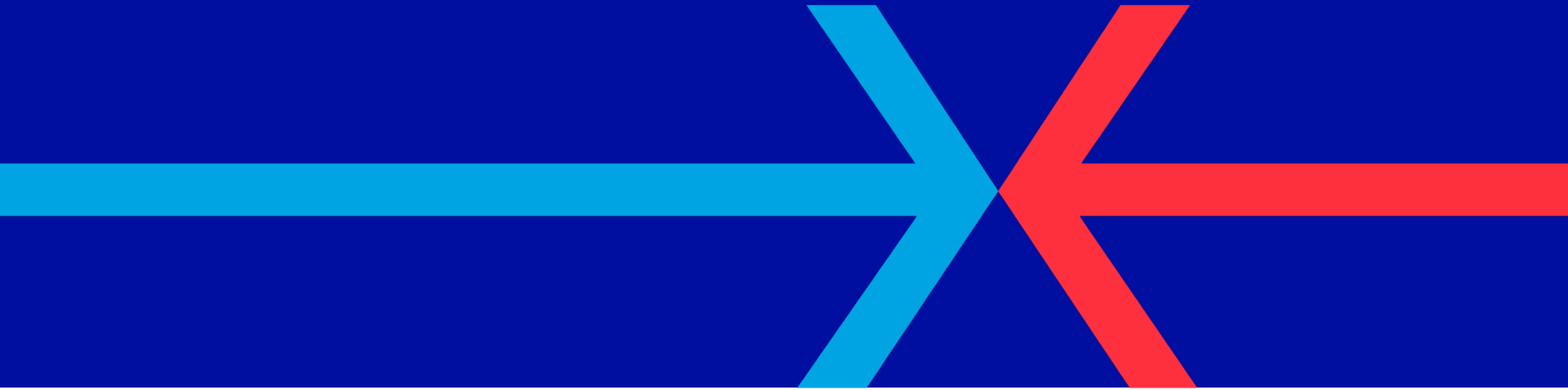
Global Partner for Renewable Generation

Building the infrastructure to power the world



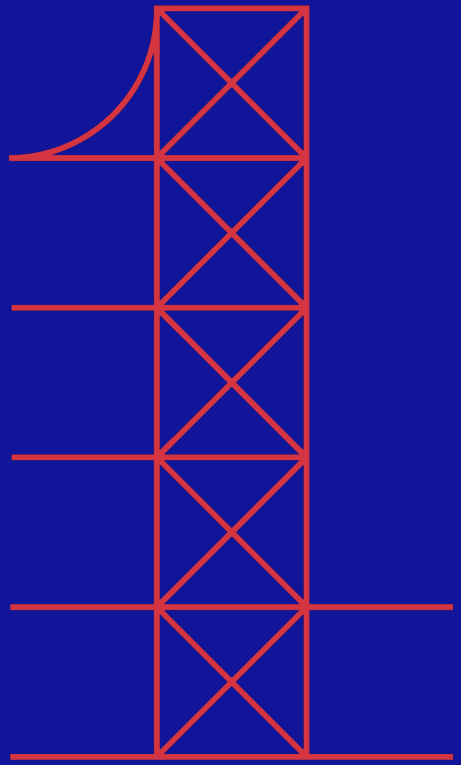
linxon

Strategies for renewable power generation

- Introduction to Linxon
- Expertise and know-how
- Renewables market
- Market development
- Generation solutions

“Offshore wind currently provides just 0.3% of global power generation, but its potential is vast … much work remains to be done by governments and industry for it to become a mainstay of clean energy transitions.”

— Dr. Fatih Birol, IEA Executive Director



Introduction to Linxon

We combine SNC-Lavalin's project management expertise and Hitachi Energy's industry leading technological knowledge into a company dedicated to turnkey electrical AC substations

... we are Linxon.

51% SNC-Lavalin

49% Hitachi Energy

We are building the infrastructure

to power the world with carbon free energy

Our global presence

600
employees

5
hubs

North America
UK, Ireland & Central Europe
Nordics
Middle East & Africa
Asia Pacific

linxon

Value proposition

Linxon combines Engineering / Construction capabilities (SNC-Lavalin) and high-quality products (Hitachi Energy)

so that customers benefit from efficient and continuously improved solutions and increased industrial productivity.

Linxon is driving sustainability by building vital infrastructure for the energy transition. We help cities grow, industries expand and communities thrive by building a crucial part of the power transmission grid.

ISO Quality and HSE Management System

Linxon is ISO 9001; 14001 and 18001 certified

We are committed to HSE, Quality and Operational Excellence

SAFETY PROTECTS PEOPLE

QUALITY PROTECTS JOBS

Certified System ™

ISO 9001

Quality

CERTIFICATE OF REGISTRATION

This is to certify that

Linxon

901 Main Campus Drive Suite 210, Raleigh, North Carolina 27606 USA

operates a

Quality Management System

which complies with the requirements of

ISO 9001:2015

for the following scope of certification

The provision of turnkey design, project management, engineering, procurement, construction, installation, commissioning and services related to products and systems integral to the generation, transmission, distribution and control of electrical power. Products, projects and services may be found in, or delivered to, power generating stations, electrical substations, substation automation systems, network management and communications systems.

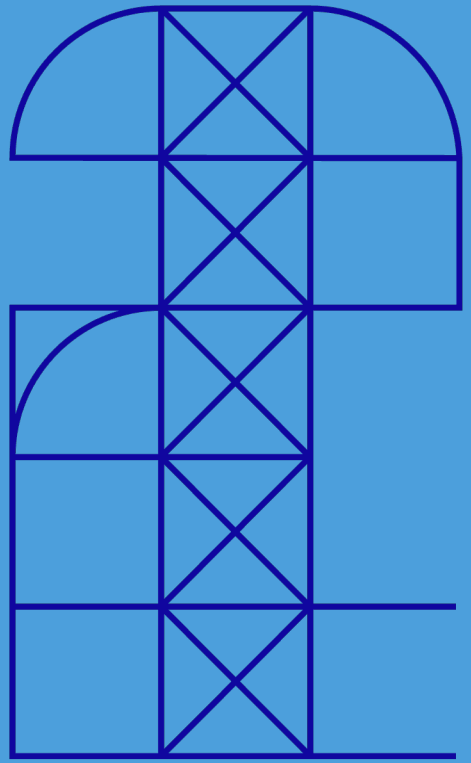
Certificate No.:	CERT-0122483	Original Certification Date:	October 17, 2018
File No.:	1701923	Certification Effective Date:	October 17, 2018
Issue Date:	October 18, 2018	Certificate Expiry Date:	October 16, 2021

Kevin Goodwin
General Manager Technical Services
SAI Global Assurance

ANAB ACCREDITED

IAF

SAI GLOBAL



Expertise and know-how

We are building the infrastructure to power the world with carbon free energy

Portfolio for turnkey electrical infrastructure

Renewable, conventional power and water generation

- → Boosting capacity
- → Enhancing reliability and increasing availability of the transmission and distribution network through proven substation designs
- → Innovative grid technologies
- → Grid stability
- → Reliability and grid code compliance
- → Digital substation solutions

Portfolio for turnkey electrical infrastructure

Concept to commissioning

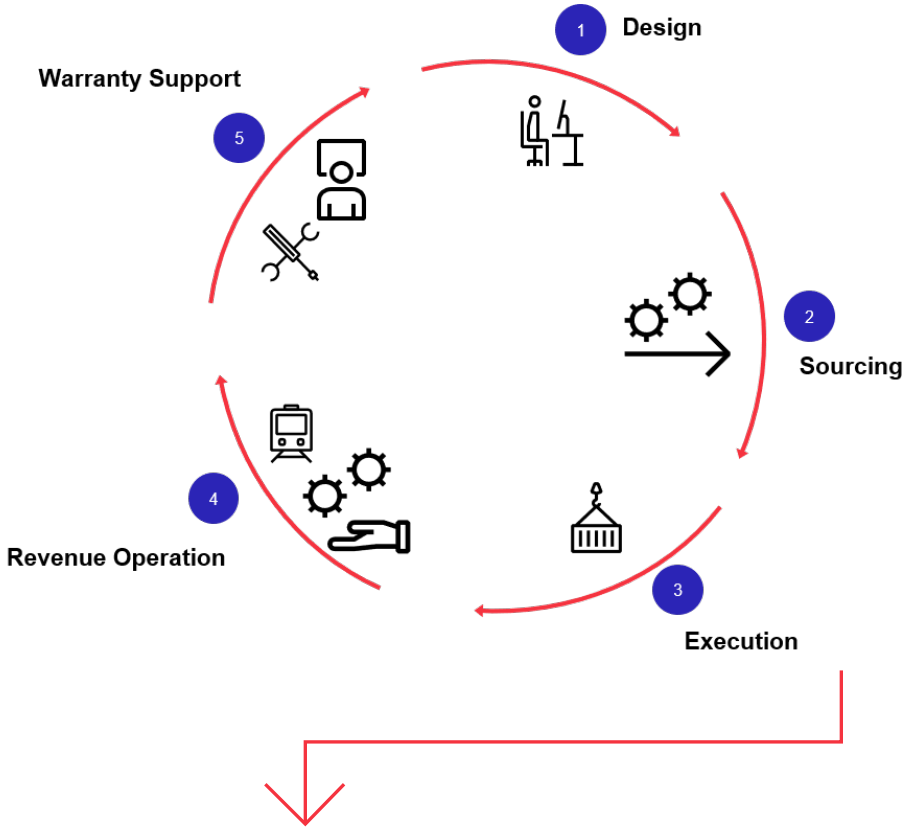
Early engagement to develop feasible and optimal solutions for our clients

In house engineering with our own OEM supervisors

Innovative solutions and project sequencing to work within challenging site limitations

Reliable partner

- A skilled, reliable and committed partner for the complete portfolio
- Predictable and cost-efficient solutions for sustainable business
- Grid-compliant solutions
- Up front planning and system studies
- Substation optimization: from design to delivery
- Familiarization of global standards



Supporting our customers throughout the entire life cycle of the project

Power and water solutions

Linxon covers a broad portfolio of power and water projects

Conventional power plants:

→ Simple cycle

→ Combined cycle

→ Integrated solar combined cycle

Renewables:

→ Solar PV

→ Onshore and offshore wind

→ Hybrid

Water generation plants:

