
ELEMENT: REGIONAL IMPACT ANALYSIS REPORT

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ABB



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Contents

Executive Summary	4
Introduction	5
H2020 Tidal Project Synergies	5
1. Statistics and Maps	7
Tidal Energy Statistics	7
Electricity Statistics	10
Socio-Economic Topics.....	12
2. Socio-Economic Appraisal	18
Demographics.....	18
Standard of living / housing conditions / vulnerable groups	19
Educational change.....	19
Social cohesion.....	20
Perception of the sea as a tidal energy resource	20
Recreational and tourism activities.....	20
Employment and business.....	20
Industrial strategy and rural regeneration	21
Commercial shipping and navigation	22
Effects on the regulatory framework.....	22
3. Renewable Energy Community Study.....	23
EU Directives and French Regulation.....	23
IDETA's REC Experience.....	24
REC Consumer Profiles	26
Tidal Turbine (RE50) Production	30
REC Consumer Participants.....	32
REC Self-Consumption and Self-Coverage Rates	35
REC Conclusion	37

EXECUTIVE SUMMARY

This report confirms that a tidal energy installation in the Etel estuary in France, Brittany, would have a positive socio-economic impact in the region.

The greatest benefit is expected in the employment and business sector, with an increase in job opportunities and commercial activity. Section 2 lists all the businesses that are impacted directly or indirectly. The top three businesses with the highest share in the capital expenditure (CAPEX) and operational expenditure (OPEX), and therefore directly impacted, are in the following:

- Water transport,
- Repair and installation of machinery and equipment,
- Manufacture of machinery and equipment,

Section 2 also details other socio-economic topics. The analysis shows that after the employment and business sector, all the other socio-economic topics are also positively impacted.

- ✓✓ Employment and business
- ✓ Demographics
- ✓ Standard of living / housing conditions / vulnerable groups
- ✓ Educational change
- ✓ Social cohesion
- ✓ Perception of the sea as a tidal energy resource
- ✓ Recreational and tourism activities
- ✓ Industrial strategy and rural regeneration
- ✓ Commercial shipping and navigation
- ✓ Effects on the regulatory framework

The report also confirms in section 3 that the creation of a tidal energy fed Renewable Energy Community (REC) is relevant in the commune of Belz. The deployment of a NOVA RE50 tidal turbine in the Etel estuary would generate 151 MWh per year which could supply the needs of 47 residential and small-and-medium-sized professional consumers. The study matched the 30-minute consumer data of 5 types of profiles in Brittany with the 30-minute production data of the RE50 turbine. The result demonstrates that with 0.3% to 2.9% of the tidal production being distributed to each of 47 consumers, the participants would consume an average of 76.3% of the production (self-consumption rate) which would cover 42.7% of their electrical needs (self-coverage rate). This shows that the creation of a tidal energy REC is therefore directly beneficial to the local community who are likely thus more open to the local deployment of tidal turbines. The creation of a tidal energy REC would hence increase the positive effects in the following socio-economic topics:

- +✓ Standard of living / housing conditions / vulnerable groups
- +✓ Educational change
- +✓ Social cohesion
- +✓ Perception of the sea as a tidal energy resource

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 pertains to work package 12 (WP12) that is focused on the socio-economic impact assessment of tidal energy and is led by IDETA. As per the ELEMENT Grant Agreement, the objectives of WP12 are to:

- Assess the socio-economic impacts of the tidal industry at the regional, national and European level.
- Conduct a market analysis, covering potential sites, policy advisory framework, consenting, recommended route to market.
- Conduct a supply chain analysis, covering potential suppliers, local content assessment, ports assessment, development of a dedicated tool to assess the local content for a tidal array, recommended targets.
- Identify and assess the potential impact of up to ten tidal, estuary and run-of-river energy sites in France.
- Extrapolate findings to assess the wider potential socio-economic impact of the tidal energy industry, with a focus on European industry and local communities.

Within WP12, there are multiple tasks. This document is associated to task 12.2 (T12.2) that refers to the “Regional Impact Analysis” and consists in the analysis of the socio-economic impact of tidal energy around the Etel test centre in France. It is led by IDETA with the support of INNSEA, CHBS, NOVA and OREC.

This Regional Impact Analysis Report is structured as follows:

- Section 1 highlights statistics and maps related to France and the region around the Etel estuary;
- Section 2 appraises the socio-economic impact of tidal energy projects for the region;
- Section 3 showcases a study for a tidal Renewable Energy Community (REC) in the Etel estuary.

H2020 Tidal Project Synergies

The ELEMENT project exploits synergies with another ongoing European Union's Horizon 2020 tidal energy project called EnFAIT – Enabling Future Arrays in Tidal. The EnFAIT Funding Grant was awarded from the European Union's Horizon 2020 research and innovation programme in January 2017 to continuously improve operations and maintenance of an array of tidal turbines in Shetland, Scotland, to drive tidal energy towards competing on a commercial basis with alternative

renewable sources of energy. This was in response to the call LCE-15-2016: Scaling up in the ocean energy sector to arrays to generate significant learning through demonstration of cost-effective tidal arrays.

The ELEMENT deliverable 12.2 uses the same impact classification and appraisal system as the EnFAIT project's deliverable 8.9 with the aim of streamlining the community impact assessment. At a later stage in ELEMENT deliverable 12.4, the assessment done in D12.2 will be compared against the EnFAIT results to highlight the differences and similarities between both projects, which are based in different countries. The ELEMENT project's regional assessment focuses on the Etel estuary communities in Brittany, France, while the EnFAIT project focuses on the Bluemull Sound communities in the Shetland Islands in Scotland, United Kingdom. There is near to 1,500 km as the crow flies between the two locations. Below figures 1 and 2 show the maps of the two project's test sites, copied from deliverable 4.1 published by France Energies Marines for the ELEMENT project.



Figure 1 – Locations of the two test sites: the Etel estuary for ELEMENT and Bluemull sound for EnFAIT



Figure 2 – Closer look on location and tidal turbine (Nova M100 in Bluemull) and (Nova RE50 in Etel).

1. STATISTICS AND MAPS

This section of the report will highlight key statistics and relevant maps on:

- The tidal energy sector for France, with a quick view also on Europe and the rest of the world,
- The electricity consumption in France and specifically the communes of Etel and Belz that follow the left-bank of the Etel estuary, and finally,
- The socio-economic topics for the communities of Etel and Belz.

Tidal Energy Statistics

The key takeaways on the tidal energy statistics for 2020 show a continued increase in world-wide deployments despite the COVID19 pandemic that slowed down construction due to lockdowns, quarantines and other sanitary measures. The main references highlighted in this chapter stem from the following reports:

- For Europe and the rest of the world, Ocean Energy Europe's "Key trends and statistics 2020"¹ published in February 2021. This chapter will refer to this report as "OEE".
- For France, Observ'ER's 11th edition of the 2020 barometer of renewable electrical energy in France published in January 2021. This document is written in French and is entitled "Le Baromètre 2020 des énergies renouvelables électriques en France"². This chapter will refer to this report as "Observ'ER".

Find below a summary of the key findings identified in these two reports.

Region	Brittany	France	Europe	World
2020 installations	0 kW	0 kW	260 kW	865 kW
Cumulative installations since 2010	N/A	N/A	27.9 MW	36.3 MW
Operating installations in 2020	5.2 MW	6.7 MW	10.1 MW	N/A
Decommissioned (end of tests/projects)	N/A	N/A	17.8 MW	N/A
Power production milestone	N/A	N/A	60 GWh	N/A
2021 projects	N/A	N/A	2.9 MW	4.1 MW
Reference	Observ'ER	Observ'ER	OEE	OEE

Table 1 – Key tidal energy data as per Q1-2021

The annual capacity installed since 2010 in Europe is far greater than the rest of the world, as shown in figure 1, although the non-European projects are starting to deploy more with a higher capacity in 2020 than Europe.

¹ <https://www.oceanenergy-europe.eu/wp-content/uploads/2021/02/OEE-Stats-Trends-2020.pdf>

² http://www.energies-renouvelables.org/observ-er/html/energie_renouvelable_france/ObservER-Barometre-EnR-Electrique-France-2020.pdf

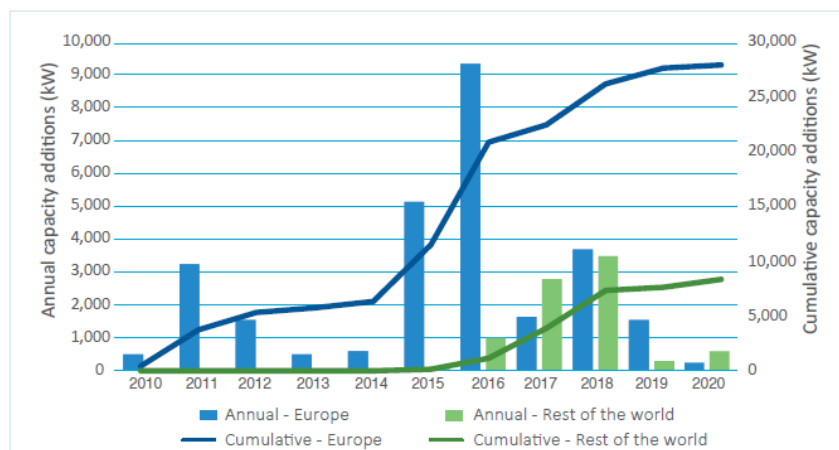


Figure 3 – Ocean Energy Europe’s “Key trends and statistics 2020” installed global tidal stream energy capacity

Although the pandemic resulted in a slower European increase in 2020 than 2019 (1.52 MW installed in 2019 versus 260 kW in 2020), no projects were cancelled and the deployments that did not make it in 2020 have been replanned for 2021. There were three European projects that were deployed in 2020. Two in Scotland, UK: one in the islands of Orkney and the other in Shetland. The latter project is that of EnFAIT with the deployment of NOVA’s fourth turbine within the Bluemull Sound array. The third project was installed in the Faroe Islands, Denmark, to the North-West of the Shetlands. It is interesting that these three projects are situated close to each other, in the same geographic area. No new projects were deployed in France in 2020.

Observ’ER regroups on a map the significant French marine renewable projects, as shown in figure 4. The map splits the tidal energy sector into coastal and estuary locations (in dark blue under the French term “énergie des courants en mer”) and into river locations (in grey under the term “énergie des courants fluviaux”).

