Strategic and economic study on the development of marine renewable energies in Brittany and Cornwall

A report prepared as part of the MERiFIC Project "Marine Energy in Far Peripheral and Island Communities"

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PREAMBLE

The primary objectives of this project, carried out between September 2013 and April 2014, can be summarised as:

- **To analyse the economic issues** arising from the development of marine renewable energies (MRE) in Brittany and Cornwall;

- **To identify strategic recommendations** associated with a long-term vision, together with a **directly operational action plan** to promote Franco-British cooperation as part of the MERiFIC project.

NB: An annex is attached to this project report.

The expertise brought together for this project is the result of a **consortium formed around recognised enterprises in the energy sector and in MREs in particular**, with complementary positions on the issues of MRE development both in France and internationally:

- **ARTELIA** – European leader in engineering, project management and consultancy formed from the merger of Coteba and Sogreah – has contributed its skills regarding support for regional public energy policies and also its teams, who contributed to carrying out studies on the MRE market, particularly regarding an assessment of resource potential, or the development of the port sector.

- **INDICTA** – consultancy on MRE reference strategy with more than six years of experience working for high-profile French manufacturers and national public bodies. The company's teams who worked on this project notably contributed to the economic and financial analyses of the many emerging MRE segments, incorporating the socio-industrial component and prospects of these new segments.

ARTELIA and INDICTA jointly managed the issue analysis phase, while INDICTA took the lead in the production of strategic recommendations and ARTELIA managed the priority action plan.

Two companies, one French and the other British, made it possible to strengthen the regional analysis of issues within the scope of MERiFIC as needed:

- **INNOSEA** – a French engineering firm specialising in the MRE sector – notably contributed to the technical analysis of regional projects and their innovation dynamic, and to the analysis of specialist jobs and training. The company is a spin-off from the École Centrale de Nantes (a specialist engineering college), which has more than 30 years' experience in MREs.

- **MARINE ENERGY MATTERS** – an MRE specialist firm in the United Kingdom – brought with it its in-depth knowledge of the South-West of the country, and more specifically contributed to highlighting the synergies and areas of complementarity for development between economic players in Brittany and Cornwall.

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INTRODUCTION: A THREE-STAGE REPORT

FIGURE 1: METHOD MAPPING OF THE PROJECT

The objective of this study is to define a regional strategy and identify the most promising innovative approaches and initiatives for the local development of MREs in Brittany and Cornwall.

This project report is structured based on three main stages:

1. The first stage presents the **situation and expected growth prospects for MREs** worldwide, with an increasingly detailed focus on Europe, then France and Great Britain, and finally the target area {Brittany + Cornwall (including the Isles of Scilly)}: the main underlying objectives are:

    - V To describe the specific context for MREs from a technical and industrial perspective (potential, maturity, investments, industrial options, etc.) and from a political perspective (what actions are in progress, what support is available). A look ahead to 2020, 2030 and 2050 makes it possible to demonstrate the strategic nature of MREs in future energy mixes, and to assess in what framework Brittany and Cornwall could benefit directly or indirectly from these development prospects.

    - V To identify the key issues for ensuring the development of MREs at regional level: the conclusion of this first part of the opportunity analysis will therefore be structured around **six issues**:

1. Industrial and economic development;
2. Technological energy planning and development;
3. Education and training;
4. Financing for the deployment of MREs;
5. Ports and land-sea interface;
6. Cooperation and governance.

- To come to a conclusion on the **risk of a discrepancy** between, on the one hand, the opportunities that Brittany and Cornwall could take advantage of through the intentions declared at national level (top-down), and on the other hand the potential and ambitions of the two regions with regard to socio-economic (including export) development as well as industrial, technological and energy development and enhancement of existing or directly accessible know-how, etc., which will make it possible to justify in full the need to develop regional initiatives (bottom-up) to aim for leadership in these innovative markets.

2. These initial elements of analysis were supplemented in the second stage with **an in-depth analysis at regional level of the six key issues identified above**. In addition, we relied on two further analytical tools:

   - Producing **benchmarks** as input data for analysis of the issues, with a view to identifying best practices, in particular those that could be implemented as part of a coordinated development of MREs in Brittany and Cornwall;

   - Conducting **workshops** to bring together all the MRE key players (public institutions, professional associations, private sector players: SMEs and large groups, etc.) around three key themes:

     1. Challenges in terms of energy, technology and R&D
     2. Industrial and economic development
     3. Education, training and jobs

3. The analysis results from the first two stages of the study made it possible to bring together all the elements required to **structure an ambitious, innovative MERiFIC vision in the third and final stage**:

   - **The five strategic recommendations** that we present aim to accelerate multi-MRE development in Brittany and Cornwall, without waiting for the national or supranational dynamic, which at this stage is too weak and poorly adapted to the specifics of the two regions, whose peninsula and island status significantly expands opportunities.

   - **Seven actions** are finally put forward at the end of the report in order to identify the priority levers to be activated in the very short term.

1 STAGE 1: OVERVIEW OF MARINE RENEWABLE ENERGIES: DEVELOPMENT SITUATION AND PROSPECTS IN THE SHORT, MEDIUM AND LONG TERM

1.1 A diverse range of marine resources j ustify the appeal of MREs in the production of renewable energy, broadly construed

If we include the exploitation of sea winds – more stable and substantial than on land – within the technical scope of MREs, MREs then fall within ten different segments (excluding marine biomass[1]). We can distinguish between:

- Large-scale energy production segments – seven of them – adopted as a priority in energy policies in response to energy and climate issues worldwide (decarbonisation of the energy mix, increase of the proportion of renewable energies, reduction of energy dependence, etc.).

- Smaller-scale energy production segments – three of them – which are now considered as alternative (or even niche) segments, and which could provide scope for strategic differentiation at regional level.

FIGURE 2: SEGMENTATION OF THE 10 MRE SEGMENTS BY INDUSTRIAL APPLICATION: PRODUCTION OF ELECTRICITY, HEAT AND COOLING

Marine biomass was excluded from this study primarily due to its lack of maturity, and because its scope does not specifically concern the issue of energy (primarily exploited in food, green chemistry, pharmacology).

In the medium and long term, then, we are heading towards an energy mix of several alternative energy segments of differing levels of maturity, on which decision-making takes place using varying types of criteria and where politics, economics, the environment and technology meet.

1.2.2 A critical initial milestone validated for MREs: global potential considered to be among the most significant of the future emerging segments

Even before anticipating the development of MREs to a greater or lesser extent in the global energy mix, the economic and political stakeholders first tried to produce a reliable assessment of the market potential offered by the different energy segments. Since the end of the 2000s, MREs have, in the eyes of investors and stakeholders in renewable energy, been emerging segments with what is considered to be **one of the greatest levels of potential to contribute over time**, much like solar thermodynamics.

This initial awareness phase was made credible partly through estimating "raw" resources – which, with all MRE types combined, correspond to more than five times the current world demand for electricity production alone (>100,000 TWh/year) – and partly through the constantly updated assessment of **Technically Exploitable Potential** (TEP). This critical concept notably covers:

- The **maturity of the technologies** and the visibility over their potential to harness the raw resource;
- The progress line and the development dynamic of their **economic attractiveness** over a period of at least 20 years (assessed using comparative modelling of total production costs in EUR/MWh, particularly in relation to the commercial and majority energy types: coal, gas, nuclear, hydraulic, land-based wind energy, etc.);
- The capacity of manufacturers to maintain sustainable production by **controlling project risks**, in other words the costs of investment (CAPEX) and the costs of operation and maintenance (OPEX), in an environment that is still largely unfamiliar to energy companies here;
- Their **social acceptability** (populations and consumers, sea users, etc.);
- Regulatory issues and **environmental impact** issues (marine protected areas, protected species, etc.);

These factors collectively evolve over time, which reflects the **dynamic, evolving nature of the TEP**. For example, a site could be deemed unattractive at present due to technical and economic considerations connected to the installation depth or the distance from the coast, but the same site could become viable if innovations (anchorage, energy convertors, connection costs, etc.) improve the cost-effectiveness of the project to thresholds that are acceptable to investors. Similarly, again on the subject of economic attractiveness, the increased cost of conventional energy sources, due to increasing rarity or the growing power of carbon mechanisms, may accelerate the development of these new energies.