→ RO desalination

→ MSF / MED plants

→ Water transmission pumping stations

Power and water solutions

Substation application experience

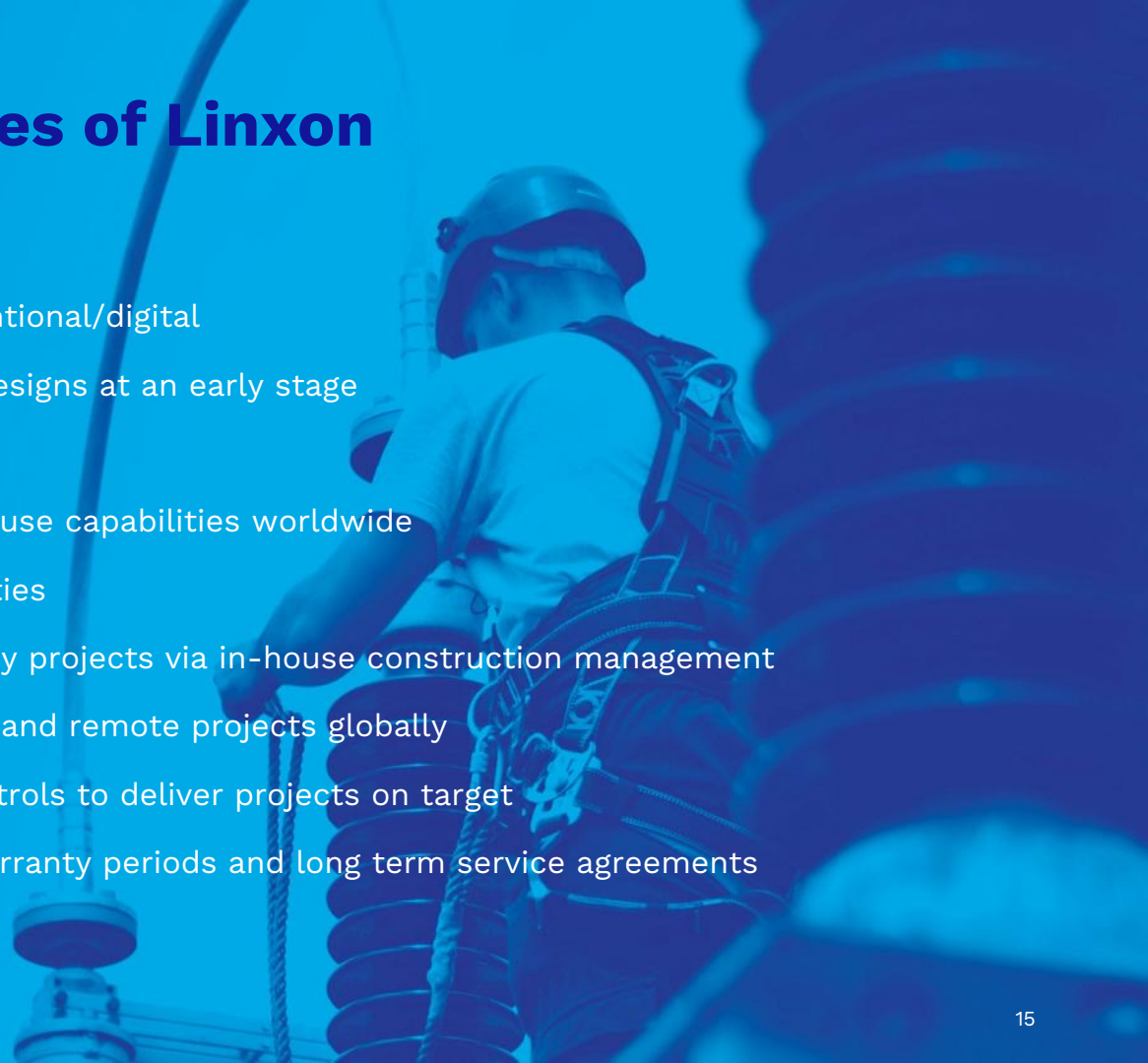
Power and water generation:

Boosting capacity, enhancing reliability and increasing availability of the transmission and distribution network through proven substation designs and innovative grid technologies.

Renewables:

Facilitating the integration and interconnection of cleaner energy while helping maintaining grid reliability and secure power supplies. Focusing on grid stability, reliability and grid code compliance.

Execution capabilities of Linxon



- → Engineer customized solutions conventional/digital
- → Provide FEED study and conceptual designs at an early stage
- → Life cycle analysis
- → Engineer project interfaces with in-house capabilities worldwide
- → Reliable partner for developers & utilities
- → Execute fast track high voltage turnkey projects via in-house construction management
- → Execute brownfield, greenfield, urban and remote projects globally
- → Implementing world class project controls to deliver projects on target
- → Skilled resources ready to support warranty periods and long term service agreements

Technology competence

Linxon's application knowledge and experience supports our customers in dealing with complex technical requirements:

- GIS, AIS or hybrid substation solutions
- Achievement of grid compliance
- Managing renewable generation within the grid system
- Grid stabilization and improving power quality
- Integrating series or shunt compensation
- Reactive power compensation (statcom)
- Design and delivery of digital substations
- Leading edge protection and control design
- After sales service including predictive and preventive maintenance solutions

Renewable integration

Reshaping the world

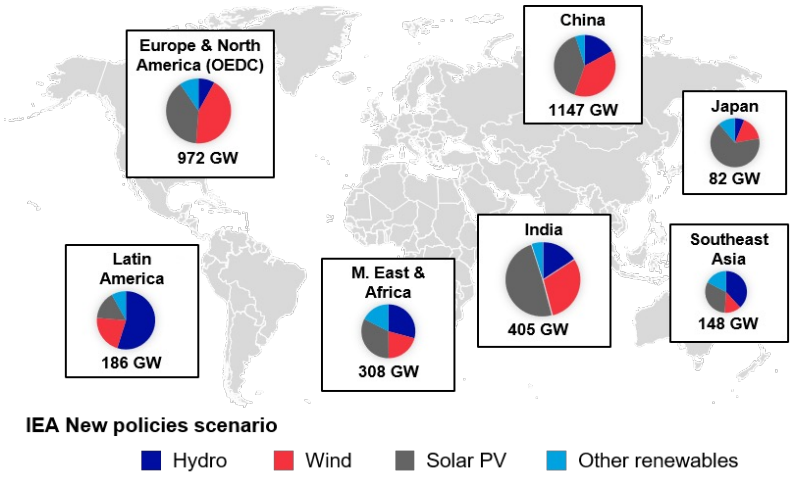
- → Renewables is a must to decarbonize the grid and reach global goals for CO2 emissions.
- → Renewables are the first alternative for any repowering program.
- → Renewables are an opportunity to produce competitive energy.
- → Solar and wind power technologies are mature but in many markets the deployment of renewables is a challenge.
- → Solar and wind power plant cost efficiency and reliability are improving.
- → Wind turbine generator capacity factors are growing in all regions, allowing better business cases for developer and owners.
- → New solar power opportunities and wind corridors are being discovered.
- → Price parity is now achieved in many markets.

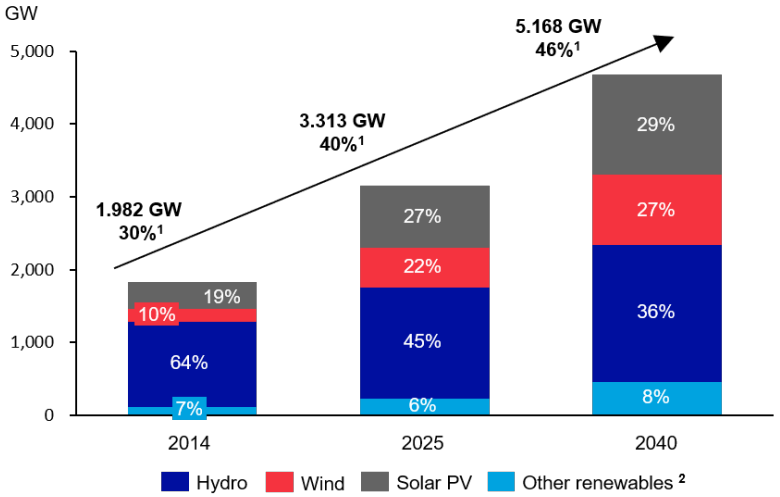
Renewable Market

Renewable energies

Global installed capacity more than double by 2040

New capacity additions 2018-2040



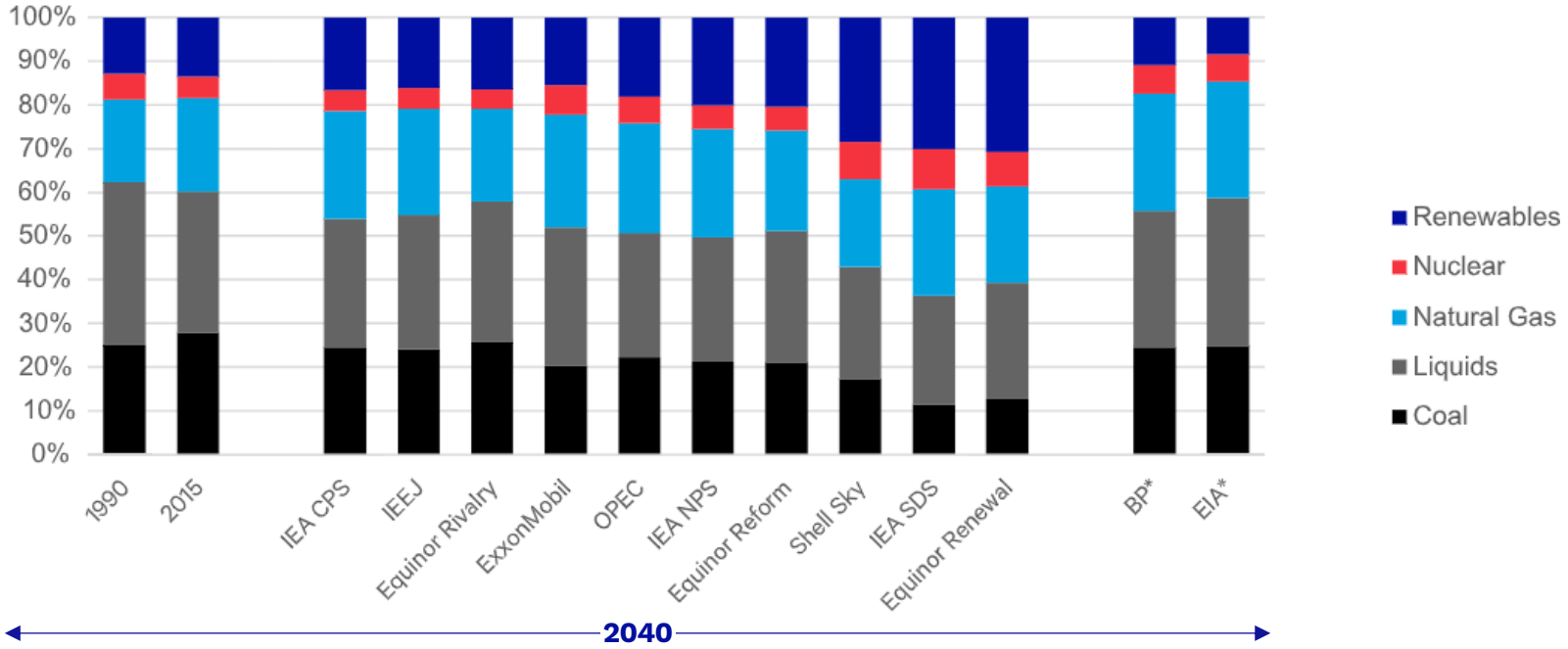


Tremendous growth of renewables is foreseen, as wind and solar become the preferred technologies for energy production

(**1**) Source: International Energy Agency (IEA), WEO report 2018.
(**2**) Other include bioenergy, geothermal, concentrated solar power and marine

