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# Electric boats market in France, Environment impact, Challenges and projects

Xavier de Montgros

French Association for Electric Boating

President

ODC Marine Associate Director

**Summary**

First *electric boat* was invented in France by Gustave Trouve in 1881.

In 1994, an association was created by university of Bordeaux, Electricity of France and industrials to develop *electric boats* for both inland and maritime waters. This association regroups more than fifty members, *shipyard*, equipment manufacturers, *batteries* and *electric drives*, ship architects, Engineering consulting firms and ships *operators* to help develop the possibilities of no emission navigation.

The association promotes all ways of no C02 emission navigation, helps in developing common rules and regulations, lobbies to get this practice develop faster, communicates on best ways to reduce emissions on waters, organizes networking to share best practice.

The Association is member of AVERE France, Federation des Industries Nautiques, Maritime Cluster, Econav…

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# 1 Electric boats market in France

Today France is proud of having thousands of electric boats in service for the leisure segment and tens of passengers boats in the passengers ferries segment, new segments are developing in freight and harbor services.

The presentation will detail market and its evolution, it will give examples of best solutions in place.

We will present down here the results of a study done by French Association for Electric Boat with The Ecole Nationale Supérieure de Techniques Avancées, ENSTA from Britany (English National Institute of Advanced Technologies of Brittany) often referred as ENSTA Bretagne. This study provides an exhaustive view of electric boats in service in both leisure and professional segments. It explains market dynamics and constraining factors. Actually, this project is a market survey which is limited to the French territory.

In the electric boat sector, there are two major segments :

- Leisure (Aquajet, Ruban Bleu, Alizé Electronic, Saviboat, Armor Nautic…), boats for fishing or short sailing.

- Professional. It includes passenger transport or ferry (having as leaders : Alternative Energies, Chantier Naval Franco Suisse, Naviwatt and ODC Marine) and small work boats (boats for maintenance or access to ports for example).

The study will also explain where full electric or hybrid solution fit and what hydrogen solution can bring to complement. It will detail benefits of serial Hybrid and parallel hybrid in the ship segments.

Keywords: Electric boat, electric, engine, power, boating, ferries, bark, environment, sail, electric drive, batteries.

## 1.1 Professional segment

### 1.1.1 Actual numbers, strengths and weakness

In recent years, the appearance of the electric boat in cities and ports seems undeniable. Many hybrid and all-electric solutions are emerging in several agglomerations in France. According to our estimates, there are today between 55 and 60 boats with electric or hybrid motorization in the professional field. Unlike the yachting sector, the evolution compared to 2013 figures is more limited. The report prepared by the AFBE in 2013 estimated about fifty professional electric boats. However, if the market evolves modestly, it should be noted that these boats have larger sizes and thus generates a turnover much higher than what is seen in pleasure.

In addition, the use remains limited today. Indeed the transport of goods or the transport of long-haul passenger seems today still complicated for full electric. The limited autonomy that electric boats have over conventional thermal boats is a major obstacle to this development. The implementation of the electric is therefore carried out on boats operating on short distances such as bus boats, smugglers or even harbour boats. The number of constructors in this industry is quite small. There are indeed three main players Alternative Energies, the Shipyard Franco-Swiss and ODC Marine, which together cover three more than two thirds of the market. Finally, Naviwatt and Mayday are developing solutions.

*Alternative Energies, cross harbor ferry in Concarneau (Source : Alternative Energies)*

Many agglomerations have refurbished their fleet of boats with a visible trend of electrifying them. La Rochelle inaugurated in 2009 two fully electric boats intended for the transport of passengers (boats made by Alternatives Energies). These were equipped with Nickel-Metal-Hydride batteries and have 15m2 of solar panels for a single daily recharge. They can accommodate up to 75 passengers and evolve to a maximum speed of 8 knots. Four years later, the city of Lorient realized the first French supercapacitor boat, the “Ar Vag Tredan”. Built by “Chantiers de l'Atlantique”, formerly STX, this boat brings innovative storage technology on board. Indeed, contrary to what is generally seen, this boat is equipped for energy storage of a supercapacitors network. This system has the great advantage of a fast charge but has the defect of a more limited autonomy than conventional batteries. The charging time is estimated at 4 minutes, an extremely low figure compared to the time required for a conventional battery.

These two projects however had to face the problem of the price (problematic important with the electric propulsion). Indeed, according to estimates made by the Telegram, the Lorient boat costs "3.2 million, or 1.7 million more than a diesel engine and 900,000 euros more than a diesel-electric hybrid", an increase between pure thermal and pure electric of more than 100%. La Rochelle, for its part, by a technology that is ultimately less innovative, estimates the extra cost due to all-electric equipment to be 30 to 40%. However, this increase in bill is accompanied by a net decrease in the cost of fuel. For Ar Vag Tredan, this reduction would be estimated at 1 million euros over the thirty years of operation planned. Also in an interview, Maxime Bono, the Deputy Mayor of La Rochelle explained precisely that : "in operation, the cost of electricity consumption is very cheap, 7 euros per day for this sea bus. By investing in these boats, it's a bit like we were refueling for 7 or 8 years in advance. In addition, cities can count on aid from the General Council and the ERDF (European Regional Development Fund), which significantly reduces the cost for agglomerations.


Hybride 100 Passengers put into service by ODC Marine in 2012

Technology has also developed in the sea, between 2012 and 2014, the company ODC Marine has delivered four hybrid boats that have allowed tourists to visit in peace and without environmental impact creeks in “Scandola Park”, or “Sanguinaires Islands” along the Corsica coast from Porto or Ajaccio.