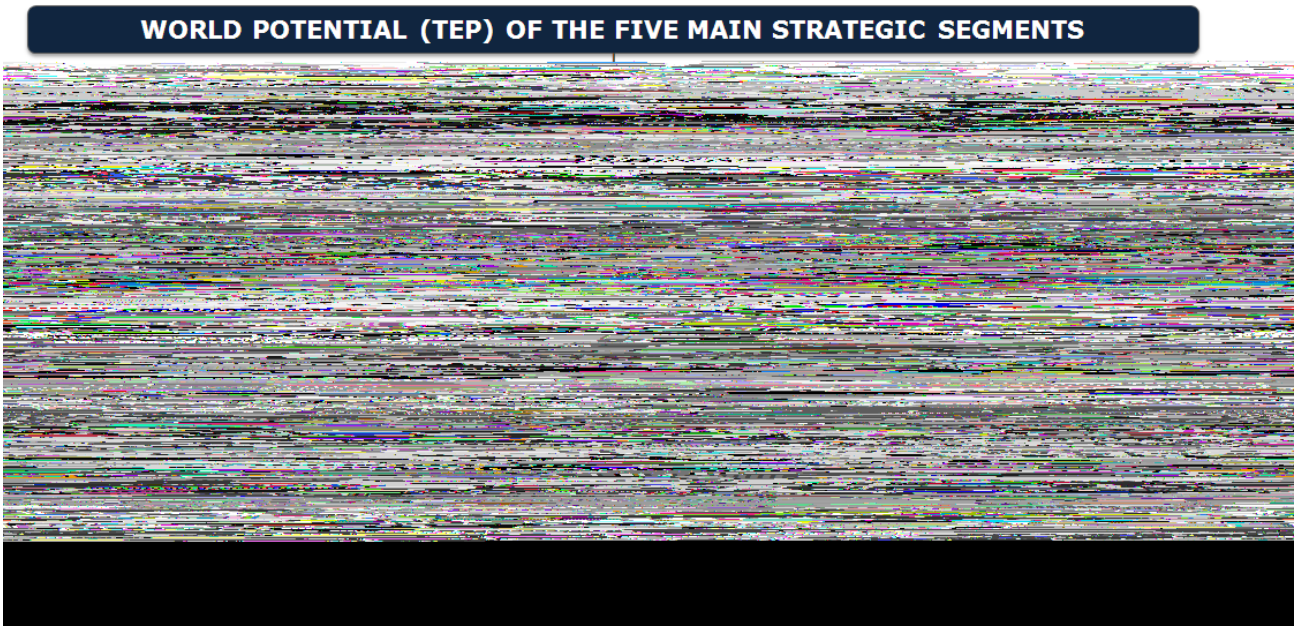
Finally, political or geostrategic considerations – with the development of new sectors of industry, qualified jobs and exportable know-how – also form an integral part of the TEP assessment criteria for each of the MRE types.

Taking into account the increased visibility that economic stakeholders have had in recent years over all the hypothetical areas that define the TEP of MREs, **INDICTA now assesses the world TEP for MREs at around 20,000 TWh/year, noting the immense potential of these emerging segments.**

NB: By way of comparison, the current world production of electricity is around 20,000 TWh/year, for a total installed capacity, all energy types combined, corresponding to installed power of a little over 5,000 GW.

This critical first step is initially intended to make the development of MREs worldwide credible over the long term, in the knowledge that other socio-economic and political milestones will need to be validated – at a variety of geographical scales – in order to prepare for the start of substantial investments in these strategic segments and the launch of the markets.

FIGURE 4: ASSESSMENT OF THE TEPS OF EACH OF THE FIVE MAIN MRE SEGMENTS



Three MRE segments have **TEPs of more than 1,000 GW** (or even several thousand GW), making it possible to envisage a significant contribution by MREs to future energy mixes over time:

- Offshore fixed and floating wind turbines have the largest TEPs (>4,500 GW), primarily thanks to the advanced technological maturity of fixed wind turbines and the feedback from the land-based wind energy industry, where the installed capacity worldwide exceeded 280 GW of installed power at the end of 2012 (Source: GWEC (Global Wind Energy Council)), i.e. more than 100,000 masts installed on land). Fixed wind turbines are subject to the bathymetric characteristics of maritime zones (maximum depth of 40-50 m), which limits their global potential to between **1,000**

and 1,500 GW, whereas floating technologies make it possible to push back this limitation to installation depths of several hundred metres, meaning that a TEP at least **three times greater** than that of fixed wind turbines can be assessed.

- Wave energy (using waves and ocean swell) has a current world potential similar to that of fixed wind turbines at **1,000 to 1,500 GW**, even though the visibility compared to more profitable technologies currently remains low (more than 150 systems currently in development worldwide at differing stages of maturity: from the simple concept to industrial-scale demonstration models tested and validated at sea). The market is therefore segmented into "nearshore" technologies located near the coastlines (up to a few kilometres away, or even with part of the overall system installed on land), and "offshore" technologies that make it possible to exploit more distant resources.
  It is the latter segment that has the largest TEP, taking into account the capacity for associated systems to be deployed in as many zones as possible and across larger areas, allowing very powerful parks to be anticipated over time (on a GW scale). Due to currently existing technological uncertainties and significant development margins on wave energy, **these estimates of potential may be re-evaluated upwards** when the technologies are rationalised in place; this is what justifies the appeal of this MRE segment for investors and venture capitalists although it is still deemed not very mature by energy companies.

The other MRE segments have a more limited TEP at **around 100 GW**, but some of them have their own characteristics capable of raising their market appeal and short-term growth prospects:

- Marine current turbines and tidal energy are two technologies primarily connected to exploiting tidal currents[3], with a global TEP assessed at **75-100 GW**, and which are connected to the localised nature of sites with high current speeds (>2m/s). High power marine current turbines, which currently attract the majority of investments, offer numerous **technological synergies with hydraulic turbines and marine propulsion**: after fixed wind turbines this segment is the most advanced MRE type, with pre-commercial developments anticipated over the next few years.

- OTEC (Ocean Thermal Energy Conversion), which involves exploiting a temperature differential of at least 20°C between deep water and surface water, has a world TEP of around **150 GW**, according to conservative estimates. The difference between the scale of the raw resource and the current TEP estimate is primarily linked to the mismatch with local electricity needs in the target areas (primarily island environments, with numerous places that are eligible for only a few hundred or even a few tens of MW). Widespread installation of systems tens or even hundreds of kilometres from the coasts would make it possible to exploit a greater amount of the

[3] We should note that there are also current turbine technologies intended to exploit river currents (river flow turbines) and thermohaline currents; these are very specific and their potential is still uncertain, so they are not examined in depth here.

resource, and would then bring the TEP for OTEC above 1,500 GW. However, at this stage, taking into account current developments concentrated around two major systems manufacturers – French company DCNS and US company Lockheed Martin – the appeal of OTEC primarily lies in its capacity to produce:

- Basic electricity, constantly available 24/7 (OTEC is therefore considered to be one of the keys to energy autonomy for tropical islands);
- Fresh water in areas where water stress is intense and developing rapidly.

¢ Finally, osmotic pressure (exploiting the difference in salinity between sea water and fresh water) may have world potential limited to **around 100 GW**, according to estimates by Norwegian energy company Statkraft, currently the most dynamic player in this segment. At this stage, the degree of maturity of the associated technologies is too low and the knowledge of environmental impact is too limited to estimate a TEP that is credible in the eyes of investors, and therefore to envisage commercial development before 2025 or 2030.

In view of the scale of future need for non-fossil fuel energies, MREs offer one of the most substantial development potentials within emerging renewable energies. Beyond current commercial projects, their future contribution is in fact seen as critical in order to aim for massive decarbonisation of the world economy so as to tackle the issues identified by the scientific community. This applies to the production of electricity, heat and cooling and indeed the production of fresh water, with substantial indirect savings in the case of the latter two industrial applications when it comes to energy consumption, since they are currently handled by conventional systems (electric air-conditioning units, desalination plants, etc.).

Although the question of whether the MRE field is capable of handling energy and climate issues (as well as issues of reducing energy dependence on third countries) now seems to be settled, **what is now particularly in question is the identification of the most mature energy segments and the date when the various markets can be launched,** so as to assess the likelihood of MREs contributing significantly to energy production by 2020 and beyond.

1.3 World and European prospects for strategic MRE segments: by 2020, 2030 and 2050

1.3.1 Five MRE segments must now be considered to be strategic worldwide for the consolidation of the sector and the acceleration of investments

The degree of maturity of the various MRE segments can be measured using the TRL (Technology Readiness Level) scale, which has been used historically by US agencies to

describe developing technologies. It also provided the basis for defining the Technology Readiness Levels in the ISO 16290 standard.

FIGURE 5: NINE-LEVEL TRL SCALE

The TRL system has nine levels, from the initial discoveries and upstream studies (TRL 1 to 3) to the final validation of the technology before it is put on the market (TRL 9), via small-scale testing and full-scale testing in actual conditions of use (TRL 4 to 8). Here we are adopting the expected date of market launch of the segments worldwide in order to position them based on their maturity.

