Technology evolutions for RES integration to the Power Grid

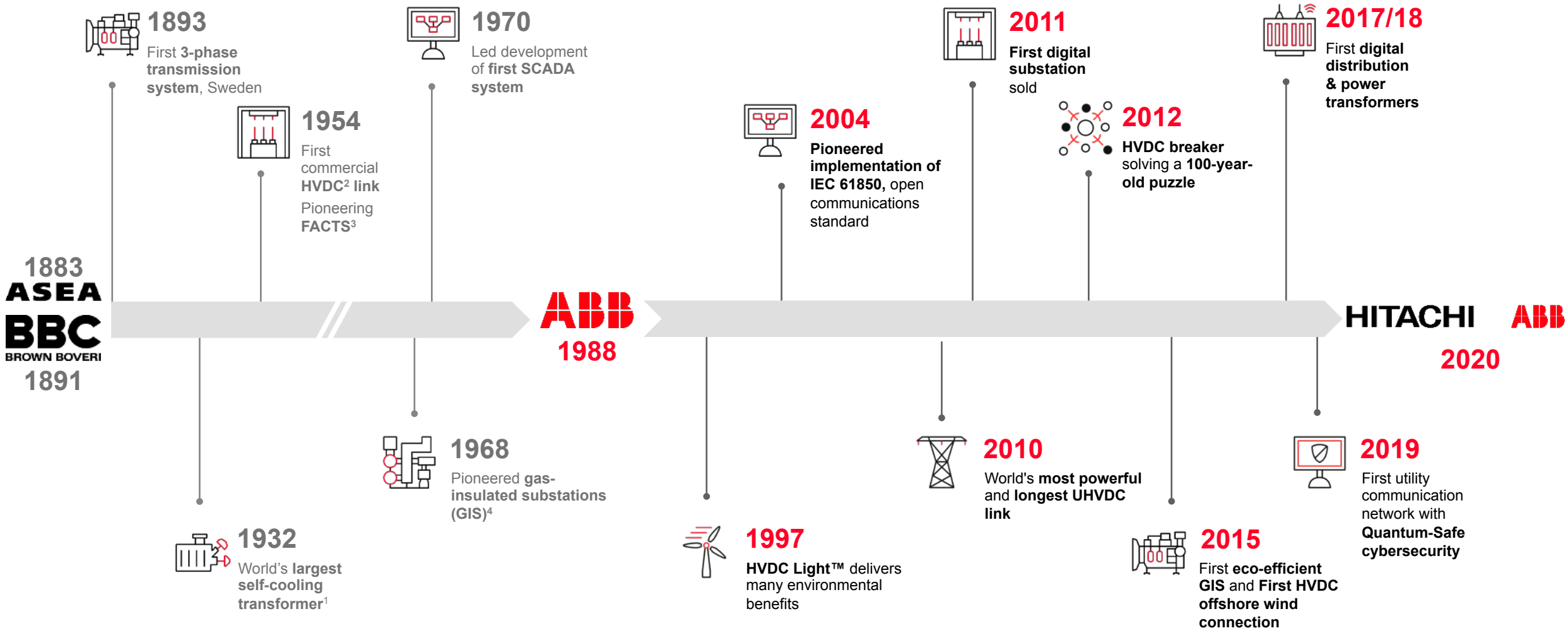
Storage & Renewable Forum, 13-14 October 2021

POWERING GOOD FOR SUSTAINABLE ENERGY

2021-10-13

HITACHI ABB POWER GRIDS

Our heritage: Hitachi ABB Power Grids



Power Grids global footprint

World's largest installed base

4 business units
- Grid Automation
- Grid Integration
- High Voltage
- Transformers

Present in ~90 countries
200 offices globally

115 factories

38,000 employees

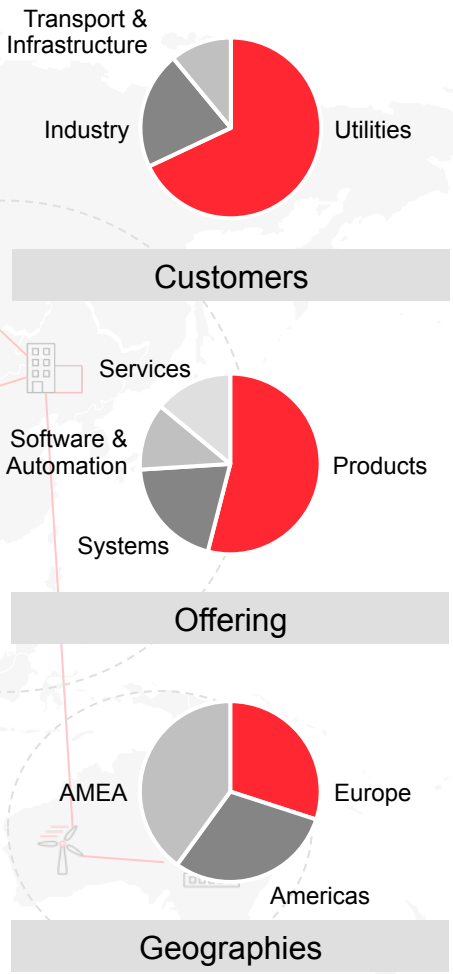
+100 years of pioneering innovation

~5,500 sales employees and field engineers

~2,000 engineers & scientists in R&D

Headquarters in **Zurich, Switzerland**

Business mix (by revenue)



Agenda

01. New Energy Ecosystem
An overview

02. Grid Edge Solutions
Digital solutions for distributed energy sources

03. AC&DC Offshore Wind Connection
Challenges and Solutions

04. “New “ Technologies
For Offshore floating S/S solutions

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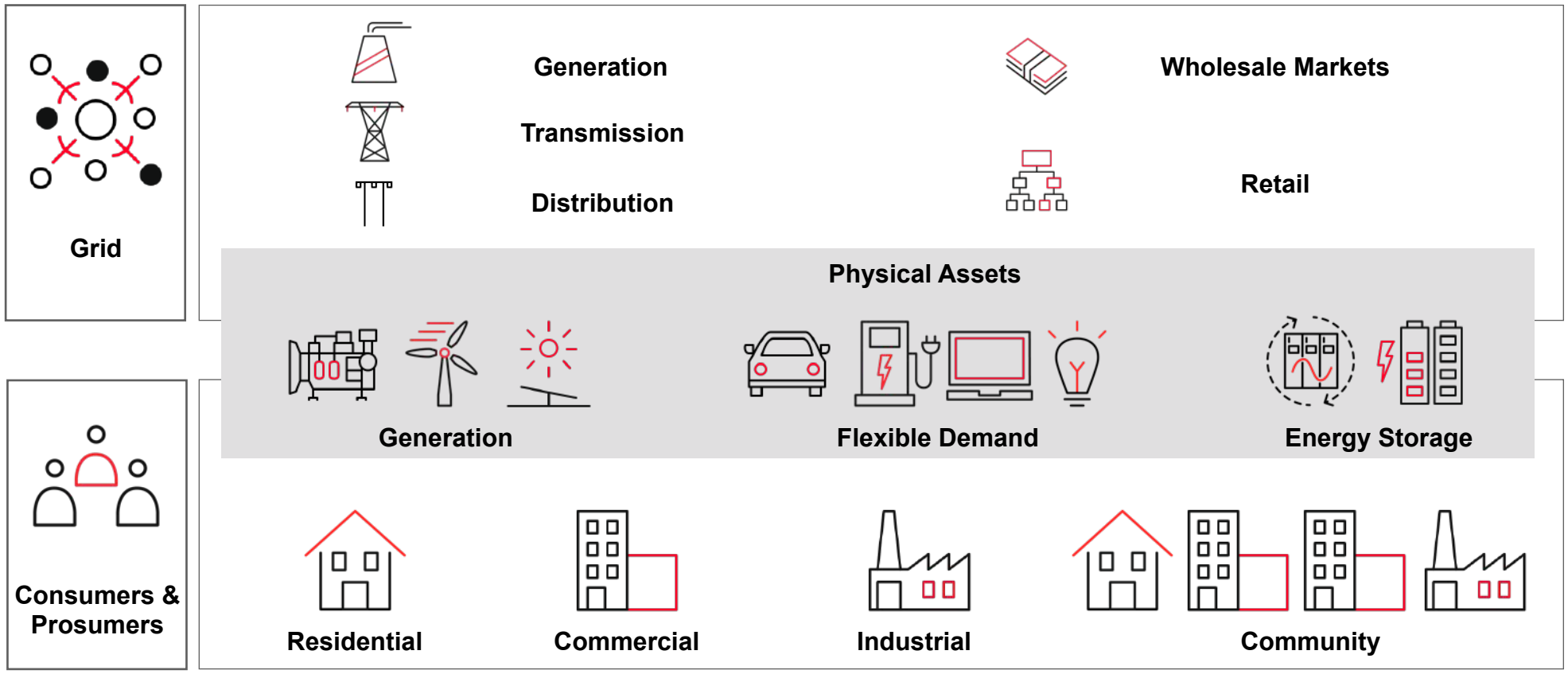
New energy ecosystem

