

Decarbonización de Sistemas de Alta Tensión / Subestaciones GIS Preambladas y libres de SF6




Trade Mission – Colorado School of Mines
September 2024

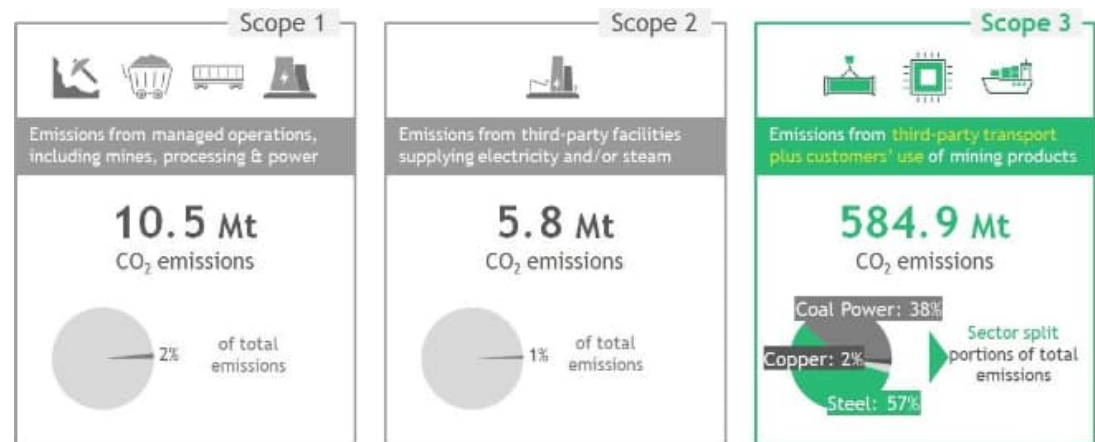
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Emissions Targets / How to drive assets decarbonization

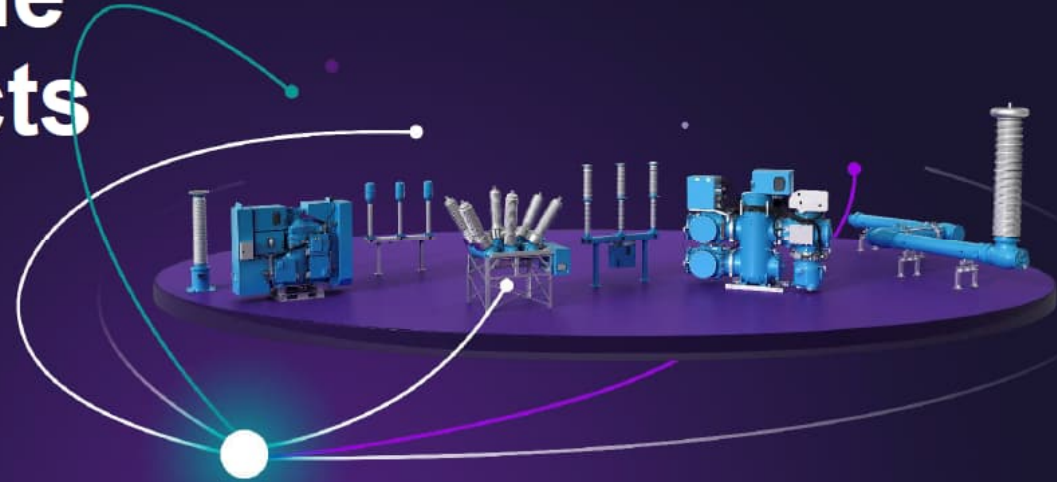


Scope	Definition	Examples
Scope 1: Direct Emissions 	Emissions from operations that are owned or controlled by the reporting company.	Emissions from direct operations, such as: <ul style="list-style-type: none"> • Equipment, vehicles, etc. and/or • Emissions from chemical production in owned or controlled process equipment
Scope 2: Indirect Emissions 	Emissions from the generation of purchased or acquired electricity, steam, heating or cooling consumed by the reporting company.	Use of purchased electricity, steam, heating or cooling, often from a utility or energy service provider.
Scope 3: Indirect Emissions 	All indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions.	Emissions from the transportation of purchased products or the use of sold products. In the mining sector this also includes emissions associated with the production of equipment, as well as with transportation and distribution of materials.



Siemens Energy Blue high-voltage products

Sustainable Zero-impact
switchgear for a CO₂-neutral future



1. The growing market demand for F-gas-free high-voltage switchgear

There is an increasingly urgent need to achieve decarbonization in all sectors worldwide – actions to reduce GHG emissions must be taken fast

- In the UNFCCC (United Nations Framework Convention on Climate Change) Paris Agreement signed by 189 countries in 2015, it was agreed to limit anthropogenic global warming to well under 2° centigrade
- Each country must determine and report regularly on how it intends to mitigate its greenhouse gas emissions and thus reduce global warming

US

2035: 100% clean electricity
2050: Net zero GHG pollution

EU

2050: First climate-neutral continent

PERU

2050: Carbon neutrality



F-gases in our switchgears and power grids require attention

Today's power grid still relies on the most potent greenhouse gas: **SF₆**

1 kg of SF₆



is equivalent to **25.200 kg**
of CO₂.

Source: Final IPCC AR6 Report, 2023

SF₆ is the most harmful greenhouse gas with a GWP 25,200 times higher than CO₂

What is global warming potential (GWP)?
It represents the heat absorption effect of any GHG relative to CO₂, which has a GWP of 1



It takes **12 years** for nature to absorb the amount of methane produced by one cow

75 kg methane p.a. GWP = 34

204 trees are needed to absorb the gas produced by one cow



~ 0.3 soccer fields



~ 1.5 cars

SF₆ installations
10,000 tons of SF₆ are installed globally every year. This gas has a GWP of 25,200



It takes **3,200 years** for nature to absorb SF₆

18,800,000,000 trees are needed to absorb the impact of the yearly installations



~ 28 million soccer fields



~ 132 million cars

SF₆ leakage
An estimated leakage rate of 0.46%¹ results in an annual amount of 46 tons



Again, it takes **3,200 years** for this gas to be absorbed

86,480,000 trees are needed to absorb the impact of the yearly leakage of SF₆



~ 128,000 soccer fields







~ 610,000 cars

¹ Source MDPI: Evaluation of SF₆ Leakage from Gas Insulated Equipment on Electricity Networks in Great Britain, August 2018

Overview of the main regulations

All these regulates health & safety and environmental topics

Regulations and committees in which GWP is discussed and consequences will be decided.

