ELEMENT: SOCIOECONOMIC ANALYSIS PLAN

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Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 815180.

1. INTRODUCTION

A Funding Grant was awarded from the European Union's Horizon 2020 research and innovation programme to develop and validate an innovative tidal turbine control system, using the tidal turbine itself as a sensor, to deliver a step change improvement in the performance. This will demonstrate Effective Lifetime Extension in the Marine Environment for Tidal Energy (ELEMENT), driving the EU tidal energy sector to commercial reality. This was in response to the call LC-SC3-RES-11-2018: Developing solutions to reduce the cost and increase performance of renewable technologies.

This document is produced to provide the detailed plan for ELEMENT WP12 (Socioeconomic Impact Assessment), and is also submitted to satisfy deliverable D12.1 of the ELEMENT project.

The document is structured as follows:

- Section 2 summarises the findings of our initial literature review
- Section 3 maps out the various stakeholders with a role/interest in the tidal energy industry
- Section 4 sets out our detailed plan for completing the remainder of WP12.

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2. LITERATURE REVIEW

This section provides a brief review of literature relevant to assessing the socioeconomic impacts of tidal stream energy in Europe. As the future economic impacts associated with this technology will primarily be driven by the extent to which generating capacity is rolled out in Europe and elsewhere, we include discussion on the estimates of total tidal stream resource and projections for installed capacities.

Global potential of tidal energy

The total power associated with the Earth's tides is vast. The World Energy Council (2016) cites Charlier & Justus (1993), who estimated the **total global tidal power resource** at approximately 3 terawatts (TW); a more recent paper by Wang et al (2012) put this figure at 3.5 TW.

While only a fraction of this total potential could practically be extracted, the addressable global resource is still very large. However, in the absence of comprehensive local resource assessments, estimates for ***potential* global generating capacity** vary widely: from about 40 GW to 600 GW, as shown in the table below[1]. Some of the variability may be explained by analysts using different assumptions regarding the capabilities of tidal device technologies: for example, regarding the minimum/maximum depths and minimum tidal flow speeds.

Source	TWh per annum estimate	Total potential capacity
Black & Veatch (2004)	153 TWh	*50 GW*
IEA-OES (2009)	800 TWh	*261 GW*
Mission d'étude sur les énergies marines renouvelables (2013)		50-100 GW
RenewableUK (2014)		120 GW
Sabella (2016)		75-100 GW
Indicta and M Prime (2017)		75-100 GW
Atlantis (2018)		99 GW
Minesto (2018)		600 GW
Wood (2019)		41 GW

Table 1 –Extractable global tidal resource estimates

In terms of ***deployed* tidal stream capacity**, there are again large variations in the available forecasts. Key recent estimates for cumulative global installed capacity include the following:

- Vivid Economics (2019) forecasts over 50 GW of global deployed tidal stream capacity by 2050
- OREC (2018) estimated global deployed tidal stream capacity of 3.7 GW by 2030 and 93 GW by 2050
- Ocean Energy Forum (2018) estimated 2.4 GW deployed globally by 2030 and 9.3 GW by 2050 under their optimistic scenario
- IEA (2012) – cited in OREC (2018) – projected a total tidal stream capacity of 101 GW by 2050, under the 'high renewables' variant of their 2 degree scenario

[1] Some resource estimates are given in TWh per annum, rather than the potential total generating capacity; where this is the case, we have derived an implied capacity figure by assuming an average capacity factor of 35%, for ease of comparison. These implied capacity estimates are given in *italics*.

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- Carbon Trust (2011) provided scenarios in which installed capacity reaches c. 12 GW by 2050 in the Medium scenario and 52 GW in the High scenario
- Ernst & Young/Black & Veatch (2010) estimated 14.4 GW cumulative global tidal stream capacity by 2050 under their base case, within a range of 5.5GW (low case) to 24.4 GW (high case).

Some analysts have also developed estimates for the potential **economic impact** of the global tidal stream industry, in terms of sales/turnover:

- Vivid Economics (2019) estimates global sales in tidal stream energy (excluding the UK) of £20 billion p.a. by 2050
- Wood (2019) estimates the global tidal stream equipment market value at EUR117 billion, and annual service revenues at approximately EUR17 billion
- Carbon Trust (2011) projected a cumulative global turnover for tidal stream energy technology of up to £126 billion by 2050, with annual sales reaching £8 billion per annum by 2050 (in their High scenario)[2].

European-level estimates of socioeconomic impacts

At a European level, Ocean Energy Forum (2018) provides an indication of the total investment in European tidal stream projects by 2030: under their optimistic scenario they estimate EUR12.5 billion investment in ocean energy in Europe, of which about three-quarters (EUR9.4 billion) is in tidal stream energy.

Regional/national-level estimates of socioeconomic impacts

Various studies have sought to quantify the potential economic impacts of tidal stream energy at national or regional levels. Here we summarise various analysts' findings for three key tidal energy markets: Canada, France and the UK.

Canada

There has long been an interest in harnessing the power of the tides in Canada, which has some of the largest tidal resources in the world.

Regarding the potential economic benefits for Canada, OERA (2015) notes that "*The lack of an established global supply chain represents an opportunity for prospective suppliers, whether in Canada, the EU or elsewhere*", and estimates that 60-70% of the value of tidal stream development would be open to an emerging supply chain (the balance being held by established large providers of turbine components and marine cable). The report finds that "*most of this 60-70% consists of goods and services that would or could be supplied at or near the tidal development site. These include a range of environmental assessment and planning services, facilities and vessel construction, device assembly and installation, and cable installation. Local operation and maintenance expenditures would exceed 80% of total annual operations and maintenance (O&M) costs*." The authors estimate that the tidal stream market could be worth Can$4 billion to Can$5 billion to Canadian suppliers over the period to 2050, on an assumption of Canadian suppliers competing in 10% of a global market worth Can$900 billion to Can$1,000 billion, and capturing a 5% market share. The estimate of the total global market size is derived from Carbon Trust (2011), which estimated that marine energy industry cumulative sales to 2050 could reach £460 billion (c. Can$1,000 billion at 2015 exchange rates).

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[2] The same report appears to be the original source for the £76 billion figure quoted in some sources as the size of the global ocean energy market. However, we note that Carbon Trust's £76 billion estimate referred to the share of the ocean energy market which could be captured by UK companies; their total global market size estimate for ocean energy (wave plus tidal) was up to £460 billion (cumulative to 2050).

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At province level, OERA (2015) estimates that 300MW of tidal stream energy deployment in Nova Scotia could lead to a cumulative GDP impact of Can$1.7 billion over the period to 2040, with an average annual GDP impact of Can$43 million p.a., supporting an average of 880 Full Time Equivalent (FTE) jobs each year (22,000 job-years over the period).

