A sustainable future: The role of power electronics in safe and SMART DC Power Grids

Aniket Sarode

Introduction

Aniket Sarode

- Technical Sales Consultant
- KWx

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- Knowledge and product supplier of power electronics
- Founded in 2002, ABB division merged in 2003
- "Early involvement" in new developments
- 2014 research changes Maritime market
- Development of the Solid-state DC Breaker in collaboration with Astrol
- Extensive knowledge of DC systems
- KWx also provides solutions for the OEM and traction industry
- Growing number of projects for sustainable energy.

Maritime DC Traction Renewable

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Our Clients


Industry


Panel Building

Medical


Consumer


Sustainable Energy


Maritime sector


OEM


Traction

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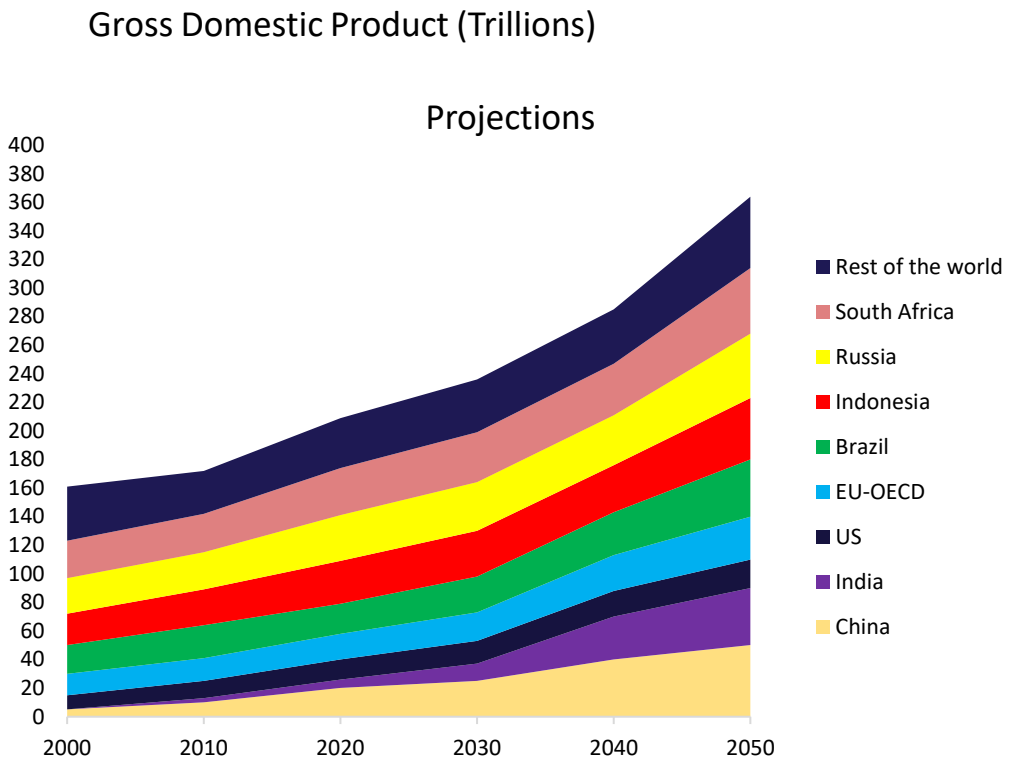
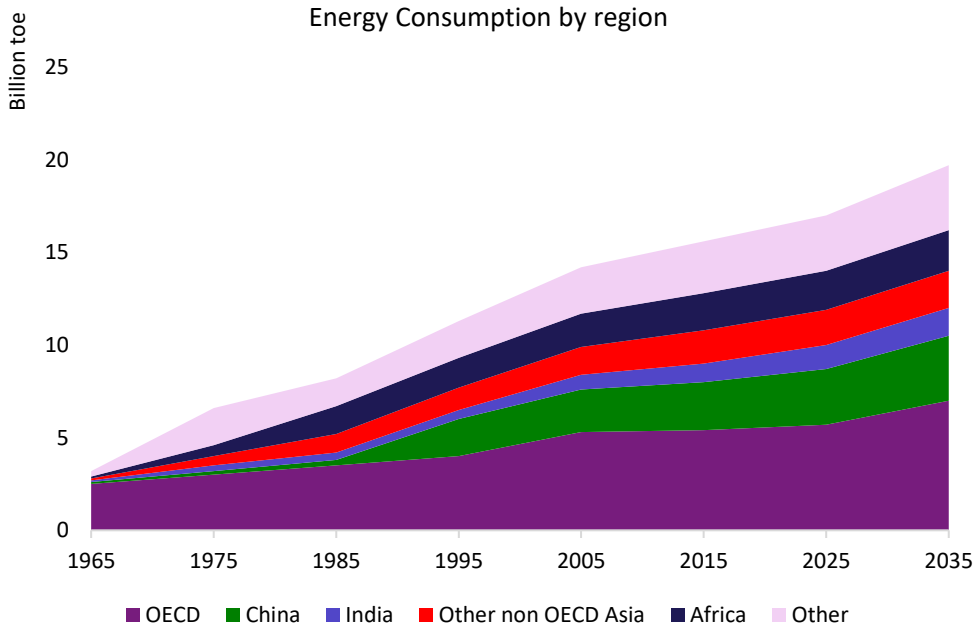
The energy landscape



