

Market barriers towards electric boats

Truls Tveitdal
Department of Design
Norwegian University of Science and Technology

ABSTRACT

This article identifies potential social and technical barriers to consumer adoption of electric boats. Psychological and sustainability issues that influence the consumer decision to purchase an electric boat are also discussed. This insight can guide the decision processes when incorporating consumer preference into electric boats. The lack of awareness and knowledge about what an electric boat offers are barriers to the adoption for the mass market. Electric boats are a step in the right direction of more sustainable and greener oceans.

KEYWORDS: Electric boat, leisure boats, sustainability, market barriers, consumer acceptance

1. INTRODUCTION

Electric boats will be more important in the near future. Our dependence on fossil fuels results in increased emissions that are associated with conventional boats. Despite the benefits of a fully electrical boat, there are several obstacles needed to be overcome before electric boats will be adopted.

The market share of electric boats is generally low across countries. Research has identified different barriers contributing to the relatively low competitiveness, relating to actual costs and cost perceptions, risks, technological conservatism, unfamiliarity and lack of knowledge (Diamond, 2009). A report by IDTechEx shows that the market for hybrid and pure electric boats and ships will rise rapidly to over \$20 billion worldwide in 2027 for consumer's vessels. The market for recreational boats is large and fast growing, especially for electric marine vessels. (F. Gonzalez, 2017) There are several barriers to implement electric boats into the market, from technical challenges to acceptance of an all-electric boat.



Figure 1: Electric boat

It is crucial to find innovative ways to decrease the environmental impact from leisure boats since a typical family boat consumes a huge amount of petrol, approximately 27,6 l/h, when cruising. The boats need to be more efficient to enable electric propulsion.

The article aims to provide an outcome that could explain the market barriers for electric boats and possibly be used as a guide for increasing the electric boat sales. This article will investigate different factors concerning these issues.

The article starts with background information on leisure boats in Norway and a short introduction on electric boats and the market trends. The

second part highlights several factors concerning the market barriers. The last part is discussion of the topic.

2. METHODS

This article is based on a literature review and interviews with people in the boat industry and consumers to get a better understanding of the market. The literature that will be investigated is a combination of electric boat- and electric car articles together with market analysis and psychological articles concerning acceptance. The interviews are done in boat stores in the Trondheim area and at a boat show in Oslo, "Båter I sjøen".

Electric boats have to be seen as a desirable commodity. To understand why it has not been accepted in this field, a review of the literature regarding acceptance is necessary. It is also necessary to understand the reasoning and psychology behind what and why people choose to buy certain things over others.

3. BACKGROUND

Norway has a long coast and a unique archipelago with opportunities for an extensive recreational boat life. The coast means a lot for the population, for regions and for business. In Norway, there are approximately 750000 leisure boats and the number is increasing. 24,5% of all households have a boat and in the south, there is a higher density of boat owners. Motorboats without accommodation are the largest single group with 38.7% of the boat park. Console boat and Daycruiser are represented as the type of boat most people own, and they are often built in fiberglass or plastic. (Kongelig norsk båtforbund, 2012)

3.1 Electric boats

The majority of water vessels are powered by petrol or diesel engines, but electric boats have also been available for over 120 years and they were very popular from the 1880s until the 1920s

(Mcintyre, 2017). After this, the oil companies took over and petrol and diesel engines have improved over the years. The 1970s energy crisis made the interest in this potentially renewable energy grow steadily again, especially since solar cells came along. This made it possible for electric vehicles and motorboats to have an infinite range like sailboats.

A fully electric boat is a boat that is propelled by an electric engine connected to a battery. The boat can either be propelled by a propeller or a waterjet. There are also hybrid diesel or petrol boats that are propelled by an electric engine, but the electricity is generated from a fossil-fueled engine and sent to a battery. This article will only focus on fully electric boats.