France

One indication of the potential economic impacts of tidal stream industry for France is given in E-cube (2013), which is cited in Mission d'étude sur les énergies marines renouvelables (2013). This study, conducted for DREAL Basse Normandie, estimated that 9 FTE jobs per MW could be created in the installation phase of tidal stream projects (3 direct plus 5.9 indirect), with a further 0.65 FTE jobs per MW throughout the operations and maintenance phase. The cumulative economic benefits to France are estimated at between EUR0.9 million and EUR1.5 million per MW (assuming a total 3.3 GW installed capacity over 30 years).

In a scenario in which 500 MW is deployed by 2030, with production of 100 MW per year, E-cube estimated that the tidal stream industry would create 1,250 direct and indirect jobs in France, with 140 of these dedicated to exports, and potentially 875 located in Basse Normandie. A further 600 jobs would be created in France through 'induced' effects (through direct and indirect employees spending their wages in local economies).

In a more optimistic scenario in which 3.2 GW is deployed by 2030, with production of 300 MW per year, the consultants estimated that this would create 5,000 direct and indirect jobs in France, including 550 associated with exports.

UK

Focusing on opportunities to the UK from the export of technology and services, Vivid Economics (2019) found that tidal stream industry exports could contribute over £540 million p.a. in Gross Value Added (GVA) to the UK, supporting nearly 5,000 jobs by 2050.The authors considered that *"The UK could plausibly ramp up turbine exports over the next 15 years to capture 20% of the market, comparable to Denmark's market share in offshore wind".*

OREC (2018) includes estimates of the GVA economic impacts for the UK associated with the tidal stream industry, from both domestic projects and exports, and considers the UK government investment (in terms of revenue support subsidies) which would be required in order to facilitate the projected growth and cost reductions. The report found that the tidal stream energy industry could generate a net cumulative benefit to the UK by 2030 of £1.4 billion, consisting of £1.6 billion GVA from the domestic market plus £1.1 billion GVA from exports, offset by £1.3 billion of revenue support. The projections assumed a cumulative installed capacity of 910 MW by 2030 in the UK (out of 3.7 GW globally). This would support a total of almost 4,000 UK jobs by 2030.

Looking further out[3], OREC (2018) estimates that the GVA for the UK of the tidal stream industry could reach £28 billion cumulatively by 2050 (68% of which from exports), with an annual value of £1.7 billion p.a. by 2050, supporting more than 23,000 FTE jobs. The analysis applies multipliers to reflect the indirect and induced economic effects associated with different types of expenditure in UK projects: a GVA multiplier of 2.34 for capital expenditure, 1.96 for operational expenditure and 1.84 for development expenditure.

Regeneris and Cardiff University (2013) looked specifically at the potential economic impacts for Wales of growth in marine energy, considering scenarios ranging from 30 MW to 750 MW of installed tidal stream

[3] Using the underlying projections which were summarised in OREC (2018), kindly supplied by OREC for this study

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capacity in Wales. Their analysis found that the development and construction of tidal stream projects could contribute £38 million to £611 million in GVA for Wales (cumulative), at an average of £1.28 million GVA per MW in the low capacity scenario or £0.81 million per MW in the high capacity scenario. Employment effects ranged from 1,060 job-years to 17,150 job-years. In the operational phase, the authors estimated that tidal stream would contribute £1.2 million to £13.2 million p.a. in GVA, supporting 25 to 310 FTE jobs in Wales.

Carbon Trust (2011) considered the potential market shares for UK suppliers in various parts of the global tidal stream industry supply chain. Based on the UK's strength in marine renewables, the report considered that UK suppliers could capture a substantial share of the tradable global market[4], with potential market shares ranging from c. 40% for core device components such as the prime mover to 2% for components with multi-industry uses where the UK does not have unique capabilities, such as generators. Under a High scenario of 9 GW installed capacity in the UK (out of 52 GW globally) by 2050, they estimated that the tidal stream industry could contribute a Present Value of c. £5 billion in UK GVA over the period to 2050, by when the industry could be supporting nearly 20,000 UK jobs – with about 70% of these jobs associated with exports.

Offshore Valuation Group (2010) looked at the potential for various offshore energy technologies serving the UK market. The group estimated the UK's practical tidal stream resource at 33 GW, and found that, by 2050, UK tidal stream projects could be supporting c. 2,000 direct jobs[5] in scenario 1 (2 GW deployed capacity by 2050), 8,000 direct jobs in scenario 2 (9 GW), or 19,000 direct jobs in scenario 3 (21 GW).

Supply chain impacts

In their estimated potential of £540 million p.a. in UK GVA from tidal stream industry exports by 2050, Vivid Economics (2019) found that the two largest components of this would be O&M services (£200 million) and turbines (£200 million), The authors note that *"It is likely that, at least in the initial years, these two activities will be highly linked. A turbine developer will also likely be required to organise, perform, or train specialists to undertake, O&M services."* Cables/connections and installation activities could each contribute a further £50 million p.a. in GVA for the UK. The authors found that there are 22 tidal stream device developers in the UK, and noted that UK companies are currently leading the world in demonstrating that tidal technology is commercially viable. They also stated that tidal stream companies from elsewhere are choosing to locate in the UK to take advantage of the momentum, opportunities, and tidal potential available. However, they warn that this position should not be taken for granted: *"The market for tidal stream technology is immature, and therefore the UK's competitive position is not yet established. France, Canada, and Japan currently pose the greatest competition to the UK and have companies undertaking the design and manufacture of tidal turbines. Given the immature nature of the market and low levels of current trade, robust market shares are not yet established."*

Regarding the current levels of supply chain involvement in a European tidal stream project, EnFAIT (2019) reports that *"The array itself is now supplied with 100 per cent EU-manufactured content, bringing the number of EU supplier countries up from four to 14. These suppliers are not limited to countries along the Atlantic shoreline (where Europe's tidal resource predominantly lies) but are drawn from across the European land mass."* The project, led by Edinburgh-based Nova Innovation, reports a total of 60 Scottish company in its supply chain.

In France, Observatoire des Énergies de la Mer (2019) found that 29% of the 200 surveyed French marine energy supply chain companies had some participation in tidal stream, but this was primarily in SMEs and start-ups, with tidal stream accounting for just 6% of marine energy employment (fixed and floating

[4] Carbon Trust (2011) estimated that £93 billion of the £126 billion cumulative tidal stream turnover to 2050 would be accessible to UK suppliers
[5] Including jobs involved in the construction, installation and operation and maintenance of UK projects, but not the wider supply chain impacts, nor jobs associated with exports of UK technology and services

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offshore wind accounted for 87% of employment between them). The same survey found that respondent companies had invested EUR6.7 million in tidal stream technology in 2018.