Growth in world economy is expected to double over the next 20 years



This gives rise to global energy needs

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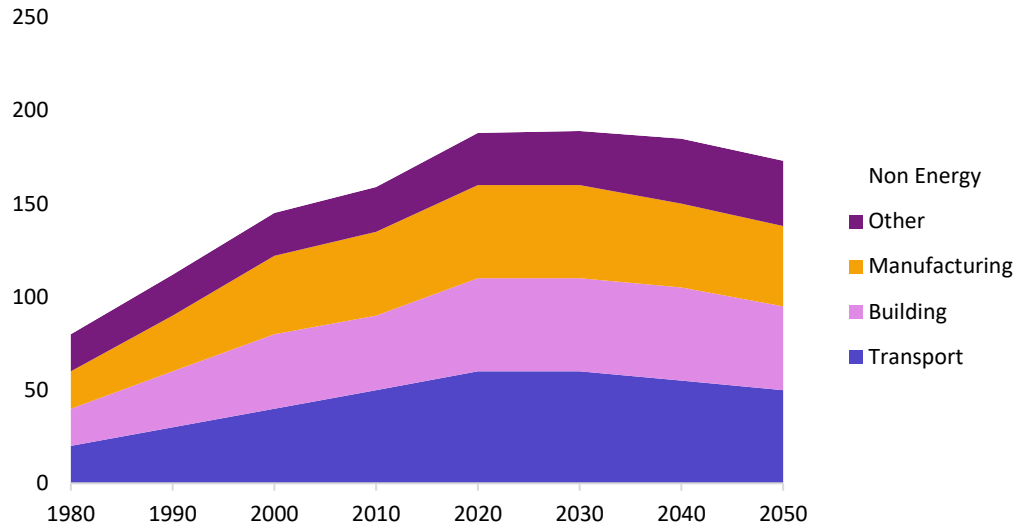
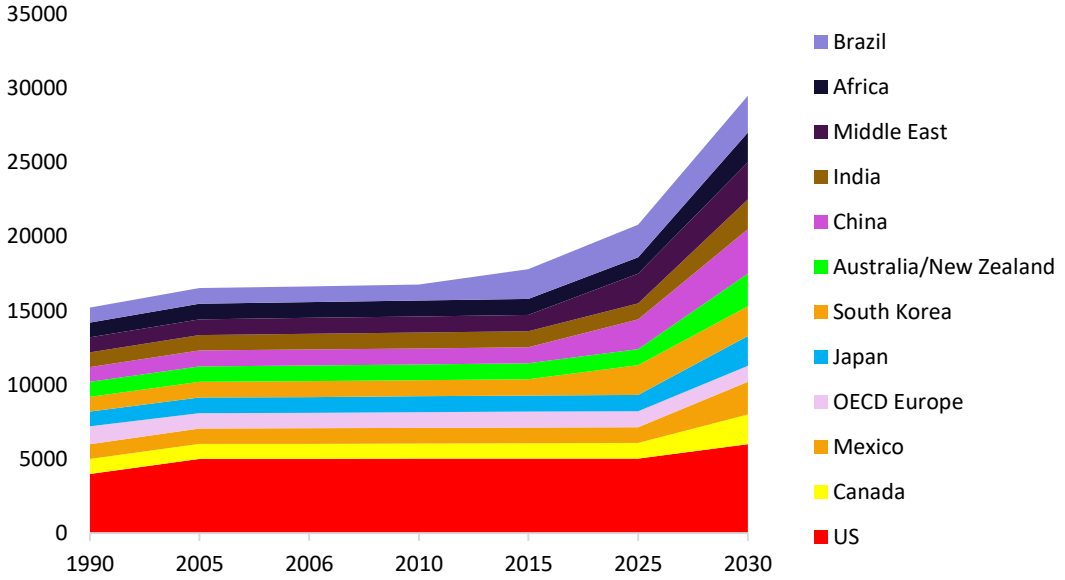
Use of energy in transport sector is also on a rise