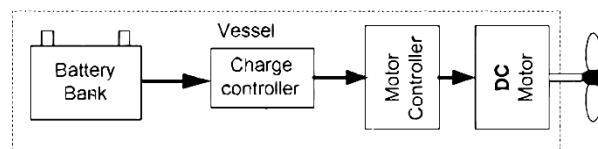


Figure 2: Fully Electric boat setup

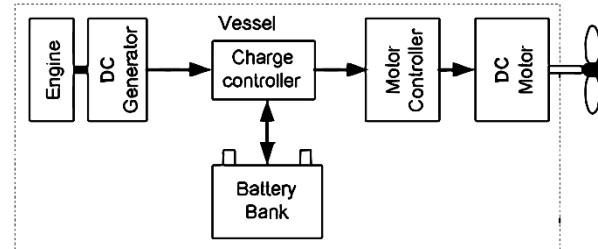


Figure 3: Hybrid boat setup

3.2 Today's market and trends for electric boats

Electric boats are currently sold in Europe and US in small numbers. There are only 100 manufacturers of electric boats, but the market is growing.

The key to developing the electric boat market is mainly depending on technical solutions such as energy storage, the efficiency of propulsion systems and use of light materials. The demand for electric boats is increasing because of environmental and health concerns, and electric transportation is an answer to this.

Due to banning the use of marine combustion engines in specific areas, and putting tight restrictions on other areas, electric boating and sailing have become more popular, especially in Austria. As a result of these restrictions, more Austrians are demanding electric boats or solar boats, which are permitted. “It is estimated that electric and solar boats represent a quarter of all boats in Austria”(M. Gonzalez, 2016).

3.3 Application of electric boats

Many compromises can be made with regards to weight and hull shape on boats that travel in controlled waters, rivers, and lakes, with small waves and without the need for much heavy safety equipment. There are a number of applications where short range does not matter. Examples could be if a boat is used for local fishing, shorter trips and for sailboats that only use engines for entry and exit from narrow marinas. Other examples are for tender boats belonging to a mother ship, used for shorter excursions to get ashore when the boat is on the swing. Situations where it is trivial to always have a certain proportion of the fleet out for charging, for

example, rental boats in a small dam in a tivoli, sightseeing boats etc. (Unknown, 2017)

There are several advantages and disadvantages of having an electric boat. The list can be long, but I have highlighted the most important ones in table 1 and 2:

Advantages
Environment friendly
Avoid engine noise
Less vibration
Less engine maintenance - no oil change, impeller change, diesel filter change, etc.
Fuel economy
Avoid local contamination
Electric motor weighs much less than the internal combustion engine, if you do not need a long range you can save a lot of weight.
The fire hazard of storing batteries is less than the fire hazard associated with storing gasoline.

