DNV·GL

Hybridization update – batteries in OSVs

The Marina Bay Sands

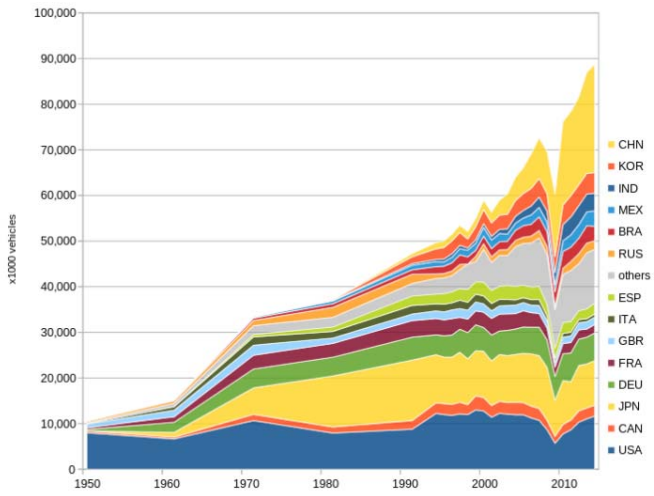
Singapore, 19-20 April, 2016

Offshore Vessel & Rig Connect Asia

A.Eknes, Segment director Offshore Service Vessels

20 April 2016

Number of vehicles (all types) produced per year world wide



Source: https://en.wikipedia.org/wiki/Automotive_industry#By_year / www.oica.net

Global sales of plug-in electric vehicles

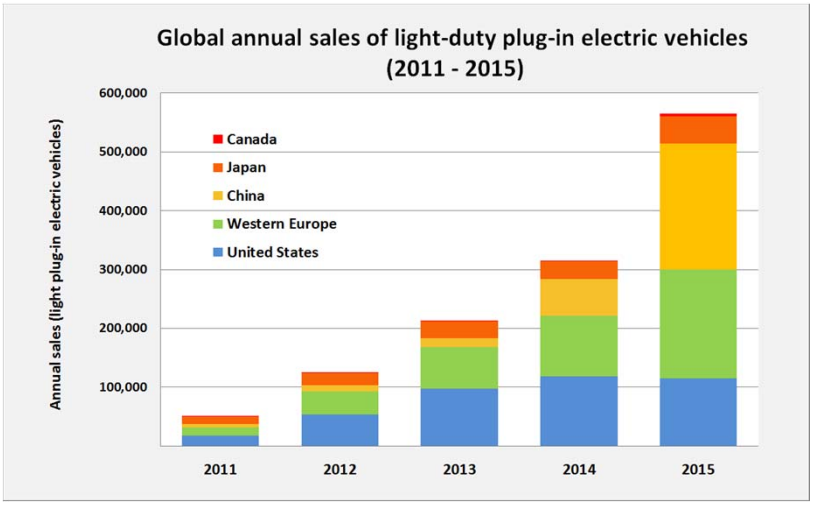


Illustration: Wikimedia / Mariordo (Mario Roberto Durán Ortiz)

Tesla Model S P85D – Ludicrous mode: 0-100 km/h in 2.8 seconds
100% battery powered, reach about 500km in one charging

Our concern:
To safeguard the vessel & her crew
- when operating in realistic offshore environment

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Batteries for offshore vessels:

Background and motivation

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Reliability of vessel systems during offshore operations

Availability is key

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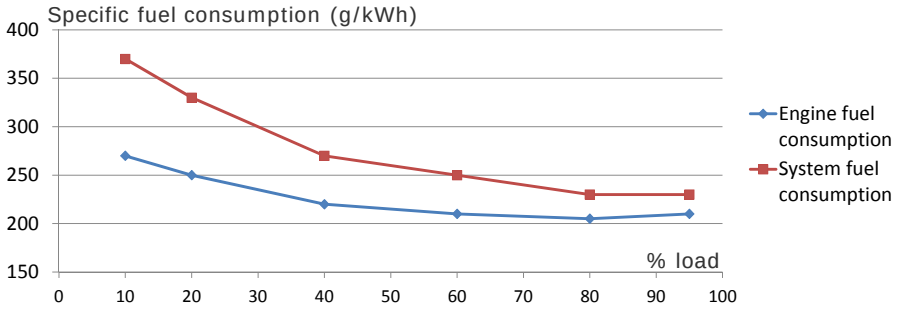
Engine utilisation for electric generator sets

