RAIL ELECTRIFICATION

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GE VERNOVA OVERVIEW

GE Separating into Three Public Companies

GE VERNOVA

GE HealthCare

Driving innovation in precision health with 4M+ installations, 2B+ patient exams per year.

GE VERNOVA

Accelerating the path to reliable, affordable, and sustainable energy, while helping provide 1/3 of the world's electricity.

GE Aerospace

Shaping the future of flight while powering 2/3 of commercial departures every day.

INDUSTRY EXPERTISES

to help drive
your energy infrastructure

POWER QUALITY

Electrical solutions to extend renewable energy penetration in existing networks.

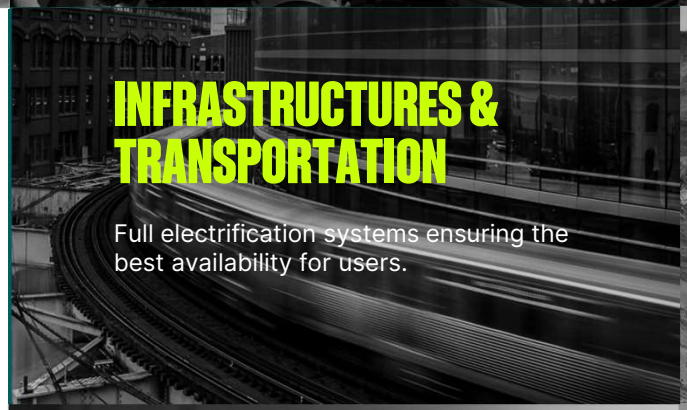
STEEL & METALS

Full-scope system solutions optimizing production times, improving productivity and product quality, and reducing operational costs and down time

GE VERNOVA

HYDRO POWER

Modular variable speed solutions optimizing efficiency, grid performance, and return on investment



INFRASTRUCTURES & TRANSPORTATION

Full electrification systems ensuring the best availability for users.

MINING & HYDROMETALLURGY

Advanced electrification and automation solutions maximizing operational efficiency and productivity and improving reliability and power density

RESEARCH & TEST

Adaptable, robust, and dynamic test systems for efficient and reliable equipment operations across the industries

H2 & MICROGRIDS

Independent and individual power supply management to help make a positive contribution to energy sustainability and ensure reliable power supply

Global manufacturing capabilities centered on Europe

3 Power Electronics manufacturing location
3 Rotating Machines manufacturing locations
10 Engineering centers

Rugby, UK
Specialty machines
Naval propulsion
Service activities

Berlin, Germany
Power Electronics
MV, LV & Special Drives
Integration, Testing & Prototyping
Service activities

Pittsburgh, USA
Power Electronics
Integration, Testing & Prototyping
Service activities

Campinas, Brazil
MV induction & synchronous motors
Specialty machines, including mining motors

Massy
Power Electronics
MV Drives
Project Drives

Nancy
MV induction & synchronous motors
Specialty machines, including very high-speed

France

RAIL

GE VERNOVA

Global demand for transport is growing fast. Both passenger and freight activity are expected to double in the next 20-30 years.

This global trend carries greater energy demand and increased CO2 emissions. As electric railways offer substantially better energy efficiency, lower emissions, and lower operating costs, rail electrification can be the only answer.

The challenge is heightened by the rapid pace of rising demand for mobility, especially in developing economies, where cities are growing exponentially, creating a need for more efficient, faster, and cleaner transportation.

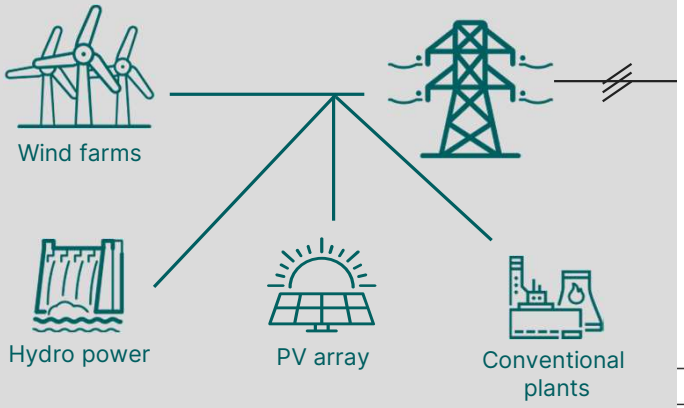
Rail has characteristics that enable it to reduce energy demand in transport and draw on diverse energy sources. It can mitigate CO2 emissions from transport and contribute to a broader transition towards sustainability.