NB: By date of market launch, we mean the implementation of a project for a park of multiple units.

- With the support of the Brittany Regional Authority, a **WaveRoller** prototype to exploit wave energy will be tested in South Finistère. The project is supported by DCNS in cooperation with energy company Fortum and manufacturer AW-Energy (Finland).
- **Floating wind turbine project supported by DCNS** (French leader in the naval sector), initially project WINFLO (Groix site). DCNS aims to produce an initial multi-megawatt model in 2017, before the production of pilot farms by 2018 and commercial farms as of 2020.

1.5.1.2 Cornwall and Isles of Scilly

Cornwall and the Isles of Scilly (IoS) have some of the most substantial MRE resources in the United Kingdom (estimated at around 3 GW, see The ORRAD (Offshore Renewables Resource and Deployment) project estimates that the following deployment levels can be achieved within 50 km of the coast by 2030:

).

This potential is supported by Cornwall via investments in infrastructure, notably:

- **Wave Hub**[10]- the biggest test and development site for wave energy exploitation technologies in the world, located 16 km off the port of Hayle (North Cornwall). It also has a licence for floating wind turbines. Across 8 km², in climate conditions deemed to be optimal, it allows a hub of four berths with a unit capacity of up to 5 MW to be connected to the mainland grid. The connection to the national grid is provided by underwater cables and an intermediate station at Hayle Marine Renewables Business Park (dedicated MRE site at the port of Hayle). Built in 2010, its current operating agreement runs until 2025, and the grid connection could go from 20 to 50 MW (depending on agreements and developments in underwater cabling). As of 2014, British enterprise Seatricity will be the first to install its *Oceanus* wave energy technology[11] there – a floating buoy that activates a pump, making it possible to send pressurised water through a turbine that generates electricity[12]. The objective is to have a 10 MW installation by 2015.

- **University of Exeter**[13]**,** which has an MRE specialist research department which can rely on dedicated experimental infrastructure:
  - **FaB Test**[14] (Falmouth Bay Test Site) – a development platform for wave energy technologies in Falmouth bay (South Cornwall). The proximity of

[10] http://www.wavehub.co.uk/about/

[11] http://www.wavehub.co.uk/news/seatricity-secures-berth-at-wave-hub/

[12] http://www.seatricity.net/content/technology

[13] http://emps.exeter.ac.uk/renewable-energy/research/research-interests/offshore/reliability/facilities/

Falmouth's port infrastructure, the favourable climate conditions and the variety of the terrain (depths, seabeds) make it possible to test the technologies in real conditions. This incubator site, which is not connected to the national grid, operates based on a system of prior consent, which makes it possible to reduce risk, uncertainty, time and cost, and therefore offers relatively facilitated deployment for pre-commercial technologies. The Lifesaver equipment developed by Fred. Olsen Bolt has been installed there in a demonstration model since 2012[15], and the objective is a commercial installation connected to the national grid at Wave Hub.

- **Dynamic Marine Component Test Facility** (DMaC) – a test rig intended to reproduce the forces and movements of components used in applications at sea. DMaC is based in Falmouth and has direct applications in the testing of wave energy, marine current and tidal energy equipment.
- **Moorings Test Facility** – dedicated installation where different mooring systems can be tested for wave energy.
- There are also other pieces of equipment and software making it possible to measure and model the marine environment[16].

- **University of Plymouth**:
  - **COASTLab**[17] – built in 2012, this houses marine condition simulation basins designed to reconstruct the dynamic phenomena of waves, currents, winds and sedimentation.
  - **Marine Innovation Centre (MARIC)**[18] – provides an interface between the university and enterprises, with the aim of promoting collaborative partnerships, identifying technology transfer opportunities and connecting up enterprises with the available test infrastructure.

A wide range of organisations involved in the development of the local and national MRE industry are based in Cornwall:

- **South West Marine Energy Park** – in 2012, the South-West of England became the first Marine Energy Park in the United Kingdom, making it possible to concentrate MRE research and development there. In view of its substantial

[14] http://emps.exeter.ac.uk/renewable-energy/research/research-interests/offshore/reliability/facilities/falmouthbaytestsitefabtest/

[15] http://www.boltwavepower.com/fabtest

[16] http://emps.exeter.ac.uk/renewable-energy/research/facilities/

[17] http://www.plymouth.ac.uk/coast

[18] http://www1.plymouth.ac.uk/location/campusdevelopments/marinebuilding/Pages/Marine-Innovation-Centre.aspx

resources, Cornwall is a major component of this Marine Energy Park (see For the specific case of the Isles of Scilly: installation potential of 5 MW of wave and current energy and Smart Grid management of distribution and capacity.

¢).

The South West Marine Energy Park is a partnership that brings together politicians, entrepreneurs, developers, academics and manufacturers connected to the MRE sector. In Cornwall, the members include public bodies such as Cornwall Council and Plymouth City Council, Regen SW, the Universities of Plymouth and Exeter and the Cornwall and Isles of Scilly LEP (Local Enterprise Partnership) as well as private sector businesses such as A&P (marine engineering), MOR Group (MRE enterprise network) and Mojo Maritime (MRE project management). The role of this partnership, which is founded on the geographic unity and marine resources of the South-West region, is to bring together the stakeholders in the MRE sector in a network, incentivise them and coordinate their activity. To do this, the main task of the SWMEP is firstly to produce a detailed plan of action shared by the political and economic partners, and to define the necessary means of funding and governance for it. The SWMEP is therefore involved at the level of defining strategies, as implementing and managing projects in Cornwall and Plymouth is the job of the ORDP (Offshore Renewables Delivery Programme).

Its purpose is to promote the development and commercialisation of the local MRE sector by creating a collaborative network that attracts investors.

Several issues are highlighted[19]:

- Access to marine energy resources and reduction of investment risks;
- Access to the best platforms to develop the technologies;
- Financial support for the development of the local enterprises involved;
- Investment in port, network and industrial infrastructure;
- Collaborative structuring of the supply chain and skills.

¢ **PRIMaRE** (Peninsula Research Institute for Marine Renewable Energy) – collaborative research institute involving several universities (Universities of Exeter, Plymouth, Bath, Southampton and Bristol). The Universities of Exeter and Plymouth offer specific courses and research topics in the field of MREs. The University of Exeter has a presence in Cornwall at the Combined Universities Campus near Falmouth.

In partnership with manufacturers in the sector, the programme is investing in MRE-related R&D in six fields: resource characterisation, MRE systems, environmental and biodiversity impacts, safe operations and navigational risks, underwater and surface electrical systems, and finally socio-economic factors.

[19] SWMEP Prospectus, January 2012

- **Regen SW** – centre of excellence in renewable energy expertise and innovation. Regen SW is a partner of the SWMEP and invests in the development of the MRE industry in Cornwall and the South-West by coordinating innovation efforts, supporting the enterprises involved and getting involved in local and national decision-making processes.
- **ORDP (Offshore Renewables Delivery Programme) –** £2 million research and development fund to support organisations looking to test equipment. The ORDP was established by Cornwall and Plymouth under the Regional Growth Fund 2, approved very recently. This fund is managed by Invest in Cornwall and, as mentioned before, it is part of the SWMEP's ongoing work to implement strategy in this specific area.
- **Marine Offshore Renewables group (MOR group) –** a network of enterprises that brings together a substantial range of marine competences present in Cornwall, including companies such as A&P, Mojo Maritime and Keynvor Morlift, specialists in MRE-related activities. The international marine development project Fugro Seacore is also present in Cornwall. These local companies are involved in MRE operations at national and international level. Mojo Maritime is notably developing a boat specifically designed for installing current energy systems.
- **Falmouth** has a huge port, engineering and marine operations infrastructure, including a deepwater harbour and secure anchorages.
- The **Hayle** harbour redevelopment project includes a dedicated MRE zone with 900 m² of office space and 1,500 m² of industrial premises[20]. The **Marine Renewables Business Park (MRBP)** is currently being built and will enable MRE enterprises to have premises very close to the Wave Hub site and the port infrastructure. The project is being financed with £15 million of public funds[21].
- **Plymouth**, one of the most important ports in the South-West and a major naval base, is located over the border from Cornwall.
- **Cornwall Council** and **Cornwall Development Company** (which includes **Invest in Cornwall**) have an expert role in the regional development of MREs.
- The **Cornwall & IoS LEP** (Local Enterprise Partnership) is responsible for local implementation of public policy on economic development, innovation and skills. The LEP plans the economic development of its region then manages and negotiates the investment funds granted by the government and the European Union. The development of MREs is included in the LEP strategy, which therefore plays a key role in terms of funding for the sector.
- In October 2013, **The Crown Estate** (the body that manages Crown property, including the sea bed of the United Kingdom[22]) announced a series of wave and

[20] http://www.investincornwall.com/wp-content/uploads/1841_IIC_HayleBizPark.pdf

[21] http://www.wavehub.co.uk/news/press-releases/14-25-million-to-fund-infrastructure-for-future-of-marine-renewables-in-hayle/

[22] http://www.thecrownestate.co.uk/media/387737/role-in-offshore-renewable-energy.pdf

current energy demonstration zones around the country. A demonstration zone off the north coast of Cornwall is to be chosen for wave energy projects, with a capacity of up to 30 MW.

