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

- Better resource utilization
- Sustainability
- Active customer involvement
- Shore-to-ship power
- Renewables integration
- Port Electrification
- Grid automation
- E-mobility
- Demand Response
- Energy storage
- FACTS
- Microgrids
- Digital Substations
- Home automation
- Energy efficiency
- Green ports
- New business models
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
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 $11.8 \text{ kg/MWh} \times 8 \text{ h} \times 12 \text{ MW} = 1.1 \text{ t NOx}$

Cars: $10,000 \text{ cars} \times 0.1 \text{ g/km} \times 1,000 \text{ km} = 1.0 \text{ t NOx}$
An environmental issue

Emission control areas

- Existing ECA area
- Potential future ECA area
An environmental issue

More stringent IMO MARPOL convention

Sulphur oxides – Sox (%) % PM

-07 -08 -09 -10 -11 -12 -13 -14 -15 -16 -17 -18 -19 -20

4,5% 4,0% 3,5% 3,0% 2,5% 2,0% 1,5% 1,0% 0,5% 0,1% 0,1% 0,5%

Global step I/II/III
SECA/ECA/CARE step I/II/III
EU 2005/33/EC (at berth)
Shore-to-ship power

Economical and environmental benefits

<table>
<thead>
<tr>
<th>Shore-to-ship power benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>No polluting emissions at port</td>
</tr>
<tr>
<td>No noise and vibrations from auxiliary engines</td>
</tr>
<tr>
<td>Low operating costs for shipowners</td>
</tr>
</tbody>
</table>

- Reduce health problems/costs
- Clean air = happy citizens
- Increase publicity
- Gain aesthetic credits

- «Green port» & «Green operator»
- Cost savings for shipowners
- Reduction of negative externalities

- Positive impact on tourism/commerce
- Positive economical impacts

Overall port development
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

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>RORO/Ferry</th>
<th>Container</th>
<th>Cruise</th>
<th>LNG / Tanker</th>
<th>FSU / FPSO</th>
<th>Shipyards / Navy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage</td>
<td>11 kV or low voltage</td>
<td>6,6 kV</td>
<td>6,6 &amp; 11 kV</td>
<td>6,6 kV</td>
<td>6,6 kV, 11 kV or low voltage</td>
<td></td>
</tr>
<tr>
<td>Max Power consumption</td>
<td>6,5 MVA</td>
<td>7,5 MVA</td>
<td>16/20 MVA</td>
<td>Approx. 10 MVA</td>
<td>Case by Case</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>60 &amp; 50 Hz</td>
<td>60 mainly</td>
<td>60 mainly</td>
<td>60 Hz</td>
<td>50 &amp; 60 Hz</td>
<td></td>
</tr>
<tr>
<td>Plugs/cables (per connection)</td>
<td>1</td>
<td>2</td>
<td>4+1</td>
<td>2/3</td>
<td>Case by case</td>
<td></td>
</tr>
<tr>
<td>Transformer</td>
<td>onboard</td>
<td>onshore</td>
<td>onshore</td>
<td>onshore</td>
<td>Case by case</td>
<td></td>
</tr>
<tr>
<td>Layout</td>
<td>Not critical</td>
<td>critical</td>
<td>critical</td>
<td>critical</td>
<td>Not critical</td>
<td></td>
</tr>
<tr>
<td>Load profile</td>
<td>Partially controlled</td>
<td>Partially controlled</td>
<td>Flat profile</td>
<td>Not controlled</td>
<td>Case by case</td>
<td></td>
</tr>
<tr>
<td>Protect selectivity</td>
<td>critical</td>
<td>Not critical (if P=7,5 MVA)</td>
<td>critical</td>
<td>Case by case</td>
<td>Case by case</td>
<td></td>
</tr>
<tr>
<td>Cable management system</td>
<td>mid cost</td>
<td>low cost</td>
<td>high cost</td>
<td>Mid cost</td>
<td>Case by case</td>
<td></td>
</tr>
</tbody>
</table>
Shore-to-ship power

System components

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

<table>
<thead>
<tr>
<th>Frequency on board</th>
<th>50 Hz</th>
<th>60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container (&lt;140m)</td>
<td>63 %</td>
<td>37 %</td>
</tr>
<tr>
<td>Container (&gt;140m)</td>
<td>6 %</td>
<td>94 %</td>
</tr>
<tr>
<td>Container tot</td>
<td>26 %</td>
<td>74 %</td>
</tr>
<tr>
<td>Ferry / RORO</td>
<td>30 %</td>
<td>70 %</td>
</tr>
<tr>
<td>Tanker</td>
<td>20 %</td>
<td>80 %</td>
</tr>
<tr>
<td>Cruise (&lt;200m)</td>
<td>36 %</td>
<td>64 %</td>
</tr>
<tr>
<td>Cruise (&gt;200m)</td>
<td>-</td>
<td>100 %</td>
</tr>
<tr>
<td>Crociera tot</td>
<td>17 %</td>
<td>83 %</td>
</tr>
</tbody>
</table>
Static Frequency Converter for S2SP

A complete portfolio

PCS100 SFC

ACS6000 SFC

0.1 – 2 MVA / unit

5 – 24 MVA / unit

Higher power ratings can be achieved by paralleling units
### Static Frequency Converter for S2SP

