Accelerating sustainable growth for Railways

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FACTS Solutions

Enhancing Railway Grid Efficiency and Enabling Renewable Integration

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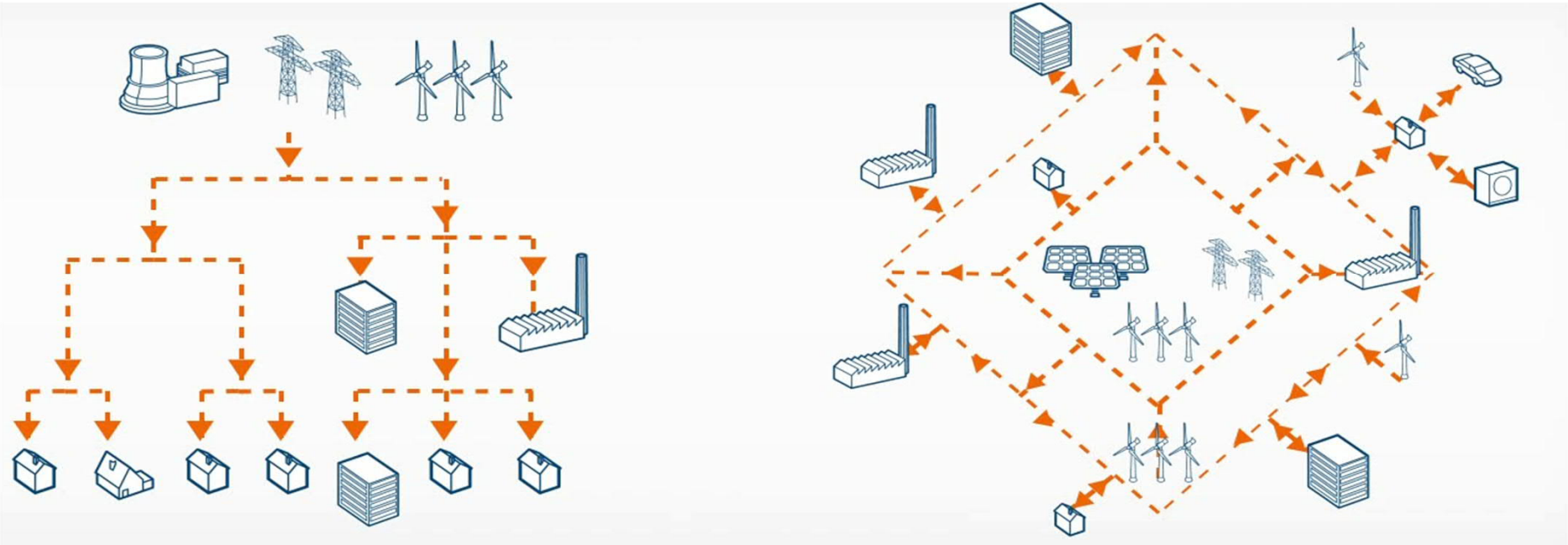
The grid is changing

Shift in the electrical value chain



The rising share of renewable energies is influencing the robustness of our grids.
Complex, sensitive and Weaker Systems -Lower fault levels