- **Cornwall Marine Network** brings together SMEs in the maritime sector in a local skills network. The MOR Group presented above is one of its sub-groups.

Finally, to conclude by identifying the organisations participating in the dynamic of our areas of study for MRE segments, here we should not forget the **MERiFIC** project, developed by partners in Finistère and Cornwall as part of **INTERREG IV A** France (Channel) England, with financial aid from the European Regional Development Fund (**ERDF**). This project is building **dynamic, shared partnership connections** to make progress in the adoption of marine energies in both regions.

1.5.2 Segment by segment objectives accompanied by operational responses

Brittany

The Brittany region is facing an unusual level of energy fragility: local electricity production scarcely covers 10% of its electricity consumption[23]. With all energy combined, Breton production accounts for only 8.3%[24] of regional energy consumption, and its peninsula location makes it necessary to import the energy it needs via the grid primarily from the East. Given the richness of its marine resources, the development of marine renewable energies is considered an opportunity and an obligation alike. Although the tidal barrage at Rance should retain its 240 MW potential in the coming years, other segments must be brought in to strengthen the sector. The Breton Electricity Pact 2010 therefore aims to bring marine renewable energy production to 1,250 MW by 2020[25]. The draft SRCAE approved in November 2013, while confirming these objectives for 2020, projects an MRE potential of between 2,440 and 3,840 MW including tidal energy as early as 2050, i.e. **1,100 MW of additional MREs by 2020 and 2,200 to 3,600 MW by 2050**.

[23] Public policies in support of marine renewable energy projects and regulatory frameworks governing the sector in France, MERiFIC project, March 2013.

[24] Brittany SRCAE (Regional Blueprint for Climate, Air and Energy), 2013

[25] Breton Electricity Pact 2010 – Annex 2

TABLE 1: MRE OBJECTIVES SET BY THE BRETON ELECTRICITY PACT AND THE SRCAE[26]

	2010		2020		2050	
	MW	GWh	MW	GWh	MW	GWh
Rance Tidal Power Station	240	490-550	240	490-550	240	490-550
Offshore fixed-bottom and floating wind turbines	-	-	1000	2900	2100 -3500	7900-10500
Marine current turbines	-	-	10	10-30	100	100-300
MRE total	**240**	**490-550**	**1250**	**3400-3480**	**2440-3840**	**8490-11350**

TABLE 2: ENERGY SAVING POTENTIAL (SOURCE: SRCAE 2013)

	Reference scenario		Proactive scenario	
	By 2020	By 2050	By 2020	By 2050
Energy reduction (/2005)	-12%	-32%	-26%	-60%
Estimated consumption (GWh)	73,700	56,950	61,975	33,500
2005 consumption (GWh)	83,750			

Cross-referencing these objectives with the energy saving scenarios set out in the SRCAE, MRE production would account for around 5% of energy consumption by 2020, and 15-34% by 2050; it covered 0.6% in 2010. Among all the renewable energies, these developments would place MRE production in front of renewable heat production (biomass, biogas, household waste, etc.), but still well behind land-based electricity production (essentially land-based wind turbines and photovoltaic solar energy)[27]. It should be noted that MRE objectives currently only concern the production of electricity, although the issues and potential cover energy in general.

Recently, the Brittany Future Pact, established in December 2013 in consultation with economic, political and social players, established certain measures to respond to the economic and social difficulties in the region. Regarding MREs, the government undertakes to do all it can to support France Energie Marine and its components in the implementation

[26] The ranges of values reflect the variability of the electricity production of the machines, together with the differing installation scenarios and the projections for technological progress.

[27] SRCAE 2013 – *Table 19: Summary of renewable energy development potential by 2020 and 2050,* (p.106)

of its work[28]. Moreover, the development project for the port of Brest must be accelerated, particularly with a view to housing the new MRE industrial sector[29]: the Pact refers to priority access to the TEN-T fund for this[30]. The ecological and energy transition is supported by ADEME [French Environment and Energy Management Agency] at a level of around EUR 33 million for 2014.

FIGURE 9: MRES IN BRITTANY, PROJECTS COMPLETED AND IN PROGRESS (SOURCE: BDI[31]).

- Offshore fixed wind turbines

Offshore fixed wind turbines are currently the most mature technology. They are already operated in the North Sea (Denmark, United Kingdom and Germany), with development on four French sites planned by 2020: Fécamp (498 MW), Courseulles-sur-Mer (450 MW), Saint-Nazaire (480 MW) and in Brittany at Saint-Brieuc (500 MW) . These four parks were the subject of a national call for tenders launched in July 2011. The contracts were awarded in April 2012; the Saint-Brieuc park will be built and run by the Iberdrola/Eole-Res/Areva

Brittany Future Pact 2013 – Article 7: Supporting marine excellence in Brittany

Future Pact 2013 – Article 7 and Article 13: Improving the accessibility of Brittany

Trans-European Transport Network - http://ec.europa.eu/transport/themes/infrastructure/index_en.htm

http://www.invest-in-bretagne.org/IMG/jpg/Carte_EMR_2013_RVB_BD-juin13.jpg

purchase a certain volume of renewable energies each year or be subject to financial penalties.

- **When funding sources need to be diversified** as projects multiply and become increasingly capital-intensive (up to several billion euros) with:
  - An **increase in the power of the public investment banks**, like German bank KfW: EUR 50 billion of renewable energy projects funded worldwide in 2012, against EUR 12 billion in 2007;
  - **Consortia and joint ventures** between project developers becoming **more widespread**, partly with the desire to share management of project risks;
  - The appearance of **new funding tools and mechanisms for investment costs**:
    - **Green bonds**: issued by public investment banks, but also by private companies (EDF) and local authorities (Ile-de-France Regional Authority, etc.),
    - **Crowd funding:** involving local citizens in the funding of a project's investment costs, making it possible to improve the acceptability of projects (something that is critical for MREs); this is a good mechanism for low power projects, especially in alternative segments (small-scale current turbines, small-scale tidal power, SWAC, etc.).

- **Of uncertainty when it comes to funding models for the electrical connection** of MRE parks to the coast, with considerable European diversity:
  - **Germany and Denmark**: complete responsibility (project management and funding) for the connection (transformer substation) covered by the TSO (transmission system operator).
  - **France, Ireland, Netherlands**: the TSO is the project manager up to (but excluding) the transformer substation and funding for the cable is provided by the developer.
  - **Belgium, Sweden**: the developer is the general contractor and funds the entire land-sea connection (land substation inclusive); the Netherlands may adopt this model.
  - **United Kingdom**: project management and funding handled by a dedicated independent operator (OFTO: Offshore Transmission Owner).

At the moment, when it comes to tools and mechanisms for support and funding of MREs, Brittany and Cornwall have **similar** profiles:

- Existence of **local bodies to support and fund R&D**:
  - In Brittany: Pôle Mer Bretagne, Bretagne Développement Innovation, etc., but also France Energies Marines and IFREMER;
  - In Cornwall: primarily CDC (Cornwall Development Company).
- **Absence to date of tools and mechanisms for funding at local level** (in a context of constriction of national mechanisms) **for high power projects** (parks supplying several hundred MW), which will be required when entering the commercial phase of the first MRE segments (offshore floating wind turbines and marine current turbines first).

Brittany, on the other hand, has a **deficit of testing infrastructure for technologies, prototypes and demonstration models compared to Cornwall, connected to a lack of sufficient funding for its implementation**. This infrastructure is essential to see the emergence of MREs at regional level, and to make it possible for technology developers to limit R&D expenses compared to an investment in their own right (test sites[55] and pilot sites[56] that make sharing of infrastructure possible). Brittany can rely on the resources of the Ecole Navale, but these are limited compared to the diverse resources available to Cornwall (FaB Test, DMaC, COAST Lab, etc.), and particularly compared to the Wave Hub test site (wave energy and soon floating wind turbines).

Brittany and Cornwall can rely on national and European developments in aid and funding tools and mechanisms, as well as on experience from the new renewable energy segments that are now commercial (land-based and offshore fixed wind turbines, photovoltaic solar power) to launch regional initiatives with the implementation of suitable tools and mechanisms.

