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OPPORTUNITIES AND CHALLENGES FOR DUTCH INDUSTRY IN THE ELECTRIFICATION OF TRANSPORT IN MARITIME AND AEROSPACE:
Power Electronics and Energy Storage as Enabling Technologies

Thiago Batista Soeiro, Anand Krishnamurthy Iyer, Sohaib Qazi, Ning Zhansheng, Reyhaneh Eskandari, Bram Oude Aarninkhof, Alejandro Latorre Correa, Gang Zhang, Regis Nibaruta.

Contact: t.batistasoeiro@utwente.nl

Outline

- *About the Presenters*
- *Electric Transportation*
- *Ground Zero Technologies*
- *Maritime Electrification*
- *Aircraft Electrification*
- *Conclusion*

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About the Presenter and Contributors

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Electric Transportation

Going Green!

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Electric Transportation

Battery Powered Electric Transportation - on the rise… All forms of transportation becoming more electric!

▲ Electric hoverboards *(Source: www.razor.com)*

Electric scooters *(Source: www.pinterest.com)*

Electric bicycles *(Source: www.stromerbike.com)*

Hyperloop(Source: www.ocregister.com)

▲ Electric trucks *(Source: www.daimler.com)*

▲ Electric buses *(Source: www.abb.com)*

▲ Electric motorbikes *(Source: www.supersoco.eu)*

▲ eVTOL *(Source: eveairmobility)*

▲ Electric ferry boats *(Source: www.siements.com)*

▲ Electric planes *(Source: www.pipistrel.si)*

▲ EVs*(Source: www.greenliving4live.com)*

▲ Train *(Source: www.railjournal.com)*

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PE&ES&EMC, the enabling Tech!

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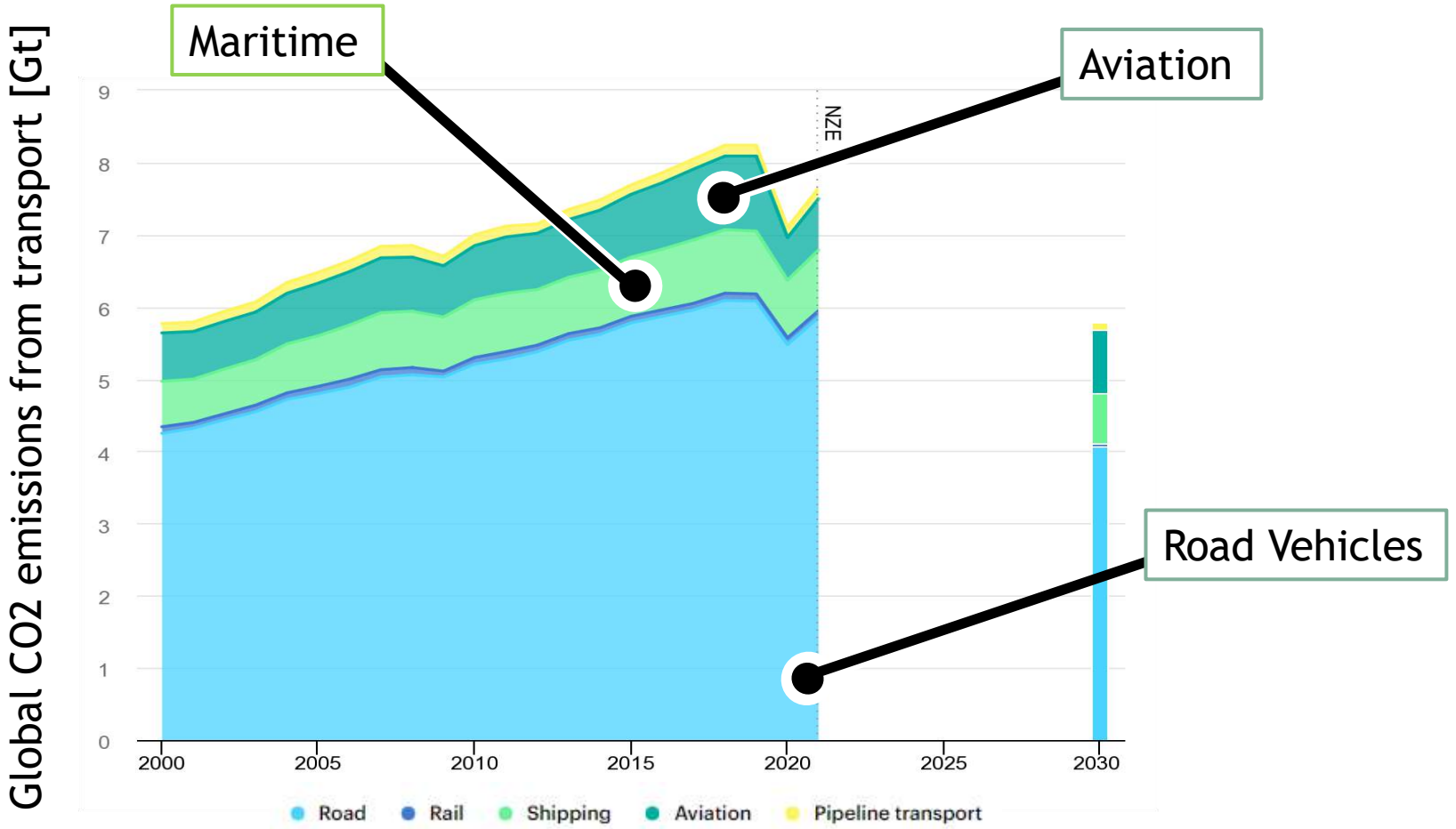
Motivation of Electric Transportation



Global CO2 emissions from transport by sub-sector in the Net Zero Scenario, 2000-2030 (Gt)
Source: International Energy Agency

After road transport, maritime and aviation have the biggest share in CO_2 emission

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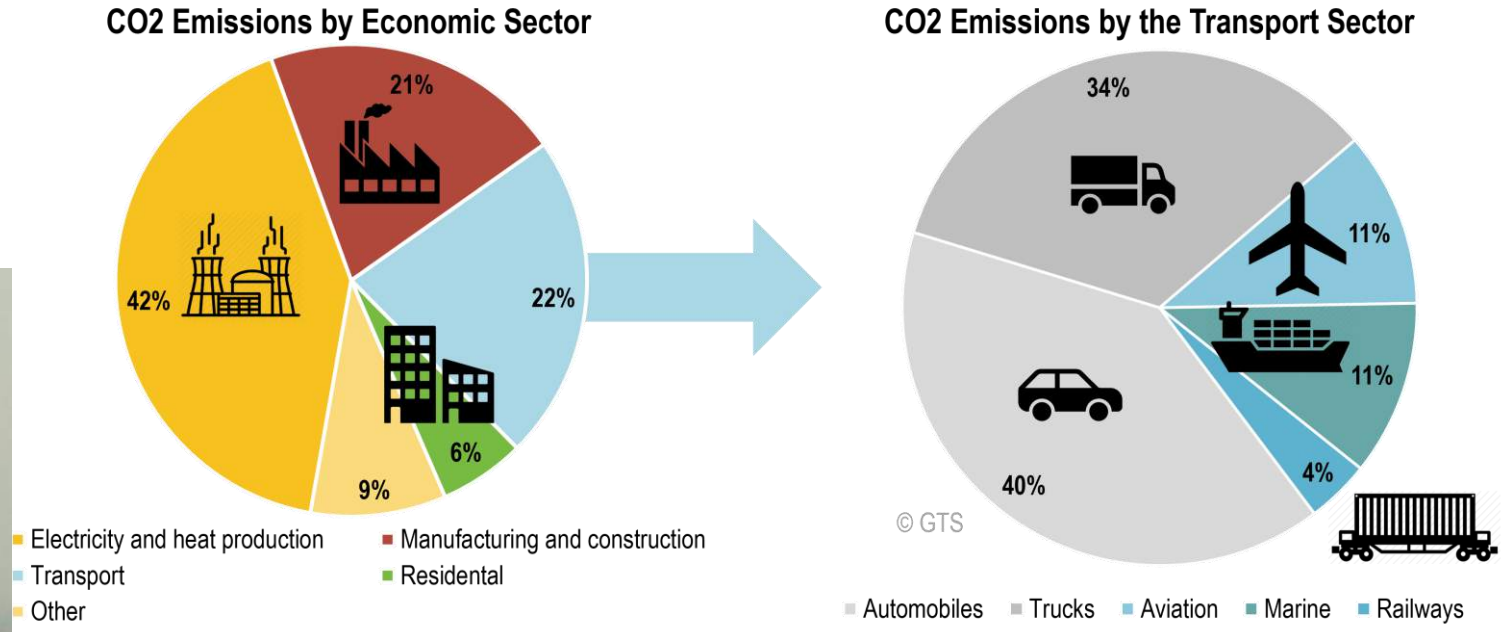
Motivation of Electric Transportation

