

PUBLIC

HITACHI
Inspire the Next

Hitachi Energy Day – Cape Town

Session 3: Enhancing grid reliability with safety by design transformers

9 March 2023

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 **Hitachi Energy**

PUBLIC

HITACHI
Inspire the Next



Innovation using Hitachi Energy Transformers

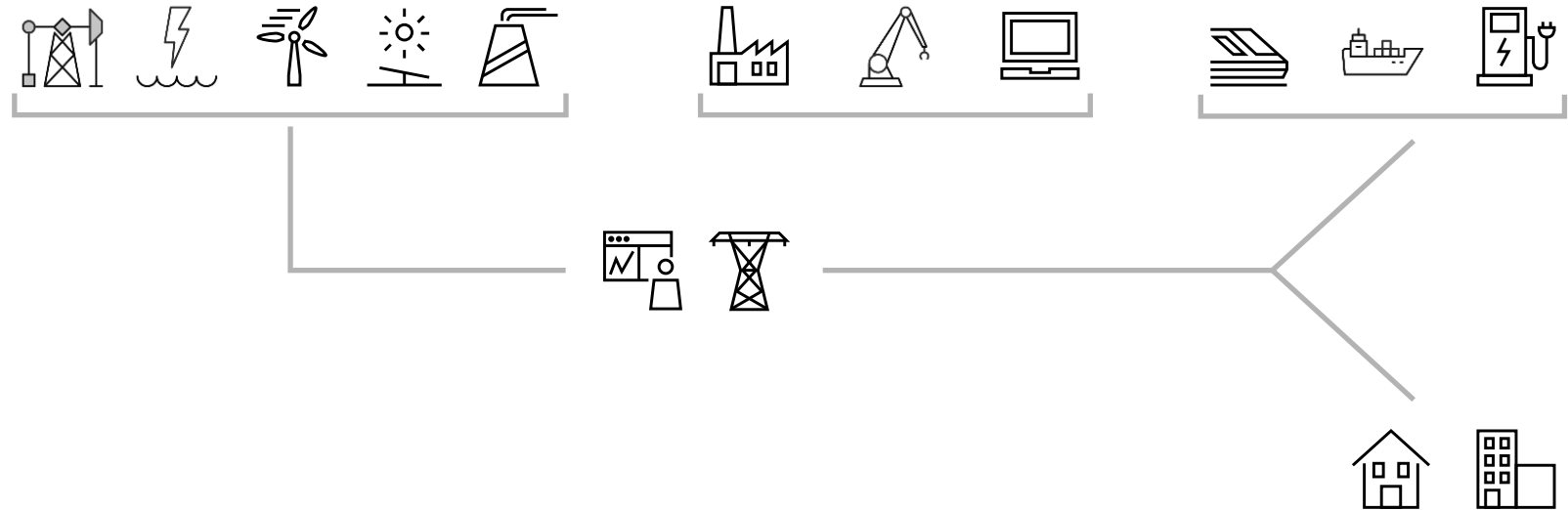
Mohamed El-Fayoumy - Transformers Application Engineer, Asia Pacific Middle East & Africa

New Innovations in Transformers

1. Introduction
2. Hitachi Energy Innovative Transformers solution for more reliability
3. Hitachi Energy Digitalization Solutions
4. Hitachi Energy Decentralization Solutions
5. Hitachi Energy Transformers Services
6. Questions and answers

Today wherever you are a transformer is powering you

- Transformers are fundamental to electrical networks, they enable efficient and safe power transmission and consumption
- With increasing complexity in the grid, transformers are also increasingly used for improving power quality and network management



Power generation



Transmission and distribution



Metals & Mining, Oil & Gas



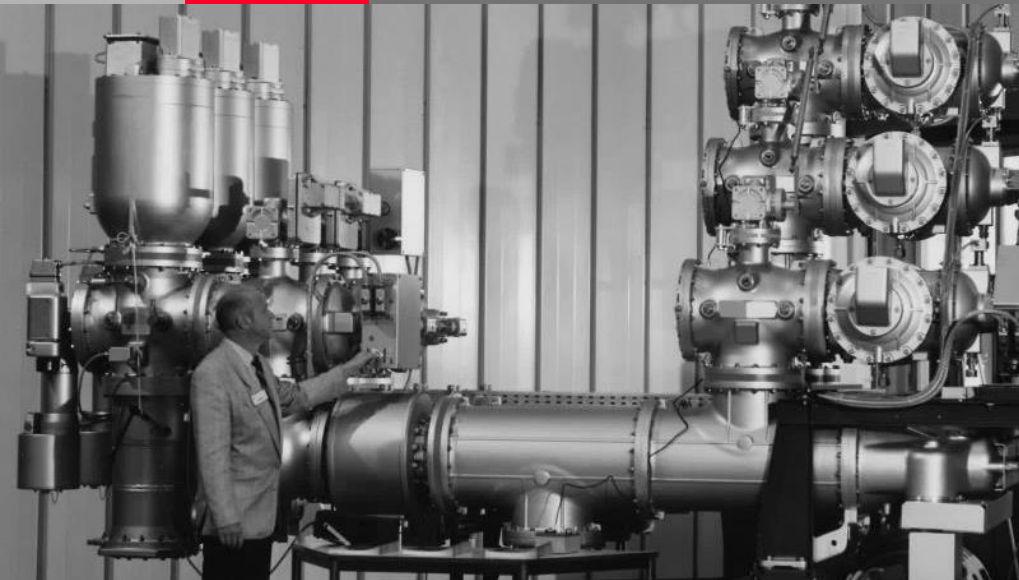
Industry



Mobility



Commercial and Infrastructure



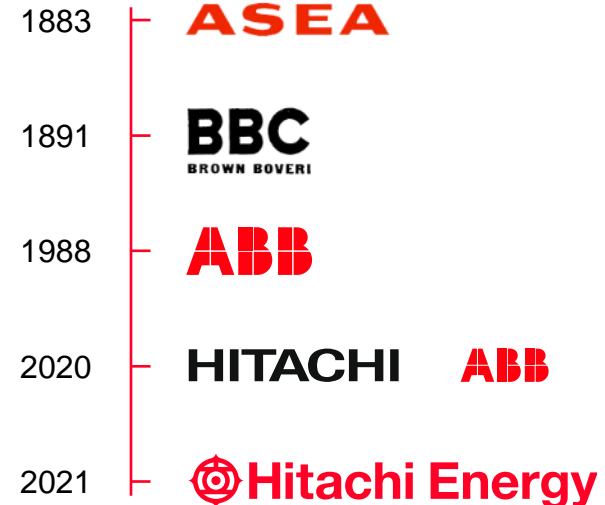
A legacy of
excellence.

A heritage of
commitment.



OUR JOURNEY

- As a global leader, we revolutionized transformer technology and pioneered many world's firsts to bring safety, reliability and efficiency to power distribution networks around the globe.
- At Hitachi Energy, we are committed to advancing the world's energy system to be more sustainable, flexible, reliable and secure.
- We continue to build on this remarkable heritage to tackle today's challenges and advance a **sustainable energy future for all.**

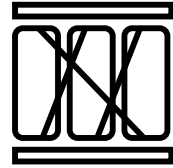


The journey continues with the world's largest installed base



>2,000,000

Distribution transformers



>325,000

Dry transformers



>75,000

Power transformers



>30,000

Traction transformers

>4,000

Reactors

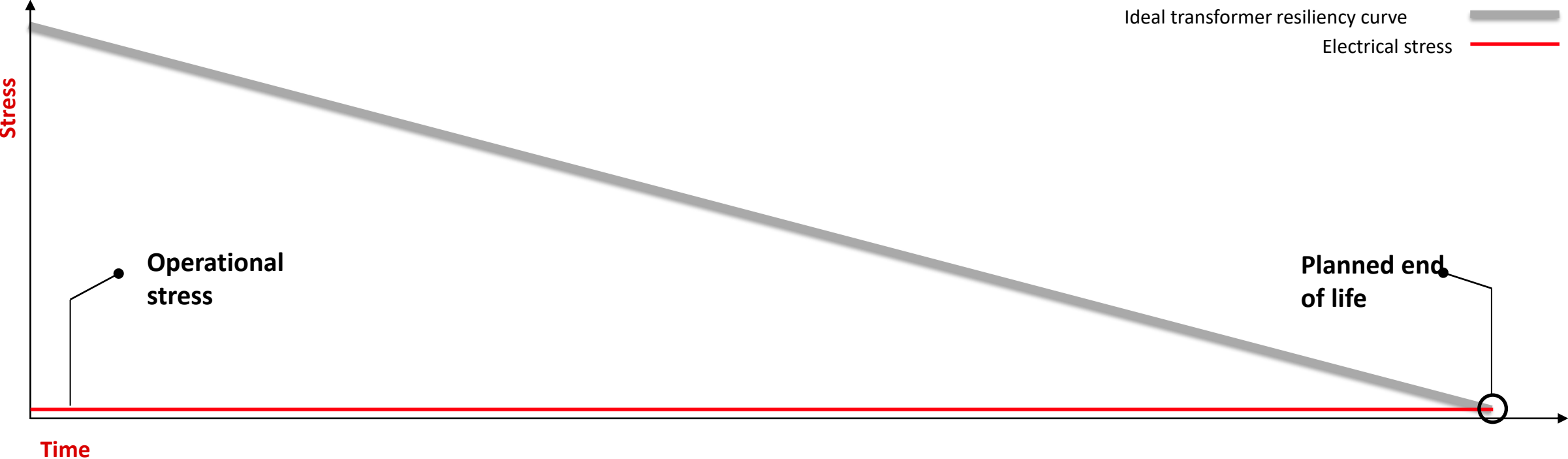
>700

HVDC transformers

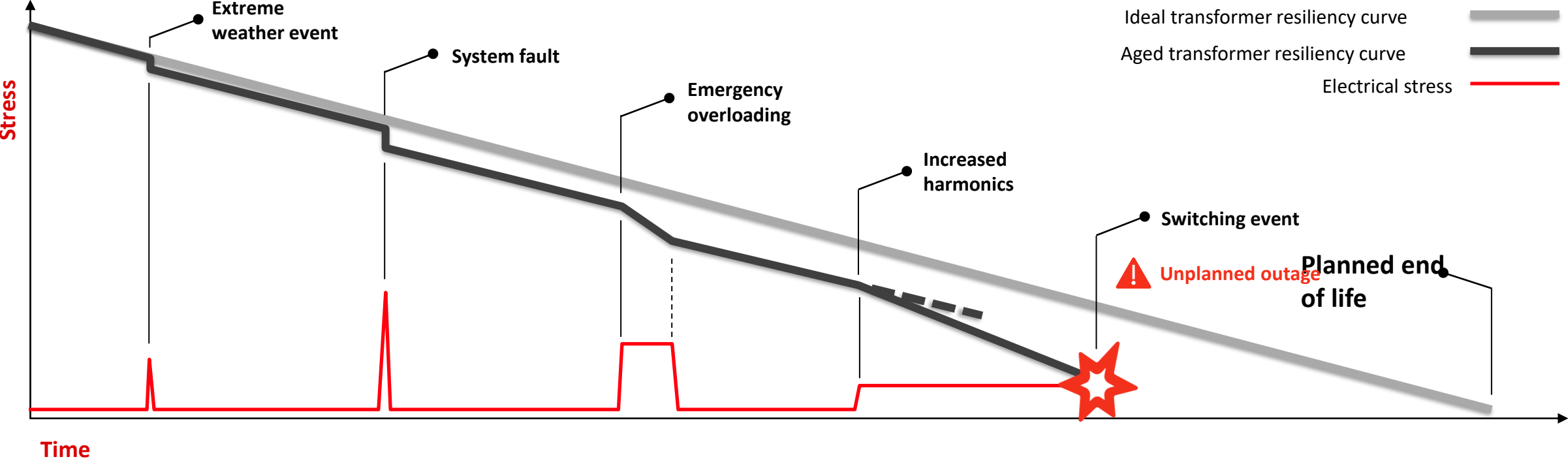
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Ideal transformer life curve



Realistic transformer life curve



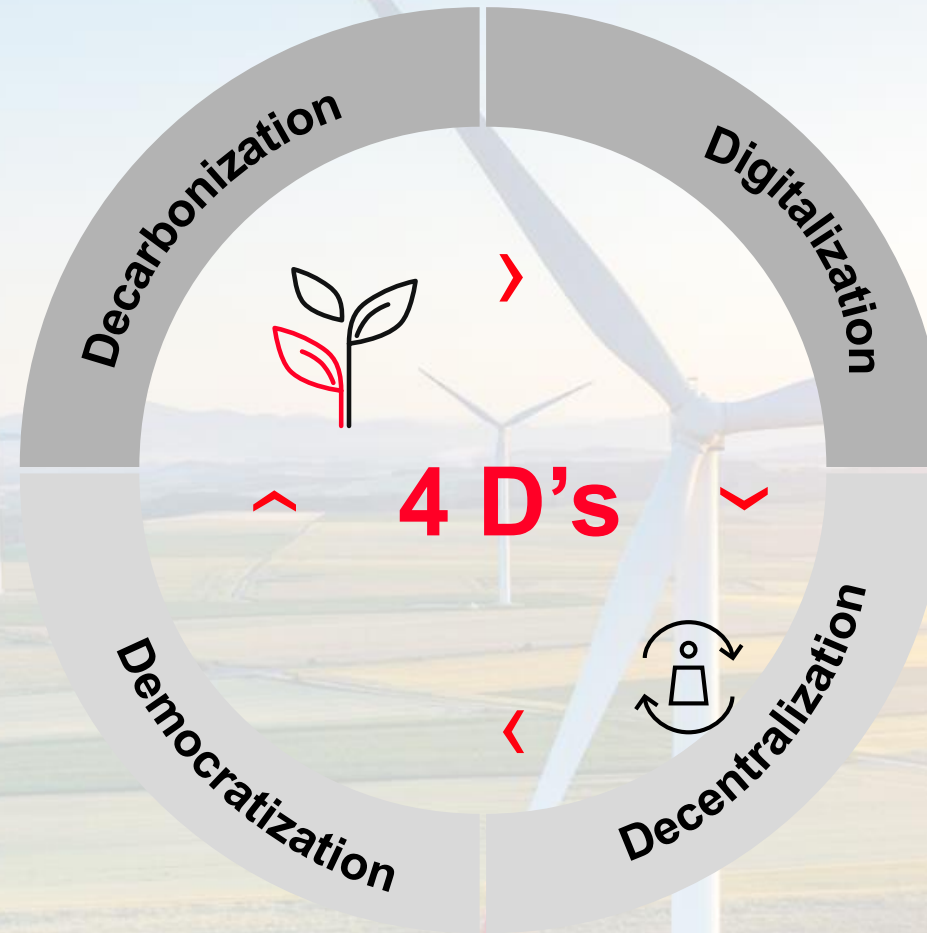
Unplanned outages are costly and result in significant downtime

DECARBONIZATION

IPCC TAR **Observed** warming of the Earth's surface, attribution of observed warming to human activities imperative to reduce carbon emissions = **we can no longer rely on burning fossil fuels.**

DEMOCRATIZATION

The energy system will no longer be confined to "Power houses" or experts, it will be opened up so that **any interested and motivated stakeholder can actively engage and make a difference.**