Under the constraints of currents and greater winds, certain agglomerations have made the choice of the hybrid like in Bordeaux (2013). Also, two dual energy boats (2014) in the harbor of Toulon embarked on an electric and thermal engine. Indeed, as Jean-Yves Dubourg points out: "Initially, we wanted to switch to everything electric. The goal was for these new boats to have the same quality of service and performance as their thermal counterparts. When we looked at the specifications, we quickly realized that the electric everything was complex for a crossing in 20 minutes given the volume of batteries needed. There was no solution to generate the electrical power needed to board 100 passengers.

$Bat^3$ *ou navette fluviale de Bordeaux (Source : Bordeaux Métropole)*

However today, according to Mr Brun, co-leader of the company Mayday, the main obstacle to the complete electrification of some boats is above all a fear with respect to the reliability of the electric one and mainly for the sea-going boats. According to him, the technology is ready, but agglomerations do not have enough perspective on it to lend complete confidence. In the passenger transport and especially at sea the safety and reliability of the boat are preponderant elements that cannot be overcome.

The other part of the professional segment is small work boats. They allow short distances in ports to reach a larger boat or can be used during maintenance operations. These are therefore very useful, do not require a very long autonomy, or a great power. They correspond perfectly to the area to which the electric boat belongs as it is proposed today.

#### 1.1.1.1 Feedback from the sponsors

To know the assets and the axes of improvement of the electric boat, we wanted to know the opinion of the agglomerations having these electric and hybrid boats. In most cases, the experience feedback is very good, only a few experiments have had trouble including Bat3 in Bordeaux who experienced repeated breakdowns at the start of the project. Overall projects have very good returns from sponsors but also from passengers.

Thus we contacted Lorient agglomeration, to determine all the strengths and axes of improvements of the boat that they had made in 2013. The representative, Mr. Brulay, expressed to us well that the first boat realized had kept all its promises and the last has experienced very few technical damages. The operation was almost continuous and this with a rate of use of auxiliary engines, small auxiliary engines, of the order of 7 to 8%, well below the limit imposed by the specifications. The return on the supercapacitors is also very encouraging. The life promised by the manufacturer, Blue Solution, is 30 years, well above the lifespan of conventional batteries. The manufacture of this supercapacitor does not require the use of rare earths whose exploitation is controversial. Finally, the post-exploitation reprocessing of supercapacitors is simpler and much less polluting than that of conventional batteries. This solution more than any other responded to the zero-emission will be defined by Lorient Agglomeration. The major disadvantage expressed by the interlocutor was the autonomy that offers these batteries, but it has indicated that it is sufficient, allowing a recharge after a round trip. Charging takes four minutes, it is also integrable to the time of rise and descent of passengers. Finally, the agglomeration knows very good feedback from users. They put forward increased comfort especially in terms of noise, but also a pride to travel in an innovative technology and "clean for the planet". The city, happy with this project, has also commissioned the development of a second boat. Its realization should take place by 2020. This new boat will evolve on a slightly longer line and subject to higher winds and currents. The question of the storage system is perhaps to be reviewed, even if the experience of supercapacitors is now a great success.

These great successes are real promises for the future of the electric boat market. Indeed, the project of the “Ar Vag Tredan” awarded at its release by the Gazette-GMF puts forward the electric and its use in the public domain. This project highlights the technological innovation that the market knows and tends to break the prejudices about the lack of power of electric boats. It is ultimately these successes, generators of innovations that tend to demonstrate the reliability of all-electric users.

### 1.1.2 Opportunities.

As a follow-up to these promising returns, we can also see that many opportunities are emerging in the electricity market. First, the emergence of several high-potential markets. For example, the city of Paris has announced that it wants to electrify boats on the Seine including, initially tourism-oriented boats. Thus, HAROPA-Ports de Paris, the Paris port community, the VNF (Voies Navigables de France) and the DRIEA (Regional and Interdepartmental Direction of Equipment and Planning) announced last summer the creation of a working group to study solutions proposed today for electric boats. This working group went to Amsterdam’s “Electric & Hybrid Marine World Expo” last summer and is currently conducting a thorough study on the subject of the electric boat. According to the statement sent to us by HAROPA-Ports de Paris, the first sector concerned should be passenger transport and tourist transport with, as previously mentioned, the electrification of these boats.

The potential of this market is of major importance. Indeed, the Seine is today the fourth most important tourist center of the city of Paris. Every year, more than 8 million visitors visit the Seine and its surroundings. This announcement is part of the increasingly important policy of clean air, among others vis-à-vis the public health problems facing the city with pollution peaks ever more recurrent. In addition to this announcement, we can see that the market remains dynamic since all the manufacturers that we contacted, have orders on the book that fills for the next three years. Finally we see that more than Paris, the plans and water courses prohibited to thermal engines are more and more frequent. Most of these areas are protected areas belonging to the Natura 2000 network.

Today, this entire network is not reserved for the use of electric motors, but this evolution is clearly conceivable in the years to come. Finally, from the legal point of view, we can see that legislation at the international level tends to favor the emergence of clean energy in the nautical sector, particularly for the transport of goods. The implementation of Cap Sulfur 2020 will limit the level of sulfide present in the exhaust to 0.5% against 3.5% today. This has an impact on the limitation of the use of heavy fuels not on the electric. This major reduction marks a real turning point and shows an ever more important policy of the world maritime organization to limit the ecological impact of a sector. Today recognized very polluting. If temporary solutions seem to be put forward, major players in the sector such as Mærsk (Danish shipowner) today advocate rethinking the fundamental problem and invest heavily to move to alternative solutions to hydrocarbons.