The European Marine Energy Centre (EMEC) in Orkney supports the testing of marine energy devices, and has hosted several tidal stream energy developers. While there is no apportionment specific to tidal stream, EMEC (2019) reports that the centre's activities contributed £285 million to UK GVA over the period 2003-2017, with £98 million for the local economy in Orkney. It estimates that it has supported an average of 282 FTE jobs in the UK over the period (110 in Orkney). The sources of economic impact include: EMEC's infrastructure expenditures, direct employment at EMEC, local supply chain impacts from EMEC's operations, and business tourism visits to Orkney associated with EMEC. The bulk of the estimated impacts comes from the GVA associated with the development of devices which were tested at EMEC (£208 million cumulative GVA for the UK, £52 million for Orkney). A further spillover benefit for Orkney has been the improvement of port infrastructure: *"Although the pier extension at Hatston was funded to support the marine renewable industry in Orkney, the development has made it possible for Orkney to host some of the largest cruise ships. Whilst large cruise ships can anchor out in sheltered bays and tender passengers ashore, cruise liners prefer to moor alongside."*

OREC (2018) provides a breakdown of how the future economic benefits from the UK's tidal stream industry may be distributed across the supply chain. As shown in Table 2 below, they anticipate that the production of the tidal devices will account for the largest share of GVA creation (37%), while O&M activities will account for the largest share of jobs supported (31%) in that year.

Task	UK GVA in 2030 £ million	GVA %	UK FTE jobs supported in 2030	Jobs %
Tidal platform	112	37%	1,210	30%
Foundations/moorings	16	5%	160	4%
Electrical	38	13%	460	12%
Installation	19	6%	450	11%
Other capex	35	12%	330	8%
O&M	69	23%	1,240	31%
Development	15	5%	130	3%
Total	**304**	100%	**3,970**	100%

Table 2 – UK GVA and jobs associated with tidal stream industry in 2030 [source: OREC (2018)]

OREC (2018) notes that *"New jobs will be supported and will continue to be concentrated in distinct regions, and will grow primarily from existing UK industries where there is strong absorptive capacity, especially offshore wind, oil & gas, steel, and maritime, through companies diversifying into marine energy."*

BVG (2015) assessed the UK's supply chain for wave and tidal stream industries. The authors considered that UK suppliers could potentially win 25% of the value of non-UK projects, based on the experience of German and Danish wind industry suppliers. It highlighted significant supply chain opportunities for export in:

- Device and component / sub-system supply and related IP
- System engineering, including design, manufacture and integration
- Specialist skills & expertise, including in project development, installation and operations management.

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In their analysis of the economic impacts of tidal stream developments in Wales, Regeneris and Cardiff University (2013) estimated the split of GVA impacts across various broad industry sectors. In their high capacity (750 MW) scenario, the £611 million total GVA from tidal stream comprised £240 million in Manufacturing & Energy sectors, £152 million in Construction and Maintenance sectors, £91 million in Distribution, Transport and Comms sectors, and £128 million in Professional and Public Services sectors.

Carbon Trust (2011) considered marine energy systems to be split into five major components: the structure & prime mover, the power take-off, foundations & moorings, connection, installation process and O&M process. They considered the UK competitive advantage to be high or very high in almost all areas, given the state of development of the industry in the UK and capabilities in related areas such as oil & gas an offshore wind. The exception was the power take-off, where the authors considered that areas such as generators and transformers have multi-sector uses and are more likely to be dominated by established global suppliers such as ABB or Siemens.

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3. STAKEHOLDERS

In the following table we map out the various key stakeholder types with an interest in the development of tidal stream energy. We summarise their specific role or interest in the industry and provide a few examples of organisations relevant to the industry in France and the UK.

Type of stakeholder	Role/interest in the industry	Examples
Electricity consumers	Users of electrical power, provided by tidal stream and other sources Ensuring that they have reliable access to electricity, at an affordable cost Minimising the carbon emissions associated with their energy use	Domestic, commercial and industrial electricity consumers
Local residents	Accessing job opportunities associated with local tidal stream developments Ensuring that visual and environmental impacts associated with local tidal stream developments are minimal	Residents in the Morbihan department of Brittany Residents in Shetland Residents in Orkney
Local fishing industry and other marine users	Ensuring that local tidal stream developments do not constrain fishing and other marine uses, and do not present risks to navigation	Brittany-based fishermen (e.g. at Lorient and Etel) Les Pêcheurs de Bretagne Shetland-based fishermen Shetland Fishermen's Association
European Commission	Climate change leadership Nurturing tidal stream energy as a new source of clean electricity for Europe, helping to reduce carbon emissions Ensuring that Europe maximises the industrial benefits associated with domestic and exported tidal stream technology and services	DG CLIMA DG ENER DG ENV DG MARE DG RTD
Industry support organisations and associations	Lobbying for tidal stream energy as a new source of clean electricity, helping to reduce carbon emissions and providing socio-economic benefits Coordinating and undertaking research to facilitate the development of the marine energy industry	Bretagne Ocean Power France Energies Marine Marine Energy Wales Ocean Energy Europe Offshore Renewable Energy Catapult Pôle Mer Bretagne Atlantique

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Type of stakeholder	Role/interest in the industry	Examples
		RenewableUK Scottish Renewables Syndicat des énergies renouvelables (SER)
National government policy-makers	Climate change policy, and managing the transition to net zero emissions Ensuring security of future energy supply Avoiding socially-unacceptable energy price burdens for consumers Putting in place policies and regulation to achieve efficient outcomes for the energy market, which achieve climate change and energy security objectives while minimising costs to consumers Maximising the national economic benefits associated with innovation and industrial development in clean energy Ensuring that visual and environmental impacts associated with clean energy developments are socially acceptable	Defra Department for Business, Energy and Industrial Strategy HM Treasury Ministère de l'Économie et des Finances Ministère de la Transition écologique et solidaire Scottish Government Welsh Government
National energy and environment agencies	Facilitating the implementation of public policy in the areas of the environment, energy and sustainable development	ADEME
Regional enterprise agencies	Ensuring that their regions maximise the industrial benefits associated with domestic and exported clean energy technology and services	Bretagne Commerce International Bretagne Développement Innovation Highlands and Islands Enterprise Scottish Enterprise
Local/regional authorities	Ensuring that their local economies maximise the industrial benefits associated with domestic and exported tidal stream technology and services Ensuring that visual and environmental impacts associated with clean energy developments are socially acceptable Licensing tidal stream projects	Departmental Council of Morbihan Municipal Council of Étel Regional Council of Brittany Shetland Islands Council Orkney Council
Environmental NGOs	Lobbying policy-makers to accelerate the transition to net zero carbon emissions	Extinction Rebellion Greenpeace