There is also a major issue of funding for Breton prototype and demonstration model test infrastructure, something that is specifically supported by France Energies Marines. If it is not possible to make ambitions relating to these sites a reality due to lack of funds, cooperation between Brittany and Cornwall for facilitated access to local infrastructure (Wave Hub, Fab Test, etc.) would be likely to accelerate the technological development of the systems and the commercial viability of the projects.

[55] Generic for a given segment, regardless of the site

[56] Specific to a site

Finally, although the absence of local funding bodies for the segment and for large-scale MRE commercial projects (and renewable energies in general) is not currently incapacitating in view of the low level of maturity of the MRE sector, it will become a critical question as the market approaches its commercial phase.

2.5 Port issues

The ports in Brittany and South-West England have been studied based on the different functions of ports for MRE segments:

- Housing the factories to manufacture components or elements of the park and its foundations;
- Hub for assembly and installation of the components;
- Harbour/logistics site for ships operating in the zone;
- Housing a maintenance (operation) base throughout the duration of operation of the park (20-25 years);
- For the park dismantling operations in the longer term when operation of the projects has ended, and in some cases, recycling activities.

The ports can be broken down into three categories:

- Industrial and commercial ports, which in general have access to large ships, wharves and open areas where part or all of an MRE project can be accommodated.
- Combined fishing and leisure ports, the most numerous, which may be attractive due to their proximity to the park zones.
- Leisure ports have been considered unsuitable (lack of space, access conditions) for MRE projects.

Brittany and Cornwall/Isles of Scilly have a large number of ports with capacity for development, primarily in terms of **operation and maintenance** activities for the parks, subject to adapting existing infrastructure.

In Brittany: only one port (**Brest**) is capable of participating in the installation of offshore wind farms and five ports (**Concarneau, Douarnenez-Rosmeur, Roscoff, St Brieuc-Le Légué** and **Tréguier**) may be able to handle works for installations of marine current turbine and wave energy parks, subject to having work done to adapt the infrastructure. Moreover, the capacity of the port at Brest and its location mean that it could also play a role for the areas in the south of England.

In Cornwall: only one port (**Falmouth**) is capable of participating in the installation of MRE parks, and potentially **Plymouth**, subject to adaptation. The port of Belfast, which is not in the same area, remains well placed to have a positive influence on the region.

In these two areas, numerous ports (between 10 and 20 Breton ports and 7 to 10 ports in Cornwall) could serve as receiving and logistics sites for the ships operating in the zone and receiving sites for maintenance bases throughout the period of operation of the MRE parks. Together, these ports would make it possible to cover the north and south coasts of the two areas.

It should be noted that the port of **Hayle** in Cornwall is in the process of development to house an MRE business park (Hayle is already home to the Wave Hub offices).

The development potential in the MRE field has been assessed based on the characteristics of the ports (port capacity, including for the industrial production/assembly and maintenance zones), the existence of test sites in Cornwall (the Dynamic Marine Component Test Facility (DMaC) and FabTest in Falmouth, and the Wave Hub in Hayle), their proximity to the MRE resource, potential sites and existing skills in terms of engineering, shipbuilding and repair, marine operations, etc.

2.6 Issues of cooperation and governance

In most countries where MRE segments have been built, their development has been supported by cooperation bodies (at regional level, around a historic job pool for example, or at national level). These bodies rely on the skills of mature segments connected to MREs such as Oil & Gas, shipbuilding and repair, and marine operations. These segments are also present and established in Brittany and Cornwall, together with the governance provided by recognised bodies (centres and clusters, and with the support of economic development agencies and local authorities).

Moreover, the creation of dedicated infrastructure for MREs (such as the port terminal at Bremerhaven) is a factor in attracting enterprises (industry, services). Current developments (ports of Brest and Hayle for example) are moving in this direction .

Partnerships between enterprises are almost always associated with research and academic institutions. These play an important role in the short and medium term to improve technical knowledge (demonstrating MRE technologies and observing the environment). In Brittany and Cornwall, higher education establishments offer specialist higher education and professional training specific to the sector (see Annex 1 to Stage 2 – Sheet 3 Education and training), and in Cornwall, they have played a part in the emergence of test sites .

Local cooperation bodies also play an important role in representing the sector in dealings with enterprises outside the area and political authorities at international level. This applies to the MERiFIC programme, which is a good example of inter-regional cooperation working on a shared project for the emergence of a new sector.

However, the cooperation networks have been built around historic or existing players, and the challenge in the coming years will be to attract new skills and enterprises and to move towards industrial cooperation projects, particularly regarding exports.

Moreover, the presence of multiple players (research centres, cooperation networks, etc.) is positive and a sign of the sector's dynamic nature. Nonetheless, it is important to remain aware of the fact that every player develops projects taking into account competing activities to avoid overlaps and to remain in a field of healthy competition, especially in view of the competition that is also in play in other areas (Scotland and Normandy for the countries under consideration here, but also Ireland, Spain, Japan and the United States).

Finally, cooperation programmes, unlike networks of players, must be maintained over time so that they do not see their efforts fizzle out at the end of the programmes, taking into account the time it takes for public and private players to make decisions.

3 STAGE 3: STRATEGIC RECOMMENDATIONS AND ACTION PLAN FOR THE SOCIO-ECONOMIC DEVELOPMENT OF BRITTANY AND CORNWALL

As a reminder, this project report is structured based on three main stages:

1. The first phase is intended to assess the **situation and prospects of marine energy (MRE) development**, identifying the numerous segments (offshore fixed and floating wind turbines, marine current turbines, wave energy, etc.) and various applicable markets (production of electricity, heat and cooling, storage), based on different areas of analysis: worldwide, European, French, English, and finally at a more local level, concentrating on the **specific features of the MERiFIC area** around the regions of Brittany and Cornwall;

2. The second phase concentrates on a **regional analysis of key issues** such as governance, planning, funding, technological innovation, training, assessment of the potential for development of the existing industrial fabric and port structures, etc., so as to identify the most relevant accessible levers for **reinforcing the socio-economic development prospects of MREs in the two regions**;

3. The third and last phase of the project – after an executive summary of the previous phases – concentrates on building an **ambitious, innovative inter-regional strategy**, defining **five recommendations** associated with an **action plan (with 7 priority actions)** that is directly operational for the political and economic players of Brittany and Cornwall.

3.1 Summary of phases 1 and 2

3.1.1 Assessment of the MRE development situation and prospects in Brittany and Cornwall

MREs include a multitude of segments offering the potential for a strategic contribution to future energy mixes. They also provide excellent **leverage for socio-economic development** in regions that have substantial marine resources alongside an economic fabric with strong development potential and appropriate governance for the specific issues of these innovative segments.

Over and above the favourable positions of France and Great Britain when it comes to the development of MREs in Europe, **Brittany and Cornwall have similar economic fabrics which, through their nature and diversity, benefit from strategic potential when it comes to MREs**. This is notably the case thanks to the historic presence of the main sea-related professions which can be directly drawn upon throughout the project value chain (education and training, R&D laboratories, specialist engineering firms, shipbuilding and repair, port infrastructure, sea transport services, etc.), as well as manufacturers and major orderers that are well established locally and liable to play a leading role in these markets which offer major export potential from both an industry and a service perspective.

FIGURE 13: A MULTITUDE OF MRE SEGMENTS TO CONSIDER, WITH EXTENSIVE APPLICATIONS ACROSS ALL FORMS OF ENERGY

Building an integrated industrial sector could contribute to fulfilling local ambitions on energy transition and decentralisation. Moreover, aiming for competitiveness by implementing potential synergies and fully exploiting the points of complementarity, strengths and advantages of the two regions will contribute to tackling export issues in order to ensure sustainable development of jobs and associated economic activity.

At the same time as seizing the opportunities arising from national or supranational policies in the coming years, extending the MERiFIC cooperation would make it possible to launch local initiatives adapted to the specific characteristics of the two regions in order to accelerate current trends. These trends are currently primarily based on growing investments in offshore fixed wind turbines and the emergence of large-scale marine current turbines, where development potential in Brittany and Cornwall is smaller than in other adjacent regions.

Making full use of the specific features of the two MERiFIC regions contributes to the identification of strategic levers to be activated in the next few years to fully exploit their advantages. In particular, we note the following shared distinctive features:

- Particularly large potential in the two main segments of offshore floating wind turbines and wave energy: the players in the MERiFIC regions have enough advantages to be able to position themselves as pioneers and harbour leadership ambitions in the two most attractive emerging MRE markets in the world, over time.
- The peninsula and island nature of the two regions: this lays the ground for strategic innovation, reinforcing opportunities in terms of alternative segments (SWAC, small-scale tidal energy, small-scale marine, river and estuary current turbines), storage technologies, and more indirectly innovative means of funding and support for MRE segments.