Good and practical system, but also large potential for improvement



Engines and systems in offshore vessels operates at low load during:
DP, Waiting/idling, Port stay

Excessive engine wear and tear
Increased fuel consumption
Increased emissions to air

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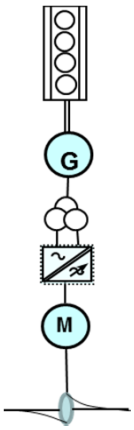
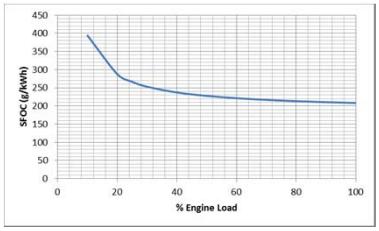
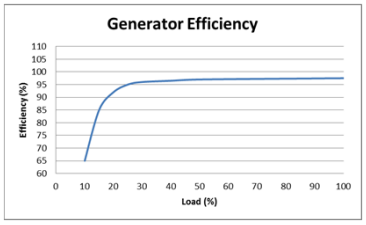
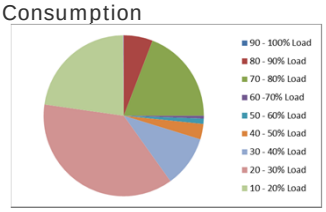
Hybrid Ships - Running energy system on optimal loads





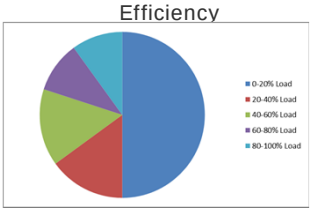


Specific Fuel Oil Consumption



OSV

Generator Efficiency



TUG

Lessons from ongoing hybridisation projects: Benefits for CHARTERER and for OWNER

Fuel oil consumption

- Up to 15% saved fuel consumption over a year

Engine saved operating time

- Between 1500 and 4000 saved engine running hours per vessel

Operability

- Better operation with less tripping/knocking
- Quicker vessel response

Safety & reliability

- Higher availability and redundance, reducing black-out risk

New technology open up for closed or semi-closed bus operation

- Open up for shutting down engines on e.g. DP operation
- Less running of engines on very low loads

Short intro to battery technology

The build up of a battery package

Cell

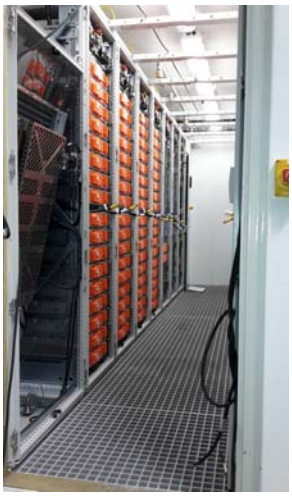
Module

Rack

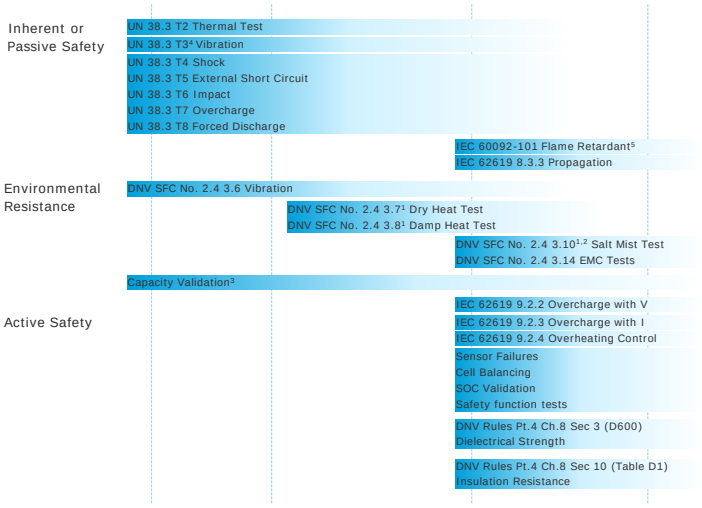
Dictionary – 'Battery':

Any large group or series of related things:

"a battery of questions"



The Path to Class approval: what tests to do at what level



Special Considerations

1. Shall not exceed maximum temperature rating of battery cell. Not intended to be a destructive test. At the module level, considerations need to be made for active cooling.

2. Does not include submersion. In humid environments, should evaluate the IP rating of the enclosure, if any. Not relevant to sub-module if no IP rating is present. Condensation as a result of dew point shall not short cell electrodes.