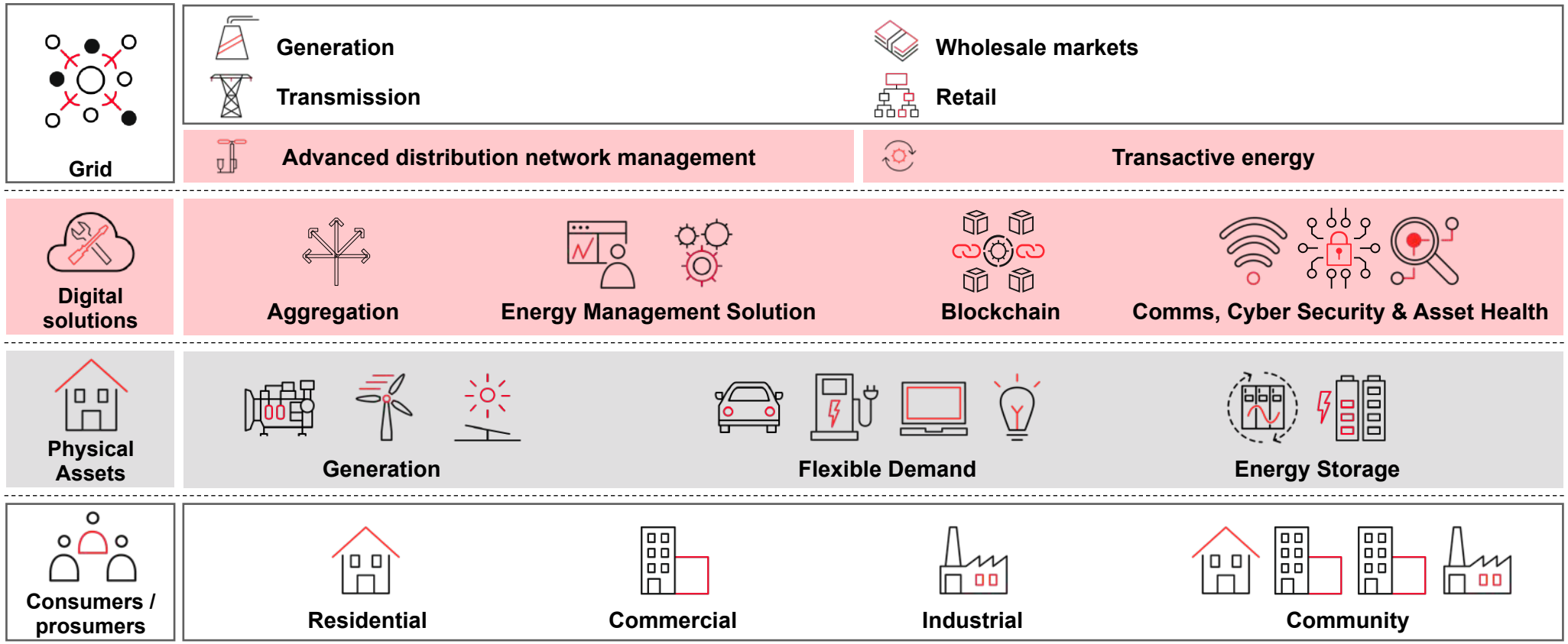


- Grid operators need to respond to a complex & distributed network
- Energy provider landscape expanding with new business models
- Growth in DERs
- Bi-directional power and information flows
- Consumers become “prosumers”, want maximum value from their assets

Evolving ecosystem due to growth in distributed capabilities

Distributed energy resources (DER)

New energy ecosystem



Digital solutions enable:

- Maximized customer value
- System performance optimization
- Grid reliability
- Energy services
- New business opportunities for energy providers

Evolving ecosystem due to growth in distributed capabilities

Distributed energy resources (DER)