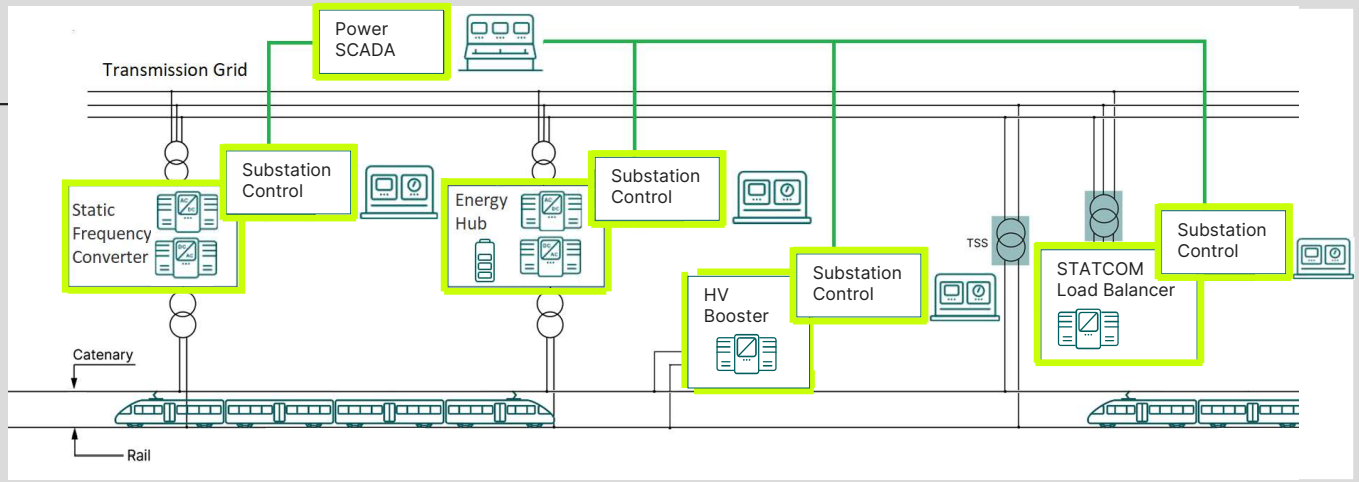
RAIL DECARBONIZATION ELECTRIFICATION SOLUTIONS FOR AC

Rail decarbonization

Electrification solutions for AC

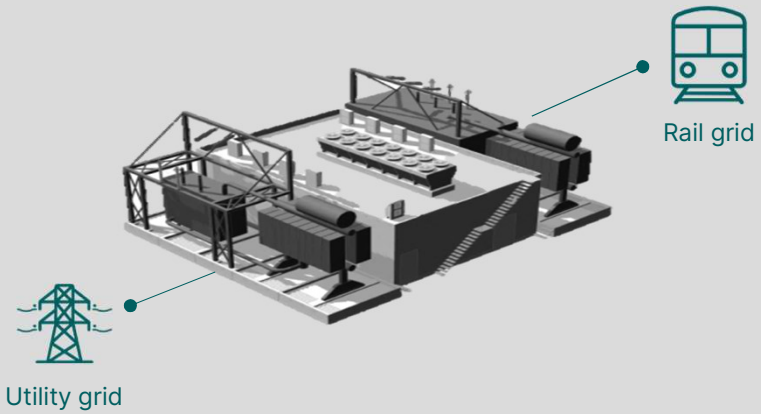
- Renewable energy growth brings new challenges to rail electrification
- Electrifying remote rail lines brings challenges for grid connections
- Power Conversion brings solutions to boost rail electrification





Our technical approach

We are technical suppliers of solutions for rail power supply management from traction power supply to grid and catenary power quality.



GE VERNOVA

+20

Years experience in rail

+6000

MVA installed in rail substations

In this second
~300 TRAINS GETTING ELECTRIFIED
with Power Conversion's power electronics

+100k

Passengers each day with Power Conversion's power electronics

To connect grids of different power parameters

→ Solutions for AC rail systems 16.7Hz ... 25Hz ... 50Hz ... 60Hz

→ DC rail system solutions

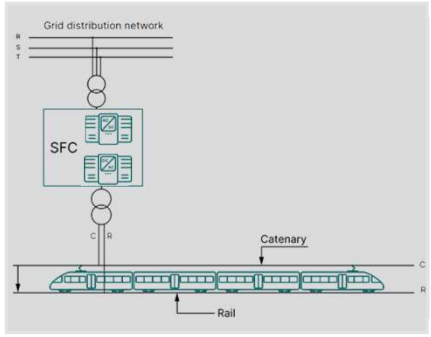
Electrification solutions for AC

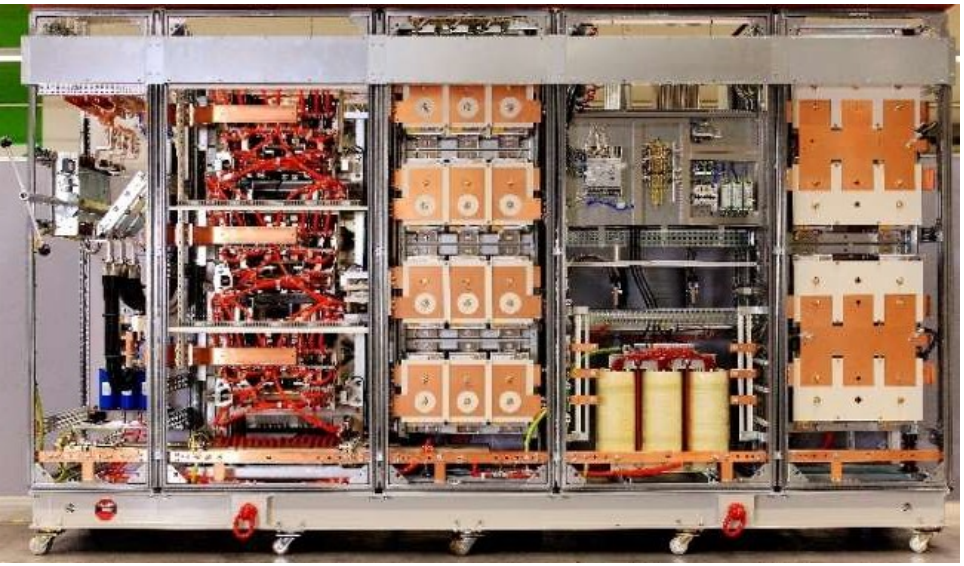
Static Frequency Conversion (SFC) solutions