RE Integration

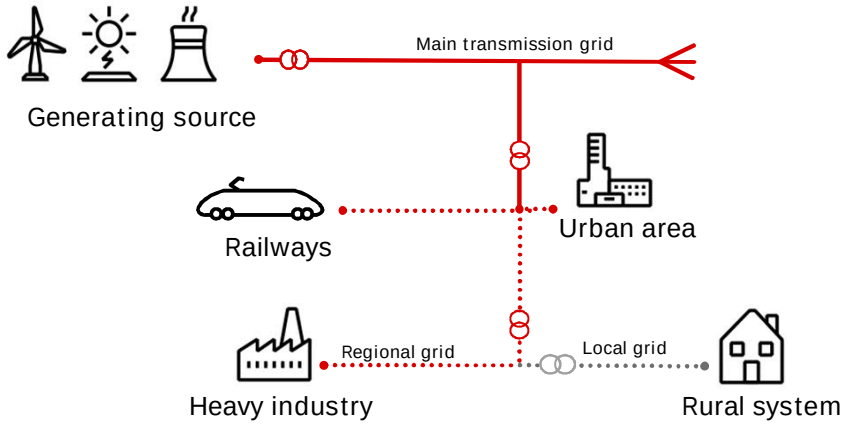
Renewable Integration with Railway Grid

Major Challenges

- RE is intermittent, seasonal
- Load dynamics, peaks
- Railway sub station connection with 2 phases(normally), Solar integration possible with 3 phases
- Phase current un-balance (Power is fed through 2 phases alternatively)
- Network voltage and Short circuit levels
- Un balance and negative sequence currents, harmonics
- protection coordination for various operating points
- Local grid code compliance, for MV/HV grid connection
- Complex study requirements

Technology Solutions

- 3 phase Load Balancer – balances 2 phase currents and grid code compliance
- Intelligent sub stations – Fed through SFC and operating in parallel with existing sub stations
- Battery storage and load balancing, Microgrids
- Digital sub stations



Power electronics based technologies to enable Greener railway Grid

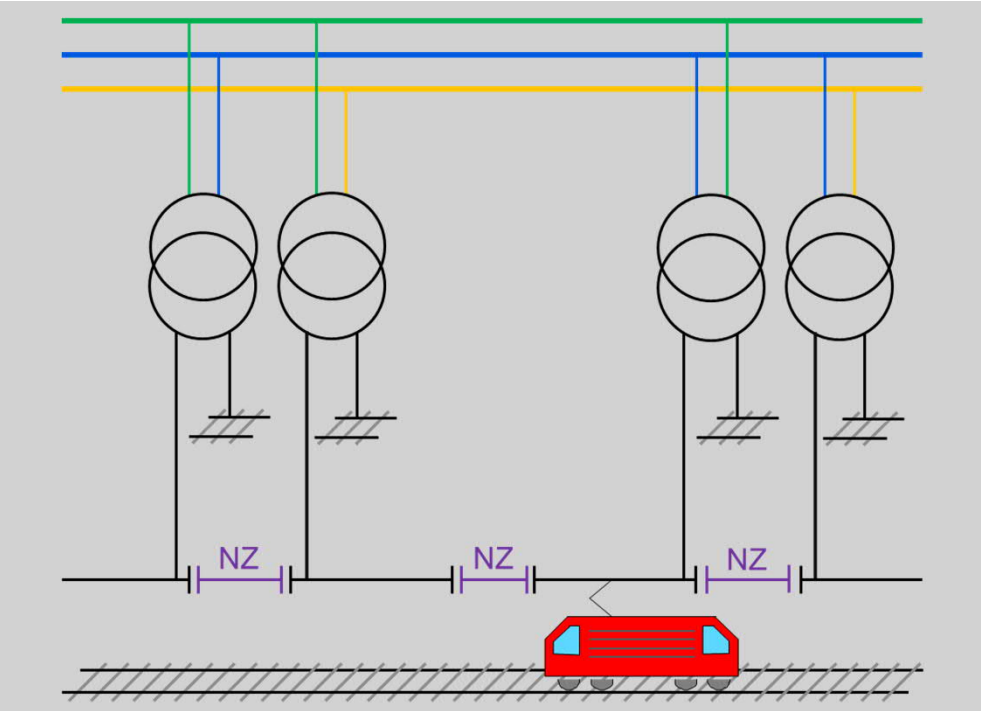
50Hz Railway Power Supply

Conventional Power Supply

Transformer Power Supply

Simple solution with drawbacks

- **Unbalance effect on feeding grid** (only two phases connected)
- **Uncontrolled power factor**
- **High harmonics injection into feeding grid from traction vehicles**
- **High voltage fluctuations in feeding grids caused by fluctuations of railway loads**
- Non optimal catenary voltage
- High catenary short circuit current
- Uncontrolled catenary power flow, i.e. regenerative energy cannot be captured in the system
- Higher peak demand, lower overall traction system efficiency
- Neutral sections due to connection to different electrical phases