In this context, we can think that the electric will change strongly in the coming years. We saw in the introduction that the use of the electric boat was still quite limited and this mainly for issues of autonomy. It can be seen, however, that today, research and development for energy storage is at its peak. The community can therefore rely on both political will and subsidies for very important research and development. For example, the LIFE or H2020 programs run by the European Union aim to subsidize innovation in the fields of ecology and defense. These projects also have the advantage of bringing together research centers, small, medium and large companies, institutions and different parts of the European Union.

Unlike the fields of pleasure, the impact of the evolution of the electric car seems more limited but remains however present. Indeed, the capacity needs as well as the powers developed are different between the automobile and the transport of goods and long-haul passengers. However, the field will be able to rely on developments in battery technologies. Finally, by the silent aspect that the electrification of a boat brings, the military sector could emerge as a market with high potential for the electric boat in the short-to-medium term. In addition, the military world, which is often quick to invest massively in new technologies, would allow ever greater emphasis on research and development in the sector. We can also think that it is in this perspective that Naval Group, internationally recognized group of construction and operation of marine buildings is today

### 1.1.3 Weaknesses

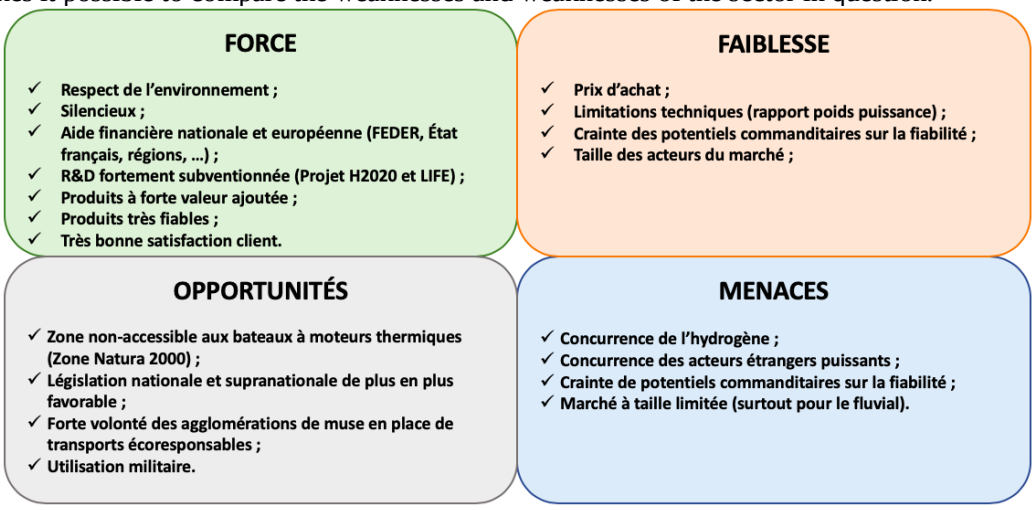
The market if it faces many opportunities for the future, it also faces threats. The first being the arrival of new competitors. The arrival on the market of strong competition (especially international) with powerful players from Northern Europe. and the emergence of Hydrogen which is an opportunity to develop electric even further. But these two elements, if they are threats for companies already in the presence, are also opportunities. Indeed, the appearance of hydrogen engines has allowed companies in the sector such as Alternative Energies to diversify their activities. Finally, the arrival of major foreign competitors will allow the sector to become more widely known with larger projects.

Finally, it is safe to say that a threat looms over the limit of the size of the market. Today the market still seems rather limited and if many opportunities appear, they must be realized to allow the sector to be sustainable. A threat linked to an electric shutdown by the discovery of more ecological

alternatives or by a completely revised ecological will can be worrying. Its likelihood is however extremely limited as the European policy of all electric seems today undeniable. So we can see, that the market finally faces few threats for the years to come.

### 1.1.4 Professional segment SWOT

In this subpart, we will summarize in a SWOT matrix all the opportunities and threats that we have put forward in the previous sub-sections. This tool offers the advantage of being visual and also makes it possible to compare the weaknesses and weaknesses of the sector in question.




SWOT for electric boats in the professional segment

First of all, it is easy to see that the market seems to be in a good position with the two most fulfilled parties, the forces and the opportunities. Current weaknesses in the purchase price and technological limitations are barriers that can be overlooked mainly by process or product innovation. However, the sector can rely on a framework that is beneficial to innovation on all points and suggests strong innovations in the years to come. Thus, we see at this moment, the emergence of electric boat project ever more promising and indicating that the known limits of the sector are in the process of being surpassed. In Iceland, an all-electric 70m long ferry capable of carrying 550 passengers and 75 cars has just been ordered by the country's administration. One can also think of the appearance of first digital prototypes of all electric cargo that appear since 2017 in the Netherlands. These prototypes, which seem to be long-term opportunities, are above all the testimony of a sector in full innovation. We can also mention the project led by two Norwegian companies, which aims to build an electric freighter by 2020.

Finally, 'sponsors' fears about the reliability of the electric, the sector will be able and must rely on these successes as the existing passengers' vessels in service and their extremely safe and reliable operations. This reluctance to change on the part of agglomerations will then disappear because the success of boats already in place tends to break these prejudices.

### 1.1.5 Professional segment prospective

To conclude, we will summarize the few figures cited later in this section entirely devoted to electric boats in the professional or service segment. Next figure summarizes the number of boats for passenger transport and the number of small work boats currently operating in France.

| | Professionnel / De service | |
|---|---|---|
| | Transport de passager / Passeur | Petit bateau de travail |
| En 2019 | 60 | 2 000 |
| En 2024 | 100 | 3500 |

Provisional table for the installation of electric boats on the professional segment

A projection in 2024 was made on the basis of the feedback of all the actors of the sector. Indeed, thanks to the exchanges with the industrial in particular, one could know their objectives of sale for 2019 but also their feeling on the importance that will take the electric one in the years to come. This collection of data and all these exchanges allowed us to reach the results given in the table.

