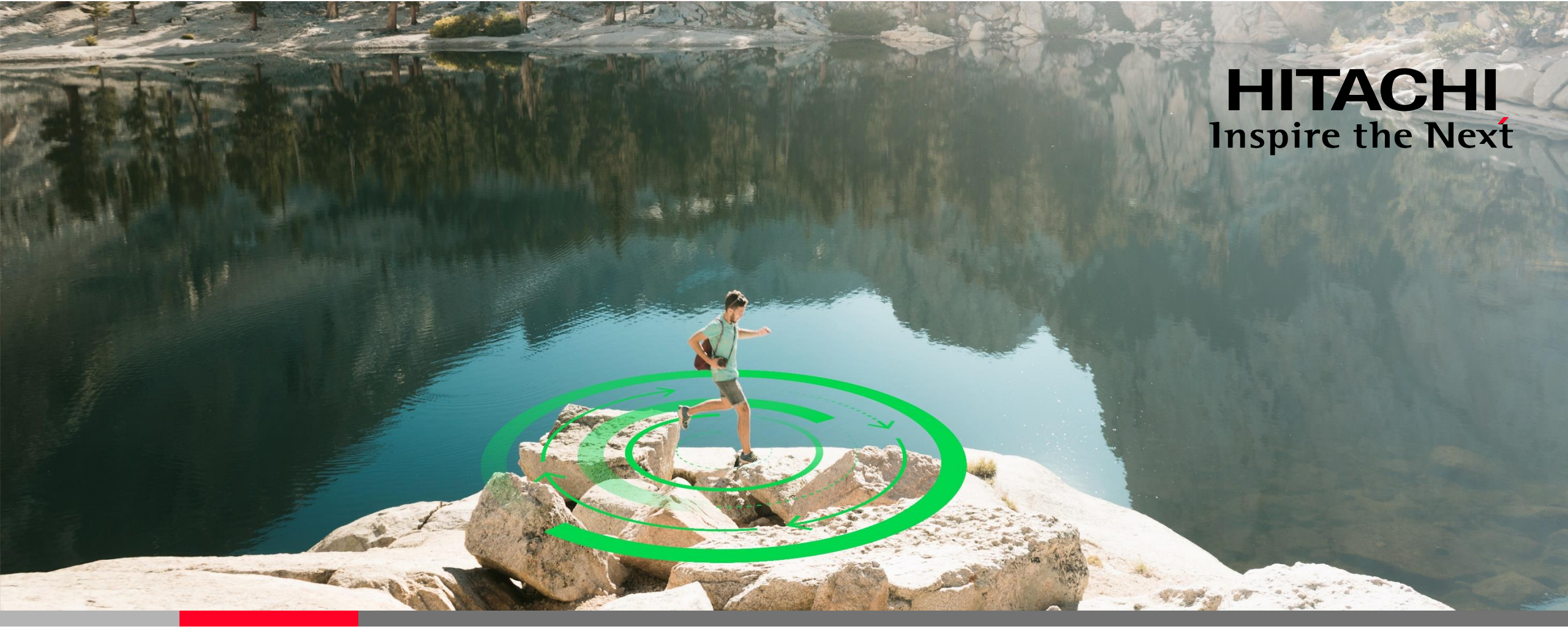


High Voltage Products: The Backbone of Electricity in Industry and Shifting Towards Sustainability (SF6 Free EconiQ)

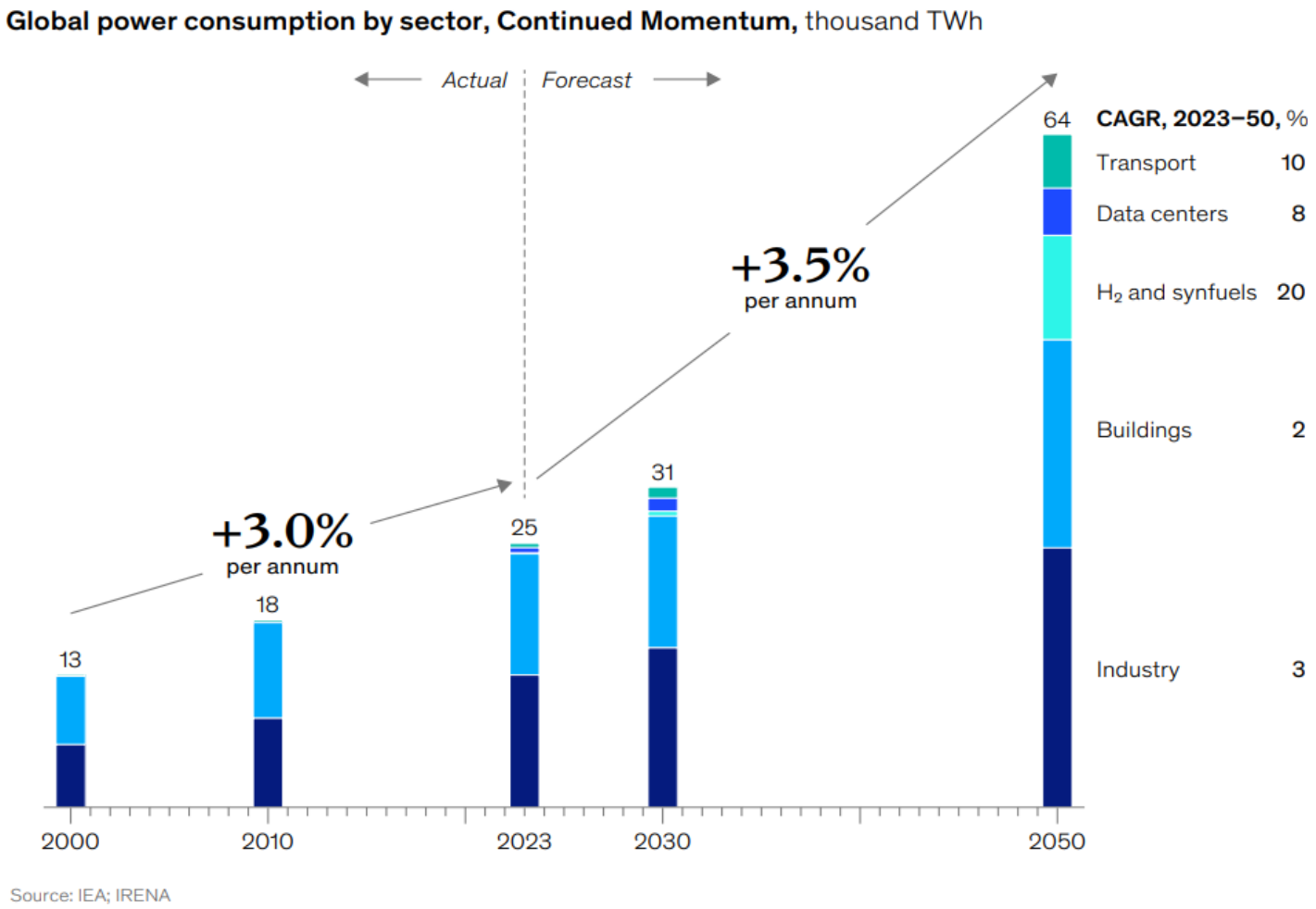
Energy & Digital World (EDW) 2024, Knowledge Session 1.2, 11:20-12:20

Nuryanda Akbar, Sales Manager, High Voltage Business

2024-09-25

Hitachi Energy

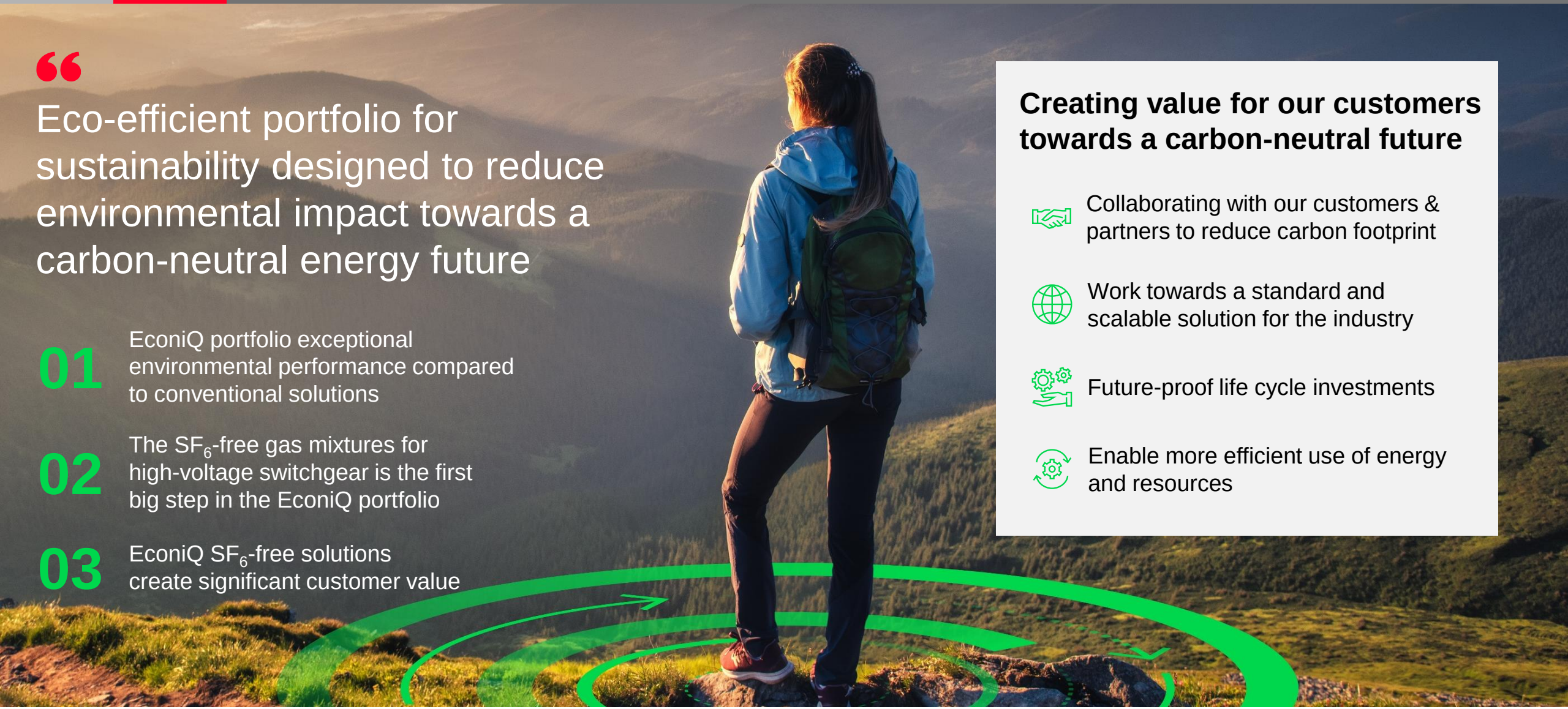
Electricity will be the backbone of the entire energy system



