ABB, APRIL 19TH 2017

Shore-to-ship power & Smart Ports

Portfolio overview

Roberto Bernacchi, Shore-to-ship power and Smart Ports Global Product Manager

Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

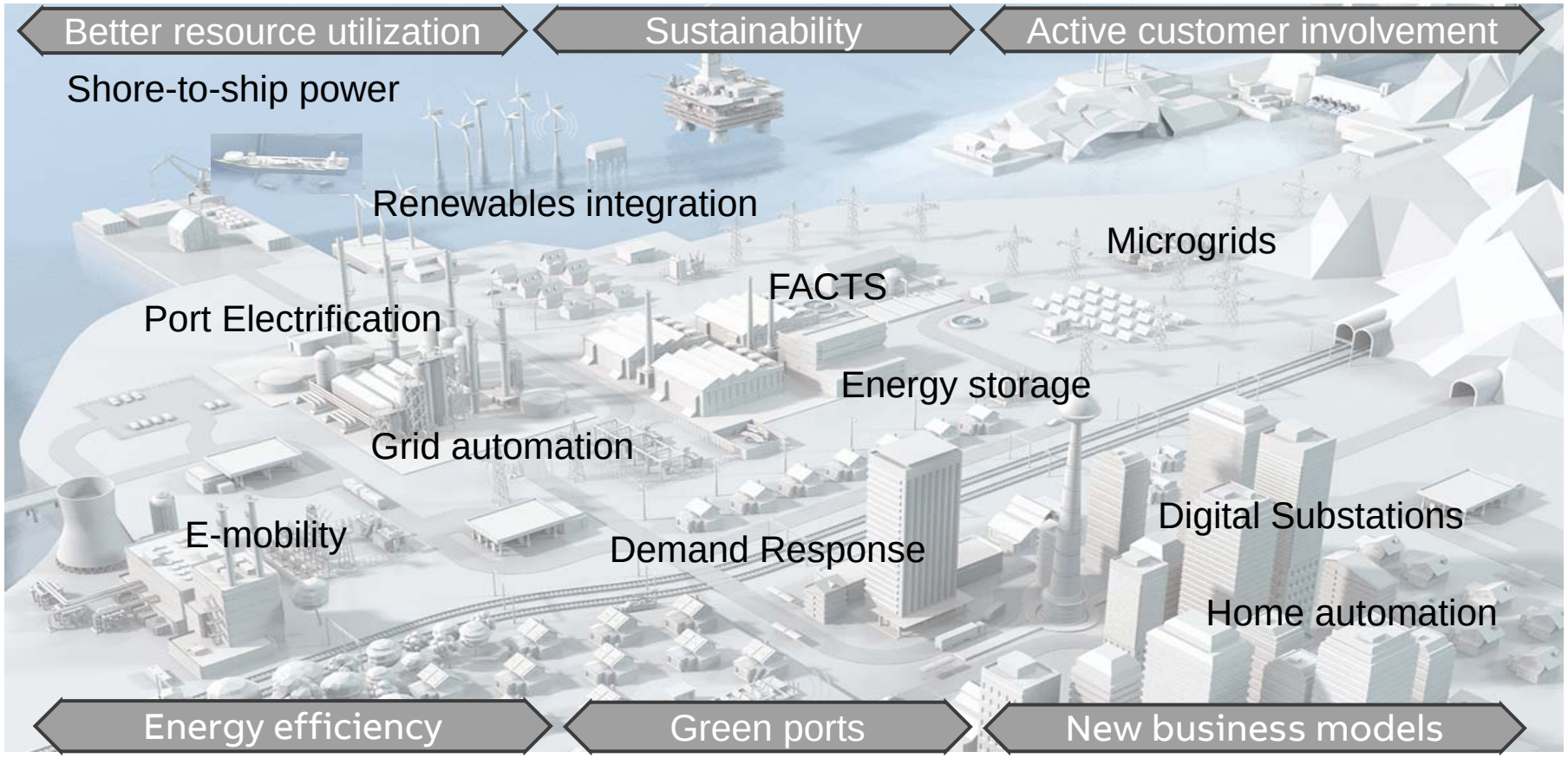
Smart Ports

Project references

Conclusions

Shore-to-ship power & Smart Ports

Key technologies driving towards Smart Ports

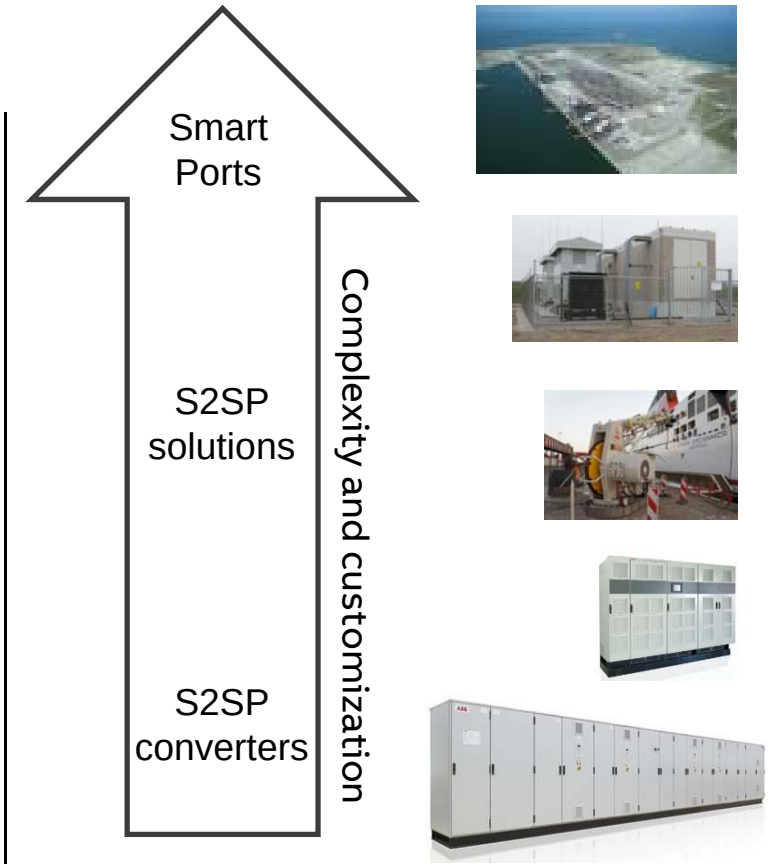


Shore-to-ship power & Smart Ports

Complete offering

From products to complex systems

- Container terminal electrification (from High Voltage Substations to MV/LV distribution)
- Shore-to-ship power turnkey systems
- Shore-to-ship power engineered packages
- Shore-to-ship power converters:
  - PCS 100 SFC
  - ACS 6000 S2SP



Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

Smart Ports

Project references

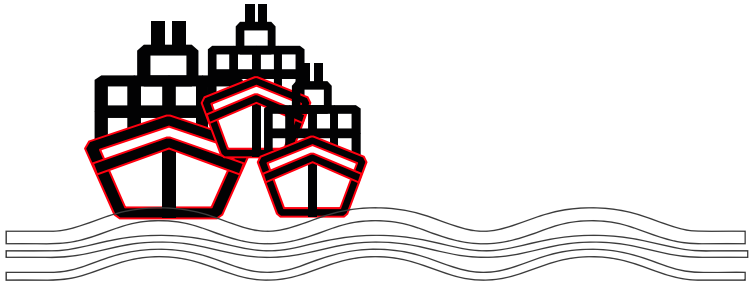
Conclusions

An environmental issue

Emissions from vessels docked in port

Auxiliary engines run by ships in port produce a large quantity of pollutants:

- SOx
- NOx
- CO2
- Particle discharge

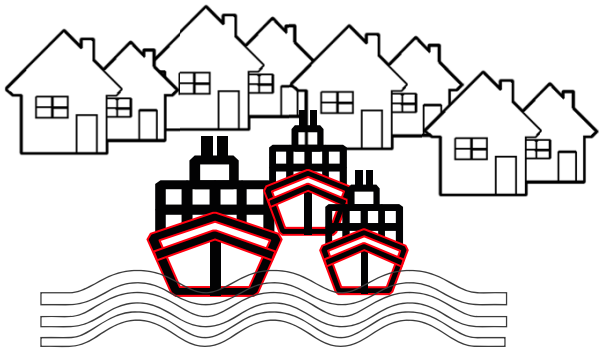


Auxiliary engines run by ships in port significantly increase:

- Noise levels
- Vibrations

An environmental issue

10,000 cars vs. 1 cruise vessel



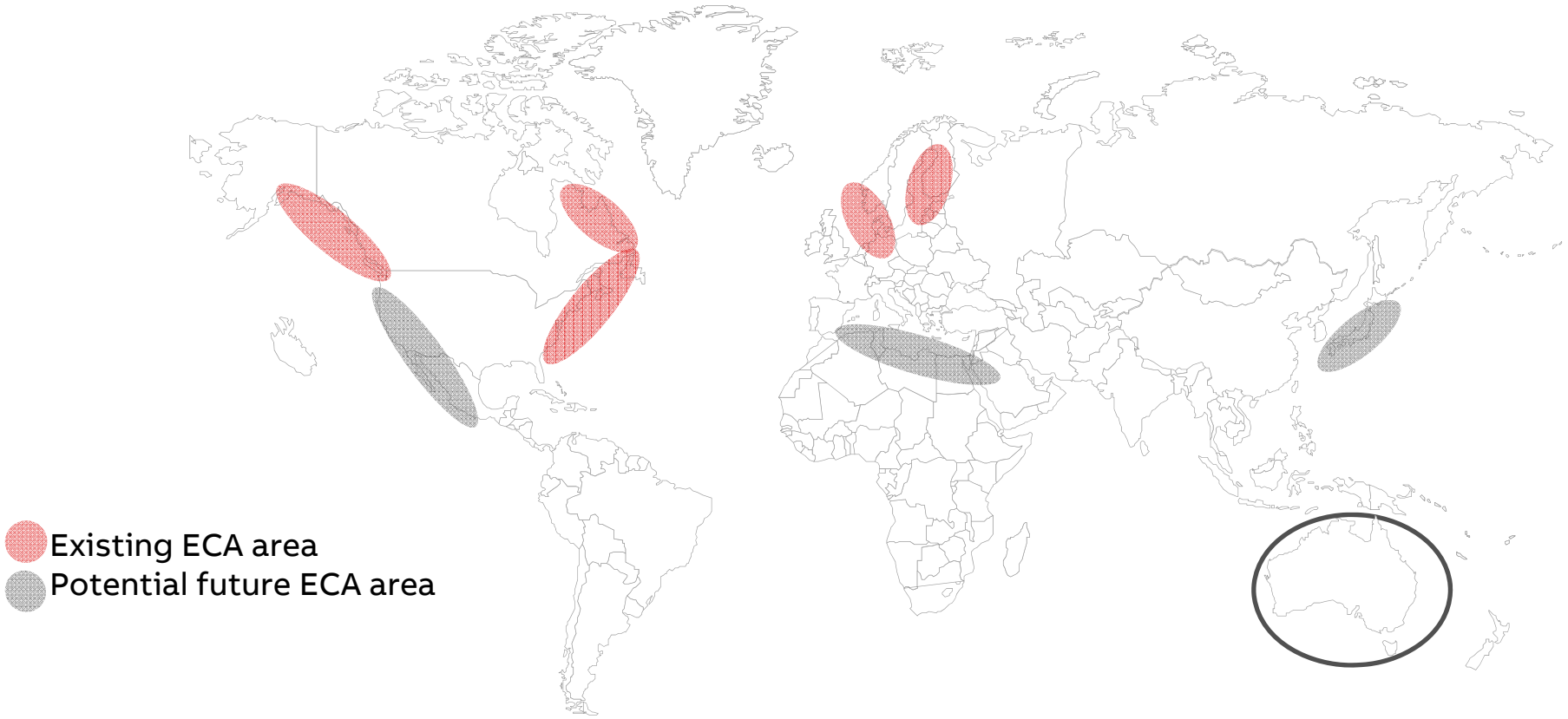
1 vessel emits NOX during 8h equivalent to 10,000 cars going from Zurich to London

