# PowerCell Sweden AB: Maranda and other marine fuel cell applications

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F-cell, WORLD OF ENERGY SOLUTIONS
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# PowerCell - Overview

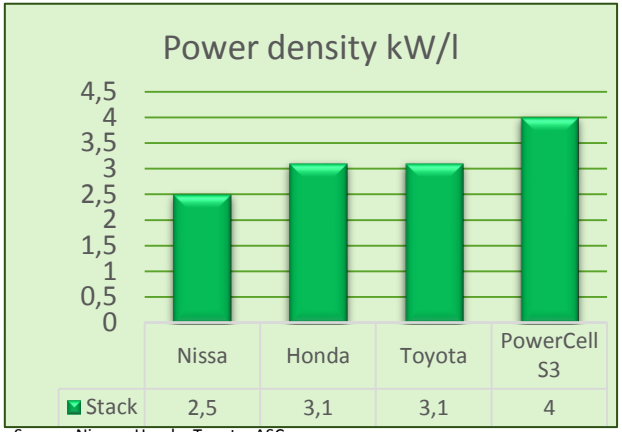
- All central functions located in Sweden
  - Subsidiary in Germany
  - Distributors: Japan, S. Korea & S. Africa
  - Joint Venture in Norway
- Industrial Spin-Out from Volvo
- Public listed on Nasdaq First North Dec 2014
- Over 10’000 share holders
- Over 50 highly skilled employees
- Advanced fuel cell and reformer laboratories
- ISO Certified 9001 & 14001

# The PowerCell Product Portfolio

| | Product name | Type | Power range | Fueled by | Applications |
|---|---|---|---|---|---|
|  | S1 | Fuel cell stack | 1–5 kW | Reformate fuel or pure hydrogen | Households, commercial properties (Micro CHP) and traffic systems |
|  | S2 | Fuel cell stack | 5–35 kW | Reformate fuel or pure hydrogen | Telecom and automotive range extension (REX) |
|  | S3 (Prototype) | Fuel cell stack | 30–100 kW | Hydrogen | Powering vehicles (Developed in AutoStack Core), Stationary |
|  | PowerPac (Prototype) | Fuel cell system (S2 + fuel reformer) | 3 kW | Diesel | Telecom, refrigerated transportation, reserve power |
|  | PS-5 | Fuel cell system (S2 based) | 1–5 kW | Hydrogen | Households, commercial buildings, telecom and security systems |
|  | PS-100 (Prototype) | Fuel cell system (S3 or S2 based) | 20–100 kW | Hydrogen | Electric power generation and energy storage (peak shaving) |
|  | MS-30 (Prototype) | Fuel cell system (S2 based) | 10–30 kW | Hydrogen | Range extender for electric vehicles |
|  | MS-100 (Prototype) | Fuel cell system (S3 based) | 50–100 kW | Hydrogen | Transportation and Automotive |

# The S3 stack

- Basic unit for automotive and other application.
  - 100 kW maximum capacity
  - Building block for a MW scale system
  - Best-in-Class power density, 4kW/liters
  - 455 cell package durable for marine application
  - 10’000h of marine cycle testing




Source: Nissan, Honda, Toyota, ASC


# S3 Fuel Cell Stack Development Path

**AutoStack Core**
Output: Hardware evolution 1 and 2

**Project complete 2013-2017**

**PowerCell S3**
**100 kW stack**
**SOP 2018**

**Application testing /**

Cars

Trucks

Marine

Material handling

Buses

**Application testing / Demand split**

**S3-A-335**
(Automotive)

**S3-M-455**
(Marine+long life MEA)

**Mass production**

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# Marine applications must go green

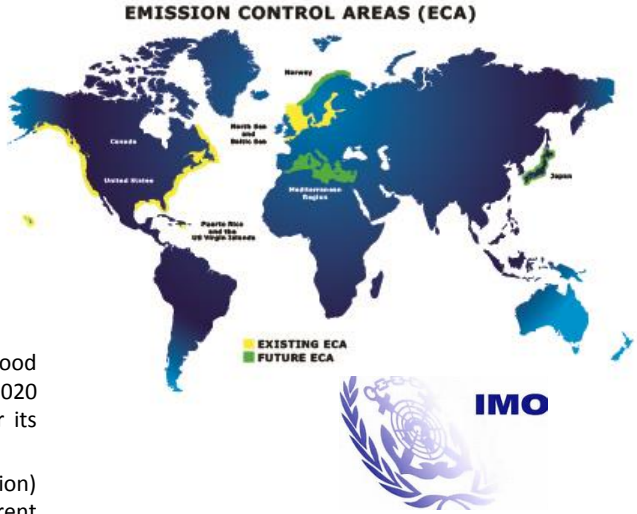
**Targeted regulations are in place in specific areas and marine stakeholders have become increasingly eco-sensitive**

