

ELECTRIFICATION OF LEISURE BOATS AND INFRASTRUCTURE

The international Arena



PERISCOPE

Interreg
North Sea Region

European Regional Development Fund



EUROPEAN UNION



BUSINESS REGION
GÖTEBORG

wsp

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1 INTRODUCTION

1.1 BACKGROUND

This study is performed in cooperation with Business Region Gothenburg (BRG) and the EU project Periscope (Platform for Expanding Regional Innovation SCOPE for blue growth). BRG has been part of Periscope since 2017 and has been in collaboration with 12 different stakeholders from six countries (Norway, Denmark, Germany, Great Britain and The Netherlands). This collaboration revolves around innovations in the blue economy of the North Sea, which aims to support and drive the ecosystem for an expanded transregional maritime cooperation as well as contribute to increased research and business opportunities within the region.

In parallel with the aforementioned EU project, another study is conducted where the needs and possibilities of the city of Gothenburg regarding the electrification of leisure boats and associated charging infrastructure is investigated. This study is named *Omställning till elektrifiering inom området fritidsbåtar* and is conducted by Ramböll in 2021 on behalf of Business Region Gothenburg, Grefab and Göteborg Energi.

1.2 AIM

The aim of this study is to map how cities and regions in Europe, primarily outside Sweden, view and relate to the developments within the field of electrification of leisure boats. The global developments in the field will also be considered in the study. Furthermore, the study will highlight which topics different stakeholders could collaborate on when it comes to enabling sustainable development for leisure boats and leisure marinas in Europe.

The results of the study will support strategic decisions that relates to the current readjustment that is happening in the field of leisure boat electrification in the region of Gothenburg as well as in Europe. The study will act as strategic basis for upcoming blue growth grants and fund application procedures on regional, national or the EU level.

1.3 DELIMITATIONS

The study will only cover the electrification of leisure boats and how it relates to sustainable development. Other aspects regarding the development of leisure boats and leisure marinas when it comes to sustainable development will not be covered in this study.

The study will not cover the needs and possibilities of the city of Gothenburg, since this is covered in the study *Omställning till elektrifiering inom området fritidsbåtar* as mentioned above.

1.4 INTENDED AUDIENCE

The study will be used in conjunction with BRG's mission to coordinate the city of Gothenburg's conversion to a transport system based on electricity, with a European outlook based on opportunities and needs of the conversation. The study will also be used and shared in the Periscope network for increased collaboration in the North Sea region 2021.

1.5 STUDY APPROACH

The study will be performed as a literature review, interviews with relevant stakeholders and an international workshop to get a basis for a future scenario regarding how the developments in Europe may look like in comparison to Sweden.

2 THE EUROPEAN MARKET FOR LEISURE BOATS

2.1 WHAT IS AN ELECTRIC LEISURE BOAT?

According to the directive for leisure boats, *the recreational crafting directive (2013/53/EU)* (EU official paper, 2013) a leisure boat is defined as a boat used for recreational activities, with the condition that the boat must be shorter than 24 meters long. If the boat is longer than 24 meters, it is considered a ship and not a leisure boat. Furthermore, recreational activities in this case means that the boat cannot be used in for any commercial purpose, business activity or in government service. In practice, this means that you cannot receive money of any kind related to the leisure boat. An electrical leisure boat is in this case a leisure boat that is either fully or partly driven by electricity.

A leisure boat is defined as:

- Used for recreational activities
- Shorter than 24 meters long
- The boat cannot be used in for any commercial purpose, business activity or in government service.
- An electrical leisure boat is either fully or partly driven by electricity

2.2 EMISSION REGULATIONS THAT AFFECT LEISURE BOATS

The EU and the UN have several regulations and directives that are applied to ships. Examples of these include SECA (Sulfur Oxides Emission Control Area) and NECA (Nitrogen Oxides Emission Control Area). SECA regulate the sulfur content of marine fuels while NECA limit values for emissions of nitrogen oxides in certain areas. However, as earlier mentioned, these do not include leisure boats who instead have their own set of directives and rules to comply with.

Recreational craft directive

At the end of 2013, the EU presented a directive called 2013/53 / EU (the recreational craft directive), which was specifically aimed to leisure boats and jet skis. The new directive then replaced its predecessor from 2009 and was introduced in 2016. The directive contains a broad arsenal of rules and requirements that include both limit values for emissions of various gases and requirements for noise levels from leisure boats. The directive regulates emissions of carbon monoxide, nitrogen oxides and hydrocarbons and the permitted levels, stated in g / kWh, depend on the engine's power as well as its type. For example, a two-stroke engine with an output of less than 375 kW cannot emit more than 75 grams of carbon monoxide per kWh. It is also mentioned that the EU may modify the rules for emissions as technology develops. Finally, the directive also provides guidelines for the prevention of unintentional discharges of polluted substances, such as oil and fuel, as well as other waste. This directive will be updated in the coming years with new information and regulation. What the updated directive entails and what the ramifications of the directive will be is currently unknown. However, it is good to know there will be updates to the directive, such as the inclusion of fossil-free boating and stronger emission regulation.

European Commission report on electrification of the transport system

The European Commission published a report in 2017 on the Electrification of the transport system to meet the EU goals of a decarbonized society. The report states (among other things) that the electrification of boats relies on the developments in other sectors, such as road vehicles and industry. Developments in battery technology is for instance being driven heavily by the automotive sector. Several milestones for the electrification of the transport sector have been identified in the report, which can be explored in Table 1.

Table 1: Milestones and targets for the electrification of small vessels in the EU.

Milestone	2025	2035	2050
Small vessels	Quantify the emission from small boats across the EU and globally.	All the small boats within Europe meets the emission standard that are applicable to inland vessels within the non-road mobile machinery regulations.	There are no boats left that uses diesel engines.
	Prioritize action required for small boats to meet the emissions standard that are applicable to non-road mobile machinery.	Boats with an electric or fuel cell propulsion system represent at least 25% of the small boat market in Europe.	The European emissions standards for small boats are increasingly adopted globally, with more than 50% of all small boats worldwide meeting the European emission standards.
	Increasing number of sold electrically propelled boats.		

2.3 MARKET SIZE FOR LEISURE BOATS

Leisure boating is ingrained in the northern European culture, with many households owning a leisure boat. In the North Sea Region, the total number of leisure boats amount to at least 3.3 million boats. This includes the countries of Sweden, Norway, Denmark, The Netherlands, Germany as well as the entire UK. The total number of leisure boats in each of these countries are presented in Table 2. More details on the type of leisure boats and engine types in Sweden can be seen in the parallel project performed by BRG as mentioned earlier (Ramböll, 2021).

Table 2: Number of leisure boats in the different countries in the North Sea Region.

Country	Amount of leisure boats
Sweden	756 000 ¹
Norway	948 000 ²
UK	541 100 ³
Denmark	57 000 ⁴
Germany	500 000 ⁵
The Netherlands	500 000 ⁶
Total	3 302 100

2.4 MARKET SIZE FOR ELECTRICAL BOATS

In the year 2019 the global market for electrical boats was estimated to be valued at 6.45\$ billion, and the market is expected to grow at a CAGR (compound annual growth rate) of 11.2% from the year 2020 to the year 2027. The final year being 14.64\$ billion.

The market for electrical boats is still in its introduction stage, and therefore it has the potential to achieve enormous growth in the forecast period. Rising need for reduction of carbon footprints, the reduction of noise as well as lower fuel wastage are also key aspects as to why this market is thriving. Electrical boats is in this case all types of waterborne vessels that are semi or fully propelled by electricity.

¹ (Transportstyrelsen, 2021)

² (Norboat, 2021)

³ (Statista, 2021)

⁴ (Miljøministeriet, 2014)

⁵ (Deutscher Motoryachtverband e.V., 2015)

⁶ (Waterrecreatie Advies, 2021)

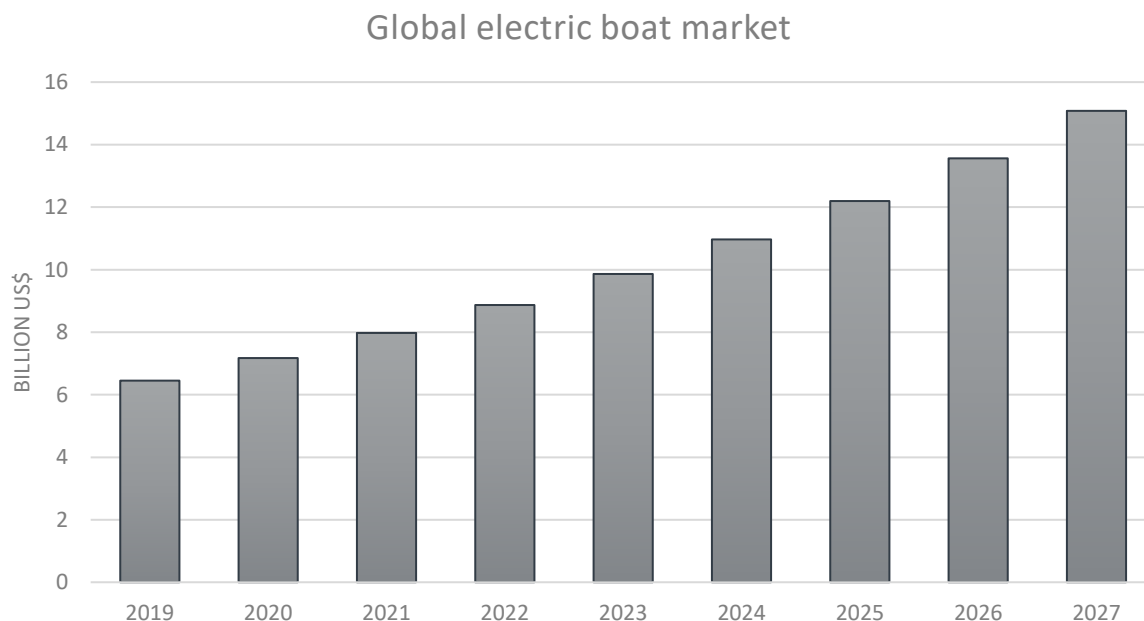


Figure 1: Forecasted global electric boat market, from the year 2019 to 2027.