Enabling digital solutions & services

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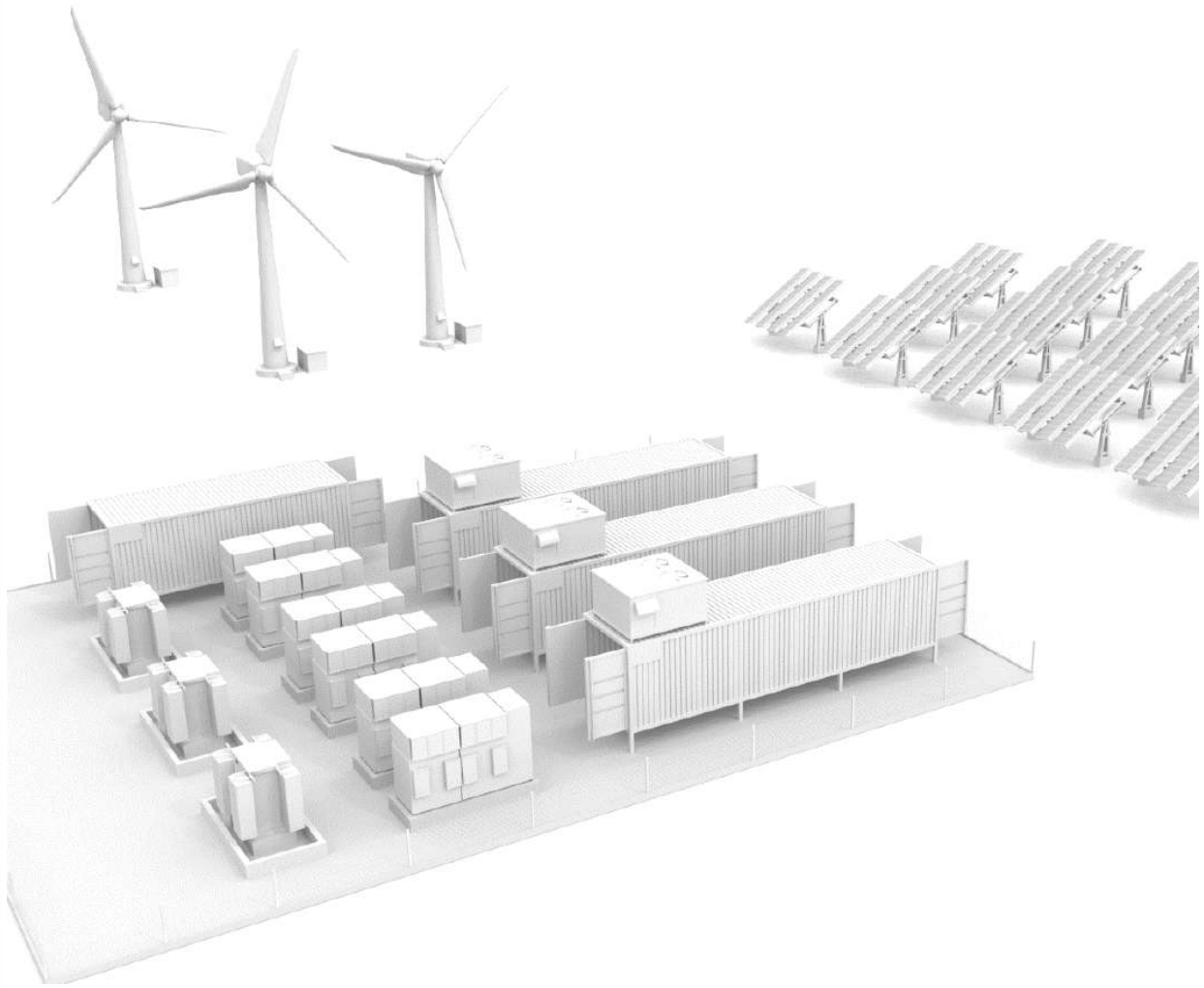
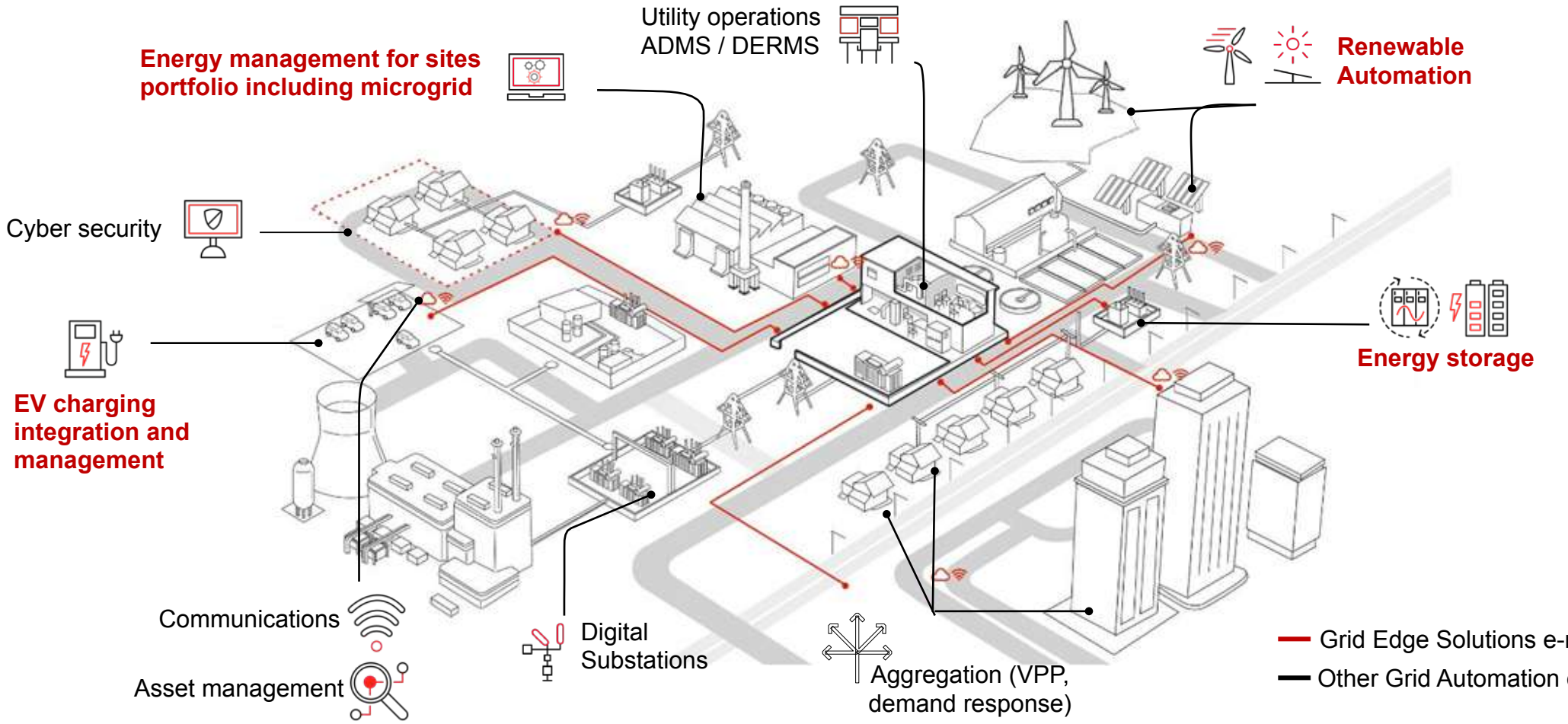


Grid Edge Solutions for Renewables and Energy Storage



Enabling new business opportunities while improving reliability and performance

ADMS: Advanced Distribution Management System / DERMS: Distributed Energy Resource Management System / EV: Electric Vehicle / PGGA: Power Grids; Grid Automation Business Line

Grid Edge Solutions for Renewables and Energy Storage

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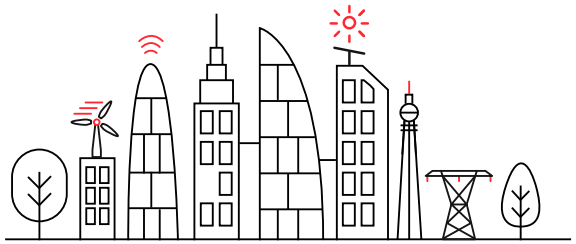
Applications & services

- Monitoring and reporting
  Energy optimization
- Monitoring and reporting
  Energy optimization
  Transactive energy
- Virtual power plant
  Demand response
  Collaborative operations
  ADMS / DERMS

Smart site

Smart district



Smart city

Edge

Gateway

Cyber-secure communications

Connected devices

Onsite Generation

Flexible demand

Energy Storage

Digitalization is enabling the future of energy – smart anything

e-mesh portfolio for Energy Storage

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Applications
SaaS Apps for improved performance

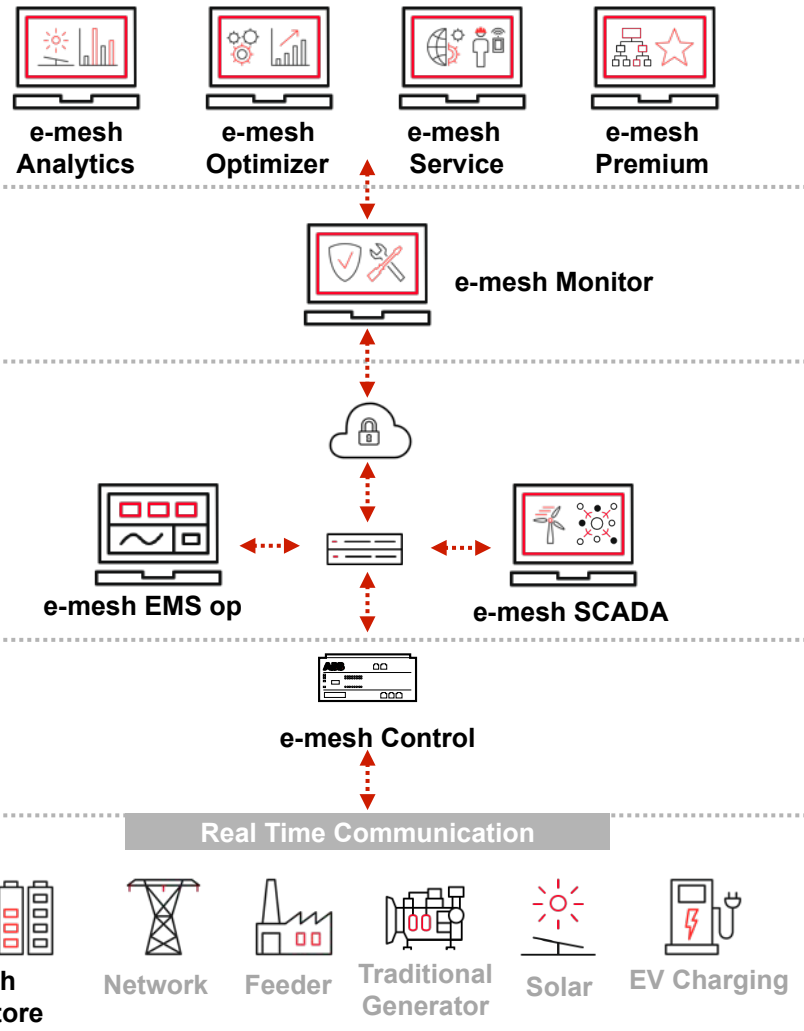
Monitor
Cloud enabled remote monitoring and control

