Modular Energy Concept

White paper report

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Abstract

This white paper is set to communicate the contents and valuable insights from the discussions held during the practical case study workshop on Modular Energy Concepts (MEC) at the Living Energy Conference 2019 in Rotterdam, The Netherlands. After a brief introduction, the project *Modular Energy Containers* with its key challenges were presented by Ankie Jansen, Port of Rotterdam to the participants. [Link to presentation]

Several organisations have joined forces in the MEC project, a Modular Energy Concept to develop Modular Energy Containers in order to make clean energy available in a flexible way for industry and the transport sector.

Outline

The workshop has identified several challenges for a Modular Energy Concept, opportunities and research questions in the following areas

- Financial and technological uncertainties
- Business models for MEC
- Operations management of modular energy containers
- Innovation & upscaling
- Data sharing
- Environmental impact

This white-paper report will be used as a basis to set up follow-up innovation projects with the stakeholders and to reach a wider international community.

Introduction

Several organizations have joined forces in the MEC project, a Modular Energy Concept to develop Modular Energy Containers in order to make clean energy available in a flexible way for industry and the transport sector. One of the main initiators of the project is Heineken. The initial use case for modular energy containers will be as modular power supply for electrical barges. As such, modular energy containers are an important addition to the existing energy portfolio, supporting the energy transition and eliminating air pollution for inland shipping in the Amsterdam-Rotterdam-Antwerp-Nijmegen area, the busiest inland navigation region in Europe.
MEC is based on 20ft containers, filled with batteries (alternatively fuel cell). Each modular energy container provides an energy supply of 2MWh, enabling a 100km range for barges. There are multiple use cases of modular energy containers, ranging from powering inland barges, grid and energy market applications (FCR, AFRR or congestion management (Copex) plus many other applications for modular energy systems in the port. Ship owners only pay for use of modular energy containers, they do not own it (pay-per-use model).

Challenges and research questions

This section reviews the various challenges that the MEC project faces and may choose to address. It is by no means an exhaustive list and is likely to evolve as the technologies and available utility incentives, programs and market offerings evolve. Understanding system configurations that stakeholders may choose to deploy not only helps define how interconnected applications are required but also helps animate what types of studies are appropriate.

Financial and technological uncertainties

There are several financial assumptions to be revisited and questions to be answered, which form the cornerstones and key preconditions for the success of the MEC initiative. These include:

- Implications of CO_2 prices and governmental incentives
  Diesel as fuel for ships has low cost, free of tax in the current regulatory framework. How efficient are the overall CO_2 savings compared to other solutions? What is the effective CO_2 price? How is the CO_2 price influencing the profitability for a MEC-initiative?
- Financial business case for barge owners
  How to fill the gap between a long term investment in a new or refitted vessel for ship-owners and uncertainty about the future energy system? The costs of batteries are still very high. Is it better to invest now or wait till the price has dropped?
- Modular vs. fixed power supply
  Why would the business case of modular batteries for ships perform better than fixed batteries? In other words, what is the underlying rationale behind a modular system vs. a fixed system? A comparison with the failure of modular battery systems in Electric Vehicles (cars) can be helpful to answer this question and explore why this use case is different?
- Technology portfolio mix
  The current MEC covers the use of batteries. How would the business model change for other technologies? What is the impact of using a heterogeneous fleet of technologies such as batteries, hydrogen fuel cells, power-to-gas (methanol) and how can this help to respond quicker to new market opportunities? Where are the tipping points?

Business models for modular energy containers

An Energy Storage Company (ESC) invests in energy containers and the infrastructure. The ESC makes the containers available in several user markets (multiple cash flows). There are several possible business models and user markets, optimising a fleet of modular energy containers as a distributed modular asset. Possible business models include the use of modular energy containers to power barges, to trade available energy stored in the modular energy containers' batteries, while connected to grid on energy markets, to reduce peak loads on the energy grid and help grid operators to build less grid and to rent out modular energy containers as mobile generators / floating power hub to facilitate and power fuel diesel vessels, peak-shaping at container terminals and powering specific event locations. A range of open research questions exist related to the evaluation of these business model options as well as their combined operations. The data-driven decision making and control mechanisms required to operate them are also of high relevance and interest to practitioners and research:

- <u>Energy service business model: barge operators</u>
A primary business model area is the provision of energy services to barge operators via battery switching services. How could such a business model be best operated?
- <u>Energy services business model: grid operators</u>
Modular energy containers that are connected to the grid while idling (i.e. not used) can be used to provide grid balancing services (especially primary, secondary reserve). How can the trade-off between the primary business models be managed? How can the participation in balancing markets be combined with the use of the modular energy containers for ship propulsion (the modular energy containers on the ship are disconnected from the grid?). The modular energy containers are designed for a specific corridor. How can the varying energy consumption for propulsion due to e.g. wind, load, etc. be handled? How can good prediction models be designed that predict the intervals of connect - disconnect of the modular energy containers to the docking station i.e. grid (based on logistics performance, real-time congestion data and reliability measures)?
- <u>Energy service business model: local energy</u>
Renting out modular energy containers as mobile generator or as a floating power hub to facilitate and power fuel diesel vessels, peak-shaping at container terminals and powering specific event locations may be conceivable? Are these viable and how do they compare to other revenue pools?
- <u>Power trading business model</u>
Trading of available energy stored in modular energy containers' batteries, while connected to grid on energy markets may be a profitable arbitrage business model. How large is the value pool and how will it likely develop in the future? What are good bidding strategies for these markets? How can the business model be combined with other types? The container operator could, for example, act on the electricity market on behalf of the shippers. The operator would take over the risks created by varying electricity prices. They could optimise their profits by forecasting the electricity prices and controlling the charging of the batteries in the docking stations of the ports.
- <u>Pricing and tariff options</u>
Development of a dynamic pricing models across business areas based on prediction of market developments and pprediction of available capacity