## 1.2 Leisure segment

### 1.2.1. **Leisure boats Market analysis**

To fully understand the opportunities and the framework of the electric boat market today, it is necessary to understand the leisure craft market as a whole. Indeed, if electricity is today a minor part of this market, we must determine the reasons by first understanding the composition and then the obstacles or opportunities vis-à-vis these populations. The boating market is firstly very well distributed. In fact, it may be thought that the populations concerned are generally senior executives, but this tendency tends to be reduced with a marked increase in the presence of intermediate socio-professional categories and retirees.

Thanks to the report of FIN (Federation of Nautical Industries), we were also able to measure the evolution of sales of outboard engines and boats between 2006 and 2017. We divided the data into 4 major categories. This allows better visibility of information, specifically on the graph.

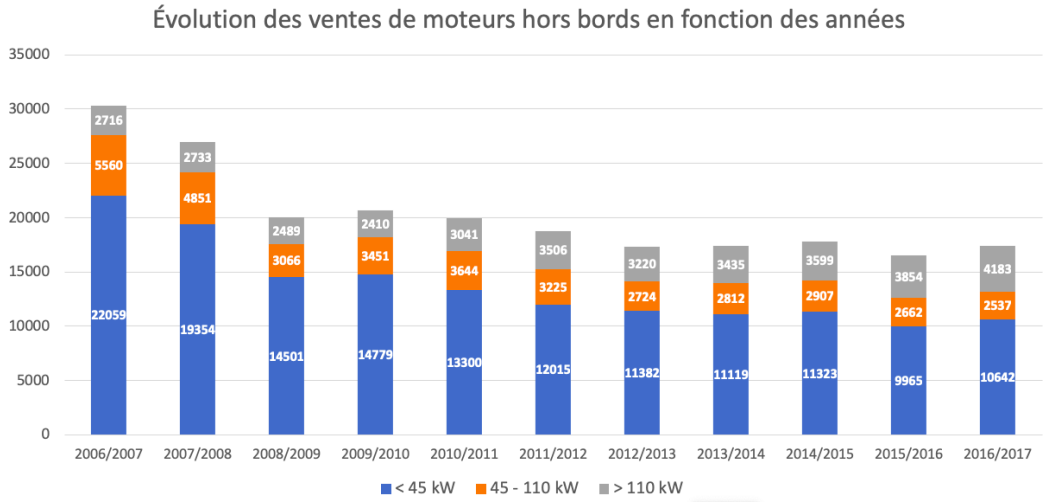
| Motorisation | < 20 kW | Entre 20 et 45 kW | Entre 45 et 75 kW | > 75 kW |
|---|---|---|---|---|
| Pourcentage des ventes | 70% | 10% | 15% | 5% |

The first two categories selected were the power ranges from 0 to 20 kW and 20 to 45 kW representing the small boats which represents a market on which the electric boat can take all its meaning. The second category consists of boats ranging from 45kW to 75kW. This market is also accessible to electric boats but with the first limits linked to autonomy when they are used at full power. Finally the last categories represent strong and very strong engines. This market is almost inaccessible for pure electric boats because it is a need for speed by the user, element now little compatible with the electric motor for a long period of use. One can for example quote the boat “Smögen” developed by the company X-Shore. It can reach a peak speed of 40 knots but has a range of only two hours if you sail at a speed of 25 knots.


*Le bateau Smögen de X-Shore (Source : AFBE)*

It is nevertheless important to note that thanks to the survey carried out with 160 people, the engine utilization rate during a classic outing at sea is only 30%. This shows that the current and especially future capabilities of the electric boat can gain room versus thermal engines.

The figures expressed throughout this section confirm our comments about the majority of electric motorization on small motorized boats. As we thought, the market of the motorization higher than 75 kW is still today only very accessible for the electric motor. We compared these sales percentages with the nautical market as a whole to measure opportunities and see general market trends in recent years.




The first notable point from this chart is the general decline in the market. After a massive decline in 2008 following the crisis, sales continued to decline more slowly. Between 2006 and 2017, the market declined by just over 30,000 outboard engines sold to nearly 17,000. This marks a 43% decrease, which is quite significant. However, it should be noted that the market is tending to revive since 2015-2016 and could correspond to the return of the good economic health of Western countries. Indeed, the market for motor boats is mainly driven by pleasure and is therefore strongly impacted by the economic period crossed (this apprehension seems confirmed by the sharp drop in the market between 2008 and 2009). The return of growth and the current economic boom therefore suggests a return to a rising market.

Another problem highlighted by this graph is that the most visible decline is now affecting the market for 110 kW lower power engines. Indeed, for engines below 45 kW, the number of engines sold has decreased from 22,000 to 10,500 while that of engines between 45-75 kW from 5,560 to 2,537. In contrast, the number of engines over 110 kW has almost doubled in the past 10 years, with 2,716 units sold in 2006 compared with 4,183 today. If these figures show a clear trend of increasing the average power of the engines used, the market for low and medium power engines still remains dominant today and the quantity of engines below 45 kW sold is still today twice the amount of motors greater than 110 kW. Thus the market is now undergoing a strong change that seems to go against the current capabilities of electric propulsion. Nevertheless, a significant potential market remains. Moreover, if the strong powers seem difficult to establish for electric today, we will see later in this report that technological developments in the coming years could change this state of affairs.