The market for electric boats is dominated by the hybrid segment, with a market share of 81,3% in the year of 2019. The reason for this is the various advantages that a hybrid vessel has over the fully electrical one. For instance, a hybrid vessel is considered more reliable, and a hybrid vessel also has the possibility for supplementary propulsion system at higher speeds. This leads to hybrid vessel being able to travel larger distances before needing to refuel and recharge. The segment for hybrid vessels is expected to continue this dominance throughout the forecasted period, with fully electrical vessels not overtaking it anytime soon.

When it comes to vessel type, commercial electric vessel accounted for the largest market share of 77.1% in the year 2019. Commercial vessels include: Passenger Cruise, Bulk Carrier & Container Ships as well as Tankers. Other vessel types that are considered are Defense vessels and Special vessels.

Regionally, the largest share of the global market for electricity boats belongs to Europe which accounted for 34.9% of the total market in 2019. Europe is anticipated to witness considerable growth in the forecasted period, with Germany being a significant contributor to this growth. The growth in Germany can be attributed to the increase in environmental awareness, along with government initiatives to promote electrically operated transportation modes. Furthermore, the growing interest in electrical recreational vessels in marine tourism and fishing activities in Europe is expected to propel the regional market growth (Market Analysis Report, 2020).

The forecasted market for specifically electrical leisure boat is not as defined as the forecasted market for the overall segment of electrical boats. Several participants of this study such as X-shore, Vita yachts and Candela speedboats have all highlighted that the market for electrical leisure boating is currently in its infancy stage. The typical customer is also said to be more of a technology enthusiast that care about the environment rather than the usual motorboater. However, according to the manufacturers this market will grow a lot in the coming years. For example, Vita yachts forecasts that there will be 1 million electrical leisure boats by 2030, which is accelerated by regulation and the fact that more and more areas will only be accessible by fossil-free boats.



Europe accounts for almost 35 % of the total market for electric boats in 2019 and the growth is expected to be significant, with Germany as the greatest contributor. The growing interest in electrical leisure boats in marine tourism and fishing activities in Europe is expected to propel the regional market growth, but the specific market growth for leisure boats is not defined in existing literature. However, manufacturers of electrical boats believe that there will be a significant growth in users of electrical leisure boats, with 1 million electrical leisure boats globally by the year 2030.

2.5 PORTS AND INFRASTRUCTURE FOR LEISURE BOATS

As mentioned in the in the parallel project performed by BRG (Ramböll, 2021), ports for leisure boats are smaller ports made to accommodate and offer service for leisure boats. Leisure boat ports' purpose varies between offering service mostly to boat owners living in the area (home ports), offering service for guests traveling by boat or only being an excursion port with less need to offer services. What kinds of service these different leisure boat ports are supposed to offer varies a lot, from just mooring of leisure boats to water, fuel, electricity, waste and sewage disposal, showers and stores etc. More details on the historical electricity demand in marinas in Sweden, and the future need for marinas with an increased amount of electric leisure boats can be read in the in the parallel project performed by BRG (Ramböll, 2021).

In Europe there are an estimate of 36 million boaters that enjoy boating with over six million boats that are kept in about 10 000 marinas (European Boating Industry, 2020). With the expected growth of the electric leisure boat market Europe's 10 000 marinas will sooner or later be faced with the demand for accommodation of electric boats, mainly being the possibility to charge the boats. Since the market is so young, unknown and scattered the demand today is very small and the amount of information on leisure boat ports in relation to electric leisure boating is very limited. However, there are some examples, throughout Europe, of ports and countries that has begun adapting to electric leisure boats. Further down we will be presenting Norway as a guiding example. There are a few additional examples of countries and cities in Europe with initiatives for charging infrastructure for boats that can be seen in section 4.

Ports in Norway

Norway is one of the countries that has come the farthest in beginning to electrify their leisure boat life, with many projects and initiatives taken by cities, municipalities and companies along the Norwegian coastline. A contributing factor has been the government's funding of innovation and sustainability initiatives. They realized that in Norway, a motor-driven leisure boat on average emitted one ton of CO₂ per year - which would make every electrified leisure boat reduce the emissions with the same amount.⁷ Therefore, Norway has set out to build the charging infrastructure electric leisure boats need, starting in the south of Norway where the boat life is wide-spread. At the end of 2019 Norway had 21 public charging facilities specific for electric boats, but that excludes individual ports' private initiatives. Arendal and Agder are two municipalities investing in home ports' over-night charging options and they also see possibilities of installing fast charging facilities in the bigger ports. More on Norwegian initiatives can be read about in section 4.2.

⁷ Arendal application to Klimasats

3 THE EUROPEAN ECO SYSTEM FOR INNOVATION

The European Green Deal is the European Commission's (EC) and Europe's overarching sustainable action plan towards a climate neutral Europe 2050. The European Green Deal and initiatives taken by the Commission are in focus for this chapter and presented in section 3.1. Alongside these initiatives there are a few other programs and initiatives relevant for this project presented in this chapter, in section 3.2.

3.1 THE EUROPEAN GREEN DEAL

"The European Green Deal is our new growth strategy. It will help us cut emissions while creating jobs." - Ursula von der Leyen, President of the European Commission.

The European Green Deal was presented in late 2019 as the EU's overarching plan to make the EU economy sustainable. It provides an action plan to boost the efficient use of resources by moving to a clean, circular economy, whilst also restoring biodiversity and reducing pollution. Within this action plan, there are different strategies, specific plans and proposed regulatory actions. Furthermore, the European Green Deal outlines what type of investments are needed as well as the available financing tools. EU aims to be climate neutral by the year 2050, and to reach the target of climate neutrality, action is needed from all sectors of the EU economy (European Commission, 2021). Figure 2 illustrates the various elements of the European Green Deal where green boxes are policies.

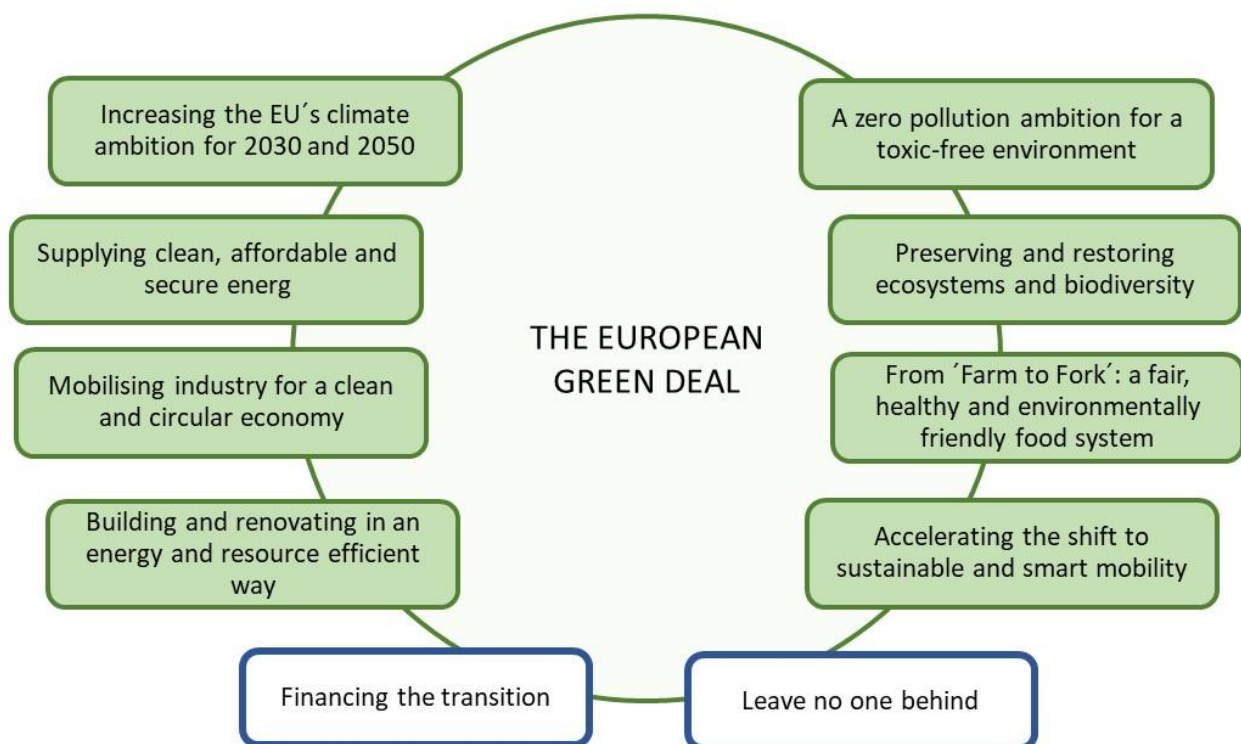


Figure 2: The various elements of the European Green Deal. Green boxes are policies (European Commission, 2019). Illustrated by WSP.