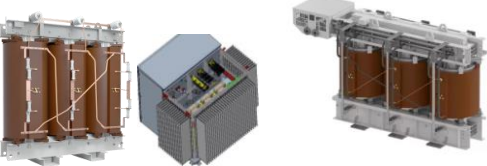



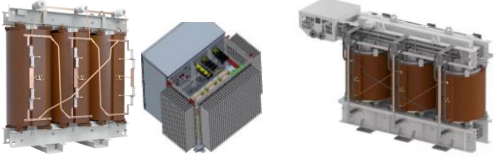






DIGITALIZATION

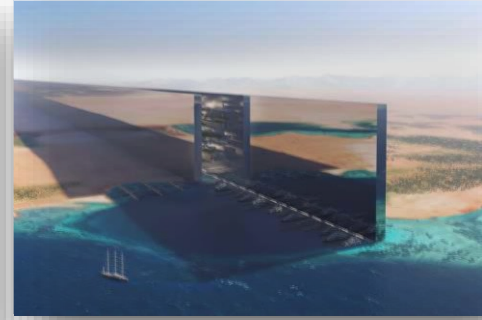
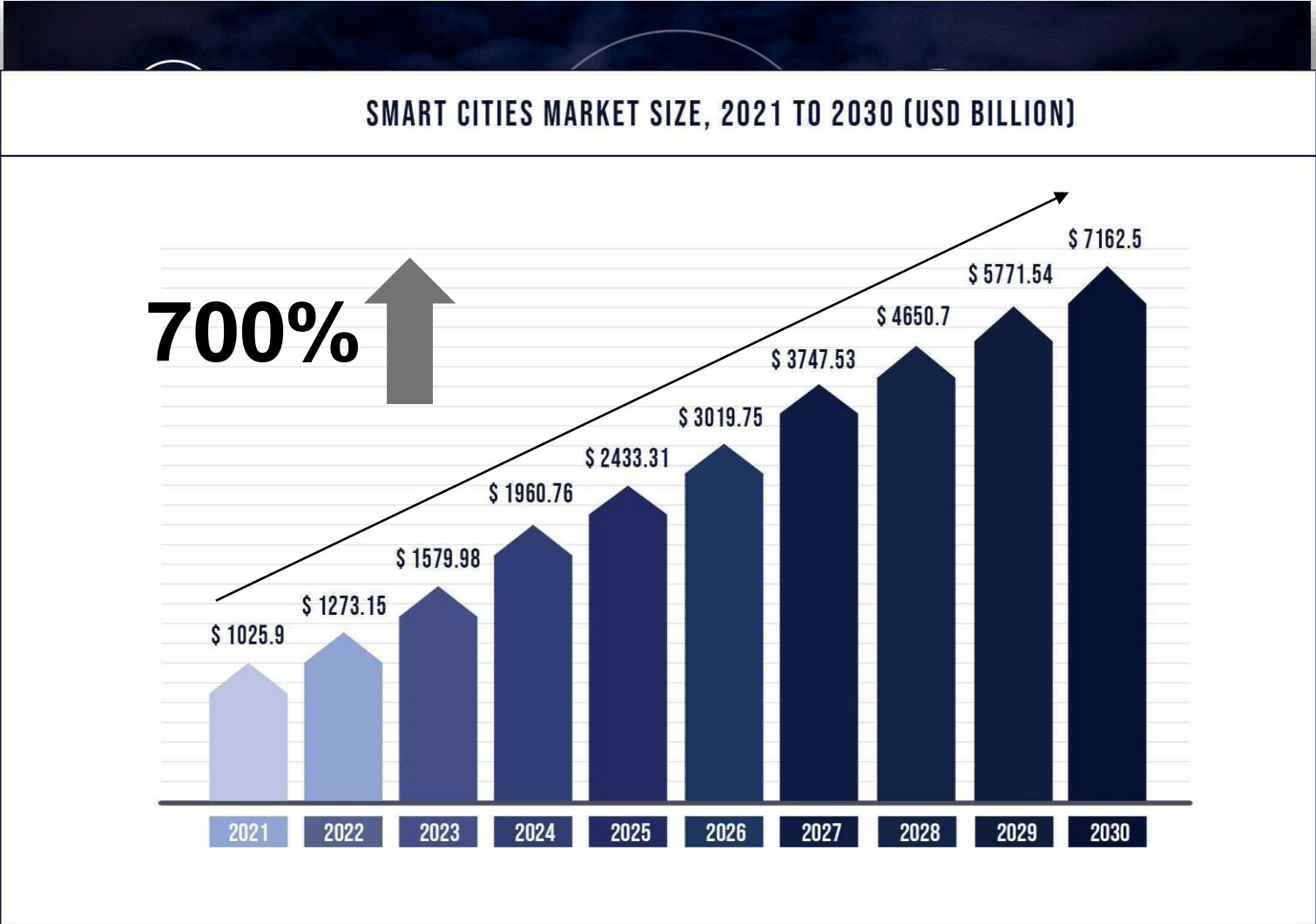
We must harness digital technologies, mastering the world of sensors and data analytics, machine learning (ML), and the internet of things (IoT).

DECENTRALIZATION

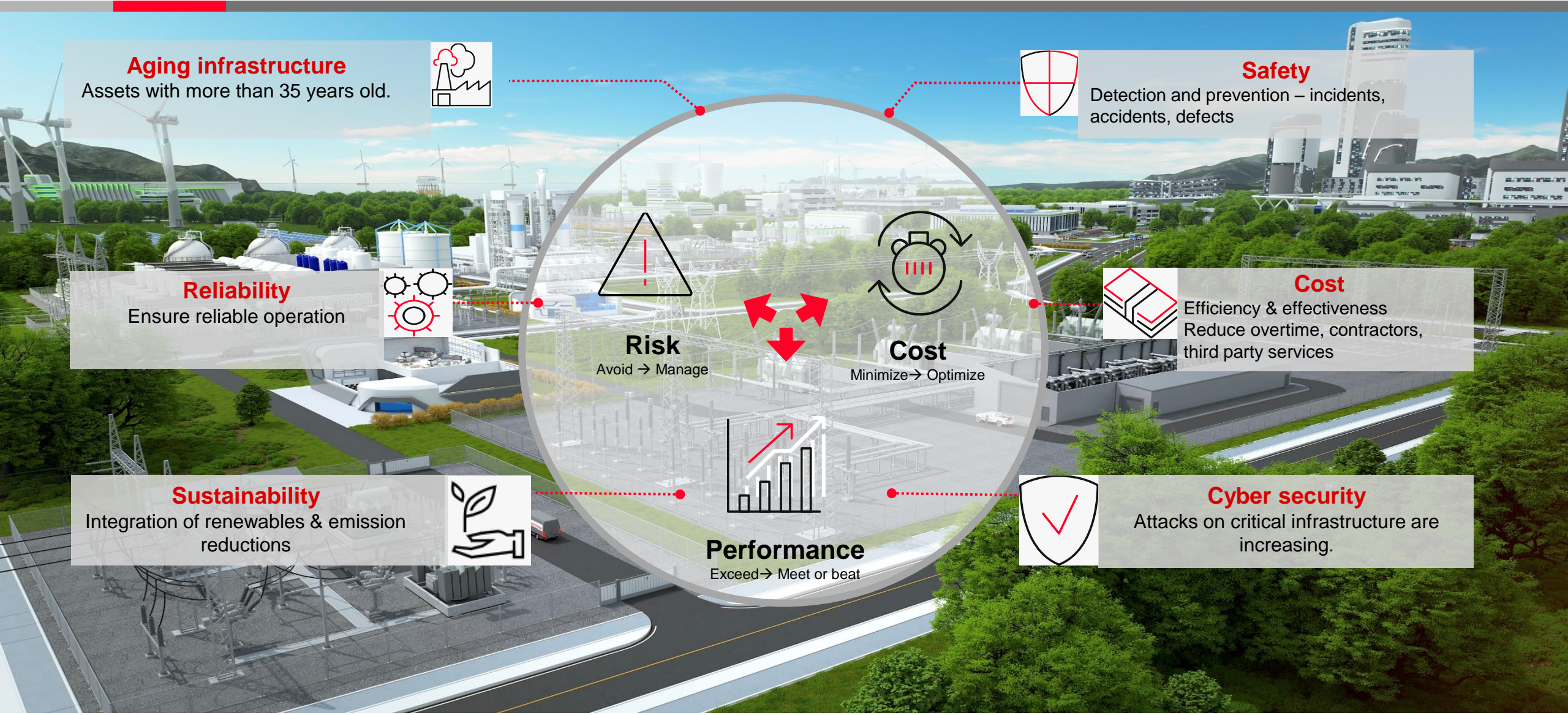
We are now embracing decentralized energy resources (DERs), moving from relatively few remote bulk generation points. Transitioning to "the grid to millions" of smaller locally based systems.

Keeping Pace with concepts that are transforming future of Energy

Segment	Digitalization	Reliability	Decarbonization	Decentralization
<p>Utilities</p> 	<p>TXpert™ Ecosystem</p>   <p>APM Edge Transformer only</p>	<p>Hi Dry</p> 	<p>EconIQ TXpand</p>  	<p>Line Voltage Regulators</p> 
<p>Renewables</p> 	<p>TXpert™ Ecosystem</p> 	<p>TVP CompactCool</p> 	<p>Fit for Purpose” (F4P) Step-up collector transformers</p>	<p>Containerized Solutions</p> 
<p>Infrastructure Dtc / Building / Trans</p> 	<p>TXpert™ Ecosystem</p> 	<p>TVP CompactCool</p> 	<p>Dry TRs Ester Filled</p>  <p>FR3 DIELECTRIC FLUID</p>	<p>Containerized Solutions</p> 
<p>Industries O&G / F&B / METAL</p> 	<p>TXpert™ Ecosystem</p>  <p>CoreSense M10 DGA Multi-GAs</p>	<p>TVP</p> 	<p>K-Factor TRs Life Cycle Analysis Dry Type TRs</p>	<p>Remote Monitoring & Services</p> 



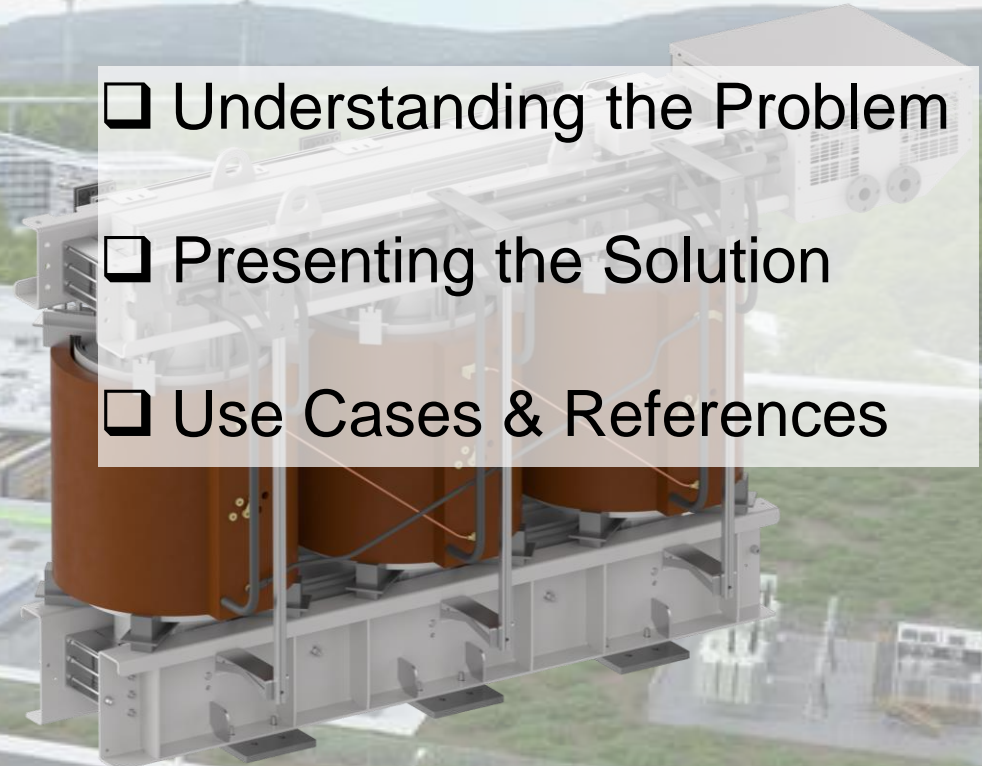
Electrification Challenges Facing Smart Cities



Transient Voltage Protection Technology



CompactCool Technology

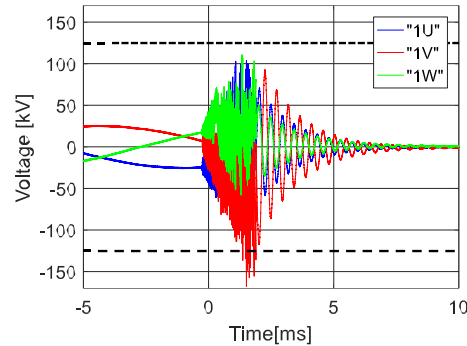


- Understanding the Problem
- Presenting the Solution
- Use Cases & References

What was known... Transformer / circuit breaker interaction induced fast transients



Vacuum circuit breakers (VCB's) have incredible arc-quenching capabilities that bring increased safety and efficiency to electrical systems

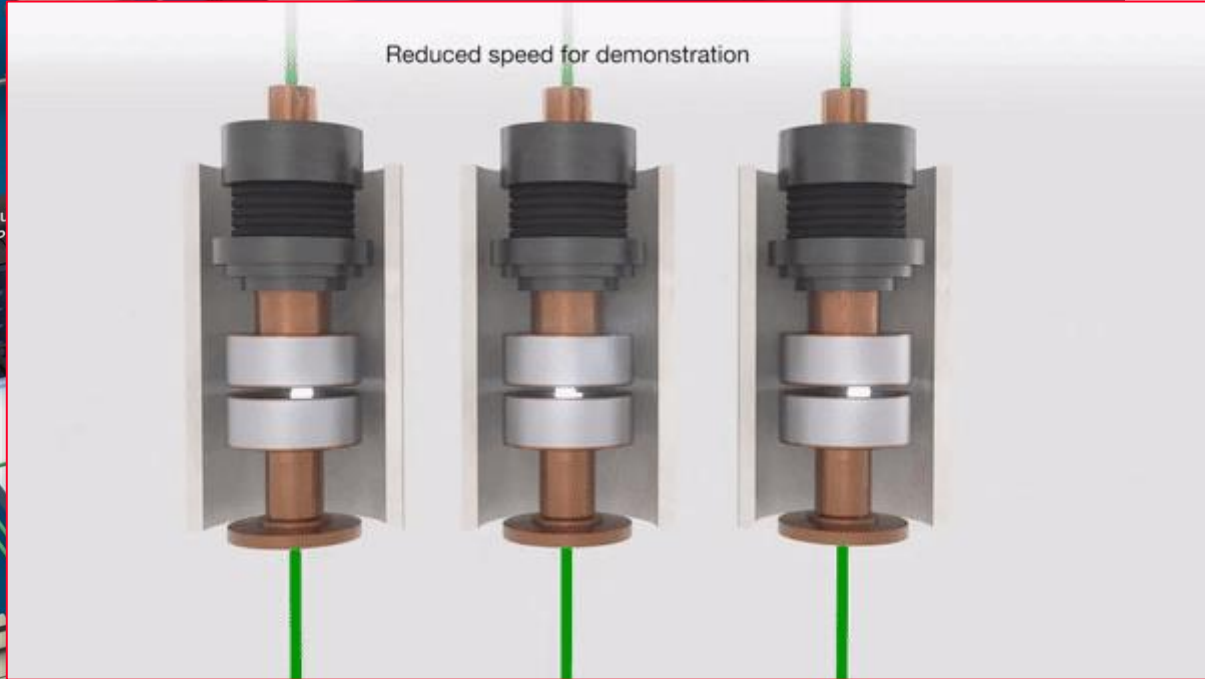
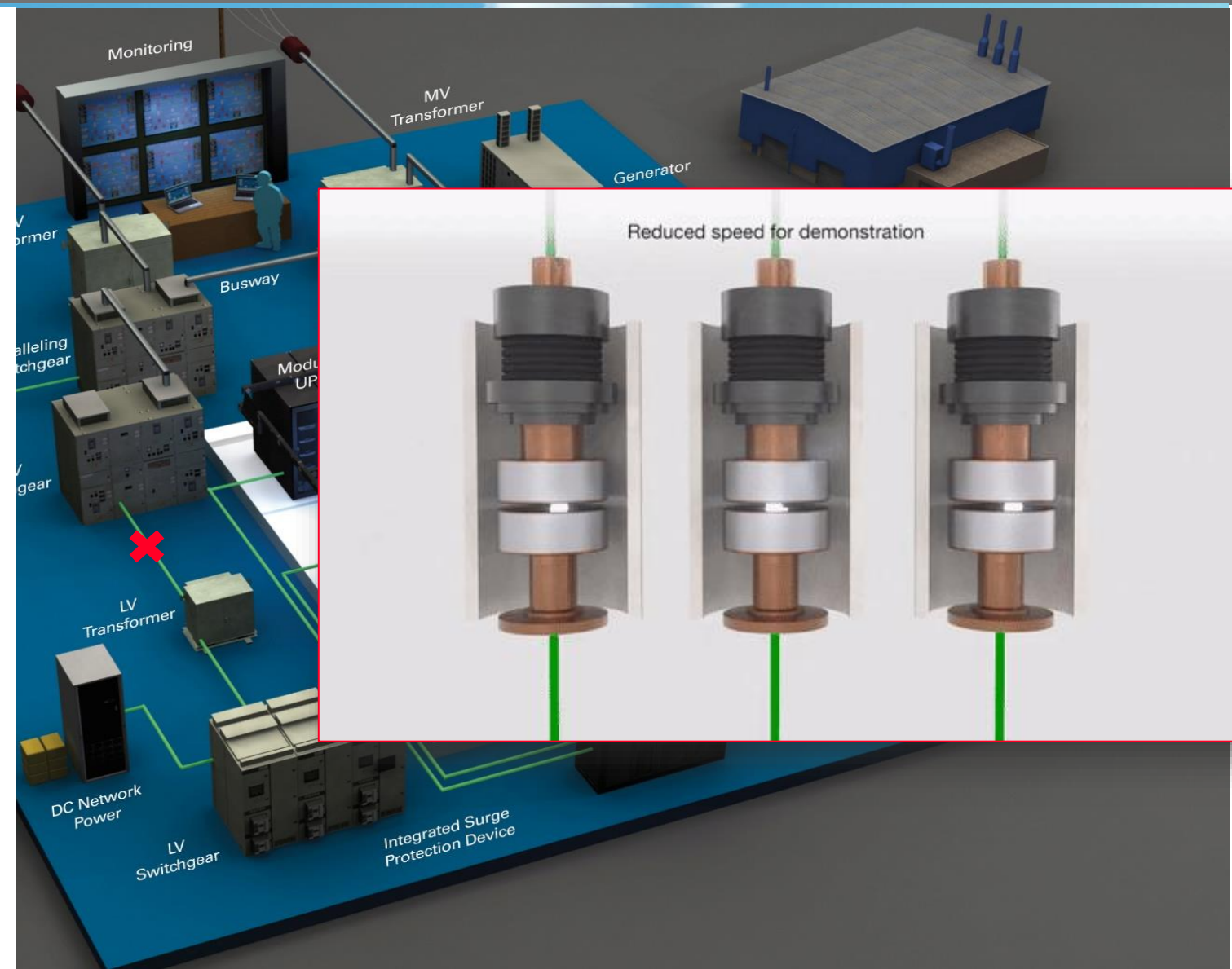
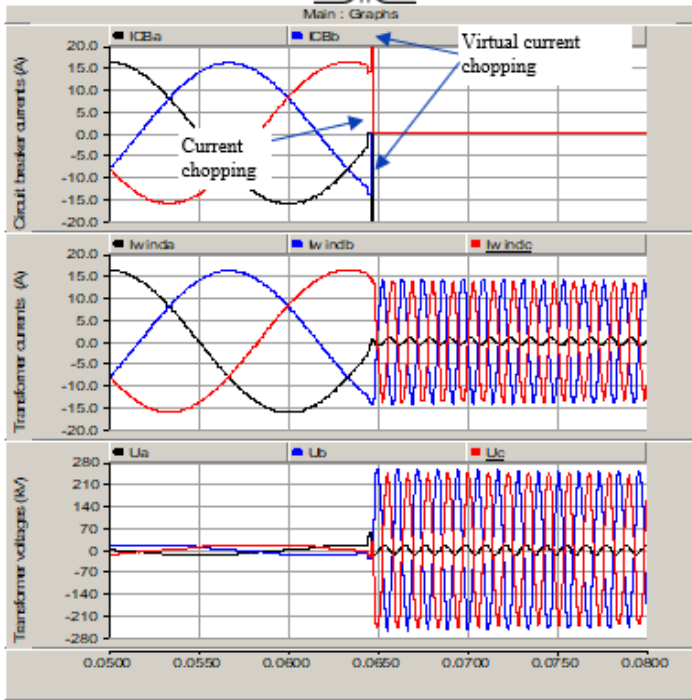
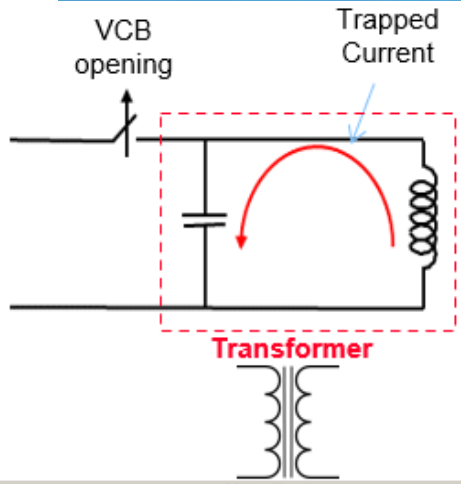