- Maritime & Aerospace are responsible for ~4% of global CO_2 emissions
- Very carbon intensive mode of transport
- Emissions expected to nearly double in 2050

Source: Inside Climate News, 2020



Source: International Energy Association. IEA and IPCC (2014) Summary for Policymakers

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EU green deal

Target: Make Europe the first climate neutral continent by 2050

- Curb greenhouse gas emissions: >55% by 2030 vs. 1990 levels
- Finance: € trillion investments
- No emissions by 2050

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R&D Funds

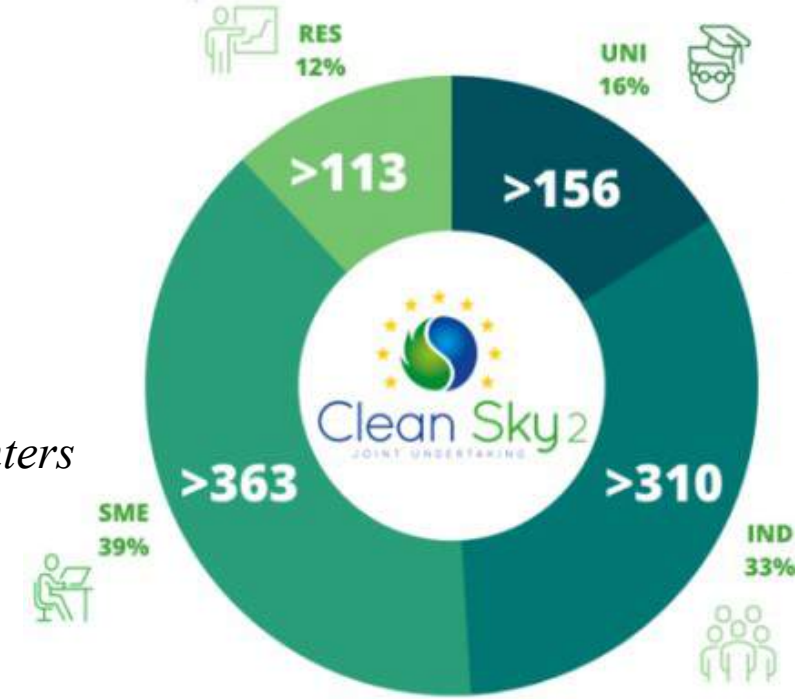
Pillar II, Cluster 5: Climate, Energy & Mobility (EU H2020)
(source: www.clean-aviation.eu/)

Universities

Industries

SM sized Ent.

Research Centers



Breakdown of Participants (Clean Sky 2)
(source: www.clean-aviation.eu/)

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Clean Aviation second call for proposals: over €350 million to drive aviation towards climate-neutrality by 2050

Decarbonization routes

KEY DRIVERS & CHALLENGE FOR AEROSPACE AND MARITIME…

0	Societal Push	Environmental Concerns Willingness to Pay Standardization
1	Innovative Propulsion & Sustainable Fuels	Full-Electric or Hydrogen Hybrid (Elect. + Comb.) Fuels from Renewables
2	Improved Battery Performance	+ Energy Density (W/kg) + Recyclability + Long Life
3	New Structure Design	Thruster Optimization New Materials/Composites Compact Power Converters
4	Digitalization	Sensors & Data Acq. Condition Monitoring Predictive Tasks Digital Space
5	Infrastructure	+ Renewable Energy + Trained Personnel + Flexible Logistic

NEEDS FOR POWER ELECTRONICS, EMI & SYSTEM INTEGRATION

Ground Zero Tech:
Renewables, Storage and S-Fuels

***Enablers** for Sensible Electric Transportation!*

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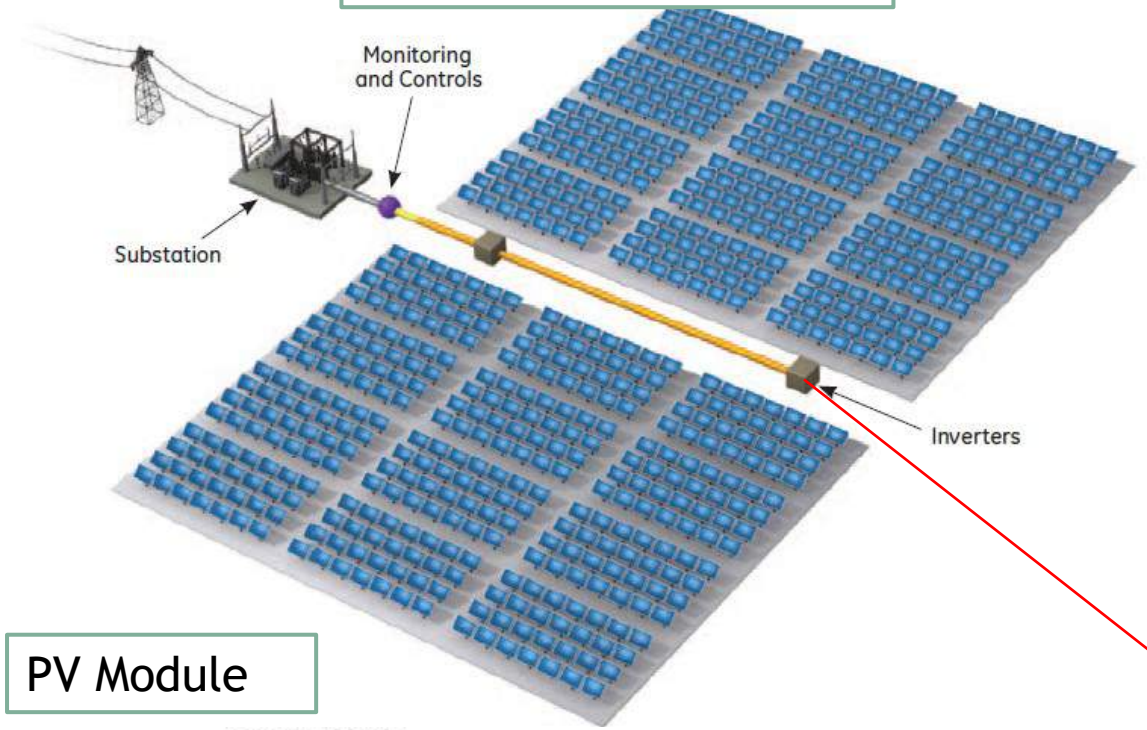
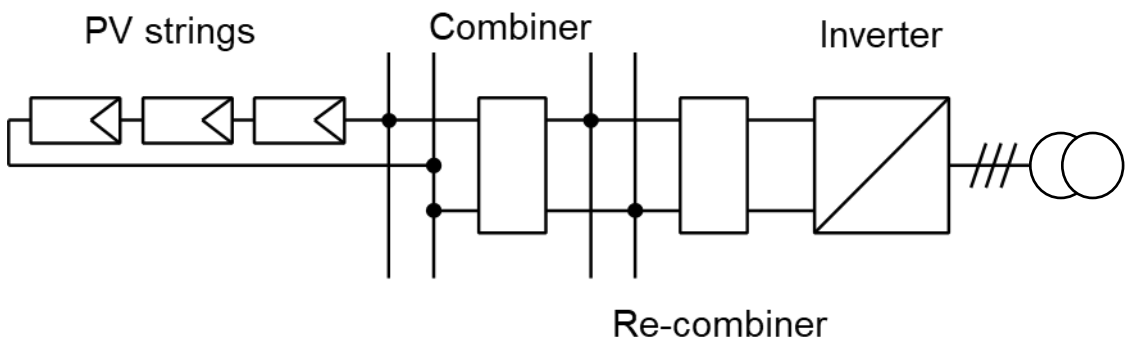
PV Renewable Energy Generation