### 1.2.2 **Leisure segment Actuals**

The yachting market today accounts for the bulk of the global sector's quantity and turnover. Today there are around 15,000 boats equipped with electric motors in the field of leisure. The latter are divided into three main categories: rental boats, private motor boats and sailboats. The yachting power market is made up of three leaders, Torqeedo, Ruban Bleu and MinnKota, who share most of the current market. However new brands such as X-Shore, Armor Nautic and Naviwatt tend to integrate the market with offers to individuals often more qualitative but also more expensive.

#### 1.2.2.1 **Boat renting segment**

Today there are 4,000 boats for hire (from hour to day) operating throughout France. This market is mainly composed of nautical stations located on freshwater courses and lakes. We contacted Amélie Douillet who worked for a long time on the base of nautical leisure of Laval in Mayenne so that she gives us her opinion on the electric boats. Indeed the nautical base of Laval has been using for some years small electric boats of 5 to 7 places called "Scoops" and whose customer returns are excellent today. Although the price is more important, almost twice as much as the purchase according to her opinion, electric boats have many advantages for rental. First, the limited power of the engines certainly limits the cruising speed but allows novice users without a license to navigate.


Finally comfort for the user is, according to Mrs Douillet, the first big advantage of the boats. The maneuverability of these is easier. The inconveniences like the noise of the engine or the smell of fuel are absent. Finally for the nautical base, electric boats are easier to use, maintenance and connecting boats to a terminal is easier than filling a fuel tank. According to her, electric boats required much less maintenance with less recurrent breakdowns than thermal models. Finally, as we can see with the automobile, the ecological awareness of the population seems more and more present. In an interview with Ouest France in August 2017, Cyril Boisseau, head of ancillary equipment at the Tourist Office in the Pays de Laval, said : "The trend is towards all-electric. Gradually, we replace the material. It's cleaner too. "

#### 1.2.2.2 **Consumer segment**

With regard to the retail market, sales fall into two main categories, auxiliary engines for sailboats and small craft for leisure boats or fishing. Today there are almost 3000 sailboats and almost 8000 private boats equipped with electric motors. As we mention in the previous section, the engines sold to individuals are mostly small and very small powers. In a questionnaire with a population of 160 students and former students, we wanted to know the limits to the expansion of the market. To avoid any bias in the results obtained (and present in Figure 20), we left open responses.

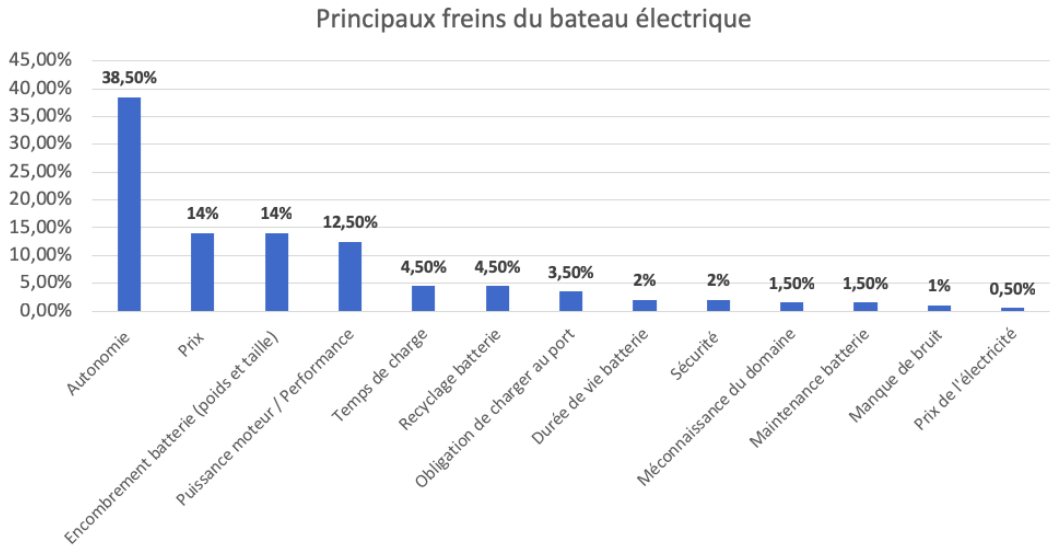
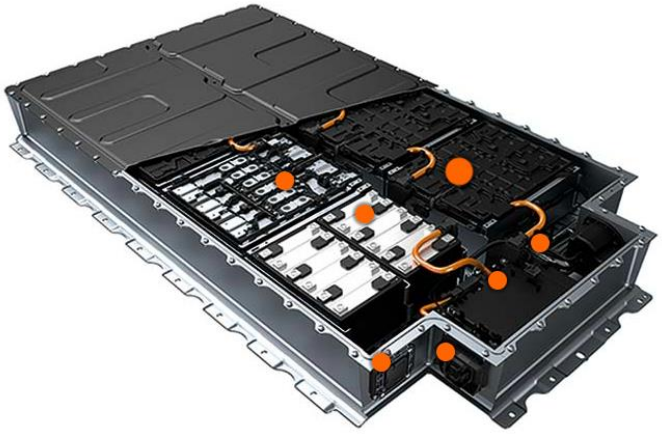



Chart of Major Electric Boat Brakes (Source : Personal Survey)

Despite this, a very large majority of the population responded that the main brake of the electric boat was the autonomy. Another worry was the size of the battery on the boat. It is clear that these concerns are related to the battery and that real innovations are expected from this side or better communication on the current possibilities. The second weakness has inevitably been the cost as a major obstacle. Finally in fourth place, we find strong concerns related to the possible performance of the boat. Although fourth, this element remains important. It represents 1 / 8th of a population warned on the subject of naval engineering and who finally seems uninformed of the real capabilities of today's electric powertrain. A need for more extensive communication therefore seems necessary today to dispel the fears of a population that may be misinformed or has an “à priori”. The manufacturers still seem aware of this problem and it is in fact one of the missions of the AFBE to prove that the electric can be a safe alternative. When we questioned these manufacturers on the limiting factors, the latter put forward mainly the price then the autonomy according to the speed of navigation. However, we see a clear difference because the price seems a brake much more put forward by the manufacturers than the panel questioned. This difference is also explained by the fact that the population questioned is not necessarily purchaser of the product today and therefore mainly questioned the technical limitations. In any case, we note that the two major weaknesses for electric boats today are lack of power and price. There is therefore a real need to continue research and development in this area in order to definitely convince the entire population.

