Grenland Energy AS

RUTER CONFERENCE – 20TH APRIL 2018

About Us

- **Strong and focused team**

Grenland Energy AS is a technology focused Maker of battery-solutions. Our knowledge and competence within Lithium Batteries gives us a leading position in the market. Through research and development, we deliver customized energy storage solutions for a demanding market. With expertise from battery-cells and electric vehicles, the company was founded in 2012. We have quickly developed to a lean organization with all required positions manned.

Skien, Norway

- **5 years and 10 employees**

Today, five years later and 10 dedicated employees, we are proud to introduce Generation III to our customers.

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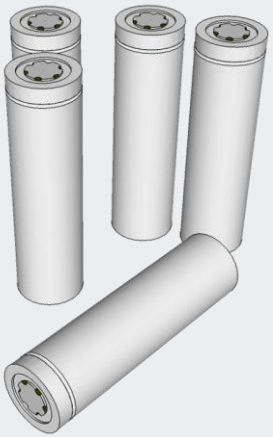
Technology basis

OUR COMPETITIVE EDGE

- **Superior safety due to patented features and small format cells**
  Increasing awareness regarding battery safety, major requirement from class and flag state in maritime applications.
- **Unrivaled power/energy flexibility due to commodity cell format**
  Our battery system can be easily tuned from an energy to a power optimized battery pack and thus will exactly fit any application.
- **Cell-supplier independent technology**
  Our base cell format is readily available in numerous specifications from many credible suppliers.
- **Lean structure and complete R&D team**
  We are a tightly integrated team with interdesciplinary competence

18650 TECHNOLOGY BASIS



- **Market growth approx +6% per year**
  pouch: +15% (mainly mobiles, tablets, toys etc) , prismatic: -10%
- **TESLA consumes approx 15% worldwide market demand**
- **Largest suppliers: Panasonic/SANYO, Samsung SDI, LG Chem**
- **World production approx 2.000 M cells per year**
  pouch: 2.000, prismatic: 1.100
- **Key success factors:**
  - Production speed = cost/kWh
  - Performance
  - Customer access, availability

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Technology Development - Pilot E

- PILOT-E is a grant for Norwegian companies, by the Norwegian Research Council, Innovation Norway and Enova.
  - Thought for new products and services within environmental friendly energy technology
  - Supports emission reductions in Norway and internationally
  - Announcement targets solutions for zero-emission maritime transport
- Develop a maritime battery system with 40% higher energy density and lower cost compared to state of the art
- Grenland Energy is partner in 2 projects with high synergy potential:

Energy Optimized Autonomuous Ferry

KONGSBERG FJELLSTRAND GRENLAND ENERGY NTNU

- Safe battery system with high energy density
- Low cost lightweight hull
- Operation optimization
- Autonomuous operations

Urban Water Shuttle

WÄRTSILÄ FJELLSTRAND GRENLAND ENERGY HYDRO sapa: SERVOGEAR

- Safe battery system with high energy density
- Space/weight optimized energy system
- Charging technology with shortest possible connection time
- optimized energy management system
- Low cost lightweight hull

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Generation III. Features Preview – MHx03.128.L

Very high cooling capability
due to large cell surface area

High energy density (@module level):

- 167 Wh/l @ 2.5 Ah cell (power cell)
- 201 Wh/l @ 3.0 Ah cell (energy cell)
- 235 Wh/l @ 3.5 Ah cell (high energy cell)

- 155 Wh/kg rack included

Weight optimized package
for dedicated battery rooms
and protected environments

Flexible mounting
orientation

Fully front servicable design

Wide cell range
available from 1.5...3.5 Ah

- True thermal runaway inhibition on cell level
  - Minimal gas in case of cell thermal event
  - Certified for use in maritime engine room when encapsulate
- 5 levels of safety and anti-propagation
  - 1. BMS monitoring of temperature and current
  - 2. Fuse on string level
  - 3. Fuse on battery module level
  - 4. Fuse on battery cell level (Video)
  - 5. Cell internal disconnection
- Master/slave capable BMS for large battery banks