Regulations / Standards	Description	Influence on
F-Gas (GHG),  GHG = Greenhouse Gases	F-gas Regulation (European Union) has to control emissions from fluorinated greenhouse gases (F-gases), aim is: Limiting the total amount of the most important F-gases to one-fifth of 2014 sales in 2030. This will be the main driver of the move towards more climate-friendly technologies; Banning the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning and foams and aerosols; Preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.	environment
Reach (PFAS Chemicals) 	REACH (EU) to improve the protection of human health and the environment from the risks that can be posed by chemicals. REACH stand for Registration, Evaluation, Authorization and Restriction of Chemicals. PFAS, a group of more than 4700 chemicals (solid, fluent, gas) that accumulate in humans and environment and is known to be highly persistent and toxic.	human health and the environment
EPA 	The Environmental Protection Agency (EPA) is an independent executive agency of the United States federal government tasked with environmental protection matters. And to to protect human health.	human health and the environment
CARB 	The California Air Resources Board (CARB or ARB) is the "clean air agency" in the government of California. The stated goals of CARB include attaining and maintaining healthy air quality; protecting the public from exposure to toxic air contaminants; and providing innovative approaches for complying with air pollution rules and regulations.	human health and the environment

Stakeholders, legislation and regulations – Details USA

Natural-origin gases with GWP < 1 are 100 % future-proof with no risk for regulatory exposure!



SF6-gas regulation – In place in CA and being implemented by other states



PFAS* Restrictions started and manufacturing being stopped by 3M in 2025



January 2022 CARB SF6 regulation effective (Law)
 1) SF6 and F-gases with GWP > 1 reporting
 2) SF6 phase-out according Table 2



* Per-und polyfluoroalkyl Substances including F-Gases C4-FN & C4-FK

Table 2. Phase-Out Dates for SF₆ GIE with Voltage Capacity > 38 kV

Voltage Capacity (kV)	Short-Circuit Current Rating (kA)	Phase-Out Date
38 < kV ≤ 145	< 63	January 1, 2025
	≥ 63	January 1, 2028
145 < kV ≤ 245	< 63	January 1, 2027
	≥ 63	January 1, 2031
≥ 245	All	January 1, 2033

July 2021 state of Maine ‘Effective January 1, 2030, any product containing intentionally added PFAS may not be sold in Maine unless the use of PFAS is specifically designated as a currently unavoidable use by the Department’ (Law)

May 2023 state Minnesota Starting January 1, 2032, the sale or distribution of any new product containing intentionally added PFAS would be prohibited unless the MPCA has determined by rule that the use of PFAS in the product is a currently unavoidable use (Proposal, bill for an act)

3M to stop production of PFAS from end 2025 (letter Dec 20, 2022) Including F gases used in switchgear

The Environmental Protection Agency (EPA) has established a PFAS* Council



New York state propose to ban SF6 based on the CARB law (Proposal published May 2023)

Natural-origin gases are the only way to achieve a CO₂ neutral and non-toxic environment in all aspects



Latest News

<https://California Sues 3M and DuPont Over PFAS Chemicals - WSJ>
<https://news.3m.com/2022-12-20-3M-to-Exit-PFAS-Manufacturing-by-the-End-of-2025>



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Legislations and regulations – Details revised EU F-gas regulation



Revision EU F-gas regulation - provisional agreement from 05.10.2023 adopted by the Parliament on 16.01. and by the council on 29.01.2024.



Brussels, 10 October 2023 (OR_en)

14400/23

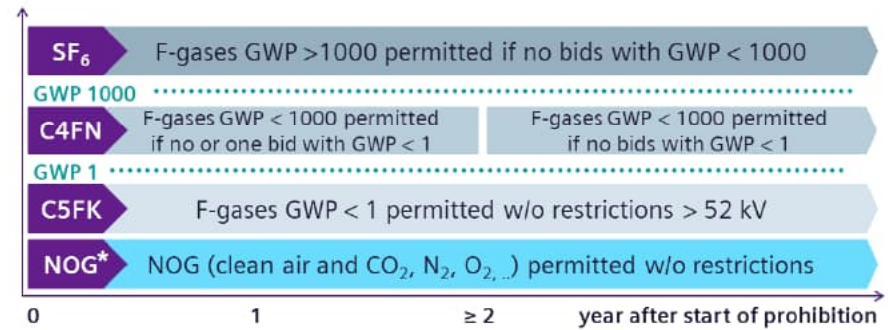
ENV 1156
CLIMA 495
CODEC 1934

[Link](#)



1) Prohibition of F-gases when putting into operation of new switchgear, if available:

medium voltage		
≤ 24 kV	all F-gases	01.01.2026
> 24 kV ... ≤ 52 kV	all F-gases	01.01.2030
high-voltage		
> 52 kV ... ≤ 145 kV	F-gases GWP ≥ 1	01.01.2028
> 145 kV	F-gases GWP ≥ 1	01.01.2032



2) **New (virgin) SF₆ prohibited from 2035** for **servicing and maintenance use, reclaimed & recycled SF₆ is possible.**

3) **SF₆ / C4-FN** are part of Annex I with **specific obligations** as reporting, certification of staff, labelling, checks of leakage detection systems at least each 6 years, release of all F-gases in the atmosphere are prohibited.