3.1.1 Financing

As seen in one of the blue boxes in Figure 2 financing the transition is included in the The European Green Deal. As a part of the European Green Deal, The EU presented the **Sustainable Europe Investment Plan**, which will mobilize at least 1 trillion EUR of sustainable investments over the next decade. Of the total 1 trillion EUR, 279 billion will go to climate and environmentally related investments. A substantial part of these investments aims to reduce the environmental impact of transportation, of which electrification is a key aspect. When it comes to the electrification of the maritime industry, supplying docked freight vessel and large ships with shore-side electricity as well as the electrification of the larger freight vessels can be considered as focus-areas of the investment plan (European Commission, 2020). However, this does not mean that projects related to the electrification of leisure boats are neglected by the EU. The electrification of leisure boats and associated charging infrastructure is certainly related to the availability of shore-side electricity, which as mentioned is a focal point of the investment plan. It can therefore be expected that projects related to the electrification of leisure boats, development of charging infrastructure in ports and similar activities has the possibility to receive EU funding.



Shore-side electricity is mentioned as a focal point of the Sustainable Europe Investment Plan presented by the EU as a part of the European Green Deal. It can therefore be expected that projects related to the electrification of leisure boats, development of charging infrastructure in ports and similar activities has the possibility to receive EU funding.

3.1.2 Research and innovation program: Horizon Europe

Research and innovation mentioned as “Mobilising research and fostering innovation” in Figure 2 are a fundamental pillar of the European Green Deal. Horizon Europe is the next EU Research & Innovation program succeeding Horizon 2020, which was the biggest EU Research & Innovation program between 2014-2020. For a list of projects related to the electrification of leisure boats that has received EU funding within Horizon 2020, see appendix 1.

The EU institutions have reached a partial political agreement, subject to formal approval by the European Parliament and Council, on Horizon Europe. This means that the exact contents of the programme have yet to be finalized, but as of right now the timespan of Horizon Europe is the year 2021 to 2027, and the Commission's proposal for the programme's budget is €100 billion (European Commission, 2021).

The structure of Horizon Europe is influenced by lessons learned from the Horizon 2020, where key novelties such as Research & Innovation Missions included in the new programme has been developed because of the evaluation. These missions will constitute an important part of Horizon Europe with the aim to relate the research and innovation better to society and citizens' needs. The missions are separated into five mission areas and each mission will have a mission board. The fourth and fifth mission of the five missions presented below is most relevant for this project (European Commission, 2019).

1. Adaptation to climate change, including societal transformation
2. Cancer
3. Soil health and food
4. **Climate-neutral and smart cities**
5. **Healthy oceans, seas, coastal and inland waters**

EC Hydrogen Strategy

Within the fourth Research & Innovation Mission: *Climate-neutral and smart cities* a **European Commission (EC) Hydrogen Strategy** was proposed in 2020, laying the foundation for a climate-neutral energy system. Today, 96 % of all hydrogen used is produced through natural gas, however hydrogen can be produced from renewable energy in electrolyzers that split water into oxygen and hydrogen. This renewable hydrogen is the one expected to play a key role in the decarbonization in EU, and the priority of the Hydrogen Strategy is to develop clean, renewable hydrogen

produced using mainly wind and solar energy (European Commission, 2020). In July 2020, the Commission presented investments of 430 thousand million euros until 2030 to make hydrogen part of our future energy mix (Vätgas Sverige, 2020). The hydrogen strategy roadmap to 2050 is illustrated in Figure 3. The application areas for hydrogen can roughly be summarized as a) heavy duty transport, b) industry and c) renewable integration such as power generation from hydrogen and flexible power generation from hydrogen.

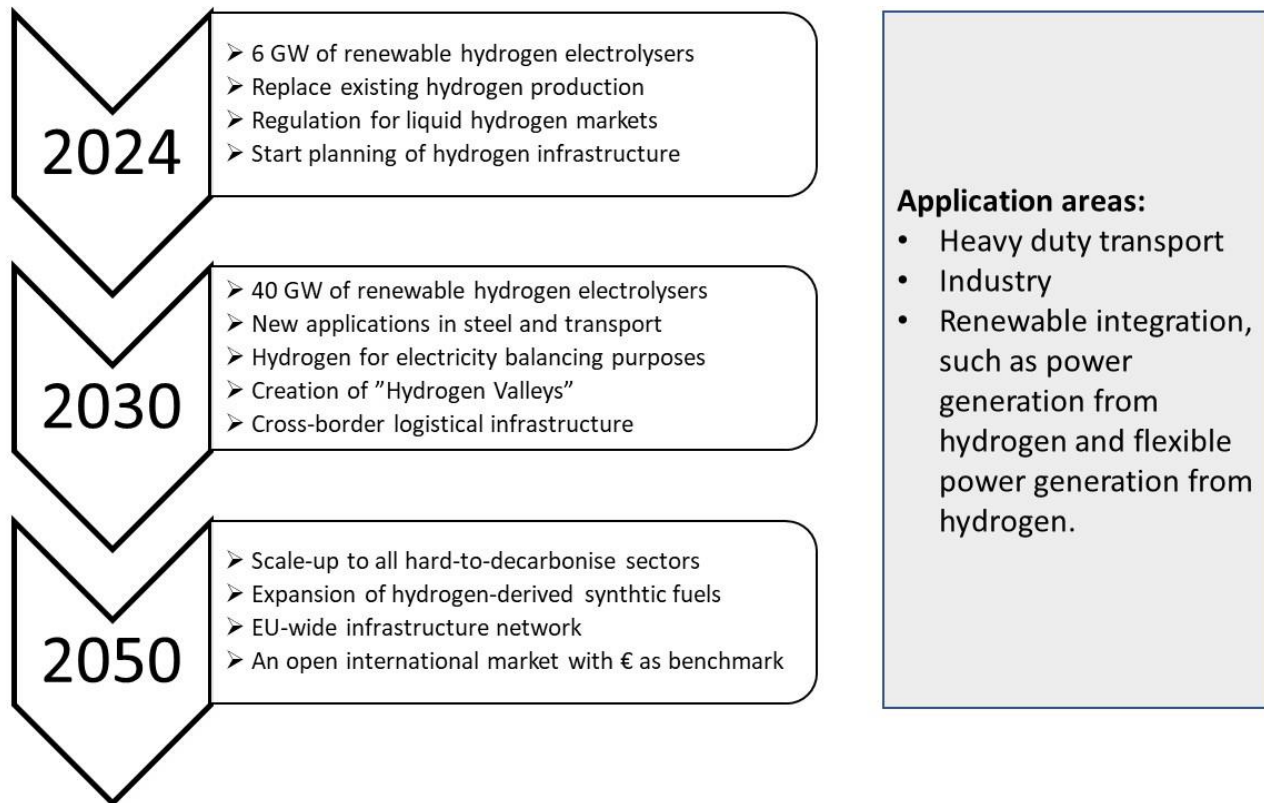


Figure 3: The EC Hydrogen Strategy roadmap to 2050 (Swedish Energy Agency Forum on Global Energy, 2020). Illustrated by WSP.



The EC Hydrogen Strategy is a result of the European Green Deal. Hydrogen can contribute to the phase out of fossil fuels and for example provide energy to sectors and applications that are not suitable for electrification.

Mission Starfish 2030: Restore our Ocean and Waters

The Mission Board on the fifth Research & Innovation Mission: *Healthy oceans, seas, coastal and inland waters* have proposed the **Mission Starfish 2030: Restore our Ocean and Waters**.

The purpose of the Mission Starfish 2030 mission is to reduce the negative anthropogenic impacts such as pollution, eutrophication, leakage of contaminants, marine litter and underwater noise on Europe's oceans and waters. Starfish 2030 consists of five overarching objectives with different focus areas (European Commission, 2020). The objective that is relevant for this study is objective 4: *decarbonizing our ocean, and waters*.

This objective contains several focus areas, two of which are *Climate-neutral waterborne transport* as well as *Climate-neutral blue tourism* (European Commission, 2020). An overview of the focus areas with 2025 checkpoints and 2030 targets can be found in Table 3.

Table 3: Focus areas and targets in objective No 4 in the Mission Starfish 2030, relevant for electrical leisure boats.

Objective No in Starfish 2030	Focus Area	2025 checkpoint	2030 target
No 4: Decarbonizing our ocean and waters	Climate-neutral waterborne transport	50% of propulsion engines of leisure boats, are converted to non-fossil propulsion. 30% of European ports are carbon-neutral and provide electricity at berth.	100% of propulsion engines of leisure boats, are converted to non-fossil propulsion. 100% of European ports are carbon-neutral and provide electricity at berth.
	Climate-neutral blue tourism	Blue belts of green transport infrastructures for connection of coastal areas through EU waterways are designated and funded	100 percent of marinas are carbon neutral and provide electricity at berth 50% of tourism resorts and accommodation are converted to low CO ₂ emission and low CO ₂ consumption.