Table 1: Advantages

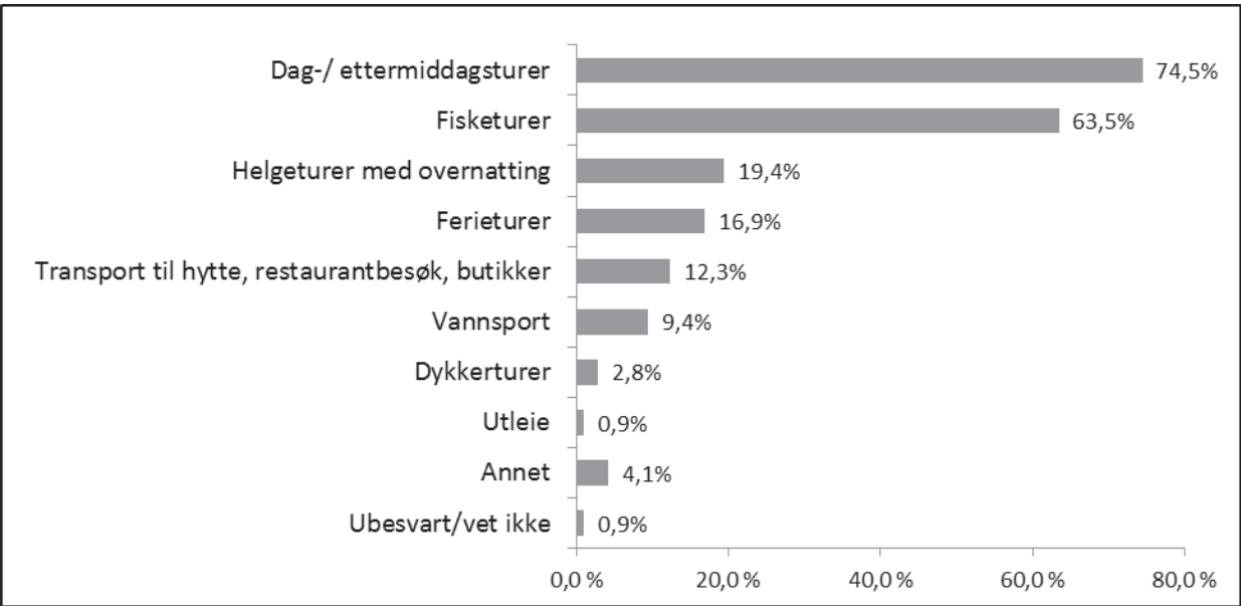


Figure 4: Boat applications
(Kongelig norsk båtforbund, 2012)

Disadvantages
You get quite a limited range of battery operation. Batteries are not near to compete with diesel or gas when it comes to energy density, and for example, solar cells do not provide near enough power to achieve what is considered a normal speed at sea.
Low power consumption and speed. A displacement hook that goes for half hull speed requires little energy.
Electric boats that are powerfull costs a lot

Table 2: Disadvantages

4. MARKET BARRIERS

Several factors can explain the market barriers towards electric boats, but I will try to focus on the most important ones. Demographics, values, and lifestyles affect not only preferences but also the practicality of a given electric boat for a given consumer. Solutions for different markets will be needed for different market categories and segments.

4.1 Consumer Psychology

Demographics can explain who is buying particular products and psychographics are more likely to explain why customers purchase certain products. Therefore, psychographics generally is more useful than demographics in understanding customer decisions.

To know the consumer's psychology helps companies and organisations to improve their marketing strategies by understanding issues like how they think, act, feel, reasoning's and why they select different things. If we look into how the consumer is influenced by the environment like family, culture, friends, signs, media, etc. we get a better understanding of different psychological aspects. By analysing the psychology, we get a better picture of who the consumer is and what he/she wants. Other points that can make marketing strategies is to know:

How consumers make decisions
Knowing the consumer knowlege
How is consumer motivated to make decisions

Table 3: Marketing strategies

This brings us to the next phycological aspect that people tend to want to buy something new but not so new that it is unfamiliar. The term MAYA (Most Advanced Yet Acceptable) say something about this consumer behavior. The man behind this term Raymond Lowey lived by this, and he believed that "The adult public's taste is not necessarily ready to accept the logical solutions to their requirements if the solution implies too vast a departure from what they have been conditioned into accepting as the norm." (designbyben, 2012)

The consumer looks to something typical of a product category. When looking back on those products, it reduces the risk of the unknown, but at the same, it is important to overcome boredom. (Hakkert, 2006)

When you know this, it is important to know your customers and investigate their distinct needs and to do this you can use a human-centered design approach.

"To sell something familiar, make it surprising. To sell something surprising, make it familiar."(Loewy, 1950s). It is a constant battle between discovering and the familiarity that defines our lives. Humans want to feel safe, but at the same time, we want to explore, do and see something new. This theory explains why we act and thinking to make up our mind about what to do. Loewy's theory was also later proved in academic research. (Hekkert, Snelders, & van Wieringen, 2003)

4.3 Consumer acceptance

Consumers tend to be resistant to new technology that is considered unfamiliar or unproven.

Therefore, policymakers and manufacturers need to identify and overcome consumer issues to counteract the low acceptance. Even though technical problems are resolved, it can take a long time before consumers acknowledge and start to use the new technology. (Egbue & Long, 2012)

According to Sovacool (2009), policymakers and technologists commonly separate social concerns from technical while describing technological advancement. However, the barriers on the social level could pose as big of an obstacle as the “technical” in the advancement of electric vehicles for the consumer market.

Research shows that some common barriers to the adoption of any new technology include lack of knowledge by potential adopters, high initial costs and low-risk tolerance (Diamond, 2009). The general public’s perception of risk is based on experience, emotions, the media and other non-technical sources (Sjöberg, 1998). In general, media and social networks often influence values that affect consumer choices (Rogers, 2003).