👉 For more information see also our Factsheet: [Link](#)

2. Siemens Energy Blue high-voltage portfolio

Our Blue switchgear portfolio already offers a solution,
with a greater mission in mind:

Achieving **Zero emissions
and **Zero** harm
in energy transmission
all over the world**

The Blue portfolio is based on game-changing technology: vacuum switching and clean air insulation

Clean air



$N_2 + O_2 =$ pure air
Zero CO₂ emissions
Zero toxicity
Zero hazard
Zero liquefaction
at low temperatures



Vacuum technology



Zero CO₂ emissions
Hermetical tightness to protect
from decomposition products
High switching performance
without degradation
Zero maintenance (sealed for life)

Gas-insulated switchgear 8VN1 Blue GIS™ up to 145 kV / 40 kA

Clean air insulation technology - customer value

Clean air is a composition of 80% N₂ and 20% O₂, cleaned and free from humidity (synthetic air)

- No Global Warming Potential: GWP = 0
- Non-toxic (no known toxicological effects: LC50, TLV-TWA, CMR)
- Non-flammable
- High stability
- Low boiling point and no liquefaction of insulation medium
- Clean air with well-known and proven material compatibilities
- F-gas free insulation with lowest requirements on training, transport, installation, operation, reporting and recycling
- C-gas free with no risk of C-decomposition
- No documentation and reporting duties for clean air gas
- No CO₂ compensation costs or risk of future tax or compensation
- No gas recycling required

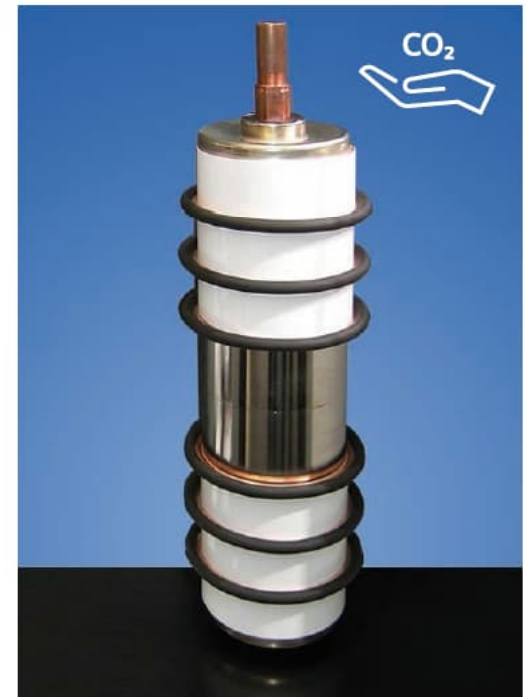


Gas-insulated switchgear 8VN1 Blue GIS™ up to 145 kV / 40 kA

Vacuum interrupter technology - customer value

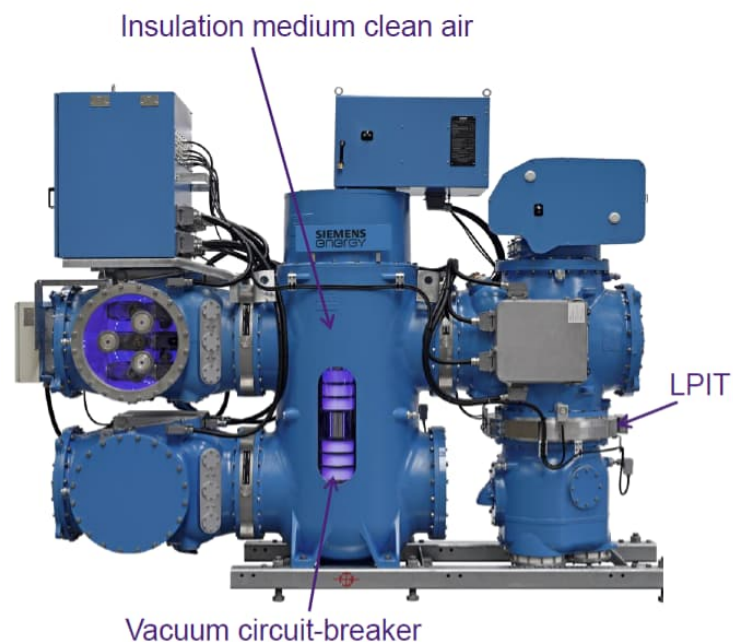
For more than 40 years successful operational experience in medium-voltage, since 2010 in high-voltage

- **High reliability**
due to the hermetically tight vacuum interrupter, eliminating any influence of decomposition products
- **High performance**
Perfect for frequent switching applications: high number of short-circuit interruptions with excellent interrupting performance at rated nominal current and rated short-circuit currents throughout life-time of the vacuum circuit-breaker
- **Perfect for low temperature**
No liquefaction of switching medium
- **No maintenance**
Maintenance-free due to sealed for life technology; no spare part costs
- **No CO₂e emissions**
Switching media (vacuum) with GWP=0; no CO₂e emissions during operation, maintenance or recycling



Gas-insulated switchgear 8VN1 Blue GIS™ up to 145 kV / 40 kA Technical data (with Non-Conventional Instrument Transformer)

Switchgear type	8VN1	
Rated voltage	up to	145 kV
Rated frequency		50 / 60 Hz
Rated short-duration power-frequency withstand voltage (1 min)	up to	275 kV
Rated lightning impulse withstand voltage (1.2 / 50 μs)	up to	650 kV
Rated continuous current - busbar	up to	3150 A
Rated continuous current - feeder / bus coupler	up to	3150 A
Rated short-circuit breaking current	up to	40 kA
Rated peak withstand current	up to	108 kA
Rated short-time withstand current (up to 3 s)	up to	40 kA
Leakage rate per year and gas compar TM ent (type-tested)		< 0.1 %
Driving mechanism of circuit-breaker		stored-energy spring
Rated operating sequence		O-0.3 s-CO-3 min-CO CO-15 s-CO
Interrupter technology		Vacuum
Insulation medium		Clean air
Weight of SF ₆ or other fluorinated greenhouse gases		0 kg
GWP Global Warming Potential		0
CO ₂ equivalent		0 kg
Rated filling pressure		0,8 MPa abs
Bay width common pole drive		1000 mm
Bay height, depth (depending on bay arrangement)		2900 mm x 3700 mm
Bay weight (depending on bay arrangement)		4.7 t
Ambient temperature range		-50 °C up to +55 °C
Installation		indoor / outdoor
First major inspection		> 25 years
Expected lifetime		> 50 years
Standards		IEC / IEEE
Other values on request		