Global electricity consumption will more than double from 20 percent to over 40 percent of total energy demand by 2050

EconiQ − our promise towards a carbon neutral future

HITACHI
Inspire the Next



Eco-efficient portfolio for sustainability designed to reduce environmental impact towards a carbon-neutral energy future

01 EconiQ portfolio exceptional environmental performance compared to conventional solutions

02 The SF_6-free gas mixtures for high-voltage switchgear is the first big step in the EconiQ portfolio

03 EconiQ SF_6-free solutions create significant customer value

Creating value for our customers towards a carbon-neutral future

- Collaborating with our customers & partners to reduce carbon footprint
- Work towards a standard and scalable solution for the industry
- Future-proof life cycle investments
- Enable more efficient use of energy and resources

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EconiQ high-voltage roadmap: Advancing a sustainable energy future for all

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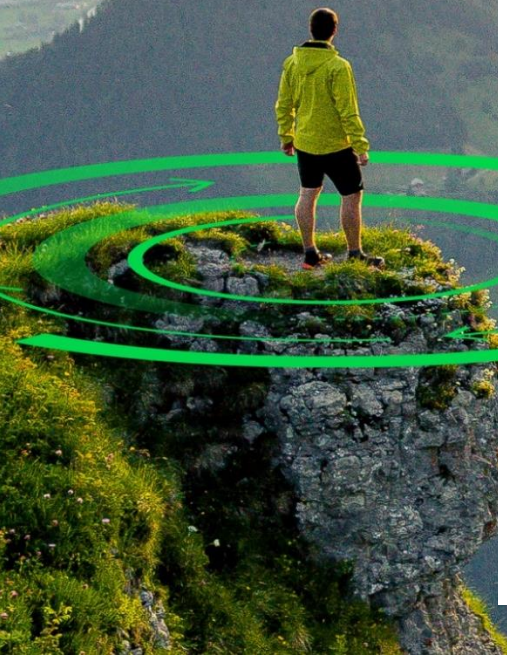
EconiQ



EconiQ high-voltage portfolio		Available now	2025	2026	2027 and beyond
Live tank circuit breaker (LTB)		72.5 kV; 145 kV; 420 kV			245 kV; 170 kV
Dead tank circuit breaker (DTB)		420 kV; 550 kV	72.5 kV** 145 kV**	245 kV	
Plug and Switch System hybrid switchgear (PASS)			72.5 kV 145 kV		
Gas-insulated switchgear (GIS)		72.5 kV* 145 kV*; 420 kV; 550 kV		245 kV	170 kV
Gas-insulated line (GIL)		420 kV; 550 kV		245 kV	
Retrofill for GIL (Service)		420 kV; 550 kV			

* 60 Hz will be available in 2025 | ** 63kA
This roadmap contains forward-looking information which are based on our current best expectations, estimates and projections.
We reserve the right to make changes without prior notice.

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EconiQ gas circuit breaker technology

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LTA

For LTB application, we are using CO_2 + O_2 to replace SF_6 in all LTB applications for insulation and switching.

Eco-efficient gas mixture

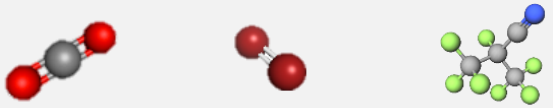
CO_2
Carbon dioxide

O_2
Oxygen

Metal Enclosed (MEB)

An eco-efficient gas mixture of CO_2 + O_2 + C4-FN (a synthetic gas) replaces SF_6 in all our metal-enclosed switchgear (GIS, DTB, PASS) for insulation and switching.

Eco-efficient gas mixture



CO_2
Carbon dioxide

O_2
Oxygen

C4-FN
Fluorinated nitrile

The EconiQ gas circuit breaker remains as compact as the conventional SF_6 solution.

Hitachi Energy

Environment, Health & Safety assessment of C4-FN

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Robust health and safety features for use in high-voltage

- Eco-efficient gas mixture is not classified as toxic
- Pure C4-FN has the lowest EU CLP* classification and is in the same category as many household cleaning products
- Pure C4-FN classified as “harmful if inhaled” at a high concentration, which is unlikely to happen because it is only used as a strongly diluted mixture and access is limited to trained personnel following safety procedures

Sustainable and environmentally responsible technology

- Does not accumulate in water, plants, or soil
- If it would accidentally escape from its tight enclosure, it would distribute evenly in the atmosphere
- Atmospheric lifetime around 30 years
- Decomposes into substances that already exist in nature

Eco-efficient gas mixture

C4-FN	Carbon dioxide and oxygen
3.5%	**96.5%**

C4-FN **CO_2** **O_2**

* The CLP Regulation is a European Union regulation from 2008, which aligns the European Union system of classification, labelling and packaging of chemical substances and mixtures to the Globally Harmonized System

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Life cycle assessment for environmental performance

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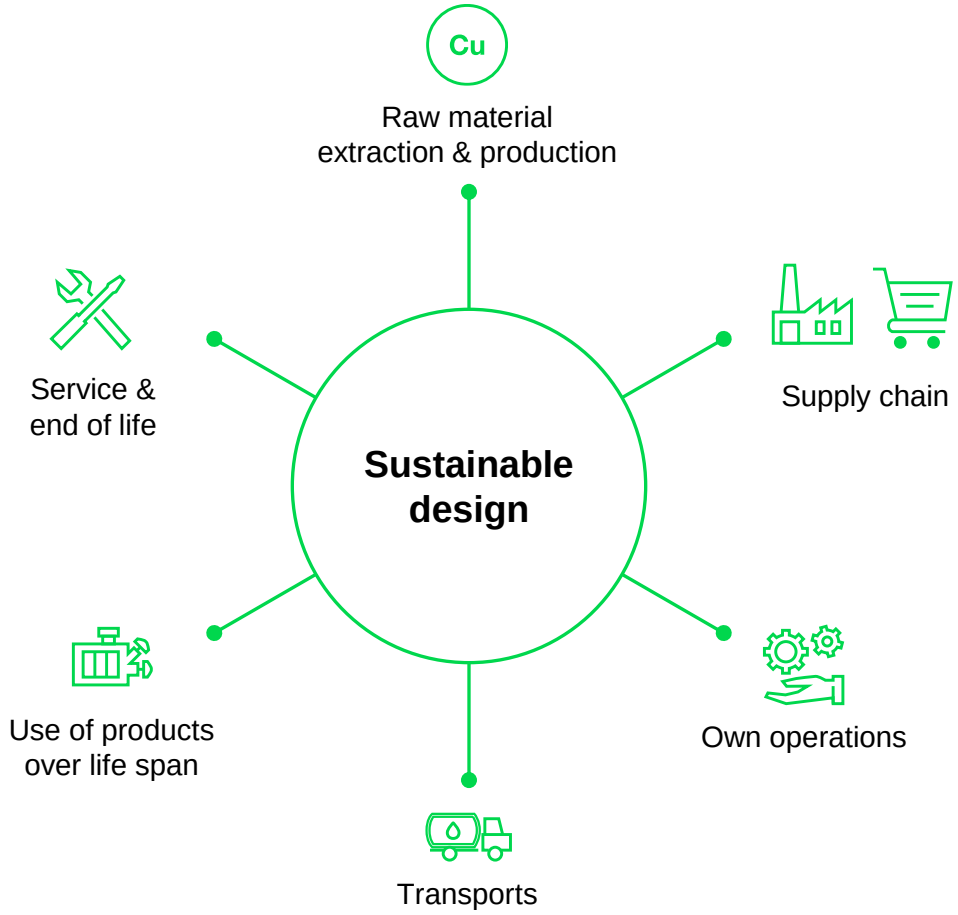
Assessing the impact on the environment

- **Quantifies** the environmental impact of a product or a system from cradle to grave
- Includes the **whole life cycle**
- **Standardized** methodology (ISO 14040 14044), databases, and expertise
- **Shows environmental hot spots** – phase of life and materials that have the highest environmental impact



LCA is the accepted state-of-the-art method
to measure environmental performance

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EconiQ has exceptional environmental performance