Renewable energies

Shares of global primary energy consumption by fuel



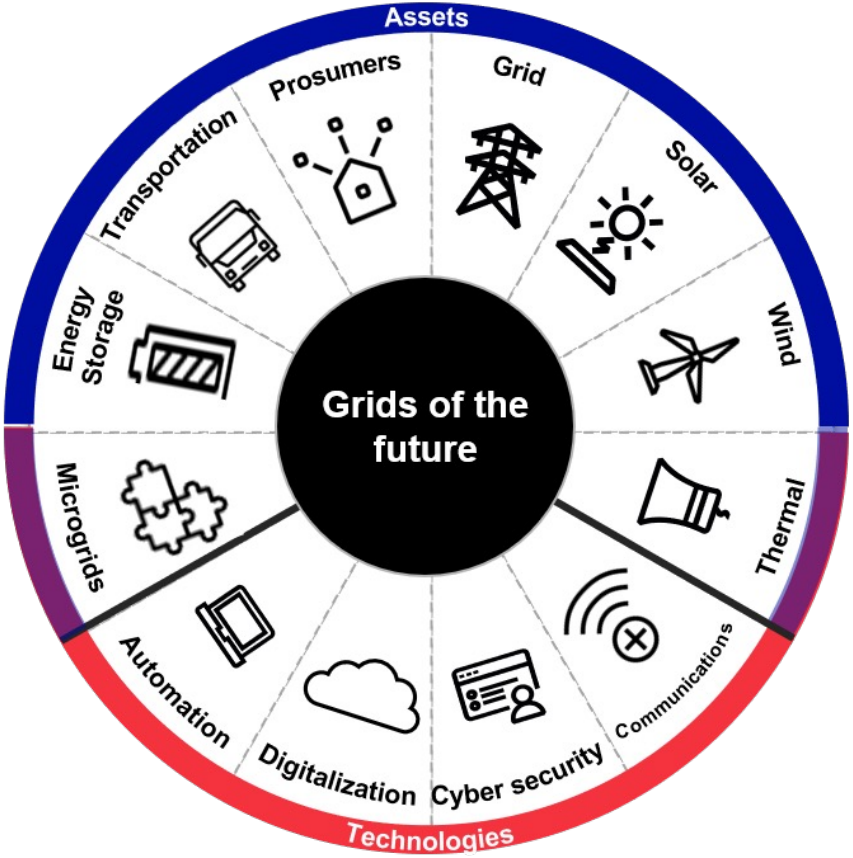
Note: The scenarios are ordered in decreasing shares of fossil energy. BP and EIA exclude non-marketed biomass energy, while other outlooks include this in renewables.

Source: RFF Global Energy Outlook 2019 Report, Published July 2019

Renewables industry overview

Renewables become important part of modern power grids

- Wind and solar technologies become cost competitive and the preferred choice for new generating facilities in many countries.
- Renewable integration is a key topic, to ensure a proper functioning of the future power grid.
- Balancing electricity supply and demand at any time requires a stronger and smarter grid.
- Power transmission interconnections need to be enhanced to facilitate optimum utilization of renewables and balancing of loads.
- Distribution networks need more control, supervision and functionality than in the past.
- Digitalization and real time communication to play a vital role for renewable integration in power systems.



Key market and technology trends in the renewable business

A combination of market pull and technology push influences the market landscape

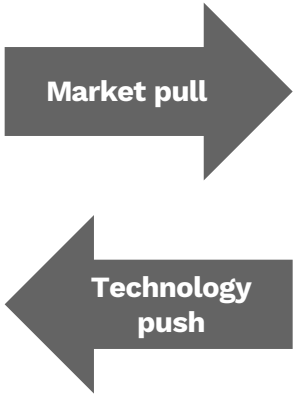
Market trends

Reduce LCOE[1] of renewable power

- Higher voltage levels to increase efficiency.
- Prepackaged/standardized and modular solutions.
- Share common infrastructure i.e. hybrid power plants (wind + solar).
- Renewable specific O&M solutions.

Increase system value of renewable assets

- Renewables to support grid operations and planning.
- Renewable power trading on the energy markets.
- Smooth grid integration through management of distributed assets (VPP[2] and DERMS[3]).



Technology trends

Digitalization[4]

- Real time communication with every asset
- Cloud and high-power computing
- Analytics and artificial intelligence

Batteries

- New chemicals
- Improved designs, reduced cost
- Improved safety concepts

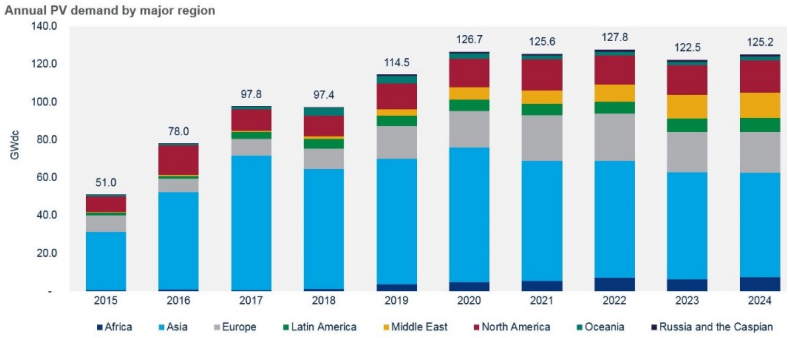
New materials

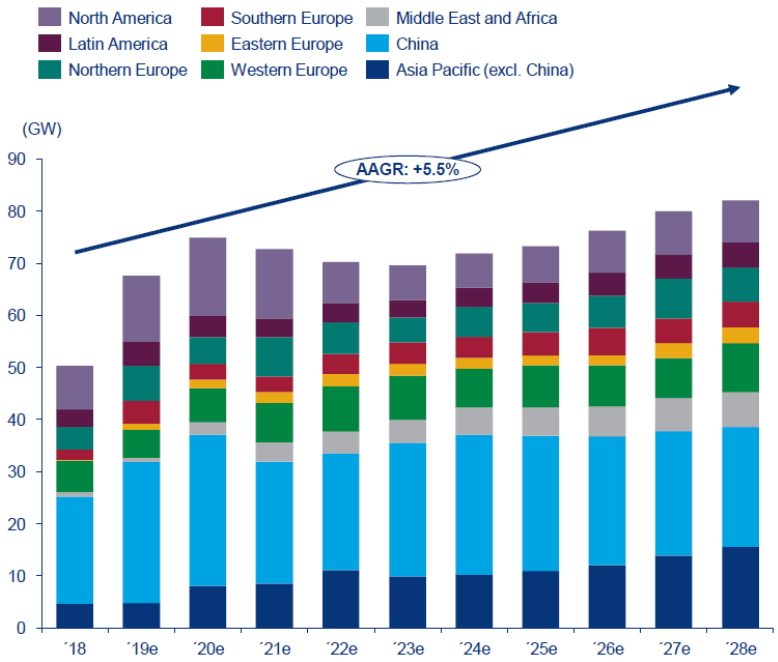
- Semiconductors
- Insulation materials
- Superconductors

(**1**) Levelized Cost of Energy
(**2**) Virtual Power Plants
(**3**) Distributed Energy Management System
(**4**) Includes comms, big data and high-power computing

Market update

General outlook

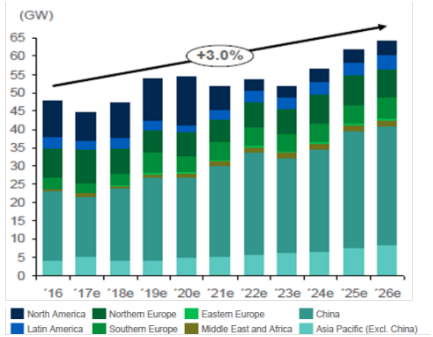




Source: WoodMac Global Wind and Solar Report – H1-2019

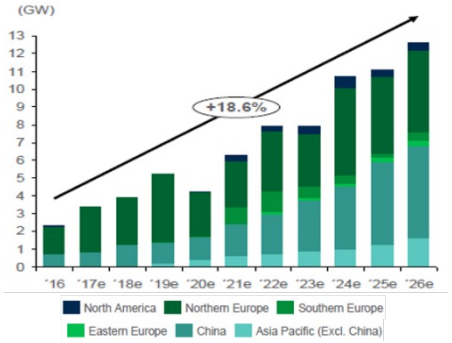
Wind market outlook

Stable onshore market and high growth of offshore and service markets



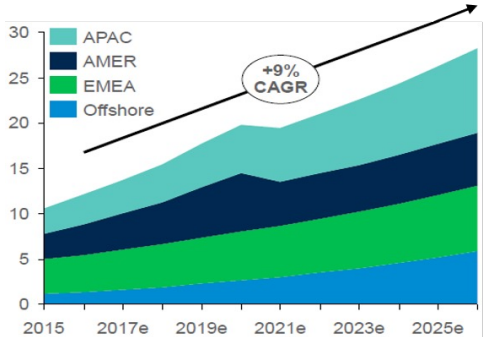
Onshore wind (GW)[1]

- Stable growth at high volumes
- US post 2020 expected to be offset by EMEA, and especially Asia Pacific



Offshore wind (GW)[1]

- Offshore market expected to grow rapidly from 2020 as more countries come online



Global O&M revenue (bUSD)[2]

- Increasing opportunities in repowering

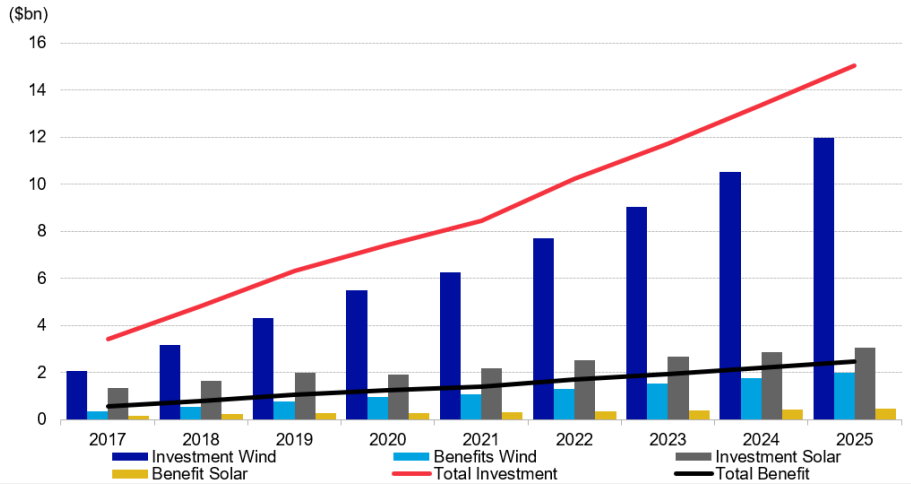
(**1**) *Source*: MAKE Consulting: Q4 Global Wind Power Market Update, Nov '18
(**2**) MAKE Consulting: Global Wind Turbine O&M, December 2018.

Wind and solar industry digitalization forecast overview

Digital investment and benefits in the wind and solar power

Why investing in digital solutions?

