Battery system concepts for fully electric vessels

Dear reader,

Half a year after our first newsletter, I may present to you our progress again!
We have been busy with selecting the right topology for our proposed hybrid battery. We performed an in-depth review of three different hybrid battery topologies, of which you can find the summary in this newsletter and on our website.

For the SEABAT project, the “module level converter” topology deemed to be the best tradeoff so here we are: the architectural layout of our new battery solutions is known!
This milestone was immediately followed by another milestone: ordering the battery cells.
This means that, after delivery time, we can finally start working on the hardware. We eagerly look forward to presenting to you the first results of our realizations.

Further on in this newsletter, you will find some updates regarding our dissemination activities. We can present to you our first paper and may share a broadcast on Dutch national television.
Last but not least, I’m happy to announce two occasions were you can meet us in public. We will be present at the TRA in Lisbon, but more importantly, you can still register for our first academic workshop. There, we will present in more detail the topics addressed in this newsletter and the topics addressed in our deliverables.

I hope to see you there!
Dr.ir. Jeroen Stuyts / SEABAT project coordinator

SEABAT facts and figures

Solutions for large batteries for waterborne transport

15 partners from 8 countries

9.58 M€ Funding from EC in H2020 program

48 months started 1 January 2021

Project

The SEABAT project follows a 6 steps approach to come to 3 key innovations:

Step 1: Development of an overarching system architecture for full-electric hybrid topologies.
Step 2: Creation of a modular hybrid high energy and high-power battery pack.
Step 3: Designing and developing a novel converter concept
Step 4: Developing a **b**attery **m**anagement **s**ystem that can handle a range of hybrid battery lay-outs.
Step 5: Proving the reduction of the production process costs in an industrial pilot.
Step 6: System integration and validation.

On the SEABAT website you find a more detailed explanation of each step and aimed innovations.

Evaluation and selection of architectural concepts

At this moment the SEABAT project has finalized step 1 of the project: Flanders Make, together with project partners DAMEN, FCSI, RINA, SOERMAR, VARD, ABEE, IMECAR, FRAUNHOFER, IKERLAN, MGEP, SINTEF and POLIT, developed a modular and flexible battery system design. During the projects’ general assembly of last February, the consortium agreed on the model level converter, based on the results presented

The main goal of the SEABAT project is to develop a cost-effective **h**ybrid **e**nergy **s**torage **s**ystem (HESS) architecture for large marine applications that is scalable to at least 1 MWh and validated at a level of 300 kWh. For this purpose, a suitable system architecture is required for a mix of high-energy and high-power batteries that allows a balanced compromise between ship energy and power requirements. In this regard, a novel electrical storage concept is needed to be flexible, scalable, energy-efficient, and cost-effective to optimally control the power flow between the high-energy and high-power batteries. While keeping an envisaged lifetime of 10-years into account.

Three HESS topologies with novel converter concepts, are explained, evaluated, and compared towards a baseline state of practice mono-type battery topology. The HESS topologies that are investigated in this work are based on the following concepts:
- Topology 1 module level converter: converter integrated into the battery modules.
- Topology 2 discrete: switching between individual cells.
- Topology 3 partial power: partial power converter integrated into the battery modules.

The evaluation and comparison of the HESS topologies is made via a generic optimization and modeling process. The inputs of the optimization are high-energy and high-power battery cell specifications, and the operational requirements of different vessels as the use case for the design process of the HESS defined in the application matrix.
The output of the optimization is the optimal size of each topology per application for 10 years operational lifetime of the vessel. The investigated topologies are compared against the baseline to the key performance indicators (KPIs) defined in the Key performance Indicators (KPI) List. The used KPIs are:
- total battery system cost;
- total battery mass;
- total battery volume;
- battery system losses;
- required amount of components for each topology.

Scores of the before-mentioned topologies:

Topology 1 scores on average on all points better than the baseline battery pack. It has the most advanced models for the different systems. However, it uses the same approach and input requirements as the other topologies.

Topology 2 scores on average higher on volume, weight and number of components when comparing to the baseline. Assigning one switching device to multiple cells, instead of one per cell, is a possible solution to improve the size and cost of this topology.

Topology 3 scores on average equal with respect to the battery pack volume. While an improvement on the other KPIs is feasible. One major improvement for this topology would be related to the DC/DC cost model, the heat sink is at the moment oversized and it would be favorable for the cost when a more optimized cooling size, and thus cost, is used.