- Large-scale marine current turbines: the potential of the physical resource is smaller than in other adjacent regions (e.g. 1,500 MW for Raz Blanchard in Normandy vs. 400-500 MW at Fromveur) and the most advanced industrial projects are outside the two MERiFIC regions (e.g. land reserved by DCNS in Cherbourg). We should however note that Sabella has expressed strong intentions regarding the port of Brest.

In relation to the major MRE segments, Brittany and Cornwall are in similar situations, where floating wind turbines and wave energy are the segments that offer the greatest development potential, whereas their neighbouring regions (respectively Normandy/Pays-de-la-Loire and Devon) are already involved in developing fixed wind turbines and large-scale marine current turbines, MRE segments that are currently more mature.

FIGURE 16: STRENGTHS AND WEAKNESSES BY ALTERNATIVE SEGMENTS AND BY REGION

	BRITTANY	CORNWALL
GLOBAL alternative segments	• **Potential not assessed** (resource) • Local fabric capable of handling **all the building blocks in the value chain**	• **Potential not assessed** (resource) • **Potential industrial opportunity** for systems on a smaller scale (a few tens or hundreds of kW)
SWAC	• **Density of needs on the coasts** (Brest, Lorient, St-Malo, etc.) • **Opportunity for local players** (producers of heat pumps, etc.)	• **Density of needs on the coasts** (Falmouth, Penzance, etc.) • **Opportunity for local players** (producers of heat pumps, etc.)
Small-scale tidal energy	• Local and historic **experience and skills** in large-scale tidal energy (Rance facility) • Presence of **numerous ports** all along the coast (Brest, Lorient, etc.)	• Presence of **numerous ports** all along the coast (Falmouth, etc.)
Small-scale marine, river and estuary current turbines	• Presence of islands • Presence of **numerous rivers and estuaries** (Odet, Rance, Vannes, etc.)	• Presence of islands • Presence of **numerous rivers and estuaries** (Fal, Hayle, Helford, etc.) • **Unfavourable bathymetry for river turbines**
Storage	• **Island context favourable to small-scale experimentation** (Ushant, Bréhat, etc.)	• **Island context favourable to small-scale experimentation** (Isles of Scilly)

Key: *Strength* *Weakness*

Opportunities exist for both regions in terms of alternative segments (apart from river current turbines for Cornwall), but they are still to be **defined and quantified**, notably through an initial assessment of the technically exploitable local resource. More generally speaking, their contribution to the aim of **energy decentralisation** justifies considering them as essential for Brittany and Cornwall over the long term.

In this respect, **SWAC and small-scale tidal energy** call for “off the shelf” components (respectively heat pumps, pipes, heat exchangers and turbines), which do not justify the creation of an industrial segment per se, as in the case of other MREs, whereas **small-scale marine current turbines, or indeed river and estuary current turbines**, could see the construction of a local industrial segment, much like the **storage segment**, bearing in mind the attractiveness factor provided by the **island** and peninsula geography of the two regions.

3.2 Production of five recommendations and their strategic variants

NB: The strategic recommendations are based on the results of a prospective exercise focused on the development of all the MREs in Brittany and Cornwall by 2030. The methodology and underlying principles of the assessment model for the associated socio-economic benefits are based on two development scenarios (upper and lower, which have no binding value at this point): the detailed results and modelling hypotheses are presented in an annex.

Considering the advantages and limitations of Brittany and Cornwall, our strategic recommendations are based on reinforcement of the **cooperation** between these two regions, in order to strengthen **local socio-economic development arising from MREs** and make it sustainable. This cooperation has the following principal benefits:

- **Reducing the costs** of technological development and industrialisation thanks to the **sharing** of suitable resources (test sites, assembly ports, service ships, etc.);
- **Smoothing** of the industrial load by making the MRE park development projects visible and coherent throughout the area of Brittany and Cornwall;
- **Improving the economic competitiveness of the segments for export**, with the formation of shared offerings (particularly in terms of upstream services, which have strong export potential), incorporating the advantages and distinctive features of the (public and private) local players in both regions;
- Improving the general level of **knowledge of the marine environment** through the pooling of know-how and expertise of the local players (enterprises, universities, etc.) in order **to speed up the road maps for technological development**.

The consortium established by ARTELIA, INDICTA, INNOSEA and MARINE ENERGY MATTERS proposes five main recommendations for consideration in the decision-making for the MERiFIC project; each of them has specific strategic variants (14 in total).

Among these **five** strategic recommendations:

- **Two** of them are based on implementing **innovative, coherent long-term regional energy policies** between Brittany and Cornwall**;**
- **The other three** are based on defining a **coordinated, controlled multi-segment strategy** by differentiating the cooperation efforts to be implemented depending on the potential of each MRE segment, both the main ones and the alternatives.

FIGURE 17: SUMMARY LIST OF THE 5 RECOMMENDATIONS AND THEIR MAIN STRATEGIC VARIANTS

REGIONAL ENERGY POLICIES	**I) Inter-regional planning for all the MRE segments**
	a) Multi-MRE spatial planning (TEP studies + objectives for 2020 and 2030)
	b) Planning of skills and strategic workforce planning
	II) Innovative local funding
	a) Funding focused on industrial resources and pooling
	b) Public and crowd funding *Ą positive impact on risk premiums and therefore the IRRs of projects*
	c) Search for a breakthrough (e.g. coupling MREs and electric vehicles)
MULTI-MRE SEGMENT POLICIES	**III) Overall vision for two strategic segments: floating wind turbines and wave energy**
	a) Sharing testing resources
	b) Joint production of shared offerings in upstream services
	c) Industrial structuring around strategic ports: Brest for floating wind turbines, to be determined for wave energy
	d) Sharing of services operational at sea (service boats in particular)
	e) In the longer term: dismantling / recycling
	IV) Making full use of opportunities in other segments (fixed wind turbines / large-scale marine current turbines + alternative segments)
	a) Wider inter-regional cooperation and maximisation of the local industrial fabric (foundations + sub-contracting)
	b) Alternative segments as a criterion for adjustment based on available resources
	V) Energy storage and autonomy
	a) Distinctive “island and export” storage offering to strengthen energy autonomy locally
	b) In the longer term: high power storage and energy decentralisation

RECOMMENDATION 1: Launch inter-regional planning for all the MRE segments (electrical and others) in order to define an agreed-upon long-term vision shared by Brittany and Cornwall.

This is an essential first step in order to bring about enough visibility for the various economic players in these segments (project developers, investors, manufacturers, etc.) and therefore to promote the emergence of these sectors at regional level. To do this, we have identified the following two strategic variants:

I.a) Launch studies to assess Technically Exploitable Potential (TEP) for each of the MRE segments, and in particular those where the visibility over the resource is currently weakest but the potential is the most promising: floating wind turbines and wave energy, as well as alternative segments.

- ü This initial phase will make it possible to define ambitious, realistic **installed capacity objectives** by agreement for each of the MRE segments in Brittany and Cornwall.

- ü The trajectories defined at this stage are difficult to reconcile (the Breton Electricity Pact sets objectives for 2020 and 2050, whereas Cornwall has set objectives for 2030), do not cover the same segments, and concentrate solely on the production of electricity and a limited number of major MRE segments.

- ü We therefore recommend defining a **single road map for the MERiFIC area for 2030**, with an initial milestone at 2020 (or 2025 for the less mature segments), **covering all the MRE segments** investigated in this project.

I.b) Launch a cooperation effort on strategic workforce planning in order to identify the critical training available in each region and ensure that the power of the entire sector increases, in terms of both quality and quantity.

- ü Training is one of the main advantages of the two regions. It will therefore be a matter of segmenting the chain of professions and identifying the sharing and specialisation factors among the various reference bodies.

- ü Moreover, a certain number of professional roles specific to the alternative segments (particularly storage and overall management of intermittent supply, notably through smart grids) could give rise to the creation of new training courses jointly developed by French and English bodies.

RECOMMENDATION 2: Implement innovative new models of funding suitable for every stage in the technological development cycle and the value chain of MRE projects.

Funding appears to be one of the main factors limiting the development of alternative energy projects, at a time when the support mechanisms for renewable energy backed by national or supranational policies are seriously under review.

We have therefore identified several **types of accessible levers of innovation at regional level**, specific to the funding of R&D projects – the direct and indirect investments required to ensure the economic viability of the first commercial projects, or downstream of the projects through sustainable support for green energy produced locally.

II.a) Establish support mechanisms focused on R&D – including integration into energy systems – as well as industrial resources, and no longer just energy production as is currently the case.