3. If the intent is to evaluate accuracy of the electronics, this need only apply to module and higher. If the intent is to evaluate variation between cells, then the cell level is included.

4. May have overlap with DNV SFC No. 2.4 3.6 at cell level

5. Evaluation of enclosure against flame – shall not transmit heat or flame to internal components

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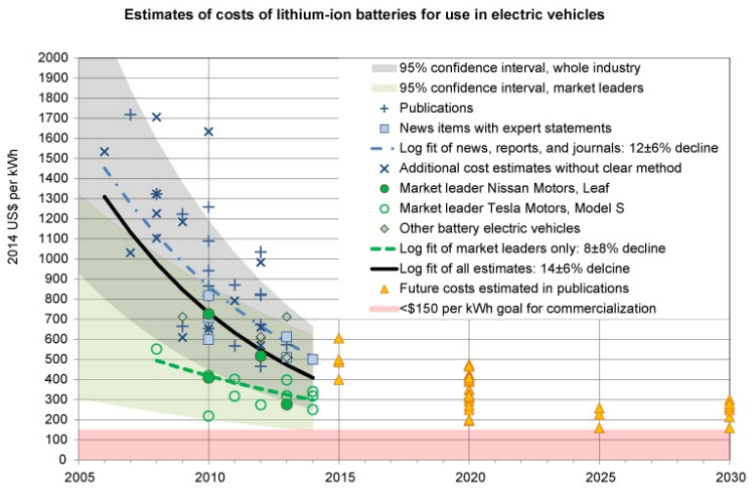
Battery costs are dropping as production volumes increases

Batteries have dropped in price by some 60–70% in the past four years



Björn Nykvist and Måns Nilsson, 2015

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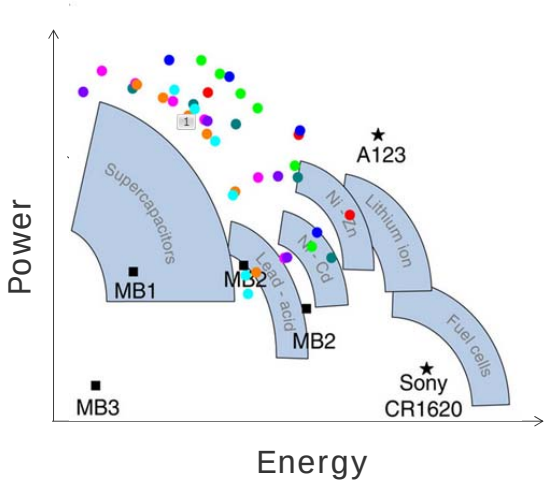
Key questions: How much power, and for how long ?



Power and energy density for modern Li-ion batteries

Chemistry	Thermal Stability	Energy Density	Power Density	Max C-Rate
Lithium Iron Phosphate ($LiFePO_4$)	Very good	Low 50-130 Wh/kg	High > 1000 W/kg	> 20
Lithium Manganese Oxide (LMO)	Good	Moderate 100-180 Wh/kg	Moderate 160-720 W/kg	8
Lithium Nickel Cobalt Manganese (NCM or NMC)	Good	Moderate 130-170 Wh/kg	Good 480-800 W/kg	10
Lithium Cobal Oxide $LiCoO_2$ (LCO)	Moderate	Moderate 40-200 Wh/kg	Moderate 130-380 W/kg	4
Lithium Titanate (LTO)	Very good	Low 40-90 Wh/kg	High 700-1300 W/kg	10
Ultracapacitors	Good	Very Low ~1-10 Wh/kg	Very High ~10,000 W/kg	100

DNVGL activities – including lessons learned

Overview – some DNVGL activity areas within battery solutions

DNVGL invested in battery technology through acquisitions and R&D

Research and Development

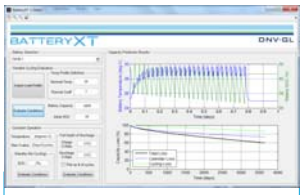
Full scale demonstration project

- Classification, risk analysis, safety issues, environmental analysis
- Modelling and simulation
- Monitoring and measurements during operation

Large Test shops for commercialisation

Test, inspections and certification laboratory

- Providing independent test facility
- Battery and energy storage R&D, consultancy
- More than 23 mill.USD invested in partnership with New York state