EMS
On-premises energy management solution

SCADA
On-premises plant automation solution

Control
Intelligent and efficient power management

PowerStore
Smart battery energy storage solution



In the cloud

- Energy forecast, production and optimization planning
- Business KPI dashboards and reports
- Improved productivity and profitability

- Monitoring and control
- Bi-directional data flow
- Remote access

On premises

- Monitoring & control
- Optimal energy production
- Operational & maintenance cost reduction

- Renewable power generation grid code compliance
- Network voltage control
- Feeder & Load demand management

- Smart battery energy storage solution
- Support for various applications including islanding, seamless transition, black start, spinning reserve, etc.

SaaS: Software as a Service

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e-mesh PowerStore

PowerStore Integrated: PS250 & PS500

The complete PCS and battery modules are integrated into a single outdoor enclosure(*).

Controller + Battery + AC & DC + Converter

Transformer

PowerStore Modular: PS1000

The PCS and battery are housed in separate enclosures(*) to achieve flexible power and energy ratings.

Controller + Battery + AC & DC

Converter

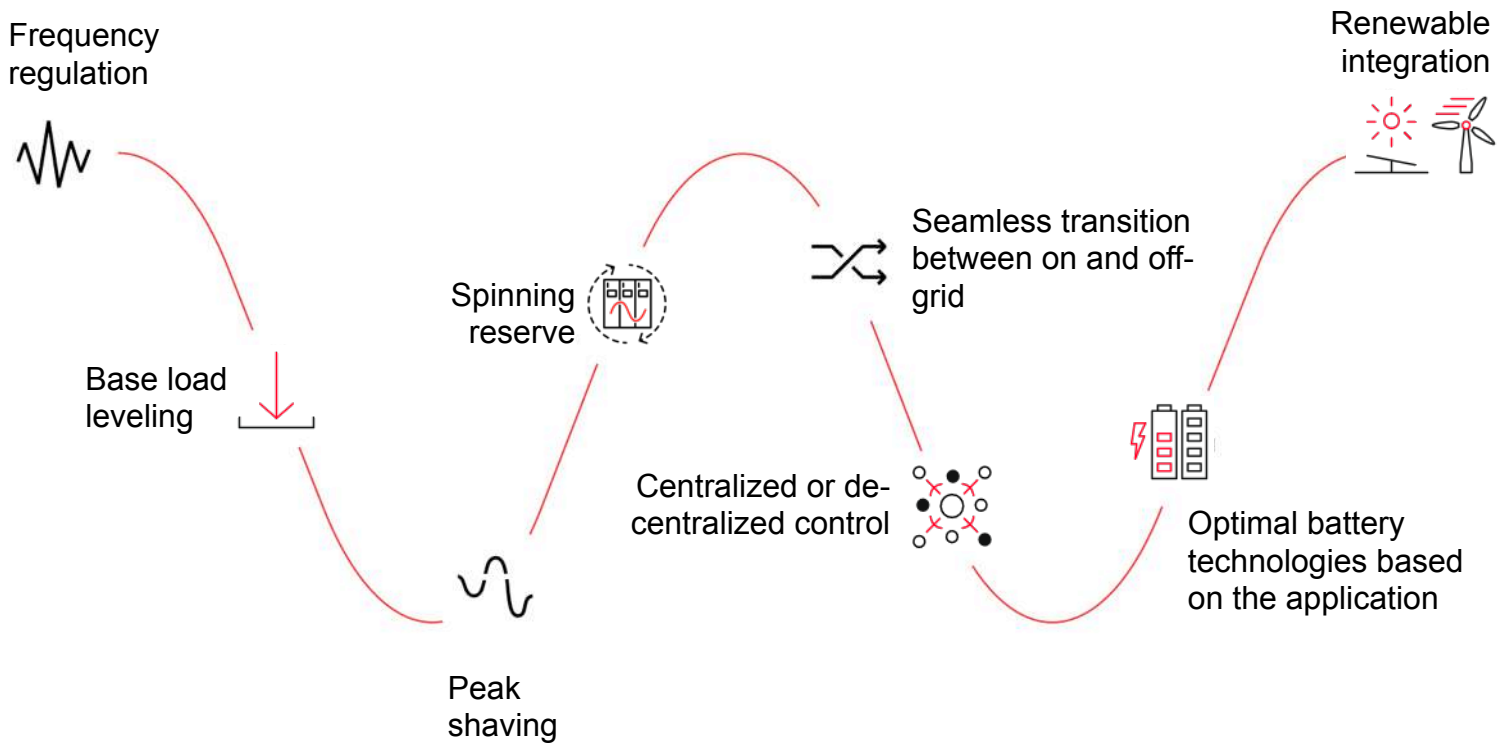
Transformer

PCS: Power Conversion System / (*) Enclosure images for illustrative purposes only. Specific project enclosures will be designed adapting to local environmental conditions and regulations.

e-mesh PowerStore

Highlights

- Designed for both grid-connected and off-grid applications
- Grid codes and standards compliant
- Intelligent and efficient power management system
- Pre-configured automation functionalities
- Productized design allows faster implementation
- Assures high level of cyber security
- Available in different sizes and configurations, based on two variants: Integrated and Modular

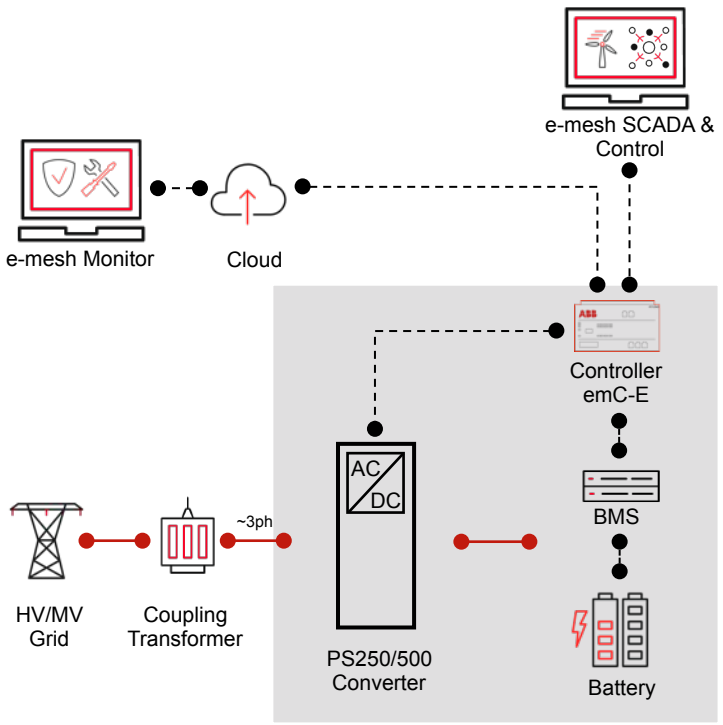


Energy storage system – enabling resilient and cost-effective access to power

IPP : Independent Power Producers / MTBF: Mean Time Between Failure

e-mesh PowerStore

PowerStore Integrated



Highlights

- Designed for Industrial and commercial, institutions & campuses
- For installations with a power requirement up to 500 kW -670KWh
- Pre-configured automation
- Cloud-based remote monitoring and control system
- Fulfill health, safety and environmental requirements
- Standardized enclosure for easy and fast transportation