## Marine Directive

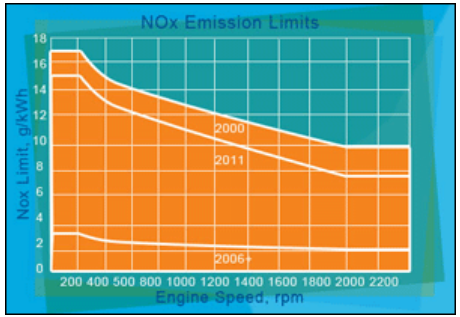


In the EU, the Marine Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and requires each Member State to develop a strategy for its marine waters .

At the international level, MARPOL (shortened Marine Pollution) is one of IMO's conventions that focus on preventing different forms of marine pollution including oil, noxious liquid substances, harmful substances, waste water, garbage and emissions of sulfur oxide and nitrogen oxide at sea. Mandatory limitations on NOx being released on the atmosphere are regulated under MARPOL Annex VI Regulation 13 and affect not only ships from signatory states but ships entering MARPOL signatory-members' waters.




IMO

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# Maranda, a FCH JU funded project,

## will accelerate the introduction of fuel cells and hydrogen in the Marine sector

***MARANDA project aims to:***

- **DEVELOP** an emissions-free fuel cell hybrid based marine powertrain system
- **ENSURE** suitability for a broad spectrum of marine applications
- **PROVE** the technical performance of the system in a target marine vessel
- **DEMONSTRATE** the economic feasibility of hydrogen and fuel cells in marine sector

*This project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking under grant agreement No 735717.
This Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme and Hydrogen Europe and N.ERGHY

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# Basic details of MARANDA project

(http://www.fch.europa.eu/project/marine-application-new-fuel-cell-powertrain-validated-demanding-arctic-conditions)

## Overall concept

- **Develop a complete hydrogen fuel cell hybrid powertrain**, including novel HRS refillable hydrogen fuel storage, **optimised for demanding marine environment**, based on the adapted automotive fuel cell stacks and balance of plant components and solutions tested in real operating environment
- **Validate** performance and durability of the PEMFC systems, **both on a powertrain test benches and in marine vessel**
- **Business analysis** to assess the economic performance within targeted sectors and applications, and the **drivers for enhancement** both technical and geographic.

## Basic project data

- Start date: March 1, 2017
- End date: February 28, 2021
- Duration: 48 months
- Project cost: 3,704,757.50 €
- Project funding: 2,939,457.50 €

## Consortium

- Coordinator: Teknologian tutkimuskeskus VTT Oy, Finland
- Powercell Sweden AB, Sweden
- ABB OY, Finland
- OMB SALERI SPA Italy
- PERSEE France
- SUOMEN YMPARISTOKESKUS Finland
  - The Finnish Environment Institute
- SWISS HYDROGEN SA Switzerland

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# Maranda objectives

**Technical and non-technical objectives of equal impact**

1

## Develop improved, industrialisation –ready system components

Identify the components that have specific marine application requirements (e.g. lifetime and resistance to shock, corrosion, power range, SU/SD, etc…) and develop full system for high efficiency and low cost Balance-of-Plant (BoP)

2

## Demonstrate and validate the system performance

Validate the system performance on a powertrain test bench and in a target marine vessel for a period of 6 months at least.

Demonstrate the CO2 performance (through Life Cycle Analysis) of current powertrain solutions and demonstrate the specific emission saving

3

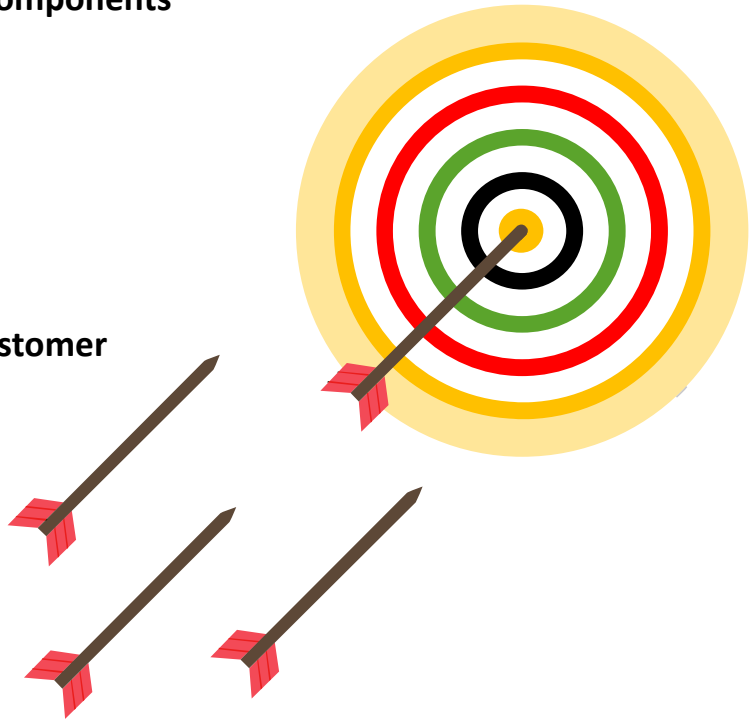
## Outlay the return on investment for a prospective customer