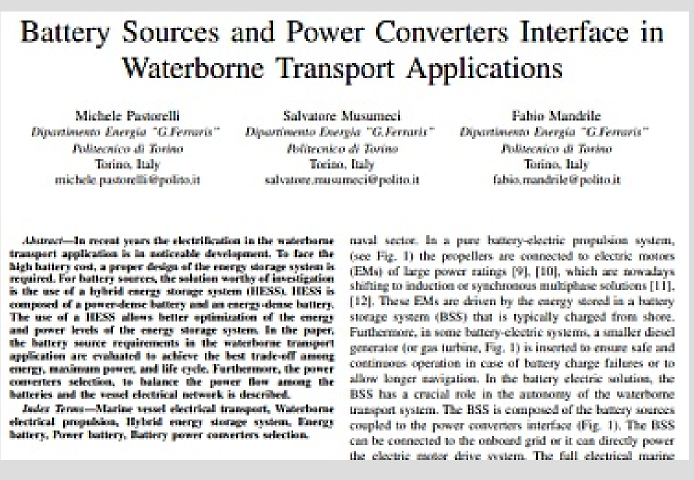
SEABAT goes public

ACADEMIC workshop

10 JUNE 2022
Are you interested in the latest trends in maritime electric propulsion?
Sign up for the (free) Workshop on Hybrid energy storage systems oriented to maritime applications

Publication

During the International Conference on electrical and electronic technologies for automotive (AEIT), SEABAT consortium partner POLITO, Michele Pastoreli, presented the publication “battery sources and power converters interface in waterborne transport applications.”
Follow the link to read the full article.



Battery Sources and Power Converters Interface in Waterborne Transport Applications

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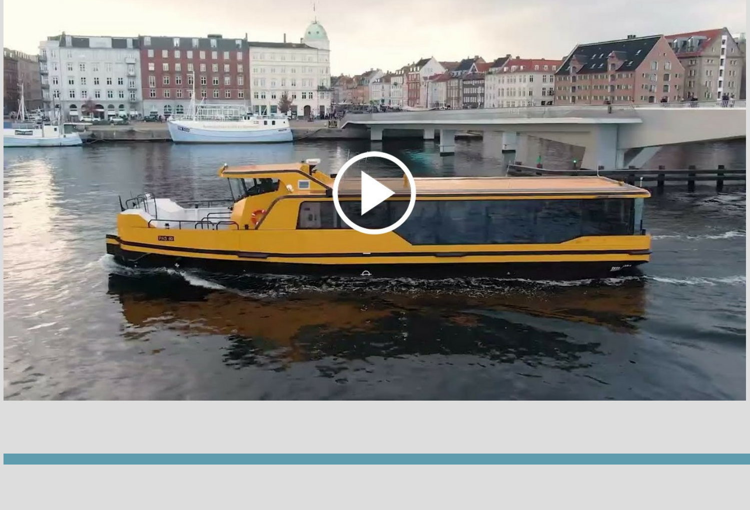
Abstract—In recent years the electrification in the waterborne transport application is in noticeable development. To face the high battery cost, a proper design of the energy storage system is required. For battery sources, the solution worthy of investigation is the use of a hybrid energy storage system (HESS). HESS is composed of a power-dense battery and an energy-dense battery. The use of a HESS allows better optimization of the energy and power levels of the energy storage system. In the paper, the battery source requirements in the waterborne transport application are evaluated to achieve the best trade-off among energy, maximum power, and life cycle. Furthermore, the power converters selection, to balance the power flow among the batteries and the vessel electrical network is described.

Index Terms—Marine vessel electrical transport, Waterborne electrical propulsion, Hybrid energy storage system, Energy battery, Power battery, Battery power converters selection.

naval sector. In a pure battery-electric propulsion system, (see Fig. 1) the propellers are connected to electric motors (EMs) of large power ratings [9], [10], which are nowadays shifting to induction or synchronous multiphase solutions [11], [12]. These EMs are driven by the energy stored in a battery storage system (BSS) that is typically charged from shore. Furthermore, in some battery-electric systems, a smaller diesel generator (or gas turbine, Fig. 1) is inserted to ensure safe and continuous operation in case of battery charge failures or to allow longer navigation. In the battery electric solution, the BSS has a crucial role in the autonomy of the waterborne transport system. The BSS is composed of the battery sources coupled to the power converters interface (Fig. 1). The BSS can be connected to the onboard grid or it can directly power the electric motor drive system. The full electrical marine



SEABAT on Dutch TV

The Dutch television channel RTLZ made an item on the importance of electrification of the marine sector and this was explained with the SEABAT project at Flanders Make. (in Dutch)

MEET SEABAT

Meet SEABAT and its project members in person at the Transport Research Arena (TRA) being the largest European research and technology conference on transport and mobility on 14-17 November 2022 in Lisbon, Portugal. SEABAT will have together with its sister project CurrentDirect a special session on the electrification of the maritime sector.

TRA TRANSPORT RESEARCH ARENA LISBON 2022 14 - 17 NOVEMBER

SEABAT partners

FLANDERS MAKE DRIVING INNOVATION IN MANUFACTURING · DAMEN · FINCANTIERI Si evolving integration · RINA · FUNDACIÓN soermar · VARD a Fincantieri company · ABEE · IMECAR · UNIRESEARCH · cea · Fraunhofer · ikerlan MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE · Mondragon Unibertsitatea Goi Eskola Politeknikoa Faculty of Engineering · SINTEF · POLITECNICO DI TORINO