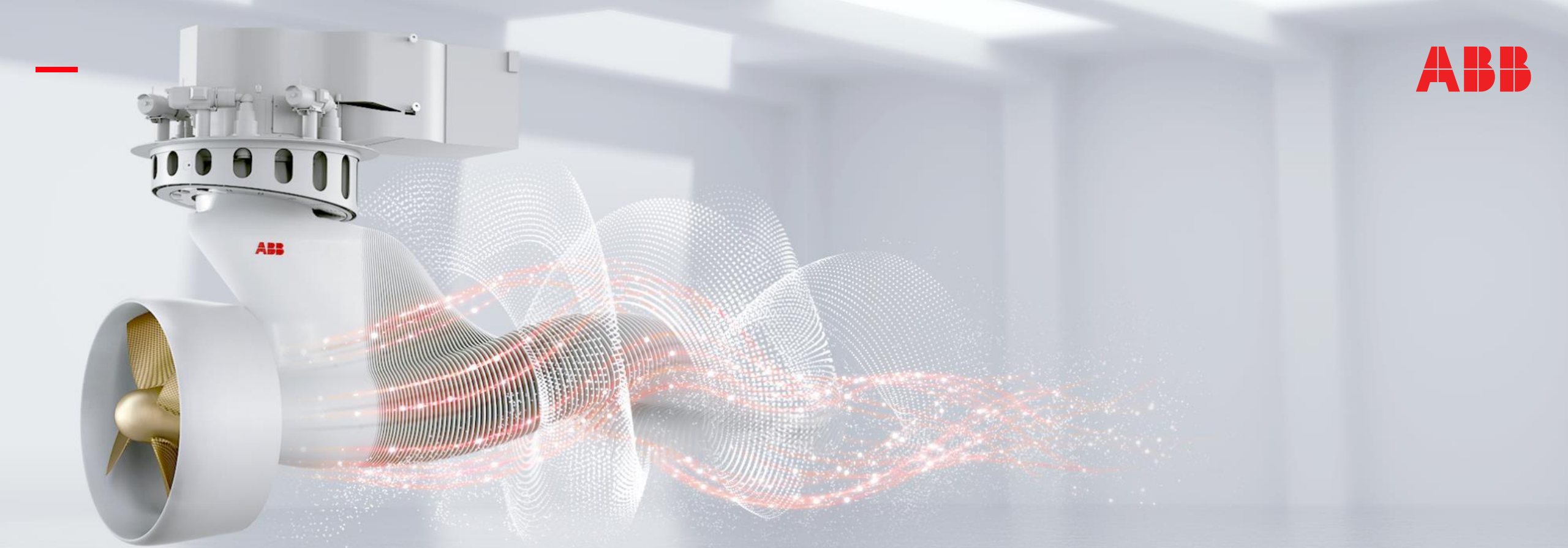

KLAUS VÄNSKÄ, 15TH JUNE 2017

# JOINT WORKSHOP ON MARITIME AND PORT APPLICATIONS

## H2 and Fuel Cells in clean marine vessels

valenciaport
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FUNDACIÓN valenciaport

European Commission

FCH | FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

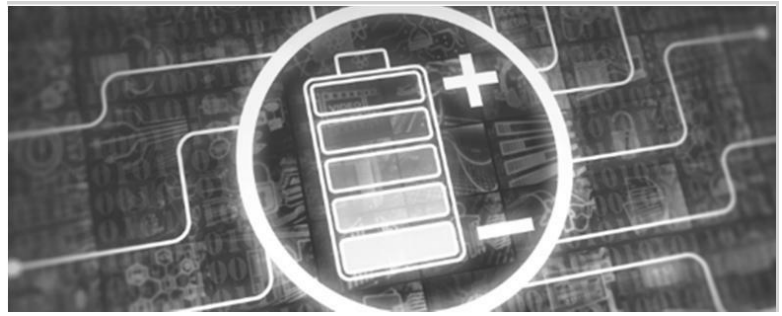
# Global megatrends transforming shipping