4.4 Diffusion of Innovation

To get the desired acceptance for a new product, we need to look at a theory that explains the diffusion of Innovation. The theory was developed by E.M. Rogers in 1962 and is one of the oldest social science theories. It explains how, over time, an idea or product gains momentum and diffuses or spreads through a specific population or social system. The result of this diffusion process is that people, adopt a new idea, behaviour, or product. Adoption means that a person does something different than what they had or did previously. An example of this could be to acquire and perform a new behavior. The key to adoption is that the person must perceive the idea, behavior, or product as new or innovative. It is through this that diffusion is possible (LaMorte, 2016).

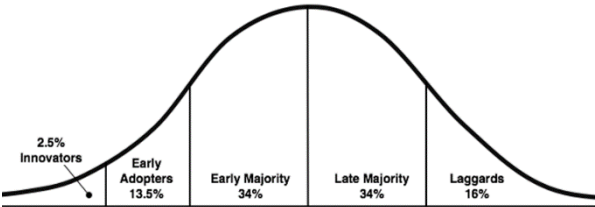


Figure 5: Diffusion of Innovation model.

The characteristics of innovation, as perceived by the members of a social system, determine its rate of adoption. Five attributes of innovations are(Everett, 1983):

1. Relative Advantage
2. Compatibility
3. Complexity
4. Triability
5. Observability

Regarding financial benefits, individuals are more likely to choose options that maximise utility based on their preferences, knowledge of alternatives and budget (Roche, Mourato, Fischedick, Pietzner, & PeterViebahn, 2010). The initial cost of an e-boat is significantly higher when compared to gasoline or diesel powered boat, and this cost increases linearly with battery size or range.

The innovation ecosystem for electric boats has its transition barriers that must be addressed for maximum market penetration to occur. Adner (2006) suggests that wide-scale deployment of new technologies is a function of three aspects of infrastructure development:

1	Product technology. This can for example be viable low cost battery technology.
2	Downstream infrastructure. For example, dealers, repair facilities, emergency services, and battery recycling options.
3	Complementary infrastructure. This is for example charging stations. Given the complexity of the innovation, mainstream consumers typically are unwilling to undertake what might be perceived as a risky purchase until all elements of the requisite infrastructure are in place

Table 4: Three aspects of infrastructure development (Moore, 2014).

To get market penetration for new technology is costly. Innovations with a complicated system is typically a slow process that takes 10-15 years or more to achieve even small penetration in the market. (Packey, 1993) *“When you got really new technology it generally takes three major versions in order to make it a compelling mass market-product”* (Musk, 2013)

To succeed with new technology to mainstream consumers, Moore (2014) suggests selecting a “beachhead,” a narrow market segment of consumers to offer “a compelling reason to buy” this new technology. This method is in contrast to the convention that a broad mass market is the most desirable. The Tesla Roadster is a good example on this. Elon Musk talks about a three-step process. Where the version one was an expansive car at low volume (here the Roadster), version two is a medium priced and medium volume, and version three is the low price high volume.

4.4.1 Relative advantage

The degree to which an innovation is seen as better than the idea, program, or product it replaces.

The perceived benefits for a buyer are the adoption (such as fuel savings) relative to the price paid and the nonmonetary costs such as concerns about battery life, charging infrastructure, resale value, and range.

4.4.2 Compatibility

It is important that the innovation is consistent with the experiences, values, and needs of the potential adopters. So how well does the new technology fit into the consumer's lifestyle? An example on this could be; is the range of an electric boat good enough? The adopters could have concerns about standards; this could be all from the different plug types and charging networks with different communications protocols and payment methods. The diffusion model tells us that consumers have a tendency to

wait and see to avoid purchasing the wrong product that does not become the common product everyone wants.

4.4.3 Complexity

How difficult is it to use a new product? Some examples on this could be, what is involved in charging at the doc, at work, or at public stations and remote areas. Are there any permits required for installation and is it required to have a membership for the charging network? How much will the electricity cost charge the boat up, and how is that cost calculated? This is questions you need to ask yourself if you consider buying an electric boat. It will then help to try out the product to see how complicated it is to use and maintain.

4.4.4 Triability

Another question is how easy is it for a potential buyer to try out the new technology? A typical test-drive can demonstrate its drivability, acceleration, and speed but does not allow the buyer to experience how it is to charge the boat or to see the other concerns that inhibit purchase.

To test drive is critical and important for potential buyers because it allows potential buyers to judge the driving dynamics and characteristics. The driving experience is an opportunity to become familiar with range and charging. This is an important step in the consumer decision process.