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Type of stakeholder	Role/interest in the industry	Examples
	Ensuring that environmental impacts associated with clean energy developments are minimised	Marine Conservation Society Royal Society for the Protection of Birds WWF
Energy regulators	Establishing and maintaining regulatory mechanisms to achieve efficient outcomes for the energy market, which achieve climate change and energy security policy objectives while minimising costs to current and future consumers Approving grid capacity upgrades to accommodate new clean energy capacity	Commission de régulation de l'énergie (CRE) Ofgem
Environmental regulators	Ensuring that visual and environmental impacts associated with clean energy developments are minimised and acceptable	Agence Française de la Biodiversité DDTM – Direction départementale des territoires et de la mer Marine Management Organisation Marine Scotland Natural Resources Wales Parcs marins
Certification bodies for tidal technologies	Developing service specifications/standards for tidal stream technology, helping manage the risks around the performance of devices and arrays, and building trust and confidence between different stakeholders Undertaking certification of tidal stream energy devices and arrays, against service specifications/standards	Bureau Veritas DNV GL Lloyds Register
Seabed and land owners	Leasing seabed to tidal stream energy project developers Ensuring that there is an appropriate allocation of the seabed, across various potential marine uses (and across different tidal stream project developers) Leasing/selling land for onshore equipment to tidal stream energy project developers	Crown Estate Crown Estate Scotland Shetland Islands Council DDTM – Direction départementale des territoires et de la mer Parcs marins
Distribution/Transmission Network Operators	Providing grid connections to tidal stream energy projects	Enedis National Grid

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Type of stakeholder	Role/interest in the industry	Examples
	Planning, funding and implementing future network developments for supporting new clean energy capacity Ensuring that local tidal stream developments do not constrain subsea electricity cables for other uses (e.g. to islands, to offshore wind)	RTE SHEPD SP Energy Networks
Electricity system operators	Balancing electricity system supply with demand	National Grid ESO RTE
Electricity wholesalers and retailers	Buying, and selling on, the electrical power generated by tidal stream projects	Ecotricity EDF Engie Scottish Power SSE
Project developers/array asset owners	Identifying and developing tidal stream sites, including array design, leases and consents Securing funding for tidal stream projects Procuring equipment and services for tidal array implementation, operations & maintenance Monitoring and maintaining array assets, to optimise yield Decommissioning tidal arrays, at end of operational life	DP Energy Nova Innovation SIMEC Atlantis Energy
Marine energy test centres	Providing consented sites, infrastructure and services to facilitate the testing/demonstration of tidal stream devices	Chantier Bretagne Sud European Marine Energy Centre Morlais Perpetuus Tidal Energy Centre SEENEOH
Insurance providers for tidal energy projects	Understanding the operational risks associated with tidal stream projects Providing insurance for the construction and operational phases of tidal stream projects	GCube JLT
Site survey/assessment equipment providers	Providing specialist equipment for the assessment of tidal flow characteristics, and the bathymetry and geology of tidal sites	Nortek Teledyne Marine

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Type of stakeholder	Role/interest in the industry	Examples
Survey service providers	Undertaking surveys of tidal sites, including flow characteristics, bathymetry, seabed geology, and marine flora and fauna	Aquatera Partrac
Turbine manufacturers	Designing, building and selling tidal stream energy turbines and supporting structures Learning from the real-world experience of their turbines, and innovating to reduce costs and improve yield	Andritz Hydro Hammerfest Lockheed Martin Minesto Nova Innovation Orbital Marine Power Sabella SIMEC Atlantis Energy SME/SCHOTTEL
Turbine component/sub-system manufacturers	Designing, building and selling components/sub-systems used in tidal stream turbines and supporting structures	ABB Shetland Composites Siemens SKF
Steel suppliers	Providing the steel used in tidal stream turbines and supporting structures	ArcelorMittal Liberty Steel
Cable and connector suppliers	Designing, building and selling the sub-sea cables and connectors used in tidal stream arrays	JDR Cable Systems SMI
Onshore electrical equipment suppliers	Providing the onshore electrical equipment used in tidal stream arrays (e.g. transformers, inverters, substation equipment)	ABB GE Siemens
Energy storage suppliers	Providing any energy storage integrated with tidal stream arrays	ITM Power redT Tesla
Universities and research institutions	Developing new knowledge around tidal stream energy Applying learning from other renewables to tidal stream energy Delivering higher education in marine renewables and related disciplines	École Centrale de Nantes ENSTA Bretagne IUEM University of Edinburgh University of Strathclyde
Professional services, including specialist consultants	Providing environmental consultancy services in support of project consenting	Black & Veatch Creocean

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Type of stakeholder	Role/interest in the industry	Examples
	Providing specialist engineering consultancy in support of tidal turbine and array design Providing due diligence engineering and financial consultancy on behalf of project funders Providing legal services to array owners and financiers	INNOSEA RSK VALOREM Wood
Tidal array O&M service providers	Managing array deployments Monitoring array performance Managing array maintenance activities	Inyanga Maritime Nova Innovation Orbital Marine Power
Port owners/operators	Providing port facilities in support of offshore array deployment/maintenance activities	Cullivoe Pier (Shetland Islands Council) Hatston Pier (Orkney Council) Port of Brest
Vessel/dive operators	Providing vessel services and divers for offshore device deployments/retrievals	Green Marine James Fisher Marine Services Jifmar Offshore Services Olympic Subsea
Transport providers	Providing overland transport for tidal stream array equipment, for deployments and retrievals	Mar-Train Heavy Haulage Trans GB
Local hospitality businesses	Providing accommodation, food and drink for project personnel, during array deployment and maintenance events	Étel hotels and B&Bs Shetland hotels and B&Bs
Local, national and international media	Keeping target audiences informed on developments in tidal energy and projects	National TV stations Local radio stations Local and national newspapers
Finance providers	Providing debt or equity finance for growing companies engaged in the tidal stream sector Providing debt or equity finance for tidal stream projects	Angel investors Banks Crowdfunding platforms Venture Capital companies

Table 3 – Tidal energy industry stakeholder mapping

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4. DETAILED PLAN

In this section we set out the detailed plan for delivering the three remaining tasks in ELEMENT WP12:

- T12.2 Regional impact analysis
- T12.3 French estuary/run of river site assessment
- T12.4 European impact analysis.

T12.2 Regional impact analysis

Objectives

The objective of this task is to undertake an analysis of the potential socio-economic impact of tidal energy on the local and regional economy around the Étel test centre in Brittany, France.

Sub-tasks

We have split this activity into the following sub-tasks:

- T12.2.1 Develop local and regional socio-economic profiles
- T12.2.2 Develop tidal array capacity scenarios for Étel
- T12.2.3 Identify potential local/regional suppliers
- T12.2.4 Consultations with potential local/regional suppliers and stakeholders
- T12.2.5 Develop model of the local/regional economic impacts, per scenario
- T12.2.6 Draft and finalise D12.2: Regional Impact Analysis Report.