To substantiate these objectives and targets, Starfish 2030 has proposed a supporting action plan which contains several recommendations and strategic ideas as to how these objectives can be met. It is argued that the action plan should be composed of financing from the Next Generation EU package, with new legislation, coordination at EU level as well as strong involvement of local and regional authorities. Examples of this is a new Green port strategy and a new EU Green Shipping Strategy.

However, it is important to note that Starfish 2030 is a proposed mission that is currently being reviewed by the EU. The full extent as to how this mission will be implemented and what it will constitute is therefore not finalized. The focus areas, strategies as well as the checkpoints referred to above are all therefore not to be taken as future policy, as they may or may not be part of the final version of the mission.



Starfish 2030 will be an important Research & Innovation mission for electrical leisure boating. The mission highlights the importance of reduced anthropogenic impacts, in different areas such as pollution, contamination and eutrophication. Furthermore, it proposes different checkpoints and targets for leisure boats such as 100% of propulsion engines of leisure boats, are converted to non-fossil propulsion by 2030. However, it is a proposed mission and is currently being reviewed by the EU.

Sustainable Blue Economy Strategy

The European Commission published in 2020 a Blue Economy Report that states that the EU blue economy is in good health and that blue sectors contribute to the recovery and pave way for the EU Green Deal (European Commission, 2020). In the report the EC announce that the European Green Deal will underpin a brand new Sustainable Blue Economy Strategy that is expected to be initialized in 2021. This strategy adds to the currently existing Blue growth strategy, which aims to support sustainable growth in the marine and maritime sectors as a whole (European Commission, 2020).

3.2 OTHER PROGRAMS AND INITIATIVES

3.2.1 Interreg

Interreg Europe, funded by the European Regional Development Fund, helps regional and local governments across Europe to develop and deliver better policy. They exist to assist public authorities, managing authorities/ intermediate bodies as well as agencies, research institutes, thematic and non-profit organizations. Organizations working with Interreg Europe must be based in one of the 27 EU Member States, Norway, Switzerland or the United Kingdom. To gain financial support actions must fall into one of the following categories; research and innovation, SME (small and medium-sized enterprises) competitiveness, low carbon economy or environment and resource efficiency.

Interreg North Sea Region (NSR) are funding projects for the North Sea Region, and the projects often deliver pilots and trials providing the evidence base for further uptake.

Periscope is a project co-founded by the North Sea Region (NSR) programme 2014-2020 and aims to support Interreg North Sea's objectives, for example by strengthening cross-sector Blue Growth innovation capacity in the NSR by bringing together the market players for knowledge sharing, acceleration and launch of new innovation-projects for sustainable business development (Interreg North Sea Region, 2021). This study is performed in cooperation with BRG and Periscope.

3.2.2 European Boating Industry

The European Boating Industry (EBI) is made up of national associations representing the recreational boating industry in European countries. This includes boatbuilders and engine manufacturers, as well as manufacturers of equipment and other companies with services within the industry (maintenance, dealers, importers, rentals etc.). The EBI defends and promotes the interests of its members on key issues ranging from Single Market legislation to blue growth, tourism and trade policy by participating in several EU-funded projects (European Boating Industry, 2020).

3.2.3 Waterborne technology platform

Waterborne is the European research and innovation platform for waterborne industries. It has been set up as an industry focuses Technology Platform which aims to institute a dialogue between all waterborne stakeholders. These stakeholders are classification societies, shipbuilders, shipowners, maritime equipment manufacturers, infrastructure and service providers, universities, research institutes and with EU Institutions including Member States (Waterborne, 2020).

The strategic objectives of the Waterborne Technology Platform are as follows:

- Establish a continuous dialogue between all stakeholders in the waterborne transport sector and in other waterborne-related sectors on R&D;
- Contribute to the widest possible consensus regarding R&D and to focusing of efforts and resources;
- Develop a common medium- and long-term R&D Vision and a Strategic Research Agenda (SRA);
- Contribute to the appropriate mobilization and allocation of the necessary financial resources (private/regional/national/EU sources);
- Contribute to the social expectations regarding clean, competitive and safe waterborne transport as well as regarding other waterborne-related activities, including education and training.

To reach the strategic objectives, it is important to engage all relevant stakeholder of the European Maritime Industry. Members of the Waterborne Technology platform are classified as either Research members, Industrial members, Academic members, Member associations or Observers. The following table gives an overview of some of the member organization of the Waterborne Technology Platform.

Table 4: A sample of membership organizations currently part of the Waterborne Technology Platform (Waterborne, 2020)

Organization	Classification	Country
Delft University of Technology	Academic	The Netherlands
University of Southern Denmark	Academic	Denmark
Aalto University	Academic	Finland
Danish Maritime	Association	Denmark
ECMAR	Association	Europe
German Maritime Centre	Association	Germany
ABB	Industrial	Sweden
European IWT Platform	Industrial	Europe
Kongsberg Maritime	Industrial	Norway
SSPA	Research	Sweden
MARIN	Research	The Netherlands
RISE	Research	Sweden
European Commission	Observer	Europe
Swedish Maritime Administration	Observer	Sweden
EFIB	Observer	The Netherlands

The Waterborne Technology platform is a cluster for innovation in the maritime industry. A focal point for the R&I in the maritime sector currently is the electrification of larger shipping vessels and the subsequent development of charging infrastructure in European ports. Although the larger shipping vessels might be the focus of the Waterborne Technology Platform, electrification of leisure boats is also part of the strategic agenda. Many technologies developed for cruise vessels, shipping vessels and larger ferries can be applied to the newest leisure boats, and on the other hand, leisure boats will be used as test beds for larger vessels. Waterborne also argues that EU increasing wealth around the world will lead to larger middle class with more disposable income to spend on goods, services and leisure activities. The EU should retain its current lead in the design, build and operation of cruise vessels, and the recreational Maritime sector will lead the world with innovative craft responding to ever increasing customer expectations (Waterborne, MESA, 2020). This further shows Waterborne and perhaps EU's focus on the shipping industry, whilst it considers the development of leisure boats to primarily be driven by market forces.



*Although the larger shipping vessels might be the focus of the Waterborne Technology Platform, electrification of leisure boats is also part of the strategic agenda. Many technologies developed for cruise vessels, shipping vessels and larger ferries can be applied to the newest leisure boats, and on the other hand, leisure boats will be used as test beds for larger vessels. **Waterborne focus on the shipping industry, whilst it considers the development of leisure boats to primarily be driven by market forces.***

4 THE INTERNATIONAL ARENA: A SELECTION OF MARKET PLAYERS

This section is a European outlook of market players in different European countries in the field of electrification of leisure boats and its marinas. These market players are either ports, boat manufactures, companies with charging infrastructure, municipalities with initiatives in the field or organizations. In Table 5 a selection of market players in Europe are summarized. In the following sectors these market players are presented further for each country, those on EU-level is previously presented in chapter 3. There are, exempt the initiatives taken these market players, a list of other market players (companies, ports or municipalities) with current initiatives of interest to be seen in appendix 2.

Table 5. A selection of market players in Europe for the electrification of leisure boats. Read more in Appendix 2.

	Market player	Type
Europe	European Boating Industry (EBI)	Represent the recreational boating industry in Europe. See section 3.2.2.
	Interreg	Interreg helps regional and local governments across Europe to develop and deliver better policy. See section 3.2.1
Sweden	Candela	Electric speedboat company
	X-shore	Electric speedboat company
	Orust E-boats	Electric speedboat company
	Greenstar Marine	Electric propulsion company
Norway	Arendal, Agder County	Municipality
	Vestland County	County
	Norsk Elbåtförening	Organization
	Evoy	Electric propulsion company
	Green Waves	Electric speedboat and propulsion company
	Kruser	Boat sharing platform
Denmark	Rand Boats	Electric speedboat company
Germany	Torqueedo	Electrical engine company
	Aentron	Battery solution company
The Netherlands	Amsterdam	Municipality
	Port of Amsterdam	Port
Great Britain	Vita Yachts	Electrical speedboat company
	Electric Boat Association	Organization

4.1 SWEDEN

According to stakeholders operating in Sweden, the country does not have any state or regional policy that aims to specifically support the electrification of leisure craft. However, Sweden does have an ambitious long-term climate goal to have net zero emissions by 2045. Furthermore, the Swedish government plans to speed up the electrification of the transport sector to reach these climate goals with includes projects for electricity roads, infrastructure for charging and an establishment of an electrification commission. The commission will, until 31th of December 2022, for example investigate possible business models and how electrification via hydrogen operation can contribute to an electrification of the transport sector and how the electrification of the transport sector might affect the electricity supply (Regeringen, 2020). Electrification of shipping and vessels are not mentioned.

Tabell 1: A selection of market players in Sweden. Read more in Appendix 2.