The Blue portfolio comprises individual products & solutions, supporting our clients on their way to Zero

Up to 145 kV

Wind Tower Blue GIS™

- 72.5 kV
- switchgear for application in wind turbines, with vacuum CB and clean air insulation
- Optimized for its special application



Blue Circuit Breaker™ Live Tank

- 72.5 kV and 145 kV
- World's first LT CB with vacuum interrupter and clean air insulation



Blue GIS™

- 145 kV
- World's first 145 kV GIS switchgear with vacuum CB and clean air insulation
- Optimized footprint by using LPIT¹



Blue Circuit Breaker™ Dead Tank

- 145 kV
- World's first 145 kV DT vacuum CB with clean air insulation
- Same footprint as SF₆ product



Higher voltages (available)

Blue Clean Air GIB™

- 420 kV
- 245 – 400 kV = combined solution GIS + Blue GIB (30 – 65% less SF₆)



Blue Instrument Transformer™

- up to 420 kV
- World's first 420 kV transformer with clean air insulation
- Same footprint as SF₆ product



¹ Low Power Instrument Transformer

4. Blue success stories

Leading grid operators install Clean Air technologies



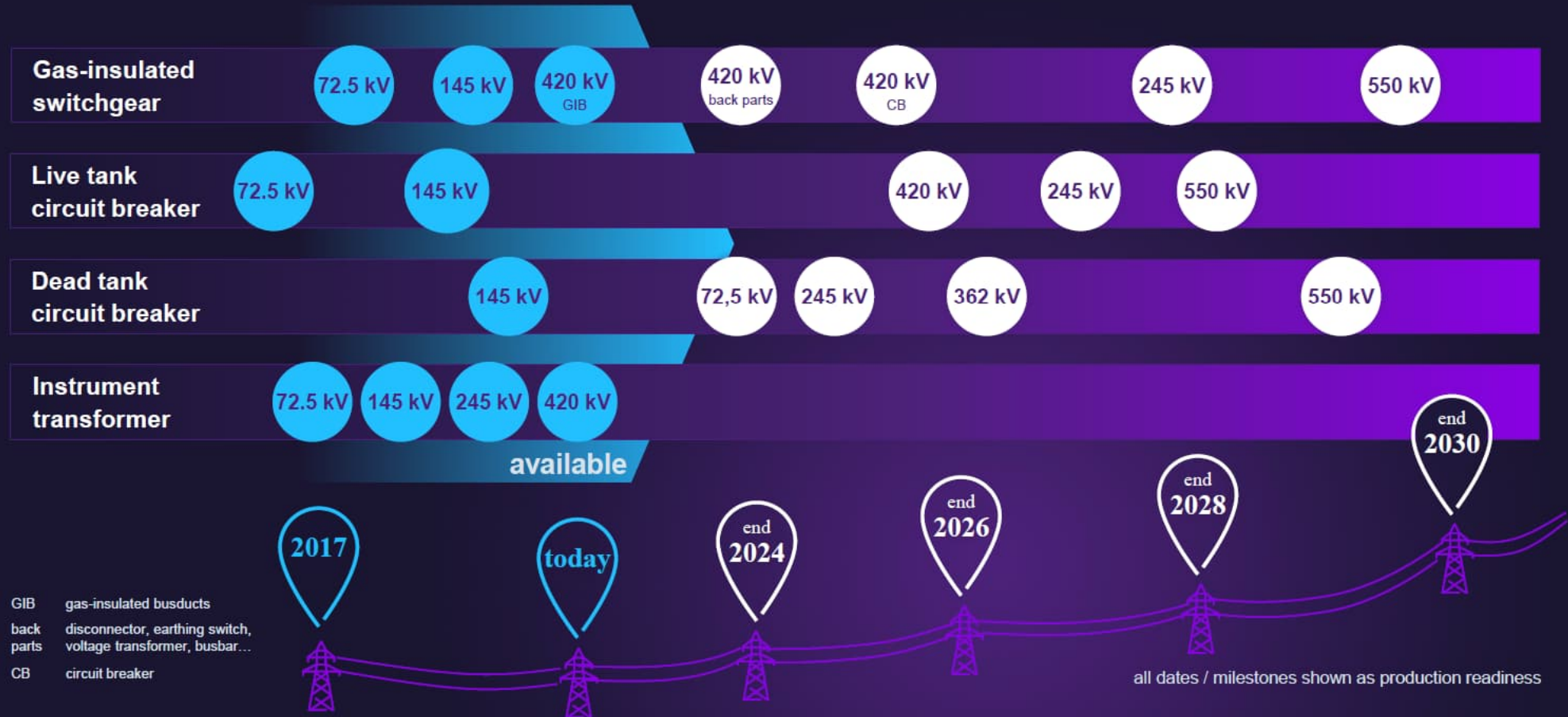
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5. Outlook for the future

Roadmap from Zero to Zero: Offering a fully F-gas-free, climate-neutral Blue portfolio by 2030

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E-House solutions for all voltage levels

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energy



E-House and Kiosk



- Easy installation and protection from harsh environmental conditions,
- E-House: For equipment or complete substation in all voltage levels up to 420 kV.
 - Kiosk: For 72 kV Blue GIS + Transformer (Usually for Wind power solutions), or Kiosk for distribution levels with MV RMU + LV Switchboard + Transformer

SKID



Good option for light loads, quick mobility, outdoor or indoor equipment, quick delivery time

Mobile Substations



Easy relocation on trailer for emergency or interim solution, any equipment or complete substation in all voltage levels up to 420kV. Can have E-House or outdoor equipment

Modular Flexible Booster



A modular skid solution to apply phase shifting technology for distribution network (<=138kV) to balance line loads, thereby increasing network capacity and avoiding expensive grid expansion where renewable energy connecting into grid. Can be relocated where needed. Includes a phase-shifting transformer module, HV switchgear or GIS module, control and protection module.