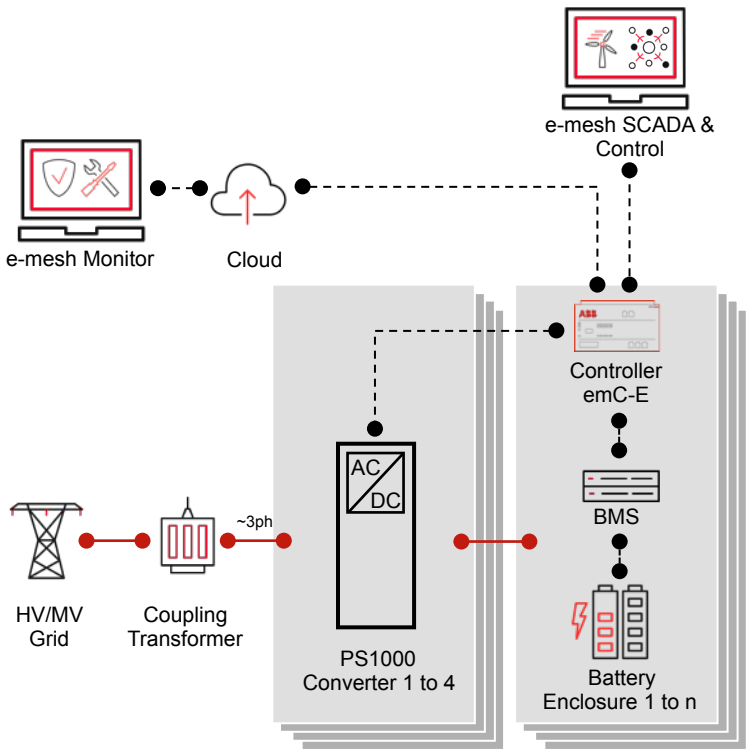
Key components

- e-mesh Control
- Grid-forming power converter
- AC and DC protection
- Battery racks and BMS
- Fire detection and suppression

Energy storage with a compact footprint

e-mesh PowerStore

PowerStore Modular



Highlights

- Modular systems in 1MW blocks, up to 100 MW+
- Individual selection based on application and customer requirements
- Can connect to all voltage levels via external transformer
- Cloud-based remote monitoring and control system
- Fulfill health, safety and environmental requirements
- Standardized enclosure for easy and fast transportation

Key components

- e-mesh Control
- Grid-forming power converter
- AC and DC protection
- Battery racks and BMS
- Fire detection and suppression

Flexible & scalable energy storage system

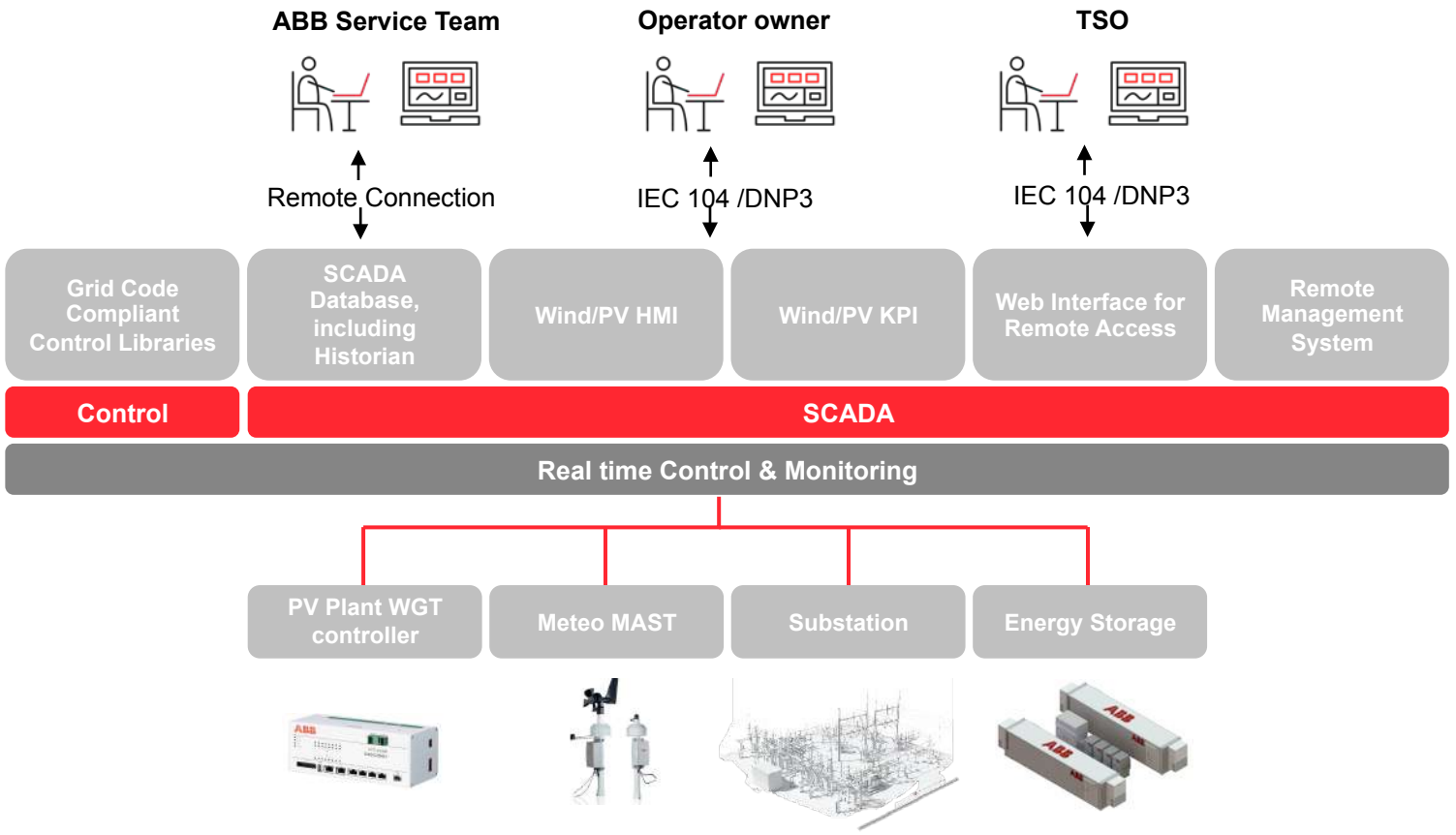
e-mesh Control & SCADA

e-mesh Control

- Single point of control for the entire plant or fleet
- Ready-to-use, pre-configured and type-tested for wind and PV applications
- Standardized protocols to connect all the assets into a single system
- A common hardware platform, resulting in cost reduction and minimal spare parts handling
- Scalable for future operations

e-mesh SCADA

- Simple and intuitive HMI that provides real-time updates and meaningful data display
- Quickly locates issues in the field
- Maximizes safety, allowing reduction in operator error



