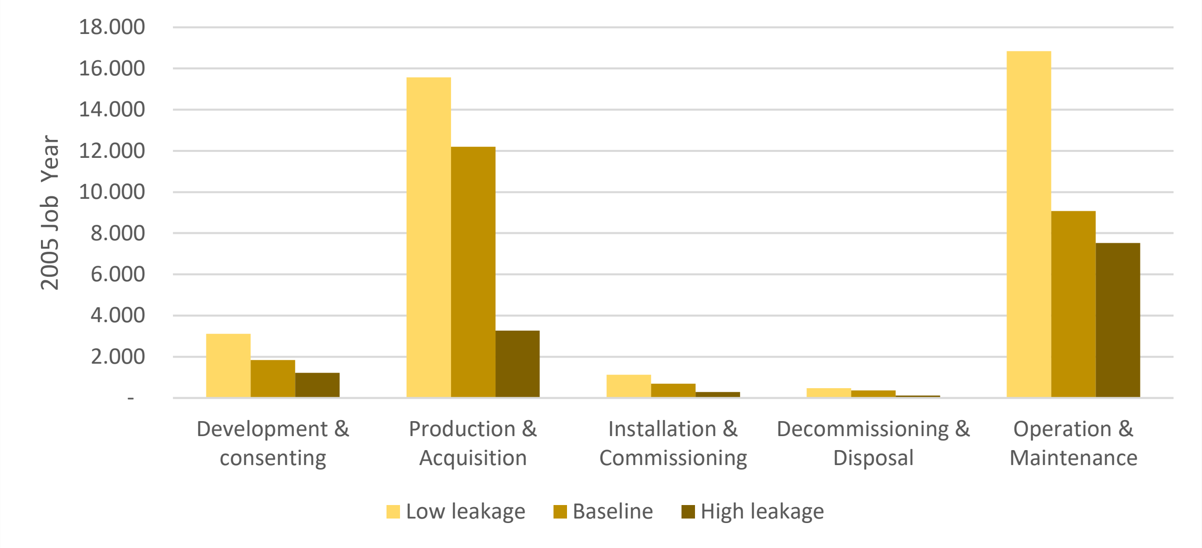

Figure 26: Sensitivity of jobs supported towards leakage rate for FLOTANT WTS within Canary Islands

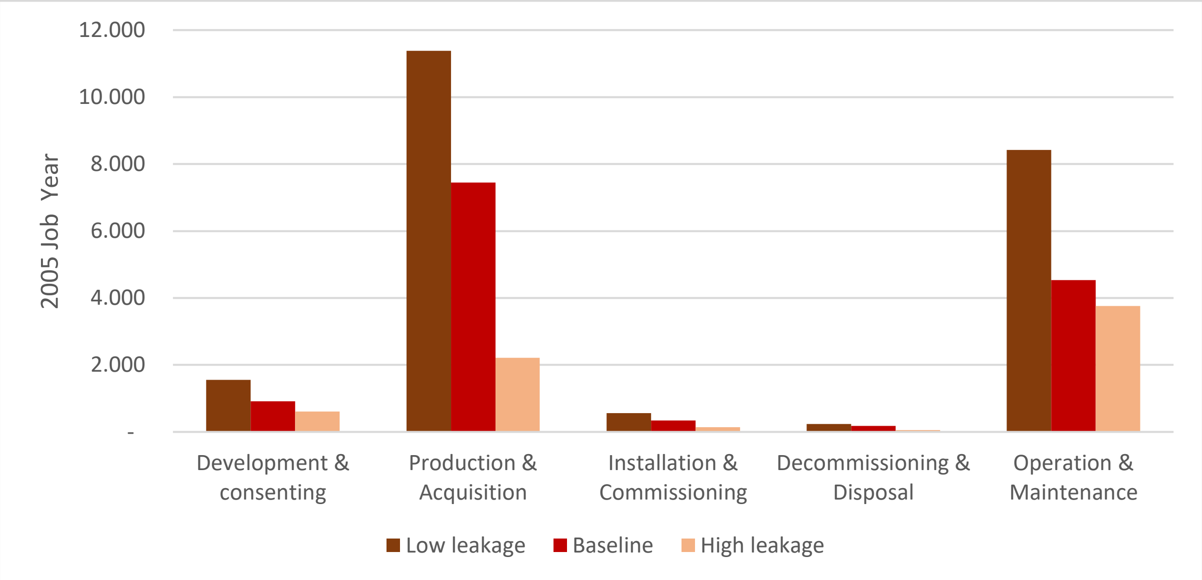

Figure 27: Sensitivity of jobs supported towards leakage rate for FLOTANT IS within Canary Islands