### 1.2.3 **Opportunities and threats**

The market today knows real opportunities that will be detailed in this subpart. It can be noted first of all that the boating market in France represents more than 17,000 units each year. Those with high potential for the electrical sector are sales of low power motors between 0 and 45 kW (this represents 10,000 units in 2016-2017). However this market can also be considered a threat since its evolution in recent years is catastrophic with a significant decrease. This opportunity therefore seems viable in the short term pending a possible diversification by the possible attainment of high power engine markets. To conquer these markets, the sector can count on an environment conducive to the research and development of new products. Although less impacted than the industrial and professional field, the number of European research grants and projects for the development of alternatives to hydrocarbons is constantly increasing. The sector can also rely on innovations that appear in more powerful related sectors such as the automobile.



BMW i3 battery used by Torqeedo (Source: Torqeedo)

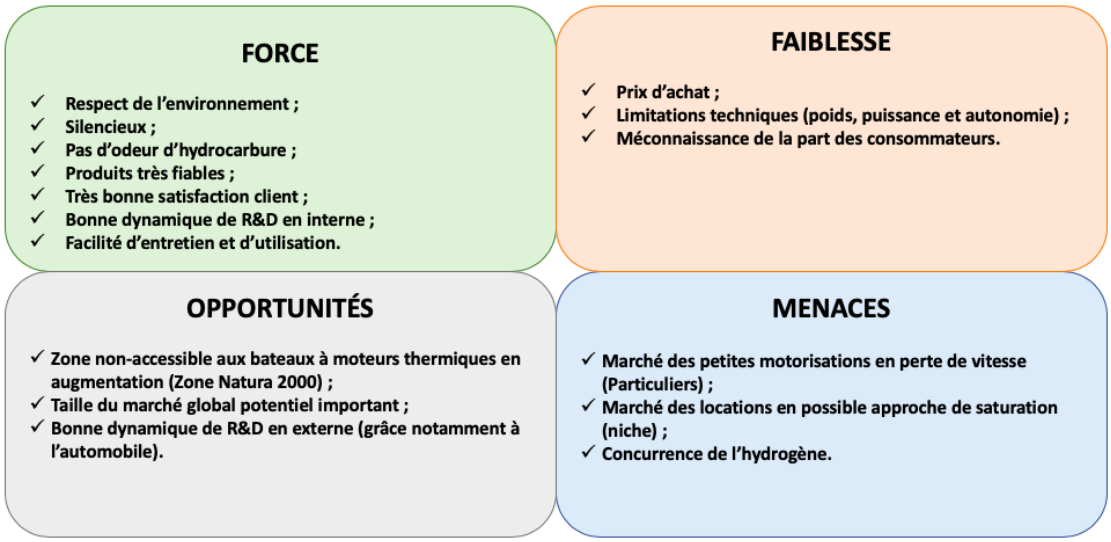
It can indeed be seen that Torqeedo uses for its DEEP BLUE solution batteries developed by BMW. These technological evolutions will make it possible to approach new markets both in the rental segment and in the private sector.

For the rental part, some companies have put forward a problem with the fact that today the market was possibly saturated (niche market). The limitation still preventing today to sell on the market nautical bases at sea and no longer on freshwater. We remain, however, skeptical of these remarks because the exchanges that we have had with the Laval river base suggested the opposite. The will of the electrification of the boats is visible and many cities want to pass in the small rental boats to the 100% green energy of which the electric boats are part today. In addition, the coverage of the territory by areas not accessible to boats with thermal engines are increasing (Natura 2000 area). Today, this entire network is not restricted to engines, but this evolution is clearly conceivable in the years to come.

The electric boat is still very unknown to the general public and false ideas that are no longer valid remain in people's heads. It is therefore important for organizations such as AFBE to communicate more on feasibility.

### 1.2.4 **SWOT for leisure segment**

In this sub-part, we will summarize in a SWOT matrix all the opportunities, constraints that we put forward in the previous sub-parts.




SWOT for electric boats in the yachting segment

We first see that the market seems in a good dynamic. For the rental part, although put forward by companies, the loss of dynamism of the market does not seem worrying vis-à-vis the comments received from the bases of leisure. Although the electric seems more and more present in nautical bases, many old engines are still to be replaced. For the retail portion, concerns have been raised about a global market dynamic that has been on the decline for some years, even though it has been recovering for two or three years. This evolution worries all the more because it mainly affects the market of the small motorization, heart market of the electric boat today. However this market remains very important and the evolution of the electric boat towards a market of higher motorization seems possible on average by a R & D today very present.

### 1.2.5 **Leisure segment Prospective**

As for the professional segment, we will give a reminder of the main figures related to yachting while proposing a projection over the next five years with regard to exchanges with industrial, commercial and journalists.

| | Plaisance | | |
|---|---|---|---|
| | Location à l'heure (barque / pédalo) | Bateau pour pêche / balade | Voile |
| En 2019 | 4 000 | 9 000 | 3 000 |
| En 2024 | 5 000 | 15 000 | 5 000 |

Forecast table of the installation of electric boats on the yachting segment.