Expertise – proven solutions

Supporting national rail operators, contracting EPC and engineering companies to design and build AC substation solutions. Efficient, reliable and safe rail traction power:

- Avoid unbalanced grid loads and resulting penalties to grid operators
- Provide reactive power control on grid and traction networks
- Increase of efficiency e.g. by reduced power consumption in railway system
- Reduce complexity for grid operator by eliminating the neutral section in overhead catenary lines
- Flexibility to connect rail grid to power grids of different providers
- Facilitate management of brake energy recovery e.g.: by sending back braking energy from catenary to the grid





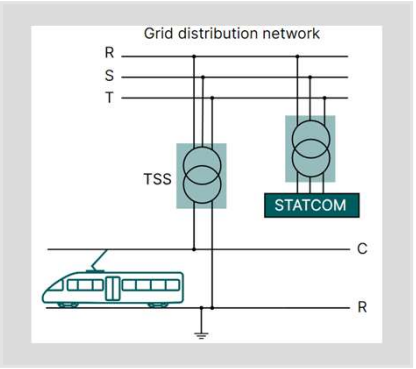
Electrification solutions for AC

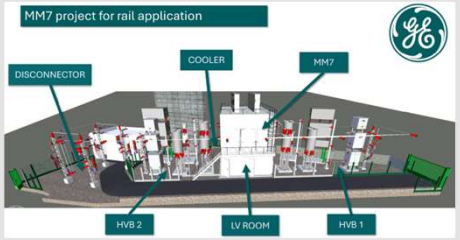
Load balancers and STATCOMS for AC rails

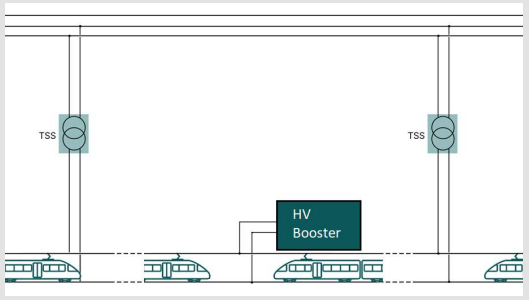
Energy mix in distribution networks sees increased penetration of renewable generation such as hydro, wind and solar. To maintain a good power quality of distribution networks, DSO are strengthening the constraints on consumers. Load balancers and STATCOM helps to upgrade power quality on common point of coupling with limited impact on Traction Power Supply already existing

Expertise – proven solutions

- Balance phase voltage / current on grid, to fulfill DSO/TSO requirement (Load Balancer)
- Compensate power factor on grid side (STATCOM)
- Low Harmonics thanks to multilevel converters
- Quick response time to follow peak supply from rolling stock







Electrification solutions for AC

MM7 – HV (high voltage) booster

Railway transportation saw increase of traffic on the last years. Existing catenary power supplies have limitations to maintain voltage level compatible with rolling-stock, limiting traffic increase capacity. High voltage boosters permit to increase and regulate catenary voltage. They can be integrated in existing traction power supplies, and do not require extra grid connection.

Expertise – proven solutions

- Supporting national rail operators, contracting EPC and engineering companies to design and build catenary boosters
- Efficient, reliable and safe rail traction booster
- Regulates AC voltage on catenary to increase power transfer
- Permits to increase distances between grid connections
- Stabilize catenary supply feeding modern rolling stock