World final energy demand by sectors EJ/yr



Transport accounts for 27% of global energy use

Million Metric Tonnes CO2



Which resulted into significant number of harmful emissions so far

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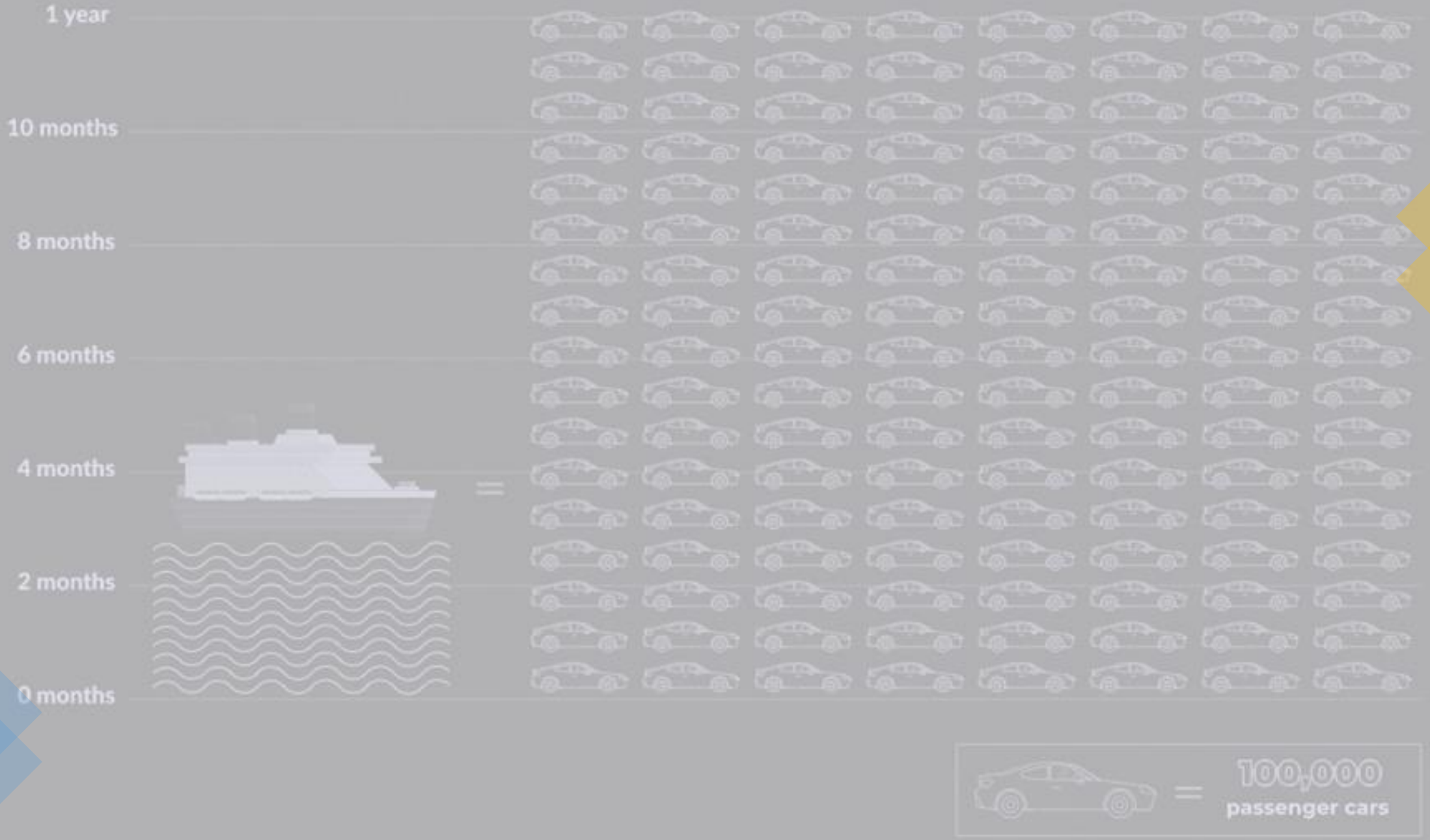
Shipping industry has its own share

- More than three percent of global carbon dioxide emissions can be attributed to ocean-going ships. This is an amount comparable to major carbon-emitting countries (World Economic Forum 2018).
- If global shipping were a country, it would be the sixth largest producer of greenhouse gas emissions.

MS Rotterdam emitted the same Sulphur pollution in 3 months as 12 million passenger cars emit in 1 year



https://www.transportenvironment.org/annual-report-2018/campaigns/ships.html

There's a clear problem…

Climate change

CO2 emissions are bringing our planet to abrupt and irreversible danger

Transport

27% of all the energy we consume goes towards transport

Replacing current use + keep up with growth

Our consumption of fossil fuels is still growing, and total energy consumption is expected to grow another 48% before 2040

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… and a clear solution

Climate change

Renewable Energy + Smart grids are promising prospects

Transport

Smart (DC) energy management system onboard.

Replacing current use + keep up with growth

Smart DC electrification and hybrid systems for energy storage.

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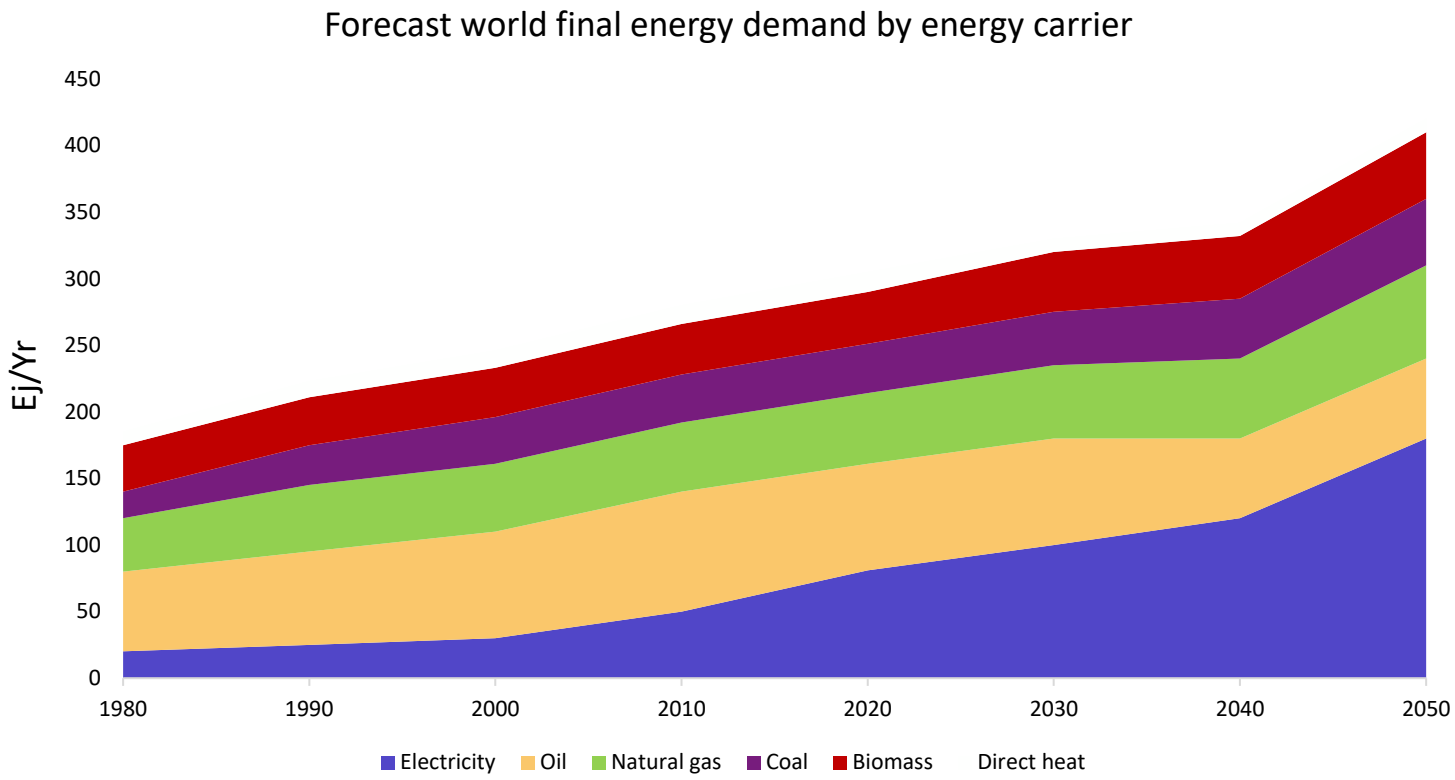
Electricity is already bound to become the main energy carrier