However, VCB (and SF6) switching can produce fast transient overvoltages inside of transformer windings; some leading to failures



These failures result in system downtime and unrepairable equipment; both incredibly costly to network managers

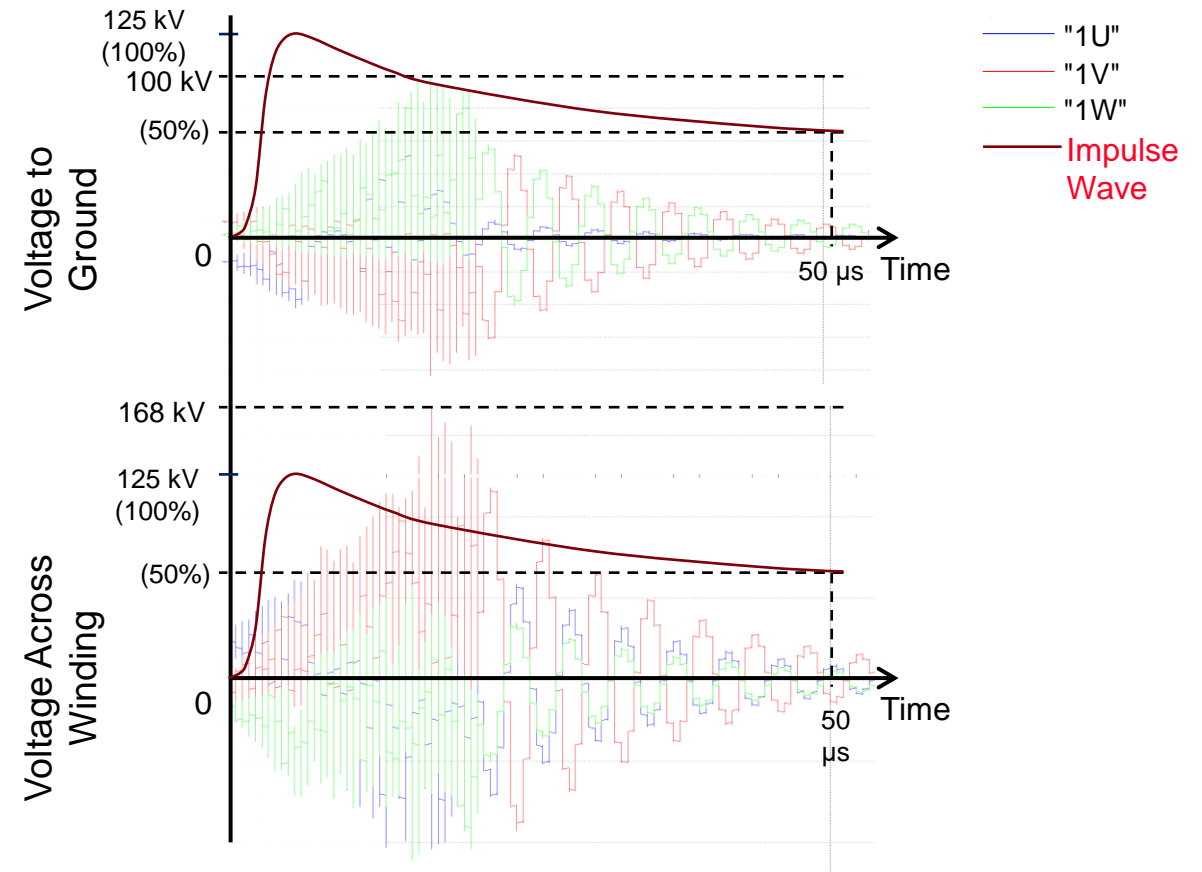
Transformers with TVP Technology : Understanding The Problem



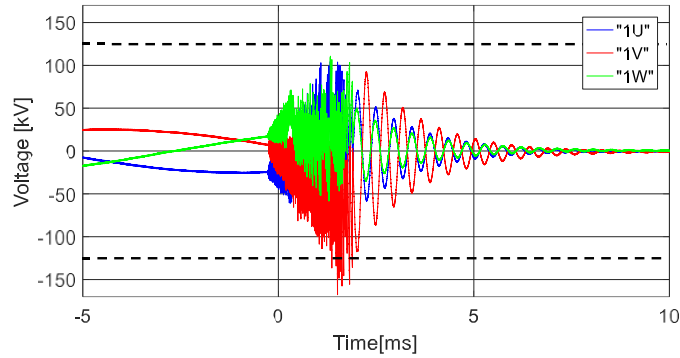
Lightning impulse vs Switching transient

Main Differences

- Impulse surge **travels into winding**;
switching transient **produced inside winding**
- Different amplitudes
- Switching has much faster rise times
- Single vs. multiple surges from switching
- Stresses in different parts of the winding



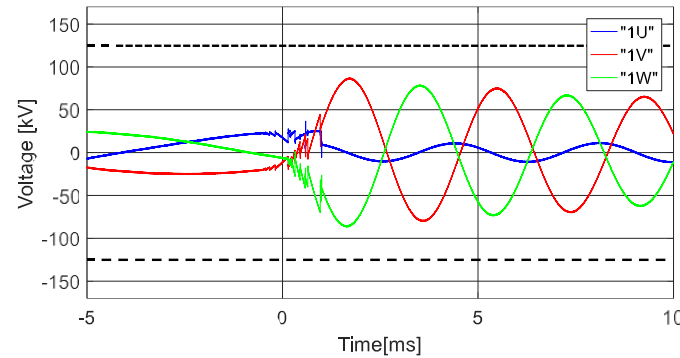
No protection



- Delta primary, VCC
- 168 kV peak voltages



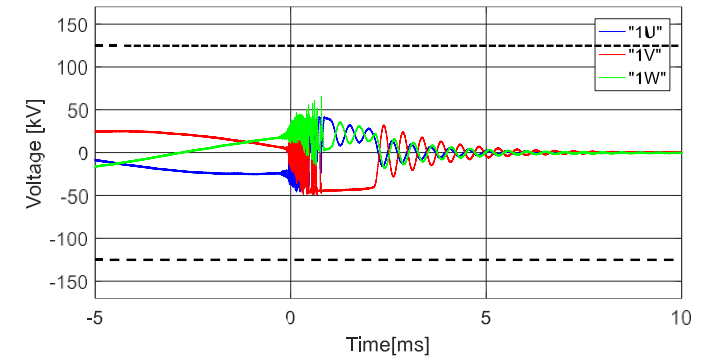
RC snubber circuit



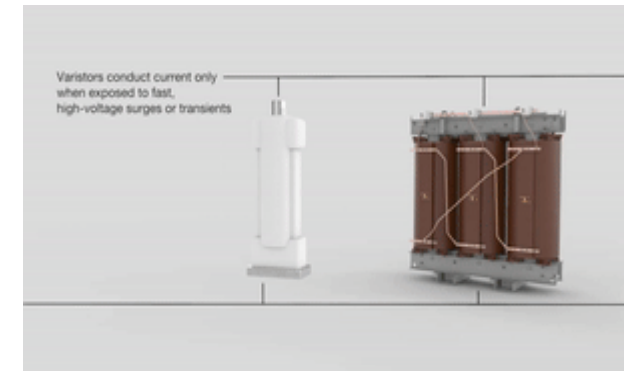
- Delta primary, VCC
- 250 Hz oscillation, 85 kV peak amplitude



Winding varistors



- Delta primary, VCC
- 40 – 45 kV (hf transients up to \approx 65 kV)



What does IEC 60076 : 2018 says... ?

5.3 Provision for unusual service conditions

- regular frequent energization in excess of 24 times per year;
- fast transient overvoltage over the limits prescribed in 11.1; i.e. basic impulse level limits

6.6 Transient voltages

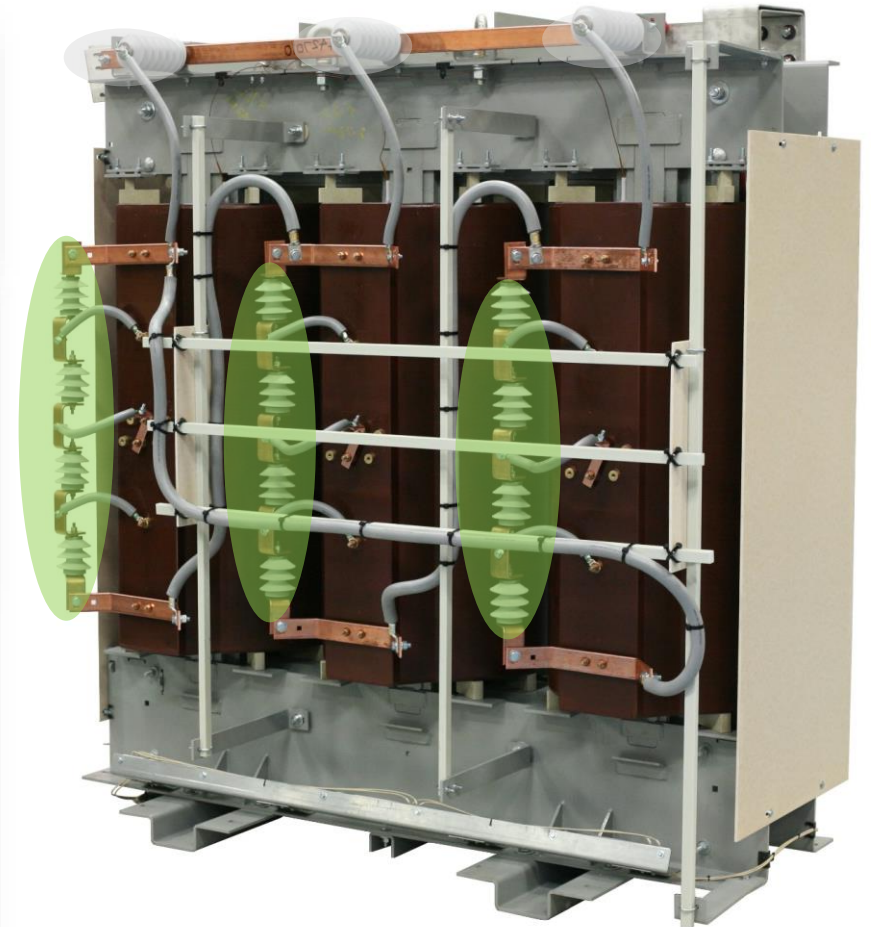
a) Normal impulse protection

Transformer lightning impulse (LI) (see IEC 60076-3) or basic lightning impulse level (BIL) (see IEEE Std C57.12.80) shall be specified. Increased transformer BIL levels by one step should be considered unless system study indicates otherwise.

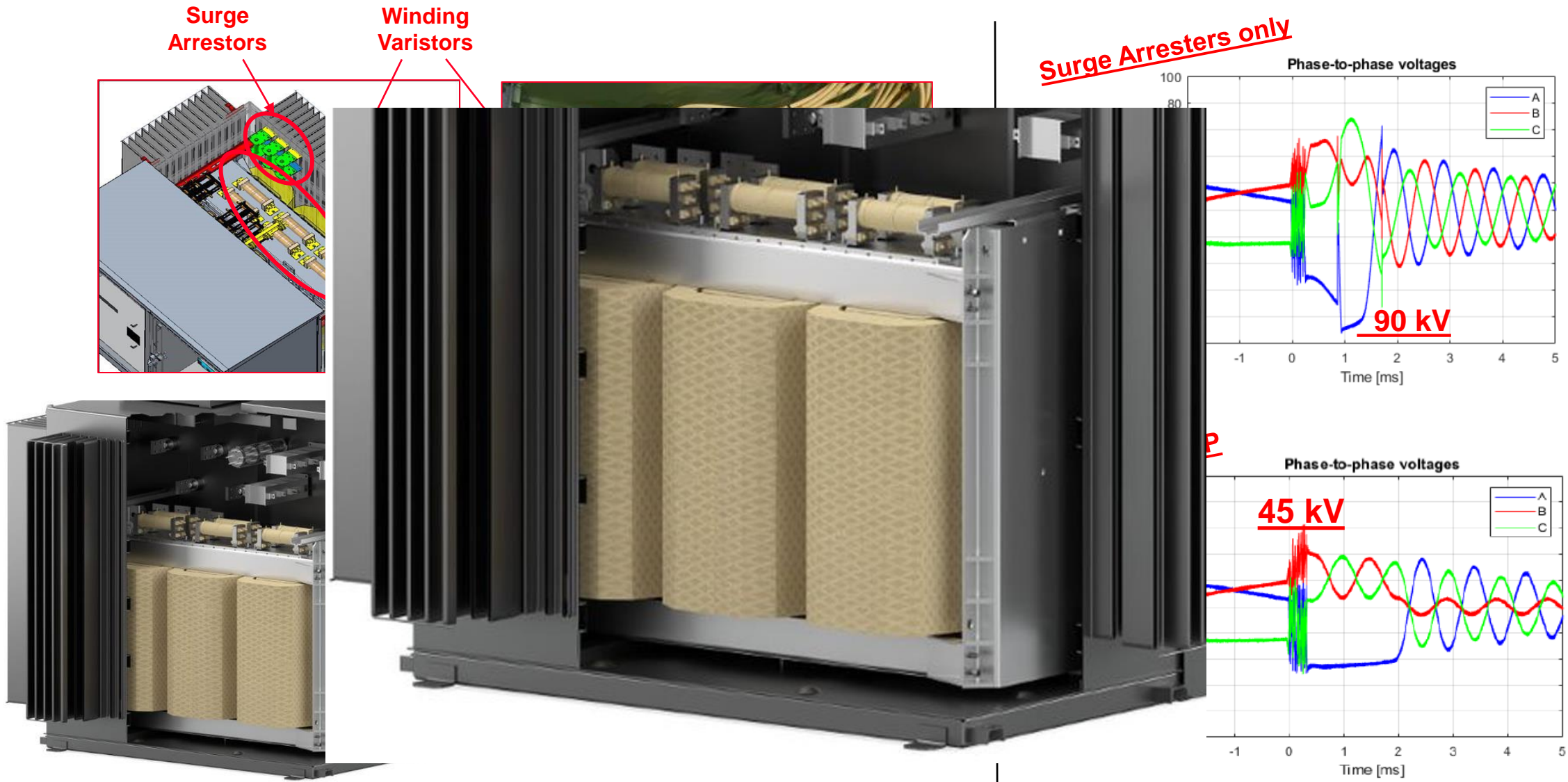
b) Switching induced overvoltages

Switching transient voltages, produced by vacuum interrupters and/or SF₆ switching devices, have resulted in dielectric failures of some wind turbine transformers. The first and last transformers in a daisy chain are typically the most vulnerable and are most at risk when currents are light and power factor is particularly low. IEEE Std C57.142 addresses this issue in depth and relates the vulnerability to current chops and voltage restrikes by vacuum or SF₆ interrupters. This is a complex phenomenon that is not covered in depth in this document but should be evaluated by a system study. If system study warrants action, mitigation techniques should be employed.

NOTE The above reference to IEEE Std C57.142 is applicable to both IEC and IEEE applications as there is no current IEC standard that covers this issue.