6 Summary of results

The FLOTANT socio-economic analysis aims to complement the LCOE analysis with insights of the potential economic benefits from the deployment of the FLOTANT project. The socio-economic analysis for FLOTANT has been undertaken using GVA and jobs metrics, which are popular metrics employed by policymakers to understand the economic effects derived from the deployment of particular technologies. This report introduces the methodology behind the socio-economic analysis of FLOTANT and presents Type II results of the GVA benefits and jobs supported in Scotland and Canary Islands. The GVA analysis is conducted for a 600 MW FLOTANT wind farm in the Canary Islands and Scotland, considering two case studies: FLOTANT WTS, which represents the entire FLOTANT offshore wind farm and the FLOTANT IS, which represents just the innovative aspects of the FLOTANT offshore wind farm (the barge, moorings, dynamic cables, SCADA and floating substation).

A summary of the results is presented in Table 7 below.

Table 7: Summary of type II results for a 600 MW wind farm of the FLOTANT technology under a baseline leakage rate scenario

	Scottish model (2014 values)		Canary Islands model (2005 values)	
	GVA (€m)	Job Years	GVA (€m)	Job Years
FLOTANT WTS	491	9,010	972	24,200
FLOTANT IS	276	4,950	508	13,400

This study found that the economic benefits obtained are highly sensitive to the inputs and assumptions. The key inputs and assumptions that effect the results were found to be:

- Case studies: Across all scenarios, the economic benefit from the FLOTANT IS is comparatively lower (almost half). This is because only around 50% of the CAPEX and OPEX for the FLOTANT array are attributed to the IS subsystems.
- Project timeline: The annual GVA and jobs supported distribution follow the trend of the project timeline i.e. the majority of GVA generated and jobs supported occur during the initial 6 years for project mobilisation.
- Leakage rates: It is seen that the results obtained are highly sensitive to the assumed leakage rates, as shown in the sensitivity analysis. The use of an aggregated leakage rate for all sectors in the Canary Islands model is seen as a source of significant uncertainty.

One of the major sources of uncertainty, and the reason the results of the Scottish and Canary Island's studies are not directly comparable, is the lack of industry specific leakage rates in the most recent Canary Islands input output table (see section 4.3). In absence of this data this study used an aggregated leakage rate across all industries in the Canary Islands, which creates significant uncertainties in the level of spend that is retained within the Canary Island's economy, and the associated GVA and Jobs. Additionally the most recent Input Output tables for the Canary Islands are almost 20 years out of date, and may not accurately reflect the current status of the supply chain.

While the results of this study do contain uncertainties, they present a broad range of scenarios and analysis of the socioeconomic benefits of deploying the FLOTANT technology. This should cover a wide range of potential future outcomes, and will be valuable to the consortium regarding future scenarios for the FLOTANT technologies deployment.

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Appendix

A.I Sectorial breakdown & categories of spending [15]

Table 8: Sectorial breakdown and categories of spending

SIC code	Category of spending	Description
	Development and consenting	
M71	Project management	Architectural and engineering activities; technical testing and analysis
M71	Consenting services	Architectural and engineering activities; technical testing and analysis
M71	Surveys	Architectural and engineering activities; technical testing and analysis
K65	Insurance	Insurance, reinsurance and pension funding, except compulsory social security
K64	Margins and contingencies	Financial service activities, except insurance and pension funding
	Construction	
K64	Construction supervision costs	Financial service activities, except insurance and pension funding
M71	Engineering and consultancy/FEED	Architectural and engineering activities; technical testing and analysis
M71	Certification	Architectural and engineering activities; technical testing and analysis
	Production and Acquisition	
C27	Supervisory control and data acquisition (SCADA)	Manufacture of electrical equipment
C25	Mooring spring	Manufacture of fabricated metal products, except machinery and equipment
C25	Anchors	Manufacture of fabricated metal products, except machinery and equipment
C28	Turbine	Manufacture of machinery and equipment n.e.c.
C25	Floating platform - Tower	Manufacture of fabricated metal products, except machinery and equipment
C23	Floating platform - Base - concrete parts	Manufacture of other non-metallic mineral products
C20	Floating platform - Base - plastic compartments	Manufacture of chemicals and chemical products
C27	Inter-array cable	Manufacture of electrical equipment
C27	Export cable	Manufacture of electrical equipment
C27	Substation (if floating)	Manufacture of electrical equipment
	Installation and Commissioning	
H50	Support Services Infrastructure	Water transport
H50	Offshore Logistics	Water transport
H52	Port Charges	Warehousing and support activities for transportation
H50	Installation of components	Water transport
M71	Commissioning and Testing	Architectural and engineering activities; technical testing and analysis
	Decommissioning and Disposal	
H50	Decommissioning	Water transport