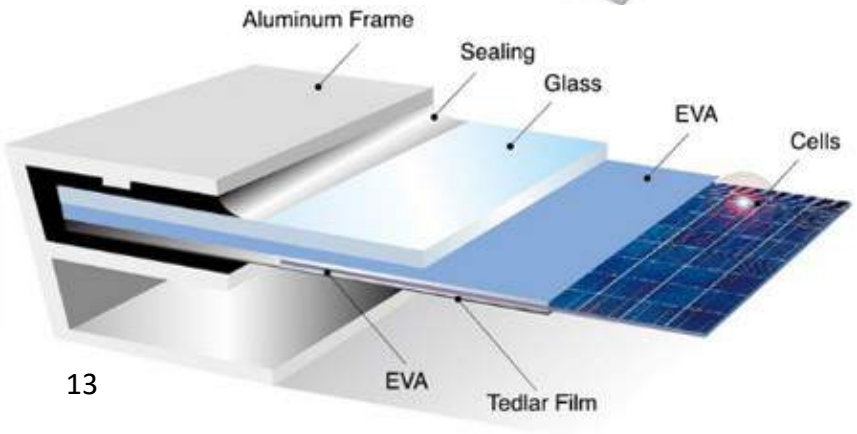
Typical PV Utility Plant



Main Circuit



PV Module



PV Inverter

ProSolar Central Inverter, GE
725 – 1000 kW

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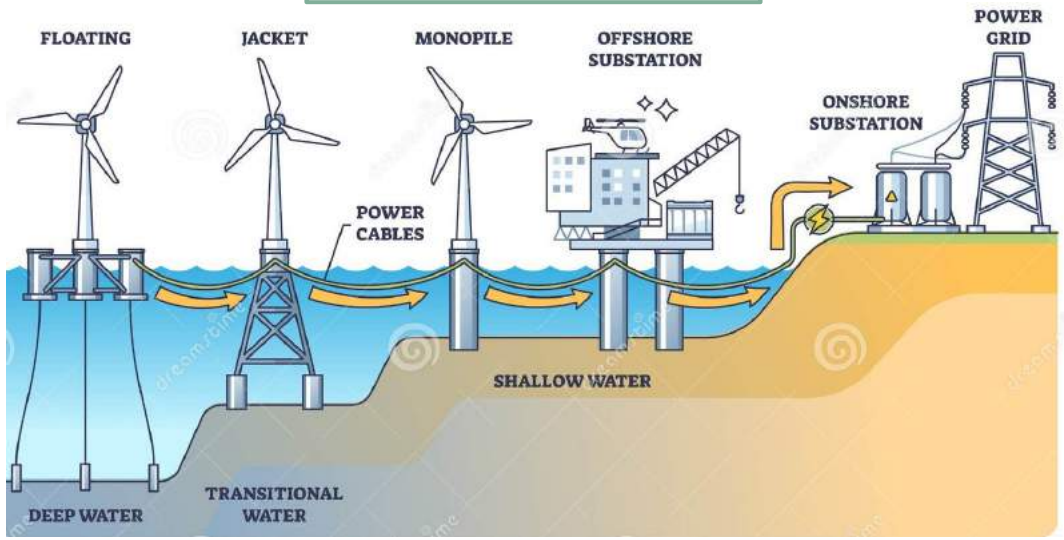
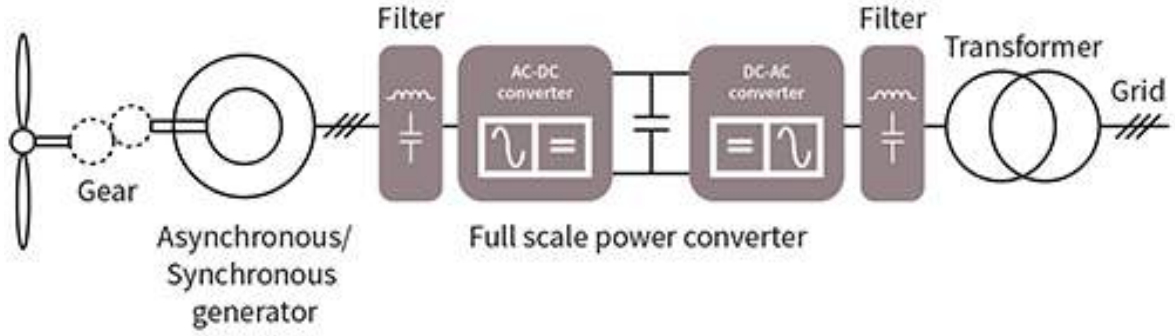
Wind Renewable Energy Generation

Typical Wind Plant

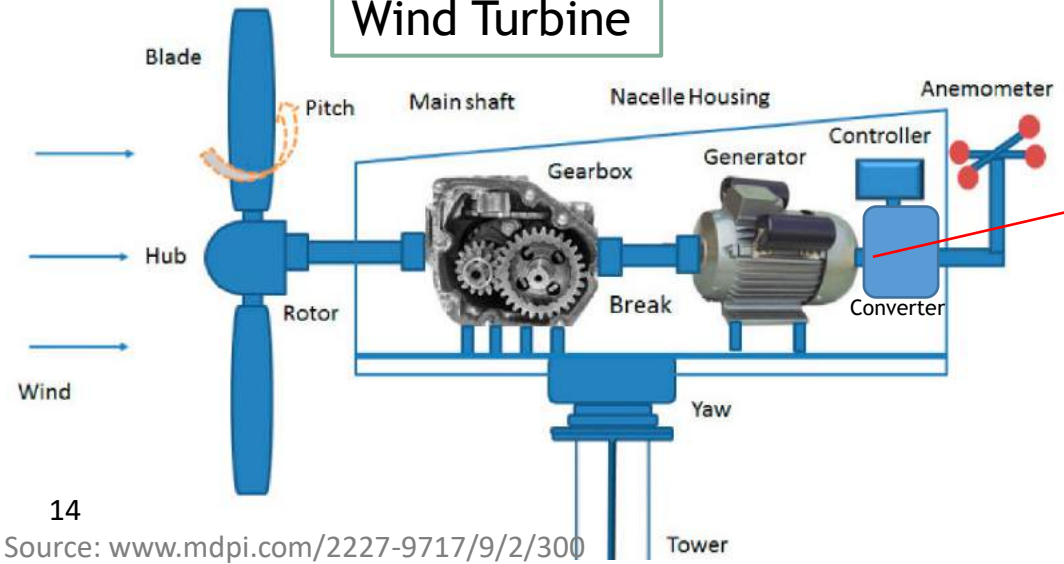


Source: dreamstime.com

Main Circuit



Wind Turbine



Source: www.mdpi.com/2227-9717/9/2/300

Wind Converter

ABB Wind turbine converter
800 – 8000 kW

POWER ELECTRONICS [INSIDE]

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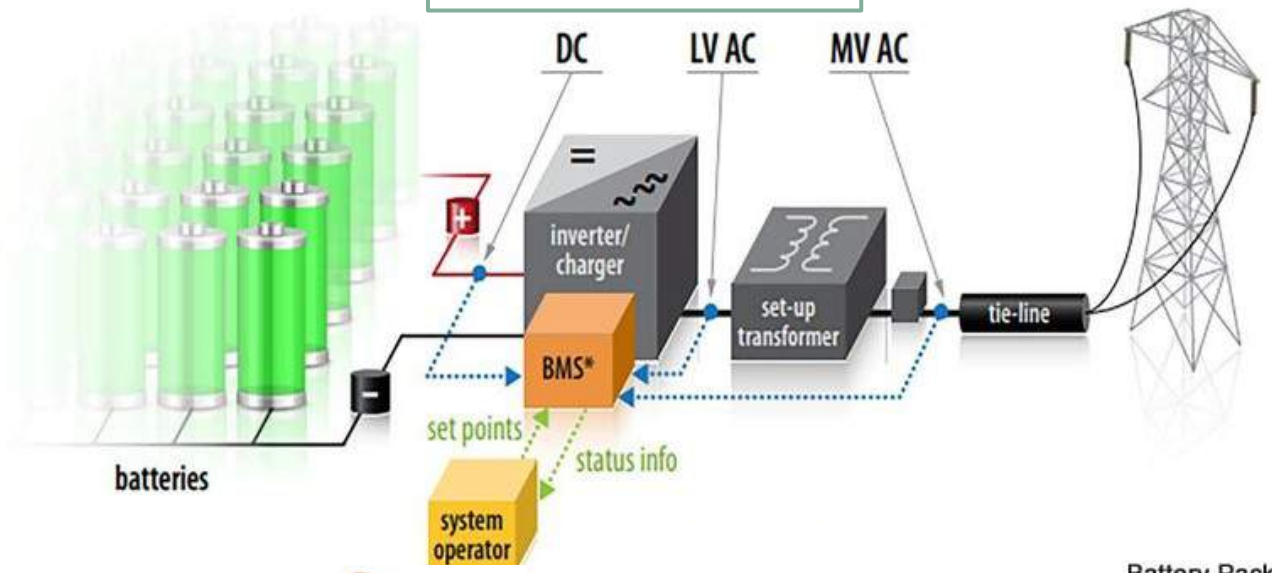
Battery Energy Storage System (BESS)

