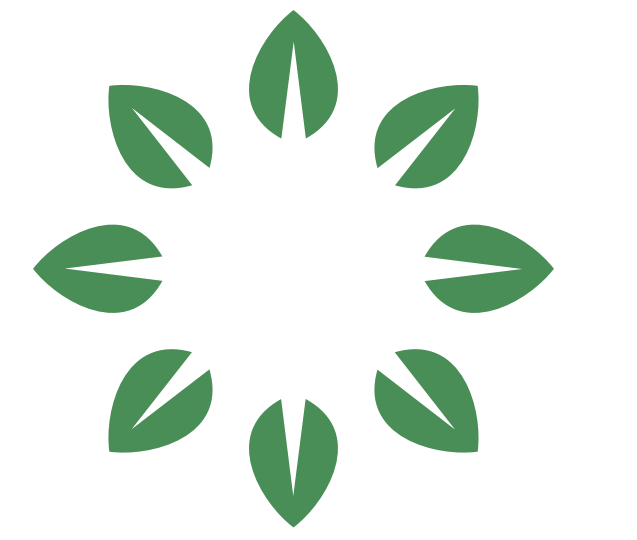


Charging technology for electric propulsion of maritime vessels and aircrafts



Bjarte Hoff¹, Trond Østrem¹, Terje Gjengedal¹, Clara Good² og Yngve Birkelund²

¹Department of Electrical Engineering (IVT), ²Dpartment of Physics and Technology (NT)

UiT The Arctic University of Norway

/ MOTIVATION

As a mean to reduce climate emissions and lower air pollution, electric vehicles has been embraced as one part of the solution. In recent years, electrification of the maritime sector (electric boats, ships and ferries) has also been prioritized by the Norwegian government and is a popular topic in research.

One of the challenges is how to charge these vessels efficiently. In Norway, the main focus has been on electric ferries, but also smaller electric boats for the fish farming and fishery industry has been developed. Charging solutions developed for large ships and ferries might not be suitable for smaller vessels.

Electric aircrafts is still in early stage of development, where only small two-seat aircrafts are available on the market. With future battery technology, electric aircrafts may replace fossil fuel passenger aircrafts for short distances.

For both small vessels and aircrafts, there are currently no standard for charging. Each manufacturer supplies their own solutions. In addition, charging is in most cases confined to airport and harbours/ports. This can result high power demand and grid challenges.

This project aim to investigate charging technology in relation to current and future demand.

/ PROJECT OBJECTIVES

Objective 1

Overview of existing charging solutions and future needs within maritime vessels and aircrafts

Objective 2

Evaluate the use of charging technologies from other areas such as electric cars and large ferries/ships

Objective 3

Investigate how charging of electric transport has influenced the electricity grid, including mitigations.

Objective 4

Active participation in relevant forums for national and international standardization.

Objective 5

Upgrade laboratory facilities for future research within charging technology

Objective 6

Map challenges, unsolved problems and topics for future research projects.

/ ELECTRIC MARITIME VESSELS

Maritime sector has operated diesel electric ships for many years, where electric motors is used for propulsion. The energy is generated from one or more diesel generators.

In order to reduce fuel consumption and emissions, some of the generators have been replaced with batteries creating hybrid vessels.

In recent years, the diesel generators have been completely replaced with battery storage in ferries, where MF Ampere was the world's first.

For smaller vessels, GMV Zero (Astrid Helene) is the first fully electric boat for the fish farming industry. In addition, a hybrid fishing boat (Karoline) has been built that uses batteries while fishing and diesel during transit.

/ ELECTRIC AIRCRAFTS

All-electric aircrafts exists today as small light aircrafts, normally with two seats. They are well suited for aviation schools, where short range and low load capacity does not pose a challenge.

To test the technology, UiT is in the process to purchase two electric aircrafts for the aviation school at Bardufoss. In addition, Avinor has purchased one Pipistrel Alpha Electro for testing and research purposes.

Major manufactures such as Airbus, Rolls-Royce and Siemens are investing in electric aircraft development, first for smaller passenger aircrafts for short distances. E-Fan X is expected to fly in 2020, based on the BAe 143 hull.

In addition, there are several prototypes and research projects where both batteries and solar cells are being used as energy source.

/ CHARGING SOLUTIONS

Charging solution comes in all kind of forms and power levels from electric ferries to electric toothbrushes, each with its own set of requirement.

It is common to separate between conductive and wireless charging.

Conductive charging

Charging is performed by connecting a plug, which provides direct electrical connection between the charger and the device being charged.