T12.2.1 Develop local and regional socio-economic profiles

In order to put the regional impact analysis into context, IDETA will initially collate and summarise various socio-economic data on the commune of Étel, the department of Morbihan and the region of Brittany. Where appropriate, indicators will be compared with the relevant national figures for France.

Key indicators will include:

- Trends in population and demographics (e.g. total population; working age people as % of total population)
- Employment by industry
- Employment location quotients by industry (to give an indication of how the industry's share of local employment compares to its share at a national level)
- Business counts by industry
- Trends in employment rate and unemployment rate
- Trends in labour productivity
- Trends in median wage levels
- Education/qualification levels
- Trends in energy demand
- Trends in greenhouse gas emissions per capita.

Sources will primarily be the official statistics for the relevant geography from France's national statistics agency, Insee.

T12.2.2 Develop tidal array capacity scenarios for Étel

The extent of the local and regional impacts of tidal energy will be dependent on the scale of tidal stream capacity implementations at or around Étel. Informed by INNOSEA's assessment of local resources (in T12.3), and in consultation with Nova Innovation and Offshore Renewable Energy Catapult, IDETA will

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therefore develop time series scenarios for the potential development of cumulative tidal stream capacity on the Morbihan coast (in terms of cumulative MW capacity operational at the end of each year). High, medium and low scenarios will be developed. At this stage, we anticipate that these scenarios will extend out to 2050, in order to be consistent with the long term projections developed for Europe in T12.4.

T12.2.3 Identify potential local/regional suppliers

In this sub-task, IDETA will identify suppliers located in Morbihan and the wider Brittany region who could potentially participate in the tidal stream supply chain. This will draw on Nova Innovation's knowledge of the types of components and services required for tidal stream developments, desk research on potential suppliers, and local supply chain knowledge from Chantier Sud Bretagne. The research will also be informed by initial discussions with Bretagne Ocean Power and Bretagne Commerce International.

The industrial aspects of the stakeholder mapping provided in section 3 of this report will provide an initial structure against which examples of local/regional supply chain companies will be given. The focus of this activity will be to provide an indication of the areas in which local/regional suppliers could realistically participate, with representative examples, rather than developing a comprehensive supplier directory.

T12.2.4 Consultations with potential local/regional suppliers and stakeholders

IDETA will then arrange and undertake a series of consultations with local/regional suppliers and other stakeholders. At this stage we envisage consulting up to 30 organisations, through a mixture of face-to-face and telephone discussions.

Target consultees are likely to include:

- Local/regional authorities: Regional Council of Brittany, Departmental Council of Morbihan, Municipal Council of Étel
- Industry clusters, associations and support organisations: Bretagne Ocean Power, Bretagne Commerce International, Bretagne Développement Innovation, CCI Bretagne
- Universities/research institutions: ENSTA Bretagne, IUEM
- Electricity network operator: Enedis
- Example suppliers identified through T12.2.3.

These consultations will use a topic guide, which will be developed by IDETA and reviewed by the partners involved in WP12. The discussions will seek consultees' views on areas such as:

- Local awareness of/interest in tidal energy, amongst residents and businesses
- Consenting processes associated with the implementation and maintenance of tidal arrays on the Morbihan coast
- Suitability of the Morbihan coast as a location for tidal stream energy
- Considerations around other marine uses, including fishing and leisure boats
- The local/regional availability of relevant skills
- Local suppliers that could potentially participate (building on the initial findings from T12.2.3)
- The scale and scope of suppliers' current operations and future plans
- Suppliers' previous experience in marine renewables, and the wider offshore industry
- Suppliers' level of interest in addressing the tidal energy market, in Brittany and beyond.

Notes will be written up from each consultation, to inform the report.

T12.2.5 Develop model of the local/regional economic impacts, per scenario

IDETA will then develop an Excel-based model of the potential local and regional economic impacts associated with the tidal stream implementation scenarios of T12.2.2, over the period to 2050. This model will incorporate assumptions on:

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- Cumulative installed capacity at the end of each year, by scenario (from T12.2.2) – leading to the new capacity installed in each year
- Overall capital expenditure per MW of new installed capacity, by year
- Indicative shares of capital expenditure, by expenditure area (consenting, turbines, supporting structures, cables etc.)
- Overall annual O&M costs, as a percentage of capital deployed
- Indicative shares of O&M costs, by expenditure area (vessels, transport, supplies, accommodation etc.)
- The proportions of capital and O&M expenditures spent with Morbihan suppliers, and with Brittany suppliers, by expenditure area
- Average GVA/turnover ratios for each expenditure area (in order to convert expenditure to GVA)
- Average GVA per employee for each expenditure area (in order to derive estimated direct employment impacts from the GVA impacts)
- Local and regional multipliers to reflect the indirect and induced effects associated with the project's local and regional expenditures
- Social discount rate, using current French government guidance (for deriving Present Values).

As far as possible, this model will seek to be representative of a 'typical' tidal stream implementation, rather than being specific to a particular technology (e.g. Nova Innovation's turbines). Its assumptions will be informed by public domain literature on tidal stream costs, inputs from the partners involved in this task (particularly Nova Innovation, Offshore Renewable Energy Catapult and INNOSEA), the findings from the consultations of T12.2.5, and secondary sources for assumptions around average GVA/turnover ratios and average GVA per employee by industry.

The model will be reviewed by the partners, and its key outputs will be:

- Time series of annual GVA impacts for Morbihan and for Brittany, for the period to 2050, for each of the three scenarios
- Time series of employment impacts for Morbihan and for Brittany, for the period to 2050, for each of the three scenarios
- Present Value of the GVA impacts for Morbihan and for Brittany, for the period to 2050, for each of the three scenarios.

T12.2.6 Draft and finalise D12.2: Regional Impact Analysis Report

Finally, IDETA will summarise the findings from this task T12.2 in a concise report. The structure will be as follows:

- Introduction and methodology
- Tidal stream implementation scenarios at/around Étel
- Overview of potential local and regional suppliers
- Economic impact estimates
    - Description of modelling approach
    - Key assumptions
    - Local economic impacts for Morbihan
    - Regional economic impacts for Brittany

The draft report will be reviewed by the partners involved in this task, and then finalised for submission.