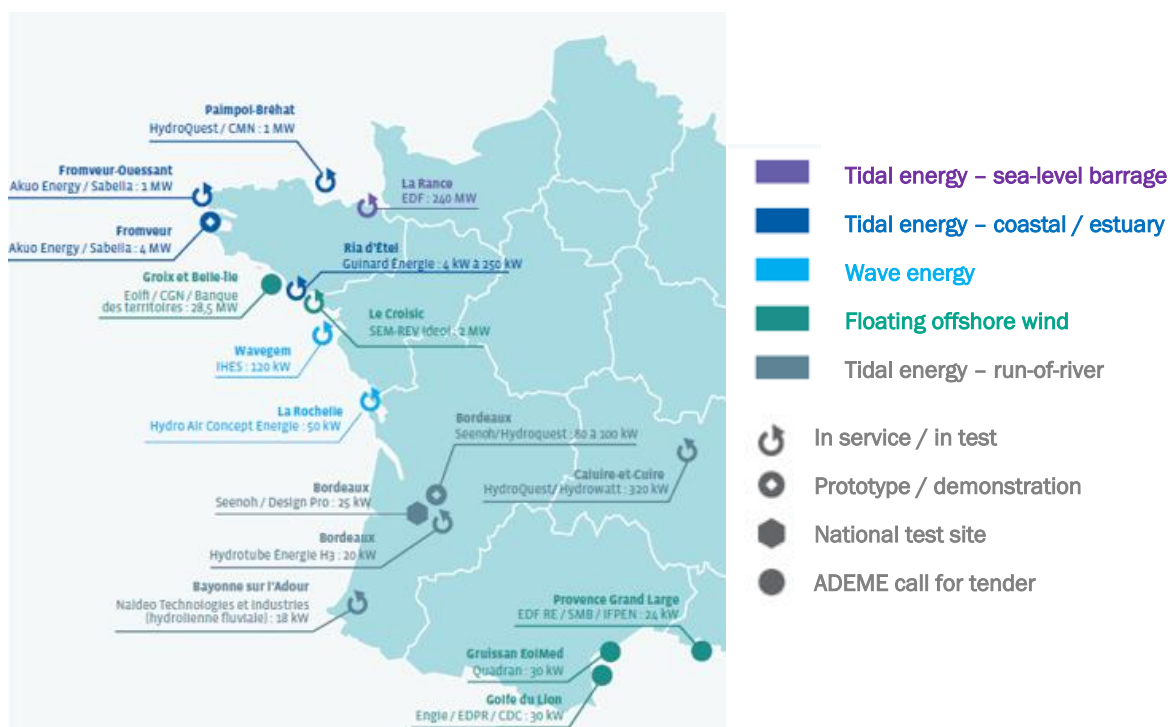


Figure 4 – Observ’ER’s “French 2020 barometer” installed marine renewable energy sites

Observ'ER shows that in 2020, Brittany was the French region with the only coastal and estuary tidal energy projects while Nouvelle-Aquitaine (or New Aquitaine) was the region with the most run-of-river energy projects, with one project in a third French region (Auvergne Rhone Alpes). These projects cumulate nearly 7 MW of installed power, as reflected in below table 2. For the future, the Ademe (the Ecological Transition Agency in France, “L'agence de la transition écologique”) considers that the French estimated power installation will be between 2.5 and 3.5 GW, with sites mainly located in Brittany (Passage du Fromveur, Chaussée de Sein and Héaux de Bréhat) and in Normandy (Raz Blanchard and Raz de Barfleur)³. Indeed, for 2020, 6.2 MW of the 6.7 MW installed tidal projects were in Brittany (93%). None were running in Normandy in 2020. Observ'ER mentions that many big companies abandoned their Normandy pilot-projects in Raz Blanchard and Paimpol-Bréhat due to the currently still too high production costs. However, Normandy is motivated in future installations in Raz Blanchard as demonstrated by the region's joint venture with Simec Atlantis Energy to first create a farm of four 2 MW tidal turbines, and then end the project with a total installation of 12 MW. This would triple the present French capacity.

Tidal energy type	Region	Location	Company	Installation (kW)
Coastal / Estuary	Brittany	Etel estuary	Guinard Energies	20
Coastal / Estuary	Brittany	Paimpol-Bréhat	HydroQuest	1000
Coastal / Estuary	Brittany	Fromveur-Ouessant	Akuo Energy / Sabella	1000
Coastal / Estuary	Brittany	Fromveur	Akuo Energy / Sabella	4000
River	New Aquitaine	Bordeaux	Seenoh / HydroQuest	100
River	New Aquitaine	Bordeaux	Seenoh / Design Pro	25
River	New Aquitaine	Bordeaux	Hydrotude Energie H3	20
River	New Aquitaine	Bayonne sur l'Adour	Naldeo Technologies et Industries	18
River	Auvergne Rhone Alpes	Caluire-et-Cuire	HydroQuest / Hydrowatt	320
Total				6733
Total in Brittany				93% 6250

Table 2 – Active tidal energy production in 2020

³ Observ'ER, page 90.

Electricity Statistics

The report will not provide statistics for 2020 electricity consumption considering that the COVID19 pandemic does not demonstrate standard consumption trends. The report therefore highlights the statistics for 2019 instead.

The French Ecological Transition Ministry provides energy statistics. The latest data available was published in January 2021 and provides the statistics for 2019⁴. The data shows a total consumption in Continental France of 425.2 TWh. For the same period, the data shows a 562.8 TWh gross electrical production, of which 0.5 TWh from ocean energy (less than 0.1%).

The ENEDIS open data platform provides the consumption data for communes per year and profile type. For Belz⁵ and Etel, the 2019 statistics show the population of consumers and their total and average consumption figures. This is shown in tables 3 and 4 below and demonstrates that the Etel location has 1586 fewer inhabitants than Belz with 45% of its real estate used for secondary residence. Belz on the other hand has 77% of main residence and a higher population. It is also interesting to note that 25% of the residential consumption is temperature-sensitive with 38% of the Belz population heating itself with electric radiators and 30% in Etel. This is a well-established manner of heating in France, and these two communes in Brittany are not an exception. Another noteworthy fact to highlight is that the majority of the population lives in residences with an area of over 80m², with 64.71% of the Belz population and 62.10% of the Etel one.

2019		BELZ			ETEL		
Type	Big Sector	Number of Sites	Total Consumption in MWh	Average Consumption in MWh	Number of Sites	Total Consumption in MWh	Average Consumption in MWh
RES	Residential	2614	12,510.97	4.79	2082	6,953.62	3.34
PRO	Unknown	58	409.70	7.06	70	653.322	9.33
PRO	Tertiary	191	1,561.72	8.18	115	941.612	8.19
PRO	Industry	16	78.58	4.91	7	137.42	19.63
PRO	Agriculture	13	192.38	14.80	unknown	< 50	unknown
ENT	Industry	2	379.81	189.90	0	0	0
ENT	Tertiary	13	3,423.15	1,343.90	14	1,702.72	722.57

Table 3 – Belz and Etel consumption in 2019

⁴ <https://www.statistiques.developpement-durable.gouv.fr/bilan-energetique-de-la-france-pour-2019?rubrique=19&dossier=170>

⁵ https://data.enedis.fr/explore/dataset/consommation-electrique-par-secteur-dactivite-region/information/?refine.nom_region=Bretagne&refine.annee=2019

Details	BELZ	ETEL
Temperature-sensitive Rate (%)	25.26%	25.56%
Total consumption of temperature-sensitive uses (MWh)	3,160.49	1,777.29
Total consumption of non-temperature-sensitive uses (MWh)	9,350.48	5,176.33
Average consumption of temperature-sensitive uses (MWh)	1.21	0.85
Average consumption of non-temperature-sensitive uses (MWh)	3.58	2.49
Number of inhabitants	3580	1994
Collective Housing Rate	14.57%	34.58%
Main Residence Rate	77.39%	55.42%
Housing Area < 30 m ²	1.75%	1.41%
Housing Area 30 to 40 m ²	2.95%	4.23%
Housing Area 40 to 60 m ²	12.58%	13.51%
Housing Area 60 to 80 m ²	18.00%	18.75%
Housing Area 80 to 100 m ²	25.38%	24.09%
Housing Area > 100 m ²	39.33%	38.01%
Electric Heating Rate	38.40%	30.04%

Table 4 – Belz and Etel residential consumption details in 2019

Socio-Economic Topics

IDETA shares in this document the key statistics found at the French national institute of statistics and economic studies (INSEE⁶) for the Belz and Etel communes. These statistics provide insight on the local demographic situation and how potentially tidal energy can impact the local communities. The chapter also provides useful maps of the region, including those found in the document “Natura 2000 Objectives for the Ria d’Etel” published in 2011 and revised in August 2012. This document and the related topics are available on the website <http://ria-etel.n2000.fr/>.

France is divided in multiple administrative zonings. Below are the six zonings that are identified for the Belz and Etel communes, filtered from the biggest to smallest size:

1. Location: Metropolitan France or European France (compared to Overseas France),
2. Region: Brittany,
3. Department: Morbihan,
4. District or Arrondissement: Lorient,
5. Inter-communality – Community of Communes (CC): Auray Quiberon Terre Atlantique,
6. Commune: Belz and Etel

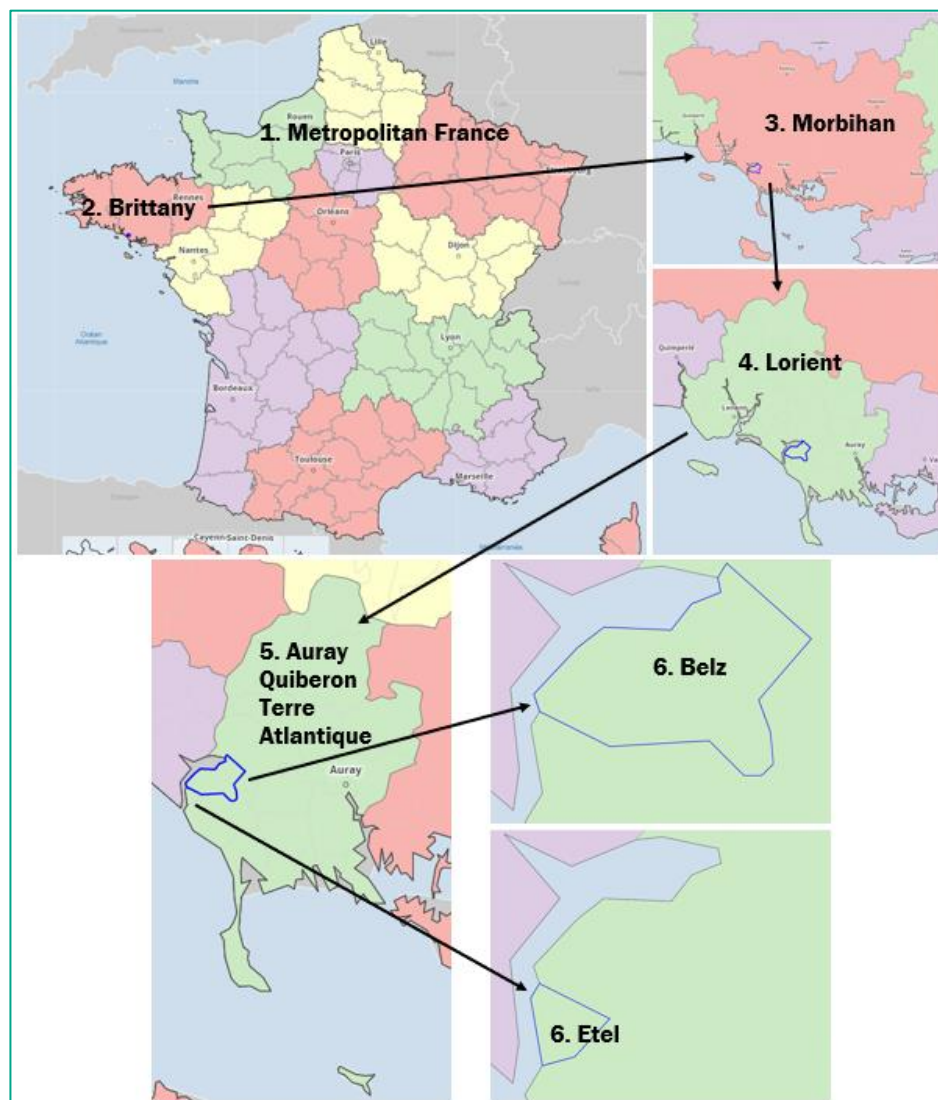


Figure 5 – Map of the French zonings related to Belz and Etel

⁶ <https://statistiques-locales.insee.fr/#c=zonage>

The above figure 5 shows the different zonings on the French map. The communes of Belz and Etel are on the south bank of the Etel estuary. The Work Package 10's test of a tidal turbine will be in the commune of Belz. The below table 5 indicates that the 15 km² of the Belz commune has a population of 3711 people in 2017 and that its real estate is comprised on nearly 72% of primary residences, with 21% of second homes and 7% vacant. This is close to the 74% of main residences within the Morbihan department and Lorient district. The national percentage is 82%. This demonstrates a relatively high residential population compared to the small Etel commune (1,7 km²) that has only 51% its real estate comprised of main residences, and 43% of secondary residences, confirming a high vacation activity. This is also seen by the number of nautical sport centres available at Etel and the Etel estuary. On the other hand, neither Etel nor Belz have many hotels or camping sites. The two communes have 1 hotel each, with 19 rooms in Etel and 8 in Belz. There are 250 camping places in Etel and 299 in Belz. The owners of second homes can instead regularly stay in Etel and Belz at their leisure as well as offer their second homes for tourists. The website maisondevacances.fr suggests in April 2021, during a COVID-19 travel restrictive period, up to 118 available staying options in Etel against 51 in Belz. The staying options might be different in normal circumstances.