Wireless charging

Inductive coupling is the most common type of wireless charging, where two coils placed close to each other acting as an open transformer. For increased efficiency, the frequency is higher than the 50 Hz grid.

Capacitive coupling is an alternative, used for low power.

/ STANDARDS

International standards for charging is important to ensure that infrastructure, (especially public infrastructure) can serve several users independent on the manufacture.

For electric vehicles, commonly applied standards are:

- SAE J1772 IEC Type 2 - AC charging up to 44 kW

- CHAdeMO - DC fast charging up to 400 kW

- CCS - DC fast charging up to 350 kW

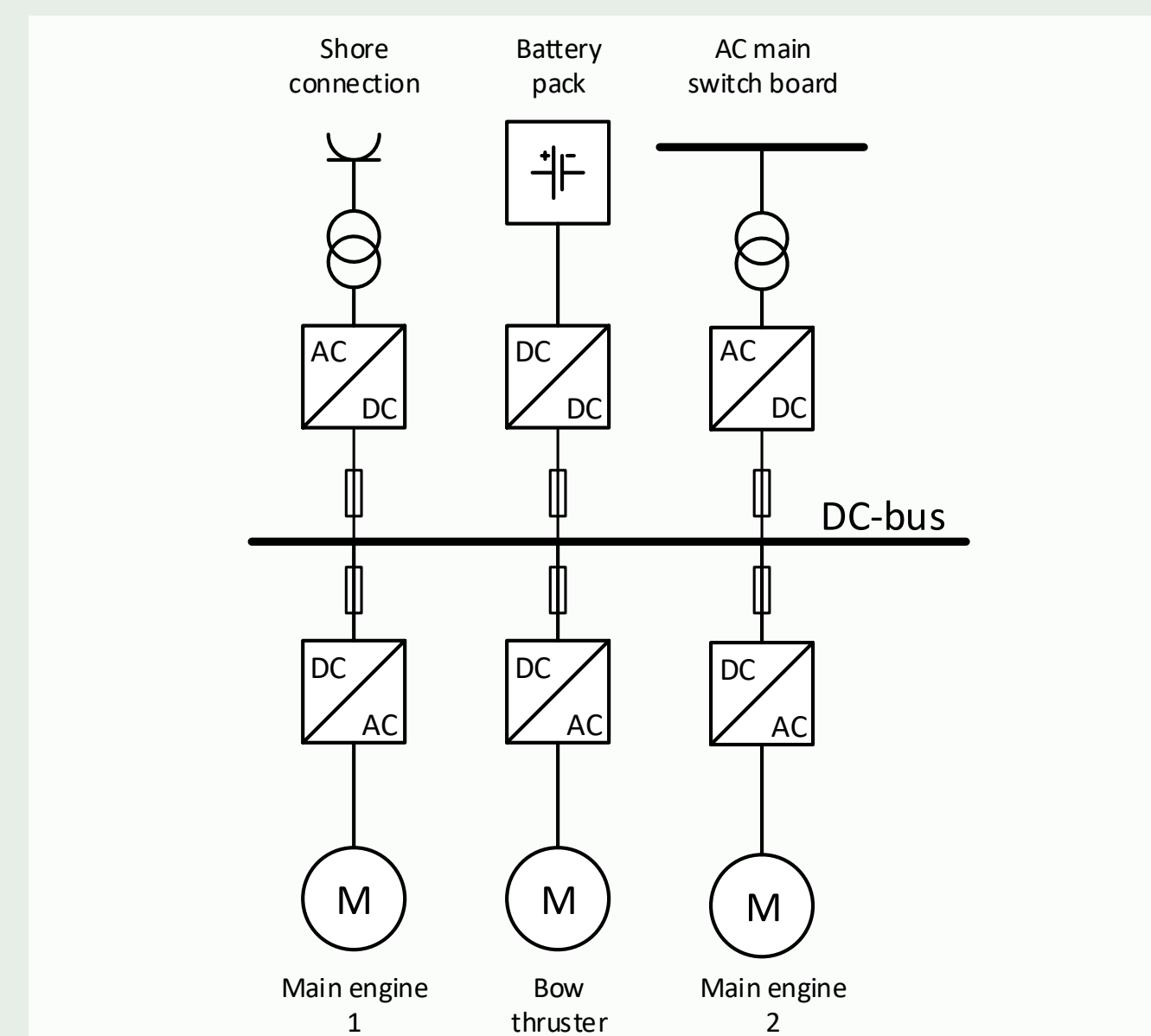
With fast charging supporting up to 400 kW, charging solutions for electric vehicles becomes a viable solution for maritime vessels as well. Sharing infrastructure between different types of electric transport systems could reduce the total cost and increase availability.