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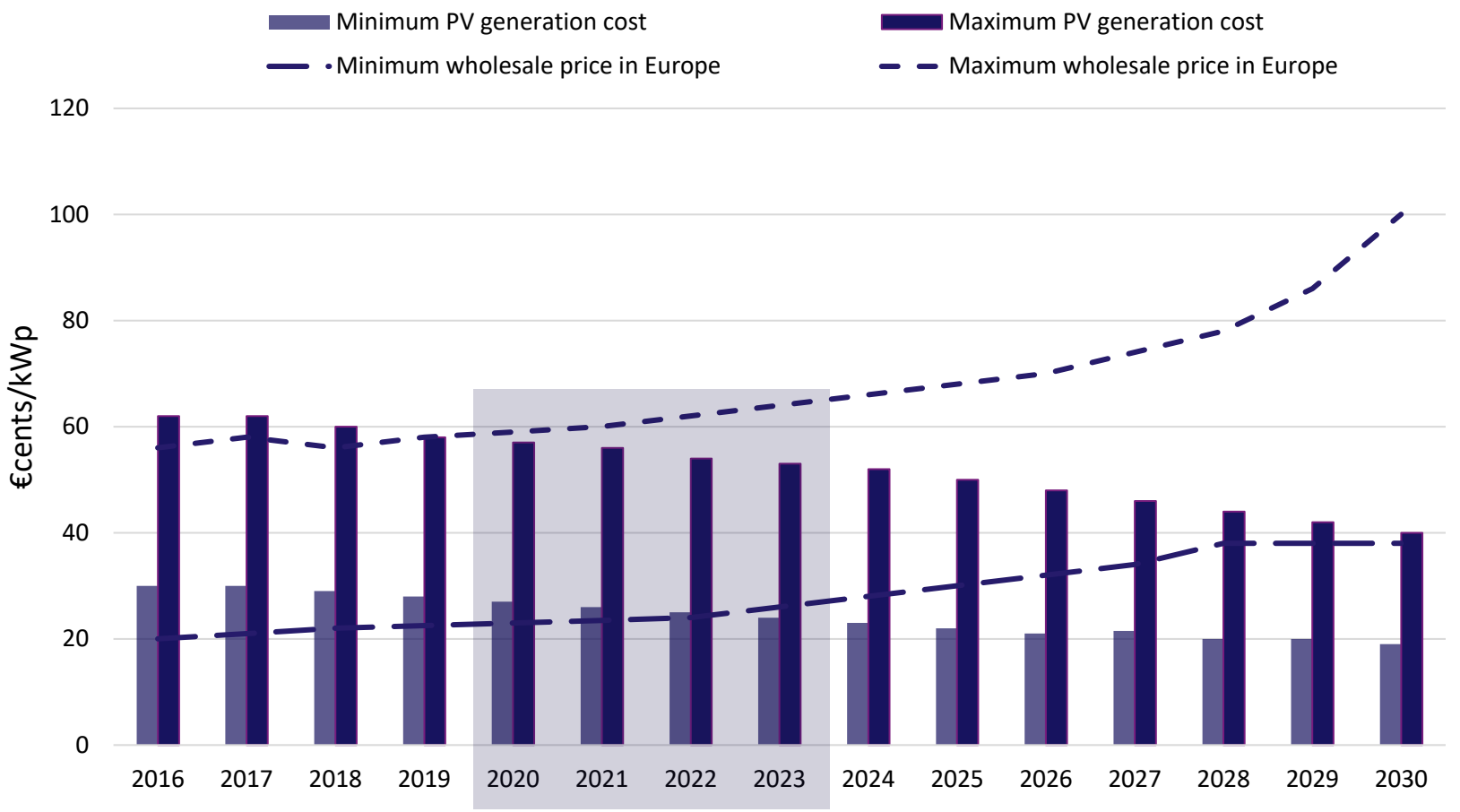
Solar PV will be competitive with wholesale prices across the whole of Europe by 2023



Comparison of PV generation costs range in EU (2016-2030) and medium scenario for Wholesale electricity price development