Typical BESS Plant



BESS Container

BESS Converter

POWER ELECTRONICS

[INSIDE]

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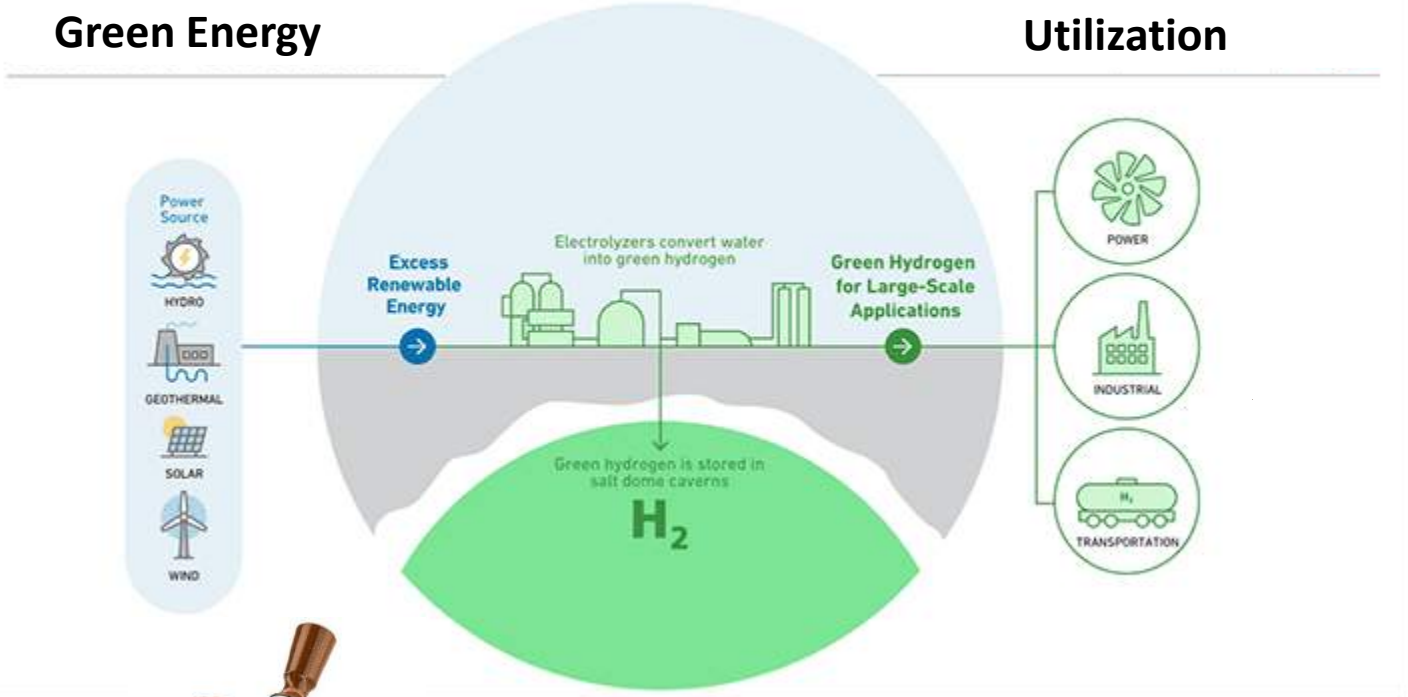
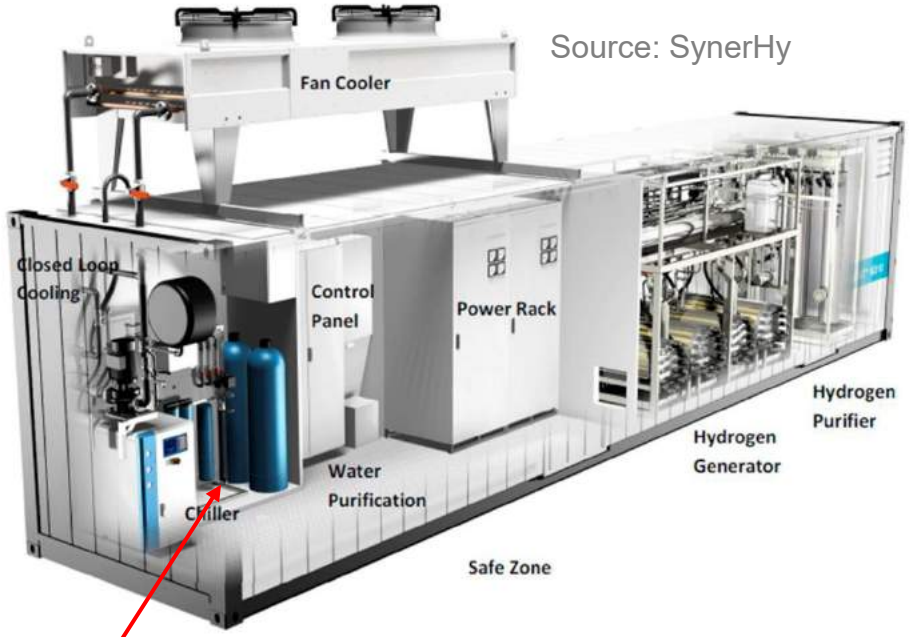
GREEN Hydrogen Production