Rank	Name	Population	Evolution	Migration	Area (km ²)	Real Estate	% of main residence
1	Metropolitan France	66,524,339	0.4	0	632,734	35,879,715	82,2
2	Brittany	3,318,904	0.5	0.5	27,208	1,919,986	79,1
3	Morbihan	750,863	0.5	0.6	6,823	464,186	74,6
4	Lorient	313,375	0.5	0.6	1,462	199,859	74,1
5	Auray Quiberon Terre Atlantique	86,692	0.7	0.9	521	68,608	58,3
6	Belz	3,711	1.2	1.8	15.7	2,590	71,6
6	Etel	1,971	-0.7	1.1	1.7	2,044	51,2

Table 5 – Key demographics (source INSEE) for the 6 zonings related to Belz and Etel

In addition, the yearly evolution in the population reflects a higher positive variance in Belz compared to the other zonings. Indeed, the general yearly evolution between 2012 and 2017 in Belz is of 1.2%, of which 1.8% is due to in-migration and -0.6% is due to natural causes (births and deaths). By comparing the population between 1968 and 2017 of Belz and Etel, it is clear that Belz continues to grow, with 3353 inhabitants in 1968 versus 3711 in 2017 (an increase of 358 inhabitants, representing growth of 10.7% over a 49-year period) while as Etel's population is declining, with 3074 inhabitants in 1968 against only 1971 in 2017 (a decrease 1103 residents, equalling a staggering 35.9% fall). The increase in population in Belz and decrease in Etel may be the effect of the higher tourism in Etel whereby residents have moved out of Etel to live in the neighbouring communes, such as Belz.

The INSEE portal also includes employment figures for the year 2017. Out of the 2061 Belz population between 15 years old and 64, 1237 people had a job, reflecting an employment rate of 60%. There was a 10.3% unemployment rate and a 29.7% inactive rate (15.5% retired, 5.9% studying, and 8.3% of other types of inactivity). 69.9% of the Belz inhabitants with a job work outside of Belz. In Etel, the employment rate was of 53.3%, while the unemployment rate of 11.6%. The 35.1% of inactive population in the age-range was reflected by 15.4% of retired people, 9.3% of students and 10.4% of other types of inactivity. 67.5% of the Etel workforce had their job outside of the commune. The main transportation method used between home and work was the car: 76% for Etel and 86% for Belz drove to work. In parallel to these figures, the poverty rate for the Auray intercommunal in 2018 was within the low numbers, at 10%. This ranks Auray at the 24th position out of 306 statistical regions in France. The French median was of 14%, with 5% at the lowest rate and 46.5% at its highest. This low poverty rate is confirmed also by the area's relatively high standard of living. This is calculated by dividing a households' available income with the consumption needs. Auray's average for 2018 was of 22,090 € per household, when the French

median was 20,830 €, with a minimum of 13,680 € and maximum of 31,060 €. This ranks Auray at the 60th position out of 306 statistical regions. The Morbihan region is considered statistically as part of the middle class and in general for Brittany the differences in standard of living between the poorest and the most well-off is the smallest of France, together with the Loire region.

The following figures provide some socio-economic maps of the Etel estuary from the previously mentioned “Natura 2000 Objectives for the Ria d’Etel” published in 2011 and revised in 2012. It will show in turn the areas in the estuary that hold shellfish farms (figure 6), nautical sports and activities (figure 7) and fishing activities (figure 8). These maps confirm that the estuary remains a waterway with a high rate of human activity, be it for work or leisure.