Prefabricated Modular Offshore Substation



Integrated Electrical Equipment, HVAC and auxiliary systems into the container for complete Offshore solutions

Blue Grid Connector



Supply of Zero carbon Switchgear on Skid or trailer, for renewable grid connections. 6 to 8 months lead time, Pretested, Control and protection integrated to allow for minimum works on site and rapid deployment of energy

Usual Equipment - Switchgears & Switchboards

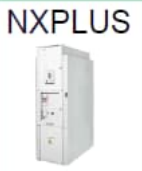
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Power transmission
High and extra-high voltage
> 52kV and up to 420 kV



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Primary distribution level
Medium voltage up to 40.5kV
up to 40kA (3s)



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Secondary distribution level
Medium voltage up to 36kV
up to 20kA (1s)

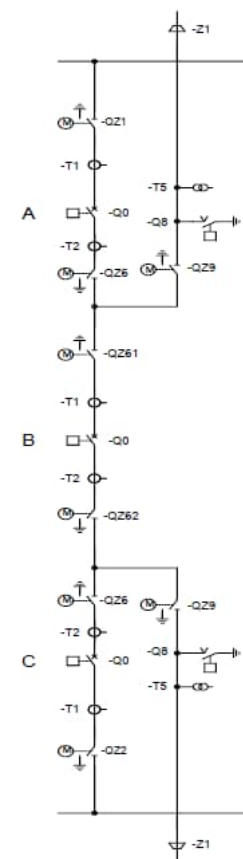
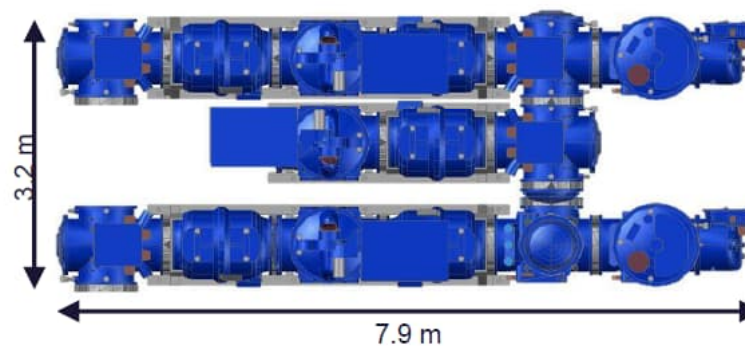


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Distribution level
Low voltage < 1kV
up to 150kA (1s)



Usual Equipment – Blue GIS 8VN1 up to 145 kV Example of 1.5CB-Arrangement



Usual Equipment - Distribution Transformers



Distribution Transformer	Renewable Transformer	Large Distribution Transformer
<ul style="list-style-type: none"> • 3-phase • For small power applications 	<ul style="list-style-type: none"> • Wind • PV 	<ul style="list-style-type: none"> • 3-phase • For large power applications 
<p>Oil Type</p>		

Usual Equipment - Others



**Auxiliary Services
(AC/DC Panels, Charger,
battery bank, UPS)**



Control & Protection



**Communication
Panel**

Usual Equipment - Subsystems



Fire detection and extinguishing system



Air Conditioning system (HVAC)



SF6 detection system

Mechanical structure characteristics

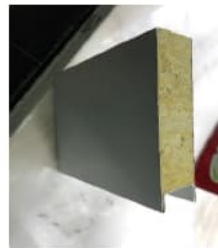
- Protection degree: IP54 or IP55 (IP65 for special projects)

Solids	Water
0 No protection	0 No protection
1 Protection against falling solids > 0.2mm	1 Protection against dripping water
2 Protection against falling solids > 0.5mm	2 Protection against dripping water
3 Protection against falling solids > 0.75mm	3 Protection against spraying water
4 Protection against falling solids > 1mm	4 Protection against spraying water
5 Protection against falling solids > 2mm	5 Protection against spraying water
6 Protection against falling solids > 2.5mm	6 Protection against spraying water
7 Protection against falling solids > 5mm	7 Protection against water jets
8 Protection against falling solids > 10mm	8 Protection against water jets

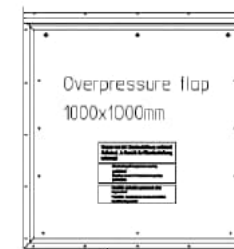
- Corrosion level: C4 (C5 for special projects)

ENVIRONMENT	EXTERIOR	INTERIOR
C1	-	Heated rooms with clean air and no condensation of water (e.g. offices, living rooms, shops)
C2	Environments with low level of pollution (e.g. rural areas)	Unheated or poorly heated rooms with occasional condensation (e.g. depots, sports halls)
C3	Most common urban and industrial environments (low salinity in coastal areas, moderate pollution)	Chemical plants, swimming pools, unheated buildings close to sea
C4	Industrial and coastal areas (moderate salinity and pollution)	Chemical plants, swimming pools, unheated buildings close to sea
C5-I (Industrial)	Industrial areas with high humidity and aggressive atmosphere (pollution)	Buildings with nearly permanent condensation and high pollution
C5-M (marine)	Coastal areas with high salinity	Buildings in areas with higher content of chlorine in air and nearly permanent condensation

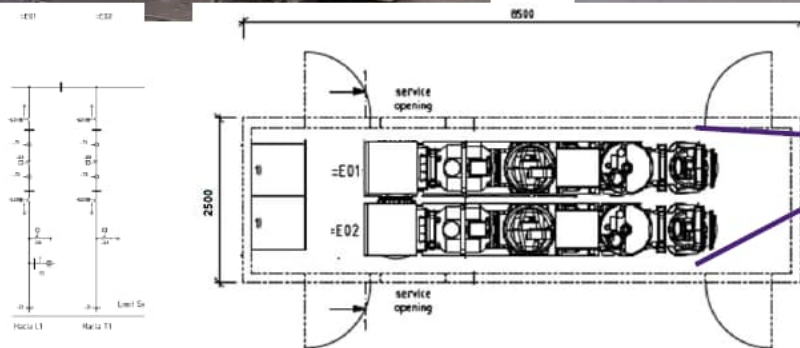
- Insulation material to keep internal temperature