Green Hydrogen Plant

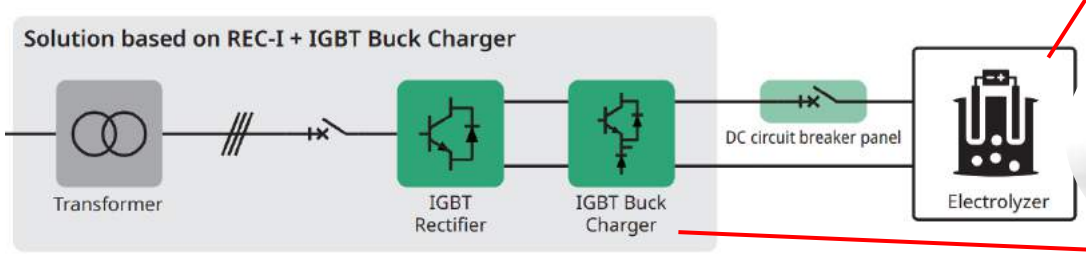


PEM Electrolyzer



Source: SynerHy

Main Power Circuit



FRIEM PSU

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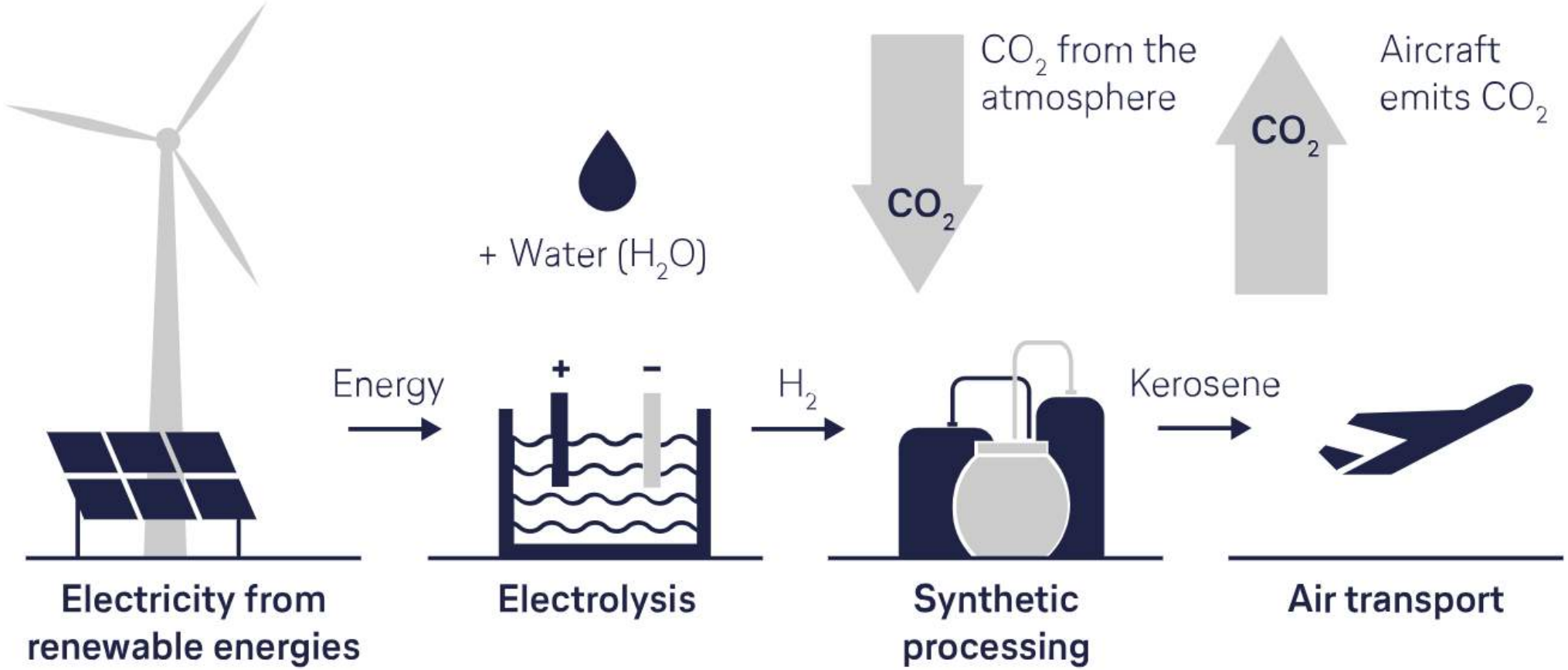
[INSIDE]

Sustainable Fuels



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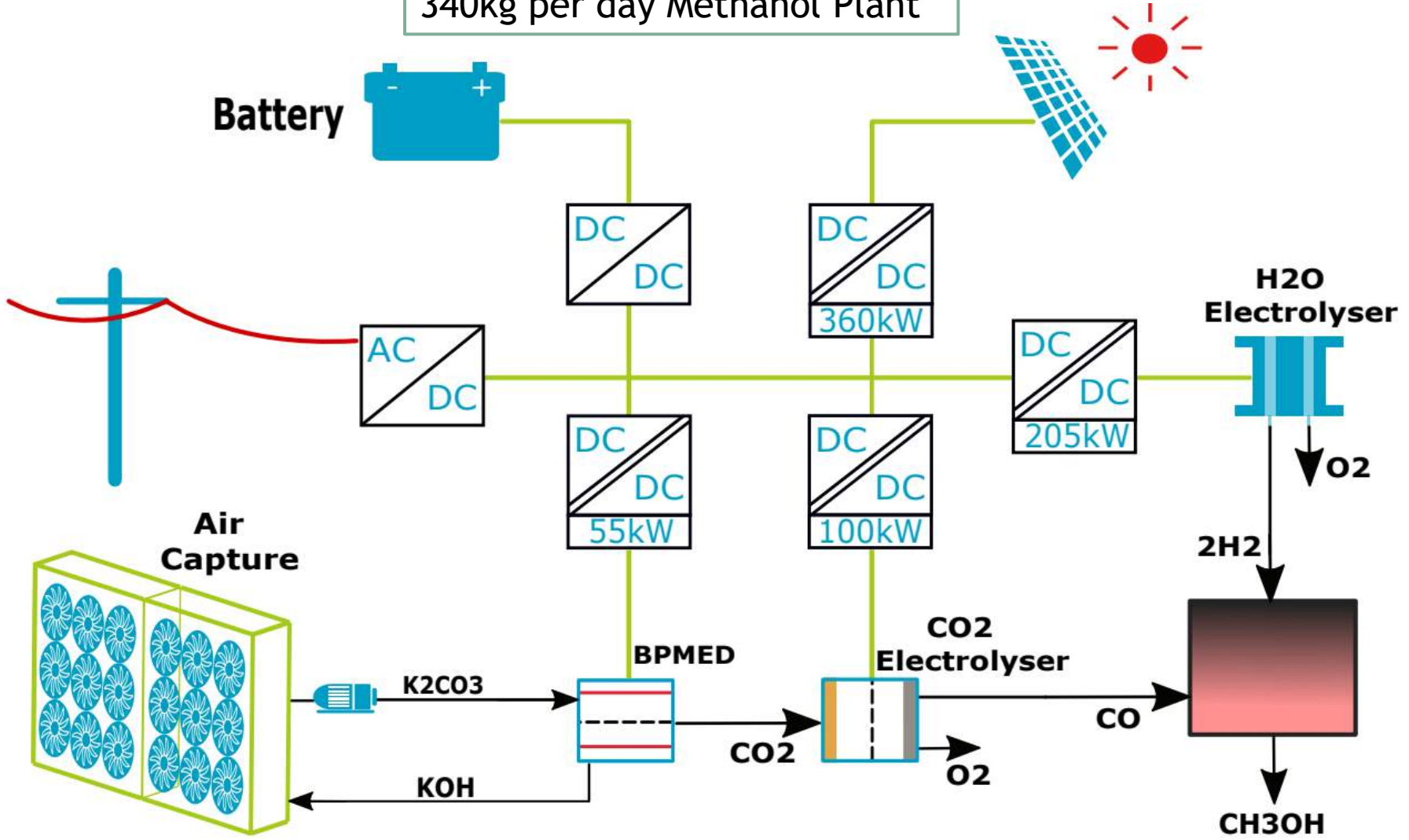
Sustainable Fuels

340kg per day Methanol Plant



Source: https://ieeexplore.ieee.org/document/9432571

Maritime Electrification

Tipping Point for DC Distribution?

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Maritime Electrification: Our Efforts

NEWS

Rotterdam harbour found to be most polluting port in Europe

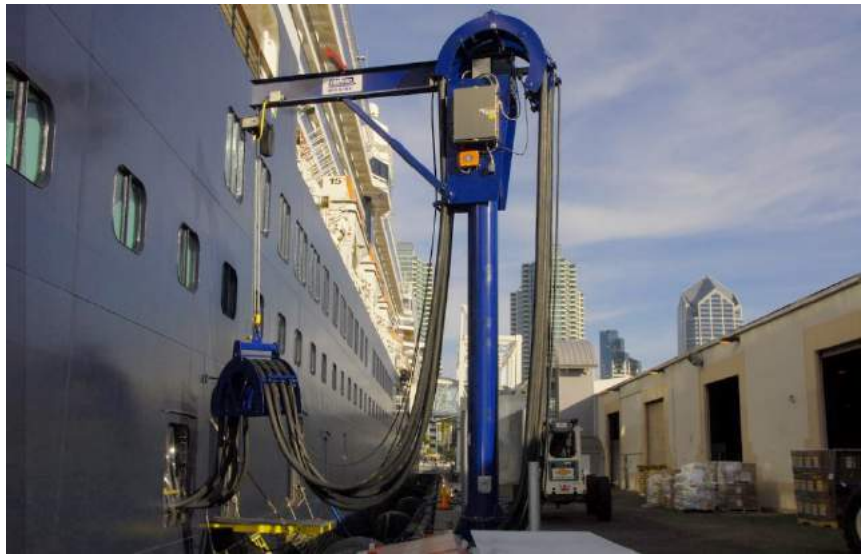
06 February 2022 By **Victoria Séveno**

The environmental organisation Transport & Environment (T&E) has found the port of Rotterdam to be the most polluting port in Europe, producing almost 14 million tonnes of CO_2 each year.