Market player	Type of initiative
Candela	Electrical speedboat company with a 7.9-meter-long hydrofoiling electric boat with a motor from Torqeedo. The battery from BMW has a capacity of 40 kWh, with a range of 50 nautical miles at the speed of 20 knots. Candela have partnered with the energy supplier Nordsol Energi for a charging infrastructure in the Stockholm archipelago.
X Shore	Electric speedboat company with an 8-meter-long boat with conventional planning hull that is equipped with a 120-kWh battery, with a range of 35 nautical miles at the speed of 20-24 knots.
Orust E-boats	Electric speedboat company with a new electric boat not yet on the market. The boat is 7-meter-long with a maximum speed of 12-15 knots. With a speed of 5 knots the range is 200 nautical miles. The battery suppliers are not yet revealed but the battery comes in two sized; 20 and 40 kWh.
Greenstar Marine	Electric propulsion company with a whole propulsion system for inboard sailboats, from propellers to the electric motor and battery packs.

4.1.1 Electrical speedboat companies

Candela

Candela is an electrical speedboat company, founded in 2014 and based in Stockholm, that has come up with a solution to electric boats' range and battery capacity problem, that originates from the fact that gasoline compared to batteries contains 15 times more usable energy per kg. Candela's solution is their first, and so far, only, boat model (called Candela Seven) which is a 7.9-meter-long hydrofoiling electric boat. The meaning of hydrofoiling is that the boat has a 1.2-meter-long retractable foil that when extended thanks to aerodynamics lifts the whole boat of the surface of the water, which frees the hull from all the water-resistance. This results in that the Candela Seven uses 80% less energy compared to a gasoline driven normal boat of the same size. The foils are in use at speeds from 16 knots to the maximum speed of 30 knots. At 20 knots the boat has a range of 50 nautical miles, which is long compared to other electric boats with bigger battery capacities. Since the boat is so power-efficient (even at high speeds) there is no need for a big battery pack, Candela Seven goes by with a capacity of 40 kWh. Candela produces the whole boat themselves in Lidingö, Stockholm, their motor is from Torqeedo and the lithium-ion battery is from BMW. In November 2020 Candela had delivered 18 boats worldwide (Candela, 2020).

X Shore

X Shore is an electric boat manufacturer that was founded in 1996 and is based in Stockholm, just like Candela. Today they offer one model called Eelex 8000 that is equipped with a 120-kWh lithium-ion battery pack and an electrical inboard motor, giving it a top speed of 35 knots and a range of 35 nautical miles at 20-24 knots. The Eelex 8000 is 8 meters long, has a conventional planning hull and it is designed for a functional boating life, with open spaces and a steering wheel with sunroof in the middle (X shore, 2020).

Orust E-boats

Orust E-boats goal is to supplement Orust and Swedens leisure boat production with both new electric boats/working boats and ferries with energy efficient and environmentally friendly propulsion without harmful emissions. Their preliminary study aims to evaluate battery selection, propulsion systems and fast charging to create a basis for a project where electrified boats can be tested under real conditions in the Orust western archipelago. Their partners include SeaDrive AS, Northvolt, Combitech, Coriolis Utveckling (Orust e-boats, 2020).

In May 2019 Orust E-boats presented Strana, an electric motorboat developed and manufactured in Sweden. Strana is though not out on the market yet. During the summer 2020 Strana was shown in different cities in Sweden and its technology has been refined since. Strana is now one step closer to entering the market. The boat is 7-meter-long and 2.25-meter-wide and has a maximum speed of 12-15 knots. The team behind Strana will not yet reveal who supplies the batteries that comes in two sizes, 20 and 40 kWh. With a speed of 5 knots Stranas range is 200 nautical miles (Strana, 2021).

4.1.2 Charging infrastructure in the Stockholm archipelago

Candela partner with Nordsol

Recently, Candela has partnered with solar energy supplier Nordsol Energi to install and develop charging stations for electrical leisure boats at several key areas in the Stockholm archipelago. The sea stations that will receive the charging stations are Strömma, Saltsjöbaden, Sandhamn, Fjäderholmerna and Utö guest port. The first installations in the aforementioned sea stations will start by early spring 2021.



Figure 4: A Candela electric boat docking at Fjäderholmerna sea station to recharge the battery.

According to Candela, the reason for this development is to aid the transition from fossil-fueled boats to electrical fossil-free boats. This project will make it possible to travel anywhere in the Stockholm archipelago with an electric boat, which previously have not been possible or very difficult. This is because of inherent problems associated with electric propulsion, such as short battery ranges and lack of charging infrastructure. However, it has been possible to get access to electricity at some sea stations but those have been few and has required a permission beforehand. Furthermore, Nordsol, who are experts at solar cells in the archipelago, will in the future integrate their expertise with Candelas' to develop charging stations where there is no electricity supply currently.

The charging stations will be free of charge, but only owners of Candela speedboats get to use them initially. However, the goal is for all electrical boats to be able to use them in the future. Moreover, it is argued that the more expensive fast-charging is not needed for the current electrical boats, as the users behavioral pattern suggest that most time is spent ashore at smaller guest port or an island. This means that guest ports, sea stations and others that want to be part of this charging infrastructure development does not need to contribute with any substantial investment (Elfordon, 2020). Electric propulsion system for sailboats

Greenstar Marine

Greenstar Marine is an electric propulsion company that was founded in 2010, but with history tracing back to the 90's. The company manufactures solutions for converting sailboats with inboard motors to electric. Their solution

includes the whole propulsion system, from propellers to the electric motor and battery packs. Greenstar Marines' system is technically advanced, for example they use their own patented solution for regeneration of energy during sailing. The regeneration system produces energy, that charges the batteries, thanks to a foldable propeller. During normal sailing the propeller is folded which lowers the boat's water resistance and enhances the speed, however during regeneration the propeller is left unfolded which forces it to spin due to the water current from the boat's movement. In return the spinning of the propeller creates a current that charges the batteries. Greenstar Marine offers both lead and lithium battery, the latter being the more efficient and modern option. They also offer two different electric propulsion systems, the reason being that there are two common types of inboard motors in sailboats. Therefore, the company is flexible and has an option for most costumers, especially since they adapt their solution after every boat's unique features. However, currently Greenstar Marine is a small company, since they have had 250 customers in total, that mostly works with prestigious yards all over the world. With that in mind this company might not be the solution for the ordinary leisure boat owner (Green Star Marine, 2021).

4.2 NORWAY

Norway is one of the countries that has come the farthest in beginning to electrify their leisure boat life, with many projects and initiatives taken by cities, municipalities and companies along the Norwegian coastline. A contributing factor has been the governments funding of innovation and sustainability initiatives (Miljødirektoratet, 2019).

One climate initiative governed by the environmental agency of Norway is *Klimasats*. Norwegian municipalities can apply to receive funding from Klimasats for projects that aim to reduce greenhouse gas emissions and contribute to the transition to a low-emission society. The government of Norway has proposed a budget of 100 million NOK for the fund in 2021. In addition to the 100 million NOK, there is an additional NOK 80 million that is specifically aimed at initiatives that reduce the emissions of speedboats (*hurtigbåtar*) and associated infrastructure (Miljødirektoratet, 2020). A few projects have been supported from *Innovation Norway*, which is the Norwegian Government's instrument for innovation and development of Norwegian enterprises and industry.

Tabell 2: A selection of market players in Norway. Read more in Appendix 2.

Market player	Type of initiative
Arendal municipality, Agder County	Charging plan for electric boats in Arendal and the Agder coast
Vestland County	A network for charging points in marinas for small boats along the coast around Bergen and the surrounding municipalities.
Norsk Elbåtforening	A contact and information center for electrical operation systems in boats. They cooperate with speedboat companies, other associations, electric propulsion companies and electrical engines companies based in Norway, Sweden and Germany. Four of the ten business members are Green Star Marine (Sweden), Candela (Sweden), Green waves (Norway) and Torqeedo (Germany).
Green Waves	Speedboat company that focus on converting existing leisure motorboats to electric, by installing their motors and battery packs, as well as producing their own boats.
Kruser	Kruser is the world's first boat sharing platform for electric leisure boats, that currently is available on ten locations in south Norway, with several more harbors in Norway coming up soon. The "boat pool" use electric leisure boats from Green Waves, Rand boats and Hydrolift, and in 2021 boats from Evoy.
Evoy	Electric propulsion and battery company for leisure boats. Current battery capacities: 65 kWh, 130 kWh and 196kWh.

4.2.1 Charging plan for electric boats in Arendal and the Agder coast

Arendal municipality

In June of 2020, the municipality of Arendal received funding of 500 000 NOK from Klimasats by developing and implementing a “*Charging plan for electric boats in Arendal and the Agder coast*”. In the Arendal municipality, there are around 14 000 leisure boats and 5 000 guest boats. 50% of these boats use fossil fuel. The charging plan will be part of Arendal’s climate and energy plan for the years 2019 – 2023, which aims to make Arendal a more attractive place to live, by maintaining the municipality’s position as one of the most ambitious municipalities when it comes to handling climate change (Miljødirektoratet, 2020).

Speed up charging possibilities

The charging plan aims to speed up the development of charging possibilities for electrical leisure boats, and thus removing a significant barrier for the possibilities of owning an electric leisure boat. Furthermore, when boat manufacturers and dealers see that the charging possibilities for electric leisure boat increases, it will be easier for them to produce and offer electric boats to the market. The Norwegian Coastal Administration has created a web solution that provides a total overview of all charging points, shore power plants, LNG plants, etc (Kystverket, 2021). The charging plan will be adapted and included in this web solution.