Summary of partner roles/inputs to this task

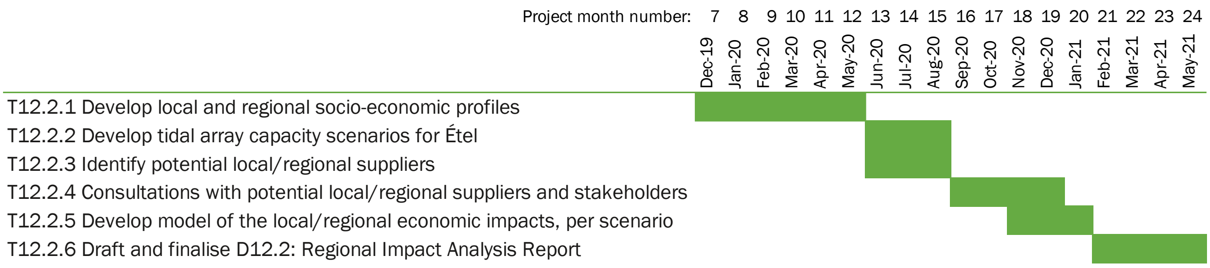
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 815180.

Partner	Roles/inputs
IDET	• Task leader • Develop local and regional socioeconomic profiles • Develop tidal array capacity scenarios • Identify potential local/regional suppliers • Arrange and undertake stakeholder consultations • Develop model of local and regional economic impacts • Draft and finalise report
NOVA	• Review tidal array capacity scenarios • Identify types of components/services required for a typical tidal stream implementation • Advise on potential cost trends for capex per MW and O&M costs • Review model of local and regional impacts • Review draft report
OREC	• Review tidal array capacity scenarios • Advise on potential cost trends for capex per MW and O&M costs • Review model of local and regional impacts • Review draft report
CHBS	• Advise on potential local/regional suppliers • Assist in local face-to-face consultations with stakeholders and suppliers
INNO	• Provide (from T12.3) indicative estimates of total practical resource at/around Étel • Review tidal array capacity scenarios • Advise on appropriate local and regional multipliers for the impact model • Review model of local and regional impacts • Review draft report

Table 4 –T12.2 Partner roles/inputs

Schedule

The schedule for this task is illustrated in the Gantt chart below, with the Regional Impact Analysis Report deliverable due to be submitted in May 2021.



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 815180.

T12.3 French estuary/river site assessment

Objectives

The objective of this task is to undertake a mapping of estuary/river sites in France that may be suitable for tidal energy deployment.

Sub-tasks

12.3.1 Suitability criteria

This sub-task will prepare a list of criteria that will enable a qualitative assessment of estuary sites, considering both major estuaries and smaller estuaries:

- Major estuaries: Garonne, Loire, Seine, Rhône.
- Smaller estuaries: Étel, Abers region in Brittany, Somme estuary, Pertuis Charentais, etc.

Within each of these estuaries, multiple sites will be considered, in terms of technical and socioeconomic criteria. The table of criteria will be detailed with quantified thresholds. A sensitivity table will be prepared with: acceptable, moderate, high impacts, as well as possible exclusions that would, alone, rule out the site.

The following technical criteria will be considered:

Technical criteria	Favourable	Unfavourable	To be studied
High-speed current	X		
Technical/Practical potential (MW installed / Energy Yield GWh p.a.)	X		
Bathymetry / tidal range			X
Soil conditions			X
Navigation area		X	
Other waterway uses			
Servitudes (gas, etc.)			X
Access to Enedis electrical connection (distribution network)	X		
Existing infrastructures	X		

Table 5 –Technical criteria, and compatibility with estuarine tidal energy

The following socio-economic criteria will also be considered:

Socio-economic criteria	Favourable	Unfavourable	To be studied
Regional strategy for offshore renewables	X		
Presence of relevant local supply chain			X
Presence of active SME/startups in the sector	X		X
Suitable zones for R&D	X		
Possible synergies with current offshore renewable activities	X		X

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Socio-economic criteria	Favourable	Unfavourable	To be studied
Presence of relevant academic stakeholders	X		

Table 6 –Socio-economic criteria, and compatibility with estuarine tidal energy

Desirable aspects will be the presence of local industries that could be part of a local supply chain. The logic for local supply, the geographical location of this supply chain, and the potential opportunities for export will also be considered.

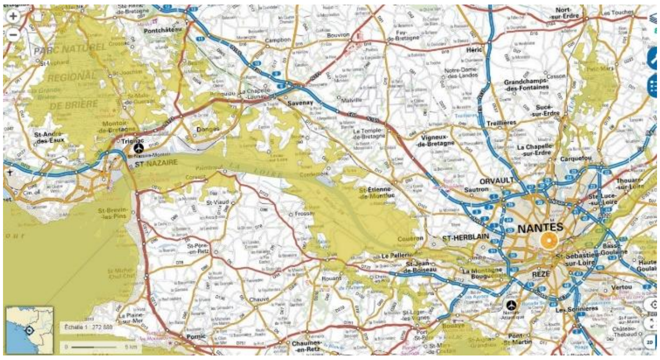
A high density of potential sites within the same area may lead to an enhanced supply chain. Such a supply chain would benefit from increased visibility (they would be able to serve multiple sites) and would in return provide economy of scale.

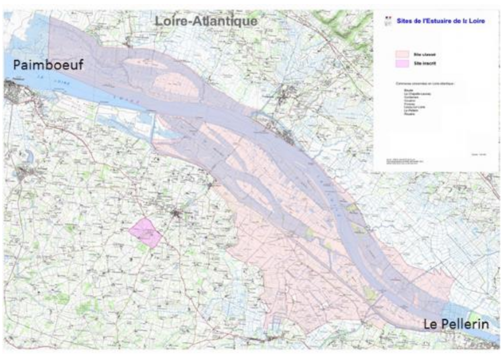
In cases where sufficient data is available, INNOSEA will seek also to map environmental criteria and their compatibility with estuarian tidal capacity deployment:

Environmental criteria	Favourable	Unfavourable	To be studied
French regulation			
Natura 2000 Zone		X	
Listed site		X	
ZNIEFF 1 and 2 (birds)			X
Loi littoral (coastline regulation)		X	
RCFS			X
AOT – DPM			X
Human activities			
Navigation channel (maritime domain)		X	
Fishery		X	
Port activities		X	
Ecological diagnostics			
Migratory fish			X
Habitats (mudflats, seabed)			X

Table 7 –Environmental criteria, and compatibility with estuarine tidal energy

In the maps below we provide an example of Natura2000 sites (left) and of listed sites (right) for the Loire estuary.