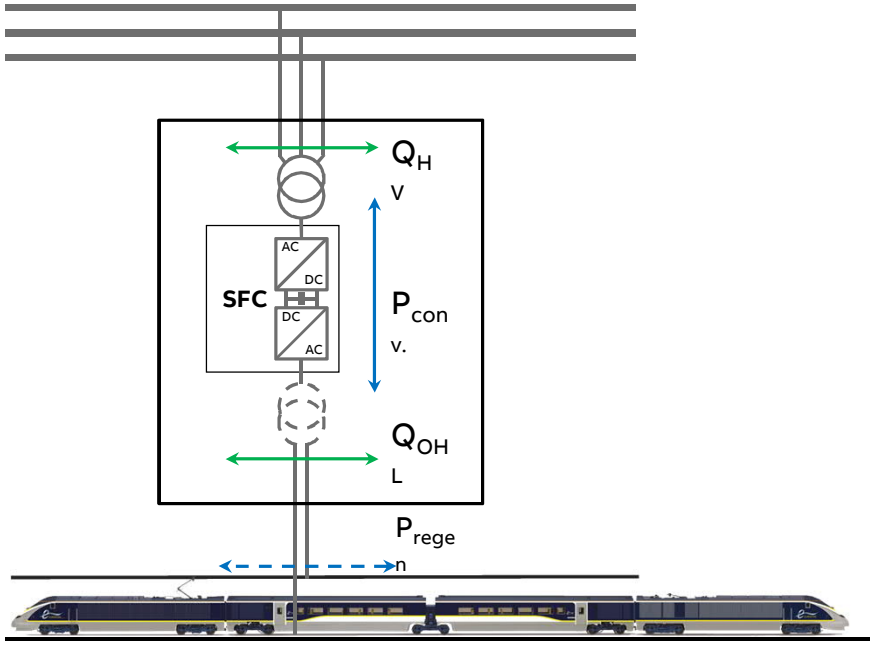


50Hz Railway Power Supply

Static Frequency Converter Power Supply

Technical benefits of SFC based supply

- 3 phase supply from HV or MV grid
- Independent active and reactive power control
  - Optimized use of regenerative energy
  - Dynamic catenary voltage control
  - Reactive power control
- Coupled through catenary system
  - Reduced number of separation sections
  - Lower rated peak for substations
  - Partial redundant supply
- Low harmonics content
- Limited catenary short circuit current
- Reference: 50 Hz railway supply in Wulkuraka Australia