## Demand for new technologies

### Digitalization

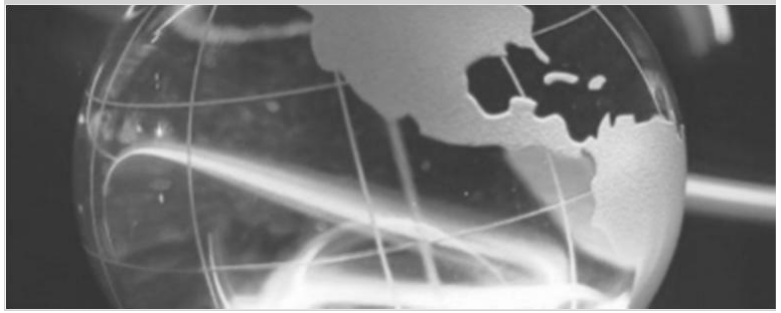
### Urbanization

### Carbon Free Resources

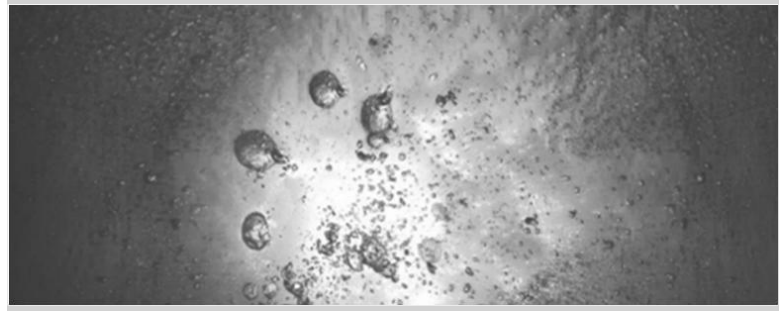


### Automation and Robotics

### Global Economic Shift



### Environment



# Megatrend Automation and Robotics

Increased demand for full electric vessels

## Mechanical ship with combustion engines

Complexity
- Complex with lots of components
- Labor-intensive maintenance
- Complex auxiliary systems required
- Mechanical wear and tear

Inflexibility
- Functionality limited by mechanical components
- Redundancy expensive and complex to build
- Not modular

**Availability == Reliability of the least reliable component**

## Electric ship

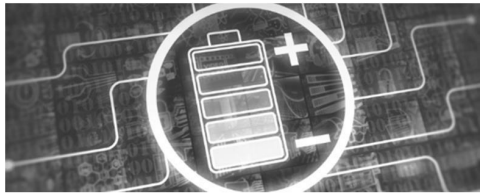
Simplicity
- Modular and simple
- Hot-swappable & remote maintenance
- 50 % less components, 50 % less IO
- Oil-free, zero emission, powered by batteries or fuel cells

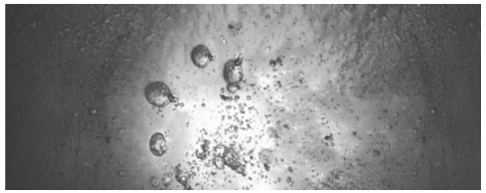
Flexiblity
- Functionality created by software
- Reconfigurable using software
- Modular, redundant and fault tolerant by nature

**Availability >> Reliability of the least reliable component**

# Megatrend Carbon Free Resources and Environment

We have either Energy Storage or Fuel Cell as an alternative





## Energy Storage driven vessels

Either hybrid or fully battery driven

- Large variety of application with hybrid configurations
- Limited vessel types if fully battery driven due to current energy density of battery (size, weight, kwh)

Ferries

Short sea shipping

Tugs

**Frequent charging set limits**

## Fuel Cell driven vessels

Either hybrid or fully fuel cell driven

- Hybrids will be seen in adaption phase
- Demand for MW range solutions
  - Simplicity
  - Mainteinability
  - Footprint
  - Cost

Cruise

Navy

Tankers

Yacht

Icebreaker

**H2 supply chain and infrastructure needed**

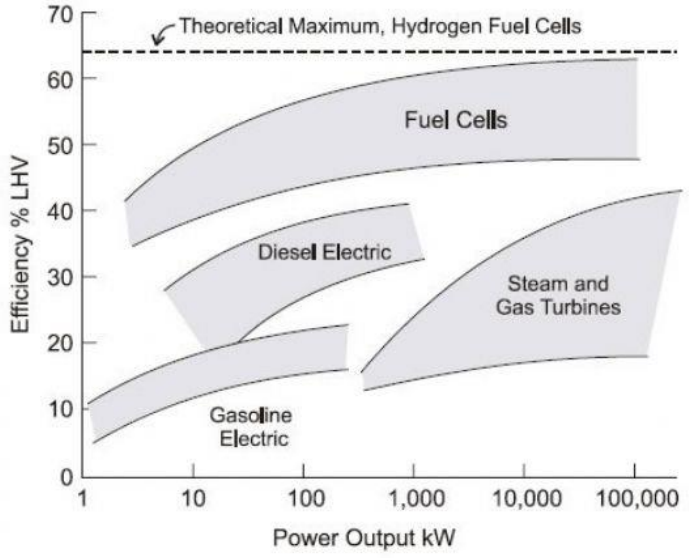
# Power source requirements for marine vessels

## There are fuel cell technologies filling the requirements

### Requirements

- Response time during load variations
  - 1st reference is a diesel engine
  - Batteries have risen the bar
- Increased efficiency requirements
- High demand to reduce emissions
- Cost / kW