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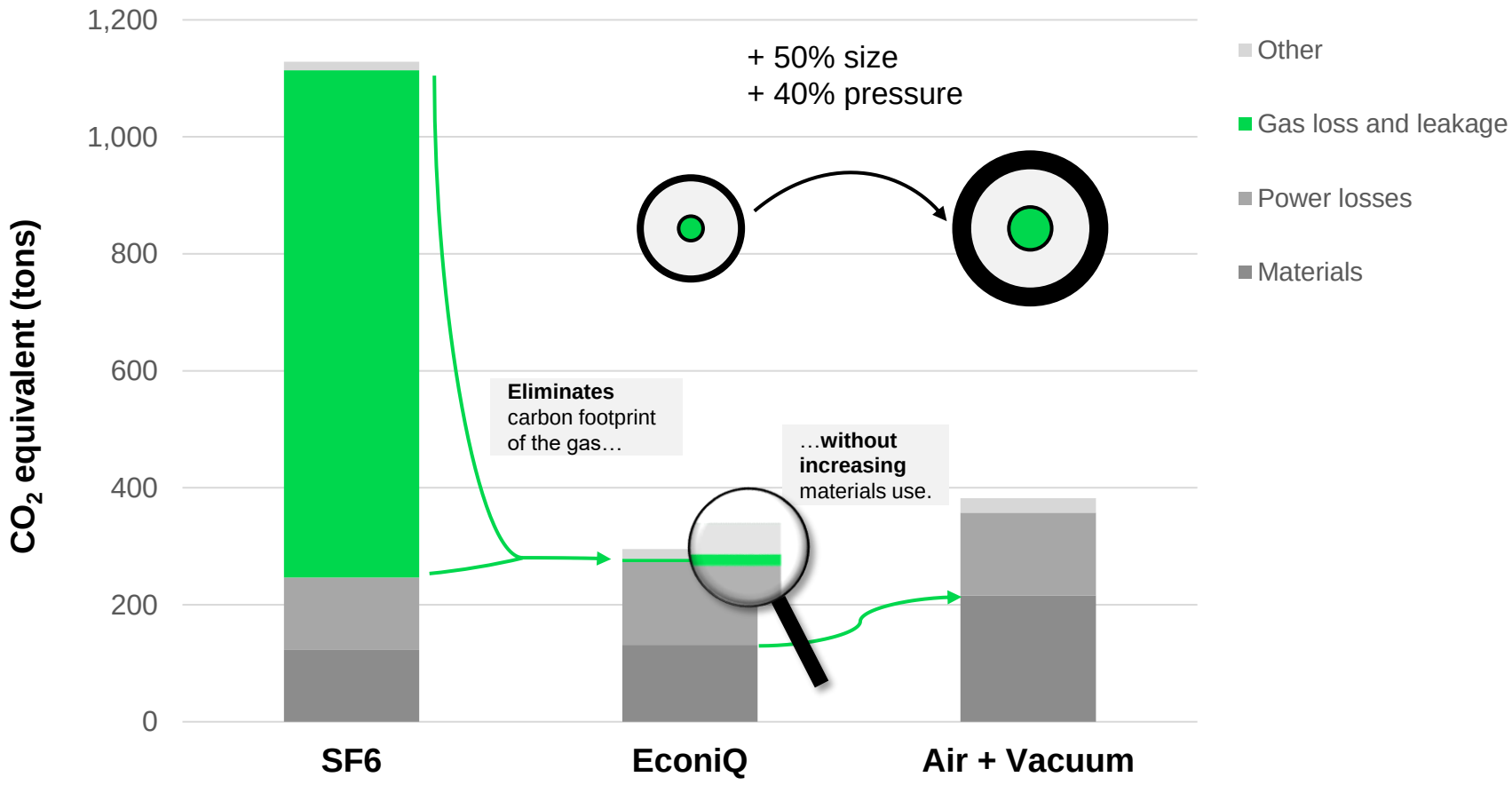
Accelerating eco-efficient innovation

Groundbreaking technologies like the EconiQ portfolio offer the lowest possible carbon footprint while maintaining size, performance, and reliability of current SF_6 equipment.

Life cycle carbon footprint of a 420 kV GIS per bay



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Gas handling equipment from multiple established suppliers

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© KELLER
© WIKA
© TRAFAG

MONITOR

Sensor


© EMT
© DILO
© WIKA

ANALYZE

C4-FN mixture analyzer


© ISM
© DILO
© BACHARACH
© Dräger

DETECT

Leakage detector

INITIAL FILLING

Mixture prepared from single gases or taken from premixed bottles and then filled into the equipment


© DILO
© DILO
© AIR LIQUIDE / Laurent Lelon
© AIR LIQUIDE

SERVICE

Fill, recover, refill
Gas is handled with service cart


© DILO
© AIR LIQUIDE

DISPOSE

Recycling or incineration

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EconiQ high-voltage global footprint

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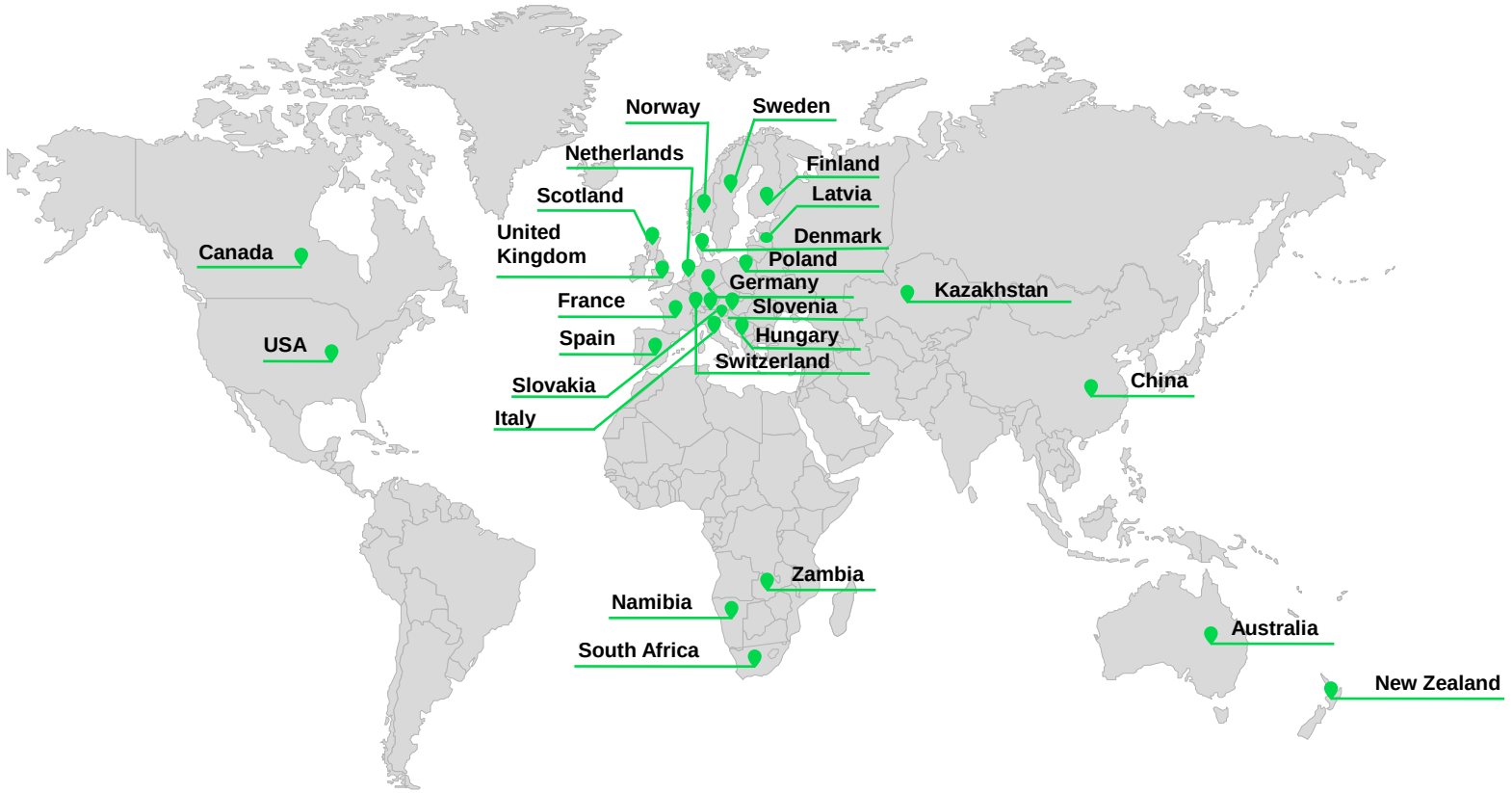
At the forefront of

Eco-efficient innovation

- Unveiled the world's first SF_6-free 420 kV and 550kV circuit breaker
- Delivered the world's first SF_6-free 420 kV dead tank circuit breaker in the US
- Delivered the world's first SF_6-free 420 kV gas-insulated switchgear in Germany
- Achieved world's first replacement of SF_6 in installed high-voltage equipment in the UK



1,200+ EconiQ units worldwide

MORE THAN **15 km** EconiQ gas-insulated lines

>10 YEARS experience in eco-efficient high-voltage technology

26 COUNTRIES Adopted EconiQ high-voltage technology to achieve carbon-neutrality targets

Hitachi Energy

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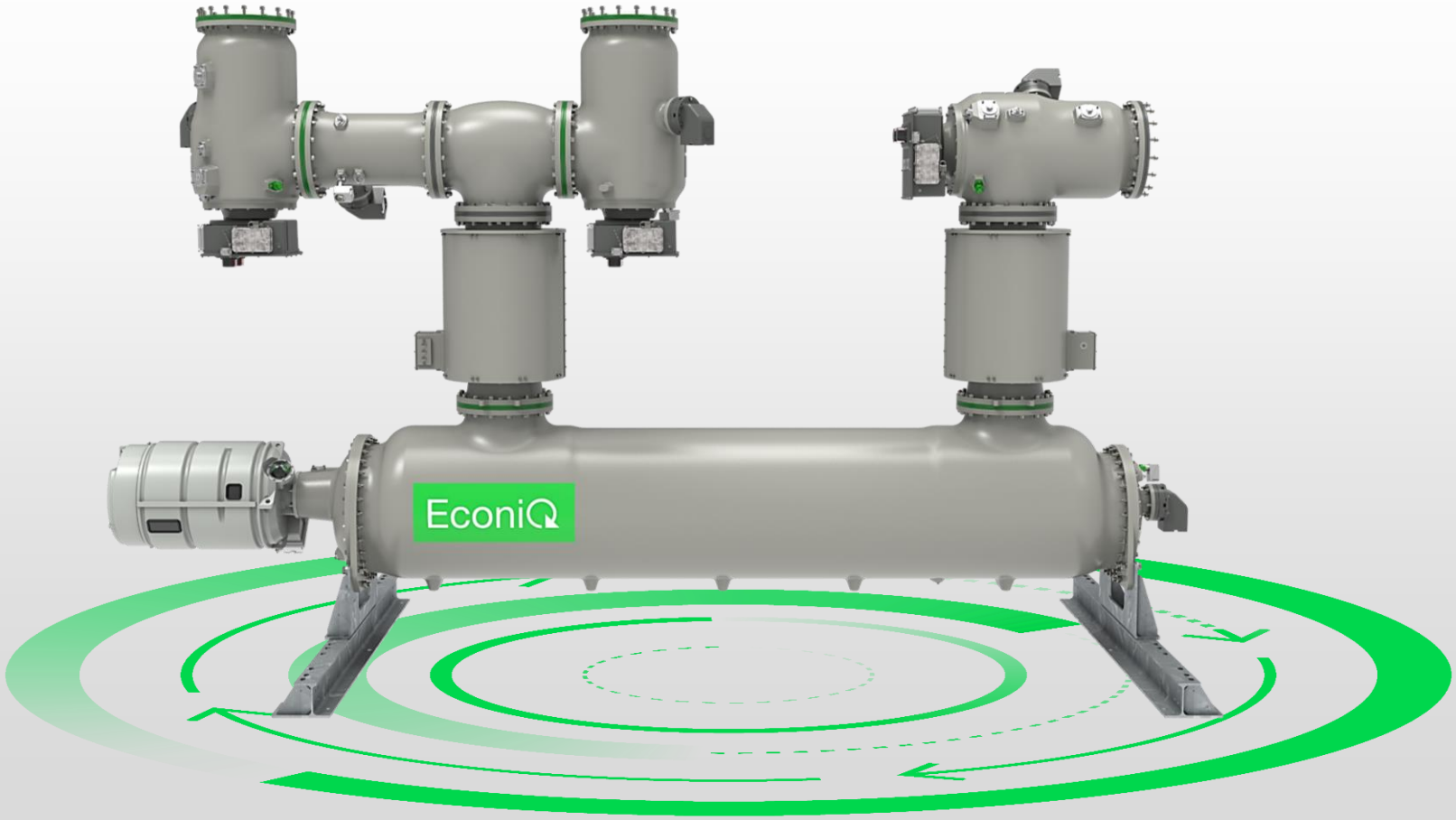
World's first fully type-tested SF_6-free 420 kV circuit breaker enabling our customers to transition to net zero