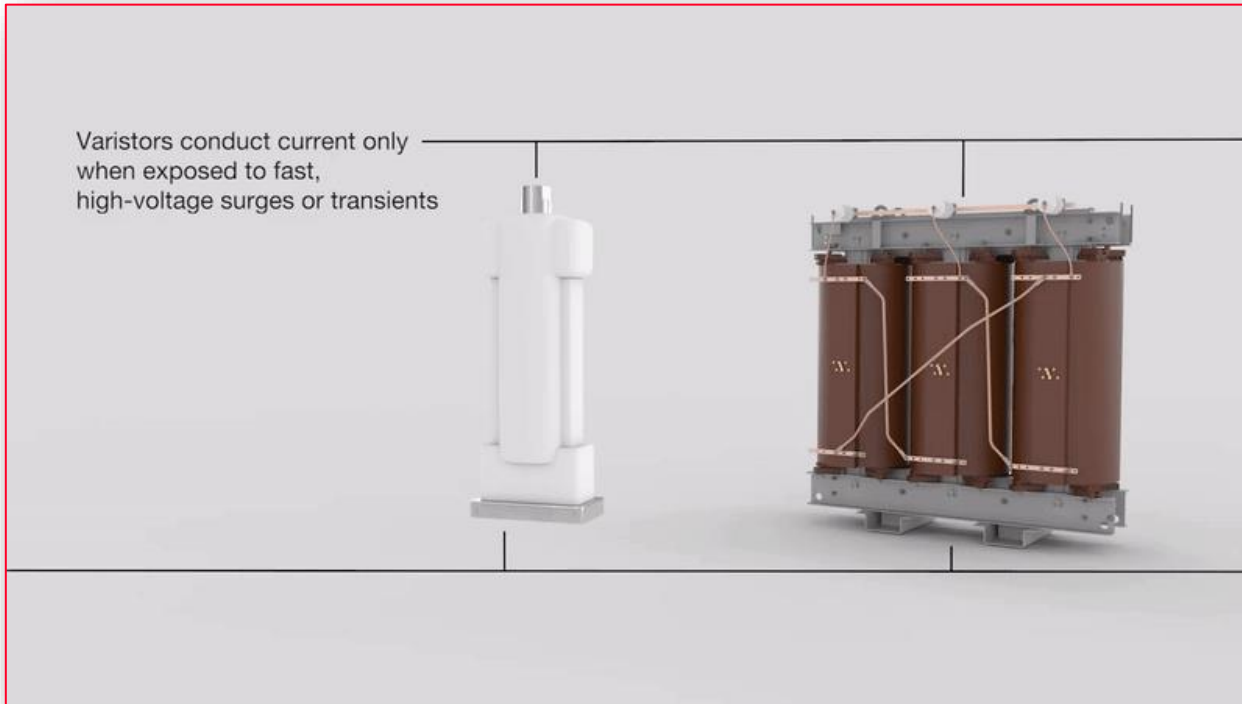
Transformers with TVP Technology : The Solution – Liquid Filled



Transformers with TVP Technology : Global Footprints



Over 1500 units installed in all global regions. Hyperscale data centers have standardized the TVP, globally



Key Technology:

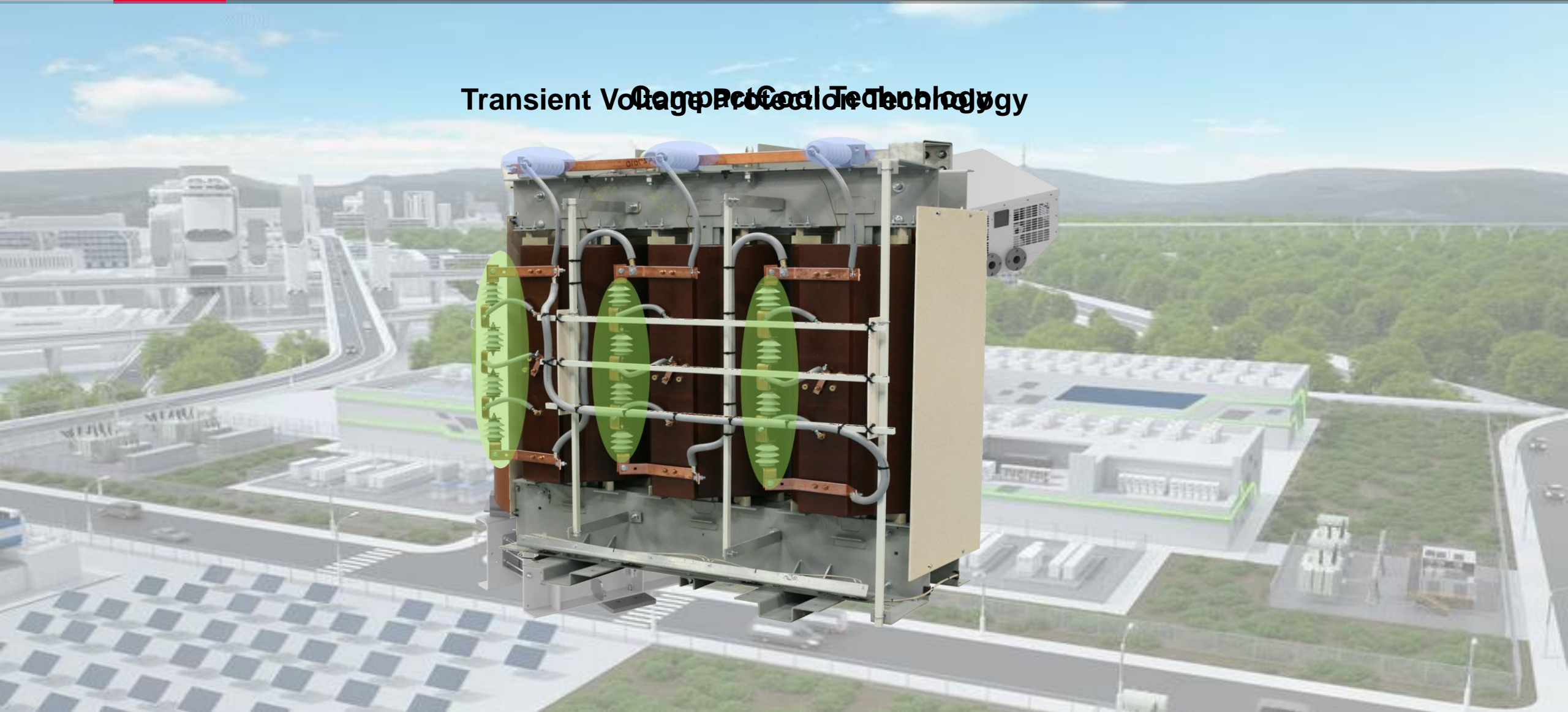
- Varistors attached to mid-points of winding
- Eliminates failures during switching
- Removes the need for system studies
- Patent awarded, global protection

Main Benefits:

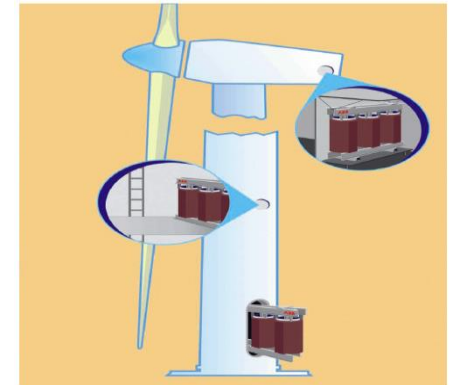
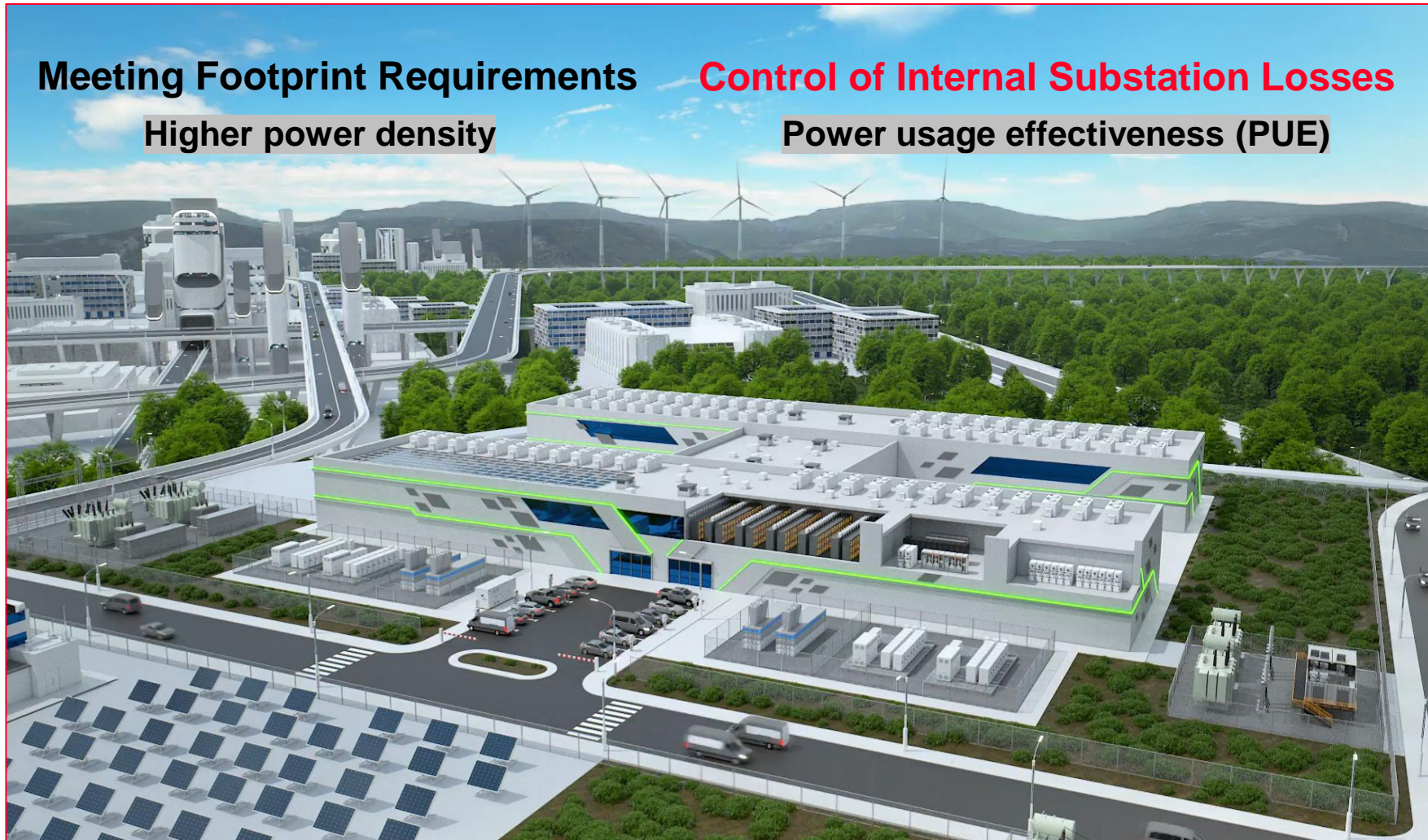
- Completely prevents failures SF6 & VCB operation
- Does not require system studies
- Varistors do not affect the size of the transformers
- Varistors are maintenance free

TVP technology — a simple solution for a complex problem

Transient Voltage Protection Technology



Hitachi Energy's CompactCool™ Technology : The Challenge



**More Watts
per
m² Needed !**

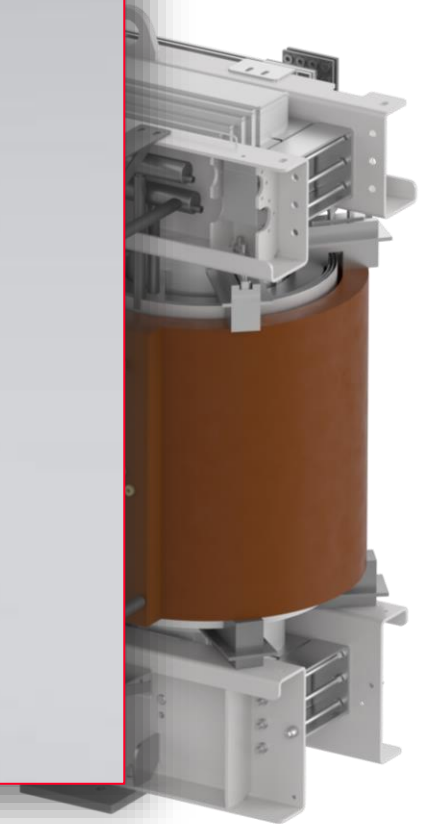


Introducing new cooling technology

- **CompactCool™** is a new cooling technology for dry-type transformers, combining solid/air insulation with liquid-cooling technology.
- It forces a **fluid** to flow through the transformer in order to remove **external heat-exchange**.
- **The heat-exchange** is achieved by circulating the fluid through a liquid-cooling source through a liquid-cooling system.
- Applicable for:
 - Vacuum cast coils
 - ***Up to 30 MVA** and above

Combines dry-type insulation with liquid-cooling

DRY TYPE



CompactCool™: A closer look into the details

Heat-exchanger

- Can be forced air-cooled (liquid to air) or forced water-cooled (liquid to liquid)
- Can be installed indoors or outdoors

Serves to extract heat from the transformer

Monitoring

- Inlet/outlet temperature sensors
- Oil-pressure sensors
- Liquid-level sensor

Serves for monitoring purposes. Same functionality than the traditional monitoring devices

Expansion tank with pressure relief valve

Same logic with conservator of liquid immersed transformers. As liquid heats up, it expands.

Electric oil-flow pump

Pump distributes cold coolant to transformer coils

Internal, closed circuit cooling system

- High-temperature ester fluid
- Both, primary and secondary windings

Fluid flows through the windings to extract the heat

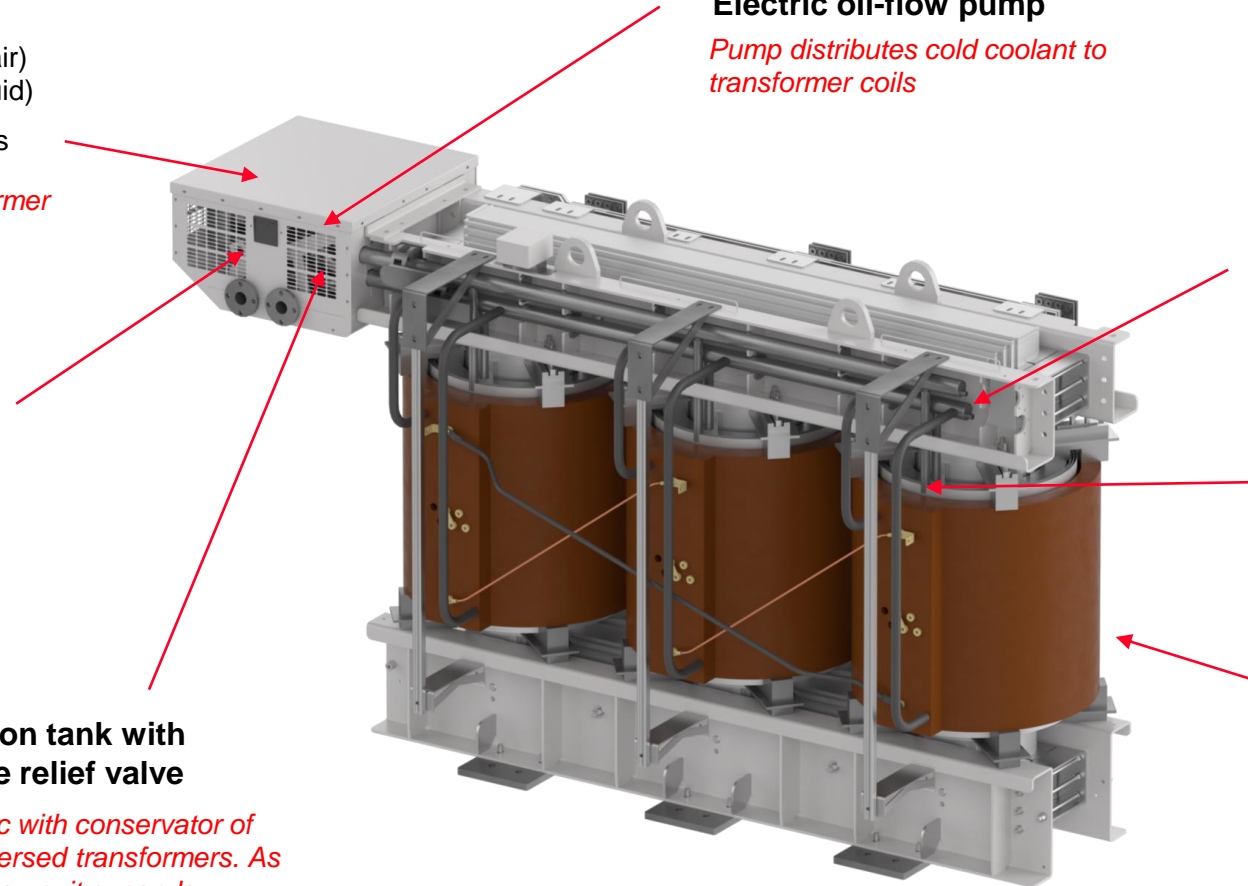
Winding temperature sensors

Nothing different than the regular winding temp sensors

Vacuum Cast Coil (VCC) windings

- Class H (180°C) dielectric insulation system
- Non-flammable materials

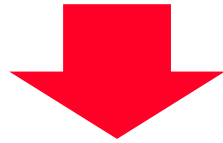
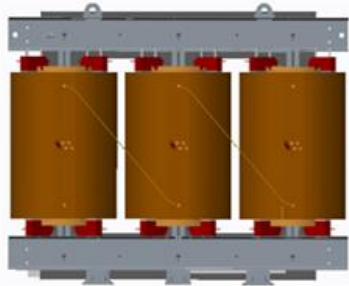
Maintains class H (180°C) dielectric insulation system