Optimized solution for renewables plants & remote-control centers

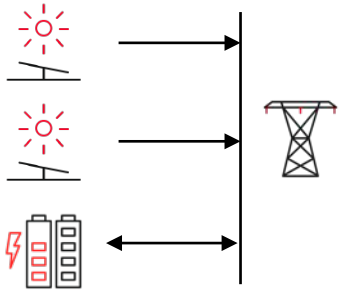
PV: Solar Photovoltaics / TSO: Transmission System Operator / HMI: Human-Machine Interface

e-mesh Control & SCADA

Plant: On-premises control & monitoring

Grid connected PV plant & PV + BESS

- Manage TSO dispatching command
- Grid code compliance
- Integration of Renewables & BESS
- Common solution for the whole plant and substation



e-mesh Control PPC

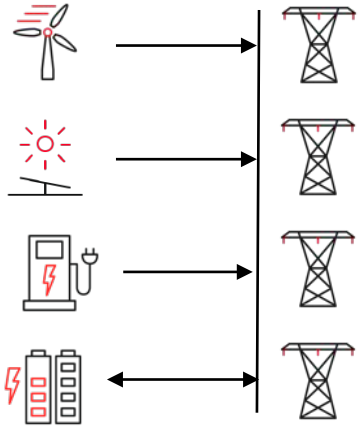
e-mesh SCADA

e-mesh Monitor & Analytics

Fleet: Remote control & monitoring

Fleet of renewable power plants & BESS

- Increased asset uptime, thus revenues
- Increased efficiency in operations & maintenance
- Manage TSO dispatching command



e-mesh SCADA

e-mesh Monitor & Analytics

Maximum renewable utilization and operational excellence

Hybrid plants : wind + solar

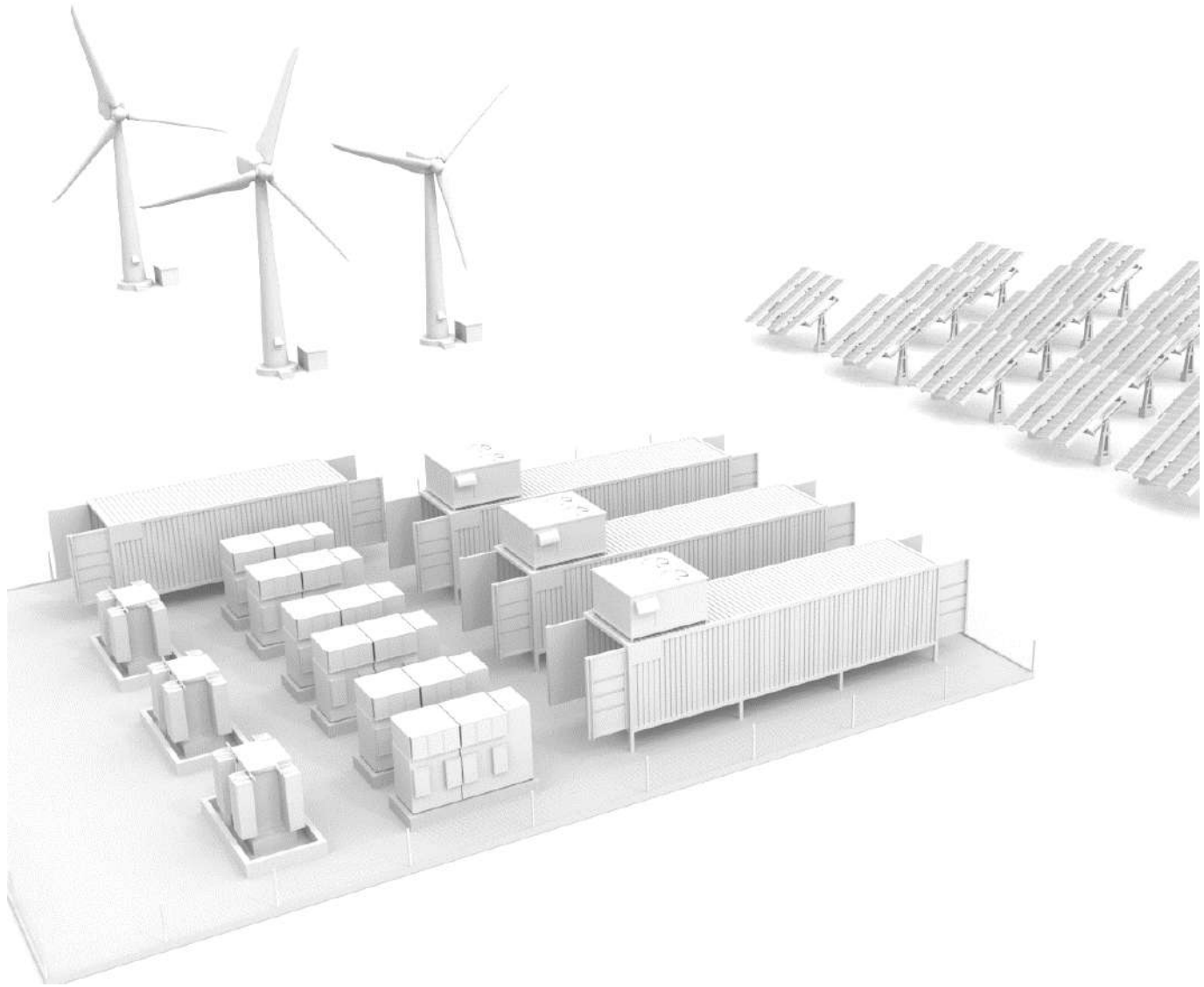
Battery energy storage (BESS) as an enabler

Hybrid plants

- There are several definitions of hybrid plants in the market
- In Hitachi ABB Power Grids a hybrid plant is when wind power and solar power are generated in the same plant
- The developers are facing the challenges in different ways – sharing power electronics or with independent power electronics
- The goal is to produce more at the same site and at a lower price – maximized LCOE

Solution

- Still very few references worldwide but a clear trend
- Optimized design of the solution is needed, and our consulting group has the experience
- Right compensation equipment – normally BESS is needed, and we have the right solution



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AC & DC Grid connection

Applications

Connecting remote generation

Interconnecting grids

AC & DC Offshore wind connections

DC links in AC grids

Power from shore/ Ship to Shore

City center infeed

Connecting remote loads

Upgrades/Life cycle services

Offshore wind connections

A comprehensive solution portfolio fitting specific project requirements

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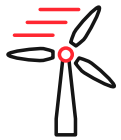
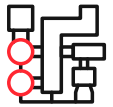
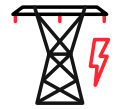
Generation	Collection	Transmission	Power Grid
 5 – 15 MW	33 kV 66 kV LFAC		HVDC best suited for long distances HVAC with reactive power compensation LFAC (16.7 Hz) HVAC	 Grid codes must be met with any solution

Holistic design is necessary to have the optimal grid connection solution

Hitachi ABB Power Grids expertise in offshore wind

Pioneer from early start of offshore wind in 2008

Borwin 1

Dolwin 1

Dolwin 2

Thornton Bank

Princess Amalia (Q7)

Various projects: equipment supply

References

A huge installed base of in Utilities, Oil & Gas and Wind power

Princess Amalie
120 MW
AC

Borwin 1
400 MW
HVDC

Dolwin 2
900 MW
HVDC

Valhall
80 MW
HVDC

Thornton Bank
325 MW
AC

Gjøa
40MW
AC, 100km

Troll 1-4
4 * 43 MW HVDC
2 * 20 MW AC

Dolwin 1
800 MW
HVDC

Goliat
60MW
AC 100km

Connecting wind power plants by HVAC

Typical arrangement and Hitachi ABB Power Grids presence

Reactive Power Compensation

Wind farms

Products

20-72 kV Collection grid

Offshore AC substation

- Products
- Subsystems
- System integration (full E-Package for HV/MV Substation)