Vessel: 1 ship x 11.8 kg/MWh x 8 h x 12 MW = 1.1 t NOx

Cars: 10,000 cars x 0.1 g/km x 1,000 km = 1.0 t NOx

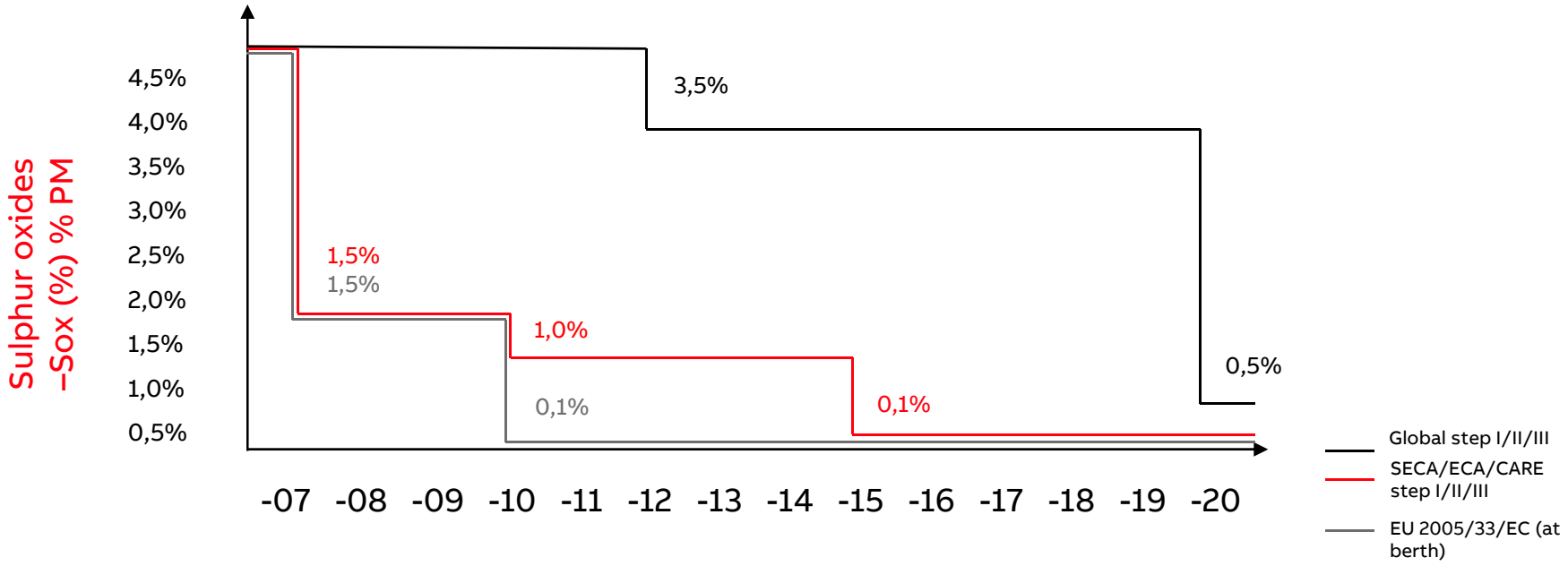
An environmental issue

Emission control areas



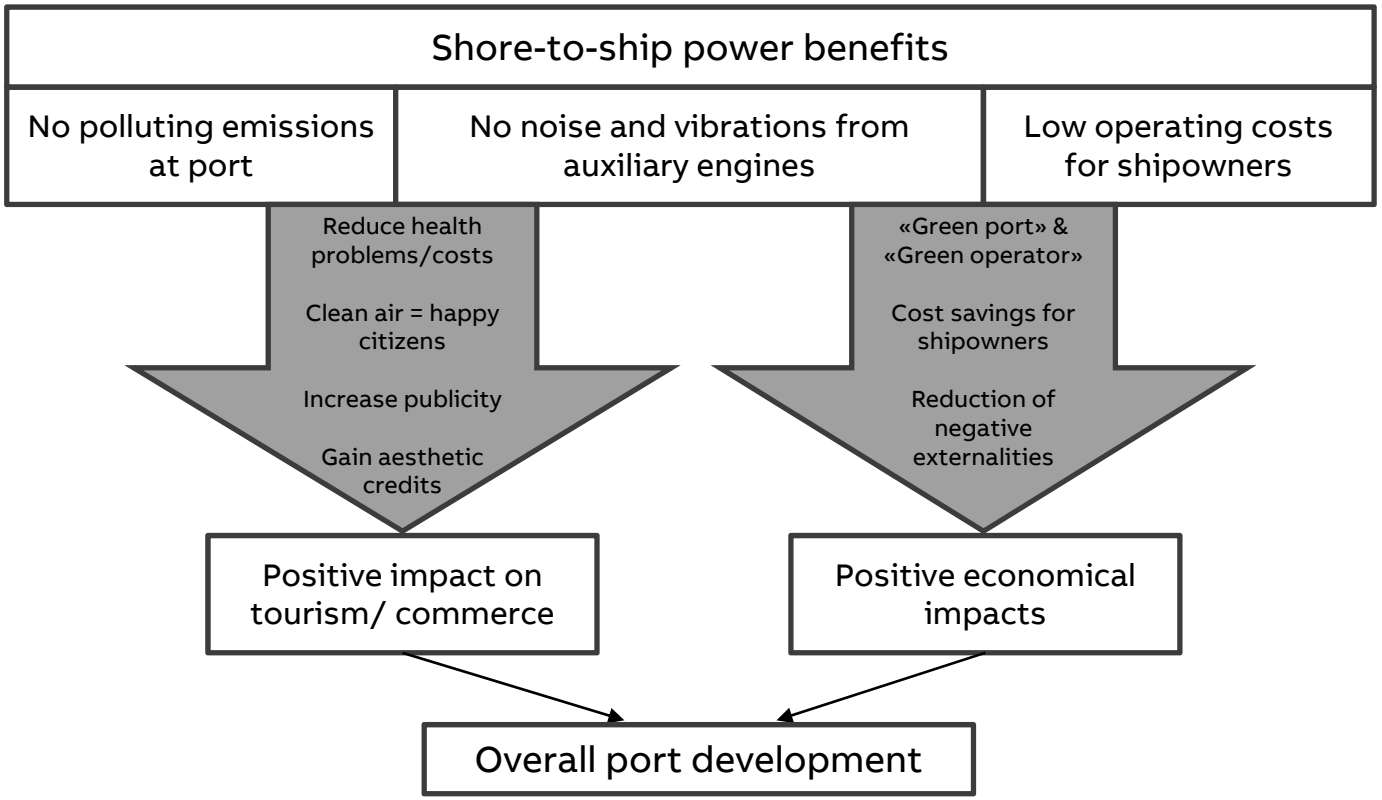
An environmental issue

More stringent IMO MARPOL convention



Shore-to-ship power

Economical and environmental benefits



Shore-to-ship power

Facts and myths

Myths

- Chicken and Egg problem – ship owner or port to invest into S2SP ?
- Few ships are prepared for shore-to-ship power
- ”There is no standard”
- ”It is too expensive”
- ”Shore-to-ship power is an unproven technology”
- ”No-one is really installing such systems”
- ”Ships produce cleaner electricity than power plants on shore”

Facts

- Public authorities have several instruments for promoting deployment
- An increasing number of newly built ships are equipped with shore power
