



**convion**

**FUEL CELL  
SYSTEMS**

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# FUTURE OF DISTRIBUTED POWER GENERATION

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## CONVION

- Enables Power generation with SOFC technology
- Leading SOFC systems in the 50kW+ power range
- Substantial IPR on SOFC system technologies
- Customer demonstrations ongoing
- History at Wärtsilä: R&D since 2001, Technology demonstration since 2004
- Established in 2012 as an independent company
- Key shareholders : VNT Management (VC), Employees and Wärtsilä Corporation

## CORE PRODUCT C60 – MODULAR 60KW POWER UNIT



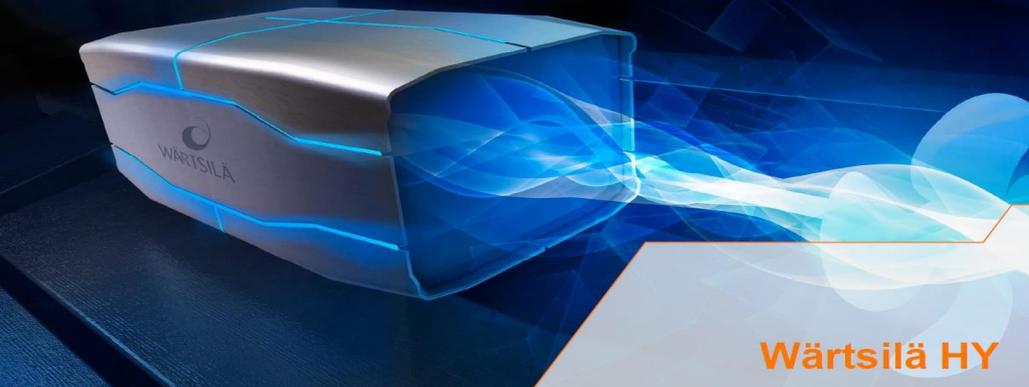
|                              |           |                  |
|------------------------------|-----------|------------------|
| <b>Electric output</b>       | <b>60</b> | <b>kW net-AC</b> |
| <b>Electrical efficiency</b> | 60+       | % (LHV)          |
| <b>Thermal output</b>        | 27        | kW               |
| <b>Total efficiency</b>      | 84        | % (LHV)          |

## The most common fuel cell types, named according to their electrolyte

|                          | FC Type     | Anode Fuel   | Cathode oxidant     | Operating temp (°C) | Efficiency (LHV)     | Application                                     |
|--------------------------|-------------|--|---------------------|---------------------|----------------------|---|
| Low temperature          | <b>PEM</b>  | H <sub>2</sub>   | Air                 | 60 – 100            | 30 – 40              | Portable<br>Small residential<br>Transportation |
|                          | <b>AFC</b>  | H <sub>2</sub>   | O <sub>2</sub>      | 60 – 120            | 30 – 40              | Portable<br>Small residential<br>Transportation |
| Intermediate temperature | <b>PAFC</b> | H <sub>2</sub>   | Air                 | 150 – 250           | 35 – 45<br>50 – 70 * | Industrial<br>Commercial                        |
| High temperature         | <b>MCFC</b> | H <sub>2</sub> , CO,<br>NH <sub>3</sub> ,<br>CH <sub>4</sub> | Air+CO <sub>2</sub> | 550 – 700           | 45 – 55<br>80 – 90   | Industrial<br>Commercial                        |
|                          | <b>SOFC</b> | H <sub>2</sub> , CO,<br>NH <sub>3</sub> ,<br>CH <sub>4</sub> | Air                 | 650 – 850           | 45 – 65<br>80 – 90 * | Industrial<br>Commercial<br>Transportation      |

Different technologies are suited for different fuels and application

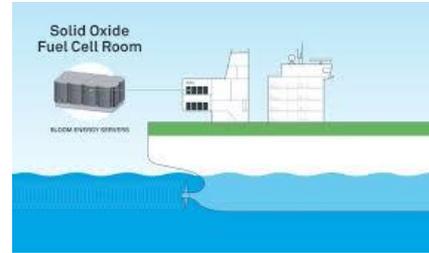
## CONVION AS PART OF MARINE REVOLUTION



### DRIVERS for change

- **IMO: reduction of GHG emissions from ships**  
50% reduction by 2050
- **IMO: Emission Control Areas or ECAS**  
Particularly SO<sub>x</sub>, NO<sub>x</sub> and PM
- **IMO Energy-efficiency requirements**  
30% improvement by 2025
- **Customers**

- Use of gas (LNG, NH<sub>3</sub> or H<sub>2</sub>) as fuel will open marine market for fuel cells
- Power generation with Hybrid systems: Main ICE engines + batteries + Fuel cells
- Better energy efficiency, flexibility and power security
- Lower local emissions: zero NO<sub>x</sub>, SO<sub>x</sub> and particulates
- Less vibrations
- No noise



- |                                     |             |              |
|-------------------------------------|-------------|--------------|
| ■ Wärtsilä : Methapu                | SOFC        | Methanol     |
| ■ Wärtsilä Norway :                 | SOFC, MCFC, | LNG (Hybrid) |
| ■ ABB : RCCL / Ballard              | PEM         | H2           |
| ■ Samsung Heavy ind. / Bloom Energy | SOFC        | LNG          |
| ■ ABB, VTT, Syke, Power cell :      | PEM         | H2           |
| ■ NN                                | SOFC        | NH3          |
| ■ Etc.                              |             |              |

Basically all main players in Marine industry are involved in fuel cell solutions

- Power density :
  - Both kW/m<sup>3</sup> kW/kg ratios are lower than ICE
- Power demand : Propulsion power up to 60.000 kW + hotel load up to 10.000 kW
  - Typical power of fuel cell product is 1 – 400 kW
- Fuel logistics
  - Fuel cells can utilise only clean fuels as gas
  - Fuel storage on board, both space (H<sub>2</sub>) and safety (NH<sub>3</sub>).
  - LNG (eNG) currently available also for main propulsion
- Cost and availability of CO<sub>2</sub> neutral fuels
- Fuel selection / availability do influence on optimal FC technology





- Hybrid power solutions ( engine + storage + fuel cell)
  - Energy efficiency is essential. In addition improved security and flexibility
- Different solution for different application
  - Small vessels, local routes can be electrical with FC power supply as "range extender"
  - Large vessels with long routes has high power demand and fuel storage capacity need
- Further development of fuel cell technologies and applications in the value chain
  - None of the current FC technologies are ready for commercial deployment for marine applications
- Fuel logistics for safe, affordable and carbon free fuels

**MEYER****VTT**

**Finland has unique value chain and opportunity to commercialize highly efficient and clean power solutions for Marine industry.**

- RCCL as leader of cruise industry
- Meyer as an innovative ship yard
- Wärtsilä as leading power solutions provider
- Convion as a leading fuel cell system provider
- Elcogen as a leading SOC manufacturer
- VTT as a leading research center in fuel cells

Thank you



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