250+ breakers ordered

Hitachi Energy

Type EconiQ 420PM63-HA

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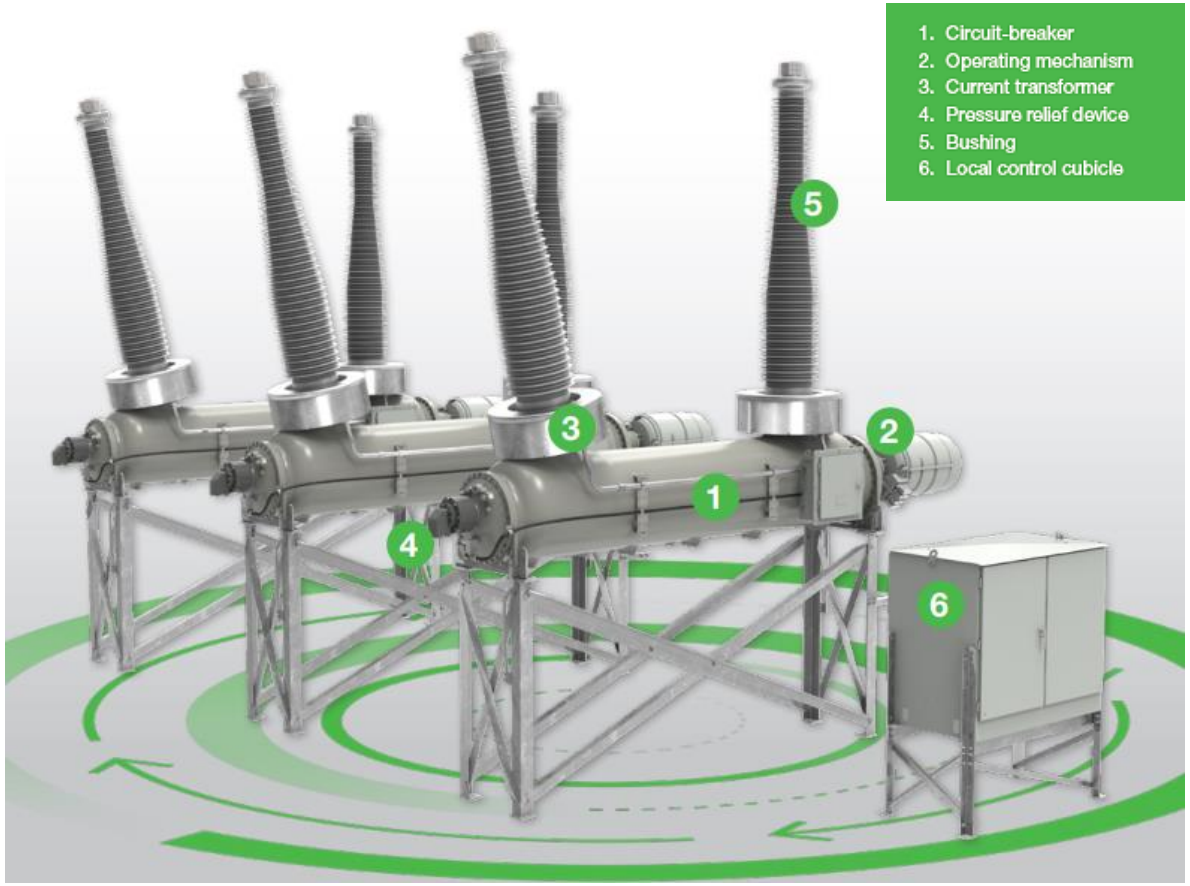
Target ratings and features

EconiQ 420PM63-HA		
Rated voltage	kV	362-420
Rated frequency	Hz	50 / 60
Rated continuous (nominal) current	A	3000 / 4000 / 5000
Rated short-circuit (interrupting) current	kA	63
Rated first-pole-to-clear factor (k_{pp})		1.3 & 1.5
Rated capacitive switching Class		C2
Rated capacitive switching voltage factor (k_c) • Line and cable charging		1.4
Minimum operating temperature, no tank heaters	°C	-30
Rated mechanical endurance class		M2
Extended electrical endurance class		E2
Independent (single-) pole operation		HMB-8



Easy operation at high performance ratings – 63 kA / 3 second short circuit rating, up to 5000 A, 100% SF_6-free, E2 class

Hitachi Energy

Hitachi Energy installs the world's first EconiQ 420 kV DTB in the US

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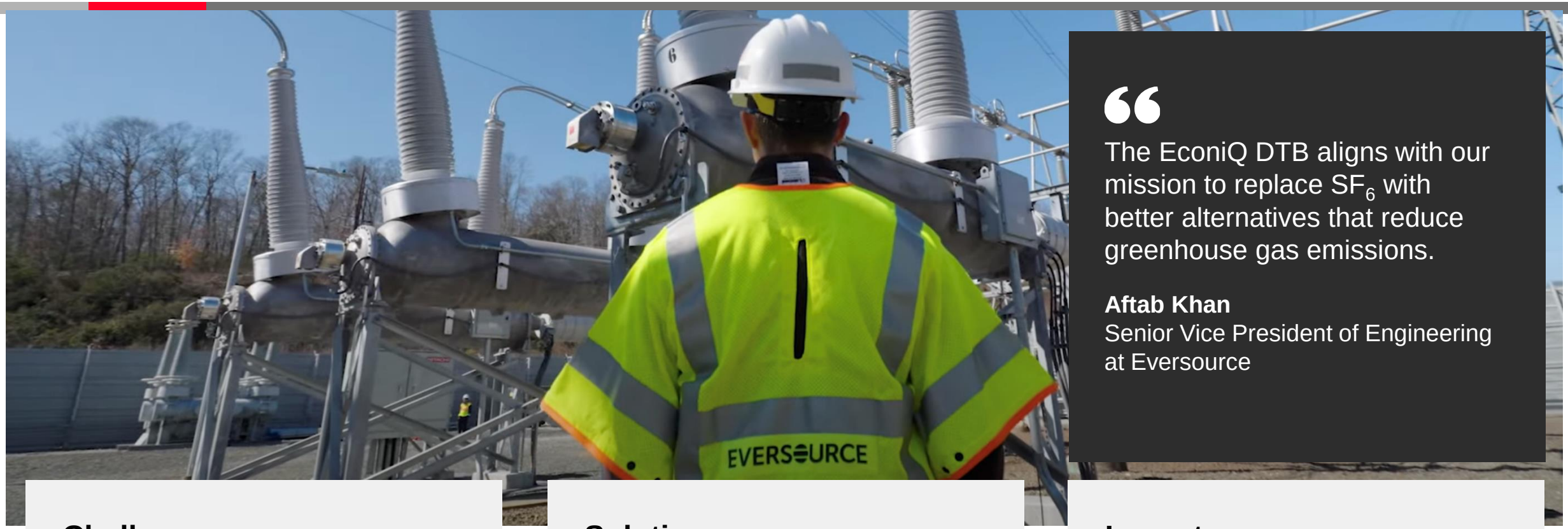

> The EconiQ DTB aligns with our mission to replace SF_6 with better alternatives that reduce greenhouse gas emissions.
>
> **Aftab Khan**
> Senior Vice President of Engineering at Eversource

Challenge

Eversource aims to build a cleaner energy future for its customers and become carbon-neutral in its operations by 2030.

Solution

Hitachi Energy installed the EconiQ 420 kV Dead Tank Circuit Breaker (DTB) at an Eversource 345 kV substation in December 2023.

Impact

The breakthrough technology will enable Eversource to reduce its carbon footprint and achieve sustainability goals