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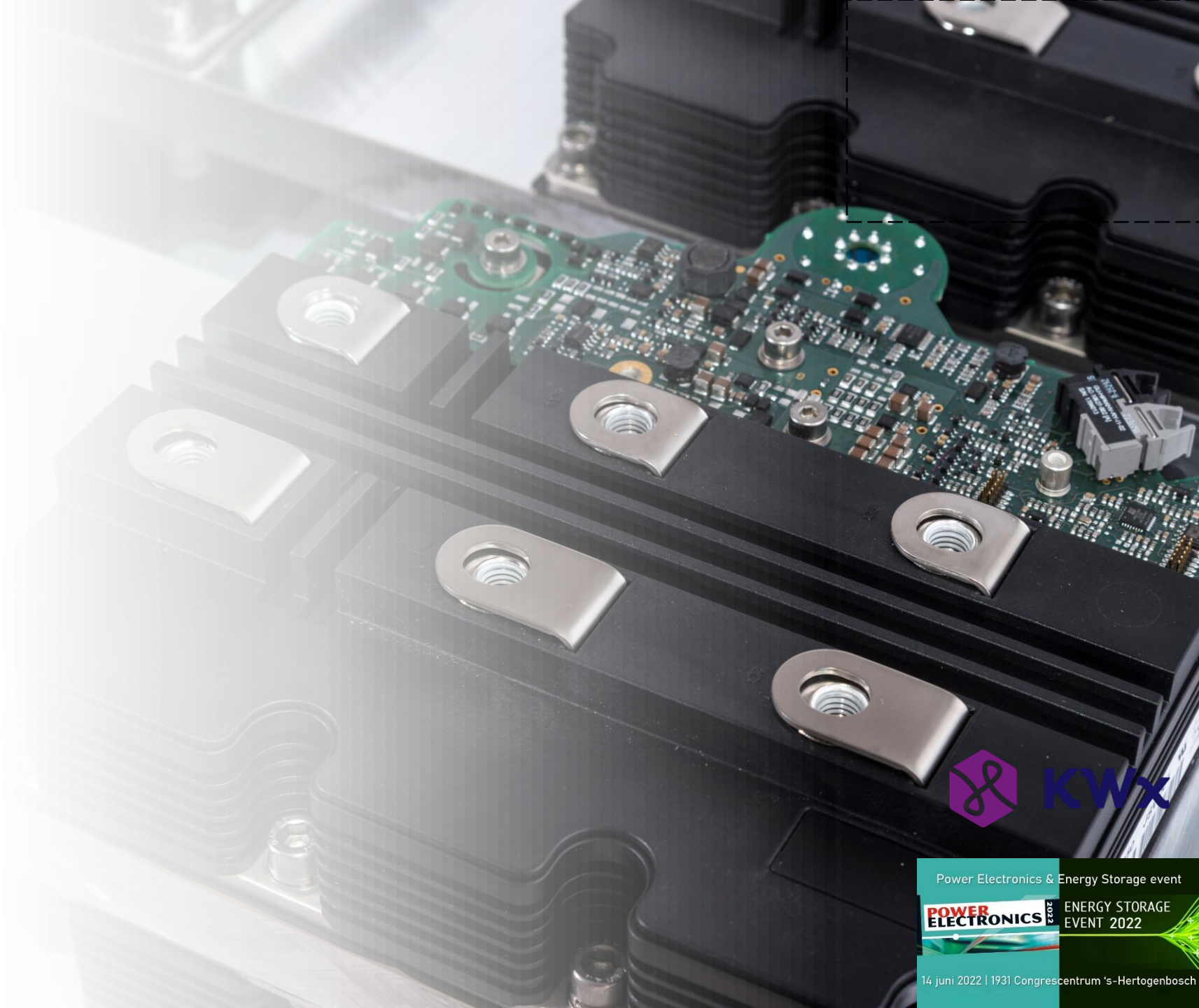
Can you imagine it without Power Electronics?

- 70% of electricity is processed by Power Electronics.
- We are already living in DC world.
- The presence and growth of Power Electronics in society come from its extreme flexibility and capability to adapt for the purpose.
- Advancements in the power electronics technology steered the development of ships in the direction of hybrid AC/DC and full DC power systems.



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Power Electronics & Energy Storage event