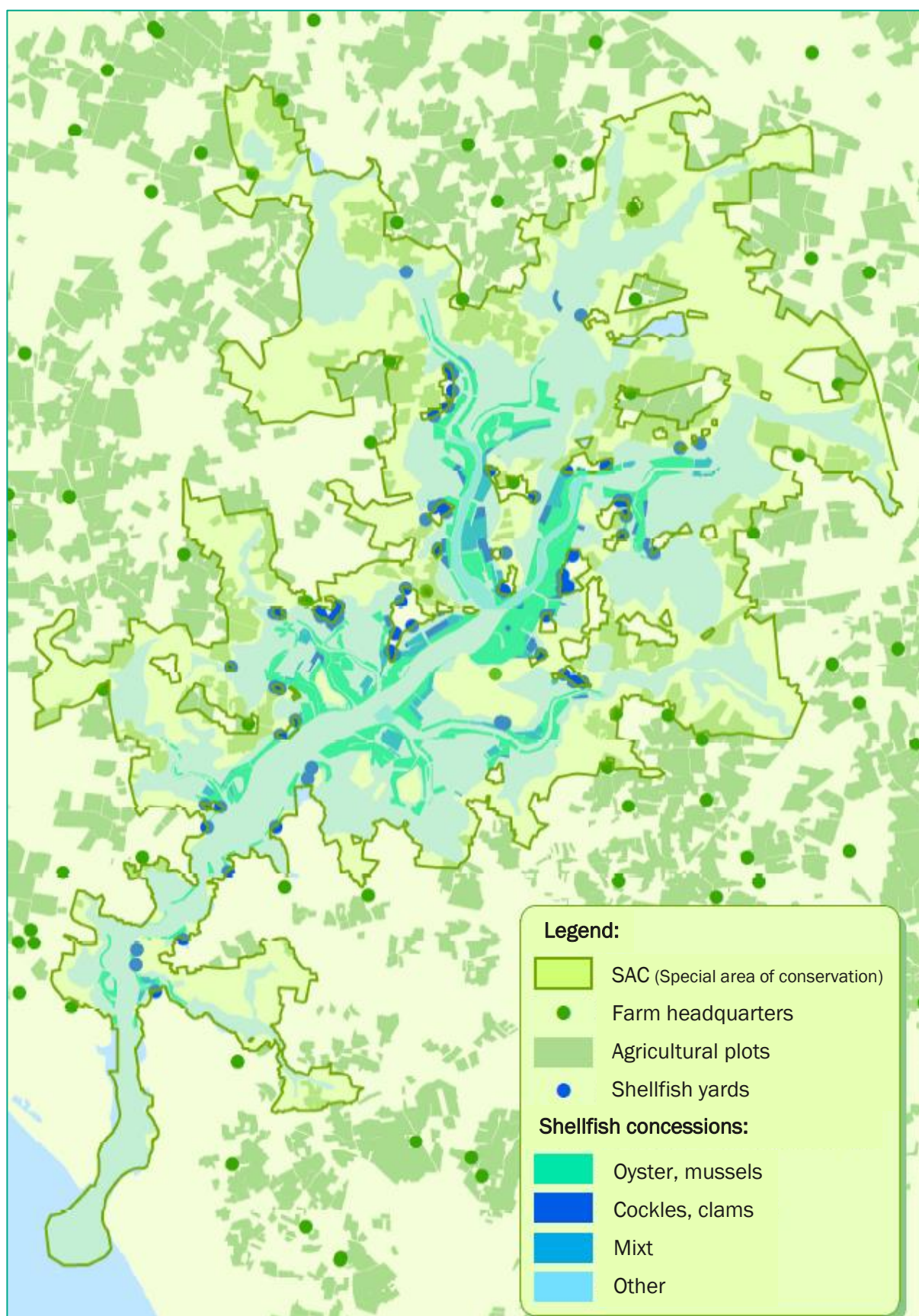


Figure 6 – Map of Etel estuary's shellfish farms and company address

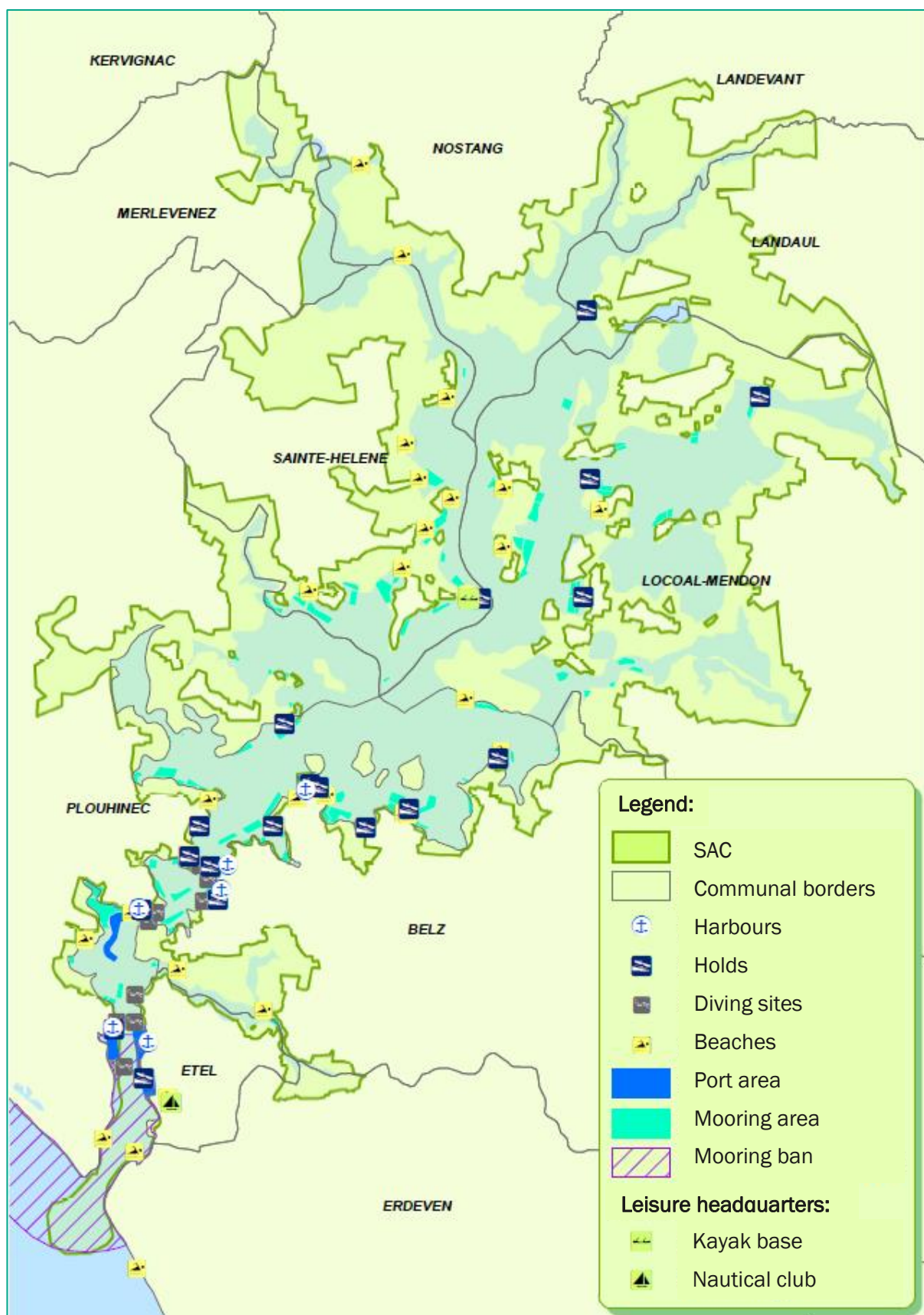


Figure 7 – Map of Etel estuary's nautical sports and activities

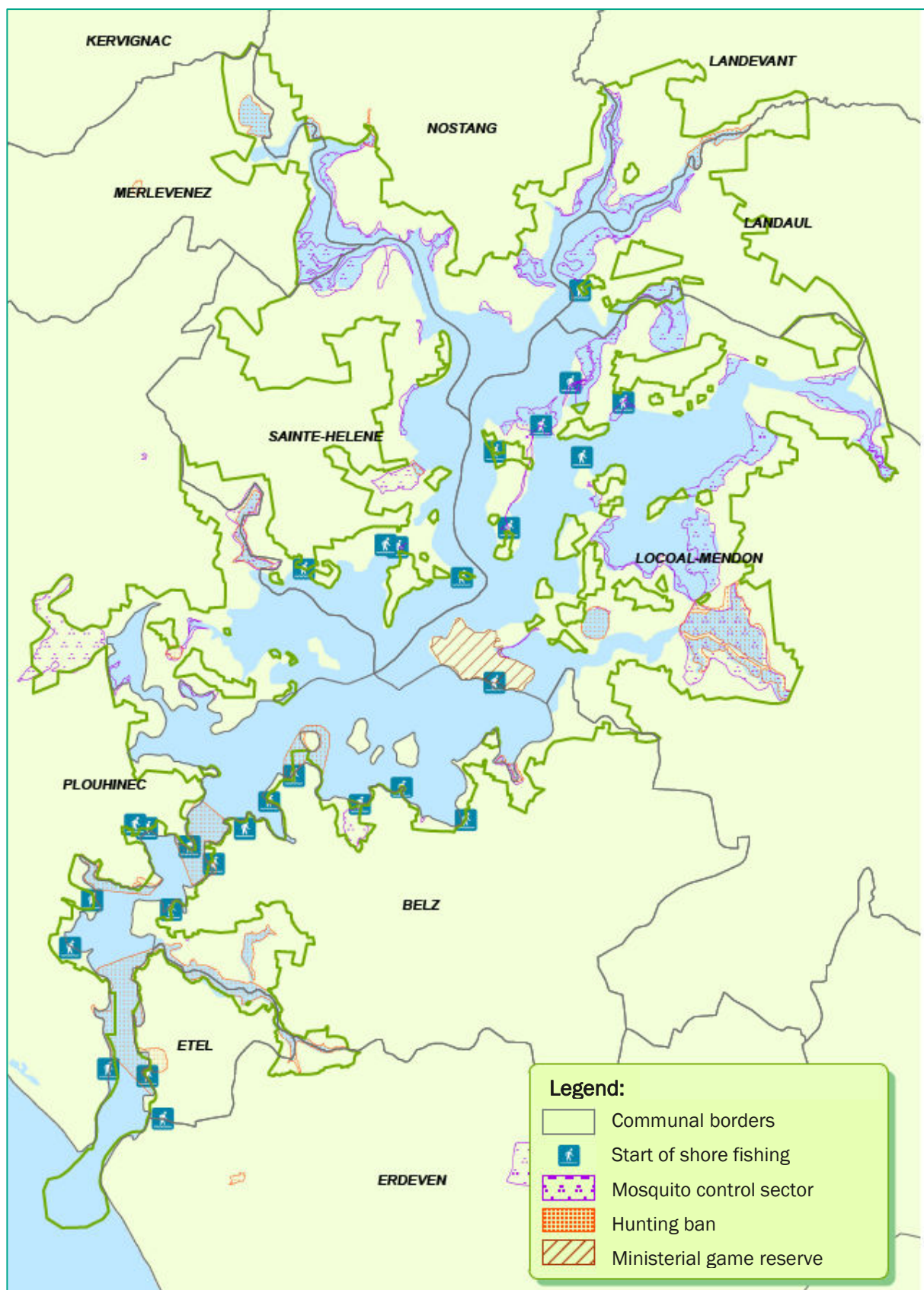


Figure 8 – Map of Etel estuary's fishing activity

2. SOCIO-ECONOMIC APPRAISAL

An initial environmental and socio-economic appraisal of the effects of tidal energy had been completed in the EnFAIT project's deliverable 8.9 by RSK at a UK and EU level. A final appraisal will be completed at the end of the EnFAIT project to note any changes in perception against reality.

This chapter of ELEMENT deliverable 12.2 uses the same socio-economic model as the above-mentioned EnFAIT one to appraise the effects of tidal energy in the region around the Etel estuary. In the future ELEMENT deliverable 12.4, IDETA will analyse the differences between the appraisal results at the UK, French and European level by comparing the ELEMENT results with the above-mentioned EnFAIT results.

The appraisal categorised the potential effects by using a visual classification. The same is applied to the ELEMENT local community impact assessment.

- Major positive effect: ✓✓
- Minor positive effect: ✓
- Neutral effect: 0
- Minor negative effect: X
- Major negative effect: XX
- Uncertain effect: ?

Below table 6 summarises the ELEMENT results expected by IDETA for the Etel region. As can be seen, there are no negative socio-economic effects. On the contrary, the effects are all positive with a major positive effect on employment and business. In addition, should a tidal energy fed Renewable Energy Community (REC) be created, this would result in extra positive impact as shown below.

Socio-economic topic areas	Etel	Etel with REC
Demographics	✓	
Standard of living / housing conditions / vulnerable groups	✓	+✓
Educational change	✓	+✓
Social cohesion	✓	+✓
Perception of the sea as a tidal energy resource	✓	+✓
Recreational and tourism activities	✓	
Employment and business	✓✓	
Industrial strategy and rural regeneration	✓	
Commercial shipping and navigation	✓	
Effects on the regulatory framework	✓	

Table 6 – Summary of EnFAIT and ELEMENT socio-economic appraisal results

The detail of these results is explained by topic area in the next sub-sections.

Demographics

The development of new technology has the potential to increase the offer of new skilled local jobs. This is interesting for the Belz commune that continues to increase in population year after year.

So far, the employment impact from the ELEMENT project has been limited to CHBS as direct project partner. Moreover, the future test of the tidal turbine within Work Package 10 is temporary. Indeed, the turbine will be decommissioned after the estuary test phase. During WP10, IDETA will note the local impact to the workforce, economic growth through expansion of the supply chain, construction or maintenance, as well as any population migration flows.

Standard of living / housing conditions / vulnerable groups

Nearly 39% of Belz households, and 30% of Etel ones, use electricity for their heating needs. If the Levelized Cost of Energy (LCOE) of tidal projects continues to diminish with projects such as EnFAIT and ELEMENT, and by consequence the price of the tidal energy can be sold at a cheaper price than the actual market or EDF prices, then this would increase the communities' consumption power, by allowing the unspent money in being used for other expenditures or in heating needs, therefore increasing standard of living. Such an increase can also benefit housing conditions should the consumer decide to spend money on improving the energy efficiency of its household, either by replacing appliances and lightbulbs for less energy-consuming ones or by isolating their houses and hence reducing their heating needs. There are multiple ways the tidal electricity, for general power and/or heating, can be sold. This can be through a specialised contract with a green energy provider such as "Enercoop", or by creating a Renewable Energy Community (refer to the REC study within this document).

The "Enercoop" provider is active all over France. It is a citizen association that aims to provide 100% green energy to consumers. In April 2021, according to their website <https://www.enercoop.fr/nos-cooperatives/bretagne>, in Brittany, there were 32 producers generating 52 MWh/year and 10,000 consumers linked to "Enercoop Bretagne". The Guinard Energies Nouvelles' tidal turbine mentioned in the tidal energy statistics was one of these producers from February 2019 until the end of their project in 2020. This turbine was installed in the Etel estuary.

In parallel, the creation of a REC can help provide tidal energy at an attractive price to vulnerable groups. Indeed, RECs are community-based and in some cases led by local authorities who wish to offer cheap green electricity to people in need.

In addition, by providing the grid with decentralised electricity, consumers can be less impacted by any power cuts from the central generation network. This increase in electricity resilience ensures consumers are not disrupted by power outages, thus creating a better comfort of living.

Educational change

Children, students and households can receive ecology lessons, energy efficiency coaching and participate to tidal turbine site visits to allow them to be more conscious of energy and ecology issues. This could be translated by age-groups into below educational topics:

- For young children, renewable energy sources, including tidal, could be an eye-opener on environmental and ecological topics.
- For secondary school children, the interest can be increased by enabling practical discussions on environmental and ecological topics to build future citizens. It can also attract children into considering related professions in these topics through the study of mechanical and electrical engineering, environmental sciences, management or other related courses.
- For university students, the theme can be part of focused research on tidal power and renewable energies as well as the continued pursuit of building a career in related opportunities.

- For households, the subject allows them to take part in the green energy transition, increase their energy efficiency and reduce their CO₂ emissions. In the case of the creation of a REC, the participants would also be more aware of when to consume efficiently. This is because by using the tidal energy when it is produced, the participants will increase their green energy self-consumption rate, thus increasing their self-coverage rate as well as reducing their electricity bill.

Social cohesion

The Work Package 12 tasks related to local community engagement should increase social cohesion. This will be monitored and shared in the ELEMENT project.

As touched on during the above-mentioned Standard of Living topic, renewable energy can be provided to a community through the Renewable Energy Community (REC) model. Such a model would become a citizen activity and enhance community spirit. It allows a group of people to join together with the single goal of acting towards a greener ecological world. The community can then also consider other activities that can contribute to energy efficiency, reduction in carbon generation, reduction in waste and other ecological awareness.

In parallel, green-energy providers like Enercoop also have a potential for social cohesion because these associations are led by citizens. For example, Enercoop is a cooperative society of collective interest (SCIC or société coopérative d'intérêt collectif in French). Enercoop Bretagne is comprised of 4020 members who bring capital for renewable projects. Moreover, 24 communities work with Enercoop Bretagne towards the energy transition.

Perception of the sea as a tidal energy resource

GUINARD has in the past deployed two of their tidal turbines in the Etel estuary. The ELEMENT project will also test a NOVA turbine at the site. These projects have and should continue to raise awareness that estuaries, as well as coastal and river waterways, can generate energy by harnessing the tide and water speed. The future local community engagement activities will include ways to disseminate this information further to the region and local communities.

In addition, the creation of a tidal REC would highlight this perception even more because the REC participants would be directly aware that the estuary current is generating their green electricity.

Recreational and tourism activities

Tidal turbines can be placed underwater and therefore have no visual impact on the scenery, to the contrary of wind turbines, for example. This should remove barriers in the construction of this type of renewable energy source, compared to wind or solar that are more visible.

In addition, tidal turbines do not induce noise that propagates in the air and therefore do not create any acoustic problems for local residents in the case of installations close to the coast such as gulfs and estuaries. Moreover, IDETA suggests placing an information board close to the tidal turbine in order to stimulate the site as an attraction point for locals and tourists.

Employment and business

In general, employment in the tidal energy sector can be promoted by sharing the related job opportunities available in the tidal business as well as in the supply chain. Professionals can be invited to speak on the subject in job forums. This is particularly relevant in Etel and Belz that have an unemployment rate of 10.3% and 11.6% respectively.