- → Manage complexity.
- → Reduced maintenance costs.
- → Optimized performance (additional power output).
- → Increase in output forecast accuracy provided to grid operators.
- → Reduce the cost of providing the service for both suppliers and asset owners.
- → More visibility to grid operators.
- → Operational data can be used by algorithms to better run the solar and wind systems.
- → The same assets (sensor, communication devices, power processing, etc.) could be used in the future for multiple grid services not in place today.



***Bloomberg New Energy Finance*: Investment in wind and solar power and the corresponding benefits**

Source: Bloomberg New Energy Finance: Costs and Benefits of Digitalizing Energy

Market Developments

Key developments influencing renewable energy

The market environment is moving faster than ever, and renewables need to be dynamic

Market design

- Redesign of most markets to benefit from renewables and DER[1] additions.
- Economic dispatch of pool of plants.
- Move towards more dynamic market setups, trading closer to real time.
- Forecasting and automation expected to become more important.

Distributed resources

- Emergence of DER1 as new source of energy and income for consumers.
- EV[2] become affordable and more appealing to drivers and corporations, bring grid challenges but also flexibility options.

Renewable Integration

- Go beyond grid codes and address system operations and planning, system protection, running with low or no inertia.
- Emergency support and grid restoration schemes from renewable plants.
- Renewables as trusted energy supply.

New business models

- New business models based on the aggregation of DER and EV.
- New revenue streams from energy and flexibility services.
- XaaS[3] appealing to many actors.
- Customers becoming competitors.

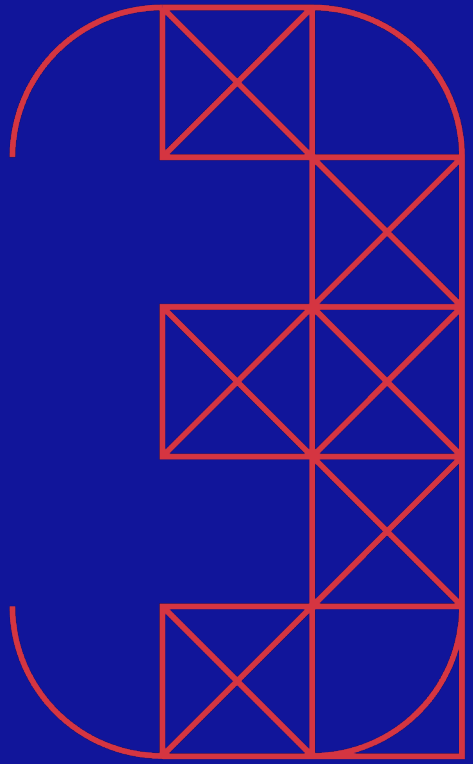
Need for flexibility

- How to do load-frequency and energy balancing in grids with high penetration of renewables.
- Hybrid power plants and role of energy storage for renewables.
- New business opportunities and business models emerge.

New technologies

- Offshore wind, solar and batteries cost out developments.
- Software and digital solutions.
- Peer-to-peer technologies and solutions.
- Cybersecurity, big data, artificial intelligence.

(**1**) Distributed energy resources.
(**2**) Electrical vehicles.
(**3**) X (energy, infrastructure, software) as a service.

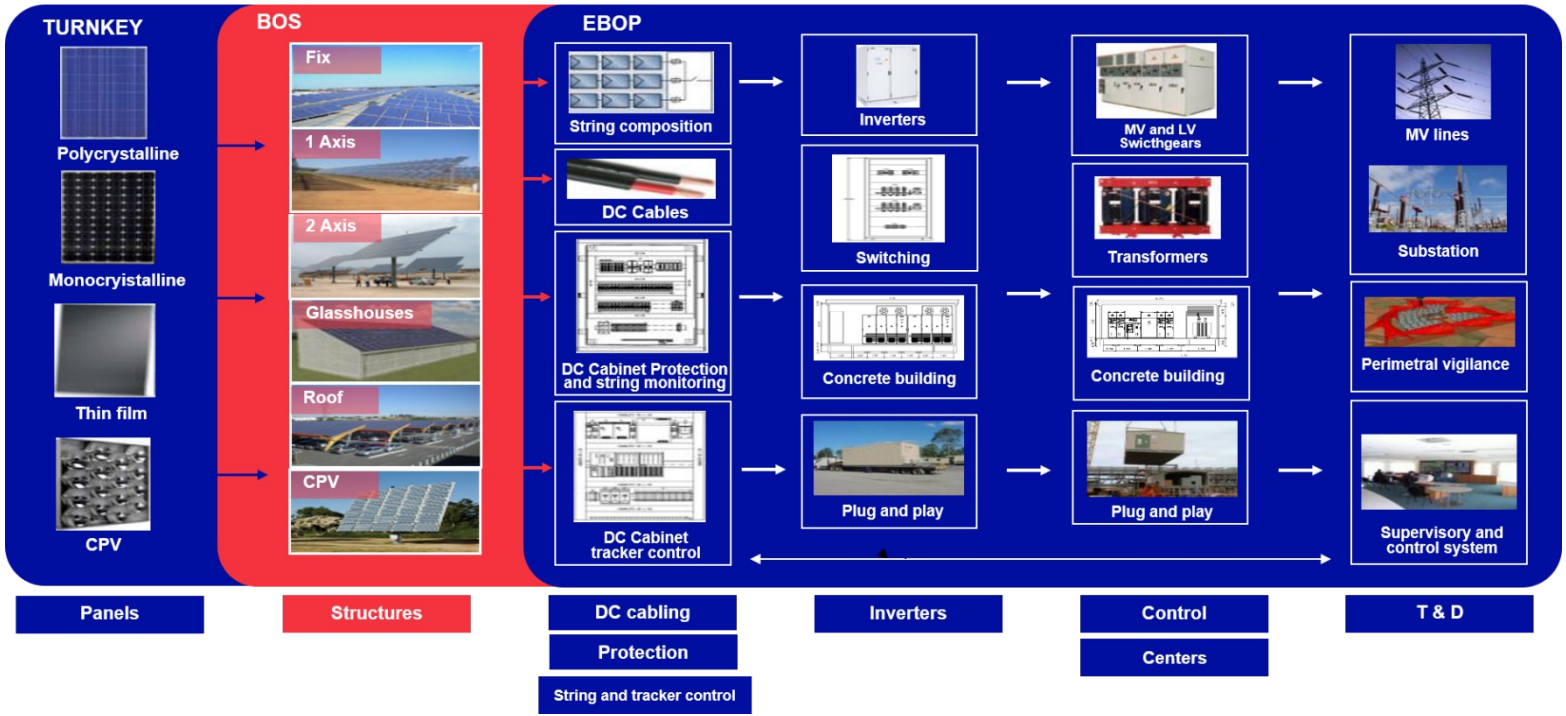


Generating solutions

Safety, quality and integrity in everything we do

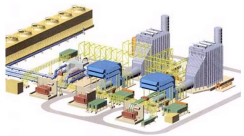

Solar

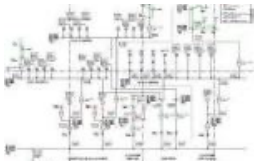
Solar integration
Introduction to PV scheme



Solar integration

Standard PV Plant Design – Competencies





High efficiency equipment selection

- Panels
- Trackers
- Inverters
- Switchgear
- Transformer
- Cable selection

Standard design

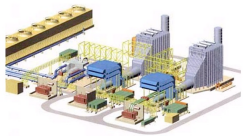
- Engineering works
- Electrical calculation
- Looses calculation
- Automation & supervision
- PR calculations
- Electrical cabinets
- Pre-Fabricated Inverter Containers
- Communications
- Operation and maintenance

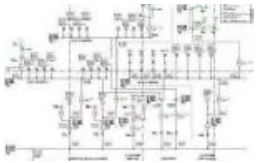
Optimized system design

- Panels classification
- Electrical looses
- Optimal power peak calculation
- Dispatchability and flexible production requested by grid operator
- Switching system.
- None assistant plant operation

Solar integration

Standard PV Plant Design Competencies





Grid feasibility studies

- → Short-circuit calculation, selectivity and protection coordination
- → Load flow calculation, components design
- → Transient system stability and dynamic behavior
- → Harmonic analysis, filtering and lining up systems settlements
- → Economical convenience and lifecycle analysis

Standard design

- → No coordination for partners' scope
- → Reduced installations costs
- → Reduced commercial risks
- → Increased availability
- → Greater flexibility
- → Reducing operating costs

Renewable integration

Generation expansion: New challenges

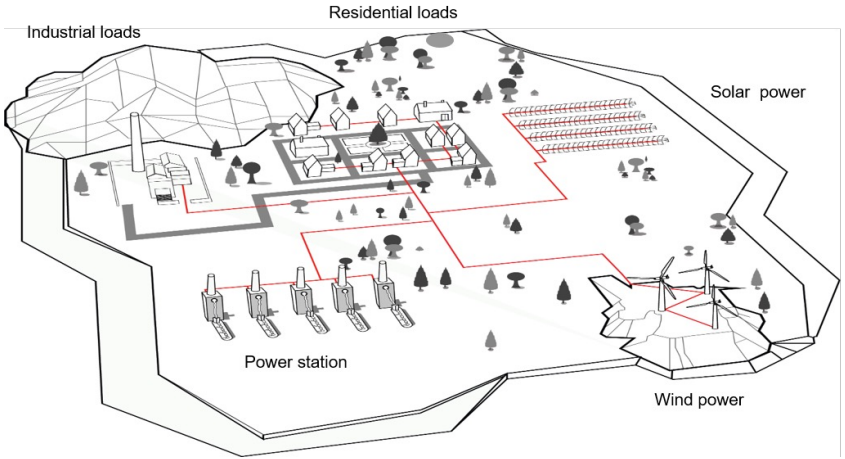
Technical

- → Adaptation to meet grid codes
- → Ancillary services for renewable energy
- → Grid integration
- → Plant control
- → Digitalization and smart grids