4.4.5 Observability

The top five reasons consumers give for their boat purchase choices are generally reliability, durability, quality of workmanship, value for the money, and manufacturer's reputation (Strategic Vision, 2013). The often-assumed influential factor when purchasing a boat is the fuel economy, and this is the primary consideration for consumers. (Båter i sjøen, 2017)

Strategic Vision study, Egbue and Long (2012) similarly found that environmental considerations

carry less weight in the purchase decision for boats than battery range and cost. Salesmen at Båter i sjøen could also confirm this. They had never got the question about how environment-friendly the boat is.

4.5 Limited range

Consumers consider what kinds of trips they do when purchasing (and using) a boat. Those thoughts and reflections will affect their views on the utility of the boat. Many consumers might not find the utility of an electric boat to be

will make up for it over its lifetime and use if it runs on relatively clean power.

The threat by the disposal of batteries is still difficult to quantify, but it is still the human hazard that can cause this global warming threat. It is therefore important to have good infrastructure for recycling the batteries. However, to recycle the batteries, we need to use an inaccessibly expensive technology. So, for the long-term fate of electric vehicle batteries remains undetermined if not the price drops for this technology. (Lambilliotte, 2014)

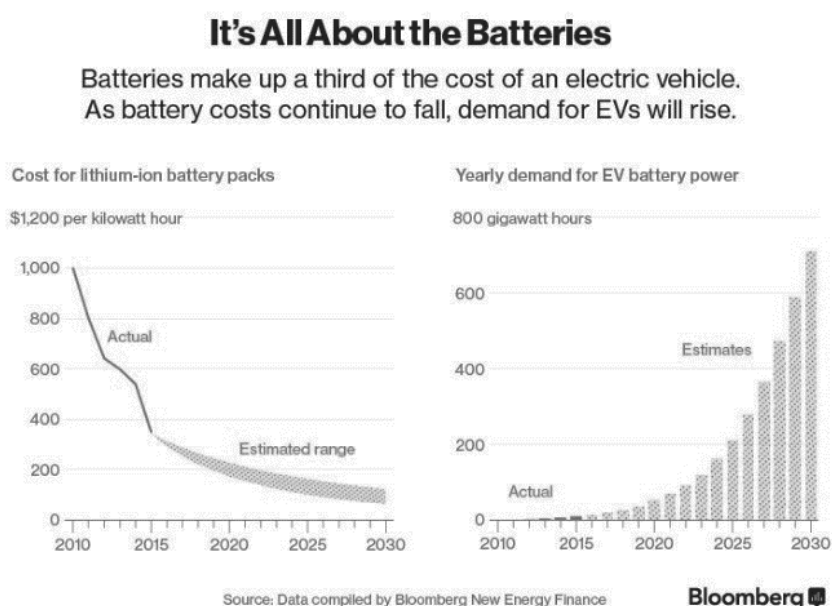


Figure 6: It's all about the batteries

substantially limited by trip distance. This range anxiety is perhaps the biggest issue to get an acceptance towards an electric vehicle(EV) (Czyzewski, 2012).

4.6 Greenness of battery electric boat

How environmentally friendly buying an electric boat depends on where you are in the world, and how sustainable and renewable the power is. Electric vehicles are significantly more pollutant than internal combustion vehicles are in the production phase. However, the electric vehicle

4.7 Sustainability

Consumers have problems to see the bigger picture and the benefits of fuel-efficiency technologies (Tsang, Pedersen, Wooding, & Potoglou, 2012). It is also assumed that the potential buyers have problems to see the economic value of an electric boat. To find the economic break-even point for an electric boat is difficult since it depends on where you get your power from. From a consumer point, it is much easier to compare retail prices. This can mislead the consumer from potentially buy an e-boat.

To address this issue, we examine how consumers perceive the innovation characteristic value for money depending on their knowledge. We suppose that consumers with a low boat involvement are also less aware of the value for money ratio of EVs and therefore perceive them more unfavorable than consumers with a high boat involvement. This insight may help boat companies to clarify the question whether to focus on informative communications may be an effective solution to overcome this adoption barrier.