- IEC/ISO/IEEE 80005-1 Standard is active
- Decrease in health expenses and increase in business opportunities at ports
- First S2SP installation back in ‘90s
- US West Coast and North Sea have a lot of installations
- Check country electricity mix vs. diesel

Shore-to-ship power

Applicable standards

Shore-to-ship power standards

- IEC / ISO / IEEE 80005-1, High Voltage Shore Connection
- IEC / ISO / IEEE 80005-2, Communication Protocol
- IEC / ISO / IEEE 80005-3, Low Voltage Shore Connection

Plugs & socket outlets

- IEC 62 613, Plugs & Socket Outlets

Voltage & frequency ratings (typical)

- Medium voltage : 6,6 / 11kV, (+ 6% / - 3,5%)
- Low voltage : 400 / 440V / 690V, (+ 6% / - 5%)
- Frequency: 50 / 60 Hz

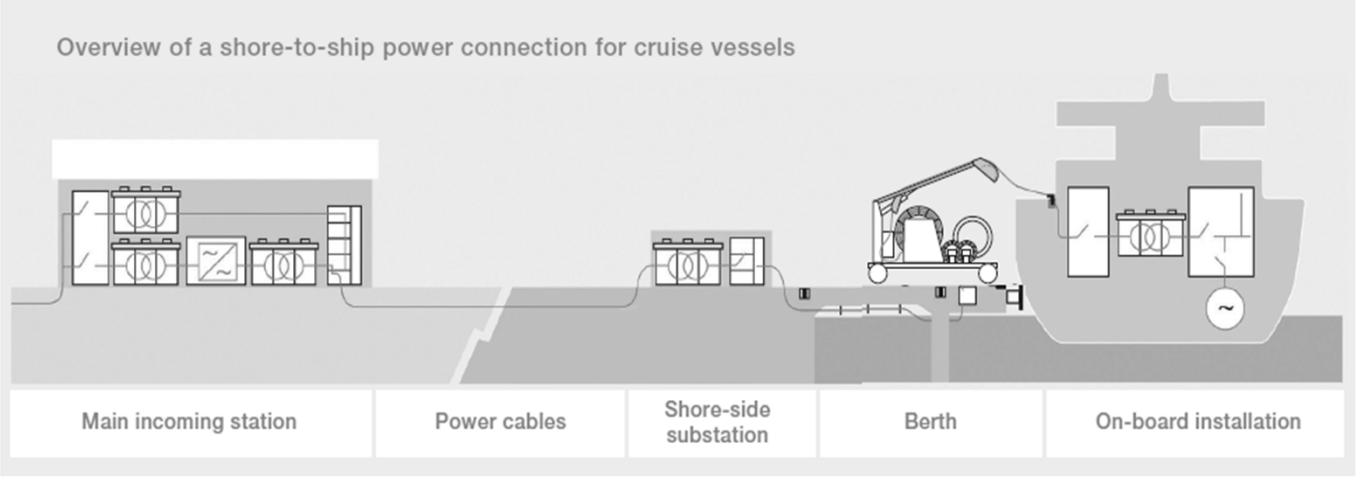
Power ratings

- Medium voltage : up to 20MVA per vessel
- Low voltage : typical < 1MVA

Shore-to-ship power

What is shore-to-ship power supply ?