Reduced Footprint, Controlled Losses, Environmentally Friendly

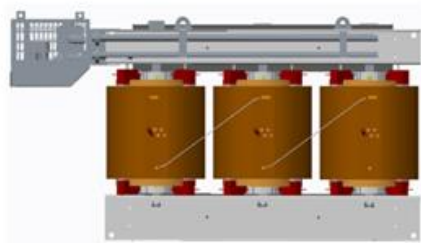
Conventional Dry

6.8 MVA transformer

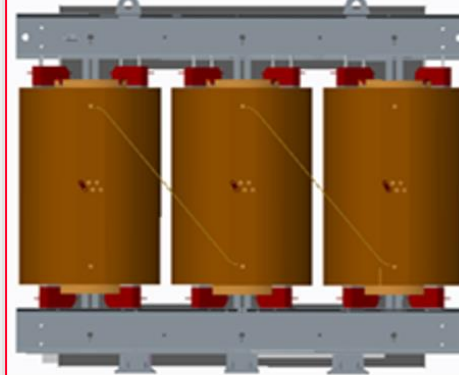


32% Volume reduction
26% Weight reduction

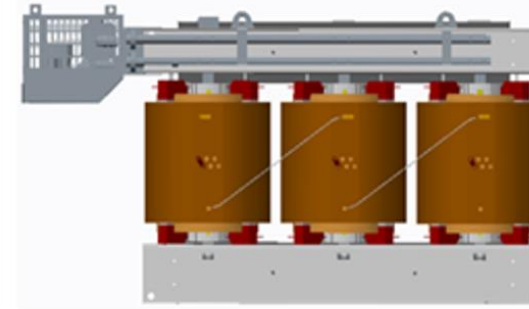
**CompactCool™
technology**



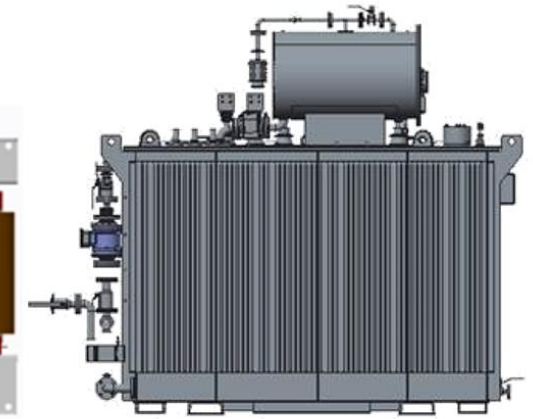
6.8 MVA Conventional Dry-type Transformer



6.8 MVA Dry-type Transformer with
CompactCool Technology



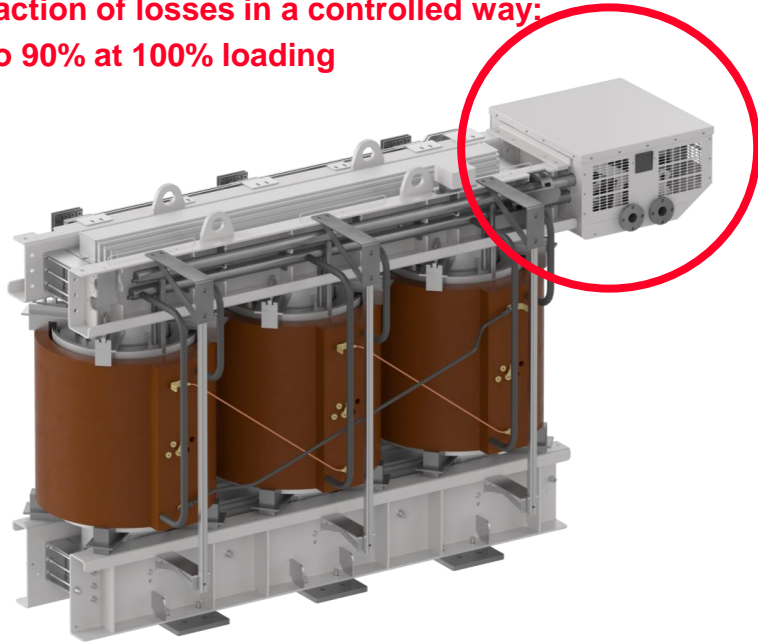
6.8 MVA Conventional Mineral-Oil Transformer



Data Center Installation

- ✓ Possibility to use central cooling systems
- ✓ Possibility to extract the losses to an outside ambient
- ✓ Lower no load losses
- ✓ Less HVAC system installation for our customers

Extraction of losses in a controlled way:
Up to 90% at 100% loading



Transfers heat out to ambient environment to improve power usage effectiveness



Outdoor Installation: Solar / Outdoor substations / Skid Installation

Perfect fit in case of height



Reduced Size
Up to 50% reduction
depending on power
the larger rating the
better

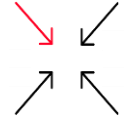
More Watts
per
Box!



**Reduced
Costs**



**Environmentally
Friendly**



**Reduced
Size**

Key Technology:

- Internal cooling system directed to winding hot spot location
- Onboard heat exchanger that captures +90% of transformer losses

Main Benefits:

- **Up to 50% reduced footprint and weight**
- **Minimized volume of liquid coolant**
98% reduction of oil
- Control of **90% transformer losses** to be directed anywhere desired (outside => reduced HVAC)
- Reduced oil containment and fire prevention systems

Game-changing technology to meet footprint requirements and reduce the environmental impact

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The challenge: Transformers reliability and life expectancy

Though robust, externalities will shorten life expectancies of Transformers

Aging equipment

As electrical equipment naturally approaches end of life, they subject networks to faults and transients causing disturbances



Environmental forces

Natural disasters, changing climates and electrical storms all stress grid equipment throughout their lifetimes

Distributed generation

Power is now flowing in all directions, creating new challenges for established grid networks



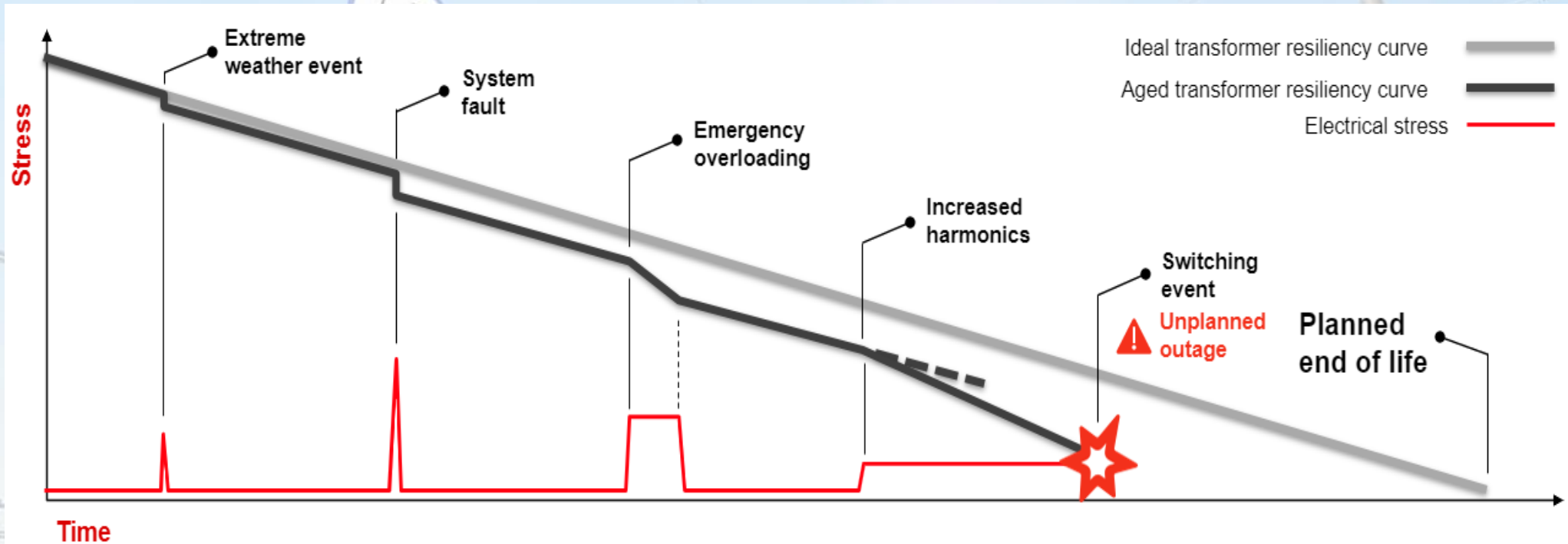
Increasing demand

Growing need for AC to DC conversion subjects electrical networks to increased harmonics and transients



External stresses are the number one cause of failure of transformers

Transformer lifecycle



Unplanned outages are costly and result in significant downtime. With proper monitoring, they can be avoided

Reduced cost and risk

- 50% lower risk of serious failures*
- 60% reduction in revenue loss due to unanticipated problems/outages*
- 75% reduction in repair costs due to early detection*



Optimized operations

- Maintenance driven by actual condition rather than time-based.
- Efforts focused on the right transformers at the right time.
- Remote analytics prior to physical inspection or costly activities.



Extend life-expectancy

- Prevents deterioration by trending and monitoring potential threats.
- Avoids unnecessary replacement with 'end of life' assessment.
- Unlocks additional capacity for added revenue.



Enhance environmental performance

- Facilitates easy integration of renewable generation sources.
- Prevents failures and their consequential environmental impact..
- Prolongs the life of the asset with predictive maintenance.



TXpert™ Ecosystem

By Hitachi Energy

Evolving the technology, retaining our expertise

2001 TEC

Transformer Electronic Control (TEC) introduced to enable condition monitoring.



2009 TEC 2.2

Improved version, building on early pioneering experience from the field.



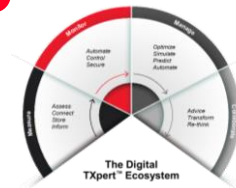
2018 CoreTec™ 4 + AAPT

Off the shelf and market competitive device, Powers the worlds first digitally native Power Transformer (AAPT).



2020 TXpert™ Ecosystem

Open, Modular, Scalable Manufacturer agnostic for Green & Brownfield.



2019 TXpert DRY

World's first dry-type digital transformer



2017 TXpert Distribution

World's first digital distribution transformer



2020 APM Edge



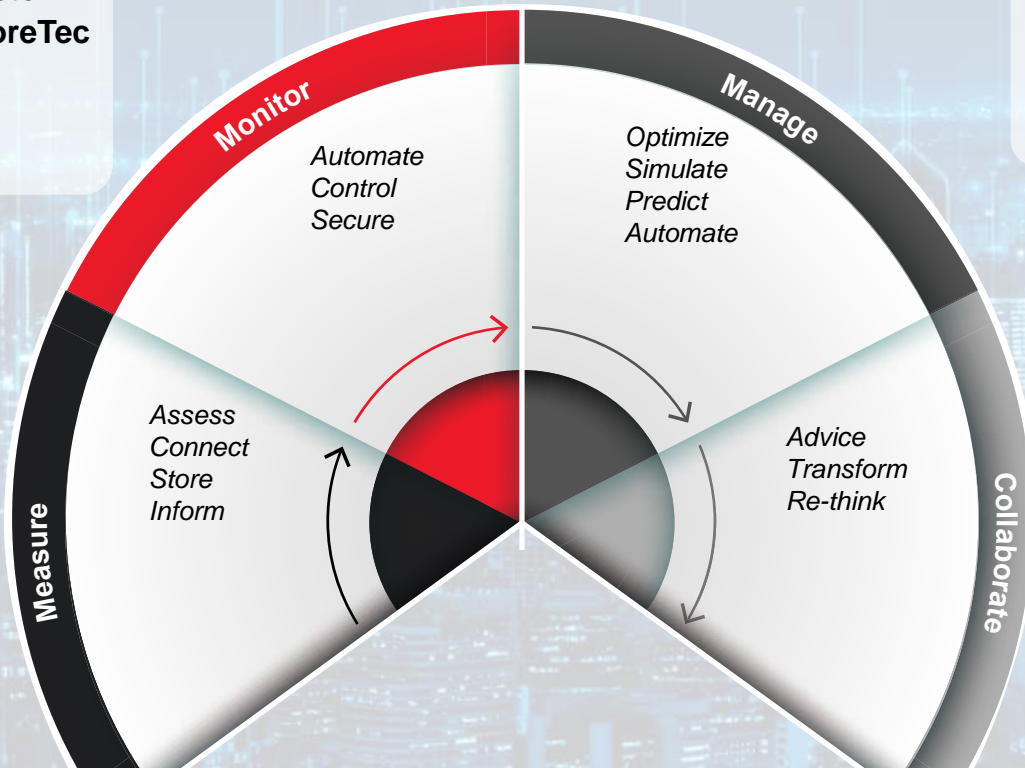
2023 CoreTec™ 5 & TXpert™ Hub

New hardware for remote monitoring. Build on the CoreTec 4 software foundation Meets cyber security, retrofitability and compatibility requirements.



2021 Remote Monitoring

The Digital TXpert™ Ecosystem



TXpert™ Hub

Transformer Monitoring System powered by CoreTec

Lumada APM

Asset Performance Management
Edge
On-premise
Cloud

TXpert Ready Sensors

Temperature, Dissolved gases, Bushing and tap changer, And more...

TXpert Services

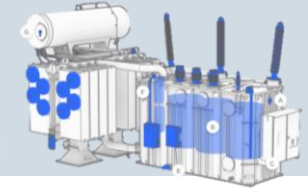
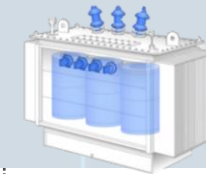
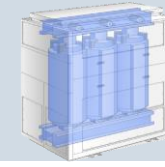
Transformer Care
Service Agreements

TXpert OnDemand
Device hire

And more...

Unlocking more value by expanding the boundaries

Actionable Insights for new and existing transformers



		Distribution DRY		Distribution Oil		Power		
		Basic	Basic+	Basic	Basic+	Basic	Basic+	Advanced
Thermal	Temperature Monitoring	✓	✓	✓	✓	✓	✓	✓
	Cooling control / Cooling exercise	✓	✓			✓	✓	✓
	Hot-spot temperature / Ageing		✓	✓	✓	✓	✓	✓
	Hot-spot forecast / Overload capacity					✓	✓	✓
Electrical	Voltage & Current Unbalance Factor / Voltage & Current Total Harmonic Distortion		✓		✓			
	Individual Harmonics / Voltage Crest Factor / Harmonic Loss Factor		✓		✓			
	Phase & Line Voltage / Reactive and Apparent Power / Power Factor / Frequency		✓		✓			
	Bushing Capacitance / Bushing Dielectric dissipation factor ($\tan\delta$ and $\Delta\tan\delta$) / Bushing Leakage current						✓	✓
Chemical	Fast forming faults with hydrogen and moisture trend analysis				✓		✓	✓
	Bubbling temperature / Moisture in paper				✓		✓	✓
	Detailed analysis with IEC gas ratios / Rogers Ratios / Duval triangles							✓
Mechanical	Number of operations / Next recommended maintenance							✓
	Contact wear for Hitachi Energy tap changers							✓

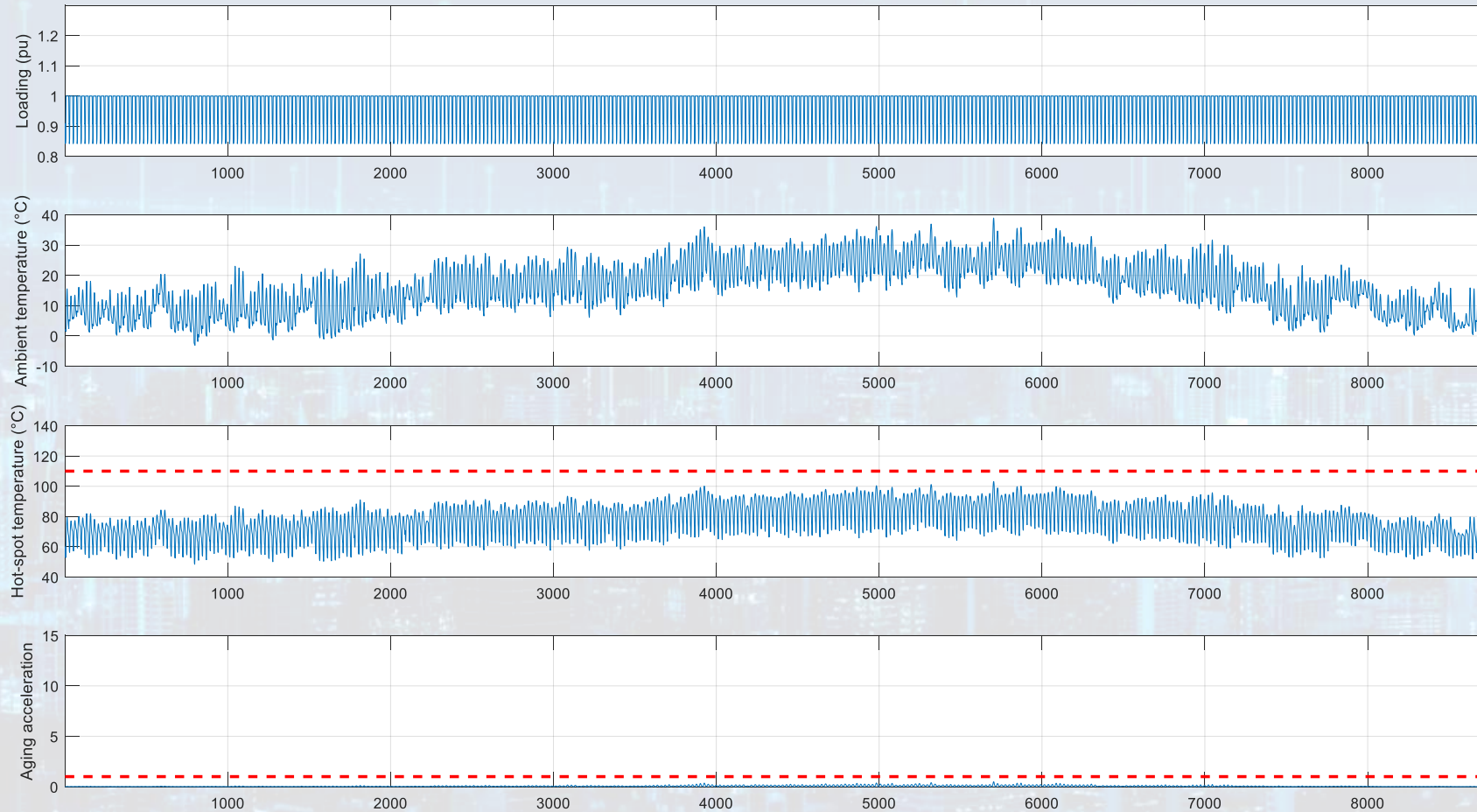
Industrial customer detects a fault

- Industrial plant installed online monitoring: DGA, temperature and load monitors on its transformer.
- Operator detected an increase of dissolved gasses due to an increase of oil temperature while constant load.
- The monitoring system allowed ABB experts to detect the blocking of a OFWF heat exchanger due to a mineral buildup.