Port PV Systems @ Rotterdam

Onshore Wind Power @ Rotterdam

Source: Port of Rotterdam



Onshore Power Supply @ Rotterdam

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Maritime Electrification: Segments

Ferries
0-40 MW

Dredging Vessels
13-22 MW

Drilling Vessels
18-25 MW

Cable Layers
13-22 MW

Offshore Support Vessels
1-10 MW

Cruise Ship
20-60 MW

Twin Azipods
20 MW each

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Key PE players on R&D

VOYEX
Hydrogen Powered

Future Proof Shipping
MARINE SERVICE NOORD
Taking care of maritime piping.
KOEDOOD MARINE GROUP
THECLA BODEWES SHIPYARDS
Van Oord
Marine ingenuity
Huisman
VAN OOSSANEN NAVAL ARCHITECTS
BAKKER SLIEDRECHT
CRYOVAT
full range in cryogenics
Nedstack
PEM FUEL CELLS
TU Delft
C-JOB
DEDICATED NAVAL ARCHITECTS
DAMEN
discom
EXHAUST TECHNOLOGY
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royal roos
Port of Rotterdam
HOLLAND SHIPYARDS GROUP
IHC
ARENARED
ENGINE MANAGEMENT SYSTEMS
TNO
MARITIME HYDROGEN
VT
MARITIME LOGISTIC SERVICES
MARIN
BETTER SHIPS, BLUE OCEANS
WÄRTSILÄ
SYSTEMS
by Schneider Electric
Wij zijn DMO
Boskalis
FEADSHIP
ROYAL DUTCH SHIPYARDS
TU/e
ZERO EMISSION SERVICES
FUGRO
RH MARINE
ROYAL VAN LENT SHIPYARD
EST-Floattech

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Challenges and Opportunities Onboard

AC & DC Distribution

- Power electronics for propulsion
- Distributed storage integration
- Ring vs radial architecture

Retrofitting

- Electrical architecture
- Cost based on vessel lifespan

Protection

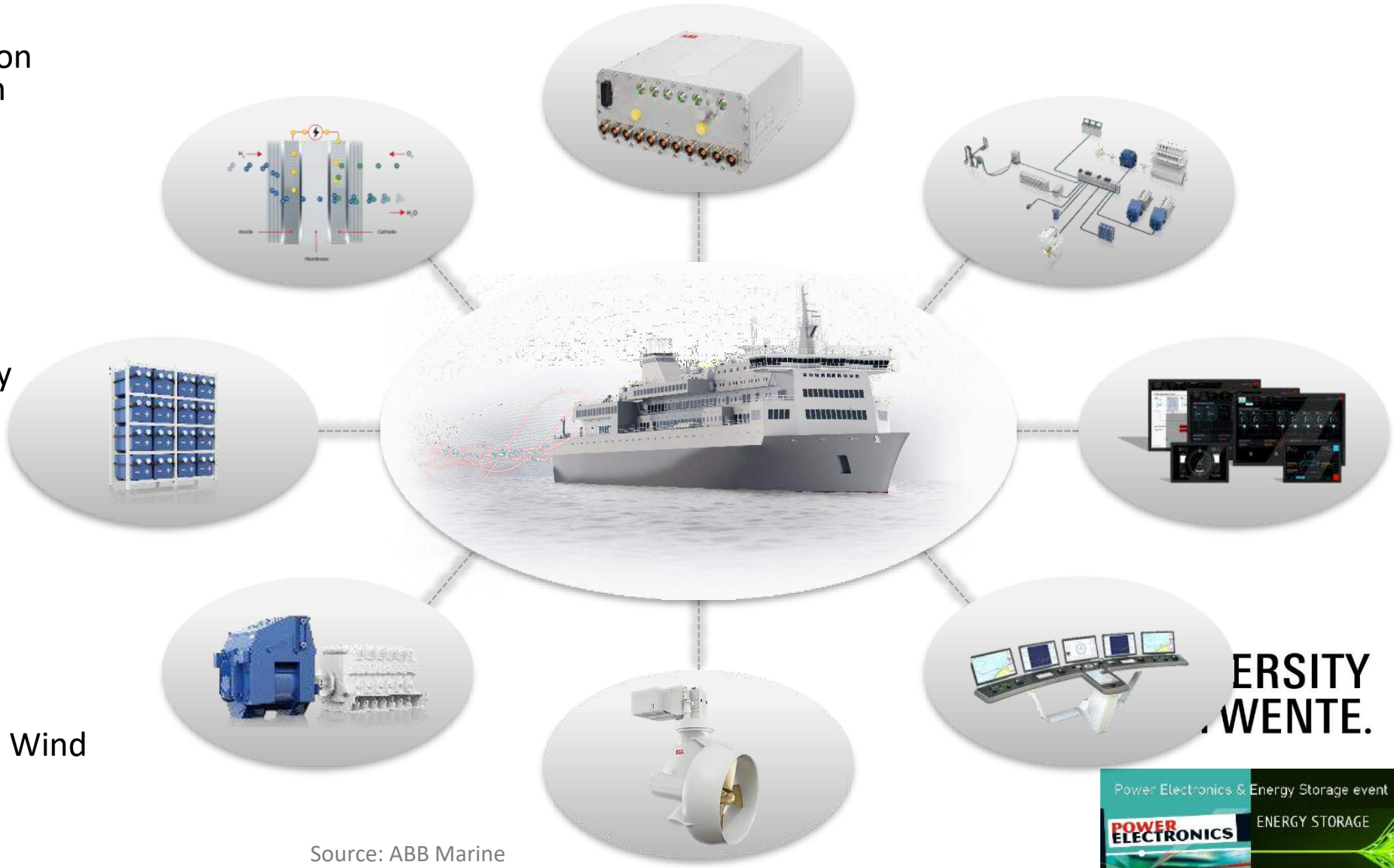
- Solid-state Breaker Technology
- Grounding Schemes

Power and Energy Management

- Intelligent Power Systems
- Hierarchical Control

Energy Storage

- Fuel Cell Technology
- Batteries, Onboard PV panels, Wind Assistance systems



Source: ABB Marine

23

Challenges and Opportunities Onboard

Integration of Renewable Energy

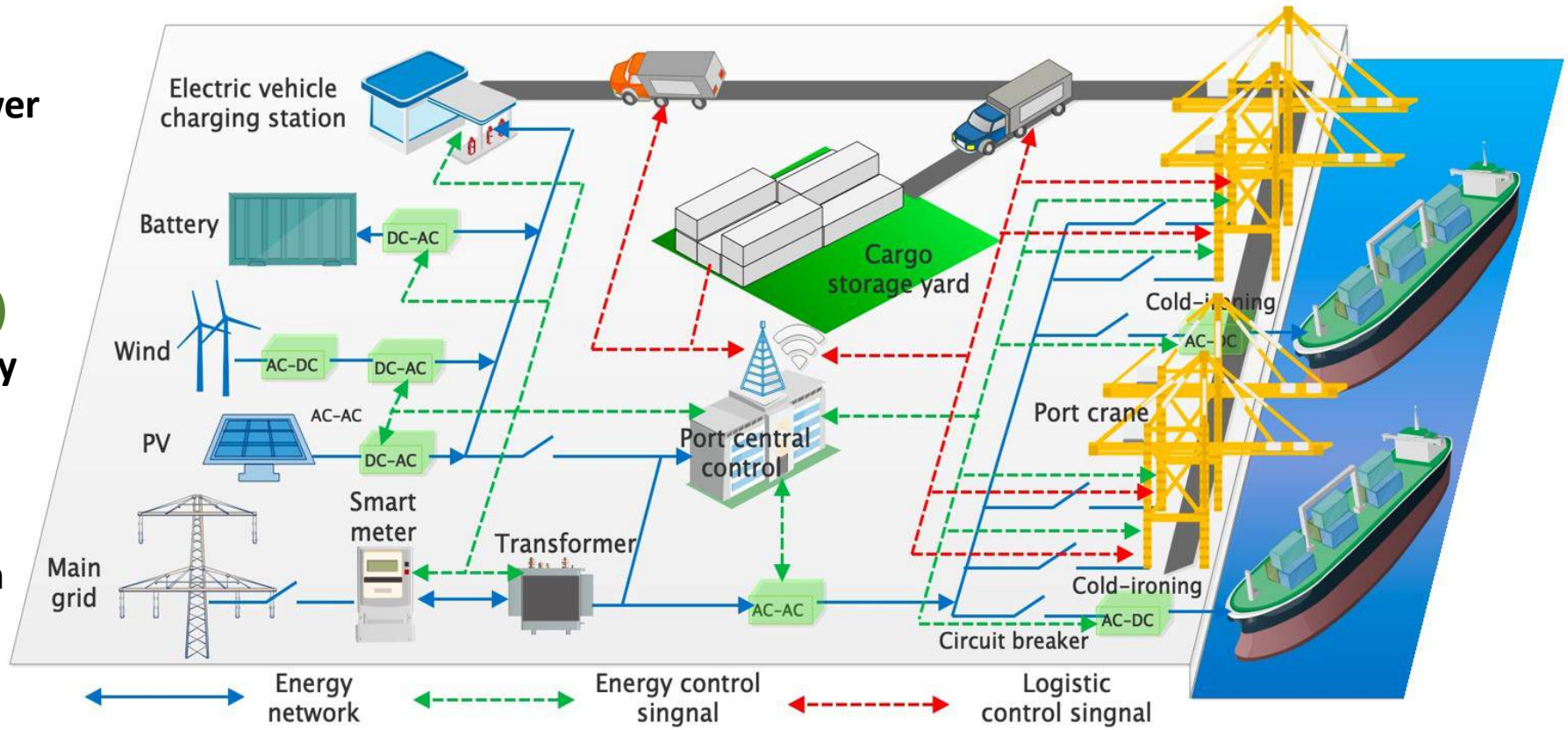
- On-shore and off-shore **wind power**
- **photovoltaic** generation
- Tidal energy

Cold Ironing (On-shore Power Supply)

- The **emission is in harbor territory**
- **Better layout** of vessel.