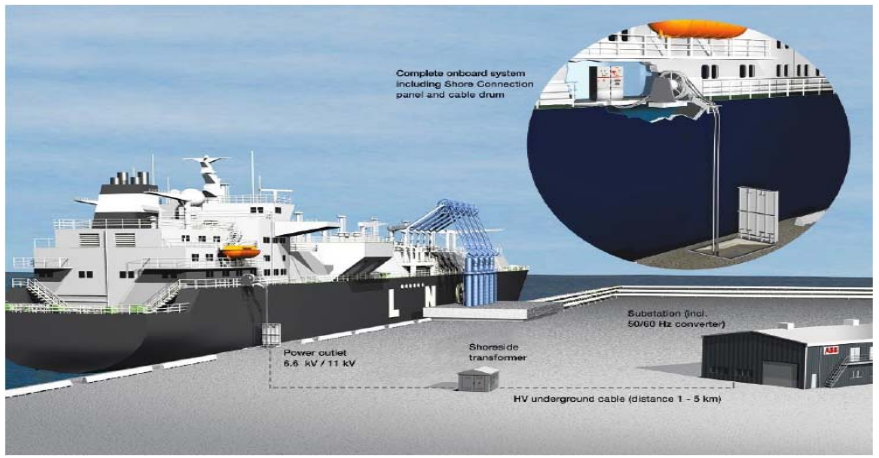
- Ships can shut down their engines while berthed and plug into an onshore power source
- The ship's power load is transferred to the shoreside power supply without disruption to onboard services
- Emissions to the local surroundings are eliminated
- Tip: Shore connection is also known as Cold ironing, Onshore power supply, Alternative Maritime Power supply (AMP), etc.

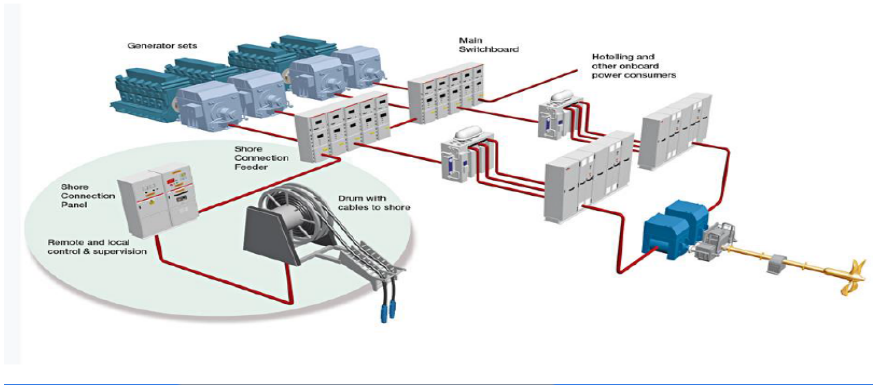


Shore-to-ship power

A turnkey approach

- Onshore:
  - Substation (including frequency conversion)
  - MV / LV distribution
  - Cable management system
  - Shore connection box/plugs
- Onboard:
  - Shore-to-ship power panel
  - Fully automated power transfer





Shore-to-ship power

Applications and segments

Characteristics	Vessel Type				
	RORO/Ferry	Container	Cruise	LNG / Tanker FSU / FPSO	Shipyards / Navy
					
Voltage	11 kV or low voltage	6,6 kV	6,6 & 11 kV	6,6 kV	6,6 kV, 11 kV or low voltage
Max Power consumption	6,5 MVA	7,5 MVA	16/20 MVA	Approx. 10 MVA	Case by Case
Frequency	60 & 50 Hz	60 mainly	60 mainly	60 Hz	50 & 60 Hz
Plugs/cables (per connection)	1	2	4+1	2/3	Case by case
Transformer	onboard	onshore	onshore	onshore	Case by case
Layout	Not critical	critical	critical	critical	Not critical
Load profile	Partially controlled	Partially controlled	Flat profile	Not controlled	Case by case
Protect selectivity	critical	Not critical (If P=7,5 MVA)	critical	Case by case	Case by case
Cable management system	mid cost	low cost	high cost	Mid cost	Case by case

Shore-to-ship power

System components

System components			
S2SP converters			Wide range of leading-edge converter systems
Transformers and switchgear			LV, MV and HV switchgear ensures safe and reliable grid connection. Full range of transformers for any local standard
Protection equipment	 		State-of-the-art protection systems for AC and DC equipment.
Control and communication systems			RTU560, AC500 or AC800M based control system according to IEC80005-2
Cable management system & sockets			Integration of Alternative Maritime Power systems into ABB solution
Indoor / outdoor packages			Scalable and flexible systems facilitate easy and safe operation

Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

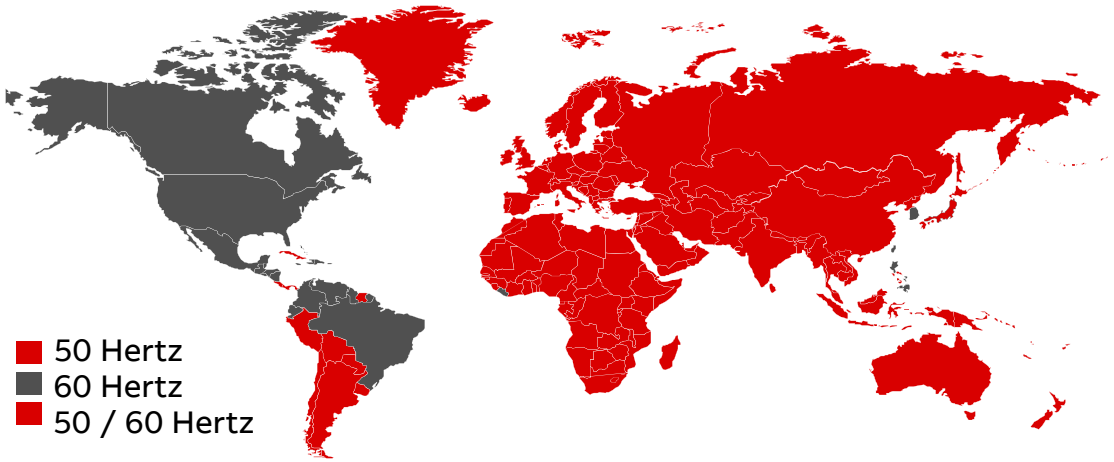
Smart Ports

Project references

Conclusions

Shore-to-ship power: frequency conversion

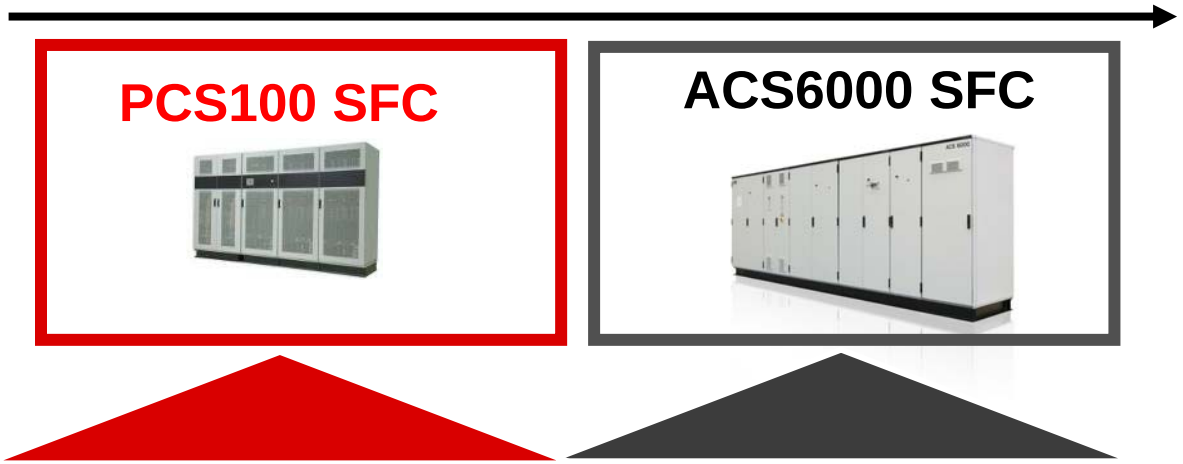
Not all of the world runs on the same frequency



Frequency on board	50 Hz	60 Hz
Container (<140m)	63 %	37 %
Container (>140m)	6 %	94 %
Container tot	26 %	74 %
Ferry / RORO	30 %	70 %
Tanker	20 %	80 %
Cruise (<200m)	36 %	64 %
Cruise (>200m)	-	100 %
Crociera tot	17 %	83 %

Static Frequency Converter for S2SP

A complete portfolio



Higher power ratings can be achieved by paralleling units

Static Frequency Converter for S2SP

Power converter portfolio

Frequency converter	Rated power	Value proposition	Application details
PCS100 SFC 	0.1 MVA up to 4MVA – LV IGBT technology – Forced air cooling – 0.1 – 2 MVA *	Lowest Opex • highest efficiency • highest availability • lowest maintenance costs Lowest Capex • Smallest weight and footprint • Scalable solution Lowest project execution & operation risk • Expert application know how available • Simulation models available ABB global footprint • Global Service organization • Global service support Benefits • Most economic solution (Opex and Capex) to make frequency fit	Market segments • Green port • Cruise • Container • RORO ferry • Shipyards • FRSU/FSU • Naval ports Standard Features: • 50 or 60 Hz grid control • Load side transformer pre-magnetization • Synchronization and blackstart Additional Optional Features: • Marine certification • NRTL certificates
ACS6000 SFC 	5MVA up to 24 MVA – MV IGCT technology – Closed loop liquid cooling – 5-24 MVA *		

* Higher power levels can be obtained by paralleling units

Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

Smart Ports

Project references

Conclusions

A Smart Port requires a Smart Grid

Ports must be …

..competitive

- Become market leaders
- Maximize return on investment

..efficient

- Add more capacity
- Ensure smooth operations

..green

- Minimize energy consumption
- Achieve highest levels of pollution reduction

A Smart Port requires a Smart Grid

European ports' environmental priorities

ESPO environmental review ranking

- Air quality
- Energy consumption
- Noise

IMO MEPC 70

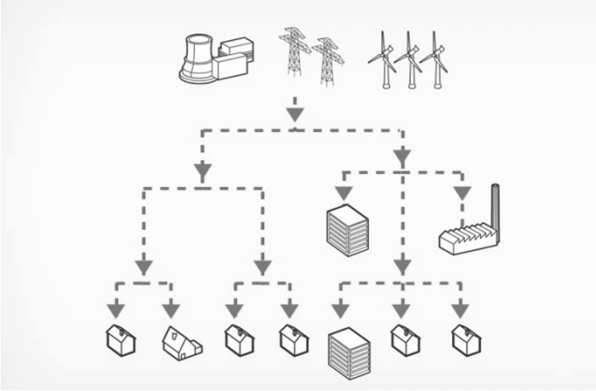
- Global data collection system
- Shipping sector's strategy on reduction of GHG emissions from ships.
- January 2020: entry-into-force of the 0,5% global sulphur cap

Smart Ports

From traditional to smart grid

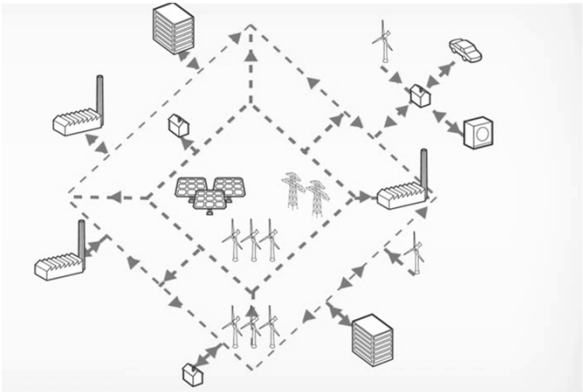
Traditional grid

- Centralized power generation
- One-directional power flow
- Generation follows load
- Top-down operations planning
- Operation based on historical experience



Smart grid

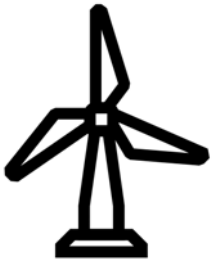
- Centralized and distributed generation
- Multi-directional power flow
- Intermittent renewable generation
- Consumption integrated in system operation
- Operation based on real-time data



Smart Ports

New consumers are entering ports

E-mobility market (E-vehicles and E-buses) is growing extremely fast



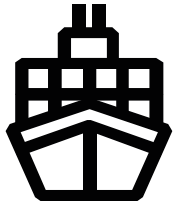
Renewables integration launch ports toward a green era