- ü The historic mechanisms for supporting the development of renewable energies have focused on direct and indirect subsidies for R&D investments on one hand, and the purchase price of the electricity produced on the other; in other words, on the systems of production and the produced electricity that is directly injected into the national grid.

- ü At regional level, beyond more conventional – but no less important – projects such as CEIs (Calls for Expressions of Interest), we think it is also legitimate to assess the **suitability of supporting and promoting investments in industrial bases on one hand and service offerings on the other (ships first and foremost, but also joint activities)**.

- ü Tools such as these, focused on local industrial loads, should be part of an **approach of energy decentralisation** without injecting the energy produced into large interconnected grids, primarily for reasons of compatibility with the European policies on free competition. In the short term, these requirements are entirely in line with the specific features of the two MERiFIC regions, particularly with regard to their island areas.

II.b) Develop public funding and crowd funding with a view to diversifying funding sources and improving the cost of risk and the social acceptability of the projects, in order to aim for genuine sharing of the benefits with the local population.

- ü Investments in MRE infrastructure are currently massively funded through bank debt (80% of CAPEX on average); about 15 specialist European banks currently define the fee requirements in line with the demand for capital of the entire energy sector (oil, coal, gas, nuclear, renewables, etc.), and access to bank loans is sometimes limited by unfamiliarity with the marine environment and lack of an accurate perception of the risk of MRE projects.

- ü Considering the current, exceptionally high level of fees on capital invested in the energy sector, we have identified **public funding (national and regional) as an important immediate lever for reducing the overall cost of MRE projects**, both

through a revision downwards of profitability requirements and by benefiting from a direct reduction in risk premiums associated with the projects.

- We also propose **identifying the conditions to enable individuals to become one of the top levers for guaranteeing the economic viability of regional MRE projects**: both for **financing the investments** and for ensuring the overall attractiveness of the projects through **signature of contracts on offers of supply to guarantee 100% green, local energy** (like the company Enercoop).
  - The increased power of this type of new mechanism (some already exist in Brittany) will be limited, in terms of financing CAPEX, to smaller projects, for investment costs of a few million or even tens of millions of euros (this lever is less suitable for “Saint-Brieuc”-type projects where overall CAPEX comes to EUR 2 billion).
  - Finally, we note that this type of initiative could heighten the awareness of citizens as to the actual cost of the new energies, and offer them attractive investments (vs. LDD [sustainable development savings account], Livret A [general savings account], etc.) while developing local industry, thereby **reinforcing the social acceptability of the projects in a sustainable way**.

II.c) Promote the emergence of breakthrough models around funding mechanisms that link MREs with other applicable segments with strong potential

- Beyond crowd funding, coupling MRE production with existing or new energy usages offers **favourable ground for innovation** for the accelerated development of innovative segments in Brittany.

- In this respect, we have identified strategic opportunities linking production of renewable energies – more specifically **MREs**, taking into account the market potential associated with the Brittany region – **and increased power of electric vehicles**:
  - The performance of electric motors is nearly three times better than heat engines, and the current sale pricing structure of electricity at national level involves a particularly attractive cost per km travelled with an electric vehicle (four times lower than petrol vehicles).
  - By overcoming the barrier of over-investment – in the short term for example through leasing, car-sharing or enterprise group purchases, the first levers for penetration of electric vehicles – users could see **three benefits** from recharging their cars via offers adapted to the costs of electricity produced at sea:
    - Even if the sale price of electricity doubled, they would retain an economic advantage compared to conventional solutions;
    - They would benefit from a massive reduction in atmospheric pollutant emissions with significant local impacts, as well as greenhouse gas emissions, with the consumption of non-fossil renewable energies such as “green fuel”;
    - Finally, they would contribute directly to the socio-economic and industrial development of their region, in this case Brittany, across

multiple innovative segments with strong export potential (specifically marine renewables and sustainability mobility solutions, two of the region's advantages).

- This innovative model, accessible at local level, makes full use of the current dynamic of innovation in Brittany, and provides **a huge, long-term funding lever** (funding through recurring travel, which has been growing constantly for decades, with mobility prospects that remain favourable in the short, medium and long term).
  - NB: By way of example, a project for construction of a garage for electric vehicles is already being evaluated on the island of Ushant. Linking with MRE projects specifically adapted to the island context would make it possible to rapidly implement this type of new model.

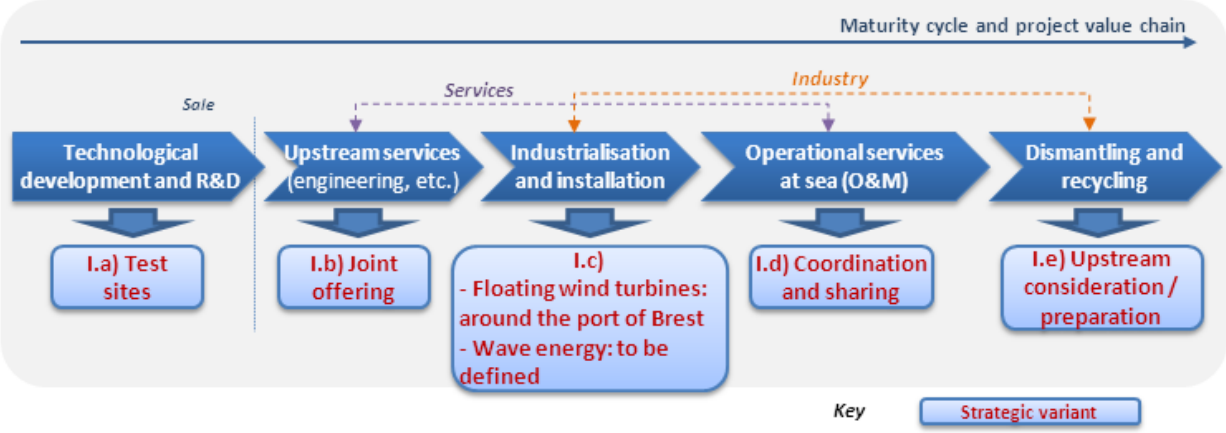
- We should finally note that this type of development would also have an impact on the broader subject of **energy storage and smart grids**, considering the stock of electric vehicles when stationary as a high power means of storage, as soon as the level of penetration of electric vehicles is significant.

NB: Beyond the MRE/electric vehicle linkage, other investigations could be carried out, notably regarding "**power to gas**", supporting the strategic potential connected to the new economic models in favour of development of Breton MREs.

Around the first two recommendations based on regional energy policy levers, we are building **three other supplementary recommendations that differentiate the socio-economic development potential** of the main MRE segments from that of the alternative segments in both Brittany and Cornwall.

RECOMMENDATION 3: **Base the long-term vision of the MERiFIC partnership on the two main strategic segments of offshore floating wind turbines and wave energy, across the entire technological development cycle and the entire project value chain** (from upstream studies to industrialisation and finally the phases of operation at sea and maintenance of the farms).

FIGURE 18: FIVE STRATEGIC VARIANTS AROUND OUR LEADING RECOMMENDATION ON FLOATING WIND TURBINES AND WAVE ENERGY



This central recommendation has five strategic variants with timescales, and is based on points of complementarity and potential synergies identified within an in-depth examination of the industrial and economic fabric of the two regions, as well as the relative attractiveness of the physical potential of each MRE segment within the MERiFIC area.

IV.a) Carry out demonstration and pilot farm tests on a coordinated basis for the two main strategic segments in Brittany and Cornwall in order to prepare and consolidate local industrial structuring and associated services as from upstream of the projects.

- ü **The establishment of test sites and pilot farms** will make it possible to carry out technological development of the floating wind turbine and wave energy systems up to the pre-commercial phase, and is an attractive feature to developers and investors in order to optimise the chance of successfully seeing the emergence of **an integrated local industrial segment with strong export potential**.

- ü The existence of the **Wave Hub in Cornwall** for testing floating wind turbines and wave energy systems leads us to give preference initially to strengthening the partnership between the two regions around this infrastructure.

- ü In the medium term, **the identification of favourable sites for testing pilot farms** (like the Groix site for floating wind turbines) will be likely to consolidate any alliances that have emerged during the first demonstration tests in Cornwall.

IV.b) Jointly build competitive shared offerings for upstream services with high added value (systems design, engineering in the field, weather and sea condition studies and services, etc.), for local projects and for export.

- Professions focused on **upstream services are one of the distinctive strengths of the MERiFIC alliance** revealed in the analysis of the economic fabric and shared by both regions.

- **Strategic alliances justified by potential synergies** would initially make it possible to optimise the costs of development of local projects.

- Over time, they could **reinforce the export potential of the Breton and English companies** through **more competitive offerings** (attractiveness reinforced by the price) and a greater worldwide foundation (accessibility reinforced in zones with preferential links to France and Great Britain in particular).