POWER ELECTRONICS 2022

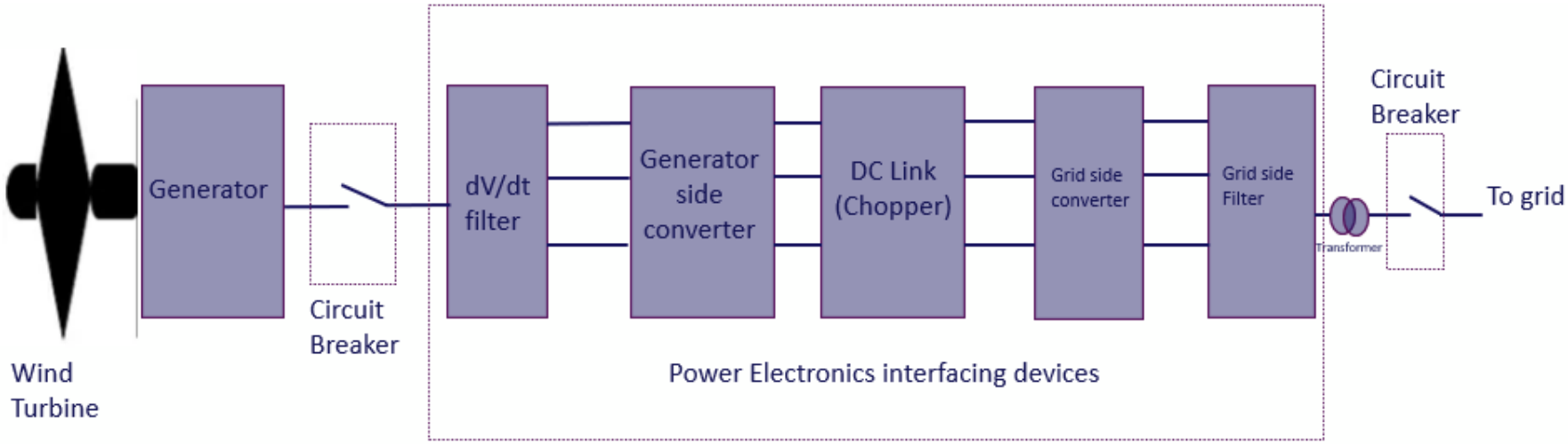
ENERGY STORAGE EVENT 2022

14 juni 2022 | 1931 Congrescentrum 's-Hertogenbosch

Contribution of power electronics devices in smart grid

Renewable energy integration

- Exponential growth of renewable energy has been enabled in the recent years, only because of technological advances in ‘Power Electronics’ devices and their ability to control power flow.
- Modular converters can be made with designs based on high power semiconductors, IGCTs and IGBTs and due to compact design, they fit easily in the turbine tower.



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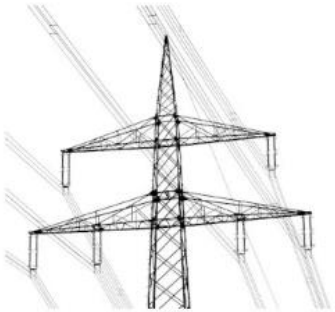
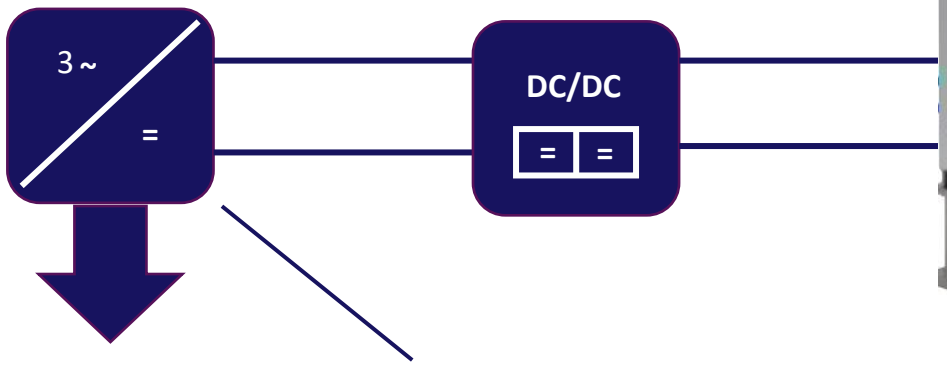
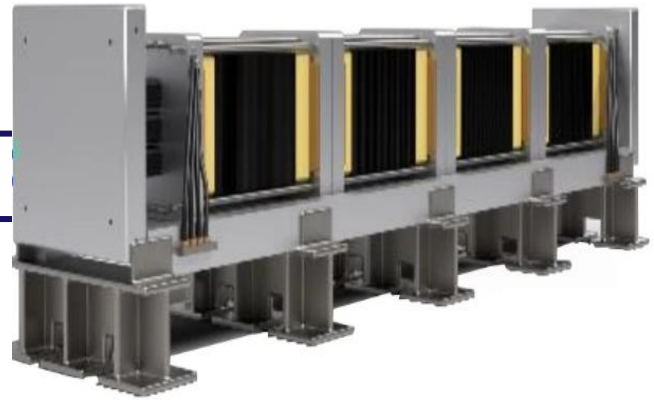
Power Electronics for Hydrogen Electrolysis

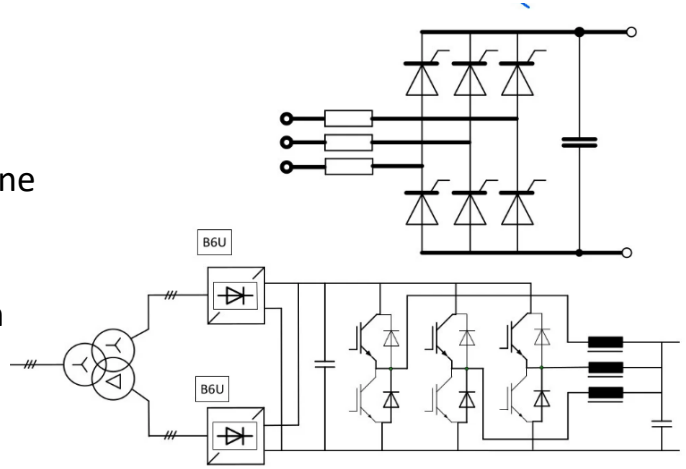






Thyristors for green hydrogen production have many advantages:

- The circuit is less complex.
- The final system is cheaper than the one with an IGBT.
- They are more robust than IGBTs.
- Possible to implement protection with fuses.
- Maximum power density is obtained with low conduction losses.



Discs

Stack

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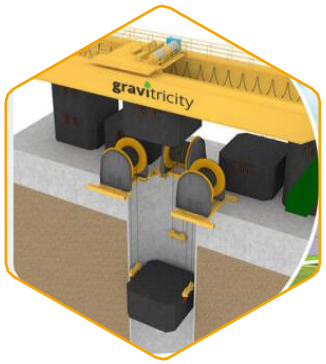
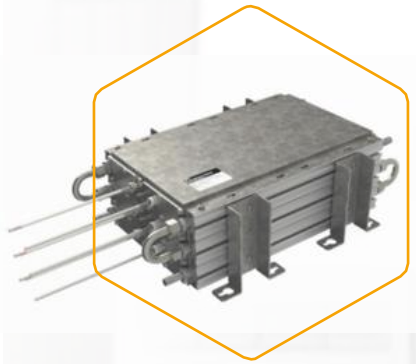
Source Infinion: Hydrogen production with Thyristors.