Build a robust business case structure able to easily integrate customer specific criteria and proven by key marine stakeholders and offer custom diagnosis to prospective customers.

4

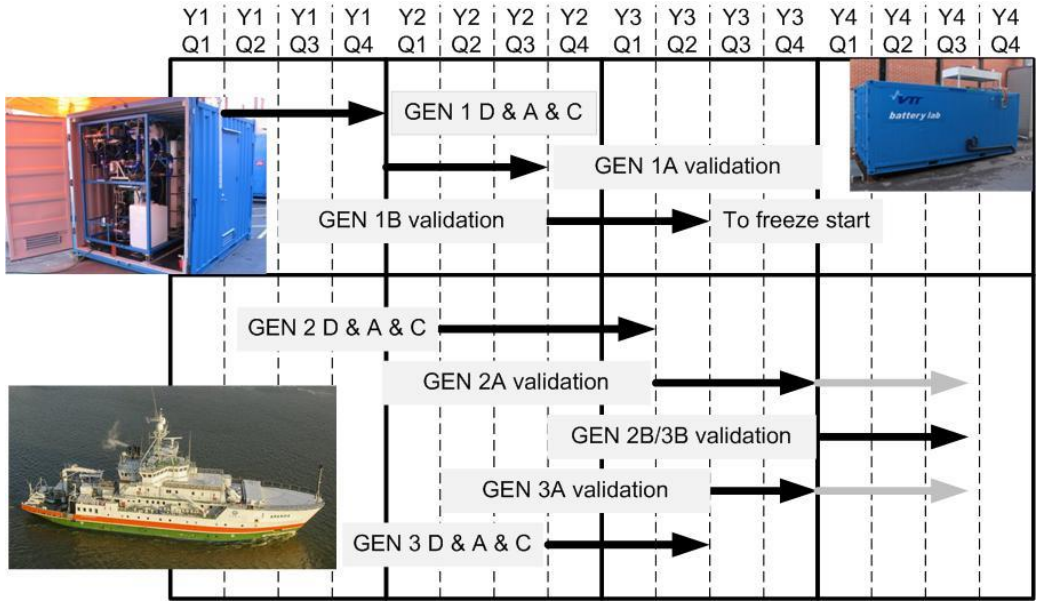
## Formulate initial go-to-market strategy

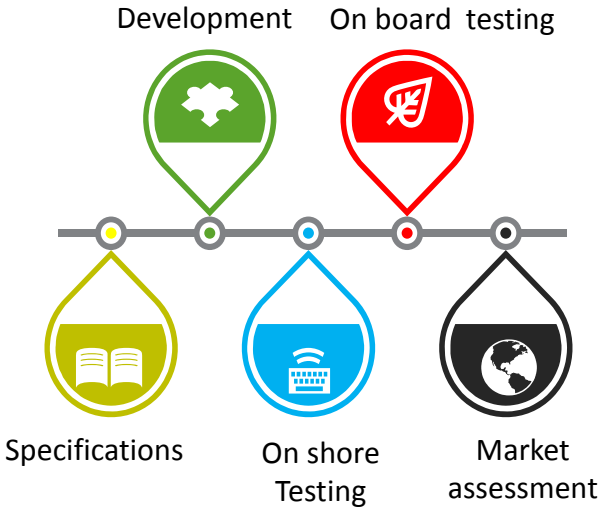
Identify the specific needs and constraints of the various market segments to assess the best potential fit for fuel cell and hydrogen and define how best to address them.