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E39	Waste management	Remediation activities and other waste management services
H50	Site clearance	Water transport
M71	Post monitoring	Architectural and engineering activities; technical testing and analysis
	Operation and Maintenance	
K65	Insurance	Insurance, reinsurance and pension funding, except compulsory social security
M71	Project management	Architectural and engineering activities; technical testing and analysis
H50	Vessel operations	Water transport
C33	Maintenance service	Repair and installation of machinery and equipment

A.II Proportion of CAPEX and OPEX spend by cost centre

Table 9: Proportion of CAPEX OPEX spend by cost centres and categories of spending

SIC code	Category of spending	% of CAPEX spend	Description
	Development and consenting	14.11%	
M71	Project management	2.49%	Architectural and engineering activities; technical testing and analysis
M71	Consenting services	2.49%	Architectural and engineering activities; technical testing and analysis
M71	Surveys	0.41%	Architectural and engineering activities; technical testing and analysis
K65	Insurance	1.66%	Insurance, reinsurance and pension funding, except compulsory social security
K64	Margins and contingencies	7.05%	Financial service activities, except insurance and pension funding
	Construction	0.00%	
K64	Construction supervision costs	0.00%	Financial service activities, except insurance and pension funding
M71	Engineering and consultancy/FEED	0.00%	Architectural and engineering activities; technical testing and analysis
M71	Certification	0.00%	Architectural and engineering activities; technical testing and analysis
	Production and Acquisition	76.37%	
C27	Supervisory control and data acquisition (SCADA)	6.82%	Manufacture of electrical equipment
C25	Mooring spring	1.49%	Manufacture of fabricated metal products, except machinery and equipment
C25	Anchors	0.00%	Manufacture of fabricated metal products, except machinery and equipment
C28	Turbine	3.79%	Manufacture of machinery and equipment n.e.c.
C25	Floating platform - Tower	23.61%	Manufacture of fabricated metal products, except machinery and equipment
C23	Floating platform - Base - concrete parts	11.96%	Manufacture of other non-metallic mineral products
C20	Floating platform - Base - plastic compartments	9.80%	Manufacture of chemicals and chemical products
C27	Inter-array cable	10.85%	Manufacture of electrical equipment
C27	Export cable	2.98%	Manufacture of electrical equipment
C27	Substation (if floating)	3.61%	Manufacture of electrical equipment
	Installation and Commissioning	6.61%	
H50	Support Services Infrastructure	0.93%	Water transport
H50	Offshore Logistics	0.93%	Water transport
H52	Port Charges	1.00%	Warehousing and support activities for transportation

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H50	Installation of components	3.32%	Water transport
M71	Commissioning and Testing	0.44%	Architectural and engineering activities; technical testing and analysis
	Decommissioning and Disposal	2.91%	
H50	Decommissioning	0.73%	Water transport
E39	Waste management	0.73%	Remediation activities and other waste management services
H50	Site clearance	0.73%	Water transport
M71	Post monitoring	0.73%	Architectural and engineering activities; technical testing and analysis
	Operation and Maintenance	*100.00%*	
K65	Insurance	25.00%	Insurance, reinsurance and pension funding, except compulsory social security
M71	Project management	25.00%	Architectural and engineering activities; technical testing and analysis
H50	Vessel operations	25.00%	Water transport
C33	Maintenance service	25.00%	Repair and installation of machinery and equipment