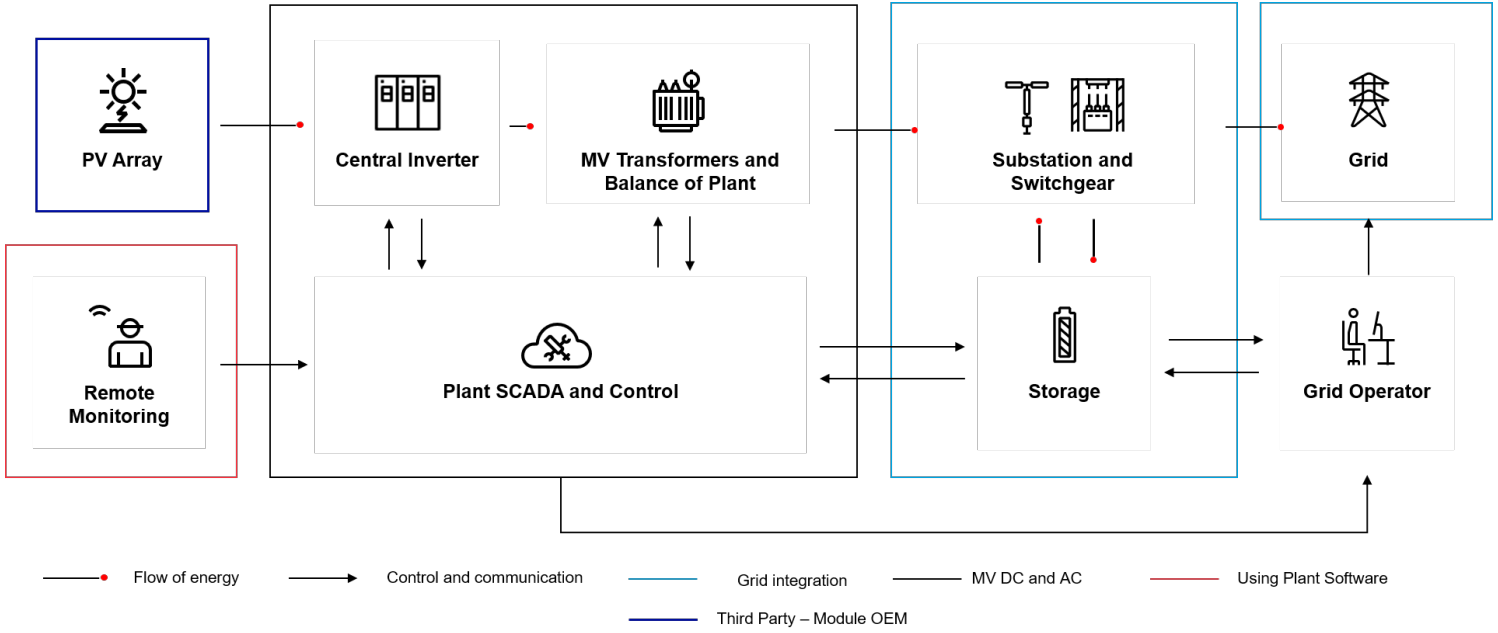
Commercial

- → Fast track installations
- → New business setups
- → Competition with other energy sources
- → Demand management

Before

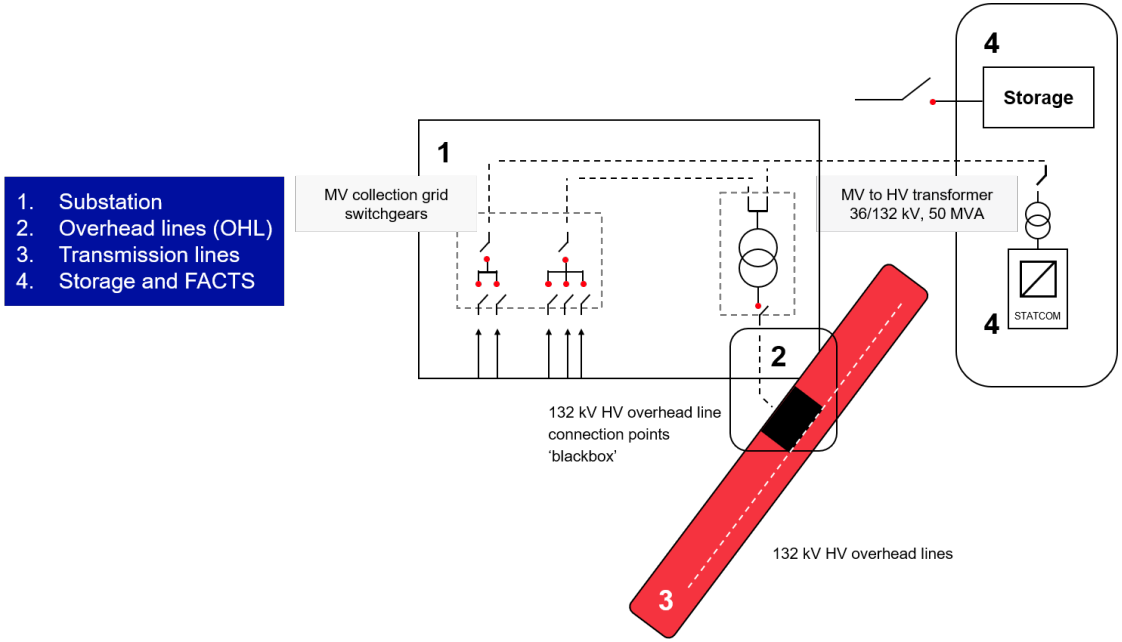


Grid integration
Scope



Project scope and collecting system

Structure of solar farm, from grid to solar generator



Hybrid plants: wind + solar

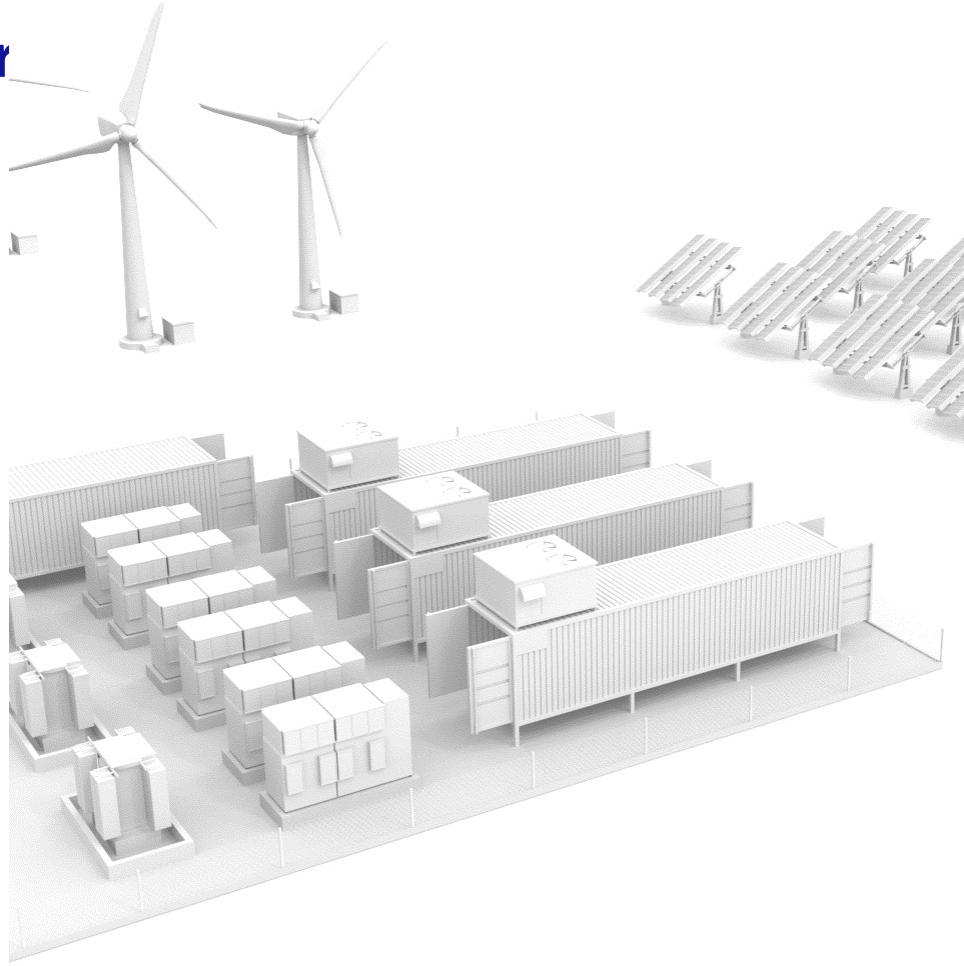
Energy storage as an enabler

Hybrid plants

- There are several definitions of hybrid plants in the market.
- In Linxon 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.

Solutions

- Still very few references worldwide but a clear trend.
- Right compensation equipment
- Energy storage solutions



Possible HV solutions

Full scope, full expertise

Ultra compact / pre-tested

→ Small footprint for challenging sites

Wide range of environments

→ Wide temperature range

→ Resists pollution, corrosion, earthquakes and high altitudes

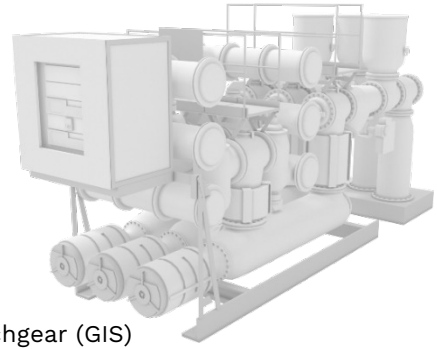
→ Modular designs with proven reliability

→ Low environmental impact and lifecycle costs

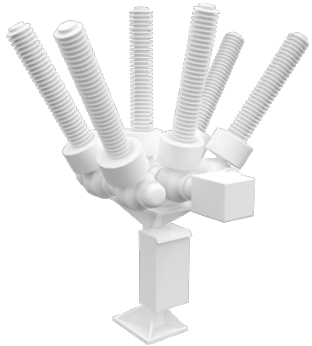
→ Reduced installation and commissioning time

→ High safety and quality standards

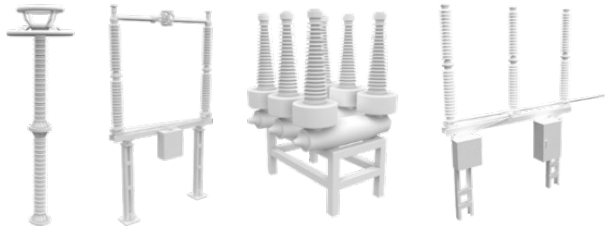
→ Advanced features for digital substations



Compact
Gas-insulated switchgear (GIS)



Rapid installation
Hybrid / H-Hybrid



Proven performance
Air-insulated switchgear (AIS)

Wind & Floating offshore wind

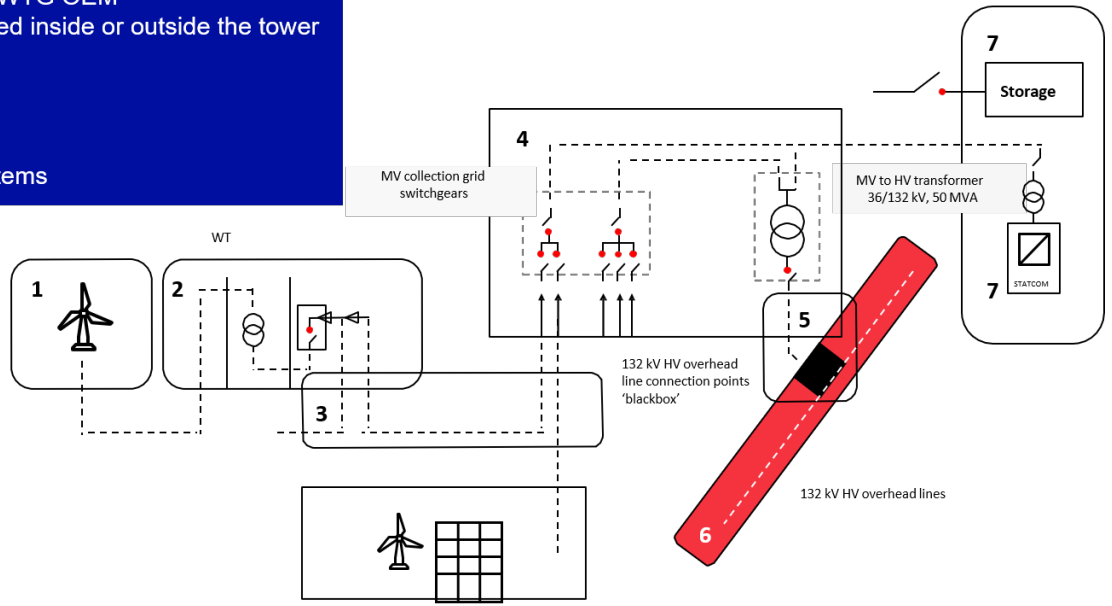
Wind integration
Reshaping the world

- → Wind power is a must to decarbonize the grid and reach global goals for CO2 emissions.
- → Renewables are the first alternative for any repowering program.
- → Renewables are an opportunity to produce competitive energy.
- → Wind power technologies are mature (onshore) but in many markets the deployment of renewables is a challenge.
- → Wind turbine generator's capacity factors are growing in all regions, allowing better business cases for developer and owners.
- → Wind power plant's cost efficiency and reliability are improving.
- → New wind corridors are being discovered.
- → Price parity is now achieved in many markets.