IV.c) In the short term, build up the industrialisation of floating wind turbines for both Brittany and Cornwall around the port of Brest, and in the medium term identify French and English port sites compatible with the industrial development of wave energy.

- **The port of Brest is currently the only compatible infrastructure within the MERiFIC area to support the industrialisation of offshore floating wind turbines,** both for French and English projects and also as an industrial logistics hub that makes it possible to internationalise these activities (although within a limited range of around 500 km).

- **This site is particularly relevant for floating wind turbines**, whose logistical and industrial proximity to fixed wind turbines is important (Brest is still trying to draw in contracting activities for the foundations of fixed wind turbines for the farm at Saint-Brieuc). This is a segment where the port of Brest can already provide evidence of experience, compared to the industrial ports available in Cornwall at present which are less suitable for accommodating systems of this size.

- **With a view to extensive collaboration, an examination of the industrial and port infrastructure in neighbouring areas (Lorient, Devon, etc.) could lead to this finding being modified somewhat, especially for wave energy**. For the latter less mature segment, the location of one or more industrial bases is still to be determined between Brittany and Cornwall, particularly after the phase of rationalisation of the technologies and increased visibility of the successful concepts; this will have an impact on the size and weight of the systems, which will be the subject of a technological consensus, and will ultimately determine the infrastructure eligible for this type of system (with or without major development works which will in any case need to be justified in economic and strategic terms).

IV.d) Coordinate and share operational service offerings during the installation, operation and maintenance phases of the farms to be built in the MERiFIC area (service ships in particular).

- ü One of the issues for the development of service offerings at sea is focused on **the rate of availability and rate of use of ships** (crew boats, supply boats, etc.), within zones that are sometimes underserved and whose activity is not sufficient to ensure the profitability of the associated investments.

- ü We therefore propose to assess **the suitability of sharing service ship operations in order to maximise their work** over a larger area defined around the projects of the two regions, thus making it possible to improve their profitability and the overall cost of the projects. Specific methods of implementation should be identified in order to guarantee the feasibility of these projects if a strong policy document would validate this opportunity.

NB: We should emphasise here that this potential for sharing in the phases of operation at sea will initially depend on **the capacity of the two regions to plan the deployment of their projects in a coordinated way**, referring back to the critical nature of recommendation 1.

IV.e) Anticipate more long-term questions connected to the opportunities offered by park dismantling and systems recycling activities.

- ü The MRE industry is in its infancy; it would still be useful, however, to anticipate the economic conditions for dismantling of the farms (lifespan of around 20-25 years), and more quickly, for wear and heavy maintenance of the systems (a blade has a lifespan of around six years, for example).

- ü The shipbuilding industry and more generally the expert marine environment industries are identified more specifically here to reinforce this final link in the value chain of the projects, in order both to **provide better visibility over the full cost of production of MRE farms**, and to **maximise the harnessing of socio-economic benefits** in each of the MRE segments.

- ü Like the shared offerings that could be built with a view to export, the parks installed locally could firstly undergo a shared examination by the players in the two regions, then:
  - o Secondly the European parks, where a competitive integrated recycling segment could offer a factor of heightened attractiveness;
  - o Over time, the world market.

RECOMMENDATION 4: Use the potential offered by each of the other MRE segments as a variable for adjusting the overall MRE strategy (as a function of the resources available, particularly to avoid risks of dispersal), by fully integrating their specific features: on one hand the major segments (offshore fixed wind turbines and large-scale marine current turbines), and on the other the alternative segments (SWAC, small-scale tidal energy, small-scale marine, river and estuary current turbines).

Although floating wind turbines and wave energy are the two top segments on which Brittany and Cornwall should build their partnership vision over the long term, **other MRE segments** offer strategic opportunities for these two regions to seize in the very near future.

V.a) Promote inter-regional development regarding fixed wind turbines and large-scale marine current turbines between Brittany/Cornwall on one hand and the most advanced neighbouring regions on the other, such as Normandy and Pays-de-la-Loire in France and Devon in England.

- These two major segments, which are more mature than MERiFIC's two strategic segments, are in the process of industrialisation in France, primarily in Nantes, Cherbourg and Le Havre.

- We recommend first **capitalising on the know-how around existing infrastructure, such as the port of Brest**, in order to harness some of the socio-economic benefits of the top-level industrial activities arising from the French and English projects.
  - In this respect, Sabella appears to be a top-level potential player for the establishment of a large-scale marine current turbine industrial base.
  - Similarly, accommodating industrial activities connected to large, heavy foundations (fixed wind turbines and large-scale marine current turbines) should be considered as a priority over the next few months.

- We therefore recommend **promoting the visibility of available local sub-contracting with major orderers** (Alstom, Areva, EDF EN, GDF Suez, Iberdrola, etc.) in order to take advantage of the indirect jobs arising from sub-contracting which could be created by building up industrial bases in neighbouring regions (Normandy with Cherbourg, Pays-de-la-Loire with Nantes, etc.).
  - **However, here we must emphasise the risk of dispersal** heralded by a desire to support the economic players in all the major MRE segments, including those where the development potential is certainly attractive in the short term but less significant over time.

V.b) Develop the alternative segments opportunistically with a view to energy decentralisation and increases in the socio-economic benefits from the development of major MRE segments in the short term.

- We have just underlined the gap between the actual or imminent industrialisation of fixed wind turbines and large-scale marine current turbines in other French and English regions, and the strategic nature of floating wind turbines and wave energy for the political and economic players in the MERiFIC alliance. The technological maturity of these two major segments is currently too low to envisage large-scale socio-economic benefits before 2020. In this respect, **alternative segments would make it possible to start the first commercial projects in the shorter term, and to generate significant socio-economic benefits before 2020**.

- **SWAC and small-scale tidal energy** are more mature segments using technologies and systems that are generally available “off the shelf” (pipes, heat exchangers, heat pumps, turbines, etc.). The potential socio-economic benefits will therefore primarily concern upstream services (engineering, etc.) and downstream services (installation, operations and maintenance).

- The still emerging nature of **small-scale marine current turbines** and **river and estuary current turbines** justifies considering the appropriateness of building a specific industrial segment that is, in particular, targeted rapidly towards export, where a location of Brittany seems more favourable for river and coastal current turbines in view of the weak prospects of this market in Cornwall.

RECOMMENDATION 5: Focus on development efforts in storage technologies (low and high power) to support the energy decentralisation of the MERiFIC areas and contribute to strengthening their energy autonomy.

III.a) In the short term, invest in the development of island storage technologies for joint construction of a complete solution with high export potential for the world's islands.

- ü Brittany and Cornwall share the need to develop specific energy solutions for their islands, where the conditions of attractiveness of innovative systems are reinforced by higher energy costs than on the mainland, as well as smaller energy needs.

- ü Sharing of development and R&D efforts by the two regions would make it possible **to build a complete joint offering to ensure the overall autonomy of islands** such as Ushant or the Isles of Scilly, and subsequently to contemplate **the export of tried and tested solutions**, with reference to strategic world market potential (target markets of application: all island environments, and, more broadly, isolated or non-interconnected environments where MRE potential is technically and economically accessible).

III.b) In the longer term, invest in higher powered storage technologies in order to manage intermittent supply and facilitate integration into the energy system of the main renewable energies, and more broadly to provide adequate resources for overall management of local networks.

- ü Beyond specific solutions to be developed in an island or non-interconnected context, **the overall management of intermittent supply** is a key issue in the massive deployment of renewable energies. **High power storage technologies coupled with smart grids** are therefore routes for development that the two regions could invest in jointly.

- ü This trajectory is in line with a desire to support the **energy decentralisation of the areas** and, in tandem with technological advances, to progressively reinforce the **degree of autonomy** of Brittany and Cornwall with sustainable energy solutions.

3.3 Summary of strategic recommendations: MERiFIC 2030 vision and key figures arising from the assessment of associated socio-economic benefits

Reminder: the prospective scenarios and the underlying hypotheses for assessing the socio-economic benefits associated with multi-segment deployment of MREs (potential for job creation, assessment of the weight of economic activities, etc.) are presented in detail in an annex to this report.

FIGURE 19: THE MERIFIC 2030 VISION BASED ON FIVE STRATEGIC RECOMMENDATIONS AND THEIR MAIN STRATEGIC VARIANTS

The five strategic recommendations produced at the end of the project are based on two complementary types of strategic decision-making:

- An ambitious shared regional energy policy around two levers for immediate activation: multi-MRE planning and innovative funding, from the most natural items to implement in a coordinated way (test resources, CEIs, etc.) to the search for breakthrough models, such as coupling the sale of locally produced marine renewable energy with the development of regional electric mobility.