Electrification solutions for AC

Decarbonization of railway supply – Energy hubs AC

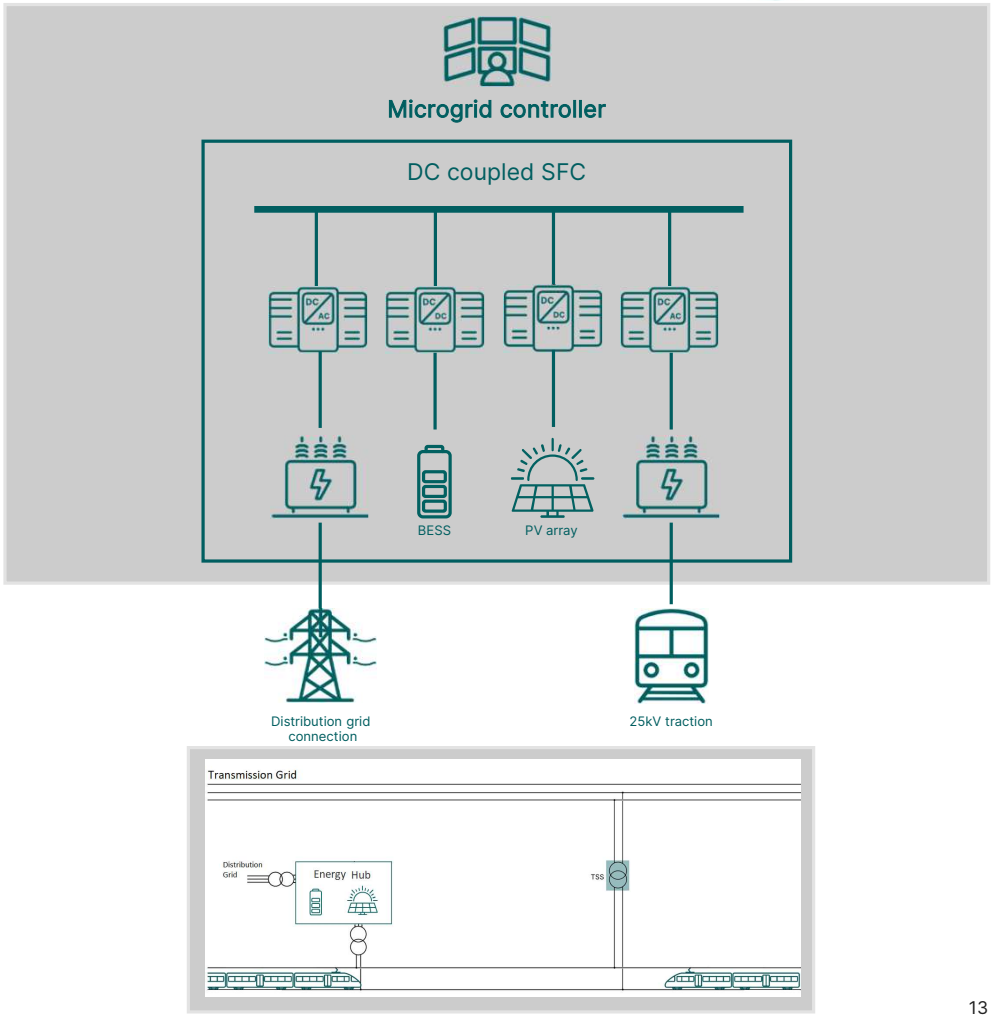
Large part of Rolling stock is still “diesel” propelled. Rail electrification can be a challenge when lines are far from strong grids. For a low traffic freight line, full line electrification can be expensive. Energy hub can help reduce the Grid connection power needed. It can be used also as super charger for battery powered trains.

Main functions

- Voltage stabilization on RN and grid
- Power injection – (energy shifting) with fast response time
- Ancillary services to the grid
- Decoupling load peaks between catenary and grid
- rolling stock energy recovery

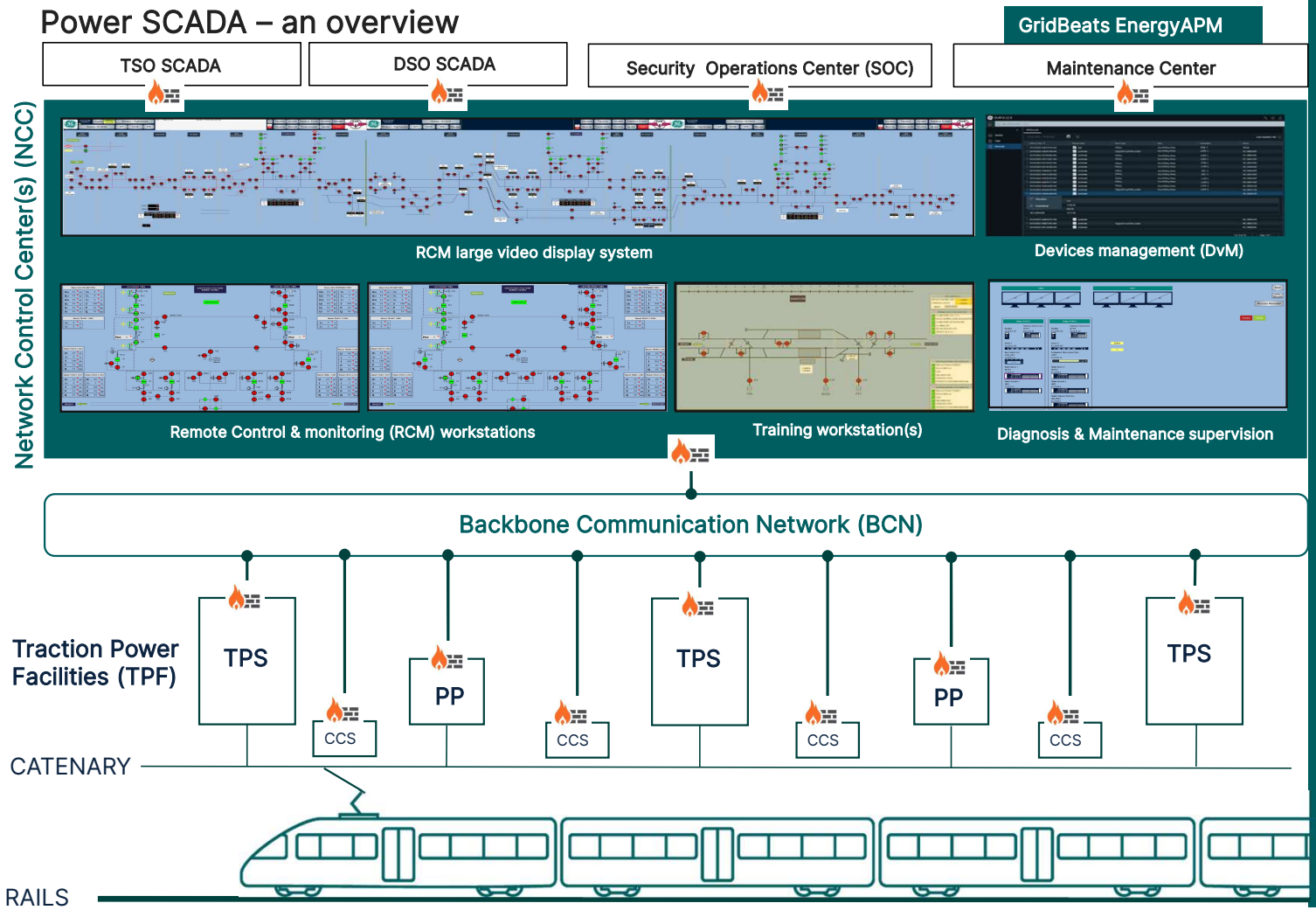
GE Vernova’s scope:

- Converters, cooling, PV panels, BESS storage, transformers, switchgear, cabling, PMS&MGC



Electrification solutions for AC

Power SCADA – an overview



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Solutions

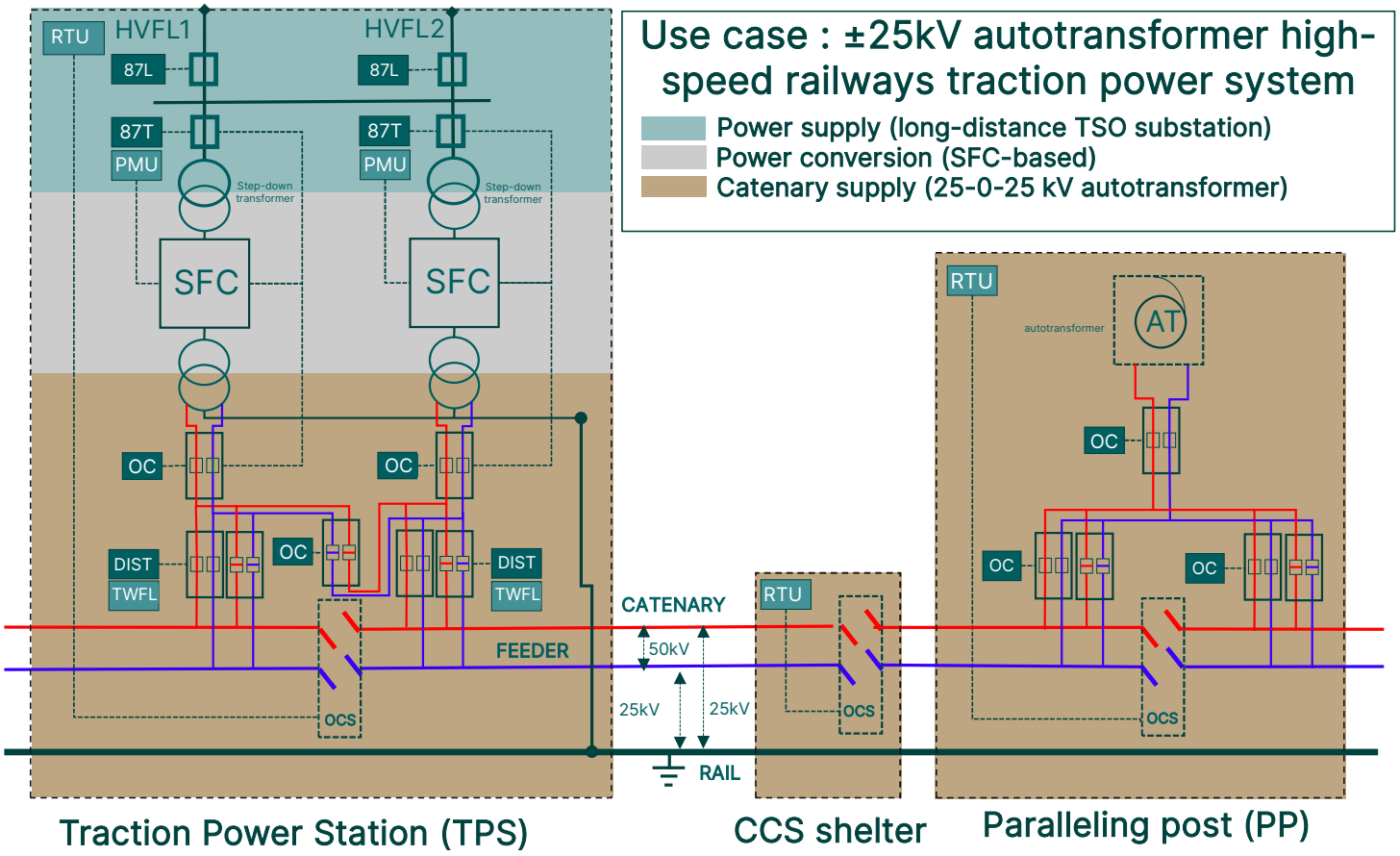
- Scalable end-to-end solution
- Top-down engineering
- Renewable integration
- Monitoring & diagnosis
- Secondary devices management
- Cyber security

Advantages

- System high availability
- Reliability
- Vendor agnostic
- Data optimization
- Asset performance