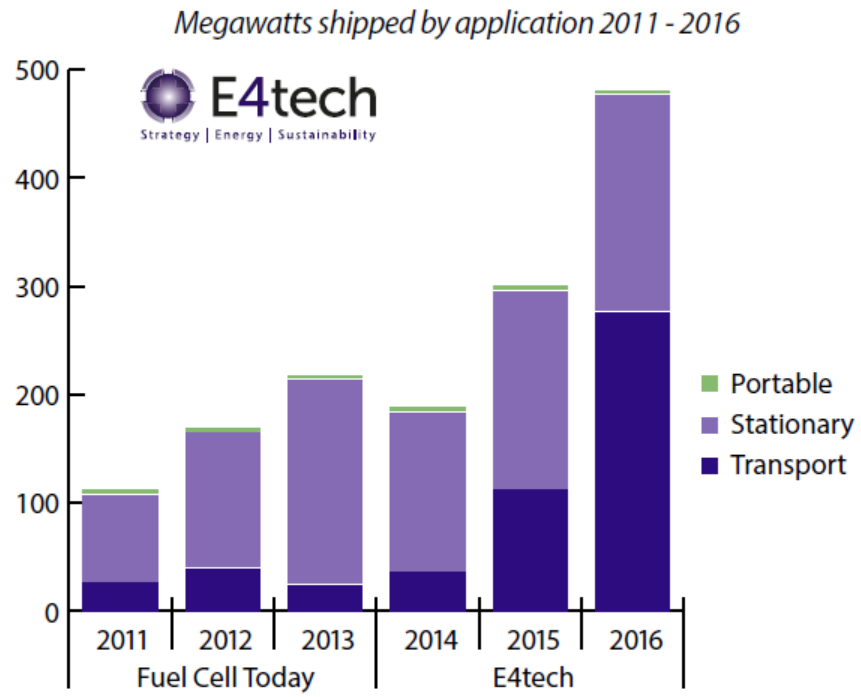
### Efficiency




Efficiency Comparison (www.micro-vett.it)

# Feasible fuel cell technology for marine vessels?
## Global production volume and cost level

### Global production volumes




Source: The Fuel Cell Industry Review 2016

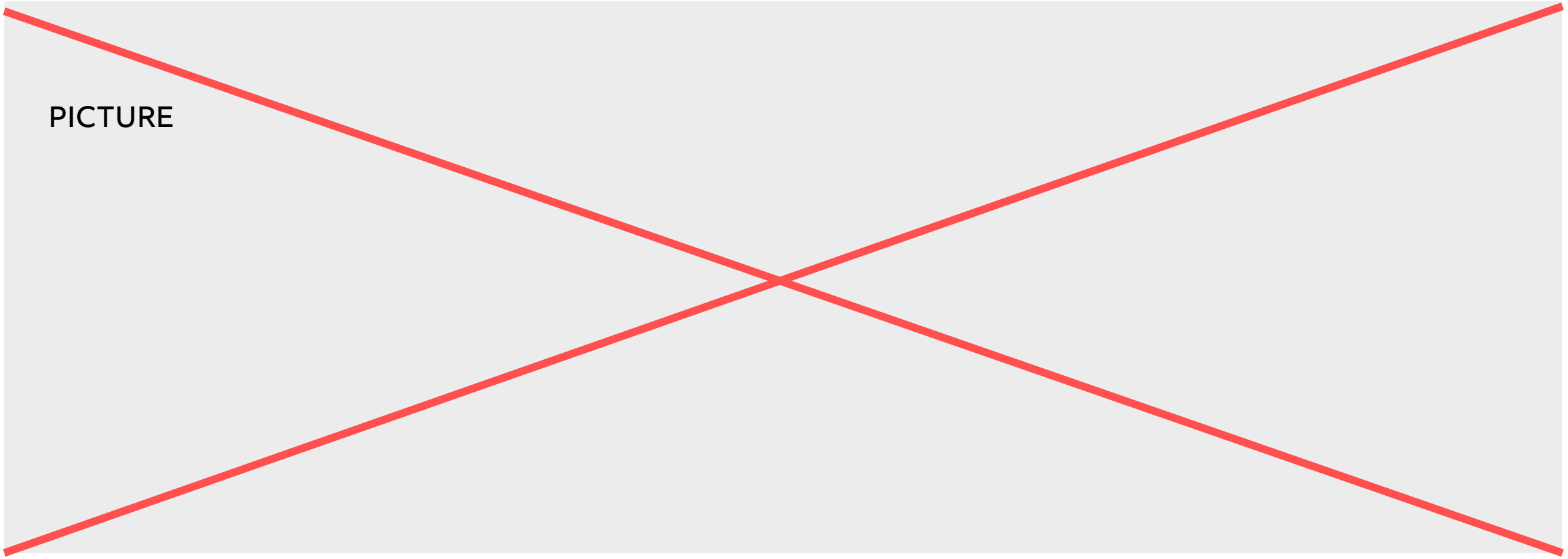
### Cost development

- We are now in a root of exponential growth
- 2016 is a first year while transportation segment is bigger than stationary
- Car, buses, trucks and forklift are driving the growth in transportation sector
- Stationary segment has been quite stable over the five years