- Overpressure flaps to release potential internal overpressure



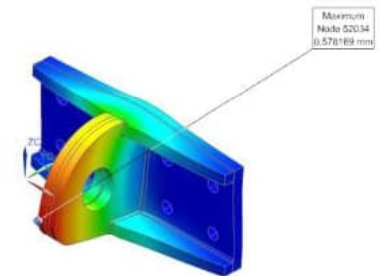
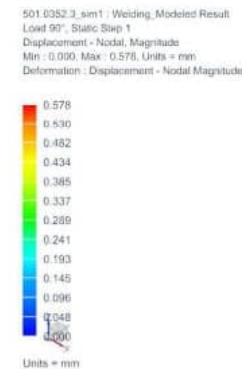
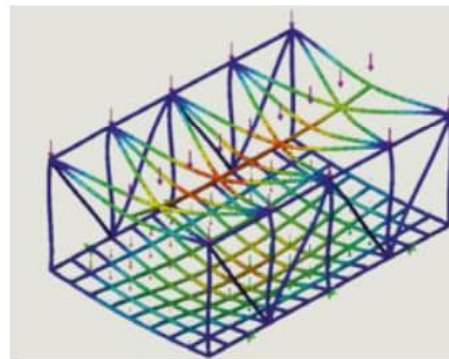
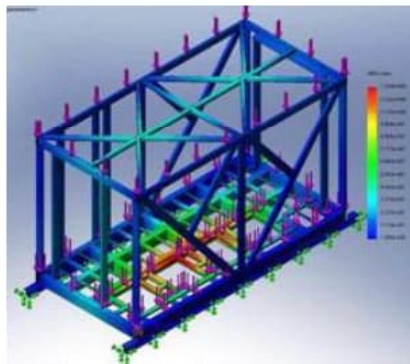
HV E-House - Layout example



Removable walls and top cover for maintenance and reducing total dimensions and weight

Advantages of **SIEMENS** energy Prefabricated solutions

- 1 Siemens Energy performs structural analysis using Finite Element Method (F.E.M.), to verify the stiffness over several conditions before manufacturing



** Note: Seismic analysis report also depending on site conditions and/or customer requirements*

Advantages of **SIEMENS** energy Prefabricated solutions

2

Siemens Energy can make a 3D Model with VR software during design stage to show customer the expected result, and verifying that there will be no mechanical overlapping among equipment



Delivery time

Remark: The delivery time here is an estimation, and can be extended if especial equipment is required by customer

Substation with E-House solution

HV

Off site work (factory)

On site work



FOB: (After P.O. and design freeze)
Approx. 7 months

MV
&
LV

Substation with E-House solution

Off site work (factory)

On site work



FOB: (After P.O. and design freeze)
Approx. 6 months

- Desing
- Manufacturing
- Installation in E-House
- Factory testing
- Transportation
- Civil works
- Installation
- Test. & Comm.

World Reference SKID

1

Data Centre Sydney



Industry	Data Centre
Scope	<ul style="list-style-type: none">• One Skid• 1 x 8DN8 bays / 132 kV• 1 x LCC (Local Control Cabinet)
Key success factor	<ul style="list-style-type: none">• Prefabricated solution• Space saving• Critical delivery time

World Reference **2** Mining in Western Australia

SKID



Industry	Mining
Scope	<ul style="list-style-type: none">• Eleven Skids• 11x 8DN8 bays / 132 kV• 11 x LCC (Local Control Cabinet)
Key success factor	<ul style="list-style-type: none">• Prefabricated solution• Digital solution with gas monitoring and arc detection system• New adjustable feet to avoid over stresses of the switchgear

World Reference SKID

3 Utility in Chile



Control & Protection equipment installed, interconnected and tested from factory



Industry	Utility
Scope	<ul style="list-style-type: none"> • 2 Skids • 4x 8DN8 bays / 123 kV • 2 Merging Units per LCC (Total 8 sets)
Key success factor	<ul style="list-style-type: none"> • Reduced footprint • Merging Units already installed and Interconnected from factory • Seismic report for the complete solution

Quick and mature process to manufacture a SKID



Design and Structural analysis



Manufacturing and assembly of the complete solution on the SKID from factory, including interconnections



Testing of GIS modules and testing of the solution over the SKID to avoid part of on-site testing