- Designed for maritime and stationary systems
- Testing according to IEC60945, UN38.3
- Certification according to
  - DNVGL Pt.6 Ch.2
  - NMA(2016) propagation test

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System Example

- Capacity of system as shown above: 923 kWh (2 module walls)
- Each string requires an EE top unit – not shown in model (adds approx 15 cm in heigth)

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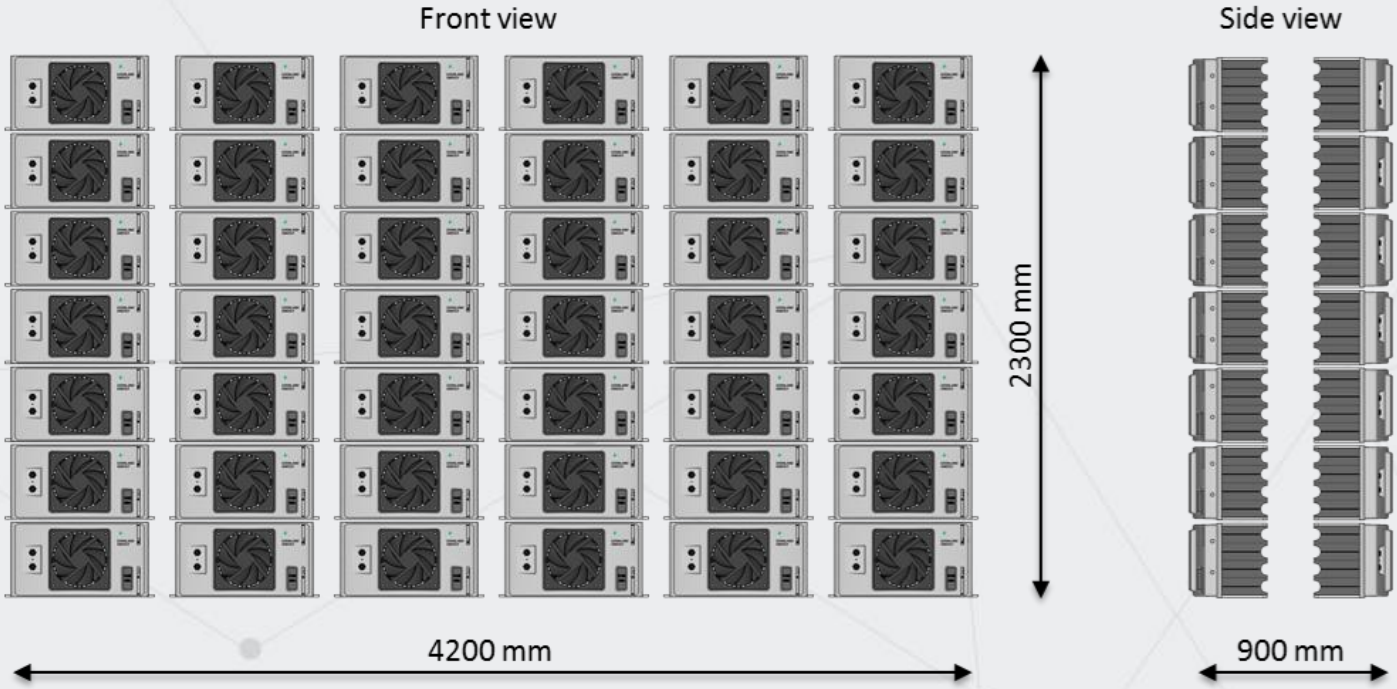
System Example



- System/string voltage: 672V...940V
- Capacity per string: 77 kWh (@3,5 Ah cell)
- Weight per module: ca. 67 kg

Notes:

- System partitioning for illustration purpose only. Modules can be arranged differently.
- Rack/retention not shown in graphics
- Air conditioned battery room required (filtered air, 15...20 degC)

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WE MAKE ENERGY DO MORE

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