Wind Project scope and collecting system

Structure of wind farm, from grid to wind turbine generator

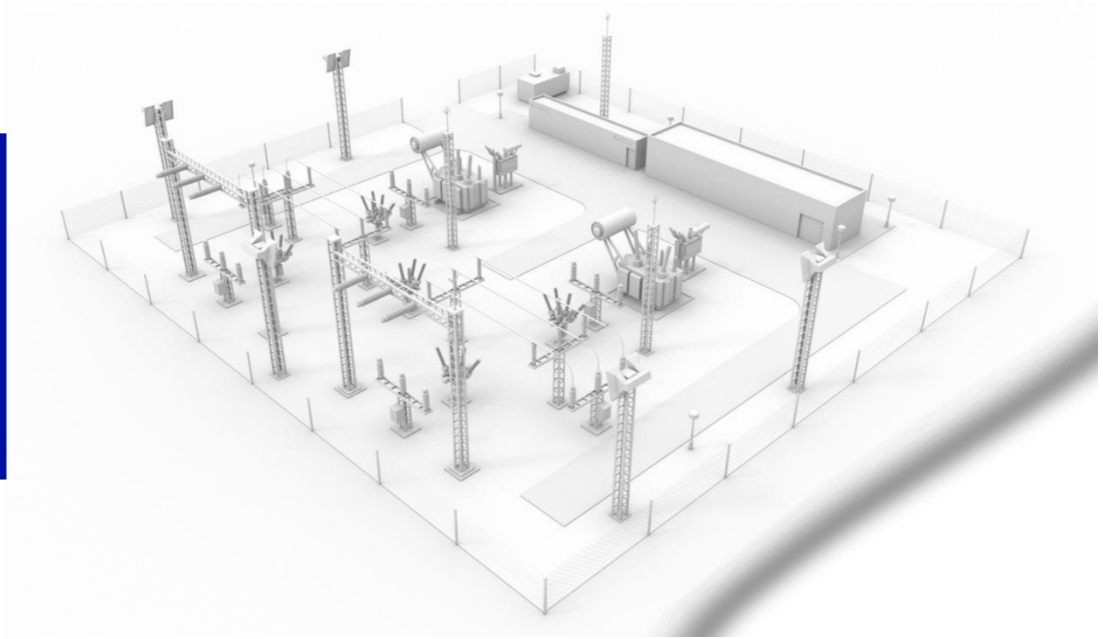
1. The WTGs are supplied by the WTG OEM
2. Ring main units could be installed inside or outside the tower
3. Medium voltage collection
4. Substation
5. Overhead lines (OHL)
6. Transmission lines
7. Storage and compensation systems



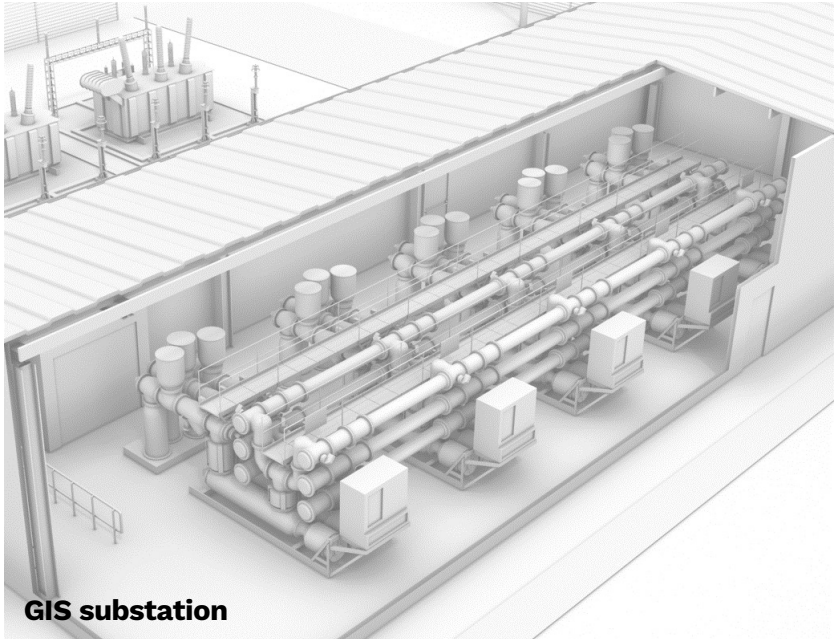
Typical hybrid solution for collection and connection

Common choice for solar collection station

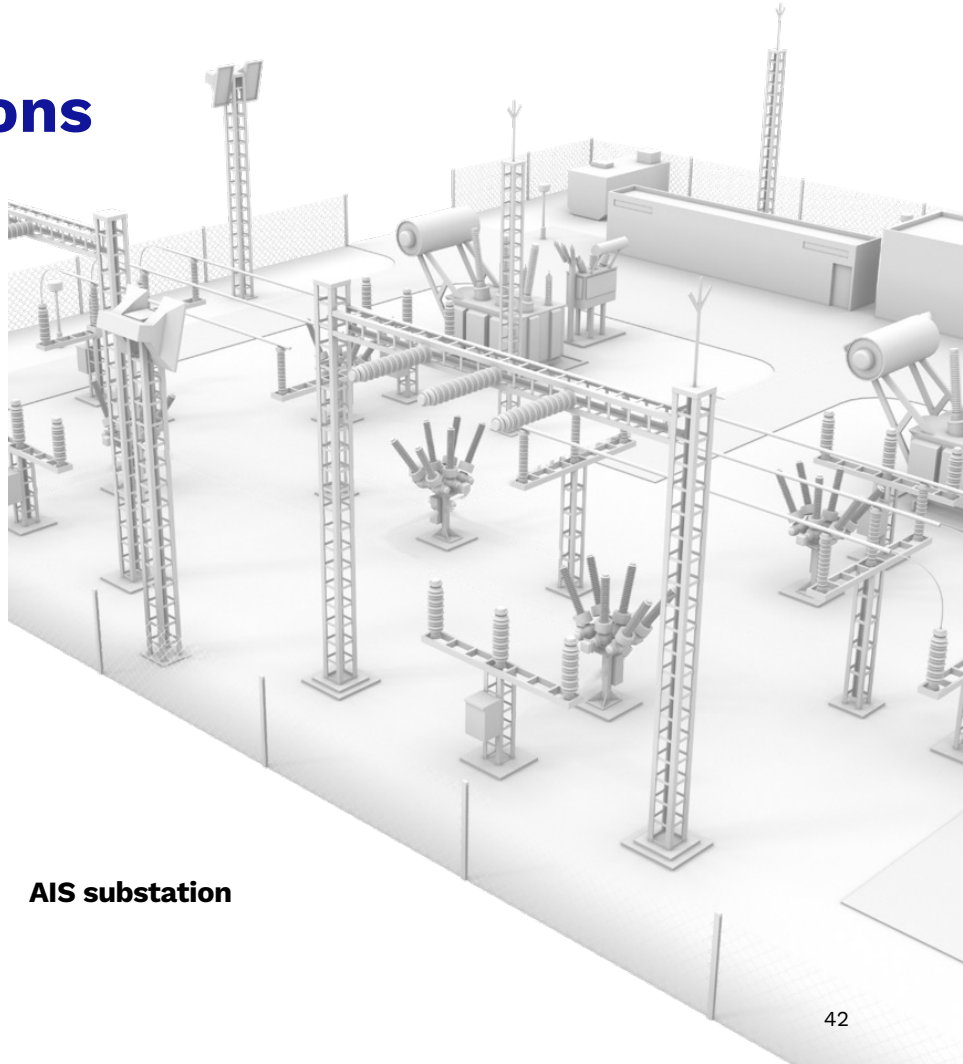
1. Hybrid equipment for line bays
2. Hybrid equipment for transformer bays
3. Hybrid equipment for bus coupler bay
4. Power transformers
5. Grounding equipment and MV cables
6. Surge arresters
7. Busbars
8. Voltage transformers
9. Line gantries
10. Control room
11. MV switchgear room
12. Ancillary services equipment



Possible substation solutions apart from hybrid type



GIS substation



AIS substation

MV collecting system

Intensive engineering and many optimization possibilities

Phase 1: System modelling

- → Cooperation between consulting and engineering
- → Detailed modeling including WTG layout and MV cable electrical parameters

Phase 2: Steady state analysis

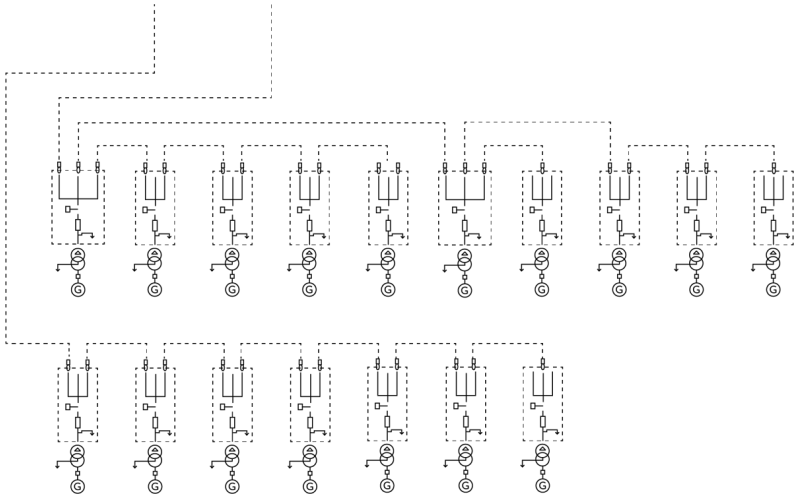
- → Load flow analysis, voltage profile
- → Accurate calculation of yearly losses

Phase 3: Short circuit analysis

- → Equipment selection
- → Grounding studies
- → Protection coordination

Phase 4: Results

- → Equipment specification
- → Losses reduction and LCOE optimization
- → Safety design and operation



Electrical balance of plant and grid integration

Quality and risk control: key products and services from one source

Customer benefits from single source:

→ Local content

→ Local contractor experience

→ Lower overall project risks

→ Project schedule control

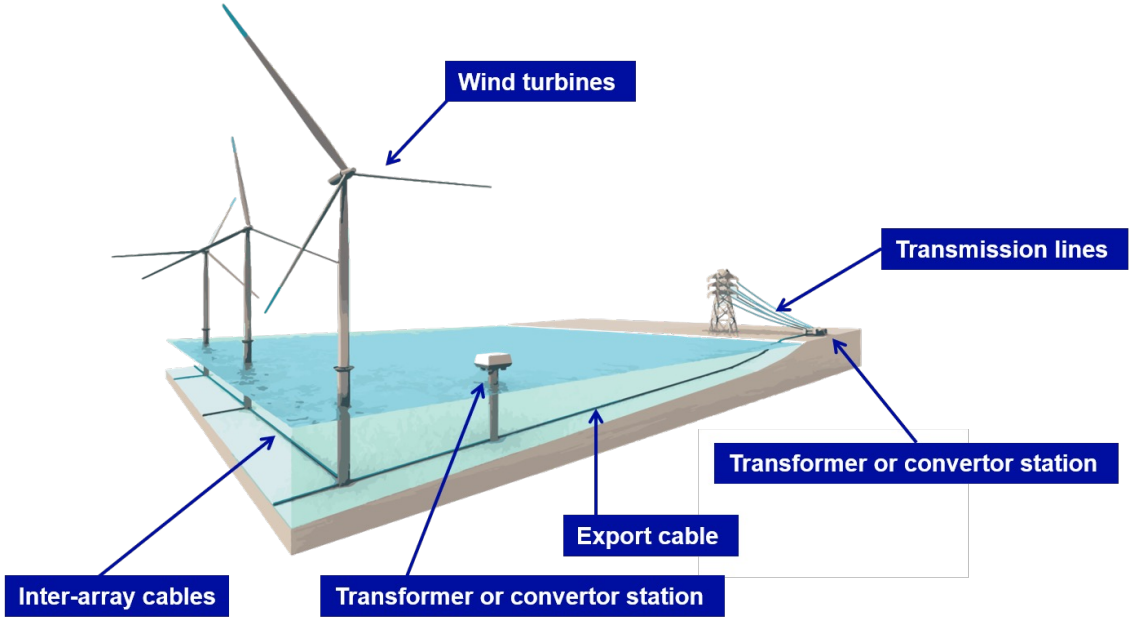
→ Value-added engineering to optimize design

→ Highest project management (PM) and site management (SM) standards

→ Highest health and safety standards

→ Fast-track projects (focused engineering, PM, SM and equipment manufacturing)

Renewable power
An offshore wind farm

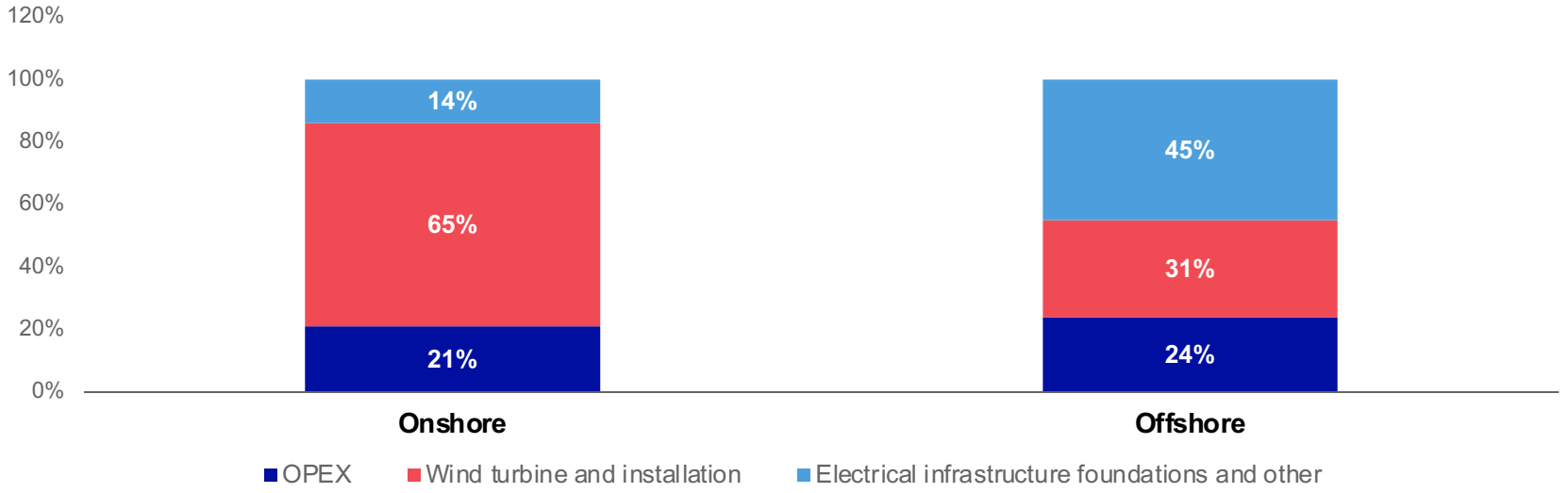


Renewable power
General EPC offering for offshore wind farm

1. Development and project management	2. Wind turbine supply	3. Balance of plant	4. Installation and commissioning	5. Operation, maintenance and services	6. End-of-life solution
→ Wind farm design	→ Wind turbine assembly	→ Subsea export cables	→ Turbine installation	→ O&M and minor service	→ Repowering
→ Surveys	→ Blades	→ Subsea array cables	→ Foundation installation	→ Major service	→ Recycling
→ Pre-FEED and FEED	→ Castings and forgings	→ Substations	→ Subsea cable installation	→ O, M & S; other	→ Restoration seabed
→ Feasibility studies	→ Drive train	→ Foundations	→ Installation; other		
	→ Tower	→ Balance of plant; other			
	→ Turbine; others				

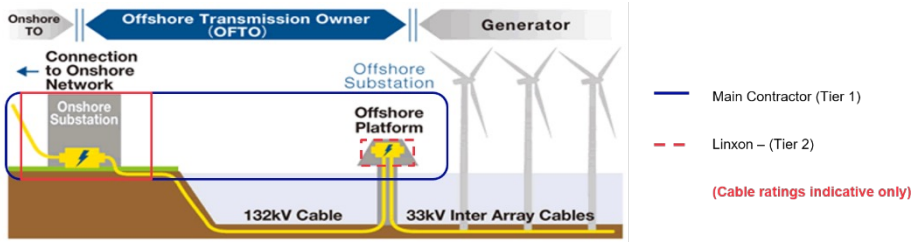
Renewable power

Cost comparison offshore and onshore wind plant



Renewable power
Visual scope split – offshore wind project

- Main contractor will wrap transmission package as main (Tier 1) EPC contractor.
- Main contractor to include the offshore export cable at their risk. Otherwise, exclude.
- Linxon to deliver turnkey onshore sub and offshore BoP at dockside.
- Linxon responsible for transmission system design and grid code compliance (core work for Linxon).
- Linxon can wrap onshore cable connection (beach head to onshore). However to be subcontracted on full back-to-back basis.
- For Linxon, except equipment that needs to be replaced under warranty, it will supply the equipment to the dockside only. Transport from dockside, installation and commissioning (under Linxon supervision) of the replacement equipment on the platform by main contractor.



Renewable power
Outline scope matrix – offshore wind project

Main scope	Sub-scope	Linxon	Main contractor
Onshore S/S		Yes	No
Onshore Cable		Yes	No
Offshore Cable		No	At Main Contractor discretion
Offshore S/S			
Engineering	HV System / Equipment	Yes	No
	Aux Equipment/LV	No	Yes
	Platform	No	Yes
Procurement	HV System / Equipment	Yes	No
	Aux Equipment/LV	*If ABB*	Yes
	Platform	No	Yes
Fabrication	Platform	No	Yes
Install	HV System / Equipment (in yard)	Yes	No
	Platform Transport & Installation	No	Yes
Commissioning*	HV Equipment (Supervision)	Yes	No
	Aux Equipment/LV	No	Yes

* All offshore commissioning supervision on cost + fee basis.

Objectives and key message

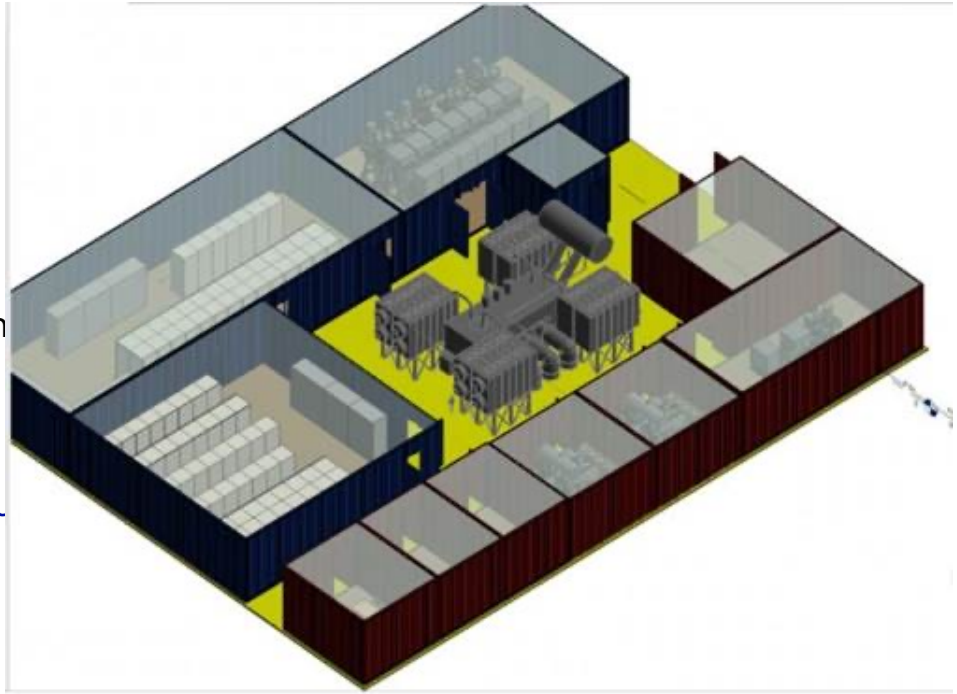
- Gain access to areas with offshore wind potential not suitable for fixed bottom offshore platforms

- Introduce a floating substation concept that can address the current market needs
  and be adapted for emerging application