Hitachi Energy

420 kV eco-efficient Gas-Insulated Substation

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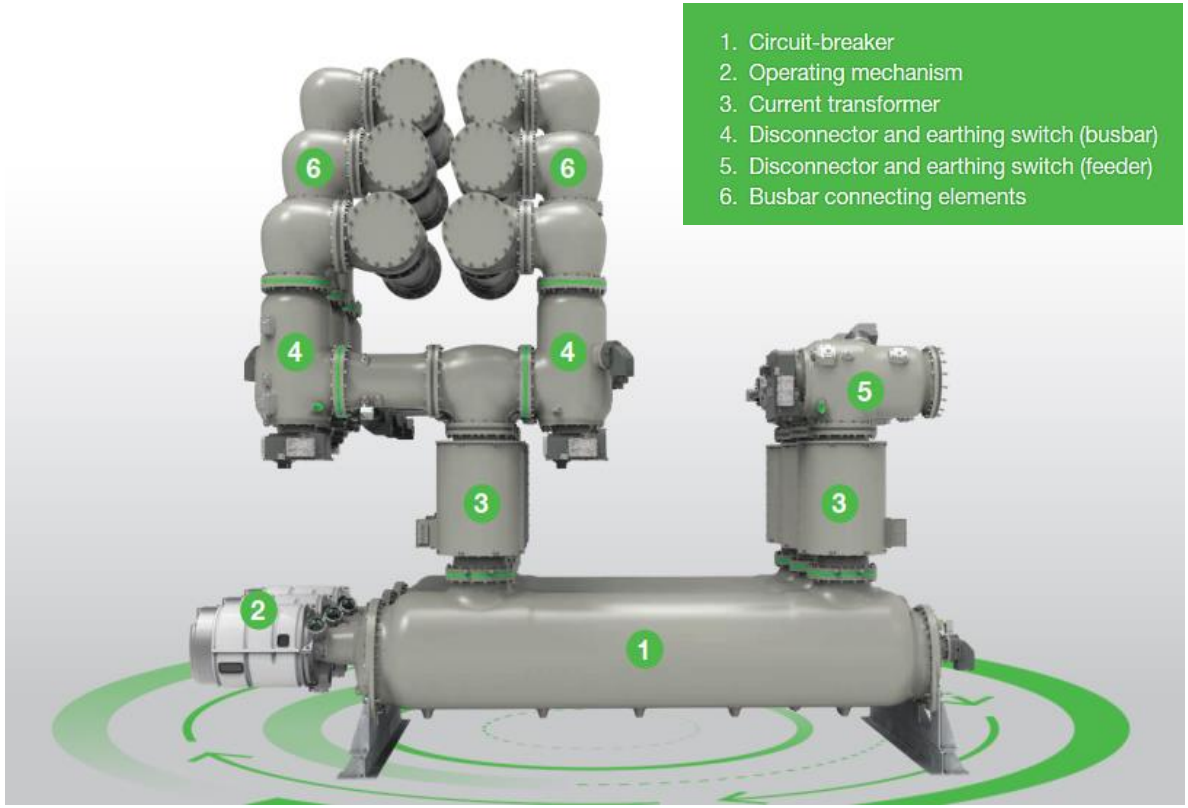
Target ratings and features

EconiQ GIS ELK-3, 420 kV		
Rated voltage	kV	420
Rated frequency	Hz	50 / 60
Rated short-duration power-frequency withstand voltage (1 min)	kV	650
Rated lightning impulse withstand voltage (1.2 / 50 µs)	kV	1425
Rated switching impulse withstand voltage (250 / 2500 µs)	kV	1050
Rated normal current (at 40 °C)	A	5000
Rated short circuit-breaking current	kA	63
Rated short-time withstand current (up to 3 s)	kA	63
Rated peak withstand current	kA	171
Circuit breaker mechanical endurance class		M2 (10,000 CO)
Circuit breaker electrical endurance class		E2
Circuit breaker capacitive switching class (k=1.4)		C2
Ambient temperature range	°C	-30…+50
Installation		Indoor / outdoor

Double Busbar Layout

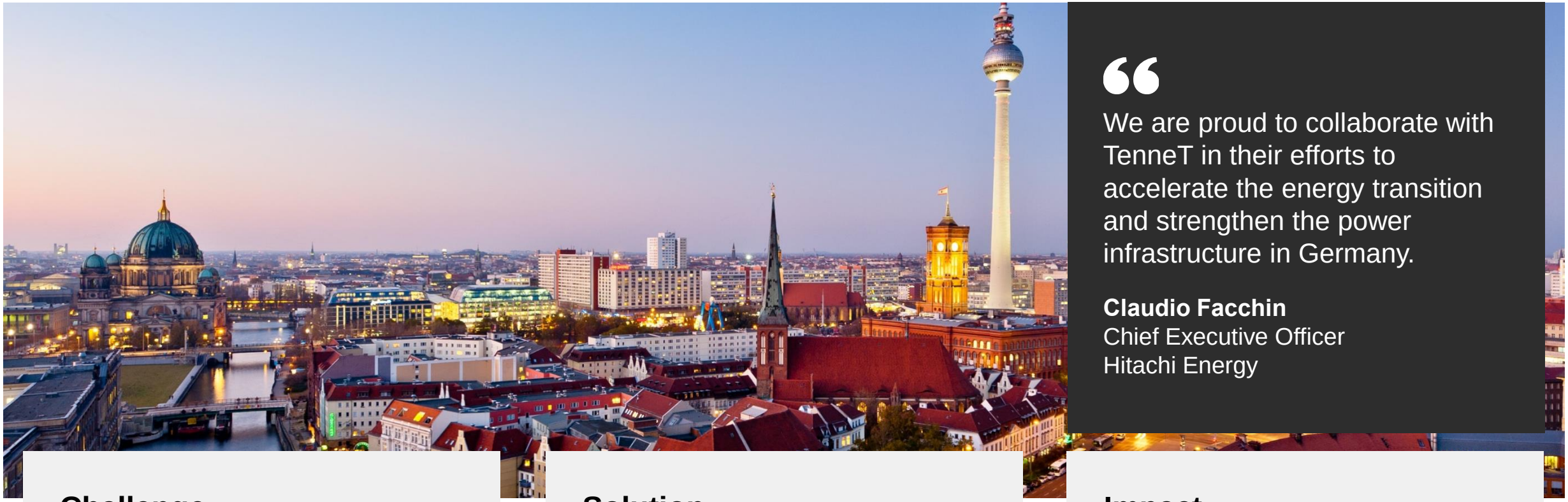


63 kA / 3 second short circuit rating, up to 5000 A, 100% SF_6-free, E2 class

Hitachi Energy

World’s first SF_6-free GIS implemented at TenneT

HITACHI
Inspire the Next



> We are proud to collaborate with TenneT in their efforts to accelerate the energy transition and strengthen the power infrastructure in Germany.
>
> **Claudio Facchin**
> Chief Executive Officer
> Hitachi Energy

Challenge

Upgrading substations with an eco-efficient SF_6 alternative to meet the growing electricity demand and support Germany’s decarbonization plans

Solution

The world’s first SF_6-free 420 kilovolt (kV) gas-insulated switchgear (GIS) and a state-of-the-art modular prefabricated grid connection solution contributes to TenneT’s carbon neutrality goals to build a sustainable and resilient grid in Germany

Impact

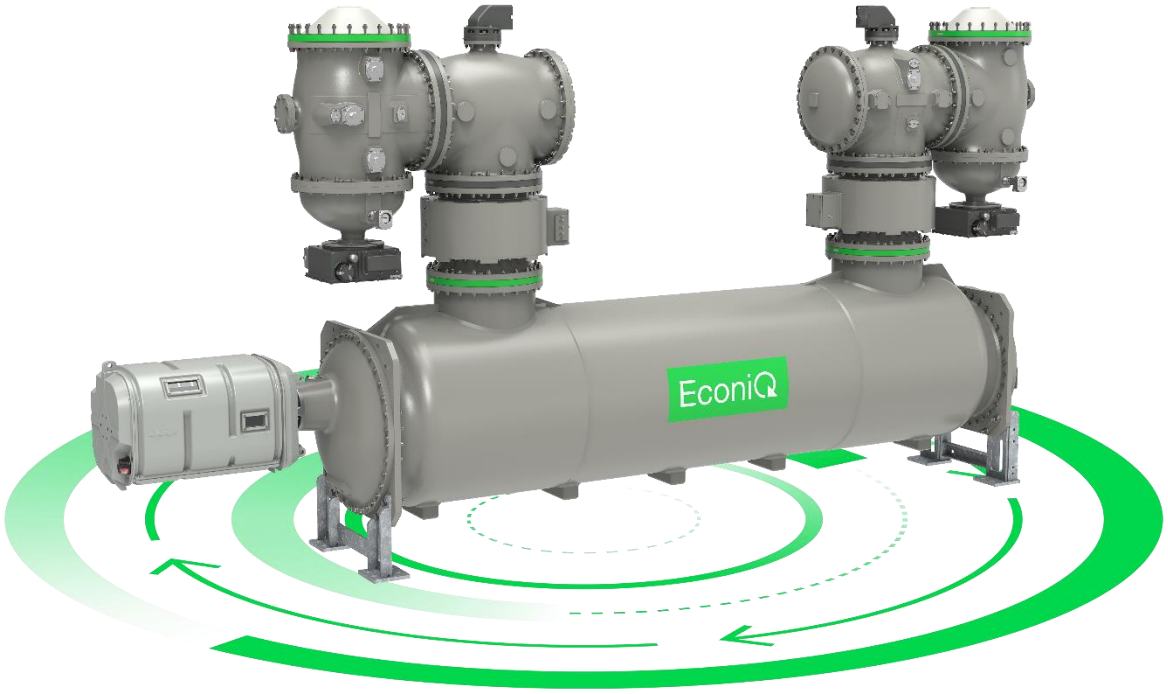
Major grid connection upgrade which significantly extends the operating life of existing power assets to ensure the longevity and continued efficiency of the existing power infrastructure

Hitachi Energy

An iconic milestone in 2024: EconiQ 550 kV circuit breaker

HITACHI
Inspire the Next

The world's first
eco-efficient 550 kV circuit breaker



Scalable to the highest voltage ratings and unlocks the widest range of EconiQ high-voltage applications like GIS and DTB

Fully tested according to the IEC and IEEE standards

As reliable and compact as the conventional SF_6 breaker technology

Practically eliminates the carbon footprint of the insulation gas

Lifetime of 40 years

Accelerates the energy transition toward a carbon-neutral future.