72-245 kV Subsea cable

Onshore AC substation

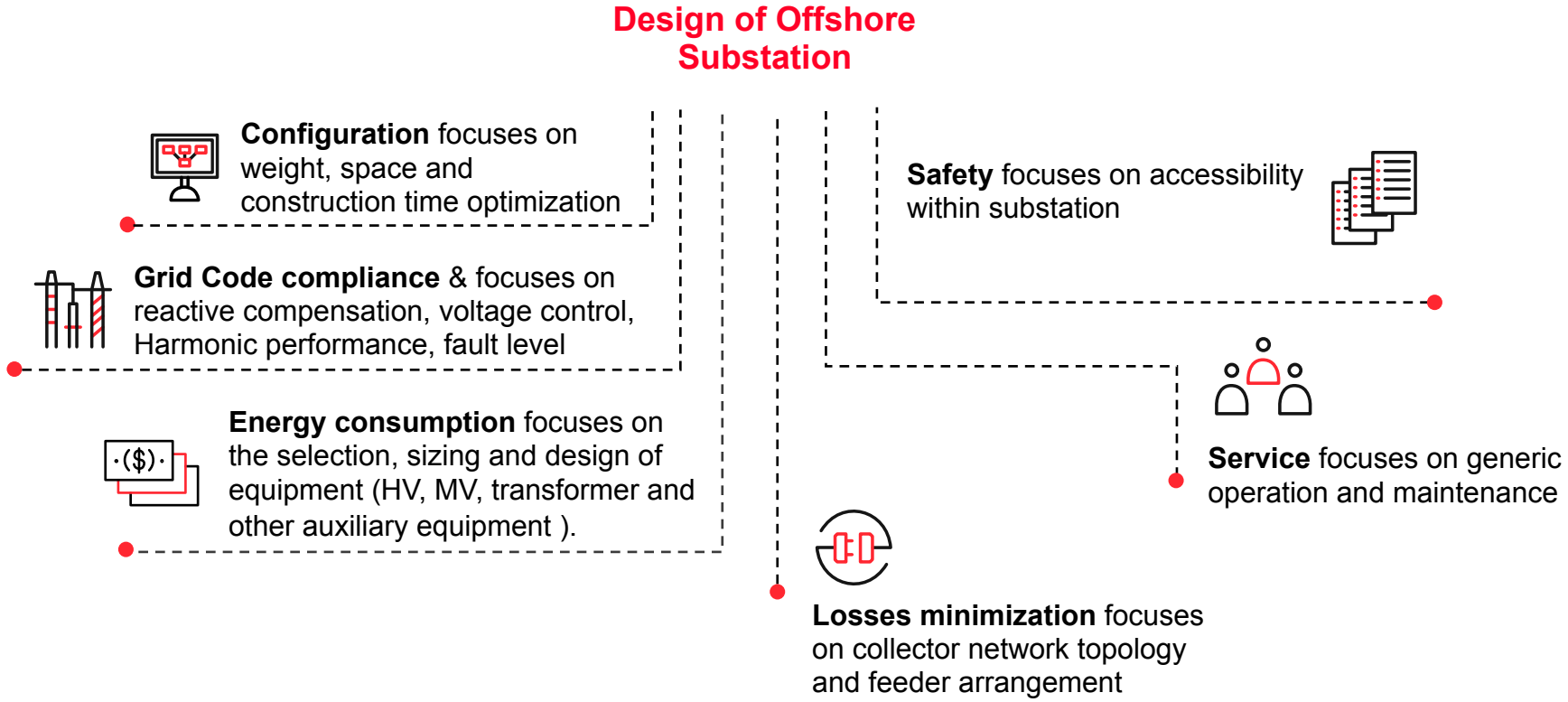
- Products
- Subsystems
- System integration up to Turn-Key Substations

Main AC network

Offshore Substation

Challenges and Solutions

- Size and mass of the topside is a major manufacturing, logistical and installation challenge
- To-date almost all substation have been bespoke designs
- Design considers the durability of electrical equipment installed off-shore
- Design to mitigate damage and risks from the harsh offshore environment
- Support structure is fabricated by large yards
- Lifecycle challenges for design, asset management, digital substation and monitoring



We work together with platform supplier to optimize space (volume), weight and time

Offshore Wind power integration

Case Study

Customer: Eon UK, Rampion Offshore Wind

Customer needs:

- 116 turbines, 400MW installed capacity, 140m tall.
- Rampion Offshore wind Farm is the first offshore wind farm off the south coast of England. Construction beginning in September 2015. The final turbine was installed in September 2017
- High impact on the community

Our response:

- Hitachi ABB Power Grids is responsible for the turnkey delivery of the onshore substation, including high voltage air-insulated switchgear (AIS), gas insulated switchgear (GIS), transformers and substation automation as well as control and protection systems

Four STATCOM (static compensator) units to ensure grid stability. These will provide reactive power compensation by detecting and instantly compensating for voltage fluctuations

Customer benefits:

- Full compliance with Grid Code requirements
- True partnership to ensure a free issue project and with very limited impact on the community

Offshore Wind power integration

Case Study

Customer: C-Power's Thornton Bank Wind Farm

Customer needs:

- To build the grid connection for C-Power's Thornton Bank 325MW Wind Farm, one of Europe's largest offshore wind sites 30 km off the Belgian coast near Ostend
- Project delivered in several phases

Our response:

- Electrical system studies, Static and dynamic studies. Grid compliance and system dimensioning
- **Offshore and Onshore substation**
  - 170 and 200 MVA 33/155 kV power transformers
  - 36 kV GIS for the incoming feeders from the wind turbines
  - 170 kV GIS for the outgoing feeders to land
  - 36 kV shunt reactors to deliver reactive power compensation
  - Neutral grounding reactors for grounding the main electrical system
  - Protection and control systems and reactive power control

Customer benefits:

- Full compliance with Grid Code requirements
- True partnership to ensure a free issue project and with very limited impact on the community
- Full scope to integrate the energy produced

Offshore Wind power integration

Hornsea II

Customer: Örsted (Denmark), Hornsea II

Customer needs:

- Hornsea Two is an 1,800 MW project, about 100 kilometer off the Yorkshire coast in the North Sea
- Completion estimates in 2022

Our response:

- THREE 240 MVA STATCOM SVC Light to Hornsea Two windfarm.
- Hitachi ABB Power Grids contract also includes the installation and commissioning of 66-kilovolt (kV), 220 kV and 400 kV gas-insulated switchgear (GIS) and 400/220 kV onshore and 220/66 kV offshore transformers and reactors
- Hitachi ABB Power Grids will also be responsible for the project management, engineering, manufacturing, supply and commissioning of the IEC 61850 based substation automation, control and protection systems for the onshore substation and the two offshore platform substations

Customer benefits:

- Studies and technical recommendation to apply reactive power compensation
- Full compliance with Grid Code requirements
- True partnership during design, tendering and project execution to ensure full FACTS potential at the customer site

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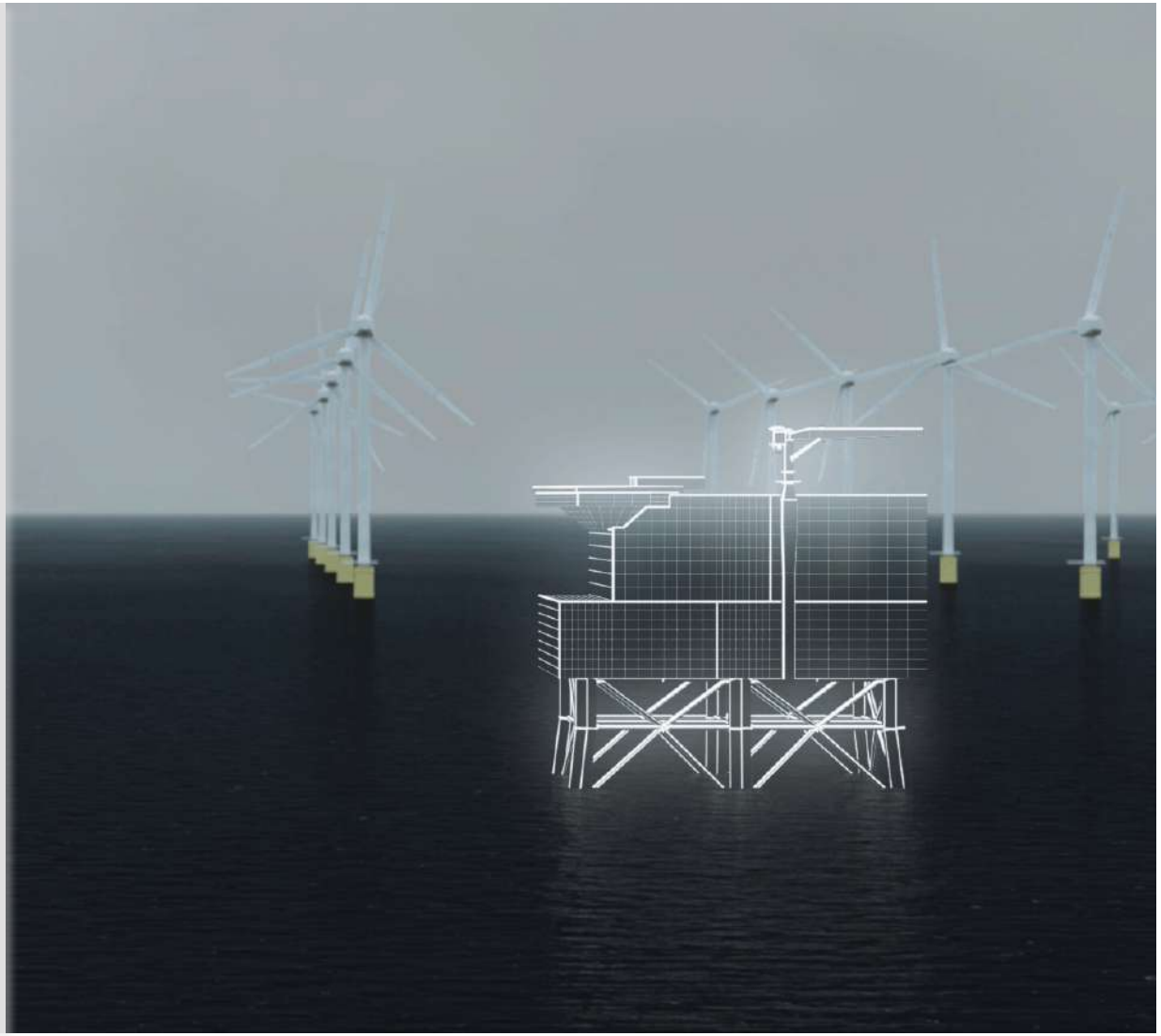