Based on data gathered with CoreTec 2

Overload Capability (1/3) - Nominal rating (500 MVA)



Unit overloaded at 100% at all time

Ambient temperature varying over time

Hot-spot temperature under limit (red line) even when Ambient is high

Aging accelerating factor acceptable

01

Local HMI

Local 7" touch screen using the integrated HDMI port



02

Portable HMI

Web server integrated into CoreTec application will render the HMI as a web page on a laptop or tablet
WIFI access allows for wireless local access



03

Remote HMI

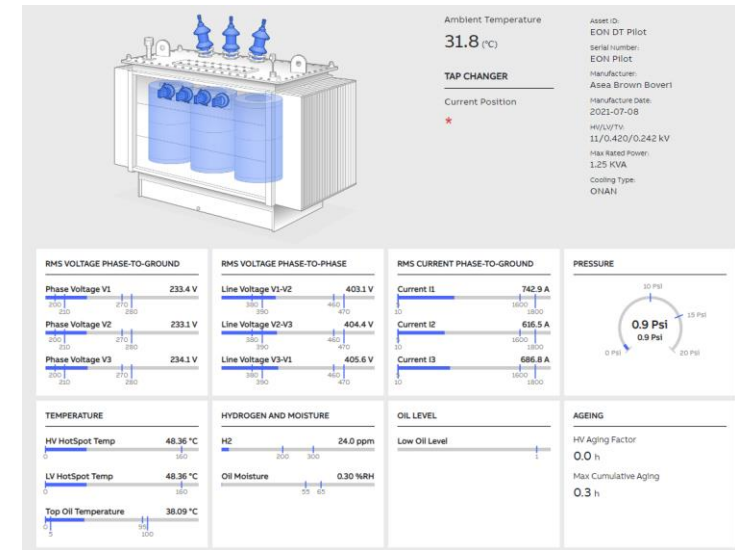
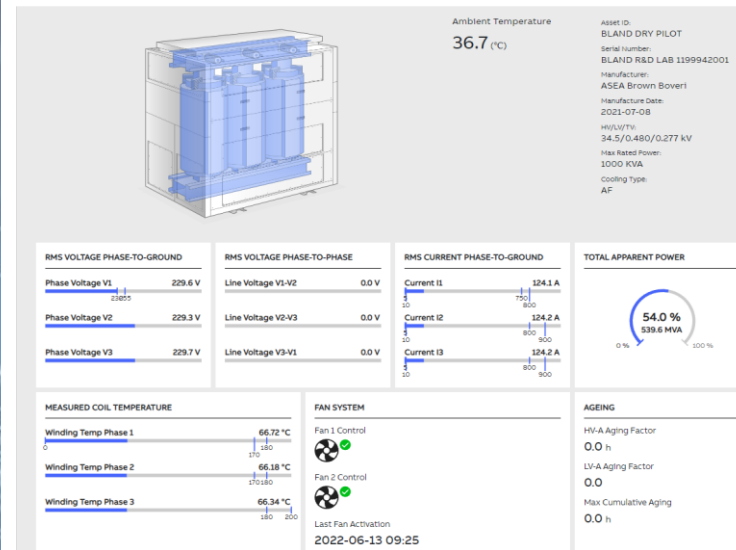
Web server integrated into CoreTec application coupled with wide area connectivity over fiber optic Ethernet or cellular allows remote management



Transformer configurations

CoreTec 5 can be configured to operate with Dry, Distribution and power transformers. Selectable via system page

Each transformer type has a specific dashboard configuration



TRANSFORMER IDENTIFICATION

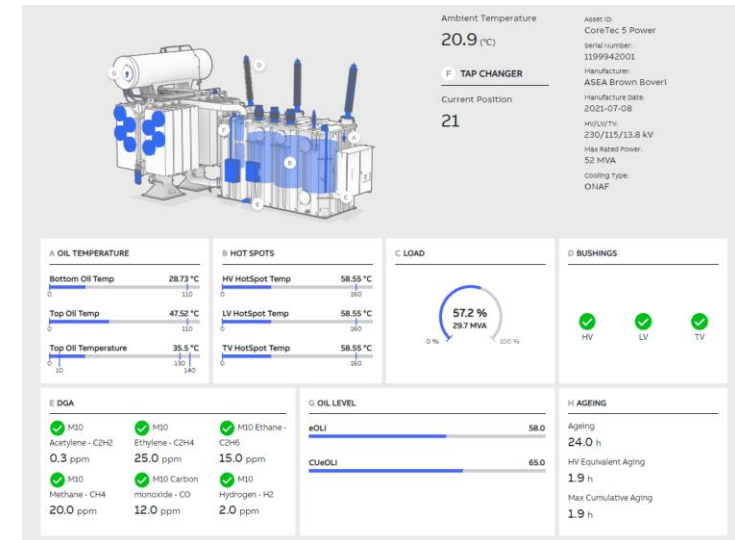
Subsystem Name / ID

TXpert Hub

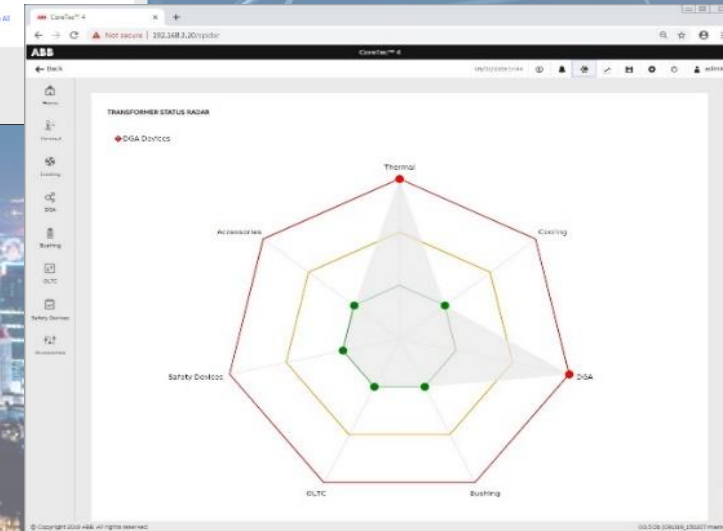
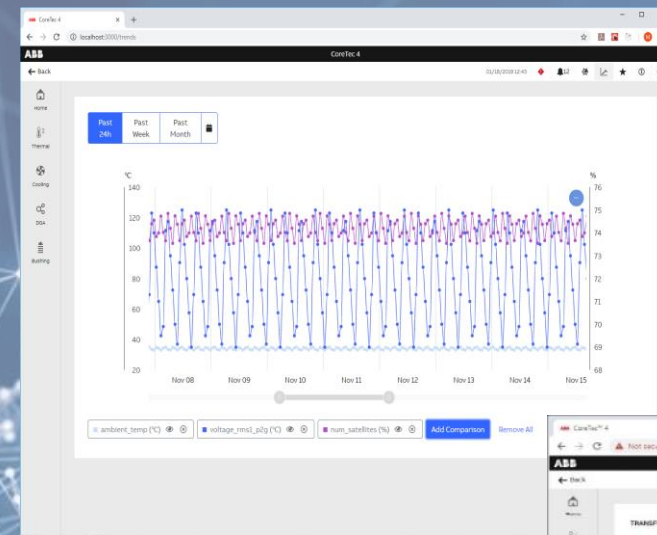
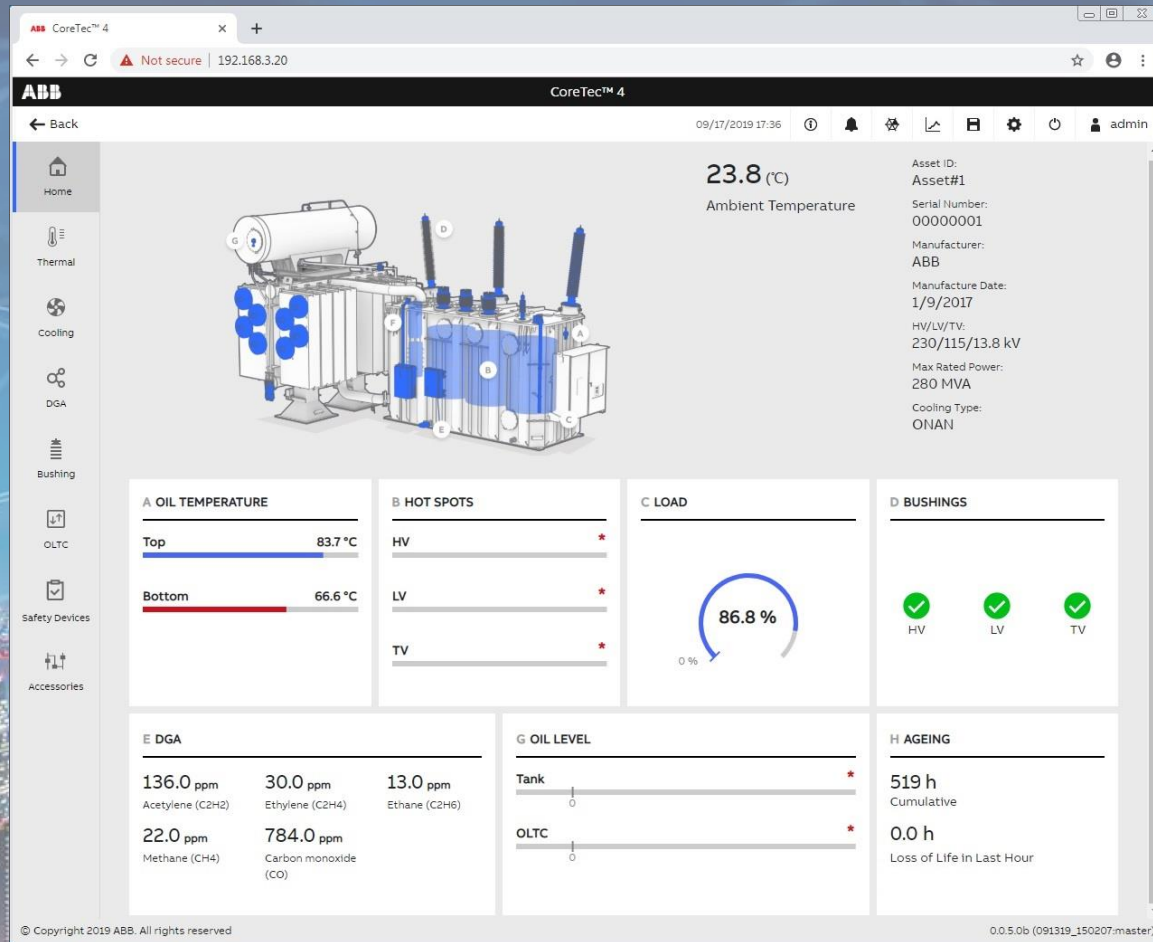
603-03801-OICU812

Transformer Type

DRY

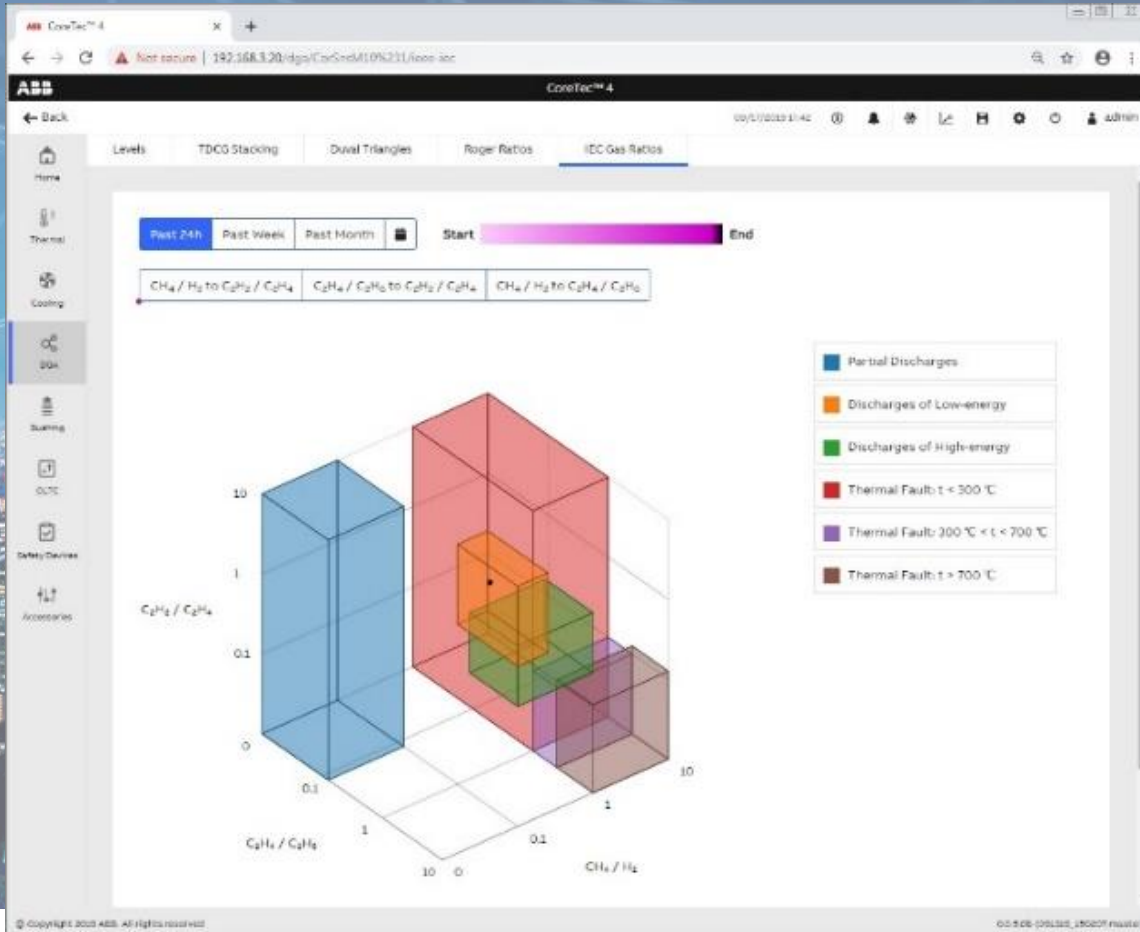


CoreTec™ 5 class leading user interface

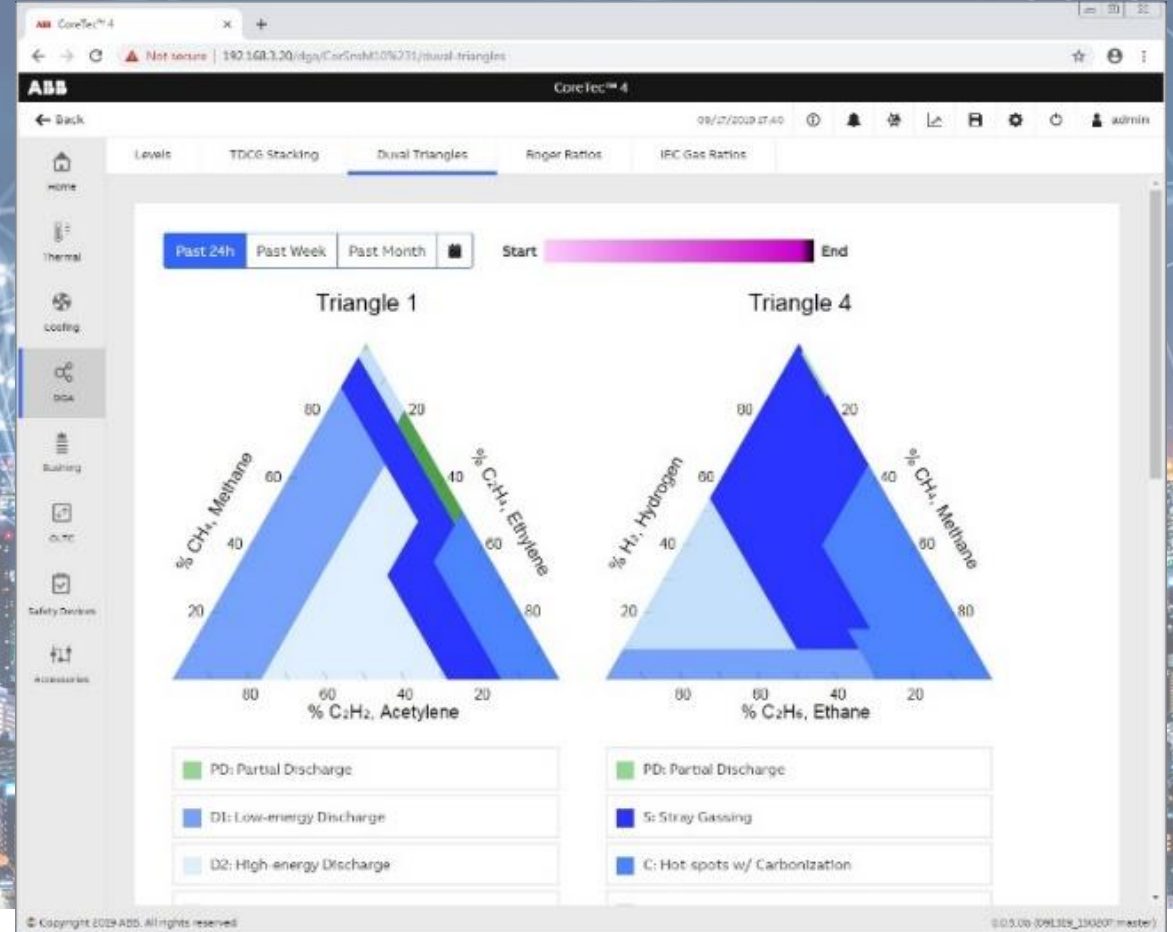


The web interface provides a visually intuitive integrated dashboard for the vital signs of a transformer