The unique selling point for an electric boat is its clean propulsion. Nonetheless, if we include the production of electricity and generation in the carbon footprint calculation, the argument of clean propulsion does not keep true. If we add recycling and disposal to the calculation, it gets even worse.

If we look at ordinary early adopters of new technology, we can see that highly involved consumers are more aware of the sustainability and delay or reject the adoption of the new tech. We expect that involved consumers are more aware of the actual state of eco-friendliness of EVs and likely perceive it as less advantageous than non-involved consumers. (Ayantunji Gbadamosi, 2013)

Potential buyers who have concern for the environment are more likely to behave environmental friendly too, for instance, reduce their ecological footprint ((Tanner & Kast, 2003);(Heffner, 2007)).

In general, we expect consumers who value eco-friendly products to have a good attitude towards EVs. There are also those consumers that are thinking of sustainability and eco-friendly solutions and still have a negative attitude towards EV. This could be because of the high cost of buying and installing electric equipment, the ambiguity of the development in technology or the lack of charging infrastructure.

To establish a powerful promotion and communication plan, we must know how consumers feel and think about electric boats. It could be, eco-friendly consumers with a bad perception towards EVs would not be drawn to the marketing that stresses the green quality of the product. It would be better to provide information that reduces consumers' uncertainties and fears towards the new technology or product.

5. DISCUSSION

It seems that one of the biggest barriers to adoption of electric boats is that most people just don't think about it as an alternative to traditional boats. For the last two centuries, fossil-fuelled boats have been used for transportation. The electric boat will change the way and how we think about boating. It will also challenge our practices on how we use our boats and push our long-held norms in a new direction.

Furthermore, most consumers have never driven an electric boat, this adds to the fact that to buy an electric boat is not on people's radar. As increasingly more people start to see a higher number of the electric boat around them, it may perform as a sort of social plague, rising the share number of electric boats. The lack of awareness and knowledge about what electric boat offers are barriers to the adoption for the mass market.

Electric boats are also attractive due to many benefits like the quietness while in use.

Consumers that have a focus on the environment are likely to value product features like electric boats eco-friendly or its greenness. Electric boats are a step in the right direction of more sustainable and greener oceans.

The advantages of electric boats are clear, but there are some improvements needed to resolve the barriers to get closer to an adoption. A key barrier to an approval of electric boats is consumer perception. As stated consumers

believe that the range of an electric boat is not high enough to satisfy their needs while almost all trips are made are within the range of an electric boat. Consumers still might find that a boat with limited-range still might meet their average traveling needs despite it does not meet their needs to make the occasional long trips. A high frequency of those “inconvenient trips” might greatly discourage a potential buyer from purchasing an electric boat with limited-range. However, if consumers have various options for making those longer trips, they could find an electric boat with shorter range to still fit their needs.

Purchasing a boat is a rational decision, and buyers weigh up several factors. If buyers believe that an electric boat is impractical, it is very unlikely that they will buy such a product. It is therefore needed for useful information around what an electric boat is and what it offers.

A technical barrier holding back the acceptance of electric boats is the battery technology. The energy density of today’s batteries cannot compete with fossil fuels. It is therefore important that battery technology is moving forward in order reduce the difference in range, as this seems to be the greatest barrier towards an electric boat.

Another technological barrier is the time it takes to charge an electric boat battery, but this charging depends very much on how you use the boat. If it is about you use for shorter periods back and forth from the harbor, it will not be a problem. Charging the boat overnight is not a problem, as consumers will not be using their boat for at least eight hours.

Electric boats are at the moment in their first stage when different prototypes are created to see how they perform. Well established manufacturers will hopefully over time start adding electric drive to their model selection.

Hopefully will the consumers who dare to buy an electric boat demonstrate the feasibility of electrification of boating, especially towards all the dwellers who are thinking of buying one. This will then hopefully encourage and stimulate more consumer to demand electric boats.

6. FURTHER REMARKS

As transportation shifts towards electrification, utilities will need to be prepared for the potential grid impacts with strategies to mitigate higher loads and shifting demand. Electric utilities can play a pivotal role in the successful integration of electric boats, through the distribution of comprehensive information, innovative ratemaking, investment in infrastructure, and collaborative partnerships with stakeholders. Establishing strategic partnerships with municipalities can open windows of opportunity for utilities to understand how battery electric boats can be designed and tailored to maximise contributions towards achieving local and regional climate and zero emission goals. If approached proactively, utilities can help catalyse a future where the economic and environmental benefits of electric boats become widespread and support both improved asset utilisation and emissions reductions.