Electrification solutions for AC traction power

Traction substations protection automation & control



Solutions

- Grid decoupling
- Power flow control
- Synchronous coupling
- Load sharing
- Voltage stability
- Peak demand reduction
- Braking power recovery
- Energy efficiency

Advantages

- Decarbonization
- Power quality and stability
- Energy savings
- Flexibility
- Downtime reduction
- High accurate fault location

GE Vernova’s scope of supply

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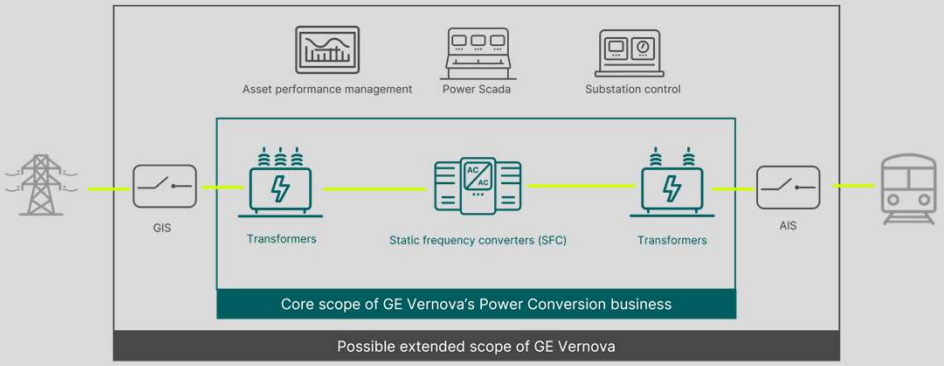
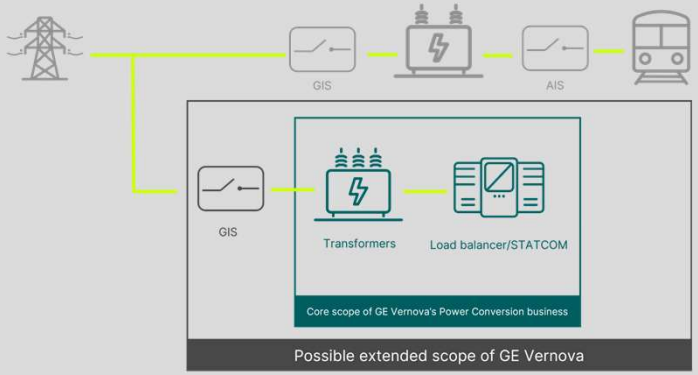
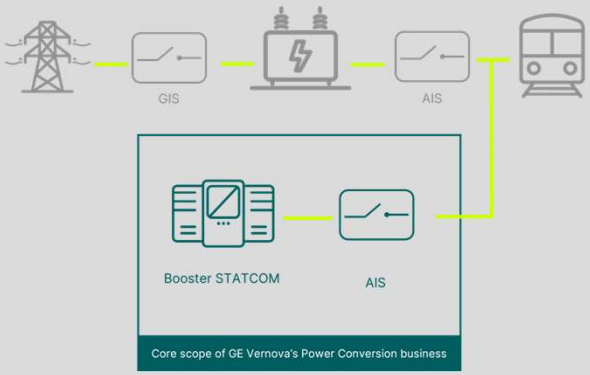
SFC for AC electrification