Demand

A state-of-the-art Port Electrification infrastructure can simultaneously supply shore power to vessels and to e-mobility recharging solution

Supply

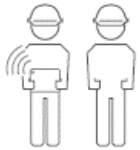
Shore-to-ship power, hybrid and full electrical ferries are now reality



Producing electricity on-shore is more efficient than on-board generation

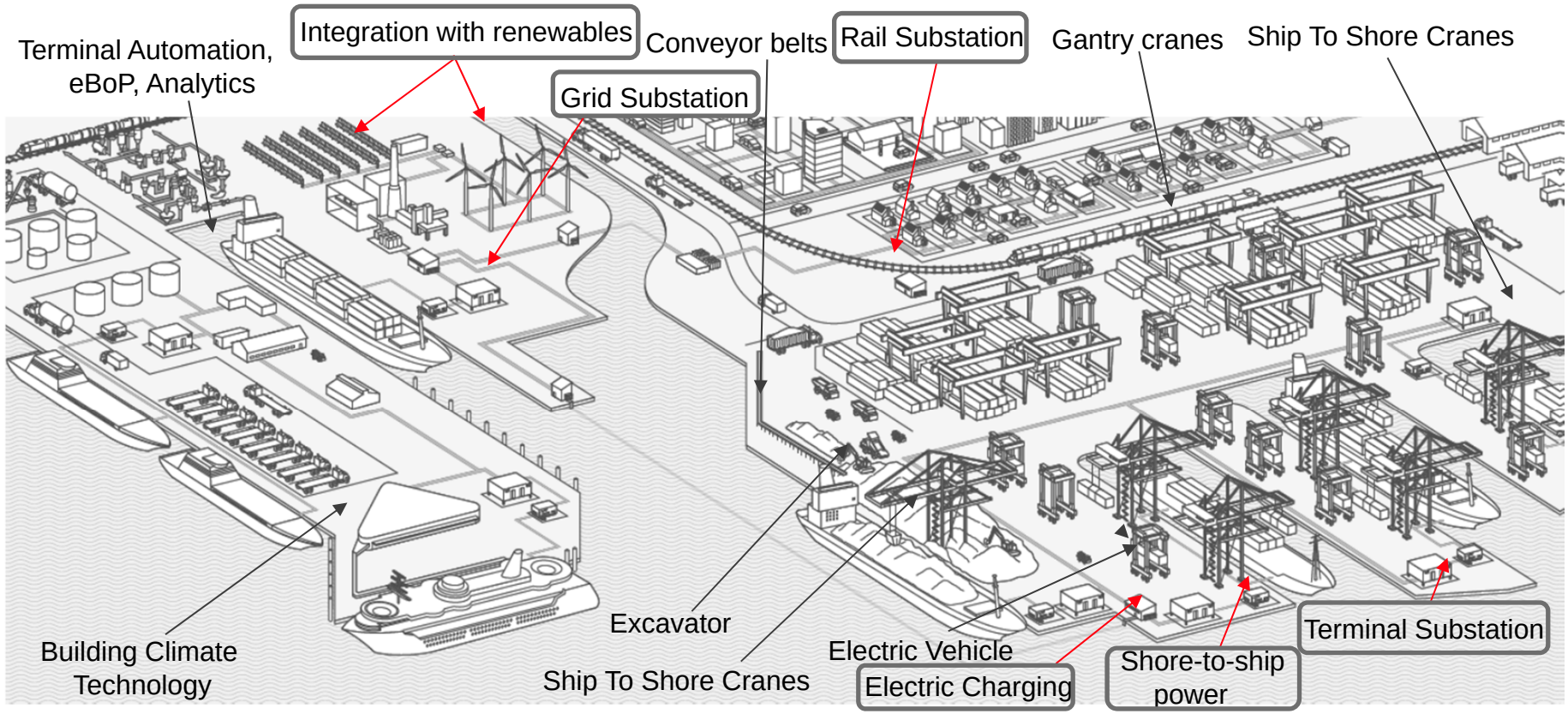
Smart Ports

Smart Ports need lean Grid Integration

Power & automation for..		Overview	Benefits
Shore-to-Ship Power		– Infrastructure to power ships with electricity from the shore when staying at berth	– Eliminate 98% of emissions and all noise and vibration – Improve quality of life near port
Port electrification		– HV Substation – MV/LV Electrification – Power Transformers	– ABB as a single interface for whole port electrification – High reliability HV products
Port Grid integration		– Port distribution grid automation – Renewables integration – Communication Networks	– Improved reliability of supply – Self-sufficient port Microgrid – Secure/powerful communication
E-Mobility solutions		– Battery-hybrid ferries charging infrastructure – EV-chargers	– Zero emission port calls – Integrated transportation (from railway to e-vehicles)
Service / retrofit		– Consulting for optimal solution – Retrofit of existing installation – Maintenance contracts / spares	– Major improvement in reliability, safety and performance – Extended system lifecycle

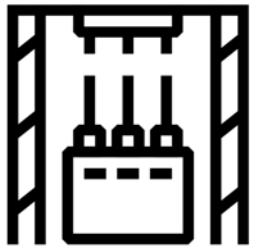
Smart Ports

High efficiency and sustainable port



Smart Ports

The electrical network



- Network Layout
- Grid Code Compliance
- Electrical Interfaces
- Safety
- System planning and advice
- Dynamic studies
- Reliability analysis
- Space Limitations
- Civil Interactions
- After sales Service

Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

Smart Ports

Project references

Conclusions

Shore-to-ship power – Rotterdam, The Netherlands

One of the world's largest S2SP installations

Customer needs

Complete electrical infrastructure to simultaneously power several vessels while berthed in the port of Hoek van Holland

- Customer

Stena Line B.V., a subsidiary of Stena AB, one of the world's largest ferry companies