Hitachi Energy

EconiQ 550 kV circuit breaker

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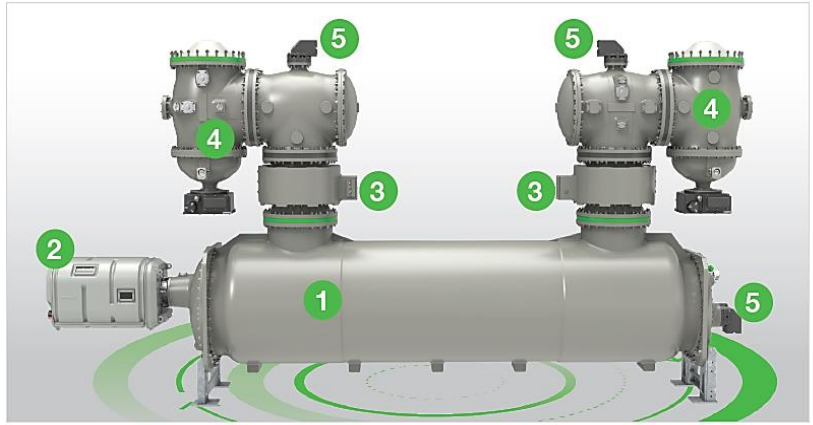
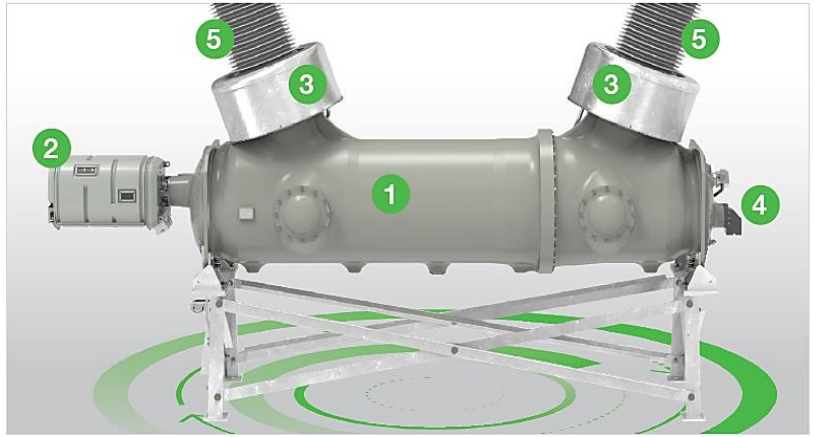
Performance data – EconiQ 550 kV circuit breaker		GIS	DTB
Rated voltage	kV	550	550
Rated frequency	Hz	50/60	50/60
Rated lightning impulse withstand voltage (1.2 / 50 µs)	kV	1675*	1800
Rated switching impulse withstand voltage (250 / 2500 µs)	kV	1300*	1300
Rated power frequency withstand voltage	kV	740*	860
Rated chopped wave impulse withstand voltage	kV	-	2320
Rated continuous current	A	5000	5000
Rated short-circuit breaking current	kA	63	63
Rated short-time withstand current (3s)	kA	63	63
Mechanical endurance class		M2	M2
Electrical endurance class		E2	E2
Capacitive switching class		C2	C2
Capacitive voltage factor for line and cable switching		1.4	1.4
Ambient air temperature	°C	-30…+40	-30**…+40
Gas mixture		CO_2 / O_2 / C4-FN	



Gas-Insulated Switchgear (GIS)

1. Circuit-breaker
2. Operating mechanism
3. Current transformer
4. Disconnector
5. Pressure relief device



Dead Tank Circuit Breaker (DTB)

1. Circuit-breaker
2. Operating mechanism
3. Current transformer
4. Pressure relief device
5. Bushing

63 kA / 3 second short circuit rating, up to 5000 A, 100% SF_6-free

* Higher ratings than IEC according to GB standard | ** Below -30 °C with tank heaters

Hitachi Energy

EconiQ 550 kV DTB supports Hydro One to achieve net zero

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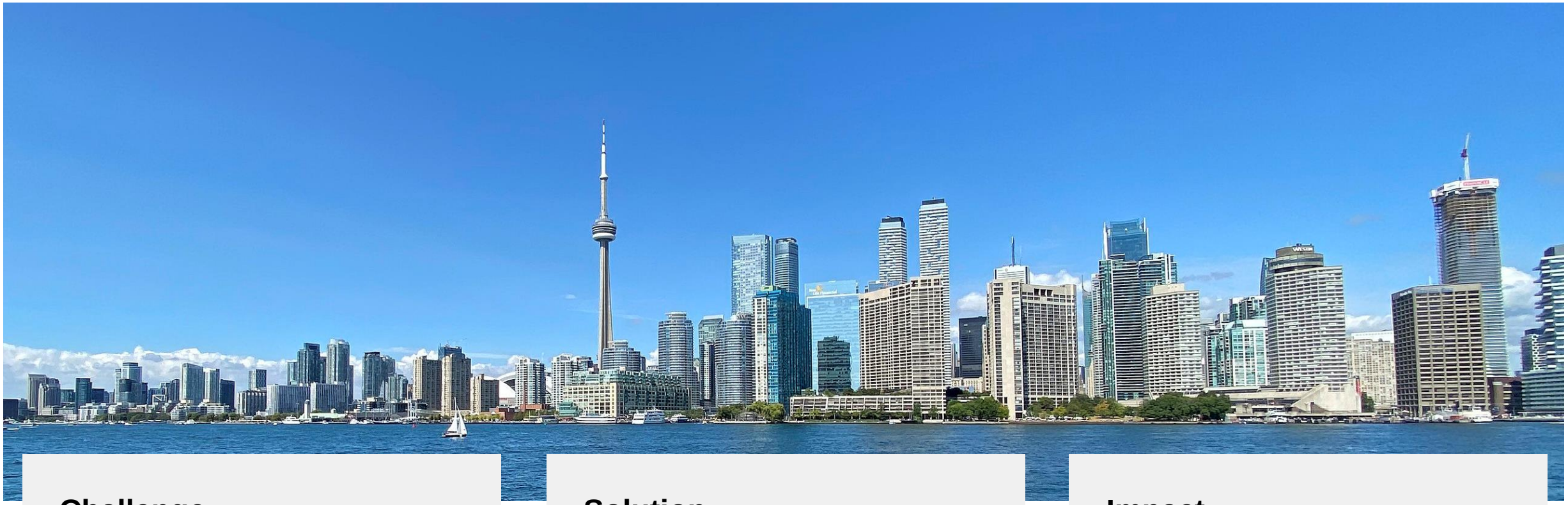

Challenge

Hydro One is Ontario's largest electricity transmission and distribution service provider. It strives to minimize the installation of new SF_6 assets to the grid.

Solution

EconiQ Dead Tank Circuit Breaker 550 kV satisfies the most stringent performance requirements. The newly ordered Dead Tank Circuit Breaker will be located at the existing 525 kV substation connecting to the Lennox Generating Station between Toronto and Ottawa.

Impact

EconiQ eco-efficient dead tank circuit breaker will support Hydro One in its goal to minimize the installation of new SF_6 assets while retaining its current high technical performance standard in the 525 kV grid.

Image: Wikipedia

EconiQ 550 kV DTB supports Wesco to achieve net zero

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Challenge

WesCo, based in Pittsburg, Pennsylvania, is committed to powering progress. It has the ambition to fulfil ambitious sustainability goals while realizing renewables projects moving at fast pace.

Solution

Hitachi Energy's EconiQ 550 kV DTB is free of SF_6 and available with suitable lead time. The pilot installation is likely to be in the 1,200 MWh energy storage facility in Maricopa County, Arizona developed by Recurrent Energy.

Impact

An important step toward contributing to the US Net-Zero Greenhouse Gas Emissions by 2050 was possible with Hitachi Energy's breakthrough technology that reduces substation greenhouse gases on high voltage equipment.

Hitachi Energy

EconiQ Live Tank Circuit Breaker – LTA

Scalable eco-efficient Live Tank Circuit Breakers

Combining the reliability and experience from gas type circuit breakers with the use of carbon dioxide (CO_2) and oxygen (O_2) as an eco-efficient insulation gas mixture

Type	LTA 72.5D1	LTA 145D1	DCB-LTA 72.5D1
Rated voltage	72.5 kV	145 kV	72.5 kV
Rated current	2750 A	3150 A	2750 A
Rated short-time withstand current	31.5 kA	40 kA	31.5 kA
Rated frequency	50 Hz	50 Hz	50 Hz
Ambient temperature	-50/+40 °C	-50/+50 °C	-50/+40 °C
Gas-mixture	$CO_2 + O_2$	$CO_2 + O_2$	$CO_2 + O_2$

New 420 kV EconiQ breaker application: EconiQ 420 kV LTA

HITACHI
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The world's first

eco-efficient 420 kV live tank circuit breaker LTA

- **Fully tested as described in** the IEC standards
- **Based on well-proven** gas circuit breaker technology
- **Same footprint asnd reliability** as the conventional SF_6 solution
- **Easy retrofit** in existing substations
- **Designed to operate** in temperatures as low as -50° C
- **Suitable for shunt reactor switching**

Hitachi Energy

EconiQ 420 kV Live Tank Circuit Breaker – LTA

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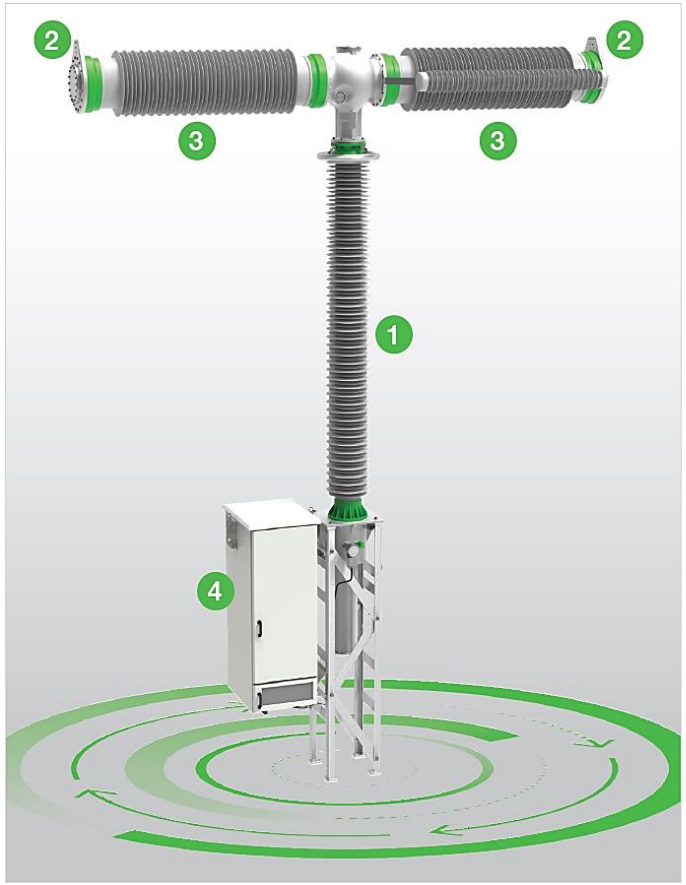
Performance data – EconiQ Live Tank Circuit Breaker – LTA		
Rated voltage	kV	420
Rated frequency	Hz	50
Rated lightning impulse withstand voltage (1.2 / 50 µs)	kV	1425
Rated switching impulse withstand voltage (250 / 2500 µs)	kV	1050
Rated power frequency withstand voltage	kV	610
Rated continuous current	A	up to 5000
Rated short-circuit breaking current	kA	63
Rated short-time withstand current (3s)	kA	63
Mechanical endurance class		M2
Electrical endurance class		E2
Capacitive switching class		C2
Capacitive voltage factor for line and cable switching		1.4
Ambient air temperature	°C	-50…+40
Gas mixture		CO_2 / O_2



Live Tank Circuit Breaker
LTA for 420 kV

1. Post insulator
2. Terminals
3. Breaking unit
4. Operating mechanism

100% as reliable and compact

as the conventional SF_6-based solution.