Gravitricity for renewable energy integration in grids





- Able to store excess energy ready to be released when needed to balance the grid.
- Can store energy at half the cost of Lithium-ion batteries.

Unique Characteristics

- Response time – zero to full power in less than one second
- Efficiency – between 80 and 90 percent
- Versatile – can run slowly at low power or fast at high power
- Simple – easy to construct near networks
- Cost effective – levelized costs well below lithium batteries

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Supercapacitors for Energy Storage and Peak shaving

- In marine DC grids, the demand of electricity is usually not even, for example, when certain bigger machines are turned on for short periods of time which generates peak in load profiles.
- The power demand for such peaks can be fulfilled by diesel generators which are costly to operate and emit pollution.
- Supercapacitors are optimal for high power charge- and discharge periods and thus suitable for peak shaving.

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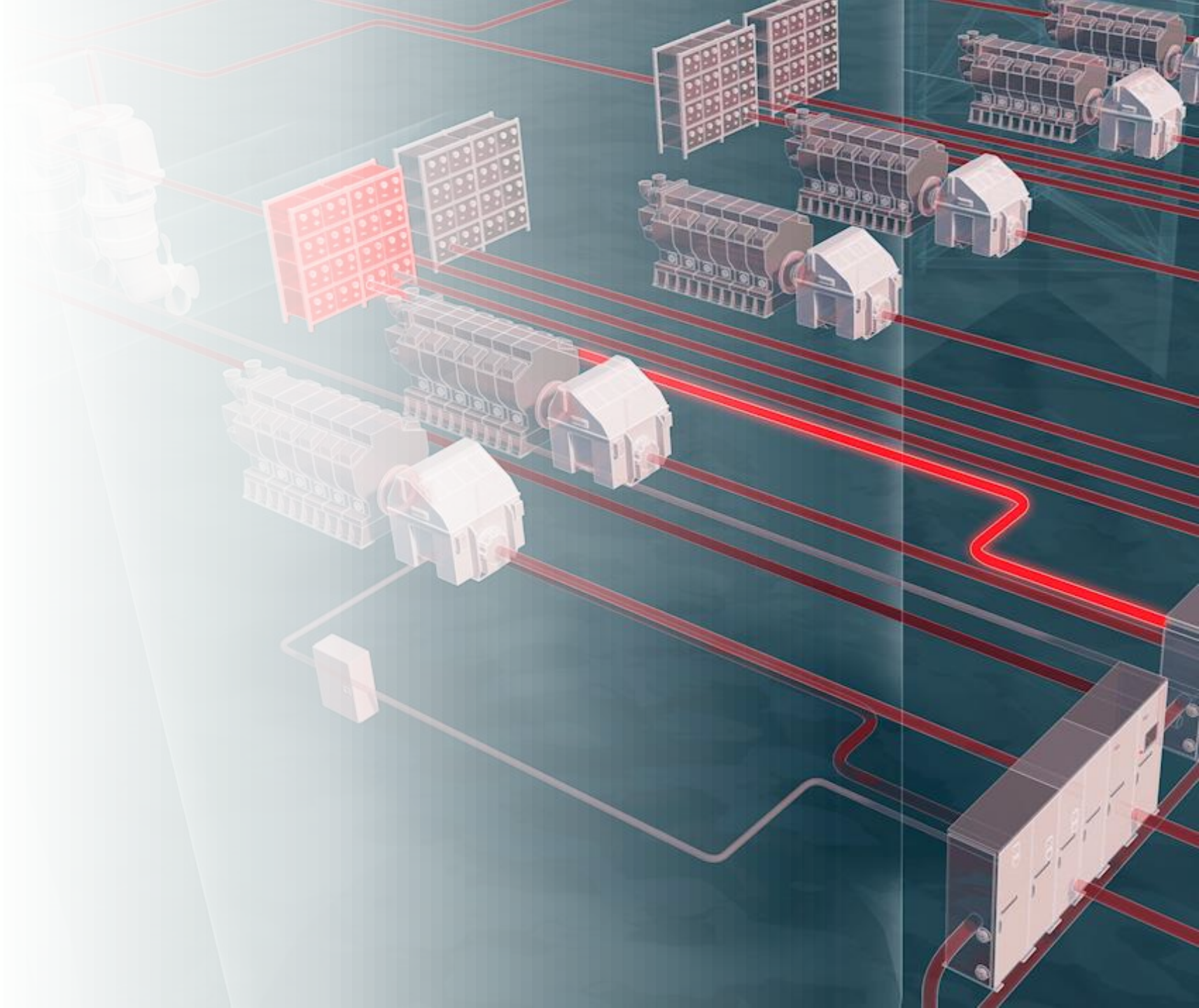
DC grids are widely used for various applications.

- DC grids provide power stability, fuel flexibility and energy storage benefits and enables system integrators to achieve protection selectivity.
- To the ship owner this provides more flexible and competitive vessel, but it poses a challenge for ship protection and safety.
- Fast fault current interruption is very important for ships at sea.



Advantages of DC Grids

Energy storage: In the onboard DC grid solution, energy storage may be included to improve the system's dynamic performance

Fit for future: Alternative energy sources will be easier to adopt in a vessel with onboard DC grid because they will not be bound to an AC system, nor will they require redesign of a main switchboard.