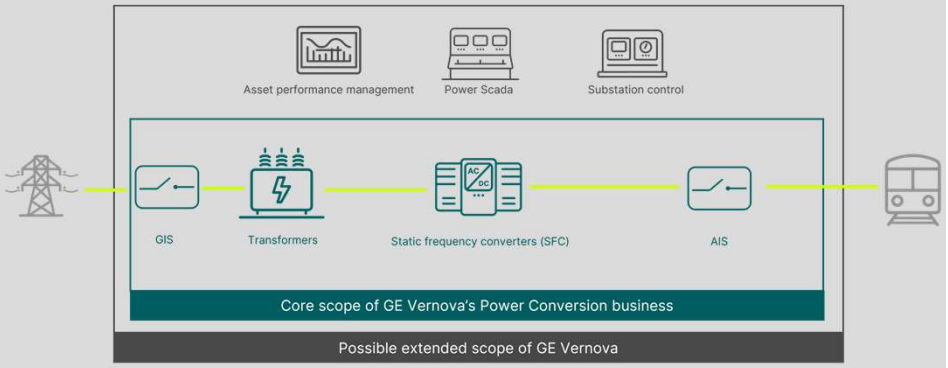
Grid load balancers/STATCOMS



Catenary voltage boosters



Substation for DC rail electrification



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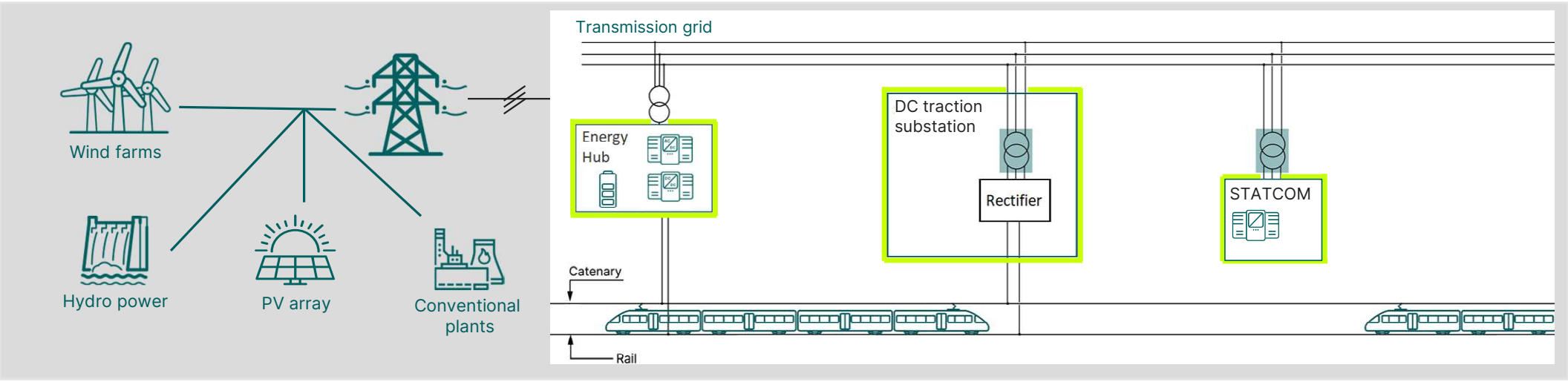

Electrification solutions for DC

DC traction substation

Typical scope

- TPS building and ancillaries
- Revenue metering
- 11kV switchboard
- Rectifier transformer and auxiliary transformer
- Rectifier
- DC switchboard
- DC charger, batteries & DC distribution board
- AC filter (space only) and DC filter (space only)

Expertise

- Full turnkey solution
- Facilitate installation : full substation tested, transported and installed on sites
- Management of certifications
- Management of civil work

Light rail and metros substations are generally installed in dense areas. Full substation remotely pre-built can offer a huge simplification of site activities.

Electrification solutions for DC

STATCOMS for DC rail

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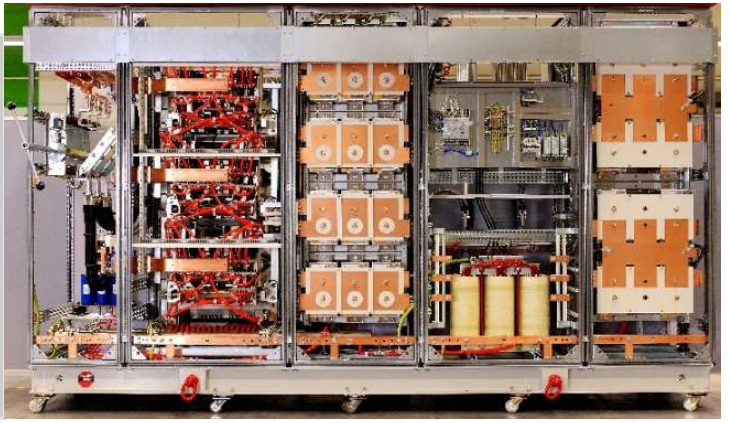

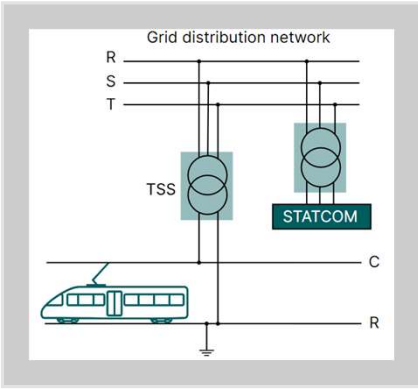

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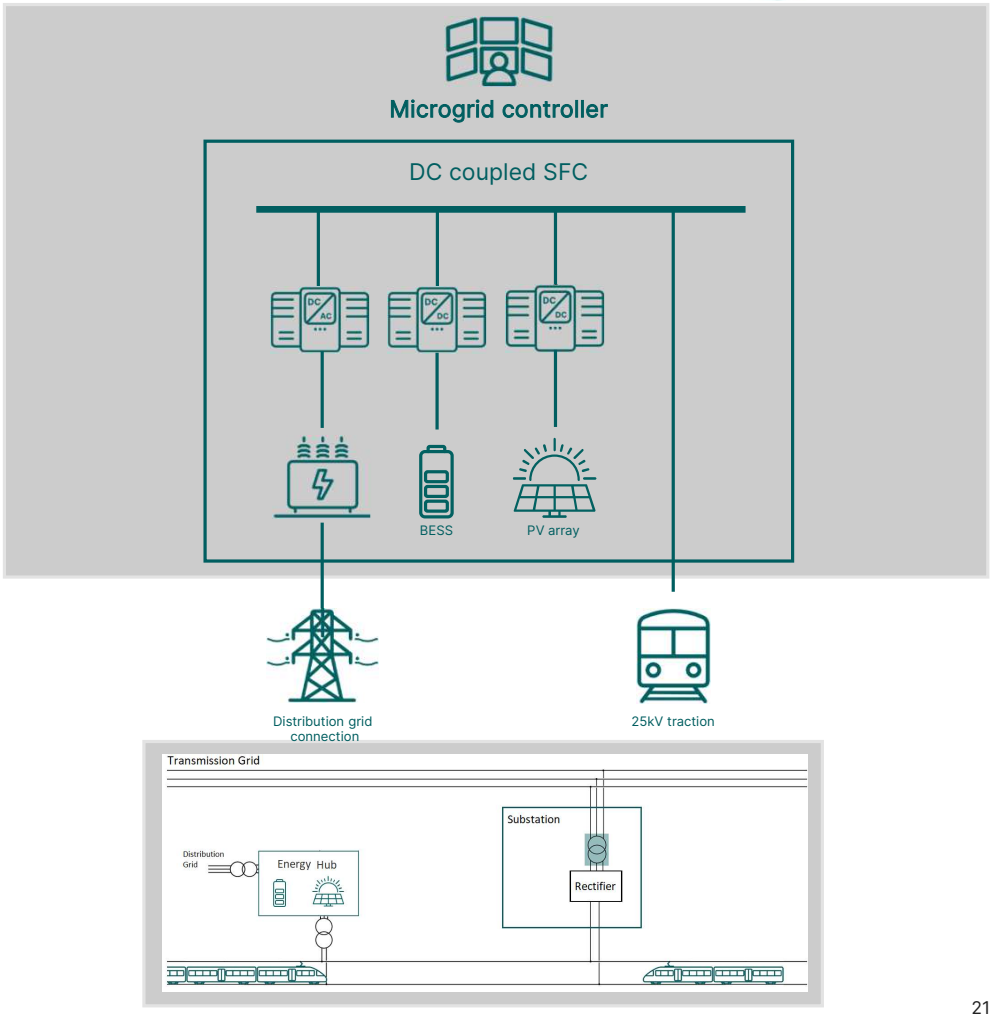