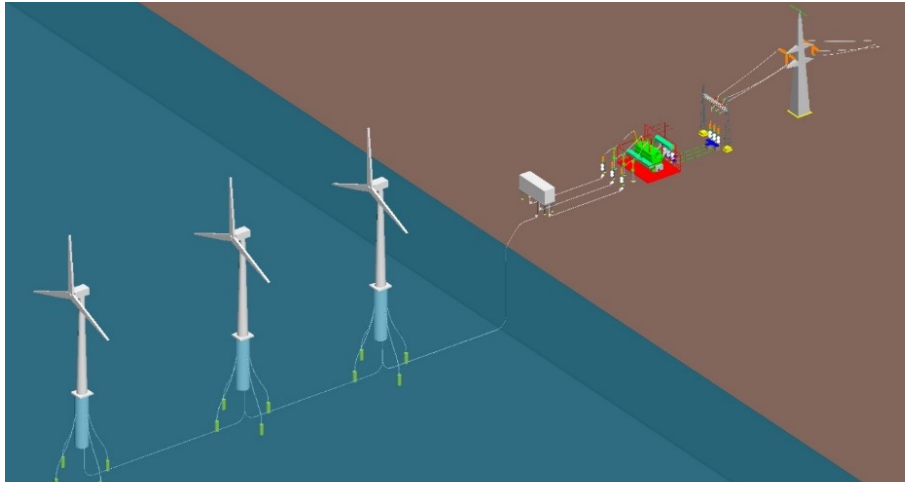
The floating substation is a reality

We want to hear from the supply chain abou
readiness

We need to hear from developers

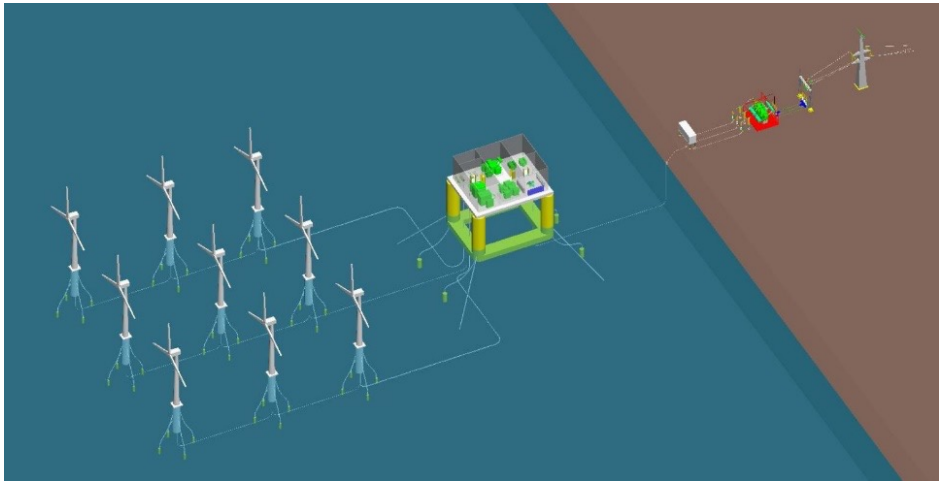


Context and applications / Floating substation



Topology A: Direct connection

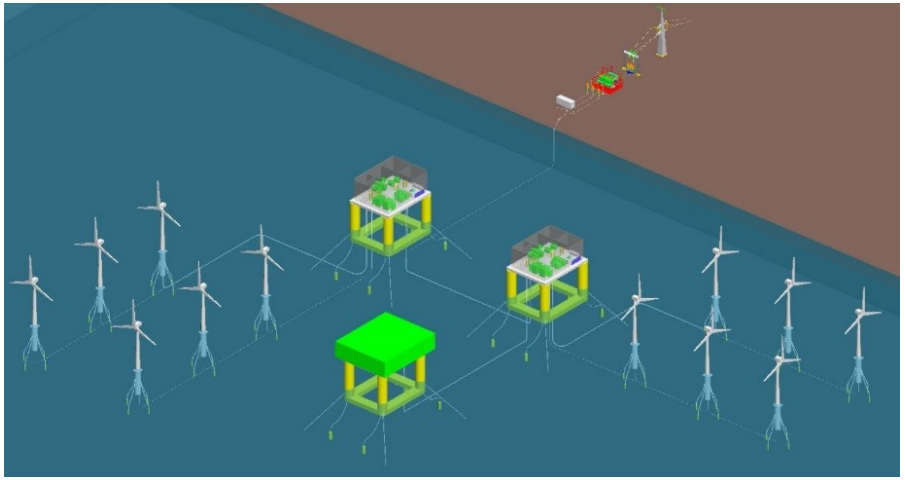
- Proof of concept for floating WTG installations
- Application for short-distances and low power
- Applications are limited to sites with deep water close to shore



Topology B: Radial wind

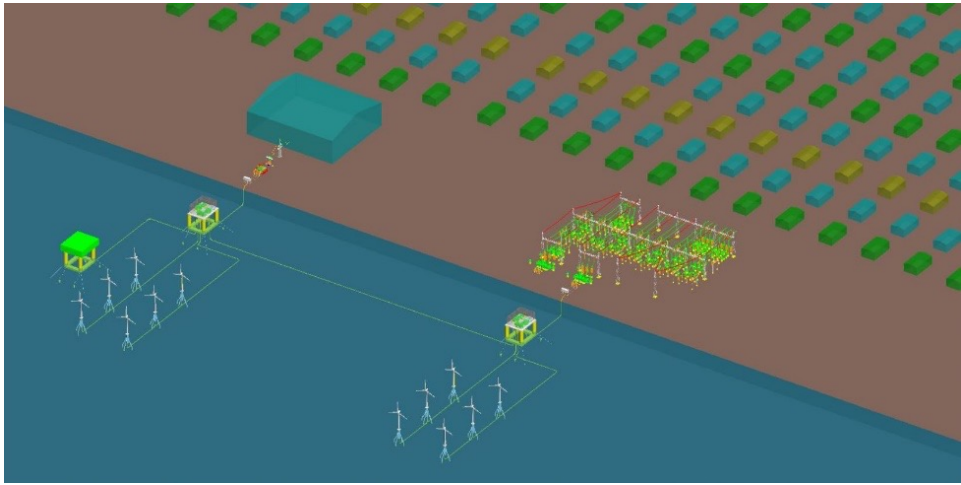
- State of the art developments
- Known application and limited number of stakeholders
- Known regulatory framework

Context and applications / Floating substation



Topology C: Aggregation of offshore resources

- Aggregation of wind generation
- Electrification of O&G platforms
- Sharing of back-up generation
- Balancing of offshore resources



Topology D: Offshore grid

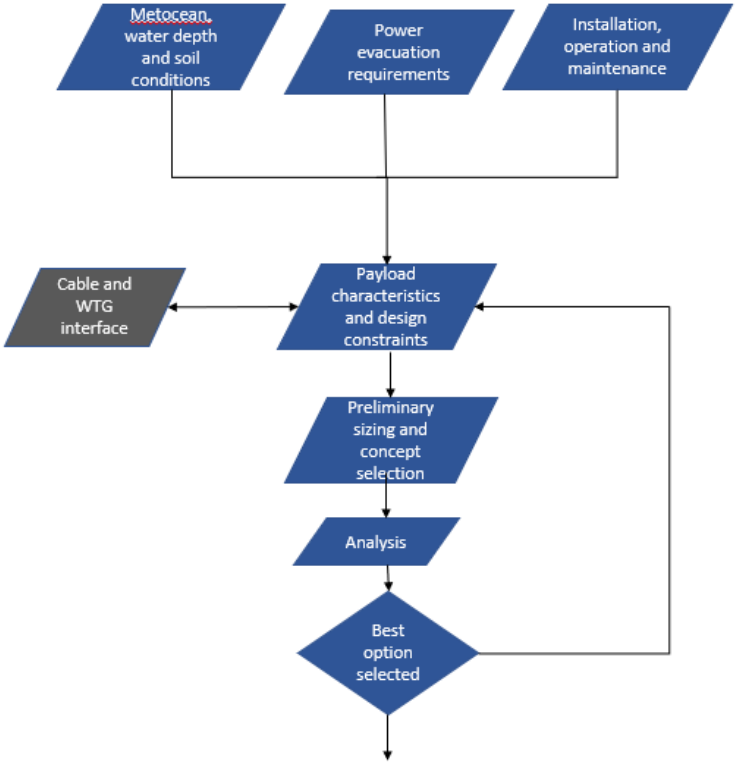
- Wheeling of power through offshore transmission
- Management of transmission congestion

Overarching design process

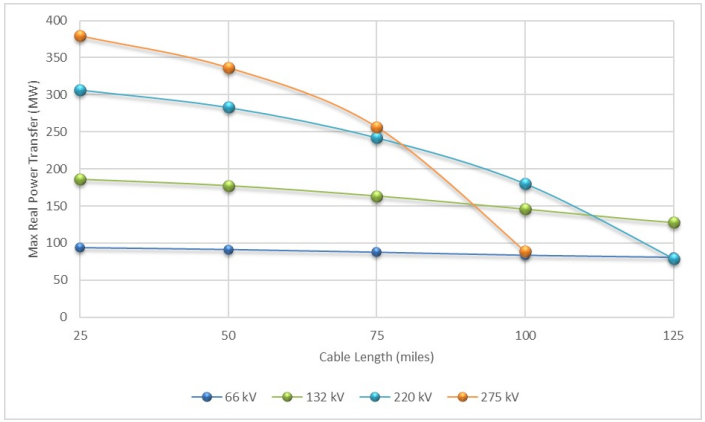
TRL level	Definition	Hull form / Structure	Electrical System Design	Interface (e.g. dynamic HV cable and WTG)
1	Unproven			
2	Basic Principles Proven			♺
3	Concept Proven			
4	FEED level definition			∞
5	Scaled prototype tested			
6	Environment tested			
7	System tested			
8	Field Proven		♺	
9	Commercial	♺ ∞	∞	

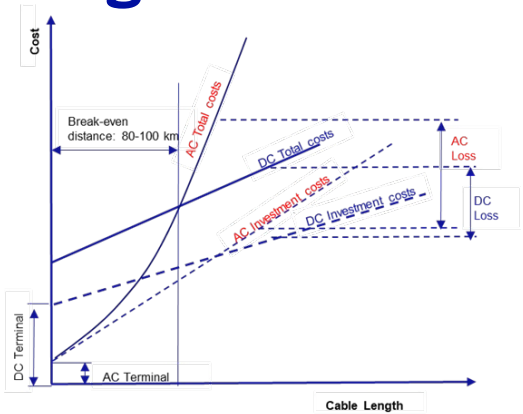
Effect of a floating substructure

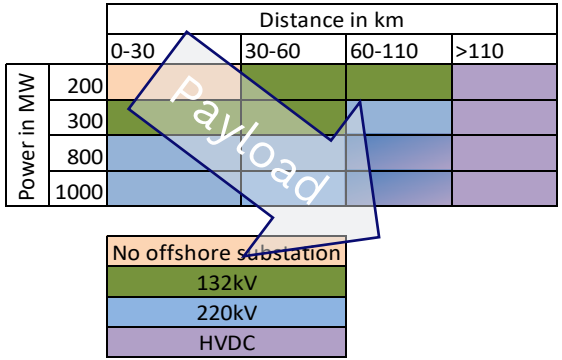
- Manufacturing / Installation / Operation / Maintenance strategy
- Payload weight vs cost is not correlated the same way as for a fixed-bottom solution
- Acceleration and tilt withstand capabilities can be managed through design



Payload selection process / Balance between potential, offshore wind farm electrical design







Effect of payload on the floating substructure

- Weight and dimensions interact in a complex way with the floating substructure movement
- Bigger and larger payload can lead to a decrease in the substructure movement
- Different location in the platform experience different accelerations

Major electrical design features selected

- Up to 300MW of power evacuation capacity
- Rated voltages of 150/66kV
- Suitable for up to 70km of export cable

Acceleration
Tilt
Weigh distribution
Dimensions
Equipment specifications