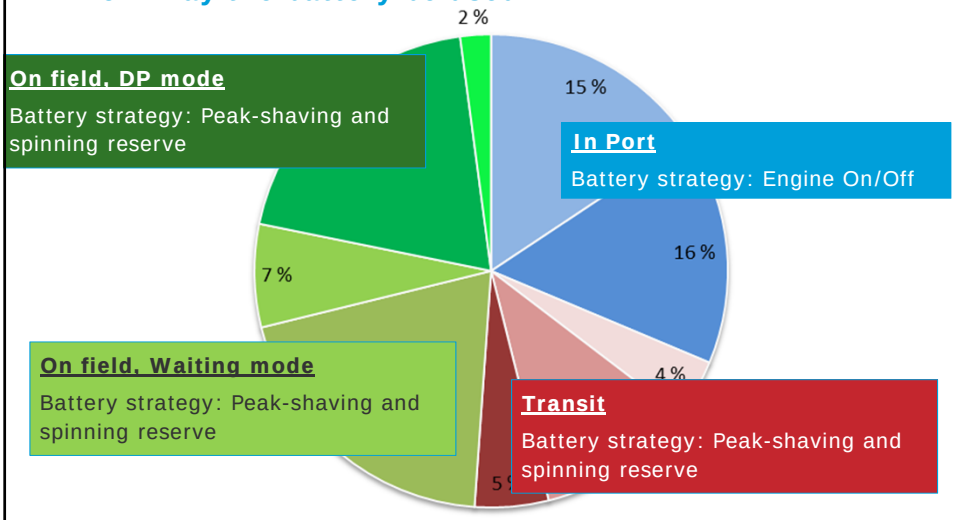


Tools and software for advisory services

Life time and reliability issues analysed

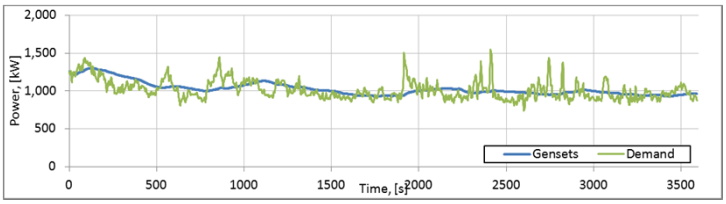
- The tools are developed from lab tests
- Unique and independent third party tools for hybrid and battery systems
- Cover a wide array of battery types

Now let's get aboard:
- How may the battery be used?

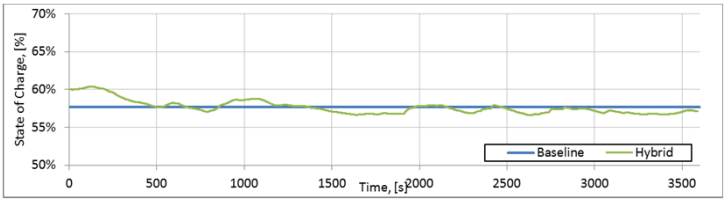


Peak-shaving strategy example

Produced power



Battery State of Charge



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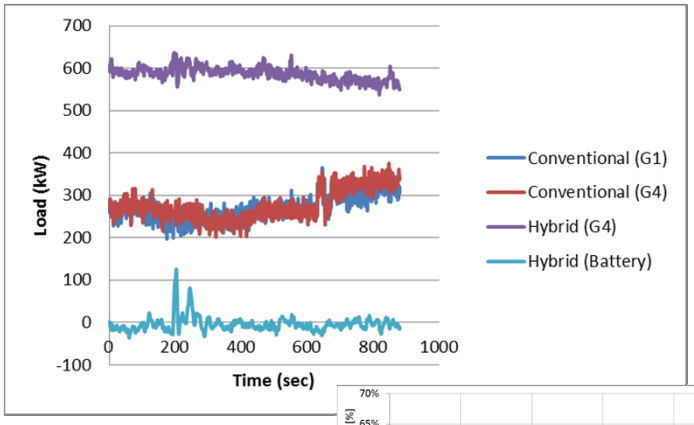
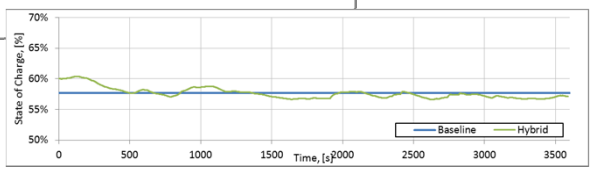
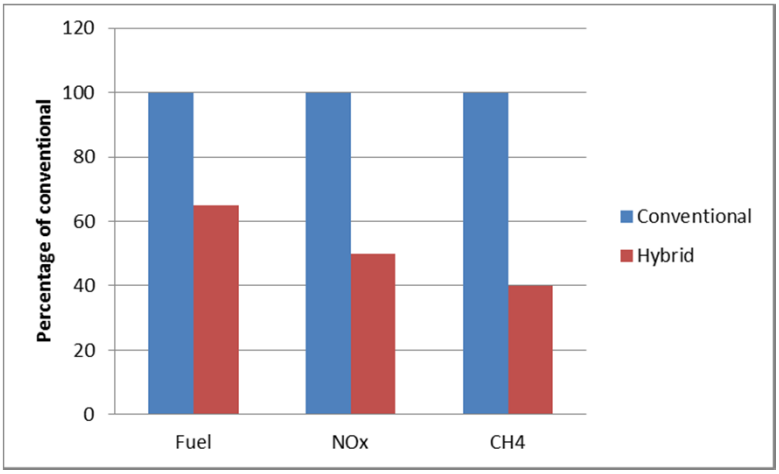
Spinning Reserve