In parallel, INNNOSEA's deliverable 12.3 on French site assessment shares data on the job content and how different businesses can support the capital expenditure (CAPEX) and operational expenditure (OPEX) of tidal energy development projects. In addition, other businesses can be

impacted indirectly by these tidal projects. Below table 7 provides a summary of the businesses expected to see an increase in activity. This reflects a major positive effect on employment and business activities.

Businesses by economic centre (NACE codes)	Employment estimation
C25 - Manufacture of fabricated metal products, except machinery and equipment	14% of CAPEX
C27 - Manufacture of electrical equipment	14% of CAPEX
C28 - Manufacture of machinery and equipment	28% of CAPEX
C33 - Repair and installation of machinery and equipment	49% of OPEX
D35 - Electricity, gas, steam and air conditioning supply	1% of CAPEX & 1% of OPEX
F42 - Civil engineering	5% of CAPEX
F43 - Specialised construction activities	Indirect
H49 - Land transport and transport via pipelines	Indirect
H50 - Water transport	16% of CAPEX & 50% of OPEX & Indirect
H51 - Air transport	Indirect
H52 - Warehousing and support activities for transportation	Indirect
I55 - Accommodation	Indirect
I56 - Food and beverage service activities	Indirect
J58 - Publishing activities	Indirect
J62 - Computer programming, consultancy and related activities	Indirect
J63 - Information service activities	Indirect
K64 - Financial service activities, except insurance and pension funding	8% of CAPEX
K65 - Insurance, reinsurance and pension funding, except compulsory social security	Indirect
L68 - Real estate activities	Indirect
M71 - Architectural and engineering activities; technical testing and analysis	14% of CAPEX
N79 - Travel agency, tour operator and other reservation service and related activities	Indirect
N81 - Services to buildings and landscape activities	Indirect

Table 7 – Impact of tidal business on French employment

Industrial strategy and rural regeneration

CHBS located in Belz is working directly on the ELEMENT project. They proactively onboarded as project partners to this European Union's Horizon 2020 research and innovation programme and lead specific tasks and deliverables in the project. Their engagement in the project is increasing their network as well as supporting their future business needs.

In addition to providing jobs and work experience to the unemployed, as mentioned in the above employment and business topic, there are no other special needs to regenerate the area of Etel and Belz. Both communes have a good standard of living and a low poverty rate. The Etel commune is a densely populated small tourist location, prone to regular tourists staying in second homes. As for the Belz commune, it is a prospering community. Nevertheless, both communes can benefit

from the decentralised electricity source produced by tidal that provides electricity resilience against central power outages and from diversifying the local economy.

Brittany, with an important deficit in terms of energy production and a high tidal current resource potential, has a real interest in developing decentralized units of marine renewable energy.

Commercial shipping and navigation

In order to receive consent by the local authorities, the RE50 tidal turbine that will be installed in Etel has to be placed in an area that will not interfere with navigation. This would be the case with any tidal project deployed in France. Moreover, NOVA has created two sizes of turbines (RE50 and M100) to potentially place the turbines in sufficiently deep waterbeds and still enable boats to pass above them.

Effects on the regulatory framework

Brittany is supportive of tidal energy projects, as can be confirmed by the previously shared statistics in section 1. The Brittany and Normandy coasts are considered to have high currents and be great prospects for tidal energy, however water speed data is not readily available for estuaries and rivers. It is therefore useful for local authorities to consent to research and development projects that experience tidal energy generation on estuary and run-of-river sites in order to promote even further tidal energy and reap the previously mentioned benefits to local communities. The Etel estuary has already received regulatory consent for tidal projects in the past with Guinard Energies Nouvelles and in the future with ELEMENT and further Guinard Energies Nouvelles projects.

3. RENEWABLE ENERGY COMMUNITY STUDY

EU Directives and French Regulation

The EU Directives 2018/2001 and 2019/944 confirm the need to promote renewable energies through the participation of local communities and active clients.

The 2018/2001 directive published on 21-Dec-2018 opens the way to Renewable Energy Communities (REC) where a group of local consumers and renewable energy producers, within a delimited area, can join forces to share on the national grid green electricity for their collective self-consumption.

The directive defines a “Renewable Energy Community” (REC) as a “legal entity:

- (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity;
- (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities;
- (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits.”

The directive clarifies that RECs “are entitled to:

- (a) produce, consume, store and sell renewable energy, including through renewables power purchase agreements;
- (b) share, within the renewable energy community, renewable energy that is produced by the production units owned by that renewable energy community, subject to the other requirements laid down in this Article and to maintaining the rights and obligations of the renewable energy community members as customers;
- (c) access all suitable energy markets both directly or through aggregation in a non-discriminatory manner.

The French law provides rules on the creation of collective self-consumer legal entities. This is the French equivalent to RECs. The French RECs need to be within a 2-km area in urban landscapes⁷ and within 20-km in more rural locations⁸. The total generation must not exceed 3 MW and the REC participants need to be linked to the low-voltage national grid.

RECs will be one of the manners to help local communities accept renewable projects close to their homes and workplaces. Increasing renewable projects will help meet the EU targets of reducing greenhouse gas emissions by at least 55% of its 1990 levels by 2030 into becoming climate-neutral by 2050. Such targets are necessary for the world’s future.

Indeed, through a REC, people can benefit directly from the security of local energy supply at affordable prices. Moreover, RECs can create benefits to the population such as employment and development as well as environmental, social and health benefits. The directive highlights that

⁷ Ordonnance dated 21-Nov-2019, TRER1932009A, published in the French Republic’s official journal.

⁸ Ordonnance dated 14-Oct-2020, TRER2027839A, published in the French Republic’s official journal.

these advantages are especially valuable in areas that are remote and rural, with low population density or undergoing partial deindustrialisation. By participating to a renewable project, local communities will be less inclined to the NIMBY-effect⁹ and hence start accepting renewable projects when they are in the neighbourhood.

This is the reason why this regional socio-economic analysis includes a study on the creation of an Etel estuary tidal-energy REC. The study will combine the 30-minute tidal production curve for the Etel site with multiple 30-minute Brittany consumer curves to identify if such a combination will allow a high self-consumption and self-coverage rate.

- The self-consumption rate reflects the percentage of local green electricity that is being consumed per 30-minute interval when it is being produced. This synchronicity reduces the strain on the national grid and avoids upstream flows of electricity.
- The self-coverage rate highlights how much of the local green electricity is being used to cover the REC participants' full electricity needs. The higher the rate, the lesser will be the electricity needed from outside of the REC, paid to an energy provider, and potentially from non-renewable sources.

IDETA's REC Experience

As a regional development agency in Belgium, IDETA develops and manages renewable energy projects in Picardy Wallonia. Some of these projects are the creation of Renewable Energy Communities. IDETA has tested RECs where the consumer participants are companies under the programmes named E-Cloud and ZELDA. IDETA has also set up a REC programme for residents, small companies and local authorities that is called COLECO. The tidal REC study will consider the participation of residents and small businesses, which is why this report will use some information gathered from the COLECO programme in addition to the E-Cloud or ZELDA programmes.

The COLECO programme is still ongoing. It was launched in 2019 and aims to create in the near future 9 solar-panel RECs in Picardy Wallonia with groups of residents, small companies, and local authorities within 9 neighbourhoods. The project also aims at coaching the participants in using energy wisely. In general, IDETA notices that REC projects are opportunities to install renewable energy sources that are more easily accepted by the local communities. The communities are interested in benefiting from the REC's local and green energy as long as this energy is fair-priced. Furthermore, RECs create an association of people that are interested in general energy-related subjects. They are therefore happy in receiving coaching to reduce their electricity bills, for example by receiving guidelines on demanding less energy, at different times and/or by changing their lightbulbs and appliances to more eco-friendly ones that consume less for the same comfort. This is the reason why IDETA is including in this Regional Impact Assessment Report an Etel estuary tidal REC feasibility study.

For the COLECO project, IDETA organised with the local authorities 9 engagement activities between September and November 2019 within the 9 selected neighbourhoods to initiate the discussion with the local residents and small companies. The objective of the meetings was to present the COLECO project to the citizens to invite them to participate in the co-construction of these RECs. These initial meetings were previously announced through local newspapers and social media as well as through direct mailing in the post. The same communication media could be used to promote engagement activities that will be organised near Etel within the continued regional impact assessment tasks under T12.2. In total, the COLECO programme was adhered by 12% of the neighbourhoods, with around 16 participants per neighbourhood, thus near to 150 participants altogether. The citizens that adhered to the project signed their consent to support the project and provided certain relevant information, such as their annual consumption. Throughout 2020, IDETA organised 9 workshops with the participants and their local townhall

⁹ NIMBY stands for "Not In My Back-Yard".

council. The theme of the workshops was on electricity consumption: the electricity bill, the consumption of home appliances, the consumption habits and the load distribution. In parallel, in August 2020, the 150 participants were sent an online survey questioning them on their motivation to adhere to the project. 57% of the participants replied. The same survey was sent in January 2021 to the local authorities and IDETA members that animated the workshops. The 12 animators replied what they understood were the participant's motivation based on what they heard during the workshops.

The online survey asked a single question:

What are the motivations that led you to get involved in a COLECO project?

Please rate 1 to 5

*(1 * Strongly disagree, 2 * Disagree, 3 * No opinion, 4 * Agree, 5 * Strongly agree)*

- Act for the environment*
- Reduce my bill*
- Engage in a participatory project*
- Learn more about my electricity consumption and adopt the right actions*
- Participate in an innovative project, in tune with the times*
- Participate in the development of my town, my neighbourhood*
- Participate in a solidarity project, making green energy accessible to all*
- Reappropriate my energy, the desire for greater autonomy*
- Pay a fair price for my electricity, set transparently*
- Participate in a local action and consume locally*

The results of the two surveys are shown in below table 8.

Motivation reasons	Participant's survey			Animators' survey		
	Top 3	Average rating	% of responses	Top 3	Average rating	% of responses
<i>Act for the environment</i>	1	4.52	90.4%		3.77	75.38%
<i>Reduce my bill</i>		4.2	84%	1	4.62	92.31%
<i>Engage in a participatory project</i>		3.94	78.8%		3.23	64.62%
<i>Learn more about my electricity consumption and adopt the right actions</i>		3.82	76.4%		3.85	76.92%
<i>Participate in an innovative project, in tune with the times</i>		3.88	77.6%		3.15	63.08%
<i>Participate in the development of my town, my neighbourhood</i>		4.16	83.2%		3.15	63.08%
<i>Participate in a solidarity project, making green energy accessible to all</i>	2	4.48	89.6%		3.23	64.62%
<i>Reappropriate my energy, the desire for greater autonomy</i>		3.94	78.8%	3	3.92	78.46%
<i>Pay a fair price for my electricity, set transparently</i>		4.18	83.6%	3	3.92	78.46%
<i>Participate in a local action and consume locally</i>	3	4.44	88.8%		3.85	76.92%

Table 8 – Participant's motivation in the COLECO project

The survey reflects that it is important for the participants to act for the environment while participating to a social and local project. Following the workshops on how to consume energy efficiently and how to understand the electricity bill, the animators perceived that the participants were even more interested in reducing their electricity bill.

This shows that citizens wish to be active in their local community but that such actions should also help reduce the electricity bill. A first step is done by companies to reduce the LCOE of renewable electricity sources. Such is the case with the EnFAIT and ELEMENT projects that aim to reduce the LCOE of tidal energy. However, this may not be sufficient to ensure a large deployment of renewable sources, since centralised nuclear energy remains cheaper than decentralised renewable ones. As such, extra financial support from governments will continue to be welcome to allow green energy to be as competitive as grey energy.