Rogers ratios



Duval triangles



1. Remote online monitoring

Monitoring equipment connected back to our experts

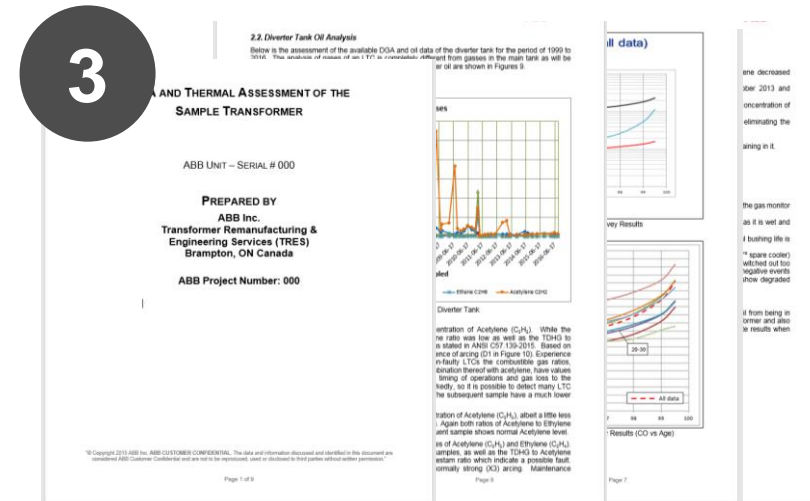


2. Remote Guidance using Augmented Reality

Inspection of procedure and equipment at site

3. Remote Consulting

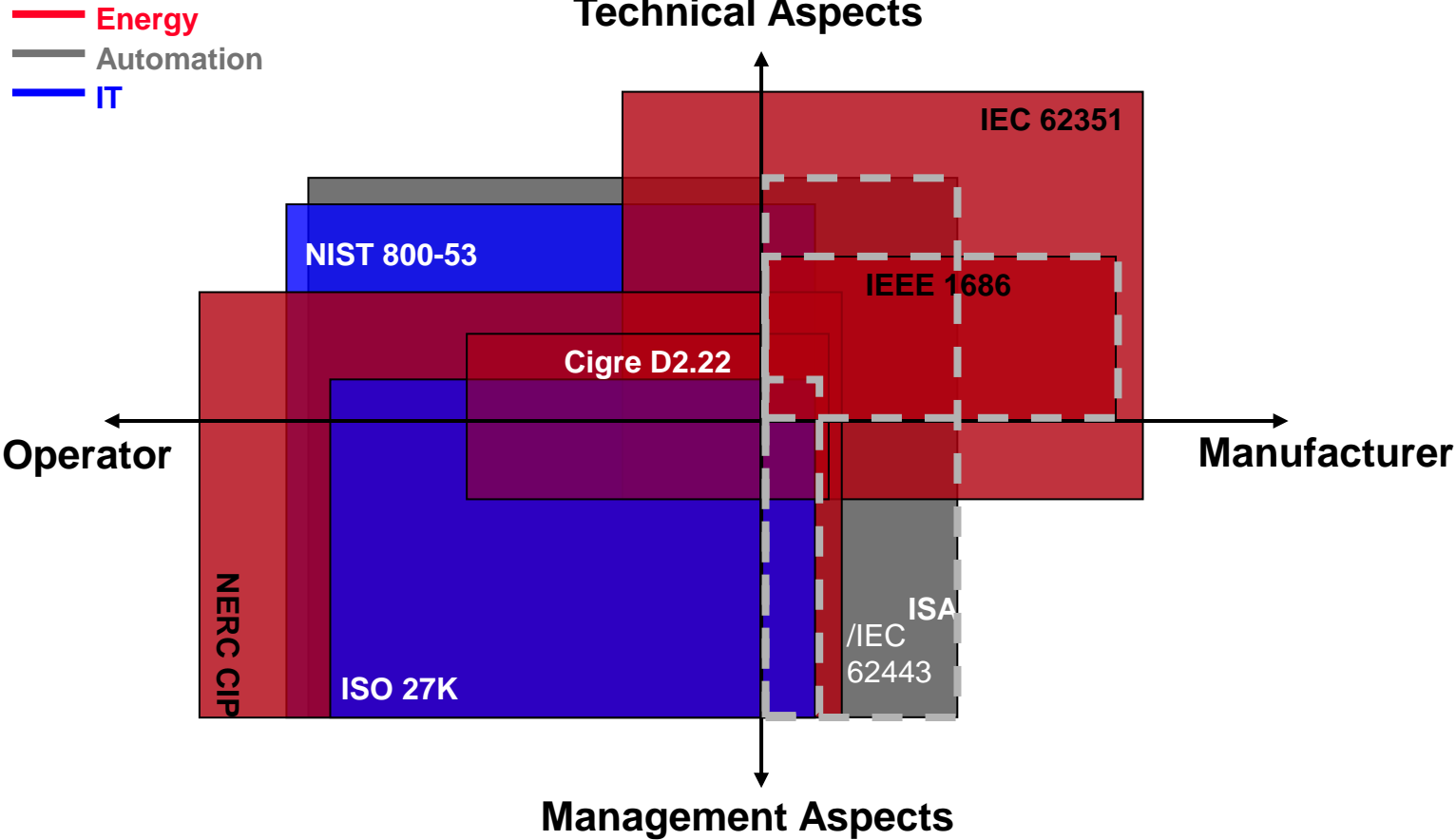
Reports for customer-gathered data



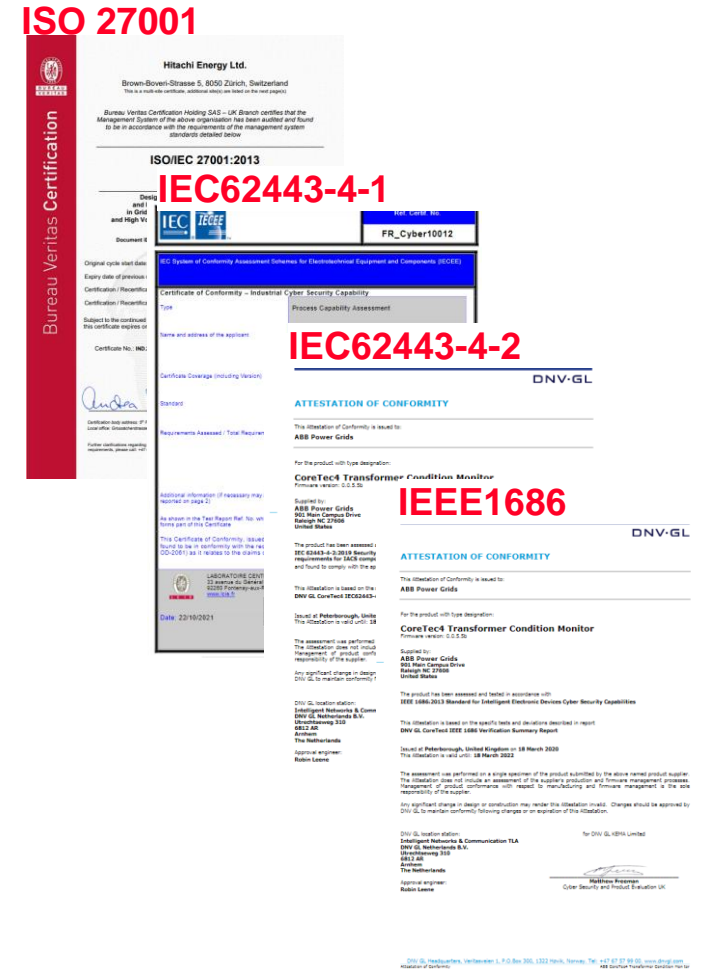
4. Remote troubleshooting

Temporary remote connection for fixing issues

Cybersecurity – TXpert Hub certifications



Graphical representation of scope and completeness of standards from IEC62351-10



Cybersecurity can only be achieved through coordinated efforts

Product development team is certified IEC 62443-4-1, meaning:

- Our products are developed in accordance to our “**Secure Development lifecycle**” (SDLC) Process
- **Products are developed from inception with cyber security in mind**
- The **Development team has the expertise**, are trained and/or follow written procedures

IEC 62443-4-1

Hitachi Energy is certified ISO 27001 which is a suite of information security standards :

- **Covers the management of information security**, not just IT / Technical Security. Includes asset management, HR security, Physical & Environmental security, etc.
- **Improved Risk Management**
- **Legal and Regulatory Compliance**
- **Preparation for Emergency / urgent Situations**

ISO 27001

Product is certified to IEC 62443-4-2, features:

- **Session Lockout** (Temporary/Permanent).
- **Network Segmentation**: product interface is not bridged with other systems
- **Denial of Service protection** in case of a malicious entity tries to overwhelm the product
- **Resource Management**: in case of a problem/crash, a watchdog will bring back the unit online
- **RBAC Account Management**: Admin can choose specific access rights per user and every user is unique. Also in accordance to IEC 62351-8

IEC 62443-4-2






Product is compliant to IEEE 1686, features:

- **No hidden access to the system or back-door**
- **Audit trail** (Secure Event Logs, e.g. Login, Time change, Config Change, etc).
- **Backup and Restore functionalities** if an event occurs, special procedure will allow for recovery of the system
- **Encryption** for access to the product: protects from “eavesdropping” from malicious entity

IEEE1686



Digital solutions for Hitachi Energy, 3rd party OEMs and Retro-fits **Digitally enabled solutions and services**

 <p>Digital Assets as enablers</p>	 <p>Asset monitoring & connectivity</p>	 <p>support customer digital experience</p>	 <p>Advanced analysis & optimization</p>	 <p>Data & knowledge Management</p>
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TXpert Ecosystem

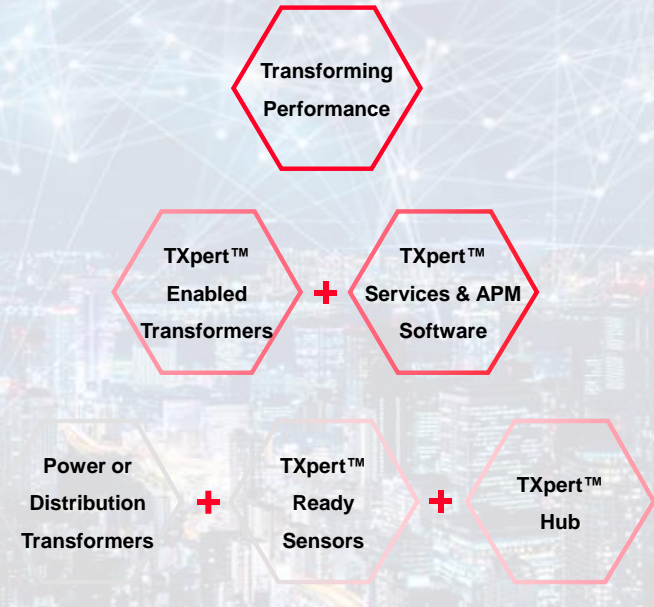
A complete suite of products, software, services and solutions.

Manufacturer agnostic

Proven intelligence from experience

Optimization of transformer and grid operations and maintenance

Transforming performance



Customer value

Multivendor digital ecosystem

Reduced costs and risks

Optimized operations

Extended life-cycle expectancy

Enhanced environmental performance

TXpert is a multivendor software enabled ecosystem that combines the value of service and software, scalable offering to our suit customers needs, across the whole life-cycle

Two Online DGA Sensors...

CoreSense



CoreSense M10



What do we measure?

Fault/gas generated→	CO	CO ₂	CH ₄	C ₂ H ₂	C ₂ H ₄	C ₂ H ₆	C ₃ H ₆	C ₃ H ₈	O ₂	H ₂	H ₂ O
Cellulose aging	+	+									+
Mineral oil decomposition			+	+	+	+	+	+		+	
Leaks into oil		+							+		+
Thermal decomposition of cellulose	+	+	+						+	+	
Overheated transformer core	+	+	+							+	
Thermal faults in oil (150°C to 300°C)			+		Trace	+	+	+		+	
Thermal faults in oil (300°C to 700°C)			+	Trace	+	+	+	+		+	
Thermal faults in oil (>700°C)			+	+	+	+	+	+		+	
Partial discharge			+	Trace						+	
Arcing			+	+	+					+	

Offline vs online measurement



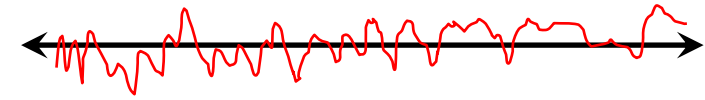
Online Measurement – Continuous!

Manual
Sampling
DGA



Previous
year

DGA online monitoring



Manual
Sampling
DGA

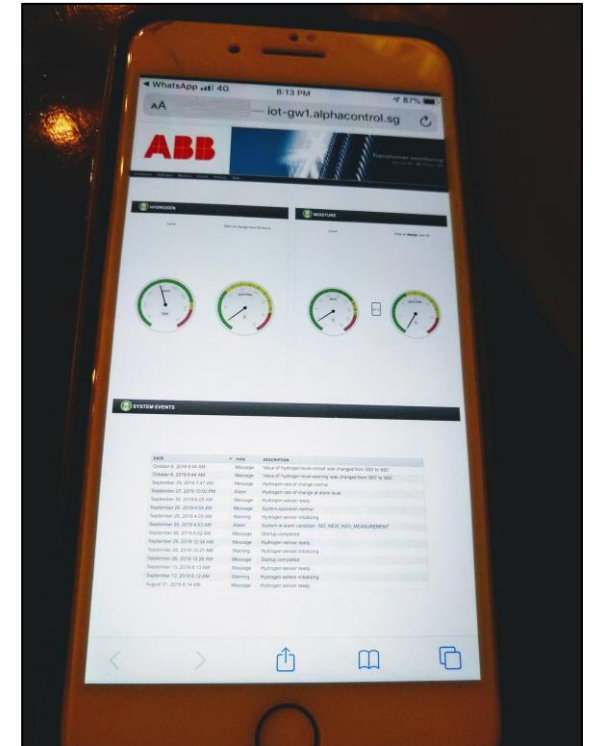


Today



Online Sensor
Technology

Site Pictures



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Site Pictures



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Use case – Transformers industrial mining

- Mine consist of 20 transformers servicing 5 drives
- A single transformer failure cost \$30,000 / Hour
- 4 outages over 17 years => 340 transformer years

$$\lambda = \frac{4 \text{ failures}}{340 \text{ transformer years}} = 1.2\%$$

- A failure takes, on average 5 days to resolve
Total cost = \$3.6 M US
Annual cost (\$3.6 M /17y) = \$212 K US / year
- 4 failures over 17 years = \$847K US / year



With proper monitoring, early warning signs can be identified and costly failure avoided!