Electrification of Logistic Equipment

- **Electric logistic equipment** help in further reduction of pollution
- The **emission within the harbor territory can be reduced**



Sidun Fang, Bin Gou, et. al. Towards Future Green Maritime Transportation: An Overview of Seaport Micro-grids and All-electric Ships, IEEE Transactions on Vehicular Technology, 2019.

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Aircraft Electrification

Tipping Point for SAS, Hybrid and Full-electric Propulsion?

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Key Players in NL

AERONAMIC

TPRC THERMOPLASTIC COMPOSITES RESEARCH CENTER

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Fokker

GKN AEROSPACE

SAMCO Aircraft Maintenance

Koninklijke Luchtmacht

MAEVE AEROSPACE

TU Delft

TENCATE ADVANCED COMPOSITES

EMBRAER

Aircraft Maintenance & Training School

BELL

nlr

AAR

StandardAero

BOEING

MAAS aviation

DutchAero a KMWE company

Airborne

Avio-Diepen Aerospace Parts & Inventory Solutions

UTC Aerospace Systems

AIRFRANCE INDUSTRIES KLM Engineering & Maintenance

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THALES

VDL

Senior Aerospace

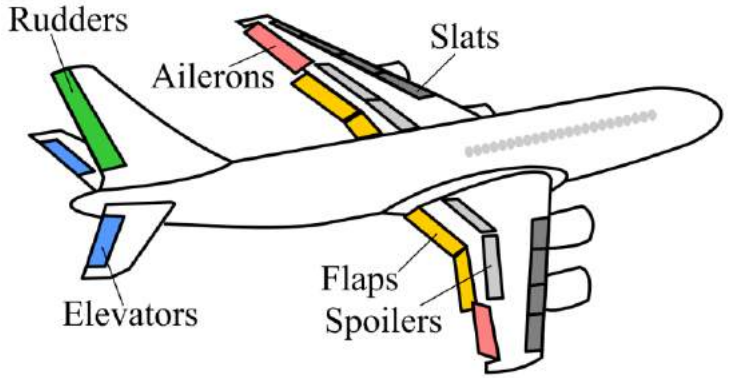
AVIOLANDA aerospace woensdrecht

AELS Aircraft End-of-Life Solutions

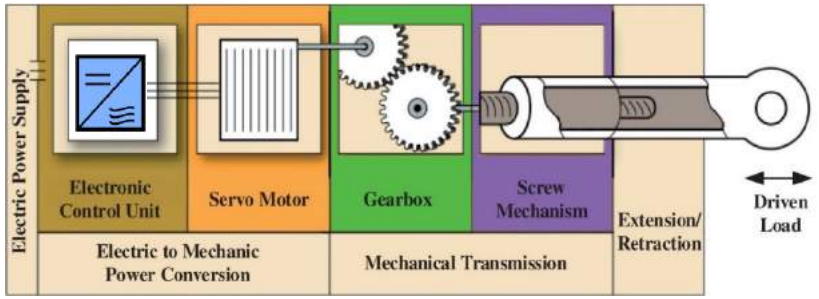
Aviation Competence Centre

More Electric Aircraft

Electric Actuators



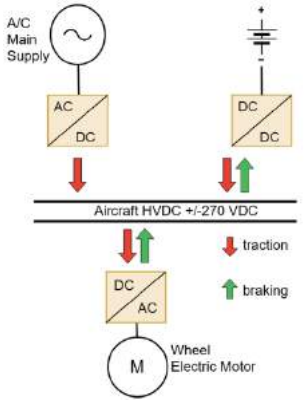
Source: Review of Electric Machines in More-/Hybrid-/Turbo-Electric Aircraft, *IEEE Transactions on Transportation Electrification*



Source: A review of electromechanical actuators for More/All Electric aircraft systems, Proceedings of the Institution of Mechanical Engineers

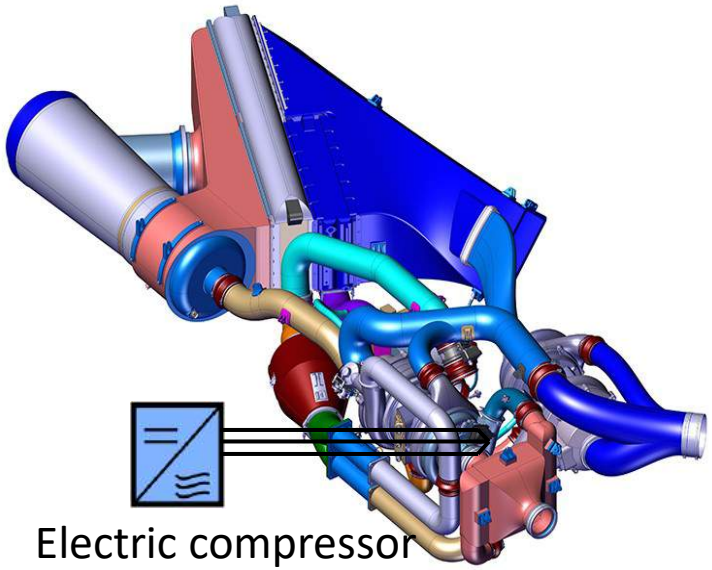
[INSIDE]

Electric Taxiing



Source: https://onboard.thalesgroup.com/electric-aircraft-pushes-back/

Electric Environmental Control System (e-ECS)



Electric compressor

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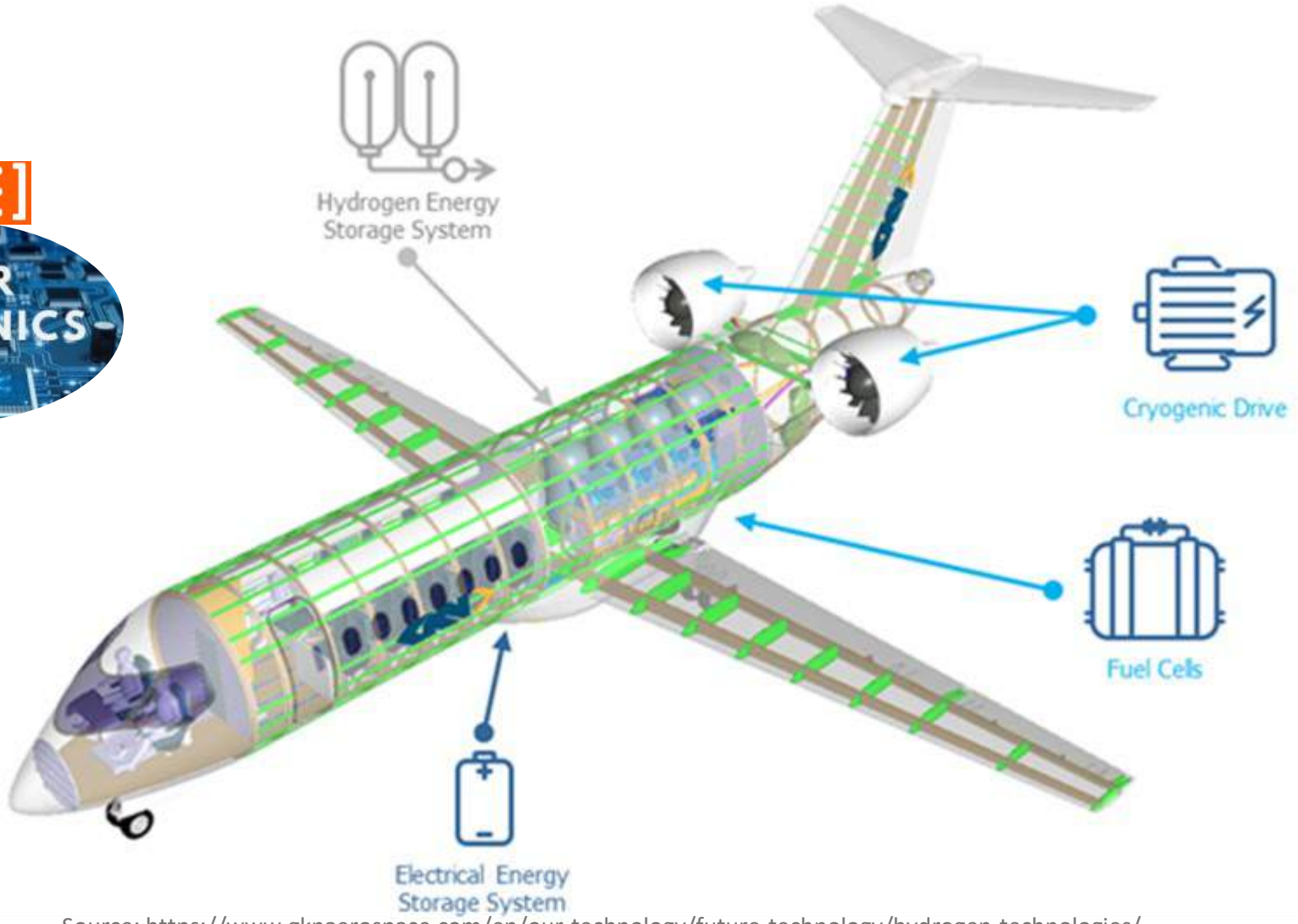
More Electric Aircraft