Increased collaboration between market players

In addition to the reduced emissions, the charging plan aims to increase collaboration between manufacturers, consumers and the municipality within the field of electric leisure boats. To further incorporate this charging plan into society, Arendal municipality plans to work with both public and private stakeholders such as harbors, housing projects, energy companies among others as well as the municipalities surrounding Arendal. Arendal municipality also plan to have a dialogue with Vestland County, who has previously worked with solutions for fast charging of electric boats in western Norway (see next section).

4.2.2 A network for charging points in marinas for small boats around Bergen

Vestland county

In June 2020, Bergen municipality was granted an application for support from Klimasats to the project for an emission-free marina. The full support of 310,000 NOK went to a preliminary project that aimed to map what is needed to establish an emission-free marina and “The Green Tail” - a network of charging points in marinas along the coast around Bergen and the surrounding municipalities. bGreen led the preliminary project and put together an interdisciplinary team (with engineers, Royal Norwegian Boating Association and Bjornafjorden municipality) to work on the project (Klimapartnere, 2020).

The preliminary project was compiled in a report published in December 2020. Sections about marinas, electric boats, infrastructure, charging and The Green Tail are followed by mandatory- and recommended actions. Where it is considered that there are actions that should be investigated further, they are stated.

Among the mandatory actions the project states for example economic incitement such as VAT exemption, continued expansion of the charging infrastructure between Bergen and Bjornafjorden and development of the digital infrastructure for The Green Tail. Furthermore, ports should inform that the shore power that is often already established in many cases is sufficient charging infrastructure as leisure boats can be charged during the night. If possible, the charging systems for electric cars should be combined with those for electric boats.

The recommended actions mainly concern funds to benefit electric boat owners, such as additional economic benefits in the port and type 2 outlets in electric boats to have a higher charging effect and load balancing functionality in the marinas (bGreen, 2020).

4.2.3 Contact and information center for electrical operation systems in boats

Norsk Elbåttforening

Norsk Elbåttforening is working for a green shift for leisure boats. They act as a contact and information center for electrical operating systems in boats and provide their members with benefits for the installation and use of these systems. *Norsk Elbåttforening* work with speedboat companies, other associations, electric propulsion companies and electrical engines companies based in Norway, Sweden and Germany. Four of the ten business members are Green Star Marine, Candela, Green waves and Torqeedo. The remaining business members are Freepower (solar boat), Seil Magasinet, Gran Seil, NSF, Zero Emission yachting and Konelig norsk seilforening. The association work to promote technical change in leisure boats by participate in trade fairs, developing charging options along the coast, being an advisory body to authorities on laws and regulations for boating and mediating contact between industry, authorities and the public. The Association also strive to influence the public and politicians so that measures are implemented that contribute to a smaller environmental footprint from boating (Norsk Elbåttforening, 2021).

4.2.4 Battery packs for existing leisure motorboats as well as new boats

Green Waves

Green Waves is a company that focus on converting existing leisure motorboats to electric, by installing Green Waves' own motors and battery packs, as well as producing their own boats. Green Waves is located in Tvedestrand, just 90 km up the Norwegian south coast from Kristiansand and 20 km up the coast from Arendal (nrk, 2019).

4.2.5 Boat sharing platform Kruser

Kruser

Kruser is the world's first boat sharing platform for electric leisure boats, that currently is available on ten locations in south Norway, with several more harbors in Norway coming up soon. The so called "boat pool" is based on several people having access and the opportunity to use the same object. By maximizing the usage of each individual electric boat, Kruser states that emissions per user are reduced by at least 95%. Kruser offers the customers four different types of memberships, that is payed for per season. They have a premium alternative that gives access to a faster boat model (35-40 knots) and a comfort alternative that gives access to cruising-speed boats (4-7 knots). For each alternative you can choose day and evening access or only day access (Evoy, 2020). Today Kruser is partnered up with and use electric leisure boats from three boat companies, those are Green Waves, Rand boats and Hydrolift. And currently they are working on a new project with electric propulsion company Evoy as mentioned earlier, to launch additional fast electric boats in 2021 to the fleet of boats that Kruser offer its members (Kruser, 2021).



Figure 5 Kruser's locations throughout the south of Norway

Kruser's goal is to broaden the market for electric leisure boat sharing and make that the new norm for their "target group" before 2030, by doing so they hope to contribute to UN's sustainability goals. One of the reasons behind their solution is a boat life survey from 2018, that stated that 52% of leisure boats in Norway on average are used 7,5 trips per year, and that 13% never are used.

4.2.6 Electric propulsion system and batteries for leisure boats

Evoy

Evoy is an electric propulsion system company founded in 2018 and based in the city of Florø in western Norway. The company provides the customers with an overall solution for electrifying a leisure boat; including motor, modular battery packs and other technicalities. Currently they offer one electric inboard motor and one electric outboard motor, the previous with a power of 450 HP and the latter with a power of 150 HP. The inboard motor is suitable for boats measuring 6-15 meters and the outboard motor is suitable for boats measuring 5,5-7,6 meters, and both systems can be installed either singular or double. In 2023 and 2025 they will update their supply and offer additional engine powers for both inboard and outboard motors. Currently they also offer three battery capacities: 65 kWh, 130 kWh and 196kWh. Evoy seems to be an electric propulsion company that focuses on offering an electric option that is similar to fossil fuel systems, their motors look like fossil fuel motors and they come in the same power-options and setups as conventional boat motors (Evoy, 2021).

Currently, Evoy is working on a new project with the boat sharing platform Kruser (described earlier). The project is set to launch additional fast electric boats (planning speed) to the fleet of boats that Kruser offer its members, with start in the beginning of the 2021 boating season. In accomplishing this goal Evoy has asked boat builders in the Nordics to produce efficient boat models suited for Evoy's electric motors and battery packs (Kruser, 2021).

4.3 DENMARK

Copenhagen, Denmark, plans to become the first CO₂ neutral city in the world by the year 2025. One step to achieving this goal is by electrifying their transport infrastructure. Therefore, the city of Copenhagen set aside 10 million DK to electrify their entire fleet of harbor transport ferries. The investment of 10 million DK went entirely into the development of the necessary charging infrastructure (The Local, 2018). The previously used diesel-powered ferries were replaced by the electrical ferries in the summer off 2020 (Visitcopenhagen, 2021). In addition to this, there are some lakes within Denmark such as the Silkeborg lakes that only allow fossil-free leisure crafts. However, Denmark is not on a state or regional level proactively supporting the electrical leisure boating market according to stakeholders operating in Denmark.

Tabell 3: A selection of market players in Denmark. Read more in Appendix 2.

Market player	Type of initiative
Rand Boats	A Danish speedboat company that provides their own boat models but incorporate electric boat motor from other manufacturers (ex. Torqeedo).

4.3.1 Electric speed boat company

Rand boats

Rand Boats is a Danish speedboat company based in Copenhagen. Rand Boats produce their own boat models but incorporate electric boat motors from other manufacturers such as Torqeedo into the finished boat. However, they also offer some models using fossil fuel motors, making them a not truly electric boat brand. Rand Boats states that they invest heavily in research and development, enabling them to produce energy efficient and streamlined boats with a sustainable design and electric propulsion, in order to be respectful of nature. The company offers carefully

designed and semi-luxury electric leisure boats that could draw the public's attention and interest to the electric leisure boat market, although it most likely would be too expensive for the average leisure boat owner (Randboats, 2021).

4.4 GERMANY

According to stakeholders operating in Germany, the Country does not have any state or regional policy that aims to support the electrification of leisure craft. However, there are some regional waterways and lakes (the Bavarian lakes in southern Germany for instance) where fossil-driven leisure craft is not allowed. Furthermore, Germany is made up of a patchwork of national and state inland waterways. All the national waterways have uniform legislation and does not discern between fossil and non-fossil leisure craft. The state waterways are not uniform in their legislation, and as previously mentioned, they may not allow fossil-driven boats to operate in their waterway.

Tabell 4: A selection of market players in Germany. Read more in Appendix 2.

Market player	Type of initiative
Torqueedo	Electrical engine company with focus on electric motors for leisure boats as well as charging equipment and apps.
Aentron	Battery solution for leisure boats (and larger boats/ships). Leisure boat owners can convert their existing leisure boat by installing Aentron batteries and an electric motor from another manufacturer.

4.4.1 Electric motors, charging equipment and apps for electric leisure boats

Torqueedo

Torqueedo is a German company that specializes on electric motors for leisure boats and the associates with the electrification of boats, such as solar charging equipment and smartphone apps among others. Torqueedo has since 2005 been a global market leader in this field of electric mobility on water. The electrical motors that Torqueedo offers are both outboard and inboard, as well as hybrid drive systems ranging from 0,5 to 100 kW on motor level (up to 200 kW on system level). As of 2020, over 100 000 boaters have chosen Torqueedo systems instead of other fossil-based alternatives (Torqueedo, 2020).

Torqueedo has since 2016 partnered with BMW to bring state-of-the-art automotive battery engineering (the BMW i3 series) to the marine market. Furthermore, Torqueedo is also collaborating with Swedish speedboat company Nimbus with their E-power concept, which is Nimbus' electrical boating project that is propelled by Torqueedo technology (Nimbus, 2021). These are just two examples of Torqueedo's collaborations, among many others. Several electrical speedboat manufacturers use Torqueedo technology in their boats, which is why Torqueedo can be considered as an important stakeholder in the field of electrical leisure boats.