/ Battery capacity and charging current

Vessel	Battery capacity	Charging power	Charging solution
MF Ampere	1040 kWh	1,2 MW	ST-Pantograf Cavotec plug
GMV Zero	350 kWh	2 x 87 kW	2 x 125 A plug 400 V
MF Future of the Fjords	1,8 MW	2,1 MW	Cavotec plug
Karoline (Hybrid)	195 kWh	44 kW	63 A plug 400 V
MF Folgefonn (Hybrid)	1000 kWh	1 MW	Inductive + NG3 plug
Color Hybrid	5 MWh	7 MW	NG3 plug

Aircraft	Battery capacity	Charging power	Charging solution
Pipistrel Alpha Electro	21 kWh	3 kW 1~20 kW 3~	Off-board charger
E-Fan 1.0	34.5 MWh	Unknown	Unknown

/ Typical electric propulsion single-line diagram



/ Communication in charging solutions

When charging for electric transport, communication between charging station and vehicle/vessel/aircraft can provide advantages such as:

- Adjust charging current according to available power at the charging station

- Coordination and power sharing between multiple charging points

- Communicate grid faults

- Energy metering to generate invoices

- Supervision of the charging infrastructure

Communication medium can be separate wires, over the power wires or wireless.

/ Shore connection standards

Shore connection to supply larger ships at ports have been standardized by IEC, IEEE and PAS. Although not made specifically for electric ships, they do supply energy that can be used for this purpose.

The standards are split between high voltage, low voltage and communication.

NEK IEC/ISO/IEEE 80005-1:2018 - High voltage

For supply over 1 MVA with a voltage of 6,6 kV or 111 kV AC.

NEK IEC PAS 80005-3:2014 - Low voltage

For supply up to 1 MVA with 400 V AC three-phase. The system uses a 350 A plug, where several plugs are paralleled for higher current levels.

NEK IEC/IEEE 8005-2:2016 - Communication

Ethernet based on MODBUS TCP and optical fiber.



Fig. 1 GMV Zero (Photo: Grovfjord Mek. Verksted)



Fig. 2 Pipistrel Alpha Electro (Photo: Pipistrel)



Fig. 3 Wireless inductive charging (Photo: Wärtsilä)

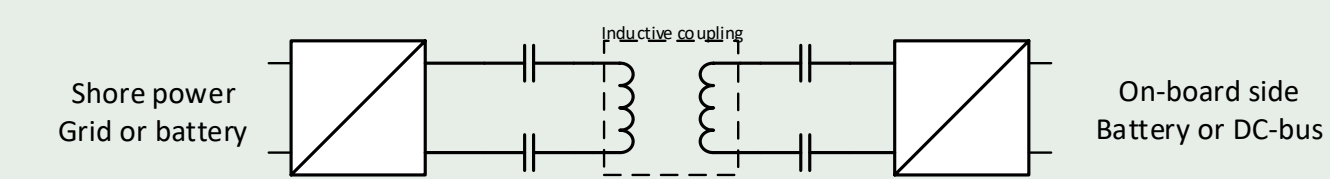


Fig. 4 Wireless inductive coupling



Fig. 5 Low voltage shore connection plug (Photo: Philip Hauge)



Fig. 6 CHAdeMO, CCS and Type 2 plug (Photo: Paul Sladen)



Ladeteknologi
for elektrifisert framdrift av
maritime fartøy og luftfart

Visit the project website at <https://site.uit.no/ladeteknologi/> to stay updated

Referanser:

1. IEC, "NEK IEC/ISO/IEEE 80005-1 High Voltage Shore Connection (HVSC) Systems," 2012.
2. IEC, "NEK IEC/ISO/IEEE 80005-2 High and low voltage shore connection systems – Data communication for monitoring and control," 2016.
3. IEC, "NEK IEC/ISO/IEEE 80005-3 Low voltage Shore Connection (LVSC) Systems," 2014.
4. Guidi, J. A. Suul, F. Jensen and I. Sorfonn, "Wireless Charging for Ships: High-Power Inductive Charging for Battery Electric and Plug-In Hybrid Vessels," in IEEE Electrification Magazine, vol. 5, no. 3, pp. 22-32, Sept. 2017.
5. Avinor, "Elektriske fly," 2018. [Online]. Available: <https://avinor.no/konsern/miljo-og-samfunn/elfly>. [Accessed: Oct. 18 2018].

Project information

This poster is a part of the project "Ladeteknologi for elektrifisert framdrift av maritime fartøy og luftfart" is financed by ARC strategic funds.

The project has a duration of one year and is a cooperaiton between the IVT and NT faculty at UiT.