# Maranda timeline

A four year project including onshore and on board vessel validations



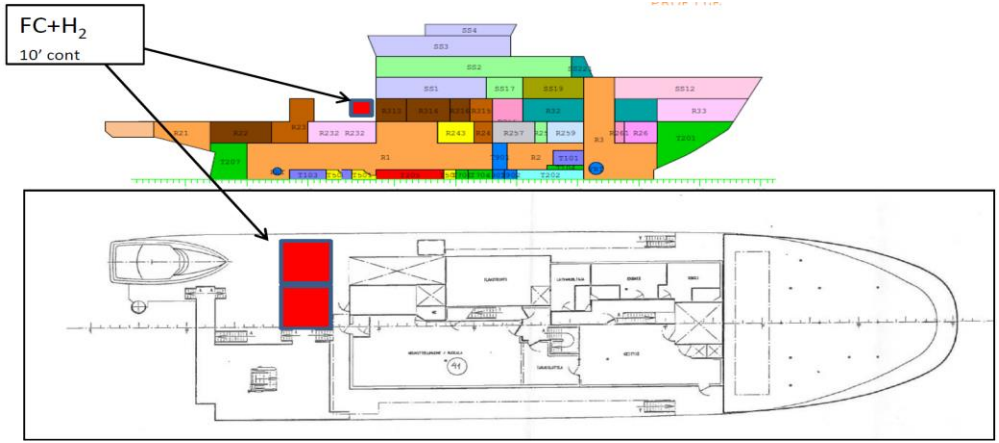




The fuel cell system will be tested in conditions similar to arctic marine conditions before implementation to the target vessel. In addition, long-term durability testing (6 months, 4380 operating hours) of the system will be conducted at an industrial site.

# The field testing vessel – ARANDA

A 165 kW (2 x 82.5 kW AC) fuel cell powertrain (hybridized with a battery) will provide power to the vessel's electrical equipment as well as the dynamic positioning during measurements, free from vibration, noise and air pollution.

Special emphasis is placed on air filtration and development of hydrogen ejector solutions, for both efficiency and durability reasons.

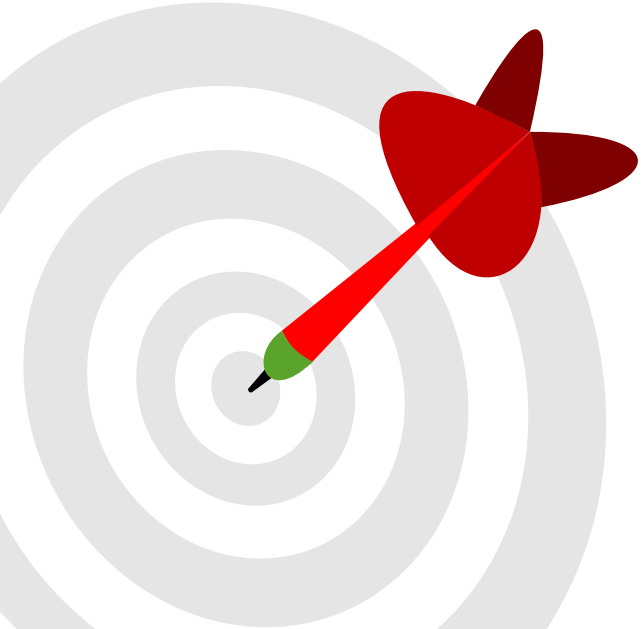




A mobile hydrogen storage container, refillable in any 350 bar hydrogen refueling station will be developed in this project.
Liquid hydrogen, more suited to larger fuel cells, will be taken into consideration in the business cases and go-to-market strategy.

# Maranda KPIs

Both technical and economical



**Fuel to electric efficiency**
50%

**freeze start capabilities**
from -35°C

**operating temperature**
[-32°;+50°]

**system cost**
< 1000€/kW*

(For 100 units / year)

**Fuel cell stack life**
15 000h

**Fuel cell systems conditions**
able to withstand the shocks, vibrations, saline environment and ship motions

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# Other projecs: Marine Propulsion - Nimbus Boats

- Feasibility study
- Construction of a demo vessel
- 2 units MS30, for propulsion


*PowerCell MS30*

# Other projects: Scalable solution – S3 Stack Module

- Example of 12 x S3-455C stack module
  - 1.14 MW at 300A operating point
  - 1.5 MW max continuous at 450A
- Stack module dimensions:
  - Height 2.4 m x Width 0.6 m x Depth 1.2 m = Footprint 0.72 m2

**=> Extremely compact stack module**

# Hyon AS: JV for hydrogen & fuel cell solution

- Enable customer a one stop shop
- Clean and profitable energy solutions
- World-class fuel cell & hydrogen technologies
- Tailored and integrated systems

HEXAGON COMPOSITES

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# PowerCell

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