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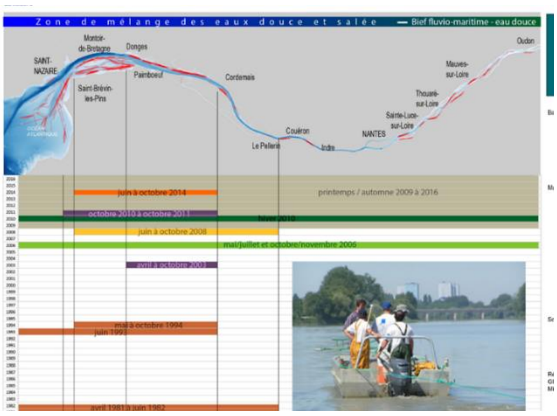
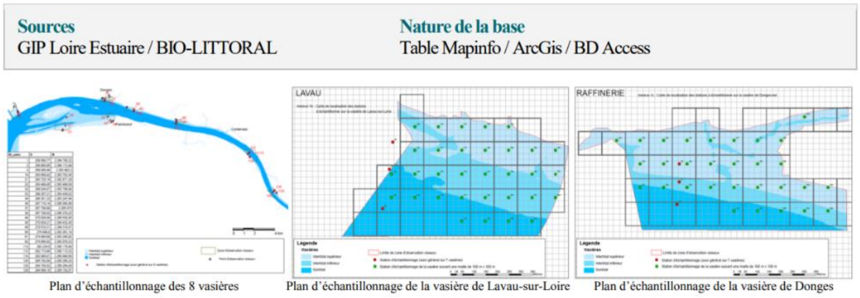
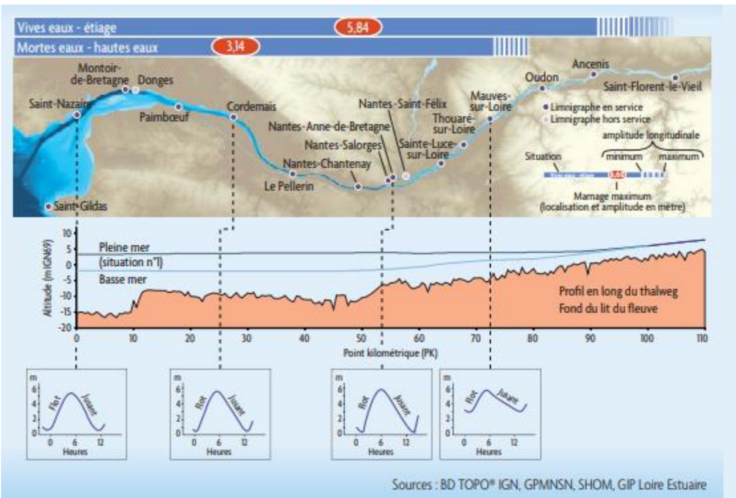
12.3.2 Data gathering, formatting and analysis

It is already foreseen that little or no data may be freely available for several locations, particularly for small estuaries. Therefore, the focus will need to be on sites where data is accessible free of charge, and INNOSEA will make reasonable efforts to search and obtain such data.

Below is an extract of local studies on the Loire estuary (GIP Estuaire Loire, Grand Port Maritime, Bio-littoral):

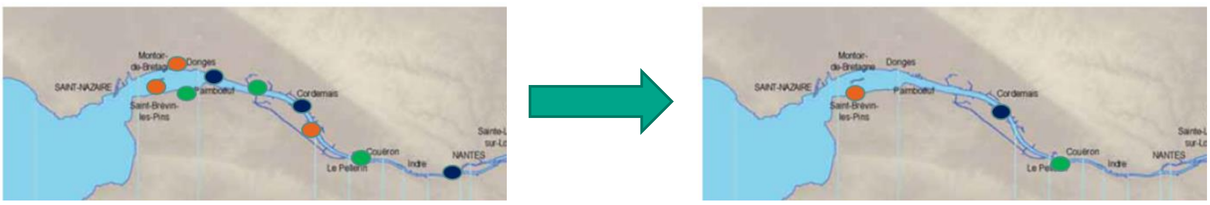






Multiple sites will be considered for each estuary. The overlap of favourable criteria will be assessed using Geographic Information Systems (GIS), in order to narrow the number of potential sites. On this basis, a series of interviews (three per estuary) with relevant stakeholders will be conducted to confirm the findings from the GIS analysis.

Identification of potential sites *Selection of suitable sites*



The report will include a list of suitable sites and the site characteristics that were gathered, using a common reporting structure across the estuarian sites.

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12.3.3 Potential local content

Following this, it will be assessed what proportion of the project capital and operational expenditures could potentially be provided by local supply chains, within the relevant regions. From T12.2.5, IDETA will provide indicative figures for capex and opex per MW of deployed capacity, and a workshop will be organised to jointly estimate the potential local shares of project expenditures at the selected sites.

This will be converted into an indicative number of jobs created at each site, considering both the jobs created during construction phase and the permanent jobs (that will remain once the project has been commissioned, for O&M and for activities for other sites). The associated indicative GVA effects will also be assessed.

12.3.4 Draft and finalise D12.3: French estuary site assessment

INNOSEA will then summarise the findings from this task T12.3 in a concise report. The structure will be as follows:

- Introduction and methodology
- Criteria to qualify a suitable estuarian location
- Overview of the estuarian sites and their suitability
- Potential local supply chain opportunities
- Conclusion on the size of the tidal estuarian opportunity in France, and recommendations for future studies.

The draft report will be reviewed by the partners involved in this task, and then finalised for submission.

Summary of partner roles/inputs to this task

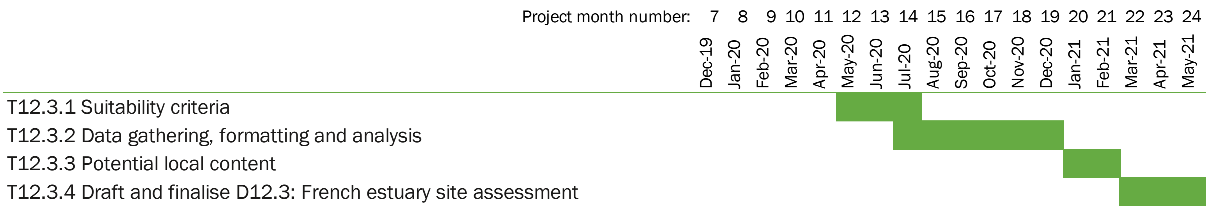
Partner	Roles/inputs
INNO	• Task leader • Develop technical, socio-economic and environmental criteria table • Analyse the estuarian sites' known characteristics • Identify preferred estuarian sites • Organise workshop with IDETA and Nova Innovation to estimate potential local content opportunities • Draft and finalise report
NOVA	• Advise on site requirements and data requirements to assess the suitability of a site • Advise on technical, socio-economic and environmental criteria • Advise on indicative capex per MW and O&M costs • Review the draft report
IDET	• Provide findings from T12.2 on local stakeholders and possible supply chain opportunities (focused on Morbihan and Brittany) • Provide findings from T12.2 on indicative capex and opex per MW of deployed capacity • Attend and contribute to the workshop organised by INNOSEA to assess the potential local content opportunities • Review the draft report

Table 8 –T12.3 Partner roles/inputs

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement number 815180.