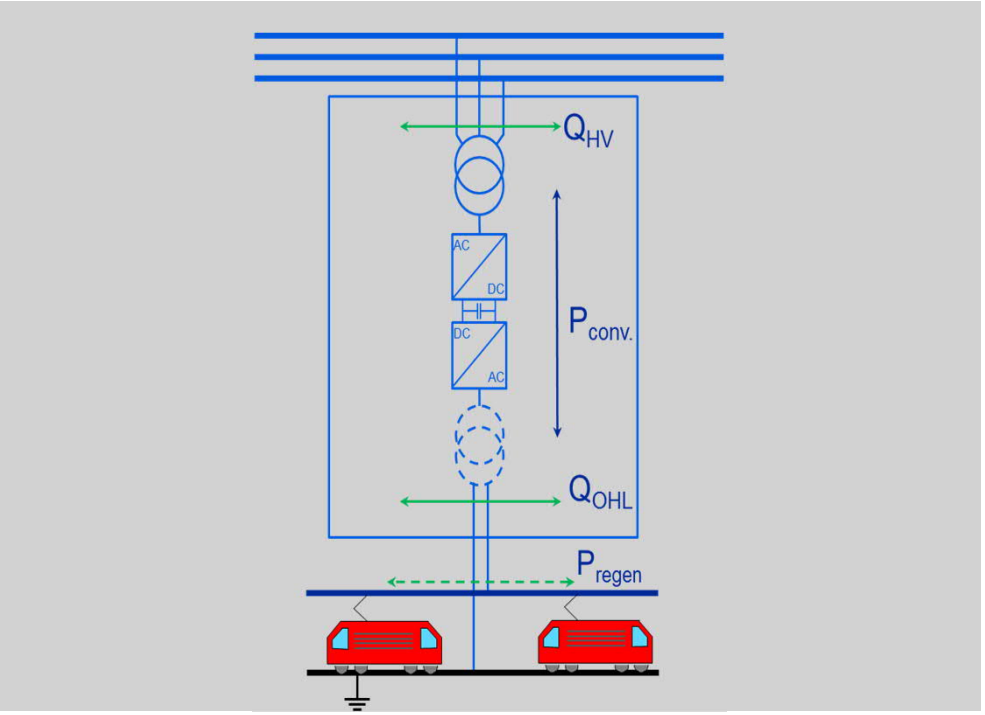


50Hz Railway Power Supply

Static Frequency Converter Power Supply

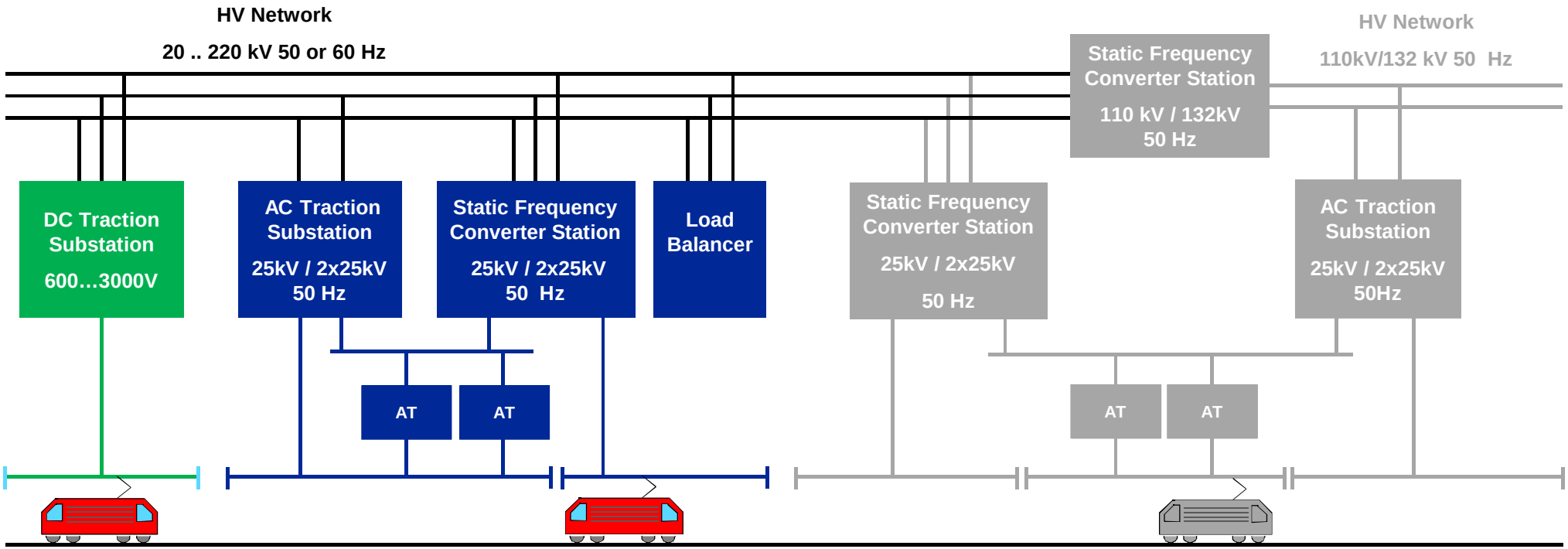
Economic benefits of SFC based supply

- Possible connection to medium-voltage grids with limited short circuit power thereby reducing connection costs
- Minimized costs for peak consumption and reactive power
- Reduced substation cost on grid side
- Reduced substation footprint
- Reduced effort for erection and permit of new supply lines
- Reduced number of substations
- Minimized number of neutral/ phase switching sections
- Improvement of maintenance costs
- Optimized use of regenerative energy
- Reduced short circuit levels on the catenary