REC Consumer Profiles

The future Etel estuary test within work package 10 is located at Belz's river side where the ELEMENT partner CHBS holds its activities. If at a later stage, tidal REC becomes a reality in the Etel estuary, the location of the tidal turbines would be in parts of the estuary where the water speed is probably higher than the WP10 test site. For this study, it is assumed that the tidal REC will be within the Belz region in Brittany.

The COVID-19 situation in 2020 has created differences in electrical consumption due to the multiple lockdowns that have increased numbers of home-workers and reduced company's' production and de facto these company's' energy consumption. As such, this study has chosen to consider the consumption profiles of 2019 instead of those of 2020.

In France, there are many different types of consumer profiles. These profiles' related consumption data are freely available per 30-minute period on ENEDIS' open data website <https://data.enedis.fr/explore/dataset/conso-inf36-region/information/>. For consumers that are connected to the grid at less than 36 kVA, it is possible to download per year and per region up to 13 different groups of profiles per 16 different power subscriptions. There is another open data website available for larger-consumers, over 36 kVA, which has not been utilized for this study since the assumption is that the tidal REC would be focused on smaller-consumers such as residents and small-companies. The website's smaller-consumer profiles are in some cases a combination of profiles for which there are not enough active consumers to show the profile alone.

Each group of profile is downloadable per subscribed power in kVA. There are:

- 6 low-voltage residential profiles (starting with the code RES),
- 5 low-voltage small to medium professional profiles (starting with the code PRO), and
- 2 large professional profiles connected to the high voltage network directly (code ENT).

In parallel, the French energy regulator ("CRE" for "commission de régulation de l'énergie") provides on its open data platform (<https://www.cre.fr/Pages-annexes/open-data>) the split in 2019 of the total annual consumption per consumer profiles that have subscribed their electricity bill with the largest French utility EDF. As per the CRE's quarterly observatory report for Q4-2019¹⁰, EDF (and small historic local public utilities) provides electricity to 74% of the French consumers, especially as the French government provides through EDF a regulated tariff that is still greatly subscribed to by consumers. The CRE open data of EDF's clients' profile split was used by IDETA to find the average annual consumption per profile.

Consumer sites per tariff (as of 31-Dec-2019)	Residents	Non-Residents
EDF's regulated tariff	23,894,000	3,037,000
EDF (+11) 's market tariff	670,000	747,000
OTHER's market tariff	8,489,000	1,327,000
TOTAL tariffs	33,053,000	5,111,000
TOTAL EDF tariffs	24,564,000	3,784,000
Ratio EDF tariffs	74%	74%

Table 9 – CRE's observations on the electricity market on 31-Dec-2021

To determine which profiles to select for the REC, IDETA made the parallel with the COLECO project. The different profile types of the participants to the COLECO programmes were reviewed to determine which consumer profile curves to select from the ENEDIS platform.

It is first useful to list what the French tariff-options linked to these profiles refer to. In all below options except the last (EP), these options are available to residents (RES) and professionals (PRO):

- The BASE option available to RES1, RES11 and PRO1 is a single tariff (same price all the time) linked to one electricity meter. A variant of this option is available for the profiles RES1WE, RES2WE and PRO1WE whereby these consumers have a second meter that reads the weekend and public holidays as an off-peak tariff. The EDF data shared by the CRE does not provide the data for these "WE" profiles, however the ENEDIS profiles combines these: RES1 plus RES1WE, RES11 plus RES11WE, and PRO1 with PRO1WE. The

¹⁰ <https://www.cre.fr/Documents/Publications/Observatoire-des-marches/observatoire-des-marches-de-detail-du-4e-trimestre-2019>

¹¹ Includes small historical local public utilities.

difference between RES1s and RES11s is that RES1s are subscribed to less than 6 kVA while RES11s are above 6 kVA.

- The HPHC option (“heures pleines, heures creuses” in French, which translates to “peak hours, off-peak hours”) under RES2 and PRO2 is a double tariff where the price changes between peak and off-peak periods. Consumers with this option have 2 meters. In the two towns to the left of the Etel estuary, Belz¹² and Etel¹³, there are 4 different off-peak periods available as shown in below table 10. In all four periods, the peak period consists of 16 hours and the off-peak period is made up of the remaining 8 hours of the day. As can be seen in the table, most off-peak periods consist in full night-time hours while one period combines night-time and day-time hours. It is the Distribution System Operator (DSO) who decides which period the consumer is charged on. These peak/off-peak periods remain the same during the weekday and the weekend. A variant of this option is available for the profiles RES2WE and PRO2WE whereby these consumers have a third meter that reads the weekend and public holidays as an off-peak period. Another variant is RES5 whereby the peak/off-peak periods are different between high season and low season. The EDF data shared by the CRE does not provide the data for RES2WE and PRO2WE, however the ENEDIS profiles combines RES2 with RES5 and PRO2 with PRO2WE and PRO6. RES2WE is available apart.

Off-Peak Periods	Night-Time Hours	Day-Time Hours	Total Hours
Period 1	11:30 pm to 7:30 am		8
Period 2	1:30 am to 7:30 am	12:00 pm to 2:00 pm	8
Period 3	9:30 pm to 5:30 am		8
Period 4	10:30 pm to 6:30 am		8

Table 10 – HPHC option

- The TEMPO option available to RES3 and PRO3 profiles has 6 meters. It consists in using a peak/off-peak measurement combined with 3 periods in the year.

Yearly Periods	Activatable on Specific Days and Dates	Minimum & Maximum Days	Off-Peak Hours	Peak-Hours
Blue	All year-round		10 pm to 6 am	6 am to 10 pm
White	1-Sep to 31-Aug, Monday to Saturday	< 35 days, > 51 days	10 pm to 6 am	6 am to 10 pm
Red	1-Nov to 31-Mar, Monday to Friday	< 18 days, > 26 days	10 pm to 6 am	6 am to 10 pm

Table 11 – TEMPO option

- The EJP option available to RES4 and PRO4 has 2 meters for a double tariff scheme. There is one meter that counts the mobile peak hours that are activatable by the consumer. These peak hours must be activated for more than 18 days and less than 26 days between 1-Nov and 31-Mar for at least 18 consecutive days from 7am to 1am the next day. The other meter counts all the remaining hours that have not been selected for the peak mobile period.
- The EP option is available only to PRO5 and is for the public lighting and other specific consumers that have their night-time consumption higher than the daytime one.

Now that the different profiles and reading options have been explained, the below table 12 with the EDF data shared by the CRE can be reviewed.

¹² <https://www.comparawatt.fr/heures-creuses/belz>

¹³ <https://www.comparawatt.fr/heures-creuses/etel>

Type	Profil	Option	Number of Sites	% of Total Sites	Total Consumption in MWh	Average Consumption in MWh
RES	RES1	BASE	1,219,079	5%	1,369,010	1,1
RES	RES11	BASE	10,590,964	41%	29,240,351	2,8
RES	RES4	EJP	430,194	2%	2,872,507	6,7
RES	RES2	HPHC	10,727,579	41%	74,721,031	7,0
RES	RES3	TEMPO	232,182	1%	1,997,099	8,6
PRO	PRO1	BASE	2,065,374	8%	13,335,937	6,5
PRO	PRO4	EJP	85,143	0%	996,966	11,7
PRO	PRO2	HPHC	459,292	2%	6,906,398	15,0
PRO	PRO3	TEMPO	69,311	0%	1,574,157	22,7
PRO	PRO5	EP	242,299	1%	1,790,650	7,4
TOTAL			26,121,417	100%	134,804,106	

Table 12 – EDF profile split in 2019 provided by the CRE

This table confirms that the main consumer profiles in Brittany are generally RES11, RES2 and PRO1. In particular, the Belz town's consumption statistics shown in section 1, table 3 also reflect that there are agricultural professionals with higher consumption that could be equivalent to PRO2 profiles.

In parallel, IDETA reviewed the ratio of the type of Belgium consumers that adhered to the COLECO programme to understand a ratio that could be used for the tidal REC study. IDETA compared the COLECO project's participants' average annual consumption and price scheme. Belgium has fewer tariff schemes than in France. The Belgium tariffs are limited to two options, which are:

- The single tariff that has the same cost all the time. This is equivalent to the BASE option and the French profiles RES1, RES11 and PRO1. Since there are not many of these profiles in France, they have been combined in the ENEDIS curves with the RES1WE, RES11WE and PRO1WE weekend tariff options.
- The double peak/off-peak tariff that is equivalent to the French HPHC RES2WE and PRO2WE profiles. In Belgium, the peak/off-peak period split is the following:
 - A higher price during the weekday's daytime (Monday to Friday from 7am to 10pm) and
 - A lower price during the weekday's night-time (Monday to Friday from 10pm to 7am) and weekends (Saturday to Sunday all day and night).

Although ENEDIS provides different curves per subscribed power, these curves are not sufficiently granular. Indeed, the consumption figures per 30 minutes are identical throughout the day. Instead, the agglomerated subscribed power for the whole profile, referred to in the platform as "P0: Total <= 36 kVA", has been chosen for the study as some of these curves provide different consumption figures per 30 minutes. Each downloaded profile has three curves:

- The "Average Curve n°1" corresponds to the average of the volumes of electricity consumed over the ½ hour for groups whose ratio (Consumption 8 am-8pm) / (Total consumption) is the highest.

- The “Average Curve n°2” corresponds to the average of the volumes of electricity consumed over the ½ hour for groups whose ratio (Consumption 8 am-8pm) / (Total consumption) is the lowest.
- The “Average Curve n°1 + n°2” corresponds to the general average of the volumes of electricity consumed over the ½ hour.

The selected curves for the study were those that provided realistic consumption data that changed for each 30-minute period (in darker green in below table 13). The ENEDIS platform provides the related curves per French region, therefore IDETA was able to use the Brittany-specific curves for the consumers subscribed to less than 36 kVA. This is shown in table 13, sorted from highest withdrawn points to lowest.

				P0: Total <= 36 kVA		
Profil	Withdrawal Points	Withdrawal Points Ratio	Total Withdrawn Energy (Wh)	Total kWh Curve n°1	Total kWh Curve n°2	Total kWh Curve n°1+2
RES2 (+ RES5)	921.283	44%	347.249.116	7.362,26	8.247,39	7.806,42
RES1 (+ RES1WE)	726.008	35%	90.699.679	2.376,91	2.286,43	2.331,84
RES11 (+ RES11WE)	155.975	7%	42.024.858	5.958,61	4.948,18	5.456,44
PRO1 (+ PRO1WE)	144.122	7%	56.547.802	5.235,87	8.976,29	7.147,32
PRO2 (+ PRO2WE + PRO6)	61.330	3%	61.795.241	12.939,70	17.954,30	15.438,26
PRO5	24.344	1%	9.491.531	9.708,12	5.233,66	7.079,18
RES4	20.426	1%	6.579.514	7.566,48	5.395,00	6.486,50
RES3	12.822	1%	5.385.410	7.096,10	7.779,40	7.440,92
RES2WE	10.197	0%	3.887.084	7.195,84	6.917,16	7.060,66
PRO3	6.073	0%	9.768.817	25.610,58	24.462,86	25.044,90
PRO4	4.607	0%	3.195.091	14.235,74	10.260,64	12.249,52

Table 13 – ENEDIS consumer statistics for Brittany in 2019
with the dark green blocks showing the curves with sufficient granularity per 30 minutes

The table demonstrates the most relevant profiles in Brittany, which are:

- RES2 (+ RES5) with all three curves (1, 2, and 1+2) providing sufficient granularity;
- RES1 (+ RES1WE) with all three curves (1, 2, and 1+2) providing sufficient granularity;
- RES11 (+ RES11WE) with two curves (2 and 1+2) providing sufficient granularity;
- PRO1 (+ PRO1WE) with only one curve (1+2) providing sufficient granularity;
- PRO2 (+ PRO2WE + PRO6) with only one curve (1+2) providing sufficient granularity.