Schedule

The schedule for this task is illustrated in the Gantt chart below. The French Estuary Site Assessment deliverable is due to be submitted in May 2021.



T12.4 European impact analysis

Objectives

The objective of this task is to assess the potential impact of tidal energy on the wider European economy.

Sub-tasks

We have split this activity into the following sub-tasks:

- T12.4.1 Update literature review
- T12.4.2 Develop global tidal energy capacity and value scenarios, by region
- T12.4.3 Develop model of European-level economic impacts by scenario
- T12.4.4 Draft and finalise D12.4 Final Tidal Energy Impact Analysis Report

T12.4.1 Update literature review

An initial literature review around the potential socioeconomic impacts of tidal energy has been undertaken for T12.1, with the findings summarised in section 2 of this report. Further literature may be published in coming months, and IDETA will update the analysis to reflect any new substantive contributions.

T12.4.2 Develop global tidal energy capacity and value scenarios, by region

The extent of tidal energy's potential impacts for the European economy will depend on the extent to which tidal energy is rolled out globally – as European suppliers will be seeking to benefit from export opportunities to global markets as well as serving European tidal projects.

A key aspect of the impact modelling will therefore be an assessment of potential global tidal stream capacity implementations, and the value represented by that in terms of capital and O&M expenditures.

Estimates for this will be developed by IDETA, informed by the literature review and by partners' views in the light of latest developments in the industry and the policy environment. As with T12.2, a scenario approach will be used, with scenarios representing High, Medium and Low capacity implementations out to 2050.

The global scenario projections will be split by continent:

- Europe
- North America
- South America
- Africa
- Asia

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- Australasia.

The starting point will be an estimate of the practical tidal stream resource for each continent, in terms of GW of installed capacity. As highlighted in section 2 of this report, there is considerable uncertainty on this in the absence of comprehensive detailed local resource assessments, and this will be reflected through the High/Medium/Low scenarios.

The next step will be to develop annual projections for the cumulative percentage of each continent's practical resource implemented out to 2050, under each scenario. This is likely to focus on estimating values at key years (e.g. 2020, 2030, 2040, 2050), with interpolations applied for intervening years. Combined with the estimates for practical resource, this will give High/Medium/Low projections for the cumulative installed capacity per continent at the end of each year, and hence the new installed capacity in each year.

Estimates for the direct expenditures (hence sales potential) associated with these scenarios will then be developed, by combining the capacity projections per continent with assumptions on:

- Overall capital expenditure per MW of new installed capacity, by year
- Overall annual O&M costs, as a percentage of capital deployed.

These assumptions will be informed by the experience of and learning rates achieved in other renewable energy technologies, and by relevant literature on cost reduction in tidal stream energy such as OREC (2018).

T12.4.3 Develop model of European-level economic impacts by scenario

IDETA will then develop an Excel-based model of European-level economic impacts. This will combine the global capacity and sales value scenario projections from T12.4.2 with assumptions on:

- Indicative shares of capital expenditure, by expenditure area (consenting, turbines, supporting structures, cables etc.)
- Indicative shares of O&M costs, by expenditure area (vessels, transport, supplies etc.)
- The proportions of capital and O&M expenditures spent with European suppliers, by expenditure area, and per continent
- Average European GVA/turnover ratios for each expenditure area (in order to convert expenditure to GVA)
- Average European GVA per employee for each expenditure area (in order to derive estimated direct employment impacts from the GVA impacts)
- Europe-level multipliers to reflect the indirect and induced effects
- Social discount rate (for deriving Present Values).

As with the analysis of T12.2, this model's assumptions will be informed by public domain literature on tidal stream costs, and inputs from the partners involved in this task. Secondary sources will be used for assumptions around Europe-level multipliers, average European GVA/turnover ratios and average GVA per employee by industry.

The model will be reviewed by the partners, and its key outputs will be, for each of the three scenarios:

- Time series of annual turnover impacts for Europe, for the period to 2050
- Time series of annual GVA impacts for Europe, for the period to 2050
- Time series of employment impacts for Europe, for the period to 2050
- Present Value of the GVA impacts for Europe, for the period to 2050.

T12.4.4 Draft and finalise D12.4 Final Tidal Energy Impact Analysis Report

Finally, IDETA will summarise the findings from this task T12.4 in a concise report. The structure will be as follows:

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- Introduction
- Literature review
- Global tidal stream implementation scenarios and values
- Economic impact estimates for Europe
    - Description of modelling approach
    - Key assumptions
    - Turnover for European suppliers
    - GVA impacts for Europe
    - Employment impacts for Europe.

The draft report will be reviewed by the partners involved in this task, and then finalised for submission.

Summary of partner roles/inputs to this task

Partner	Roles/inputs
IDET	• Task leader • Update literature review • Develop global tidal array capacity and value scenarios • Develop model of European economic impacts • Draft and finalise report
NOVA	• Review global tidal array capacity and value scenarios • Advise on potential cost trends for capex per MW and O&M costs • Advise on the indicative breakdown of capital and O&M expenditures by expenditure type • Advise on potential share of expenditures for European suppliers, per continent and per expenditure type • Review model of European impacts • Review draft report
OREC	• Review global tidal array capacity and value scenarios • Advise on potential cost trends for capex per MW and O&M costs • Advise on the indicative breakdown of capital and O&M expenditures by expenditure type • Advise on potential share of expenditures for European suppliers, per continent and per expenditure type • Review model of European impacts • Review draft report
INNO	• Review global tidal array capacity and value scenarios • Advise on appropriate Europe-level multipliers, GVA/turnover ratios, GVA per employee, and social discount rate for the impact model • Review model of European impacts • Review draft report

Table 9 –T12.4 Partner roles/inputs

Schedule

The schedule for this task is illustrated in the Gantt chart below. The Final Tidal Energy Impact Analysis Report deliverable is due to be submitted in May 2022.

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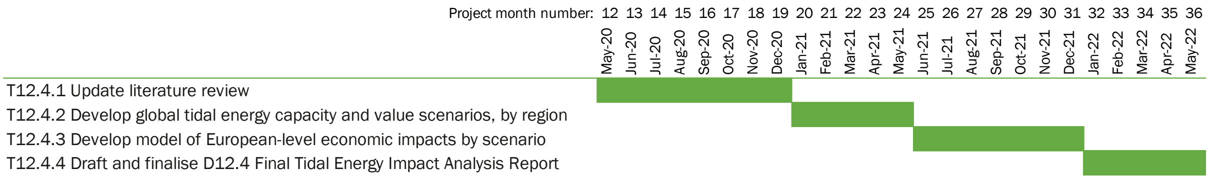

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