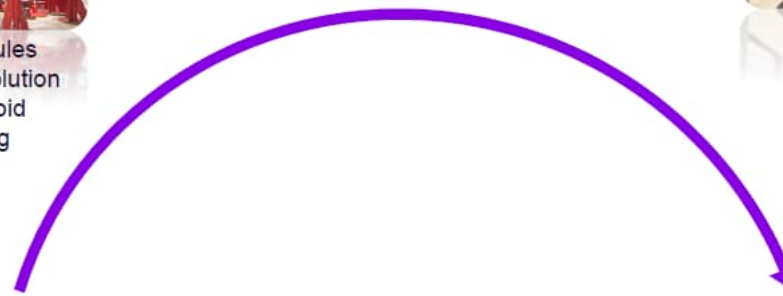
Ready for delivery



Easy installation and reduced testing on-site



Quick energization



Advantages Conventional vs. pre-fabricated concept



Flexibility

Easy mobilization and relocation



Cost optimized

Up to -30% for the complete project



Efficient Schedule

Up to -30% for the complete project



Safety

= less insurance



Weather independent



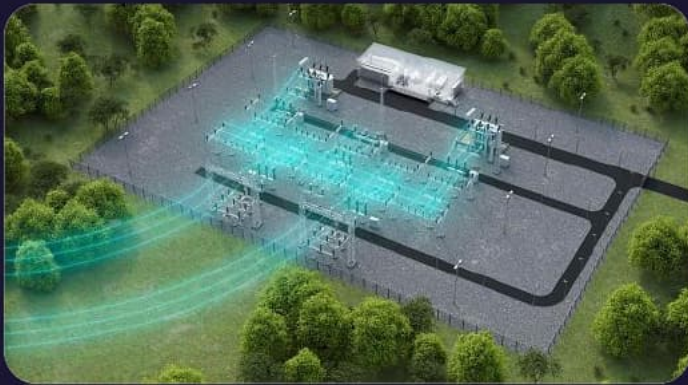
Less manpower



Lower footprint

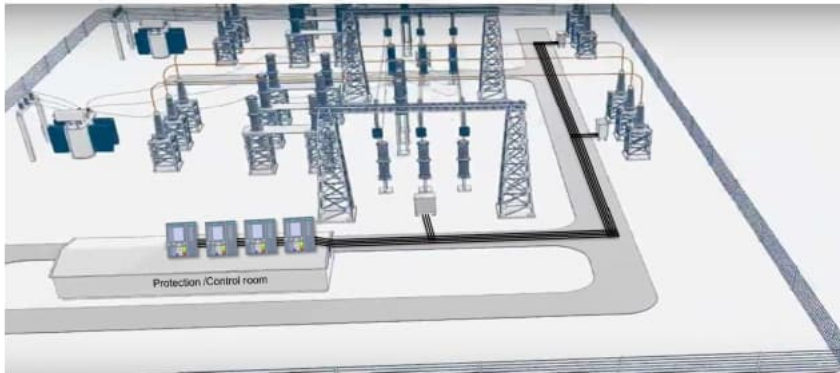
Digitalization

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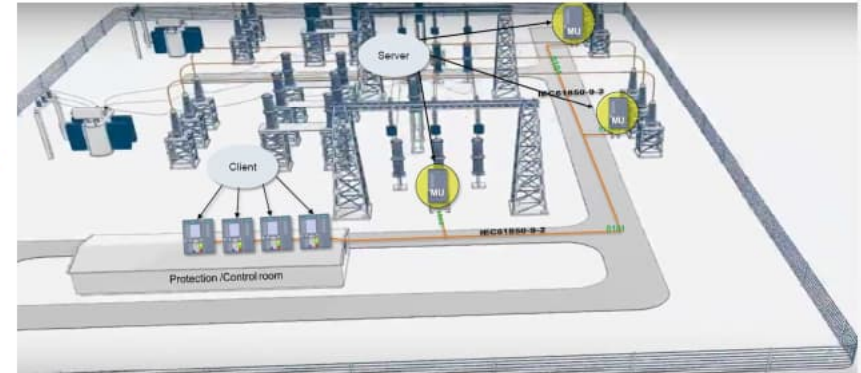