Railway Power Supply

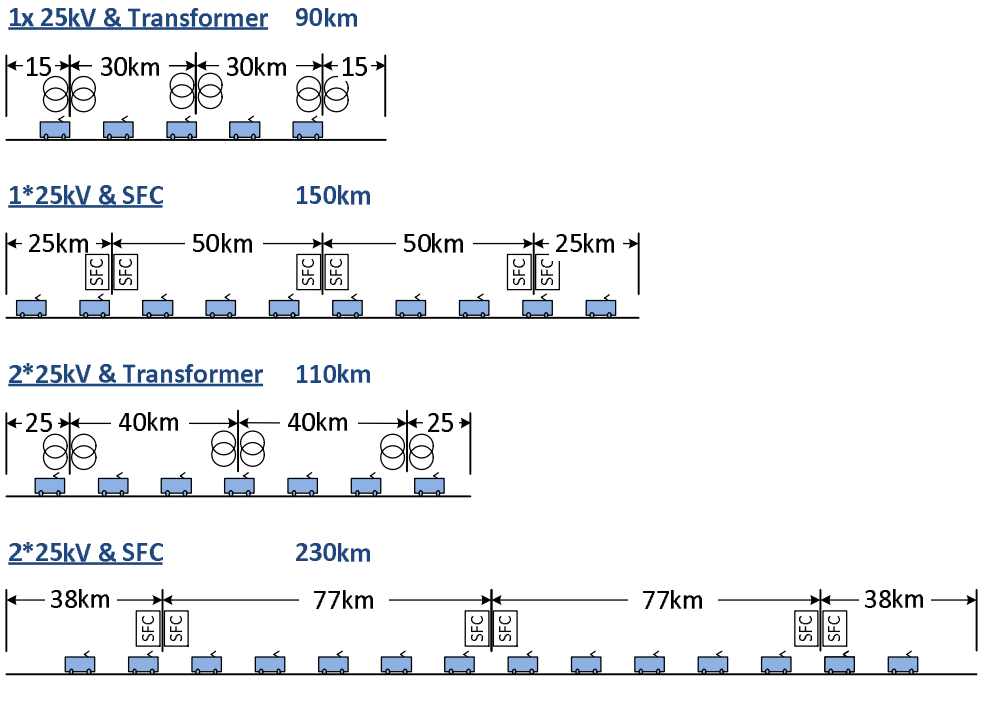
Overview of Electric Traction Feeding Concepts



Railway power system simulation 25 kV/50 Hz

Simulations results

- Increased distance between feeding points with SFC
  - Voltage control capability
  - Catenary supply at higher voltage
  - Independent from supply grid voltage
  - No unbalance effect



Wulkuraka rail grid intertie

Australia

Customer needs

- Increased energy demand for the Brisbane Rosewood Line and for a new rolling stock maintenance depot nearby
- Conversion of country's 3-phase 50 Hz grid to 1-phase 50 Hz railway grid without unbalance effects to the supplying grid

ABB response

- Turnkey solution incorporating a 20 MVA static frequency converter
- Transformers, switchgear, control and cooling systems
- Design, engineering, installation, commissioning and civil works

Customer benefits

- Stronger railway corridor performance
- Higher power supply without fault current rating increase

Customer: Queensland Rail, Australia
Start of commercial operation: 2015

Limburg traction power supply

Germany

Customer needs

Secure energy supply of the 280 km/h DB ICE high-speed line from Frankfurt to Cologne in Germany

ABB response

- Converter station of 8x 15 MW
- Frequency converters, transformers, switchgear and control system
- Design, engineering, installation, commissioning and civil works