- Year of commissioning

2012

The entire installation, both onshore and onboard the ships, was accomplished within a year and was activated at the Stena Line ferry terminal at the port of Rotterdam in June 2012

ABB response

- Turnkey shore-to-ship power installation including design, engineering, project management, installation and commissioning
- Complete substation and automation package based on PCS 6000 static frequency converters rated at 6 MVA

Customer benefits

- Mitigation of negative impact of ferry operations on the local community and the environment
- Reduction of fleet's fuel consumption
- Greenhouse gas emissions reduced by 98%
- Less noise and vibrations

Shore-to-ship power – Gothenburg, Sweden

First 50/60 Hz shore connection in Sweden

Customer needs

Shoreside power supply to a vast number of Stena Line vessels while at berth

- Customer

Processkontroll Elektriska AB Stenungsund

- Year of commissioning

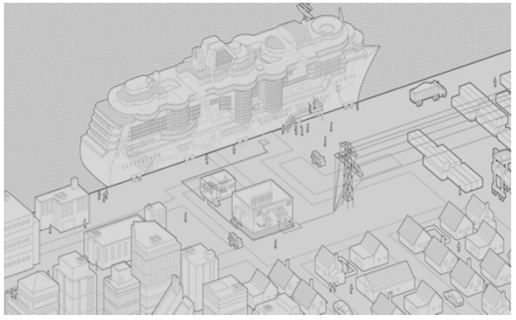
2012

ABB response

- Turnkey 11kV Grid Integration, including Safe+ GIS switchgear 6 bays 50Hz, 4 bays 60Hz, and 2 transformers type Resibloc
- Two static frequency converters 1250kVA
- PLC system type AC500

Customer benefits

- Dependable project execution from design to start-up, and state-of-the-art equipment
- Reliable shoreside power supply to ferries
- Reduced emissions, low-frequency noise and vibrations
- Better environment for passengers, crew, dockworkers and local residents



Shore-to-ship power – Delimara, Malta

A smart solution for a LNG-to-power plant

Customer needs

- Shore power supply for LNG-to-Power plant to supply a Floating Storage Unit Vessel
- Modular and expandable solution

- Customer

J&P - Avax

- Year of commissioning

2016

ABB response

- Modular containerized solution:
  - No.2 Transformer Containers
  - No.1 Frequency Conversion Container with two independent static frequency converters, each rated 1500 kVA
  - No.1 MV Switchgear, protection and control system container

Customer benefits

- Lower OPEX costs than on-board generation
- Full redundant system to enhance reliability and minimize maintenance down-time

Shore-to-ship power – Dalian, China

Twin power supply for container terminal

Customer needs

- Shore power supply for Dalian Container Terminal
- Outdoor solution with minimized civil works
- From Engineering to Commissioning in 6 months

- Customer

Dalian container terminal

- Year of commissioning

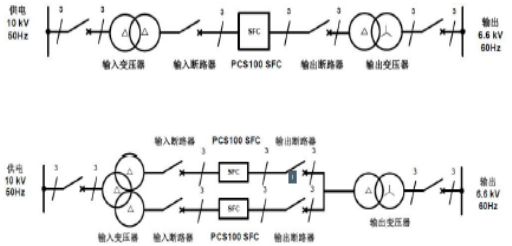
2016

ABB response

- One set 2 MVA, one set 3 MVA Static frequency converters type PCS100
- Turn-key package including: SFC, Transformer, Switchgear, PLC, Socket box, Engineering and commissioning

Customer benefits

- Highly modular solution specially designed according to specific customer needs
- Maximized use of the S2SP system for two vessels simultaneous connection



Shore-to-ship power – Ystad, Sweden

Another Swedish port goes green

Customer needs

Minimize the negative environmental impact of the vessels remaining at berth

- Customer

Processkontroll Elektriska AB Stenungsund

- End User:

Ystad Port Authority

- Year of commissioning

2012

ABB response

- Turnkey 12kV substations including:
  - MV Switchgear
  - Input / Output Transformers
  - 6,25 MVA Frequency Converter
  - Control and protection System

Customer benefits

- Double frequency vessels supply full flexibility (50 Hz and 60 Hz) and reliability
- Pre-engineered solution with short delivery and commissioning time
- Support for port electrical grid seamless integration of shore-to-ship power
- Reduced emissions, low-frequency noise and vibrations

Shore-to-ship power – Fincantieri, Italy

Standard containerized solution for shipyards

Customer needs

- Shore power supply for Castellamare shipyard for newly built vessels
- Outdoor solution with minimized civil works
- Short delivery time of 15 weeks

- Customer

Fincantieri

- Year of commissioning

2014

ABB response

- Standard containerized solution, air-cooled, including frequency converter, isolation transformer, LV switchgear
- One static frequency converter PCS100, 1000kVA, rack-mounted

Customer benefits

- Scalable solution suitable for all shipyards
- Lower OPEX costs than 60 Hz diesel genset
- Improved efficiency at partial loads
- High reliability owing to converter redundancy

Smart Ports solution – Moin, Costa Rica

Container terminal electrification

Customer needs

- Electric power solution for the largest infrastructure project in Costa Rica's history
- Capability to handle container ships with around eight times higher capacity compared to the country's other terminals

- Customer

Van Oord BAM

- Year of commissioning

2017

ABB response

- Main HV / MV substation
- Distribution substation and reefer substation including transformers, switchgear, grounding and panels in yard
- Reefer rack installation: plugs, panels and lighting
- Electrical conductors

Customer benefits

- Optimized solution
- Single interface for all electrification supplies

Agenda

Business Unit Grid Integration (BU PGGI) offering and positioning

Shore-to-ship power landscapes and uses

Frequency converter technology overview

Smart Ports

Project references

Conclusions

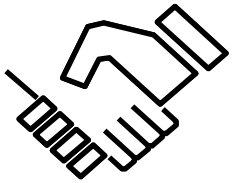
Conclusions

Shore-to-ship Power & Smart Ports with ABB

- One single partner

- Since the beginning

- With global presence



- And total committment!