**Power converter portfolio**

<table>
<thead>
<tr>
<th>Frequency converter</th>
<th>Rated power</th>
<th>Value proposition</th>
<th>Application details</th>
</tr>
</thead>
</table>
| PCS100 SFC          | 0.1 MVA up to 4MVA | Lowest Opex  
- highest efficiency  
- highest availability  
- lowest maintenance costs  
- Lowest Capex  
- Smallest weight and footprint  
- Scalable solution  |
|                     | – LV IGBT technology  
– Forced air cooling  
– 0.1 – 2 MVA * |
| ACS6000 SFC         | 5MVA up to 24 MVA | Lowest project execution & operation risk  
- Expert application know how available  
- Simulation models available  
- ABB global footprint  
- Global Service organization  
- Global service support  |
|                     | – 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

IMO sets 2020 date for 0.5 % global sulphur cap. More details to follow. #MEPC70
**Smart Ports**

From traditional to smart grid

<table>
<thead>
<tr>
<th>Traditional grid</th>
<th>Smart grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Centralized power generation</td>
<td>- Centralized and distributed generation</td>
</tr>
<tr>
<td>- One-directional power flow</td>
<td>- Multi-directional power flow</td>
</tr>
<tr>
<td>- Generation follows load</td>
<td>- Intermittent renewable generation</td>
</tr>
<tr>
<td>- Top-down operations planning</td>
<td>- Consumption integrated in system operation</td>
</tr>
<tr>
<td>- Operation based on historical experience</td>
<td>- Operation based on real-time data</td>
</tr>
</tbody>
</table>
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
- A state-of-the-art Port Electrification infrastructure can simultaneously supply shore power to vessels and to e-mobility recharging solution
- Shore-to-ship power, hybrid and full electrical ferries are now reality
- Producing electricity on-shore is more efficient than on-board generation

Demand

Supply
### Smart Ports

Smart Ports need lean Grid Integration

#### Power & automation for...

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

<table>
<thead>
<tr>
<th>Customer needs</th>
<th>ABB response</th>
<th>Customer benefits</th>
</tr>
</thead>
</table>
| Complete electrical infrastructure to simultaneously power several vessels while berthed in the port of Hoek van Holland | ▪ 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 | ▪ 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 |

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.
## 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

### 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

---

Customer
Processkontroll Elektriska AB Stenungsund
Year of commissioning
2012
## 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

<table>
<thead>
<tr>
<th>Customer needs</th>
<th>ABB response</th>
<th>Customer benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore power supply for Dalian Container Terminal</td>
<td>One set 2 MVA, one set 3 MVA Static frequency converters type PCS100</td>
<td>Highly modular solution specially designed according to specific customer needs</td>
</tr>
<tr>
<td>Outdoor solution with minimized civil works</td>
<td>Turn-key package including: SFC, Transformer, Switchgear, PLC, Socket box, Engineering and commissioning</td>
<td>Maximized use of the S2SP system for two vessels simultaneous connection</td>
</tr>
<tr>
<td>From Engineering to Commissioning in 6 months</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Customer
Dalian container terminal
- Year of commissioning
2016
Shore-to-ship power – Ystad, Sweden

Another Swedish port goes green

<table>
<thead>
<tr>
<th>Customer needs</th>
<th>ABB response</th>
<th>Customer benefits</th>
</tr>
</thead>
</table>
| Minimize the negative environmental impact of the vessels remaining at berth | Turnkey 12kV substations including:  
  - MV Switchgear  
  - Input / Output Transformers  
  - 6,25 MVA Frequency Converter  
  - Control and protection System | Double frequency vessels supply full flexibility (50 Hz and 60 Hz) and reliability |
| Customer  
Processkontroll Elektriska AB Stenungsund  
End User:  
Ystad Port Authority  
Year of commissioning:  
2012 | 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

<table>
<thead>
<tr>
<th><strong>Customer needs</strong></th>
<th><strong>ABB response</strong></th>
<th><strong>Customer benefits</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore power supply for Castellamare shipyard for newly built vessels</td>
<td>Standard containerized solution, air-cooled, including frequency converter, isolation transformer, LV switchgear</td>
<td>Scalable solution suitable for all shipyards</td>
</tr>
<tr>
<td>Outdoor solution with minimized civil works</td>
<td>One static frequency converter PCS100, 1000kVA, rack-mounted</td>
<td>Lower OPEX costs than 60 Hz diesel genset</td>
</tr>
<tr>
<td>Short delivery time of 15 weeks</td>
<td></td>
<td>Improved efficiency at partial loads</td>
</tr>
</tbody>
</table>

- Customer
  - Fincantieri
  - Year of commissioning
  - 2014

- **Customer benefits**
  - High reliability owing to converter redundancy
## Smart Ports solution – Moin, Costa Rica

### Container terminal electrification

<table>
<thead>
<tr>
<th><strong>Customer needs</strong></th>
<th><strong>ABB response</strong></th>
<th><strong>Customer benefits</strong></th>
</tr>
</thead>
</table>
| - Electric power solution for the largest infrastructure project in Costa Rica’s history | - 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 | - Optimized solution  
- Single interface for all electrification supplies |
| - 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
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 commitment!