Challenges in Floating Substation

Dynamic motions and accelerations

Floating Offshore Wind Substations

- **Classical voltage level**
  - 33 - 66 kV/132 - 220 - 400 kV
- **Classical switchgears**
  - Gas Insulated Switchgear (GIS)
- **Classical transformers**
  - one or multiple 3-phase 50-400 MVA
- **Classical auxiliaries**
  - FACTS, shunt capacitor banks
  - Diesel generator sets (or Batteries) for security
- **Typical challenges**
  - **Dynamic motions and accelerations (>1.2 g)**
  - Vibration and corrosion
  - Space (normally 40 m^2/MVA)
  - Weight (normally ~5 - ~10 t/MVA)
  - Cost (normally ~700 k USD/MVA for full eBoP)
  - HVDC solutions (if >~50 km from shore)
  - Local content/local labour sourcing
  - Efficiency requirements

Electrical Equipment for floating

Hitachi ABB Power Grids studies and solutions

- Products for substations ranging from 100 to 600 MW, 33 or 66/220 kV AC with reactive compensation – With room for expanding/ reducing in power and voltage.
- Product development with specific focus on structure fatigue effects of electrical equipment
  - Collaboration among equipment product specialists, foundation experts, and topsides experts
  - Evaluation of Static (transformers and reactors) vs dynamic equipment (switchgears)
  - Design to cope with diverse and extreme environments (US, Japan, Western Europe…)
  - Use of solutions and expertise from Marine and offshore Oil and Gas industries
- Well-adapted industrial solution with existing supply chain for a cost competitive design.
- Design and products suitable to meet local content requirements, standards, and certification requirements.

Specialty and industrial power transformers

Renewable

Hitachi ABB Power Grids' liquid-filled transformers are ideal solution for onshore and offshore wind applications. Their reliable, energy-efficient and compact construction is well suited for installation in wind turbine towers or nacelles.

Product scope

- Available for 36 and 72.5 kV class
- Available for power rating superior to 10 MVA
- Modular, compact and lightweight solution

Why Hitachi ABB Power Grids

- World's leading manufacturer of 66 kV wind turbine transformers for the world's most powerful offshore wind turbines
- Best-in class solution to withstand sudden variable loading and typical extreme environmental events of offshore conditions
- Hitachi ABB Power Grids' turbine transformers are specially designed to meet the specific application needs
- Estimated installed base of more than 1,000 units worldwide
- Key actor in international technical standard publication and in the forefront in developing new requirements for transformers
- Specialized service team for onshore as well as offshore interventions

Specialty and industrial power transformers

Established solution for 66kV large offshore wind turbine

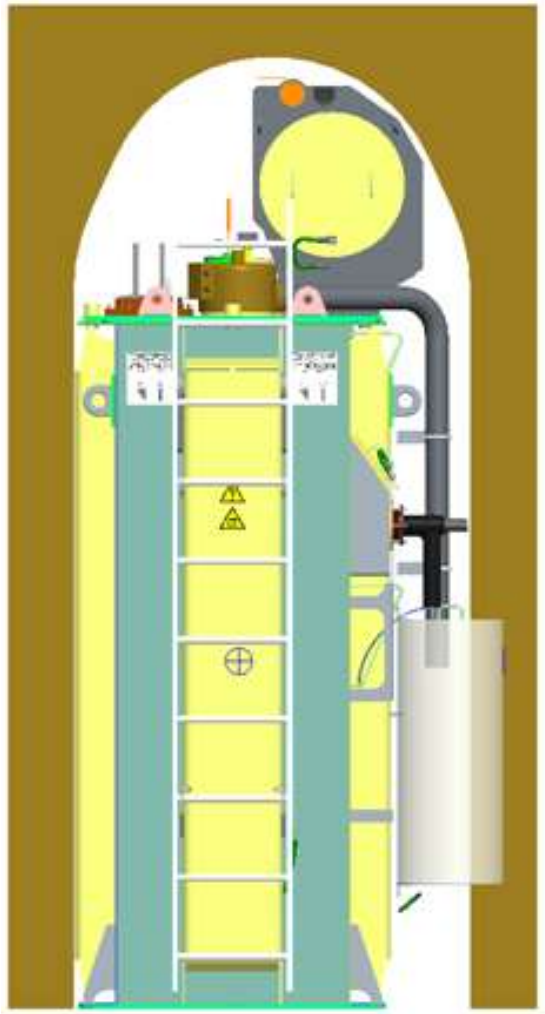
Slim transformer design accomodates stringent wind turbine dimensional requirements

– The transformer can be taken in and out from the wind turbine door

Slim transformer design allows the use of a smaller turbine door: better turbine tower mechanical strength

– Smaller turbine structure cost for OEM

Forced oil and forced water cooling to minimize transformer footprint and overall dimension



Specialty and industrial power transformers

Sub-Sea and Offshore

Offshore transformers

- Subsea Transformers
- Converter Transformers
- OLTC Feeder Transformers
- Converter Step Up Transformers

Customers

- Oil & Gas producers on offshore platforms, gas fields, FPSO vessels and movable units

Features

- Hazardous areas
- Green Transformers
- Corrosion protection
- Water cooling
- Submersable solutions

Specialty and industrial power transformers

Marine transformers

Liquid type transformers for Marine

- Propulsion Transformers
- Hotel Transformers
- Magnetising Transformers

Customers

- Marine Industry

Technical features

- Compact design
- Normal cooling options + passive water cooling
- Qualifications for Marine Industry
- Green Transformers

Specialized transformer designs for specific marine applications

UHVDC transformers
Product portfolio

New technology level enables bulk power transmission over long distances in land and sea

Hitachi ABB Power Grids technology enables interconnection of all today existing HVDC transmission voltages with all today existing HVAC transmission voltages

- Hitachi ABB Power Grids have delivered over 100 UHVDC Converter Transformers
- Power transmission >12 000 MW
- Transmission length >3000 km
- Minimal losses, 30% less compared to conventional technology
- Gives access to remote power generation sources
- Less footprint and material needed for the interconnection

Image: 1100 kVDC / 10,000 MW Converter Transformer

Technology evolution enables efficient response to challenges for new power solutions and applications

POWERING GOOD FOR SUSTAINABLE ENERGY

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Hitachi Energy

A new era starts, but the legacy remains and the tradition continues…

Hitachi Energy