Digitalization – Merging Units

Conventional solution

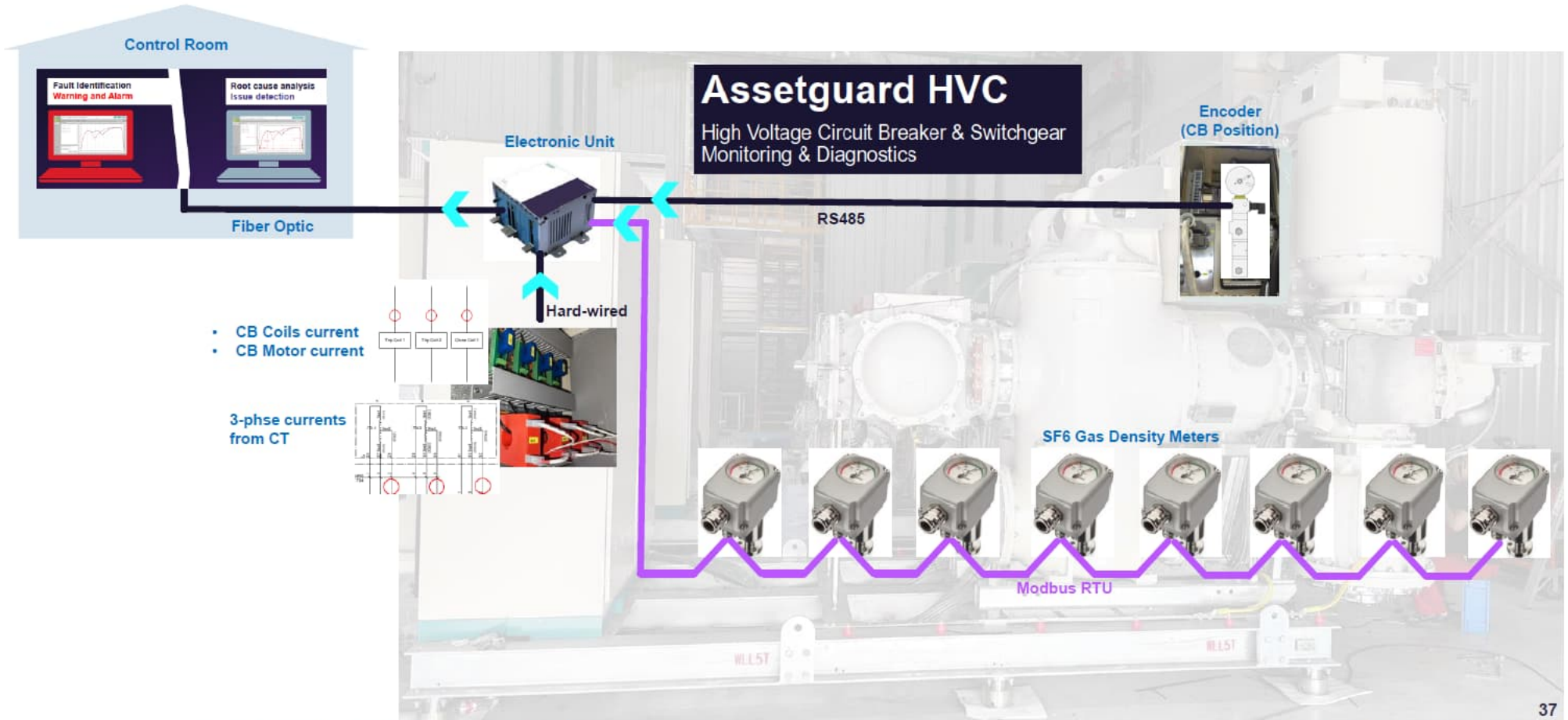


Process Bus solution



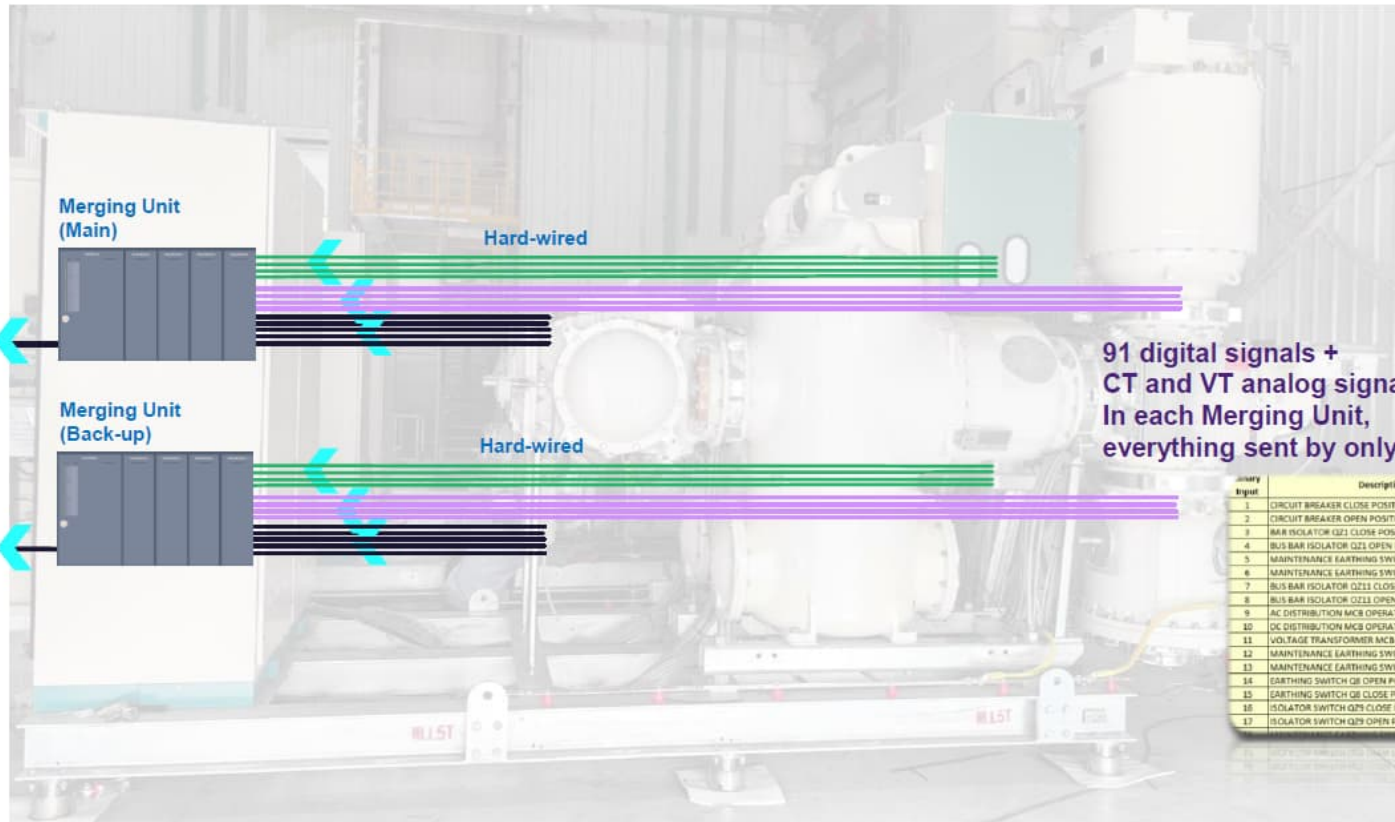
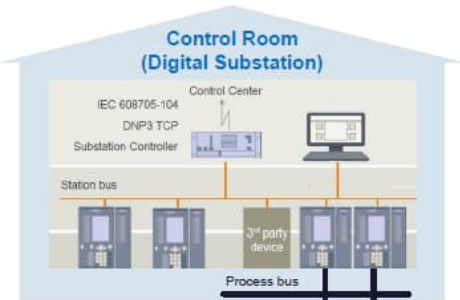
Digitalization - 132kV GIS SKID project "MKO" - Australia

Digitalized GIS solution incl. **CB monitoring system** from SE Italy



Digitalization - 110kV GIS SKID project “Desalant” - Chile

Digitalized GIS solution including **Merging Units**



91 digital signals + CT and VT analog signals
In each Merging Unit, everything sent by only one Fiber Optic

Binary Input	Description	Function
1	CIRCUIT BREAKER CLOSE POSITION	INDICATION
2	CIRCUIT BREAKER OPEN POSITION	INDICATION
3	BAR ISOLATOR Q21 CLOSE POSITION	INDICATION
4	BUS BAR ISOLATOR Q21 OPEN POSITION	INDICATION
5	MAINTENANCE EARTHING SWITCH Q21 OPEN POSITION	INDICATION
6	MAINTENANCE EARTHING SWITCH Q21 CLOSE POSITION	INDICATION
7	BUS BAR ISOLATOR Q211 CLOSE POSITION	INDICATION
8	BUS BAR ISOLATOR Q211 OPEN POSITION	INDICATION
9	AC DISTRIBUTION MCB OPERATED	ALARM
10	DC DISTRIBUTION MCB OPERATED	ALARM
11	VOLTAGE TRANSFORMER MCB TRIPPED	ALARM
12	MAINTENANCE EARTHING SWITCH Q211 OPEN POSITION	INDICATION
13	MAINTENANCE EARTHING SWITCH Q211 CLOSE POSITION	INDICATION
14	EARTHING SWITCH Q2 OPEN POSITION	INDICATION
15	EARTHING SWITCH Q2 CLOSE POSITION	INDICATION
16	ISOLATOR SWITCH Q25 CLOSE POSITION	INDICATION
17	ISOLATOR SWITCH Q25 OPEN POSITION	INDICATION