IDETA therefore selected these 5 profile types and specifically the curve number 1+2 for the tidal REC study.

Tidal Turbine (RE50) Production

The tide is a predictable natural phenomenon. It is the rise and fall of the sea that is driven by the gravitational forces of the moon and the sun and the earth's rotation. The tide will influence the

water currents' speed and direction. Within a single day, in Shetland and Brittany, the coast will follow a cyclic semi-diurnal tide whereby there will be two high and two low tides each day. It takes six hours to go from the peak of the high tide to the peak of the low tide. Moreover, there is a two-week cycle between the lowest tide and the next lowest tide, and between the highest tide and the next highest tide. The figure below shows the tide height between 29 April 2021 and 20 May 2021 in Brittany at the shore of Quiberon, close to the Etel estuary, found on the website <https://www.tide-forecast.com/locations/Quiberon/tides/latest>. Considering this predictable cyclic tidal movement, the energy produced from the tide using tidal turbines is equally predictable.

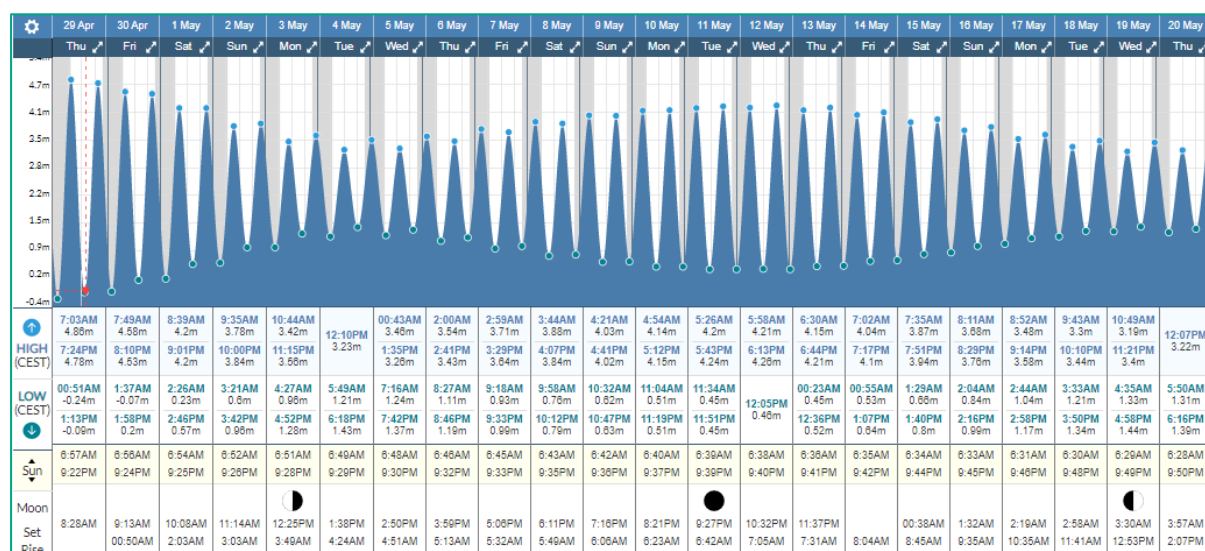


Figure 9 – Tide chart forecast for Quiberon, Brittany, France

This study will assume that a NOVA RE50 tidal turbine will be used for the potential REC. This is the turbine that will be used for the WP10 estuary test. This machine has a nominal power of 50 kW. IDETA has used confidential power production curves received from NOVA for the full year 2020 that details for every 15 minutes the power production against the current speed noted at the Bluemull Sound, Shetland, Scotland location (EnFAIT project). This current speed runs from up to -2.7 m/s (metres per second) one-way to up to +2.7 m/s in the other direction when the tide turns.

These Shetland current speed measurements have been used for the Etel tidal REC study. Indeed, although there are no time-lined current speed data curves for the Etel estuary, the previously mentioned document on the “Site Natura 2000 objectives for the Ria D’etel¹⁴, Tome 1”, page 56, mentions observed highest (coefficient 120) current speeds of 2.57 m/s at “Magouër Nord” and 4.12 m/s at “Pont de Lorois”. The Shetland current speed is therefore a realistic low estimate for Etel.

« On observe un maximum de 5 nœuds au jusant par coefficient 120 au Magouër Nord, à Nohic et au vieux passage, de 8 nœuds au pont Lorois (GIRARD. A, 1996, d’après SHOM, 1968). »

Based on these measurements, IDETA estimated that at full-service, meaning without maintenance or other interruptions, a single RE50 tidal turbine would generate 151 MWh per year. The 2020 production curves were translated into 2019 30-minute data for the study to synchronise against the 2019 30-minute French consumer profiles, as will be shown further below in figures 10 and 11 of the analysis.

¹⁴ Note that the full “Natura 2000 RIA D’ETEL” publication is available on the website <http://ria-etel.n2000.fr/participer/le-docob-du-site>.

REC Consumer Participants

As previously mentioned, the participation rate at the initiation phase of IDETA's COLECO projects was of 12% of the total neighbourhood. Indeed, there were nearly 150 representatives that adhered to the project out of a total of 1200 homes and buildings within the 9 sectors. Each sector had 9 to 22 adherents, with an average of 16 participants per REC. This is also close to the general number of REC participants in France. The ENEDIS figures for March 2021 showed an average of 14 participants out of 45 active RECs (referred to in France as “collective self-consumption activities” or “activités d’autoconsommation collective” in French), as shown in below table.

Active RECs	Consumers	Producers	Total Participants	Power (kVA)	Consumer /REC	Producer/ REC	Participant /REC
45	567	82	649	1309	13	2	14

Table 14 – ENEDIS active RECs as per Q1-2021 in France

However, considering the high production of the RE50 tidal turbine that generates 151 MWh per year, a REC with only 14 participants would not be optimum. The 14 participants could have been split into, for example, 6 RES2, 5 RES1, 1 RES11, 1 PRO1 and 1 PRO2. By matching the 30-minute production for a year with the 14 participants' profile curves, the analysis shows that these 14 participants would be able to cover around 65% of their electricity demand, which is an interesting self-coverage rate. However, they would only self-consume around 36% of the tidal electricity, meaning that 64% of the tidal energy would need to be dealt with in other ways. For example, if the REC was part of the Enercoop association, the surplus could be sold through the 100% green electricity provider to its clients for a government-fixed price of 0,06 €/kWh. However, the current Levelized Cost of Energy (LCOE) of tidal would not make this REC model financially viable.

Instead, for this study, IDETA identified the maximum number of participants to the REC that would have a higher self-consumption rate (the percentage of tidal energy being consumed by the REC participants) and a reasonable self-coverage rate of at least 40%, meaning that 60% or less of the consumers demand will be covered by another energy source, probably sold through a market energy provider. Indeed, it is not possible to cover 100% of a consumers' demand in green electricity when counting per 30-minute (for France) or 15-minute (for Belgium) periods each day if there is no storage facility. Storage in the ways of batteries is generally expensive to buy and maintain and will hence increase the LCOE of the REC project. This study will therefore not include a battery in its analysis, however we note that the falling costs of both tidal energy and storage mean that this solution could become increasingly attractive in the future.

For this study, IDETA considered the Belz commune. Belz is an urban commune with an area of 15 km² and according to ENEDIS 2892 residential and small professional consumers. Since the French law mentions that RECs in urban locations must be contained in a 2 km² zone, only 13.33% (2 km² out of 15 km²) of the 2892 consumers were first selected. This first selection brings the potential REC neighbourhood to 348.4 residential consumers, 0.2 agricultural consumers and 4.2 other small-professional consumers. A second selection criteria was then applied to reflect the COLECO-observed REC participation rate of 12%. This reduces the participation to 42 residents and 5 small professionals. It is possible to map the annual consumption average of PRO1 and PRO2 with the ENEDIS statistics showing the annual average consumption of the different small-professional sectors. This results in a REC of 4 PRO1 and 1 PRO2. However, the ENEDIS statistics do not clarify the numbers per residential profile types. As such, the residential consumer number was split into specific profiles. This last and third selection criteria used the number of consumers from the three Brittany selected residential profiles (921,283 consumers with RES2 profile, 726,008 with RES1 and 155,975 with RES11) to create the RES profile ratio: 51% of the 42 residents become a RES2 profile, 40% become a RES1 profile and 9% a RES11 profile. The selection criterium are shown in below table 15 and reflect a tidal REC of 47 participants, comprised of 21 RES2 profiles, 17 RES1 profiles, 4 RES11 profiles, 4 PRO1 profiles and 1 PRO2 profile.

Type	Sector	N° of Sites	Average Consumption in MWh	Selection 1) REC Max Location (2km/15 km Belz = 13.33%)	Selection 2) COLECO Participation rate (12%)	Profile	Selection 3) RES Profile Ratio (total 1,803,266 RES)	N° of REC consumer participants
RES	Residential	2614	4.79	348.4	41.8	RES2 (+ RES5)	51%	21
RES						RES1 (+ RES1WE)	40%	17
RES						RES11 (+ RES11WE)	9%	4
PRO	Other	265	6.72	35.3	4.2	PRO1 (+ PRO1WE)	Round down	4
PRO	Agriculture	13	14.80	1.7	0.2	PRO2 (+ PRO2WE + PRO6)	Round up	1
		2892						47

Table 15 – potential tidal REC participants

To view the simultaneous consumption by the 47 REC participants of the green tidal energy production, below figures provide the total consumption curve against the production curve for two consecutive weeks. For each day, the 2 high-tide and 2 low-tide phenomena can be seen on the graph by the 4 peaks in production per day. Moreover, the two consecutive weeks also reflect the change from a lower tide week to a higher tide. These figures also highlight that the production is lower than the demand during the low-tide week while it is higher than the demand in the high-tide week.