BACK-UP

REFERENCES

Rail References AC

SFC : Static Frequency Converter
HVB : High Voltage Balancer

Site	Countr	Power	Application	Year
Le Landy	France	4x 1,5MW	Test Center	1994
LGV Paris-Lyon	France	8x 8/20MVAR 8x 2/5MVAR	Serial Compens. catenary	1995
Jübeck	Germany	12 MW	SFC catenary 50/16,7Hz	1995
Olskroken	Sweden	2x15MW	SFC catenary 50/16,7Hz	1999
New York, NYCTA	USA	4MW	SFC, Active Filter	1999
Valenciennes	France	5 MW	Test Center	2000
Düsseldorf	Germany	15 MW	SFC catenary 50/16,7Hz	2000
Borken	Germany	5.5 MW	SFC catenary 50/16,7Hz	2001
Thyrow 1-4	Germany	4x 15 MW	SFC catenary 50/16,7Hz	2004
Thyrow 5-6	Germany	2x 15 MW	SFC catenary 50/16,7Hz	2005
Thyrow 7-8	Germany	2x 12 MW	SFC catenary 50/16,7Hz	2006
Olskroken	Sweden	15MVA	SFC catenary 50/16,7Hz	2007
Tâlle	Sweden	2x15 MVA	SFC catenary 50/16,7Hz	2007
Alsvjo	Sweden	2x15MVA	SFC catenary 50/16,7Hz	2007
Ange	Sweden	2x15MVA	SFC catenary 50/16,7Hz	2007
Lerthe	Germany	4x 32 MW	SFC	2009
Aschaffenburg	Germany	4x 32 MW	SFC	2009
Cologne	Germany	2x 37.5 MW	SFC	2011
Mannheim	Germany	120 MW	SFC Feeder 50/16,7Hz	2013
Belfort	France	2MW	Test Center	2014
Bauhinia	Australia	2x 8/18MW	SFC catenary 50/50Hz	2014
Lohsa	Germany	3x 15MW	SFC catenary 50/16,7Hz	2016
Moreton Bay	Australia	2x 13 MW	SFC catenary 50/50Hz	2016
Bützow	Germany	2x 15MW	SFC catenary 50/16,7Hz	2017
Schwerin	Germany	2x 15MW	SFC catenary 50/16,7Hz	2018
Niederbiegen	Germany	2x 15MW	SFC catenary 50/16,7Hz	2019
DFCC	India	10x +/-4MVAR	HV Booster	2020
DFCC	India	2x +/-20MVAR	HV Balancer / Statcom	2020
Paris, SNCF EOLE	France	4x +/-20MVAR	HV Booster	2022
Sete Rios, Lisbon	Portugal	1x +/-30MVAR	HV Balancer / Statcom	2023

Recent Experiences of Rail Electrification DC

PROJECT NAME	CLIENT	ASSET OWNER	SCOPE	DATE OF AWARD	DATE OF COMPLETION
Canberra Light Rail 2a	Canberra Metro Consortium	ACT-Government	Design, supply and commission 750V DC Traction Power Substations	Nov-24	27*
Gold Coast Light Rail 3	John Holland	Gold LinQ	Design, supply and commission 4 x 750V DC Traction Power Substations	April-22	October-26*
Parramatta Light Rail 1	CAF	Transport for NSW	Design, supply and commission 7 x 750V DC Traction Power Substations	May-19	July-24*
Newcastle Light Rail 1	Downer	Transport for NSW	Design, supply and commission 2 x 750V DC Traction Power Substations	September-17	February-19
Canberra Light Rail 1	Canberra Metro Consortium	ACT-Government	Design, supply and commission 5 x 750V DC Traction Power Substations	July-16	February-19

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