Customer benefits

- Reliable rail power supply
- Remote control of the converter station from the power control center in Frankfurt
- De-icing function of rail catenary

Customer: Deutsche Bahn (DB) Energie, Germany
Start of commercial operation: 6 units in 2002 / 2 units in 2005

PCS 6000 SFC Rail

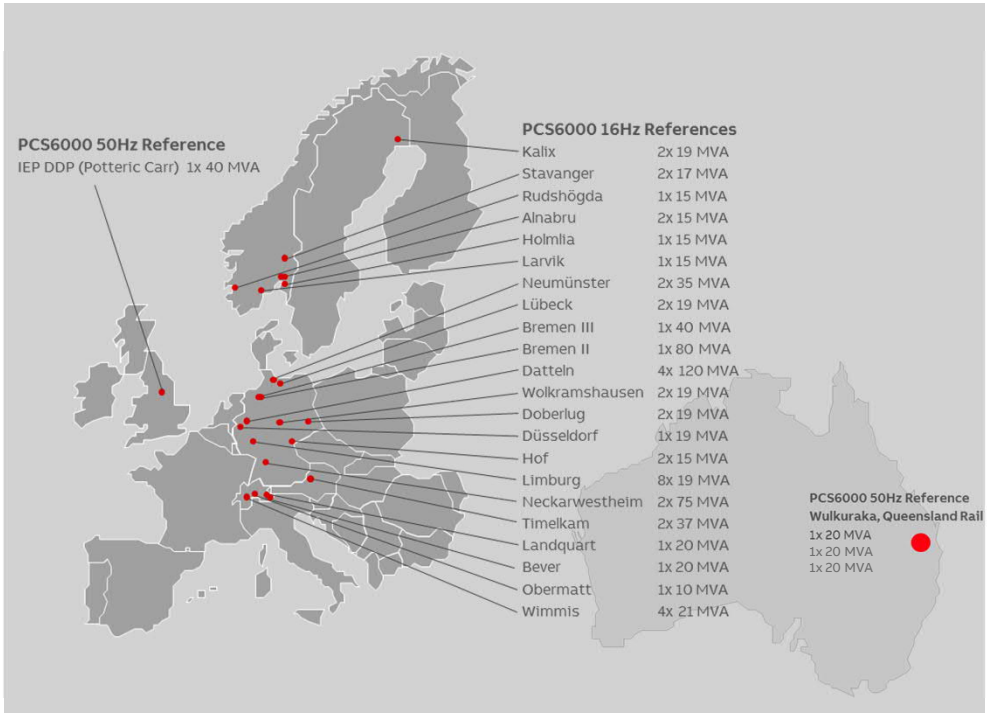
ABB References

PCS 6000 Rail SFC References

- Largest installed base
  - more than 45 SFC units in operation,
  - more than 1.5 GW SFC installed power
- More than 20 years of experience in applications for rail power supply
- Proven control and protection algorithms for 17 Hz and 50 Hz
- Satisfies high reliability and availability demands

Preferred supplier for 50Hz railway supply:

- Wulkuraka, Queensland Rail (Australia)
  1x 20MVA, in operation since 2016
- IEP DDP (Potteric Carr), Network Rail (UK)
  1x 42 MVA, awarded May 2017
- Northgate and Moolabin, Queensland Rail (Australia)
  2x 20 MVA, awarded September 2017



Power quality in RAIL for maximizing the energy efficiency, Renewable integration

Summarizing ….

- Electrical grid is changing, more dynamic, distributed renewable power integration and grid code compliance is necessity
- Railway electrical load is primarily a single phase load on the grid presenting unbalance and power quality issues to solve
- Power quality issues especially Power factor, Unbalance and Harmonics are best solved at the TSS level for efficient Railgrid.
- At the larger rail network level, STATCOM based load balancer can provide effective & efficient compensation, improve the Rail grid voltage profile
- SFC driven sub station can provide network compensation for unbalance, reactive power, harmonics and also improve overall track efficiency and utilization