4.4.2 Battery solutions for leisure boats (and larger boats)

Aentron

Aentron is a battery solution company founded in 2015 and based in the south Germany city of Gilching. Aentron provides lithium-ion battery packs suited for both larger boats in the transportation industry and smaller private leisure boat owners. They offer three capacities in their batteries; 1, 2 and 10 kWh, and three voltages; 12, 24 and 48 V. Their batteries are modular and can be incorporated with products from other manufacturers.

The maritime classification society has certified Aentron GmbH in the areas of shipping, offshore installations, speedboats and light boats. They have the DNV-GL Type Approval Certificate (TAE00003BY), which is needed for batteries in ships and yachts and they have the ISO 16315:2016 which is a certification for Small Craft Electric Propulsion Systems for leisure boats, smaller crafts. Aentron's battery solutions could enable leisure boat owners to

independently convert their boat by installing Aentron batteries and an electric motor from another manufacturer (Aentron, 2021).

4.5 THE NETHERLANDS

In the Netherlands, the municipality of Amsterdam has implemented stringent emissions legislation for canal cruise boat, leisure boats and other ships sailing in the city of Amsterdam. The implemented legislation requires all canal cruise boats and all leisure boats operating in the city center to have net zero emission by the year of 2025. By the year 2030, all leisure boats outside the city center has to be emission free, this also includes all other modalities. The main driver for implementing this legislation is to improve the air quality of Amsterdam's inner city, furthermore the overall reduction of greenhouse gas emissions is also considered to be important. The greenhouse gas emission savings associated with the electrification of the canal cruise boats have been estimated to be around 70% in comparison to the usage of diesel. This legislation is also in line with Amsterdam's Climate Plan, which aims to increase the energy efficiency of Amsterdam as well as increasing the usage of renewable energies by 20% in the year 2020. Other benefits that can be attributed to the electrification of canal boats are noise reduction in the city as well as an improved outside image of Amsterdam (PPMC, 2021).

Tabell 5: A selection of market players in the Netherlands. Read more in Appendix 2.

Market player	Type of initiative
The municipality of Amsterdam	Stringent emissions legislation for leisure boats, as well as canal cruise boats and other ships, in the inner city of Amsterdam. In 2030 this encompasses the entire city with a plan to have all canal boats in Amsterdam fully electrified. A road map is compiled which addresses issues such as charging infrastructure for this action.
Port of Amsterdam	The port of Amsterdam has partnered with the energy startup company Skoon Energy to bring mobile energy storage (battery) into the port of Amsterdam and the inner city, since the current grid connections do not provide sufficient capacity to meet the needs during peak months (April and May). This is done with the usage of a large battery, which is placed on a barge.

4.5.1 Fully electrified canal boats in Amsterdam

The municipality of Amsterdam

There are currently around 120 large canal cruise boats and many smaller ships operating in the canals of Amsterdam. These 120 canal boats are planned to be fully electric by the year 2025, which calls for further development in the battery charging infrastructure. A roadmap has been made for this implementation, and this roadmap suggests that cooperation in development and know-how between the shipping companies, the integrated development of the charging infrastructure, safety and regulations. The batteries are either lead-acid or Li-ion, and the battery capacity of the canal cruise boats is 200 to 250 kWh, which is about three times more than the average electrical car.



Figure 6: The canals of Amsterdam.

4.5.2 Mobile battery in the port of Amsterdam and the inner city

Port of Amsterdam

In April and May every year, the number of river cruise docked in Amsterdam is at its peak. Current grid connections do not provide sufficient capacity to meet the vessels' power demand. Because of this, the port of Amsterdam has partnered with the energy startup company Skoon Energy to bring mobile energy storage into the port and the inner city. This is done with the usage of a large battery, which is placed on a barge. Furthermore, the floating battery will help balance the grid and provide cruise vessels with renewable electricity, which removes the need for large cruise vessels to use their on-board diesel generators. The battery will be charged from renewable energy sources, such as Windpark Ruigoord, solar panels from rooftops in the port area and energy from biomass by waste-to-energy company AEB. The battery will be on the barge for six months, and it will service the city's electric boats during the heavy demand of the tourist and tulip season in the year 2020 (Skoon, 2021).

The floating battery is currently rentable until April 2021. It can supply electricity to a range of different events, project or activities, which does not necessarily need to be linked to maritime based activities. The floating battery project is part of the "Project Clean Amsterdam" which is being run in cooperation with the Port of Amsterdam. The port has an ambition to become an emission-free port by the year 2050, and as previously mentioned, the municipality of Amsterdam has implemented stringent emissions legislation for canal cruise boat and other ships sailing in the city of Amsterdam. The legislation requires all canal cruise boats to have zero emission by 2025. The floating battery project along with the emissions legislation highlights how different stakeholders (municipality, private companies and ports) can collaborate to support electric maritime actives, as well as reducing local emission related to the maritime industry.

4.6 GREAT BRITAIN

Tabell 6: A selection of market players in Great Britain. Read more in Appendix 2.

Market player	Type of initiative
Vita Yachts	UK based electrical speed boat company that has installed three of their own speedboat superchargers along the French Riviera, with an addition 8 planned in 2020.

4.6.1 Speedboat superchargers along the French Riviera

Vita Yachts

The UK based electrical speed boat company Vita Yachts has installed their own speedboat superchargers along the French Riviera, at ports in St Tropez, Cannes and Monaco. By the year 2019 there were 3 superchargers in use (1 for each port), as well as a planned installation of 8 supercharger at various smaller ports along the coast. These additional installations will be done during the year of 2020. The superchargers have a capacity of 150 KW, which reduced the average charging time of electrical speedboats from 6 hours to 1 hour of charging time (Butler, Vita electric boat chargers will be recycled aluminium, 2020).



Figure 7: Vita Yacht's electric speedboat and superchargers.

Monaco was the first port to install Vita Yachts' supercharger in May 2019, which can be attributed to Monaco and The Yacht Club of Monaco's (YCM) aim to reduce its pollution and environmental impact. YCM as well as the Prince Albert 2 of Monaco foundation (FPA2) are frequent partners of Vita Yachts in this venture to promote and advance the adoption of electric boating in the Mediterranean. FPA2 is a fund that aims to support various projects in sustainable maritime activities, where sustainable yachting practices is one the key focus areas (Butler, 2019). The success of Vita Yachts and its network of supercharger along the French Riviera is a testament to the viability of electric boats and connected charging network. However, this success could be attributed to Monaco's monarch Prince Albert the 2nd and his influence over Monaco as well as the French Riviera at large. Although this may be the case, it still shows the importance of collaboration between different actors (state, ports and private companies) to develop these kinds of solutions.

5 SCENARIOS FOR FUTURE WORK

This section provides examples of different scenarios for a future development of the electrification of leisure boats and its infrastructure. To come up with sustainable and successful initiatives for an increased development of the electric leisure boats market, collaboration to bring people together is one overall important aspect. The collaboration between leisure boat owners/users, boat and motor manufactures, stakeholders from academia and others is important no matter what scenario for BRG to go forward with.

Figure 8 illustrates main players in the ecosystem for electrification of leisure boats and its infrastructure.

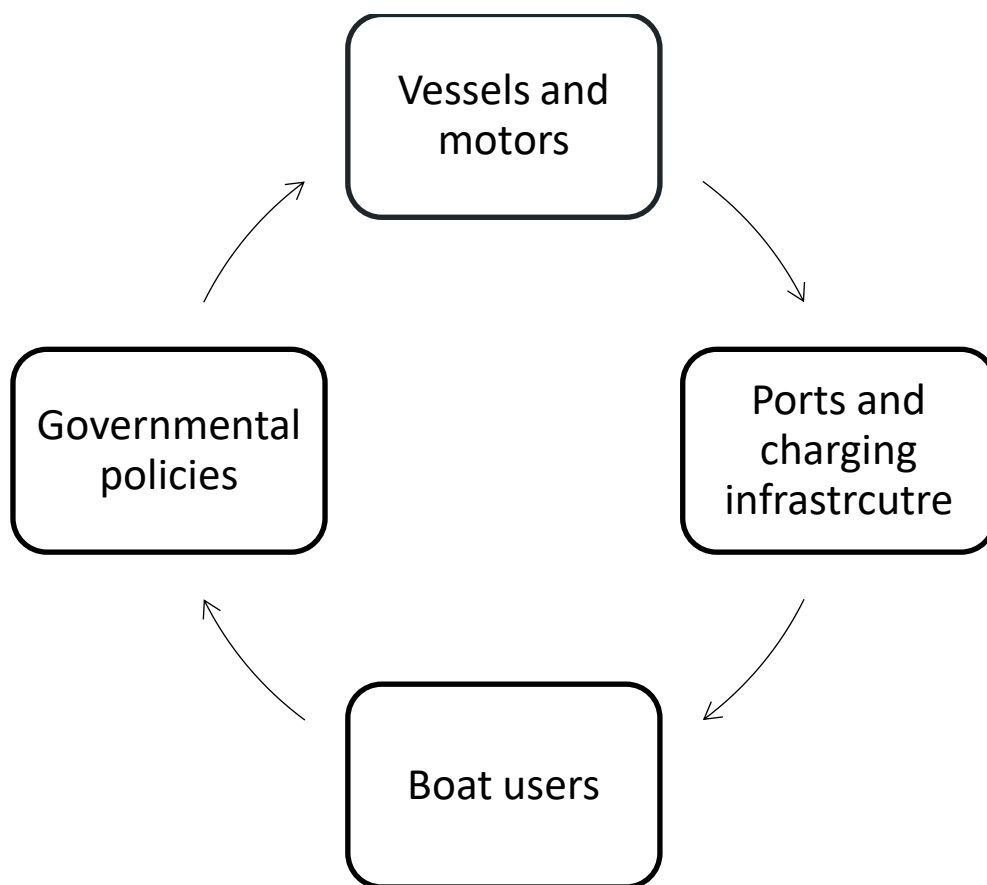


Figure 8: Main players in the ecosystem for electrification of leisure boats.