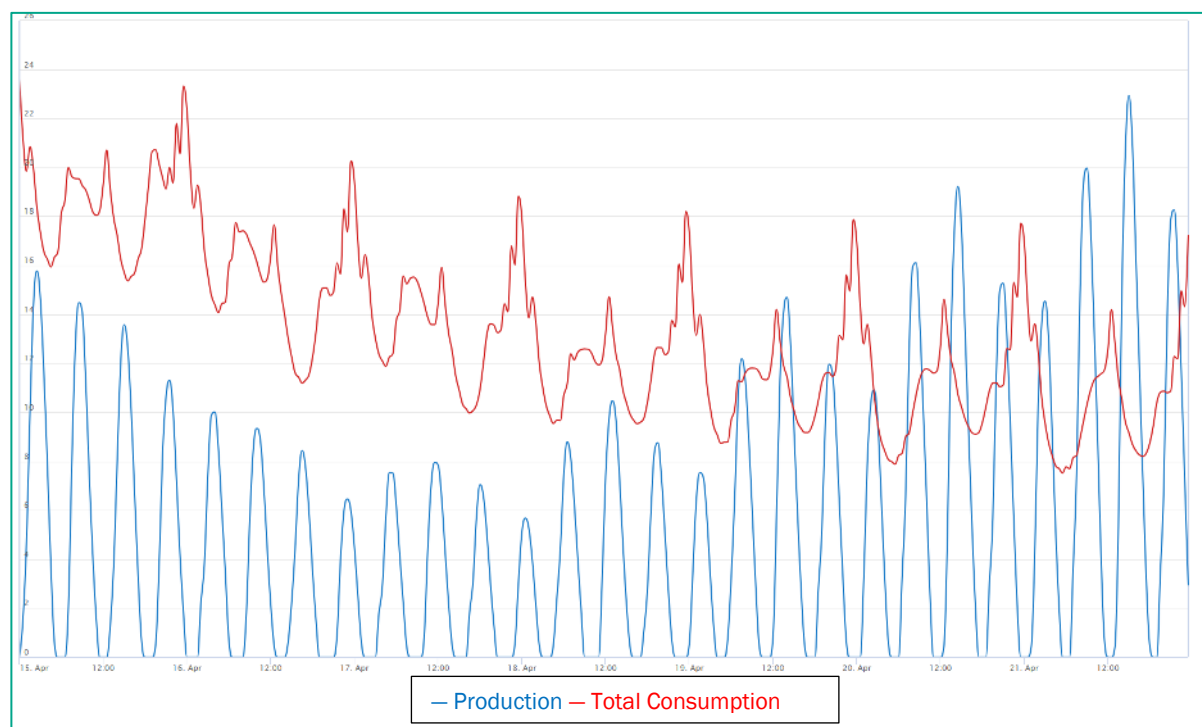


Figure 10 – Production and total REC consumption curves during a low-tide week

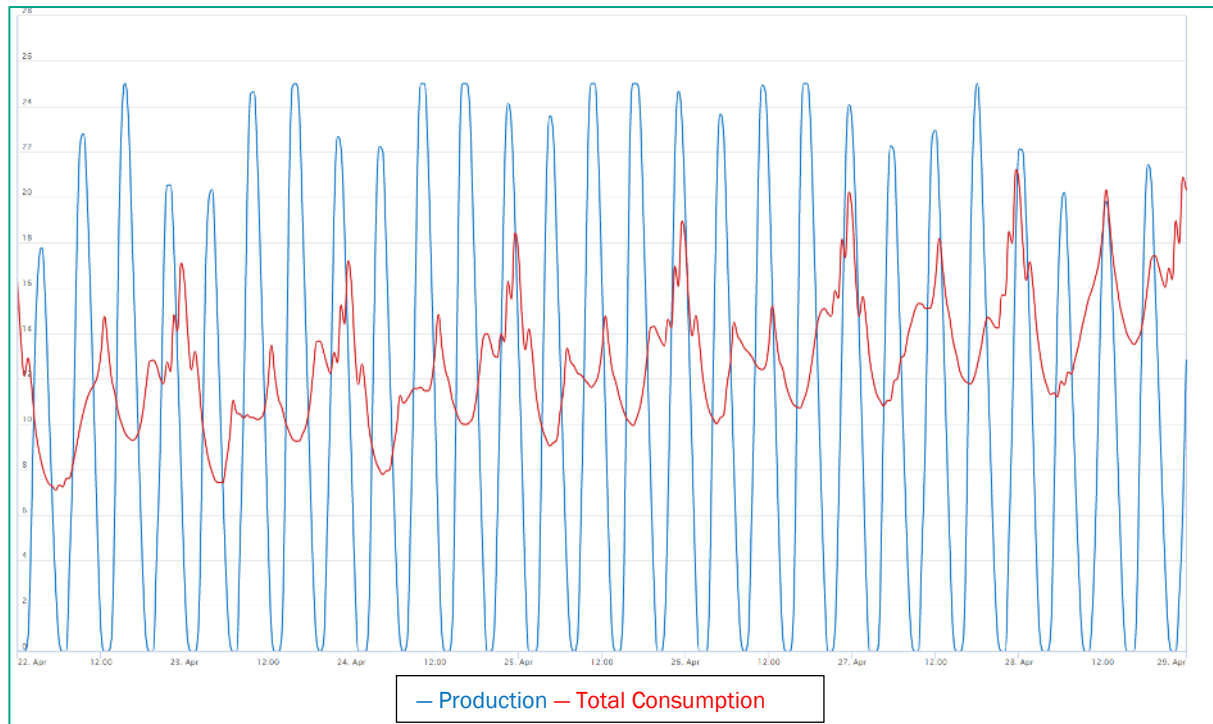


Figure 11 – Production and total REC consumption curves during a high-tide week (week after figure 10)

Below figure 12 reflects the 5 different types of profiles that were used for the study, whereby Type 1 is the curve of one RES2 (+ RES5) profile (equivalent to peak/off-peak residential consumption), Type 2 of RES1 (+ RES1WE) (equivalent to 6 kVA week/weekend residential consumption), Type 3 of RES11 (+ RES11WE) (equivalent to over 6 kVA week/weekend residential consumption), Type 4 of PRO1 (+ PRO1WE) (equivalent to week/weekend small-business consumption) and Type 5 of PRO2 (+ PRO2WE + PRO6) (equivalent to peak/off-peak small-business consumption).

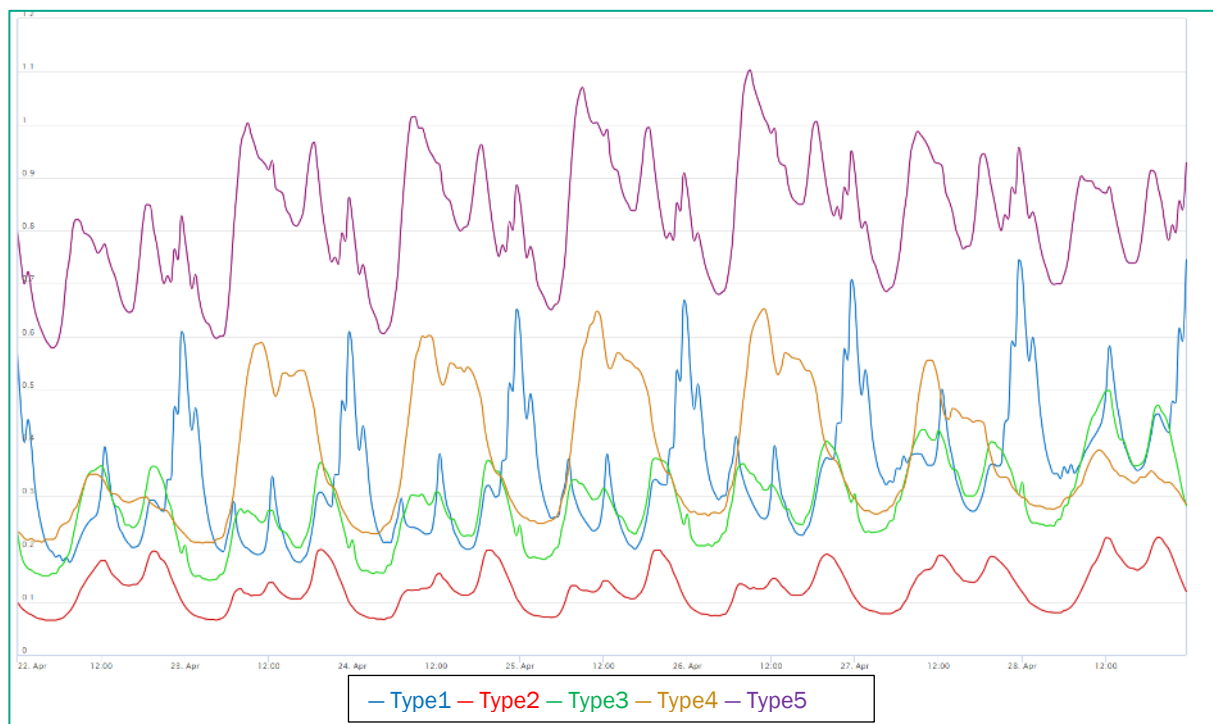


Figure 12 – Production and total REC consumption curves during a high-tide week (week after figure 10)

REC Self-Consumption and Self-Coverage Rates

Now that the study has determined the number of REC participant profile types, the optimum self-consumption and self-coverage rate can be counted. To reflect the default methodology in France, IDETA used the prorated consumption of each total profile type to create the distribution key that is used to share the tidal energy. For example, for the 21 RES2 consumers, the distribution key is 60.85% because the total annual consumption of the 21 RES2 profiles (163,934 kWh) makes up 60.85% of the total annual consumption of the 47 REC participants (269,427 kWh). This is equivalent to one RES2 consumer receiving 2.90% of the REC production for 74.56% of self-consumption and 41.71% of self-coverage.

	21 x RES2 (+RES5)	17 x RES1 (+RES1WE)	4 x RES11 (+RES11WE)	4 x PRO1 (+PRO1WE)	1 x PRO2 (+PRO2WE + PRO6)	TOTAL 47 participants
Total per profile:						
Distribution key (%)	60.85%	14.71%	8.10%	10.61%	5.73%	100%
Total annual consumption (kWh)	163,934	39,641	21,825	28,589	15,438	269,427
REC production (kWh)	91,710	22,176	12,209	15,993	8,636	150,726
REC consumption (kWh)	68,380	17,572	9,502	12,573	6,999	115,026
Non-REC consumption (kWh)	95,554	22,068	12,323	16,015	8,438	154,398
REC surplus (kWh)	23,329	4,603	2,707	3,419	1,636	35,694
Self-coverage rate (%)	41.71%	44.33%	43.54%	43.98%	45.34%	42.69%
Self- consumption rate (%)	74.56%	79.24%	77.83%	78.62%	81.04%	76.31%
Individual data per participant of each profile:						
Distribution key (%)	2.90%	0.70%	0.39%	0.51%	0.27%	100%
Total annual consumption (kWh)	7,806	1,888	1,039	1,361	735	269,427
REC production (kWh)	4,367	1,056	581	762	411	150,726
REC consumption (kWh)	3,256	837	452	599	333	115,026
Non-REC consumption (kWh)	4,550	1,051	587	763	402	154,398
REC surplus (kWh)	1,111	219	129	163	78	35,694
Self-coverage rate (%)	41.71%	44.33%	43.54%	43.98%	45.34%	42.69%
Self- consumption rate (%)	74.56%	79.24%	77.83%	78.62%	81.04%	76.31%

Table 13 – tidal REC distribution key, self-consumption and self-coverage rate

The table reflects that each participant would be able to have an average self-consumption rate of 76.31% and a self-coverage of 42.69% with an average distribution key of only 1% of the tidal production.

The residential peak/off-peak consumers (RES2 and RES5) would self-consume the tidal energy at 74.56% while self-covering their total consumption needs by 41.71% with only 2.90% of the tidal energy generation. The smaller residential single-tariff or week/weekend tariff consumers (RES1 and RES1WE) would self-consume 79.24% which self-covering 44.33% with only 0.70% of the produced tidal energy. The larger residential single-tariff or week/weekend tariff consumers (RES11 and RES11WE) would self-consume 77.83% which self-covering 43.54% with even less of the tidal energy (0.39%). As for the professionals, 0.51% of the tidal energy would cover 43.98% of the needs of small non-agricultural professional with a self-consumption rate of 78.62%, while 0.27% of tidal energy would cover 45.34% of the small agricultural professional consumers' needs with a self-consumption rate of 81.04%. This REC would therefore clearly benefit the Belz participants, through the production of green local energy that will be highly self-consumed.

REC Conclusion

The study confirms that the Belz commune would be a good candidate for a REC of 47 consumers and 1 RE50 tidal turbine. This study does not include any financial aspects, such as the price of the electricity, nor the cost of the installation. This is because tidal energy must first reduce its levelized cost of energy through continued improvement in research and development. Even without the financials, the study demonstrates that tidal energy has a predictable high production capacity that can help increase the deployment of renewable energy sources needed to reach European targets of green energy and CO2 neutrality. By combining tidal energy deployment with a REC model, not only will a large part of the Belz local community benefit to green local energy, but moreover the projects will create a social cohesion that will accept renewable energy sources and support energy efficiencies.

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