As it was said previously, the number of electric boats currently operating on French soil :

- 4,000 for rentals per hour or half day (with main actor Ruban Bleu) ;

- 9,000 for fishing and tour boats (with MinnKota as main actor) ;

- 3,000 for sailboats (with Torqeedo as main actor).

The projection was made by talking with these actors but also with other companies like Saviboat for example. The current trend is indeed very clearly sales growth. This will involve an evolution and an improvement of the technologies while continuing the communication in order to reassure the public opinion on the capacities of the electric one to impose itself in the marine environment in the coming years.

# 2 Environment impact

Environmental impact of current thermal engines solutions are critical as rejects happen both in water and in the air.

The main issue being that of old Diesel technologies still in use on boat in service, for more than twenty years, with no treatment of Oxides nor small particles. We will detail reject levels of NOX, CO and CO2 for those solution as well as impact of installed base.

We will also review issues of Gasoline 2 and 4 strokes outboard engines on the leisure market and on small professional ships.

## 2.1 Thermal engines and their impact, regulations.

You are not unaware that the exhaust emissions of ships are without filter and without catalysis, and most often in the water. (Wet exhaust). So these exhausts pollute our cities and our coasts far more than road vehicles and they pollute both the water and the air.

For more than 25 years, the electric propulsion for boats has been a proven solution, industry has been structured, tourist navigation solutions, more than 5,000 vessels in service, and passenger transport, with around fifty daily service vessels proving it. For the moment, the public is very late in using these technologies without the release of greenhouse gases and without other NOX type discharges.

We propose to focus on two types of fleets that would be welcome to switch to all-electric or Hybrid propulsion in some cases.

The fleet of service vessels of the ports and waterways of France as well as the fleet of the transport of passengers or tourists operated by the regions, communes or metropoles.

## 2.2 Environmental Impact of outboard gasoline engines

There are approximately 900 service vessels in the French Maritime and Fluvial marinas (26% of which were built before 1998).

These ships from 3 to 12 m have motorizations from 50 to 200 HP, average motorization of 90 HP, standard of the market.

If we consider that each ship runs 2 hours per day and is equipped on average with a 90 HP engine, running an average of 23 HP, every day of the year, then the rejections can be estimated as follows :

| Env. impact | one 90 HP Motor | On a vessel | On 900 Vessels |
|---|---|---|---|
| | kg/h at 23HP or 17 kW | 2h/ day over 1 yeqr | in tons/year |
| NOX | 0,289 | 202 | 182 |
| CO | 2,295 | 1607 | 1446 |
| CO2 | 6,9 | 4830 | 4347 |

Renewal is about 90 boats per year considering, a service life of 10 years.

Electrical solutions for marinas already exist and can perform exactly the same functions.

However, it would be necessary to :

- facilitate financial access to these electrical solutions,

- promote the installation of fast charging stations in certain strategic ports.

Thus, in less than 10 years, at least 95% of the fleet could be replaced by non-GHG emitting vessels, reducing CO2 emissions by 95%.

## 2.2 Environmental Impact of professional Diesel Vessels

Fleets of passenger ships with 25 to 300 seats in river and sea.

There are approximately 700 passenger transport vessels operating in France for transport or for tourism, including 120 passenger vessels operating either by region, municipality or metropolitan area or by public service delegation.

These ships from 8 to 24 m have thermal engines from 150 kW to 2000 kW.

Passenger or tourist vessels operated by the regions, municipalities or metropolitan areas or by public service delegation.

A) Those of them traveling short distances, smugglers and ferries, and those of them navigating in limited-speed areas inland waterways, ports and protected areas, may switch to all electric.

Take an average motorization at 300 hp.

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| Env. impact | Two 150 kW Motors | On one vessel | on 30 vessels |
|---|---|---|---|
| | kg/h at 80% power | 8h/ day over a year | in tons/year |
| NOX | 2,25 | 6300 | 189 |
| CO | 0,2 | 560 | 16,8 |
| CO2 | 210 | 588000 | 17640 |

The cost of all-electric powered vessels is 30% to 70% higher than the same diesel ships, ie an average cost of 300,000 euros, so the investment to increase to 100% of electric vessels on 30 boats in ten years is 1 million euros a year. The return on investment on these solutions for boats operating 8 hours a day and 300 days a year is less than 5 years, also on ships whose life is 10 years, the operation is largely profitable, moreover it is very profitable for the environment.

B Those navigating in the sea over long distances or at speeds greater than hull speeds, planning navigation, fast or fluvial shipping or lake traffic on large current areas, could switch to Hybrid propulsions, allowing them to navigate without emissions when entering or leaving port and in protected areas. The impact on the environment is important in these cases.

No emissions in harbor or protected areas, which are often much less water, and which concentrate the rejects. Impact for wildlife, flora, water quality and biodiversity are then huge.

In this case the ships can be in all electric on batteries recharged on the network for 2 hours navigation per day thus they avoid to use the engines even to 25% of their power to sail on approach or in the protected zones, the gain for an average ship in this category, ferry of two 700CV engines is important.

Impact also for residents and passengers due to a sound level of 30 to 50 dB in electric navigation, when the thermal solutions are at 70 to 90 dB.

These ships of 100 to 300 passengers have thermal engines of 400 to 2000 kW, they sail commonly 12 to 18h per day. They could be electric 2 hours a day.

Let's take a conservative average at 2 times 600 kW.