63 kA / 3 second short circuit rating, up to 5000 A, 100% SF_6-free

Hitachi Energy

Breakthrough EconiQ 420 kV LTA support SSEN to achieve net zero

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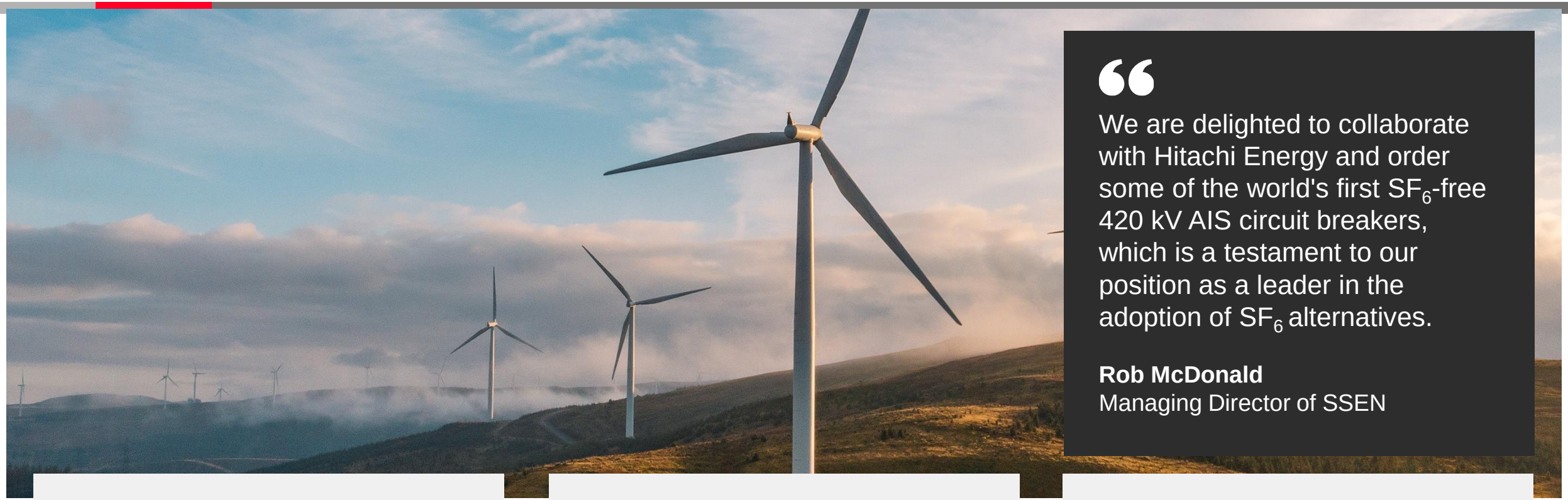

> We are delighted to collaborate with Hitachi Energy and order some of the world's first SF_6-free 420 kV AIS circuit breakers, which is a testament to our position as a leader in the adoption of SF_6 alternatives.
>
> **Rob McDonald**
> Managing Director of SSEN

Challenge

SSEN, the UK-based international energy company supplies 10,200 GWh of renewable energy per year. It requires pioneering sustainable energy solutions to fulfil their aim to be net zero by 2030

Solution

Hitachi Energy will deliver the new generation EconiQ 420 kV LTA that will eliminate 100% of the CO_2 equivalent emissions related to the insulation gas and strengthen the network

Impact

The new order supports SSEN's plans to phase out SF_6 entirely and cut its carbon intensity by 80% by 2030, while also enabling at least 20GW of renewable energy, 2 million EVs and 1 million heat pumps to be connected to its electricity network

Hitachi Energy

Breakthrough EconiQ 420 kV LTA support TenneT to achieve net zero

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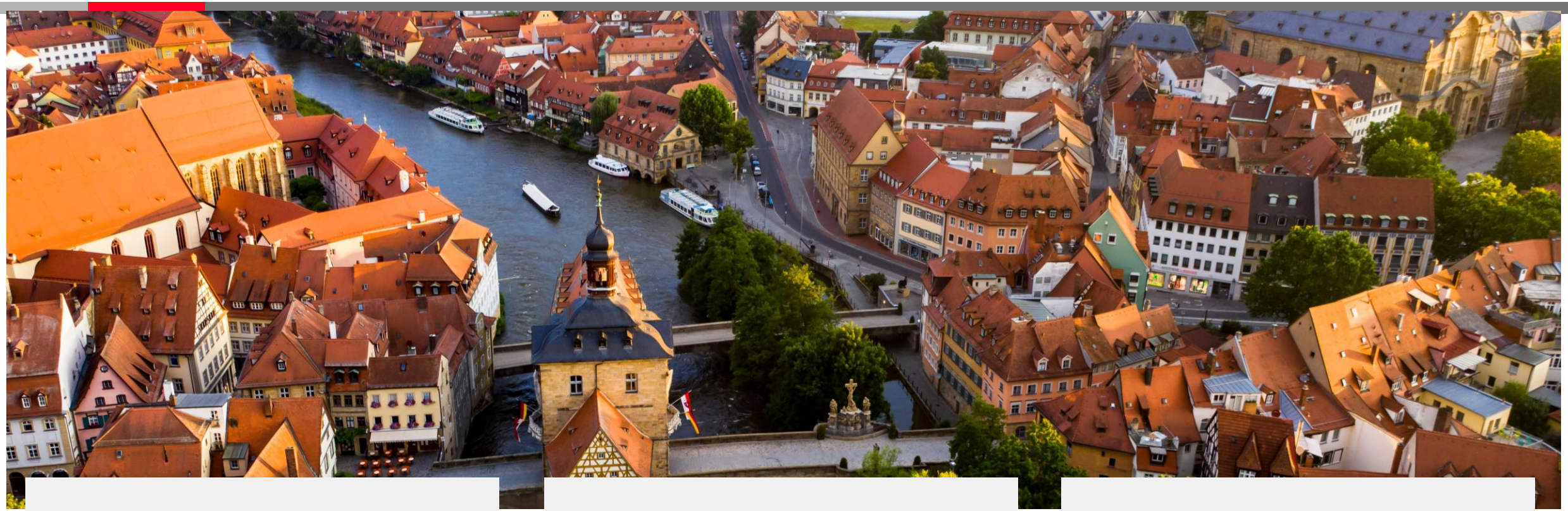

Challenge

Rebuilding a substation with an eco-efficient SF_6 alternative to meet the growing electricity demand and support Germany's and The Netherland's decarbonization plans

Solution

The eco-efficient EconiQ Live Tank Circuit Breaker (LTA 420 kV) is a reliable solution to eliminate 100% of the CO_2 equivalent emissions related to the insulation gas and strengthen the German and Dutch grids. The innovative breaker will be installed in an existing 380 kV AIS substation.

Impact

Contributing to TenneT's plan to cut at least 30 percent of its scope 3 upstream emissions by 2030 with the target to achieve carbon-neutrality by 2050.

EconiQ breaker contributes to Norway’s journey towards net-zero

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> We are excited to join forces with Hitachi Energy to bring new and innovative EconiQ technology that reinforces our strategy for sustainable operations.
>
> **Atle Isaksen**
> Head of Grid Development, BKK Nett

Challenge

Rebuilding a substations with an eco-efficient SF_6 alternative to meet the growing electricity demand and support Norway’s decarbonization plans

Solution

The eco-efficient EconiQ Live Tank Circuit Breaker (LTA) is a reliable solution to eliminate 100% of the CO_2 equivalent emissions related to the insulation gas and strengthens the Norwegian grids

Impact

Contributing to Norway’s plans to cut at least 50 percent of its greenhouse gases by 2030 with the target to achieve carbon-neutrality by 2050

Hitachi Energy

EconiQ gas-insulated lines ELK-3, 420 kV

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The EconiQ GIL enables significant reduction of SF_6 compared to standard layouts.

The modular design of the product allows multiple configurations and substitution of the insulation gas with an eco-efficient alternative.

Performance data – EconiQ GIL ELK-3, 420 kV		
Rated voltage	kV	420
Rated short-duration power-frequency withstand voltage	kV	650
Rated lightning impulse withstand voltage	kV	1425
Rated frequency	Hz	50 / 60
Rated normal current	A	5000
Rated withstand current	kA	63
Rated peak current	kA	171
Installation		Indoor / Outdoor

The data are not limiting values. Additional data on request.

Hitachi Energy

EconiQ retrofill supports National Grid in achieving sustainability targets

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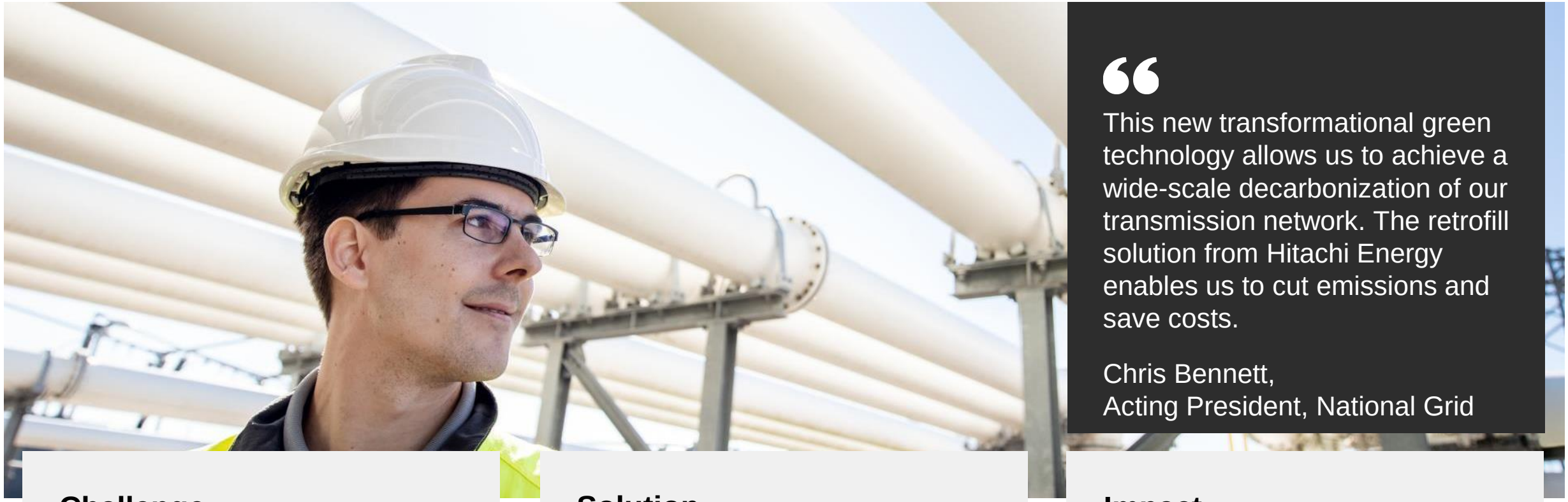