Battery State of Charge



Measured fuel saving - Spinning Reserve

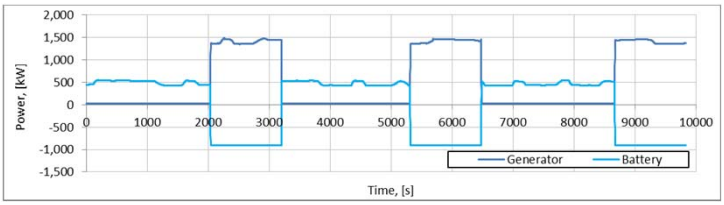


ON / OFF strategy example

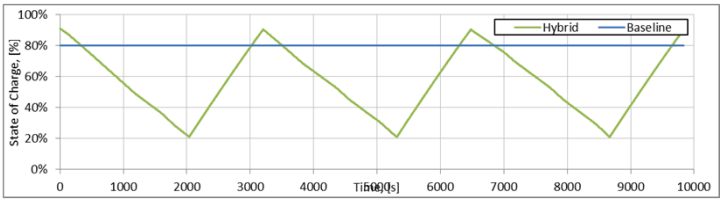
The battery is covering ALL the loads until it is discharged.

Whereafter the gen-set is covering the load and charging the battery.

Produced power



Battery State of Charge



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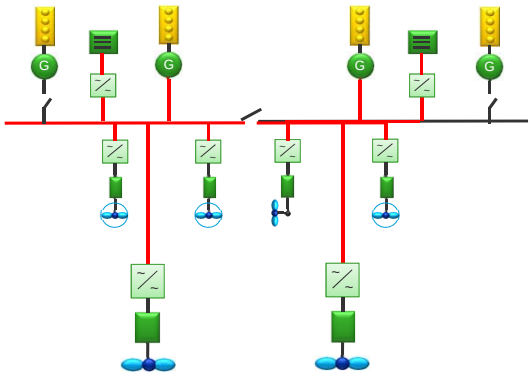

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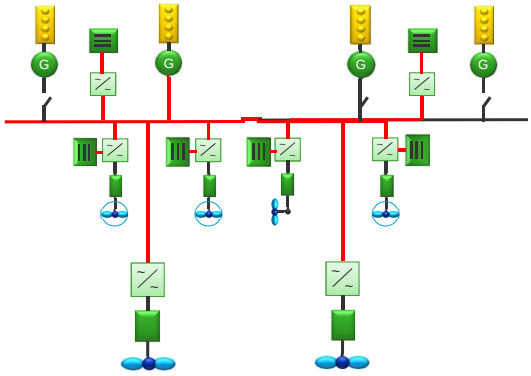
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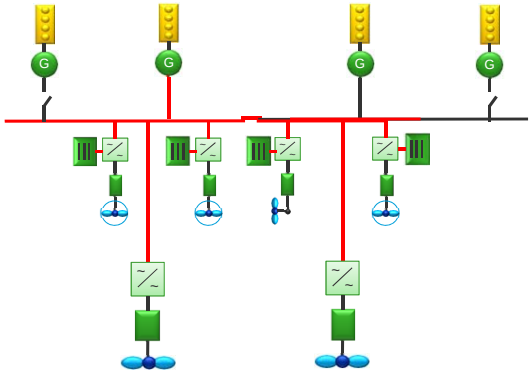
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Classification Rules and safety considerations