5.1 BOAT USERS

Short summary:

Demonstration and communication are important, whatever strategy for implementation of electrified leisure boats. The information needs to be available for the broader audience and include what is done today. Several actors in Sweden have expressed an interest in a network of players in the electric boat area.

There are examples of good initiatives that could contribute to the broadening of the public's knowledge and interest of the electric boat market. This knowledge might lead to more and more private owners entering the electric leisure boat market, which in turn would lead to further expansion of the market.

Test beds

One such good example in Sweden is the small company *Solarboats* based in central Stockholm. Solarboats offer private persons and companies tours with electric boats driven by solar panels on the roof of the boats (Solarboats, 2021).

Exhibitions

There are several big boat exhibitions, with an increased focus on electrical boats, that could help broaden the knowledge and increase the interest on electric leisure boats. One specific example is the Lydløs (silent) boating festival for electrical leisure boats in Arendal, Norway. The purpose of the festival is to help accelerate the transition to zero emissions at sea, as well as encouraging commitment towards sustainable boating solutions for the climate and the environment. The festival is organized by the Lydløs association and is arranged in collaboration with the Electric Boating Association of Norway together with Arendal Municipality, Arendal business association and the city of Arendal. Prominent electrical boating manufacturers such as Candela, X-shore and Green Waves among others will all be part of the festival (Lydløs, 2020).

5.2 PORTS AND CHARGING INFRASTRUCTURE

Short summary:

WSP assesses that ports and its charging infrastructure for electrified leisure boats is an area whose development is lagging. There are a few international examples, but ports need support in their decision-making process regarding the type of service that ports should and can offer, but also about communicating to boat users what opportunities exist today. In this development, WSP believes that it is important to learn from, and benefit from, the electrification of the automotive industry.

The number of leisure boats in the summery has its peak during a few summer months and a leisure boat is used only a few hours a day (and not every day) for recreational activities. Since it is used for recreational activities they also often need to charge at the same. There are some challenges that come with this usage pattern:

- Ports for leisure boats are smaller ports with a various offer of services, and services often provided to accommodate those who live nearby. The infrastructure available today is not sufficient for fast charging, but electricity is often available as one of many services in the port.
- Current grid connections can have difficulties to provide sufficient capacity to meet the power demand from boats when they all charge at the same time. This is the case in the port of Amsterdam in April and May, but the same situation can be true for Sweden which is experienced with the electrification of cars.

Communication

In Norway, the Vestland County project recommend that ports communicate with the leisure boat owners and inform that the shore power that is often already established in many cases is sufficient charging infrastructure as leisure boats can be charged during the night.

Added value with multi-purpose usage

Leisure craft usage peaks in summer months and is significantly lower in all other parts of the year. Therefore, it is important to integrate charging infrastructure for leisure craft within existing charging infrastructure. This, to make sure that the charging infrastructure is fully used during all parts of the year. Such integration could for instance be with existing charging infrastructure for electric cars, ferries or other boats. An example of this is the Vestland Country project, which recommends that the leisure craft charging infrastructure is combined with that of electric cars, and that a network of charging points in marinas along the coast is established.

Energy storage in ports

One possibility to overcome the challenge with sufficient power capacity in specific ports is energy storage solutions, such as batteries. A solution for energy storage (battery) that is used to solve this specific issue in Amsterdam, is the floating battery project in the port of Amsterdam as mentioned earlier. This is also a good opportunity for marinas to test the actual uptake ahead of investing in permanent infrastructure. This lower risk trial basis for the charging facilities might encourage smaller marinas etc. to look into the possibility of charging for electrical leisure boats.

There are several interesting actors that specialise in mobile electrical storage systems, such as for example Northvolt (Northvolt, 2020), Alpha ESS (Alphaess, 2021), Merus (Merus Power, 2021), Alfen (Alfen, 2021) and EuroBat (Eurobat, 2016). For example, the Voltpack Mobile System by Northvolt is a power supply solution that can be configured for varying energy and power needs in a variety of areas. One mentioned main application is charging of electric vehicles, but it can probably be used for boats as well. As a development partner to Northvolt, Vattenfall has supported the systems design and functionality. They have built a new service that they call power-as-a-service, meaning that they bear the investment cost and then for example rent out energy storage to help companies convert from fossil fuels without having to risk capital (Northvolt, 2020).

An energy storage can be used both as a back-up for power capacity, but also used for flexibility. Since a leisure boat is docked at the port most of the time the energy stored in the boat battery can be sold back to the grid.

5.3 GOVERNMENTAL POLICIES

Short summary:

Regulations from politicians and economic reliefs for electric leisure boats and its infrastructure are something that can help end-users to consider electric leisure boat to a broader extend.

Regulations

There is divided opinion on whether restrictions are the best way to increase the use of electrical leisure boats. One thinks that the focus should be ownerships rights, another think that restrictions are crucial to kick-start the market.

One aspect mentioned at workshops is that regulations that forces people to use electric boats only, can force people to use boats to a lesser extent or for those with lots of money, this is primarily a concern mentioned by the boating industry.

The floating battery project in the port of Amsterdam along with the emissions legislation (restrictions) highlights how different stakeholders (municipality, private companies and ports) can collaborate to support electric maritime actives, as well as reducing local emission related to the maritime industry.

Financial relief

There is more coherence regarding the necessity of financial relief, but there are divided opinions about who should contribute with this support; private actors (such as boat manufacturers) or the municipality/regions.

With VAT exemption, for example, electrification can be made a cheaper option for the end-user, the same with funding for charging infrastructure. In Norway, for example, they have subsidies for electrical cars and Klimasats is an initiative where a few projects have received funding for electrical boats projects and its infrastructure. The Vestland county project in Norway project address VAT exemption as a mandatory action to establish an emission-free marina. Recommended actions mainly concern funds to benefit electric boat owners, such as additional economic benefits in the port and type 2 outlets in electric boats to have a higher charging effect and load balancing functionality in the marinas.

5.4 VESSELS AND MOTORS

Short summary:

The development of electrified leisure boats is ongoing today and is the player that is at the forefront of the development.

Today there are several different variants of leisure boats with electric propulsion, ranging from fully electrified motorboats to older slow boats, or sailboats, which have been converted to electric propulsion with engine replacement. Different electrical speedboat companies also have different strategies when it comes to how the vessels are prepared for different types of charging infrastructure. Candela Speedboats focuses on reducing wave friction and making the vessel as light as possible. This leads to their boats being more efficient than their counterparts and therefore being less reliant on fast charging infrastructure. For normal use, Candela considers that normal charging is perfectly fine.

However, Candela highlights that fast charging infrastructure is needed if the boat is used more extensively than once every second day, or if longer distances are supposed to be traversed. Vita Yachts argues that fast charging is very important for electrical leisure craft. This is because it takes

around 15 hours to fully charge most electrical leisure craft, which makes it impossible for electrical leisure craft to be flexible and be at sea for longer periods of time without access to fast charging.

Fully electrified leisure boats are expensive, and since they mainly are used by private persons only a few summer months and as a recreational activity, buying an electrical leisure boat is a huge investment.

Boat renting and sharing

One possibility to come around the problem that an electric leisure boat is too expensive for everyone to invest in, is for people to share boats more in the future. This trend has already been seen for electric cars where several car-sharing companies are allowing users to rent or share electric cars per hour/day or longer. One of the selling points has been that a car is only used for 5 % of its time. This could therefore be a possible solution be possible since most people don't use their boats that much.

Another possibility is so called "boat pools" where you can rent an electric leisure boat. There are some initiatives available today. One mentioned earlier (section 4.2.5) is the Kruser platform in Norway which is currently available on ten locations in south Norway, with several more harbors in Norway coming up soon. Another example is the Let's Boat company based in central Gothenburg, Sweden, that offers electrical rental boats to those who want to travel on Gothenburg's waterways. The boat is booked online and requires no license (Letsboat, 2021). The Kruser platform cooperate with different boat manufacturers, some boats are exclusively used within the platform.

The business model for boat pools need to be adapted to the pattern of use of leisure boats as well as the type of typical user. The business models maybe should not reflect how a leisure boat have been used historically but adjusted to a future usage pattern with a possible changed behavior by new generations. User behavior and future needs for leisure boat owners is important to map to be able to achieve successful business models.

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