REFERENCES

- Ayantunji Gbadamosi, I. B., Sonny Nwankwo. (2013). *Principles of Marketing - A Value-Based Approach*. Palgrave.
- Båter i sjøen. (2017, 7-10 september) *Messe/Interviewer: T. Tveitdal*.
- Czyzewski, A. (2012). How to solve range anxiety. Retrieved from <https://www.newscientist.com/article/dn22401-how-to-solve-range-anxiety/>
- designbyben. (2012). MAYA: Most Advanced Yet Acceptable. Retrieved from <https://designbyben.wordpress.com/2012/10/15/maya-most-advanced-yet-acceptable/>
- Diamond, D. (2009). The impact of government incentives for hybrid-electric vehicles: Evidence from US states. *Energy Policy*, 37(3), 11.
- Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. *Energy Policy*, 48, 12.
- Everett, R. M. (1983). *Diffusion of innovation* (3 ed.). London: A Division of Macmillan Publishing Co., Inc.
- Gonzalez, F. (2017). *Electric Boats and Ships 2017-2027*. Retrieved from <https://www.idtechex.com/research/reports/electric-boats-and-ships-2017-2027-000509.asp>
- Gonzalez, M. (2016). Market round-up: Europe. Retrieved from <http://www.ibinews.com/country-reports/euro-round-up-5734>
- Hakkert, P. (2006). Design aesthetics: principles of pleasure in design *Psychology Science*, 48(2), 15.
- Heffner, R. R. (2007). *Semiotics and Advanced Vehicles: What Hybrid Electric Vehicles (HEVs) Mean and Why it Matters to Consumers*. Retrieved from
- Hekkert, P., Snelders, D., & van Wieringen, B. C. W. P. (2003). Most advanced, yet acceptable': Typicality and novelty as joint predictors of aesthetic preference in industrial design. *British Journal of Psychology*, 13.
- Kongelig norsk båtforbund. (2012). *Båtlivsundersøkelsen - Fritidsbåtlivet i Norge 2012*. Retrieved from Oslo:
- Lambilliotte, L. (2014). How Green are Electric Cars. Retrieved from <http://large.stanford.edu/courses/2014/p/h240/lambilliotte2/>
- LaMorte, W. W. (2016). Diffusion of Innovation Theory. Retrieved from <http://sphweb.bumc.bu.edu/otlt/MPH-Modules/SB/BehavioralChangeTheories/BehavioralChangeTheories4.html>
- Loewy, R. (1950s). Quote. In.
- Mcintyre, G. (2017, January 21, 2017). Hybrid yacht cruises into False Creek for Vancouver Boat Show. Retrieved from <http://vancouversun.com/news/local-news/hybrid-yacht-cruises-into-false-creek-for-vancouver-boat-show>
- Moore, G. A. (2014). *Crossing the Chasm* (3 ed.).
- Musk, E. (2013) *Elon Musk the mind behind Tesla SpaceX and solarcity*. TED talk.
- Packey, D. J. (1993). Market penetration for new technologies
- Roche, M. Y., Mourato, S., Fishedick, M., Pietzner, K., & PeterViebahn. (2010). Public attitudes towards and demand for hydrogen and fuel cell vehicles: A review of the evidence and methodological implications. *Energy Policy*, 38(10), 9.
- Rogers, E. M. (2003). *Diffusion of Innovations* (5 ed.).
- Sjöberg, L. (1998). Why do people demand risk reduction? *Safety and Reliability*, 7.
- Strategic Vision. (2013). *New Vehicle Experience Studies of Vehicle Registrants*. Retrieved from
- Tanner, C., & Kast, S. W. (2003). Promoting Sustainable Consumption: Determinants of Green Purchases by Swiss Consumers. *Psychology and Marketing*, 20, 19.
- Tsang, F., Pedersen, J. S., Wooding, S., & Potoglou, D. (2012). *Bringing the electric vehicle to the mass market: A review of barriers, facilitators and policy interventions*. Retrieved from
- Unknown. (2017). Eldrift.