Technology used in transportation segment will get benefits of growing volumes -> should have remarkable cost reduction in coming five years

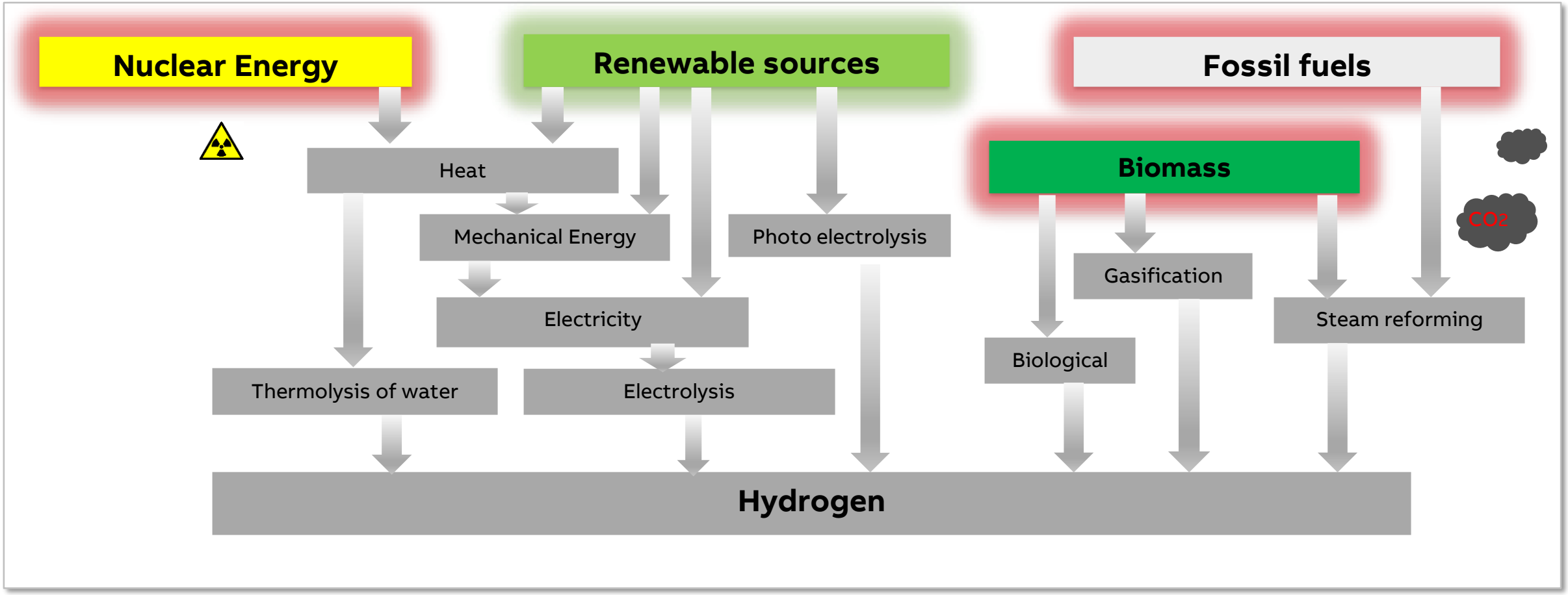
# Todays PEM technology for marine vessels

Ready to have fully fuel cell powered vessel



# H2 production and supply chain

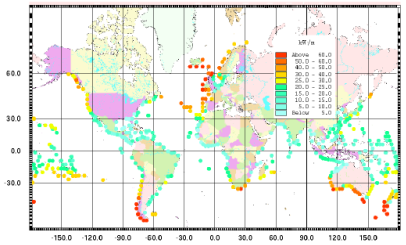
## Production pathways



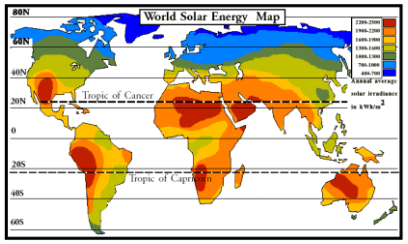
# Waiting to have a global carbon free LH2 supply chain

From production to consumption

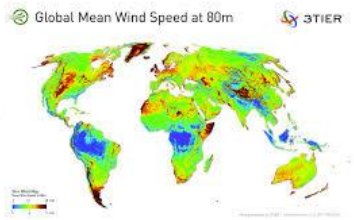
**Wave energy spots in coastline**



**Solar radiation spots**




**Wind energy spots**




Hydrogen


Either LH2 bunkering vessel or port infrastructure for LH2 bunkering