Hydrogen-based Propulsion



Source: https://www.gknaerospace.com/en/our-technology/future-technology/hydrogen-technologies/

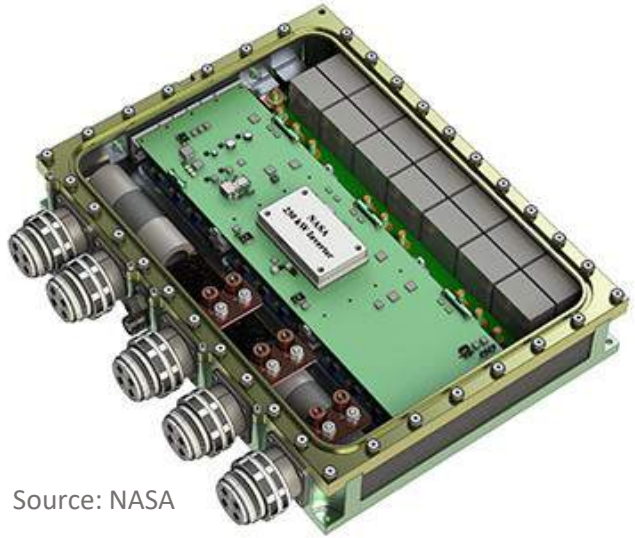
Opportunities

Propulsion Optimization

- **Superconductive** electric motors

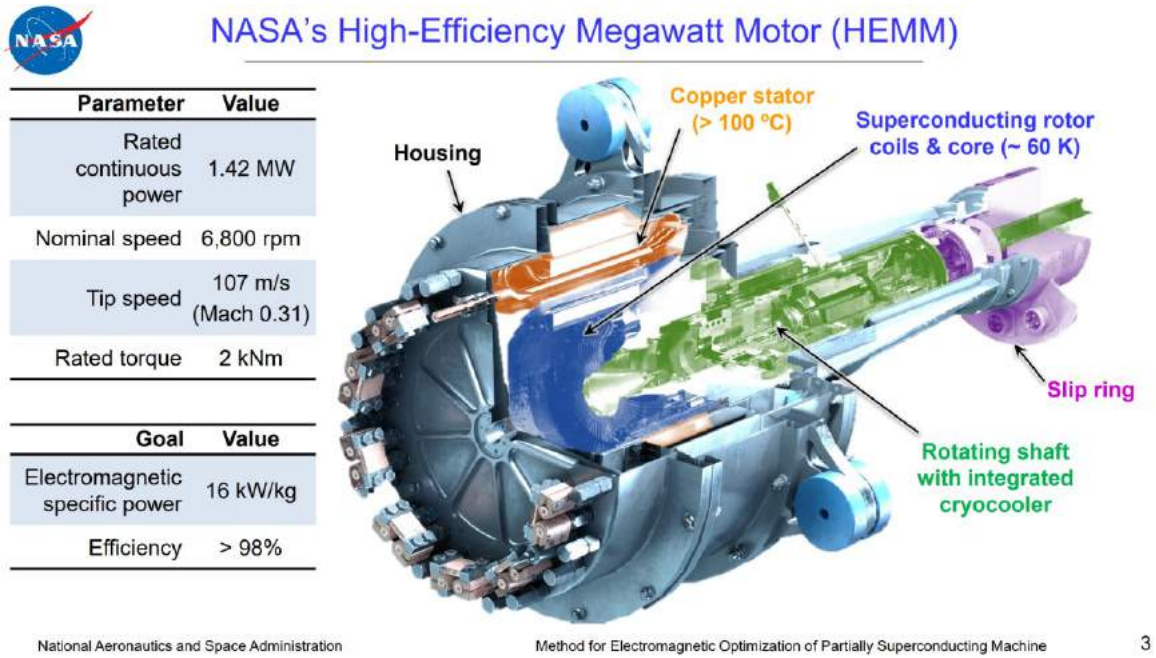
Power Electronics

- MW-range
- **High power density**

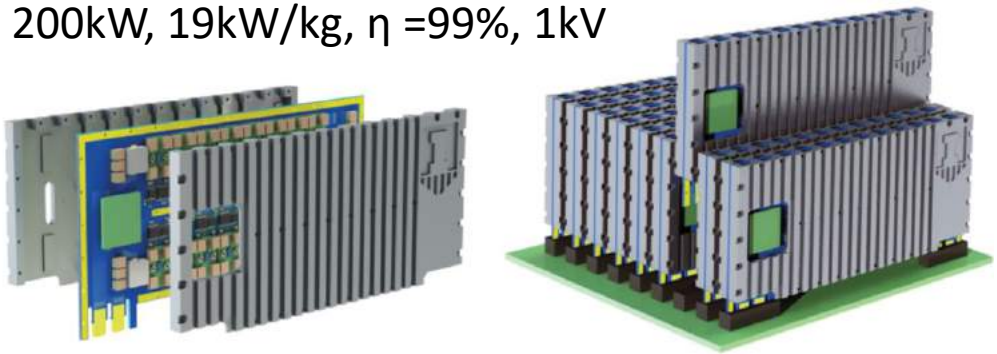


Source: NASA

250kW, 10.6kW/kg, η =99.3%*, 1kV



200kW, 19kW/kg, η =99%, 1kV



Source: University of Illinois Urbana-Champaign

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Conclusion

Power Electronics and Energy Storage is the Path forward for Electric Transportation

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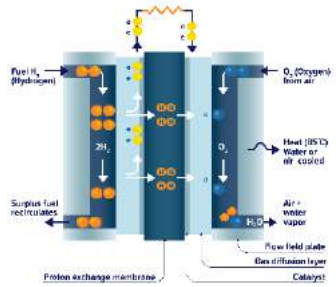
Key challenges and opportunities of electric transportation

Challenges

- Infrastructures:
  - Energy storage capacity
  - Charging infrastructure
  - Scalability

- Maintenance, Repair, Overhaul:
  - Skills and Training
  - Facilities (Upgrades)
  - Availability/Timely

- Standards and Regulations:
  - Systems Compatibility and safety
  - Regulatory compliance
  - Testing and validation standards



Opportunities

- Low carbon Propulsion:
  - Alternative & Sustainable fuel
  - Environmental performance
  - Energy management & optimization

- Ultra efficient systems:
  - Light weight material
  - Power Electronics
  - Structural Design

- Safety and Reliability:
  - Redundancy & Fault tolerance
  - Digitalization
  - Cybersecurity measures

Key challenges and opportunities of electric transportation

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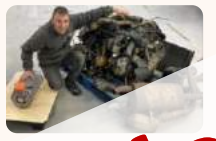

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Huge Challenge but Together & with Power Electronics and Storage &EMC we Can Do it!

Questions

10.00. Sailing into a Greener Future: Power Electronics at the Shore and in the Ship

13.30. Power electronics and EMC on board All-Electric Aviation, a marriage for success

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