A vessel of this type can make the entrances and exits of ports maneuvers and crossings protected areas at 70% of its hull speed, in this case the engines operate at 20% of the power and reject:

| Env. impact | Two 600 kW motors | On one vessel | on 80 vessels |
|---|---|---|---|
| | kg/h at 20% power | 2h/ day over a year | in tons/year |
| NOX | 2,8 | 1960 | 156,8 |
| CO | 0,4 | 280 | 22,4 |
| CO2 | 300 | 210000 | 16800 |

These hybrid propulsion ships have a purchase cost of 30 to 50% over the same diesel propulsion vessels, so to pass the fleet in hybrid in 10 years it would be necessary to invest on a fleet of 80 boats : 8 times 600 000 euros per year or 5 million euros per year.

Conclusion:

With the electric one very serious savings can be made on the costs of the energy as well as on the costs of maintenance, the electric motors not requiring neither polluting emptying nor maintenance.

The return on investment will be accelerated only when electric drive systems are cheaper, which is only possible by economies of scale of production. It is therefore necessary to initiate the democratization of these systems so that they are cheaper than thermal systems.

This reasoning does not take into account the negative externalities implied by thermal systems of course. In fact, it is certainly already profitable to switch to systems without direct CO2 emissions.

So by investing over 10 years:

5 million euros per year to convert the 900 easement boats of the ports of France

6 million euros per year to convert the 100 public passenger transport vessels or those in public service delegation to electrical

We would avoid rejections following ten years:

| Avoided emissions | Over 10 years |
|---|---|
| | in tons |
| NOX | 5279 |
| CO | 14851 |
| CO2 | 387870 |

Saving more than 10 million Energy and Maintenance costs for utilities or transport.

# 3. Challenges and projects

In here we share challenges encountered in the development of this industry.

We will propose following solutions to develop this market faster and reduce in consequence pollutions from boats.

As a result we will also list areas where a no emission navigation should be largely encouraged and for which benefits.

Boats are getting cleaner and cleaner but most diesel engines still in service are still without filters or catalyze, and they reject fumes in water ! So, it is essential to transition faster toward no emissions.

We will present several ship projects that offer good alternatives both in maritime and inland waters.

## 3.1. Challenges

To develop more usage of no emission best ways would be to enforce restricted areas where only no emission is allowed, there are still very few in France.

Plugging in Harbors is progressing very slowly inland as well as coastal.

New norm ISO 16315 developed to secure usage of electric propulsion on boats still need to be enforced.

Still very little help in financing professional boats while detaxation is still in place on diesel.

## 3.2 Progress

Some National parks think of limiting areas for electric navigation only as Cassis National Park as an example.

“Voies Navigables de France “ is financing up to 16 M euros on cleaner boats for inland freight and soon extended to passengers boats via ‘PAMI” 40 % of cost limited at 100k.

Paris financing help 33 % of limited at 9k euros.

ADEME is financing research projects up to 45 % innovative projects 600k to 5M.

Few harbors with plugs, more testing mode i.e. east canal near Strasbourg.

Discussion on moving some part of public fleet to electric propulsion will take place in 2019.

## 3.3 Typical Projects


Aquajet for kids, Autonomy 7 to 10 h at 8 km/h, Easy piloting by kids

**By**


Derby 4.30 & 4.90 with POD, Easy to pilot, Autonomy 7 to 9 h, Speed up to 7-8 km/h by

Electric Service boat for Harbors ZenPro 580, Designed for all key functions, Semi inflatable Aluminum hull, 8 Pax , Fast 25 knots, Long autonomy 15 h, Robust

By NAVIWATT


- Full electric luxury inland House boat, Solar energy

By BOATHOME RETHINKING LIFE ON WATER

Sailing catamaran 51 Foot, Catamaran Hybrid, Autonomy 15 h at 3 knots or 7,5 h at 5 knots

- By

50 passengers plug in hybrid, Recyclable aluminum hull, Hybrid for clean navigation in protected areas, First diesels in France with Catalytic converter, Waterborne painting (Solvent free), LED and solar panels, Noise reduction…

- By

Water taxi on foils, 20 Knots,

By SEABUBBLES

First Hydrogen passengers boat approved, experimented thru 2018, unlimited autonomy

By alternatives energies

## References

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Calculs CO2 : https://www.econologie.com/emissions-co2-litre-carburant-essence-diesel-ou-gpl/

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## Authors

With more than thirty years of experience as Manager and Director in the automotive, personal computers and naval industries, Xavier de Montgros has developed his competencies in global High Tech.

Xavier has led sales, engineering, procurement, supply chains and services operations across the world at Renault, SNR, Hewlett Packard and ODC Marine.

He holds a mechanical engineer degree from ECAM in France, as well as an MBA from IAE in Paris. He is also certified as an International Executive and Mergers and Acquisitions expert from INSEAD in France.

Since 2010, Xavier Joined ODC Marine, as Associate Director, to help develop the passengers boats into renewable energies. ODC Marine has developed a range of electric and hybrid boats for 12 up to 200 passengers using the Lithium batteries and permanent magnet motors. These boats have been in successful operations since.

He has been president of AFBE since 2014.

AFBE
ASSOCIATION FRANCAISE POUR LE BATEAU ELECTRIQUE

The French Association for Electric Boat, was created in 1994 to develop the electric boat market in France. Our members are : ◦ Boats builders, ◦ Solutions providers, ◦ Equipment manufacturers, ◦ Engineering companies, ◦ Operators and users, local authorities.

Our objectives are : To promote the design, construction and use of electrical boats, to Insure safety and competitiveness and to Get national support for this market. We also encourage operators and communities and Promote exchanges within the organizations and Establish relationships with counterpart foreign associations.

Our activities include : Participation in nautical events, conferences, information website and newsletters, market research, being a privileged interlocutor of authorities, Lobbying to get financial or regulation support, Participation in the work of norms, regulations or financing mechanism, Promoting recharge points, exchanges within the community.