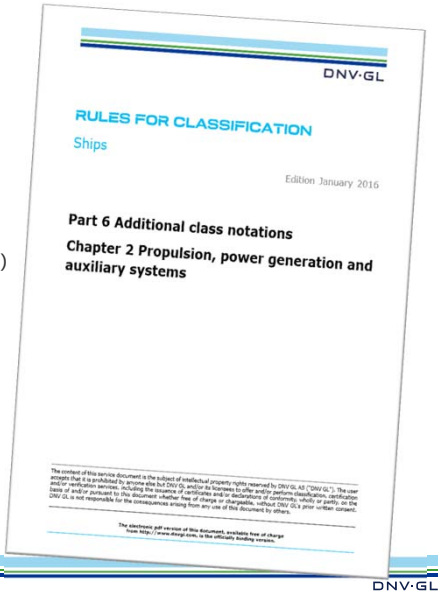
DNV GL Rules for Battery Power, launched January 2016

The requirements cover:

- Battery systems used for propulsion and for efficiency improvements
- Requirements for:
  - Certification of the batteries
  - Documentation req's
  - Battery space req's including ventilation, fire safety
  - Battery Management System (control system)
  - Electrical system issues
  - Battery deterioration

Class notations

- '**BATTERY POWER**' - where batteries are used for propulsion or as redundant source of power
- '**BATTERY SAFETY**' - where the battery is NOT used for propulsion (such as for peak-shaving)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RULES FOR CLASSIFICATION

Ships

Edition January 2016

Part 6 Additional class notations

Chapter 2 Propulsion, power generation and auxiliary systems

New DNVGL Rules for DP, introduced October 2015: Opens up for use of batteries as «spinning reserve»

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More info on our internet resource center for Battery/Hybrid:

«Battery and Hybrid Ship Service» at dnvgl.com

- **DNV GL rules for battery classification** — Class notations battery safety and battery power
- **Class type approval** — Lithium batteries
- **Battery/Hybrid ships - a new green business case?** — Register for the PDF presentation held at Nor-Shipping 2015
- **Battery Ready flyer** — 2 pages (PDF, 1MB)
- **Hybrid-electric Propulsion Systems flyer** — 2 pages (PDF)
- **BEST test and commercialisation centre brochure** — Promoting a clean energy society through innovative energy storage technologies (PDF, 1MB)
- **A blueprint for green shipping** — Read the article in our Maritime Impact issue 02-15
- **Maritime battery forum** — Visit the website
- **DNV GL partner zone on The Guardian website** — Five futuristic projects that could transform our coastlines
- **DP Rules**
- **Maritime battery systems introduction course** — Learn more
- **Seatrade award for DNV GL-classed e-ship Ampere** — Read the press release
- **Battery XT flyer** — Battery system sizing and design life verification (PDF, 2MB)
- **Economy for hybrid ships** — Business case information (PDF)
- **The ReVolt - a new inspirational ship concept** — Watch the video
- **Green coastal shipping article** — Download the article (PDF)
- **Research blog** — Get your hybrid cranes now!

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Practical examples of battery and hybrid systems

RoPax and ferries

Battery size typical 1-3 MWh






Photo courtesy of Corvus Energy

Smaller ferries and harbour vessels

Battery size typical 0.5-1 MWh






Photo courtesy of Corvus Energy

Tug and OSV






Photo courtesy of Corvus Energy

Yachts and special purpose vessels
battery size typical 0.5 – 1 MWh



Photo courtesy of Corvus Energy

DNV GL Classed vessels with batteries under construction

Edda Freya (new build)
Battery Hybrid
Owner: Østensjø

Viking Queen (retrofit)
Battery Hybrid
Owner: Eidesvik

New build 126 Havyard
Battery Hybrid
Owner: Fafnir Offshore

Viking Energy (retrofit)
Battery Hybrid
Owner: Eidesvik

New build Söby
Battery Power
Owner: Ærö Community

Seasight (new build)
Battery Hybrid
Owner: Brødrene Aa

New build P310 Crist
Battery Hybrid
Owner: Finnferries

New build 372 Kleven
Battery Hybrid
Owner: ABB AB

OV Bøkfjord (New build)
Battery Hybrid
Owner: Kystverket

Grieg Star (retrofit)
Battery Hybrid
Owner: Grieg Star

Global impact for a safe and sustainable future

Battery and Hybrid Ship Service at www.dnvgl.com

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