> “This new transformational green technology allows us to achieve a wide-scale decarbonization of our transmission network. The retrofill solution from Hitachi Energy enables us to cut emissions and save costs.
>
> Chris Bennett,
> Acting President, National Grid

Challenge

Support National Grid’s vision of eliminating SF_6 from all its high-voltage assets by 2050

Solution

Hitachi Energy successfully replaced SF_6 from installed high-voltage gas-insulated lines with EconiQ retrofill solution at 420 kV Richborough substation in UK

Impact

The innovative EconiQ retrofill solution will deliver superior environmental performance eliminating 755 Kgs of SF_6 - equivalent to taking 100 passenger cars off the road.*

* Based on the assumption that a car emits 19 kg CO_2 equivalent per 100 km, drives 10,000 km per year, and an estimated leakage rate of 1 % per year for gas-insulated lines

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EconiQ technology contributes to Scotland’s sustainability targets

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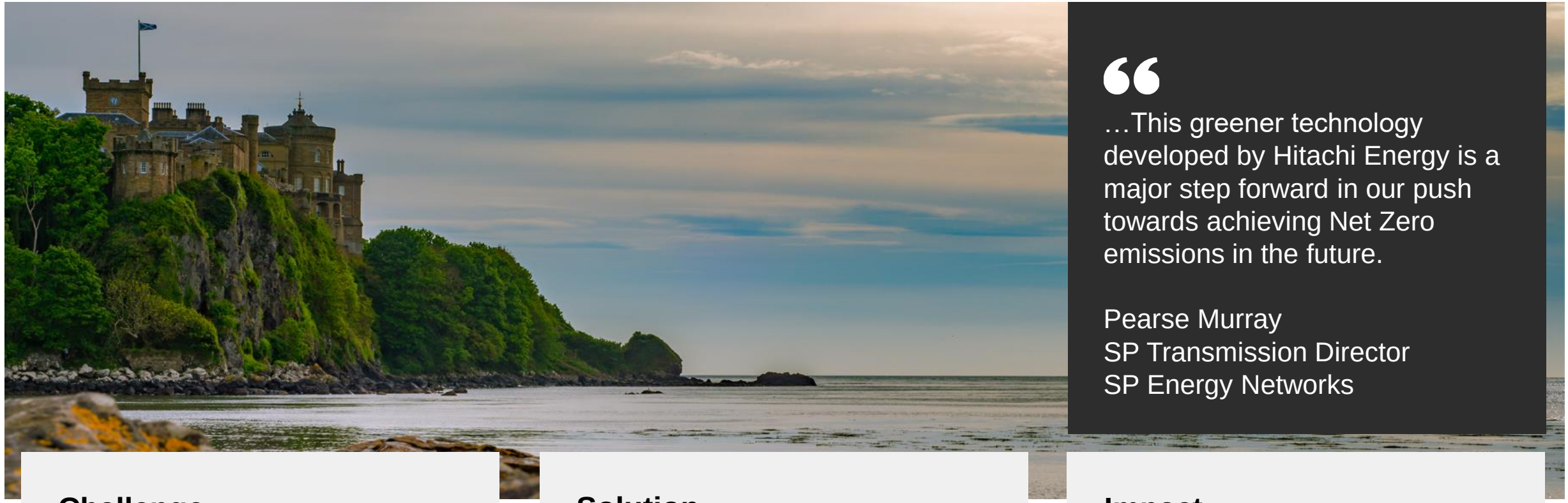

> “…This greener technology developed by Hitachi Energy is a major step forward in our push towards achieving Net Zero emissions in the future.
>
> Pearse Murray
> SP Transmission Director
> SP Energy Networks

Challenge

Decarbonizing the power grid, upgrading ageing energy infrastructure and bringing advanced technologies to the Scottish power transmission network.

Solution

1,500 meters of reliable and eco-efficient EconiQ gas-insulated lines, which contains no SF_6 and eliminate CO_2-equivalent emissions throughout the total lifecycle.

Impact

Refurbishment of a strategic substation with pioneering EconiQ technology and contributing to Scotland’s goals to reduce greenhouse gas emissions to net zero by 2045.

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High-voltage Switchgear manufacturing facilities

Tangerang, Indonesia

Hitachi Energy

High-voltage Switchgear manufacturing facilities

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Tangerang, Indonesia

Air-Insulated switchgear shop floor

Gas-Insulated switchgear shop floor

High-voltage Switchgear manufacturing facilities

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Testing

Testing Facility

- High-voltage products are completely tested according international standards and Power Grids quality assurance procedures
- Explosion proof test chamber for LTB products
- Gas-insulated testing transformer for GIS products
- Mechanical testing according to IEC 62271-100
- High-voltage testing according to IEC 62271-203
- Leakage test according to IEC 62271-1
- Partial discharge detection for GIS IEC 62271-102 and IEC 60271

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High-voltage Switchgear manufacturing facilities

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Product Portfolio

State-of-the art HV products and technology

- High-voltage circuit breaker Live Tank Breaker (LTB), type LTB-D-72.5 – 170 KV, the world's most installed HV breaker
- Horizontal center break disconnector SDF 72.5 – 170 KV for maximum reliability and minimal maintenance
- Instrument transformer CVT and CT up to 170 KV
- Gas insulated switchgear, type ELK-04 with ratings up to 170 KV, 4000 A and 63 KA

LTB

SDF

GIS

CVT

CT

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High Voltage Products Success Stories
150 kV Senayan GIS

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PLN Unit : UIP – JBB
GIS Type : ELK-04 Indoor
Nb. Bay : 15 Bay, 5 Dia

Background
Senayan Gas Insulated Substation consist of 15 Bay in 5 Diameter.
Senayan GIS is under PLN – JBB Operation and located in center of Jakarta Capital City. This Substation is aimed to reinforce the reliability of electricity supply to Jakarta network.

Project Status
Delivery of GIS was near to end of 2018 and I&C of this Substation was completed in August 2019 and put in operation since then.

Hitachi Energy Solution
- Reliable ELK-04 GIS fits to this critical substation,
- Supported by HE local experienced and Certified Field Service Engineer during I&C.

35 Days of I&C and Project Completion was meeting with PLN Contract Schedule.

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High Voltage Products Success Stories
150 kV Tambak Lorok GIS

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PLN Unit : UIP – JBT II
GIS Type : ELK-04 indoor
Nb. Bay : 34 Bay

Background
Tambak Lorok Gas Insulated Substation consist of 34 Bay – Indoor Type.
Tambak Lorok GIS is under PLN – JBT Operation and located in outskirt of Semarang City. This Substation is aimed to replace the existing Air Insulated Substation to reinforce the reliability of mid Java electricity network.

Project Status
All Material have been delivered to the site and the I&C of this Substation is expected to commence in this September due to customer constraint.

Hitachi Energy Solution
- Reliable ELK-04 GIS fits to this critical substation,
- supported by HE local experienced and Certified Field Service Engineer during I&C.

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High Voltage Products Success Stories
150 kV Asahi Mas GIS - Extension

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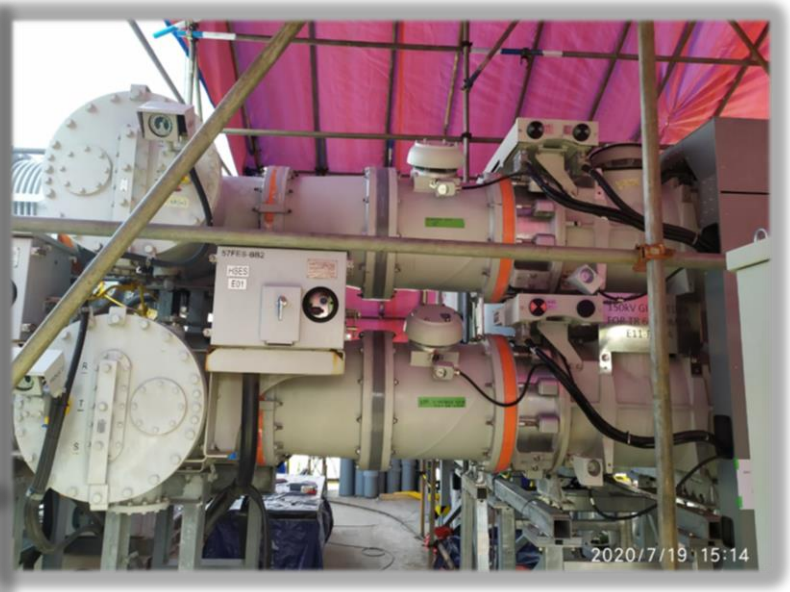
Customer : Asahimas
GIS Type : ELK-04 Outdoor
Nb. Bay : 5 Bay

Background
Asahimas is a Chemical Industry located in Banten Province
This Substation is aimed to extend the Power Plant capacity to the existing substation and ensure the reliability of electricity supply into their operation.

Project Status
Delivery of GIS was in May 2019 and the I&C of this Substation was completed in October 2019 and put in operation since then.

Hitachi Energy Solution
- Reliable ELK-04 GIS fits to this critical substation Outdoor application,
- Customized adapter to the existing HITACHI GIS
- Local Design LCC and Secondary
- supported by HE local experienced and Certified Field Service Engineer during I&C.

Project Completion was meeting with PLN Contract Schedule.



Project Scope

3 (2TB + 1LB) Bays extension Outdoor for Industrial supply

2 (1TB + 1LB) Bays extension Indoor application

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