<u>Operations management of modular energy containers</u>

Operations management of modular energy containers poses a significant challenge, which research can inform. The configuration of the modular energy containers network architecture is related to logistics and energy optimisation and constrained by the existing infrastructure (logistics and energy grid). Just-in-time logistics of modular energy containers are necessary in order to optimise the performance.

We summarize selected topics in this area which may require attention:

- Interface and systems architecture
  What is the best design of the system architecture? The interface design is crucial for every modular system. How modular should it be? The danger is to be locked into one interface solution which cannot cope with other technologies.
- Technological Framework
  Are standards needed or these already exist for electrical barges? (e.g. for sharing of information)
- Digital logistic network configuration and coverage
  How should the network be configured, and what is the best geographical coverage. A multiple hub strategy up to Germany is conceivable
- Asset requirements capacity
  How will the supply of sufficient battery capacities be handled for the chosen business models? How many battery units are required to provide the required service level?

Innovation & Upscaling

The current MEC business plan foresees a start-up, upscaling and expansion phase which follow consecutively. During the startup phase 1-6 pilot vessels will join the network. During an upscaling break-even will be reached at c. 100 vessels. In an expansion scenario 400-600 participating vessels are envisioned. There are several scenarios and scope to take into account, while upscaling. Research questions include:

- Ownership
  This is a networked/platform innovation, where there is not a single natural owner. Ownership structures remain an open issue.
- Involvement of stakeholders
  How can stakeholders be involved? How to get customers on board (i.e. shippers). For the pilot a 10-year excl. contract with Heineken is foreseen.
- Standards and regulation
  What (data)standards are needed to scale up?
- Scale up scenario of value
  How to scale up from one corridor to a network of corridors. Is the key to innovation focused on innovating within one value chain or is the innovation potential in merging of different value chains / corridors (simultaneously)?
- International boundaries

How do companies co-operate and co-ordinate international waterway regulations in terms on energy storage and usage for inland shipping and what are implications for the MEC project?

- Incentives & Policy
  How can municipalities incentivise ship owners to purchase electric barges?

Data-sharing / data platform

Modular energy containers will generate different types of data, such as energy use, GPS, ETA, battery management. Several stakeholders, such as OEM, barge operators, terminal operators, shippers, authorities could gain and benefit from using this data, making logistics more efficient. Main question here is how to share this data and link it to (existing) data platforms?

- Using data from modular energy containers to improve reliability, logistics performance and energy system optimisation
  How can modular energy containers' data technologies be designed enhancing different roles in the shipping supply chain and improve reliability and logistics performance as well as the energy infrastructure?
  How can just in time logistics be linked to optimising of the energy system, storage vs use?

Environmental impact

The CO2 savings are estimated at 1000 tCO_2/yr/vessel of savings (tank to propeller). This excludes the battery life cycle CO2 output. Other environmental impacts are related to Nox, PM (air quality) and noise reduction. An important question for research pertains to the quantification of these effects. The following questions may guide the analysis:

- What is the environmental impact of the MEC project (in different scenarios), including the battery life cycle impact?
- How much does the concept rely on the constant availability of cheap & renewable energy over the coming years? The modular energy containers will compete on the electricity markets with other users like road transport, heat and home consumption. Where is the MEC use case placed in the merit order of demand?

Conclusions

The MEC project links the energy system to the logistics network, thereby creating opportunities to further optimize the in-land water way system in terms of logistics performance and environmental sustainability, while creating new business opportunities for different stakeholders involved. The modular energy concept creates a demand for ever more flexible and modular IT solutions combined with energy demand, supply and storage. Ideally, the modular energy containers should be located where the data is produced, i.e. locally and close to the user. Ports have an interest in this technology to reduce emissions of pollution, CO2 and noise. The development of this technology should not only focus on certain corridors in the Netherlands. Cooperating projects in Germany would help to make this system successful on the large-scale (international).
A challenge is to position this innovation in a traditional sector. Shippers are typically old family businesses. The change from fossil fuels to electricity will change their entire business model. The variable costs will change. Already today firms are taking over the risks from buying diesel at the fuel markets for the shippers. The modular energy containers' operator can act on the electricity market on behalf of the shippers. Will the shippers invest in the necessary electrical engines? They are used to replace their engines every 10-15 years. How can they find the money when the banks are not investing into an uncertain future of the shipping industry?
Workshop participants agreed that the following steps are important in further adoption and scale up of MEC:

- Build up trust in the technology and its cost effectiveness
- Align decision-makers and work towards a tipping point
- Cooperation with brand owners (like Heineken) to make it international successful

Additional resources:

- Inland Waterways Transport © ROYAL HASKONINGDHV 2019
- Container for the uninterruptible power supply, Friedhelm LOH Group 2018
- Supporting diverse roles for people in smart energy systems, Elsevier energy research and social science 2019