Power stability and quality benefits: In the AC-grid system, both voltage and frequency are required to be monitored and controlled for maintaining the power stability. However, in the DC-grid system, there are no reactive power interactions, and then the system control is oriented to the voltage only.

Efficient and weight/fuel saving: In addition to boosting efficiency by up to 20 percent, other benefits include space and weight savings of up to 30 percent and flexible placement of electrical equipment.

Operational optimization: DC distribution system allows for new ways of thinking regarding operational optimization. The system can combine different energy sources such as engines, turbines, and fuel cells.

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Challenges in DC grids

- Safety
  - Prospective short circuit currents up to 300kA
  - High dI/dt (up to 1000A / µs)
  - Selectivity and complex safety scenarios due to new system topologies.

- Market demand and availability
  - Lack of available (dedicated) DC components
    AC -> DC components like fuses but also a restricted portfolio due Voltage levels higher than 1000V.
  - Lack of up-to-date guidelines and standards
    Different organizations (NEN, IEC, IASC, IEEE) are in the process of updating the standards based on market development. KWx is participating in different norm committees.

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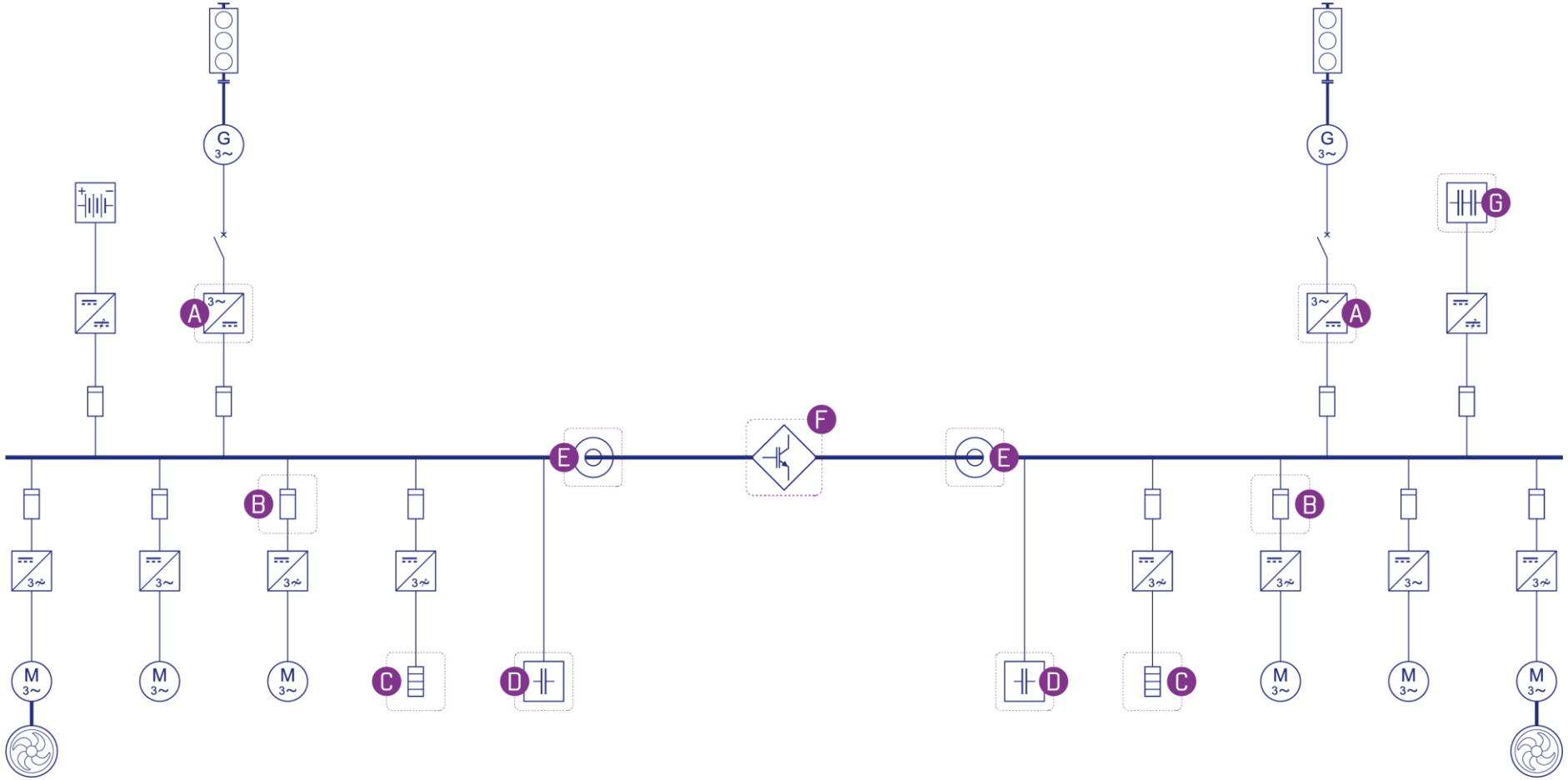
Onboard grid protection

- Solid state DC circuit breakers can provide very short reaction time and fast current interruption thanks to the properties of power semiconductor devices.
- The high current solid state DC circuit breakers have revolutionized system protection for safe, arc-less, high-efficiency DC systems.

Key benefits:

- Ease of integration
- Cost efficient and green solution
- Safety
- Maximum vessel uptime and minimum maintenance cost
- Closed bus operation.

Essential Power Electronics components in Marine DC Grids



A Rectifier Assemblies

B High Speed Fuses

C Power Resistors

D Capacitors

E Current Sensors

F DC Breaker Switches

G Supercapacitors

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Thank you

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