Background & Project Scope

- TATA Steel Thailand envisaged a vision to achieve “zero” failure for its transformer fleet in November 2019.
- Engaged with Thailand Transformer Service and APMEA Application Engineering to understand and build case study for **online DGA monitoring**.
- Thailand Transformer Service secured order for repair for a **failed 72MVA** Electric Arc Furnace transformer. Proactive selling of **CoreSense M10** to use with the repaired transformer.
- Confidence in refurbishment work and customer confidence in CoreSense M10 performance, led to:
 - 15 x CoreTec 4.0
 - 5 x CoreSense M10
 - 9 x CoreSense HM
 - 15 x APM Edge Licenses

Customer Voice

*“The TXpert™ Ecosystem from Hitachi ABB Power Grids immediately caught our attention as it delivers the **high-performance characteristics** and features needed to digitalize our transformers and achieve our vision of zero failures. To start with we, decided to install the **CoreSense™ M10** in one of our refurbished 72 MVA transformers. We are satisfied with the field performance of the unit and the ease of use. After very stringent assessment of several vendors, we decided to award the order for several CoreSense™ M10 multi gas and CoreSense™ single gas units to Hitachi ABB Power Grids along with the TXpert™ HUB and APM Edge software.”*

**Dr Aree Wangsupphaphol, Department Manager
Maintenance Expert Group**



Benefits of TXpert™ Ecosystem [3]:

- ~ 60% reduction in failure rate and asset downtime
- ~ 35% increase in transformer lifespan
- Reduced maintenance costs and time

New Innovations in Transformers

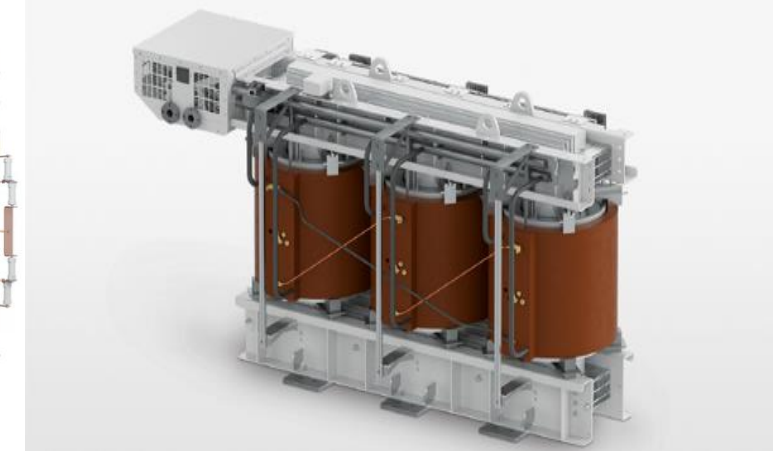
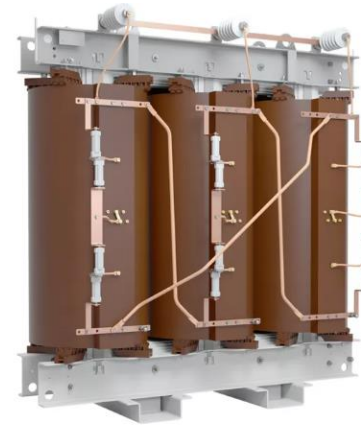
1. Introduction
2. Hitachi Energy Innovative Transformers solution for more reliability
3. Hitachi Energy Digitalization Solutions
4. **Hitachi Energy Decentralization Solutions**
5. Hitachi Energy Transformers Services
6. Questions and answers

Transformer to fit the inverter and project conditions

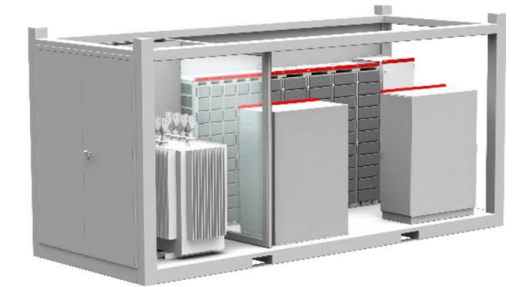
Standard transformer is NEVER the right solution

- Harmonics
- DC voltage components
- Peak voltage on LV side
- Loading & ambient temperature
- Electro-magnetical compatibility (Emc)
- Short Circuit strength
- Fast acting voltage transient
- Thermal cycling
- Harsh environmental conditions
- Alternative fluids

know-how, experience and capabilities to provide the optimal transformer for the project requirements



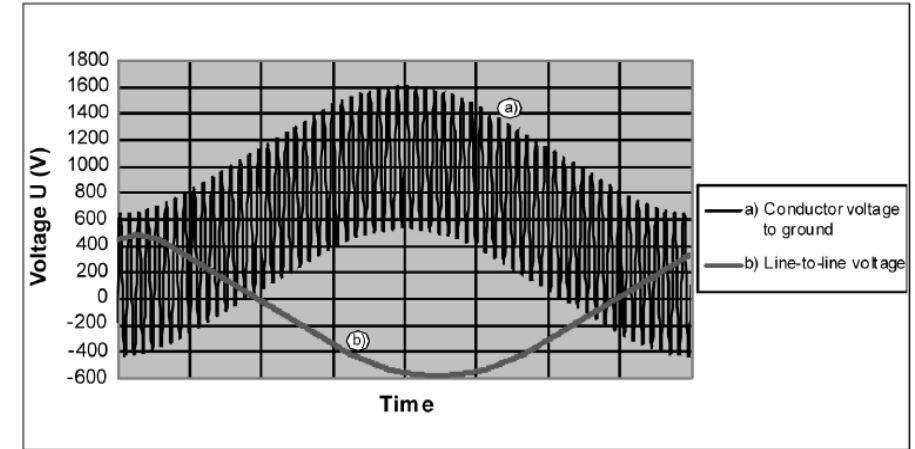
Complete portfolio of “Fit for Purpose” Transformers:
DTR & DRY (Compactcool) & Pad mounted



Why not a standard transformer?

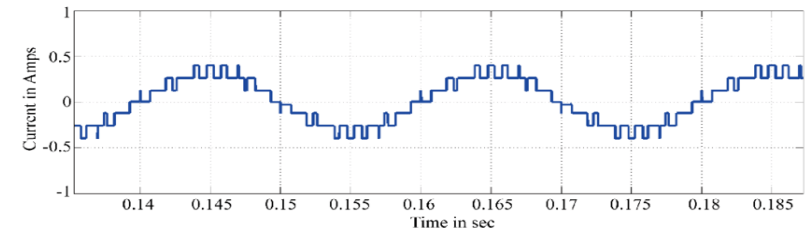
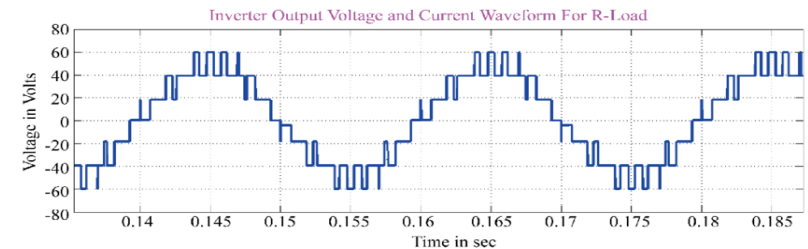
Non-symmetrical load and voltage

- **Unbalanced currents** from the inverter circuits may cause an unusual flux pattern creating higher than expected heating in windings.
- **Unbalanced voltages** from the inverters can cause core or winding heating, excessive core noise, and possible core saturation, hence, elevated excitation current and core temperature.



DC bias

- Significant increase in the magnetizing current can saturate the core, which may result in increased core temperature and circulating currents in structural parts.
- In liquid-filled transformers, higher core temperature may lead to generation of hydrogen gases.
- Higher Audible sound level
- Possibility of a resonance in the case of a cable-connected pad-mounted transformer. Nonlinear self-inductance of the transformer and capacitances connected in the system (such as cable capacitance and filter capacitance of the inverter) may contribute to cause a resonance (when the transformer core is saturated due to the dc bias). **(IEEE C57. 159 – 2016)**

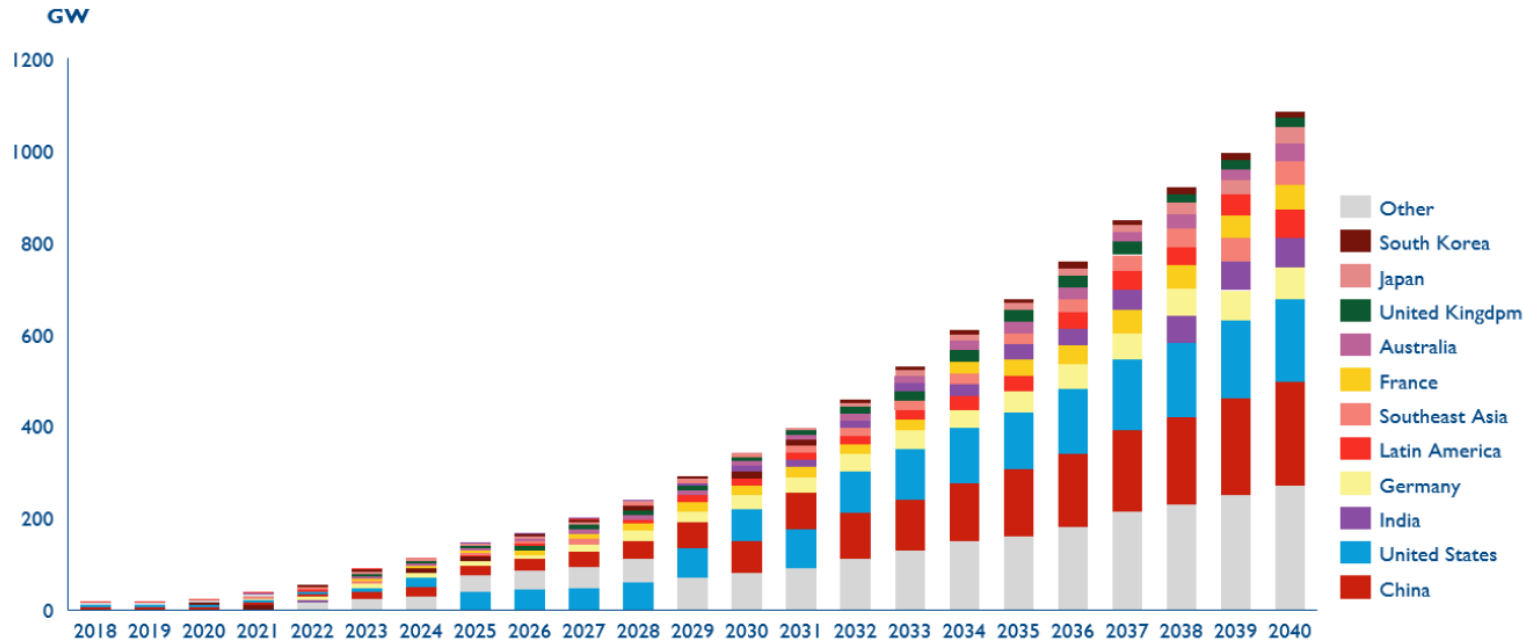


Why not a standard transformer?



Standard Designs that are not considering the renewable application challenges have witnessed several failures

Figure 5: Growth of the energy storage capacity (excluding PHS) globally 2018-2040 (BNEF)



Battery Energy Storage System PQplus



Examples of independent inverter and battery modules:

- Up to 32 x PQstor1 inverters: max power 960 kW
- Up to 14 x battery racks: max energy 960 kWh

<https://www.kallanish.com/en/news/power-materials/market-reports/article-details/ev-metals-to-build-saudi-arabias-first-battery-chemicals-complex-0221/>

South Africa's Eskom moves forward with 500 MW BESS initiative

South African utility Eskom has selected contractors for 343 MW of battery storage projects to be deployed in remote locations with limited access to distribution networks, but in proximity to large-scale renewables.

AUGUST 3, 2022 **MARIJA MAISCH**



Côte d'Ivoire's first large-scale solar farm will be equipped with Saft battery storage system

By [Andy Colthorpe](#)

May 11, 2022 **37.5MWp solar PV power plant in Côte d'Ivoire (Ivory Coast).**



Morocco-UK Power Project: Solar, wind and 5GW of battery energy storage

By [Alice Grundy](#)

September 29, 2021



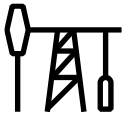
<https://www.kallanish.com/en/news/power-materials/market-reports/article-details/ev-metals-to-build-saudi-arabias-first-battery-chemicals-complex-0221/>

Segments



Industry and commercial

- Demand management meeting the highest peak loads without paying additional power fees
- Improve power quality
- Available backup power for critical loads and equipments



Utilities

- Flattening demand peaks, thereby reducing stress on grid equipment
- Allows higher mix of intermittent of renewables into the grid
- Enables grid code compliance



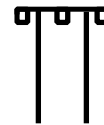
Renewables

- Acts as a buffer and smoothens out the renewable generation allowing for seamless grid integration
- Smoothens the output and controls the ramp rate (MW/min or kW/min) to eliminate rapid voltage and power swings on the electrical grid
- Aligns wind and solar generation peaks with demand peaks



Electrification of transportation

- Electric vehicles adding a new challenge to already congested distribution networks
- Can provide power from the batteries to charge vehicles and reduce the demand on the grid
- Enables DC fast charging without increasing demand charges
- More power available for increase in high-speed railway lines and for chargers of battery powered trains

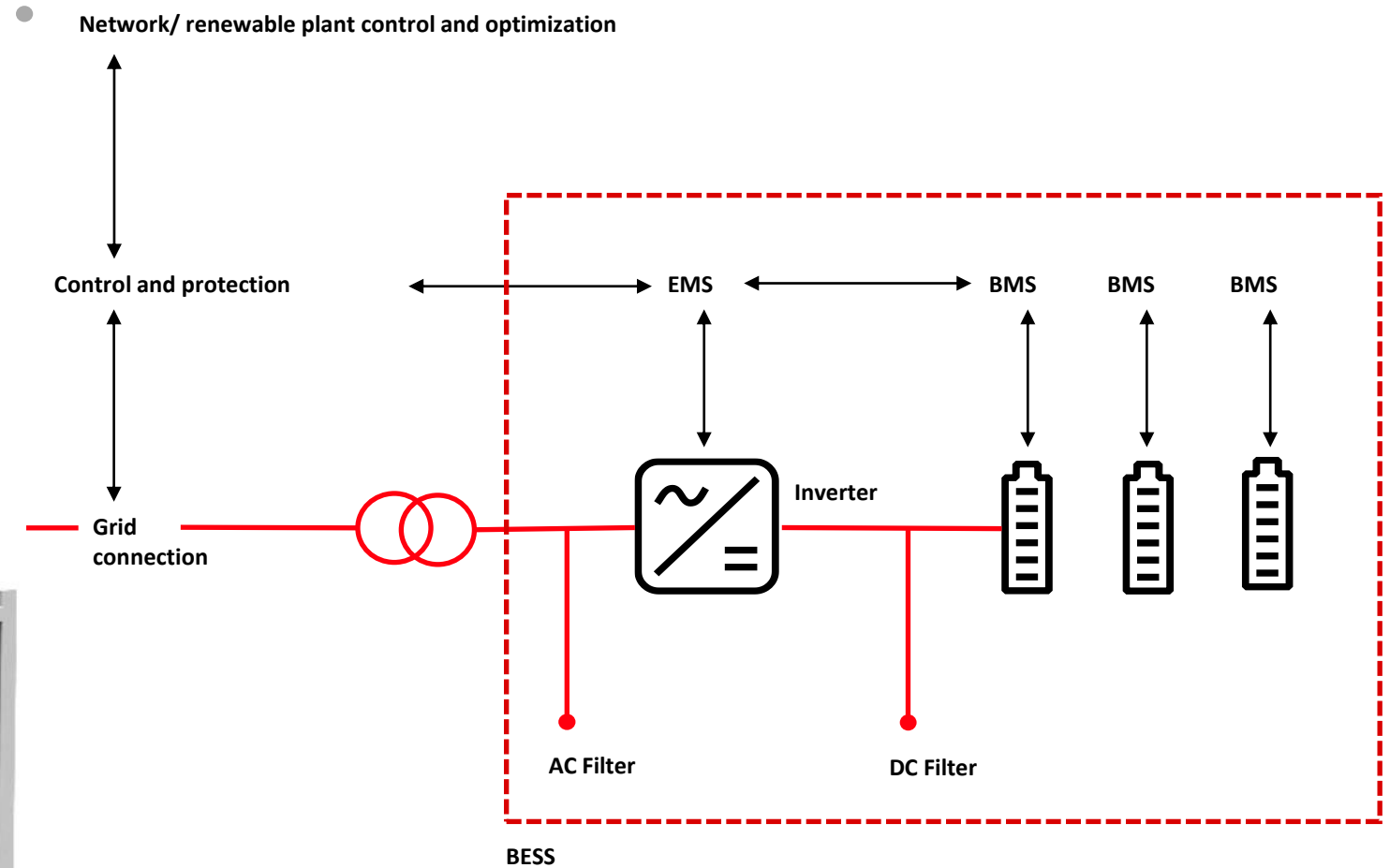
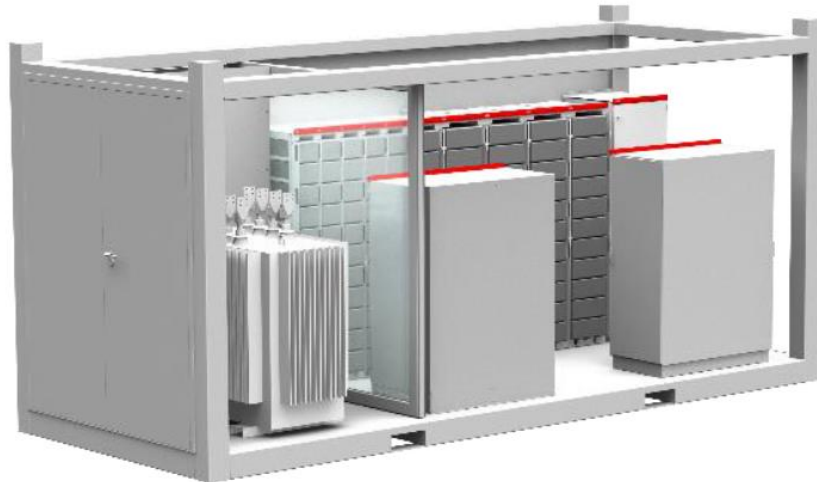


Microgrids

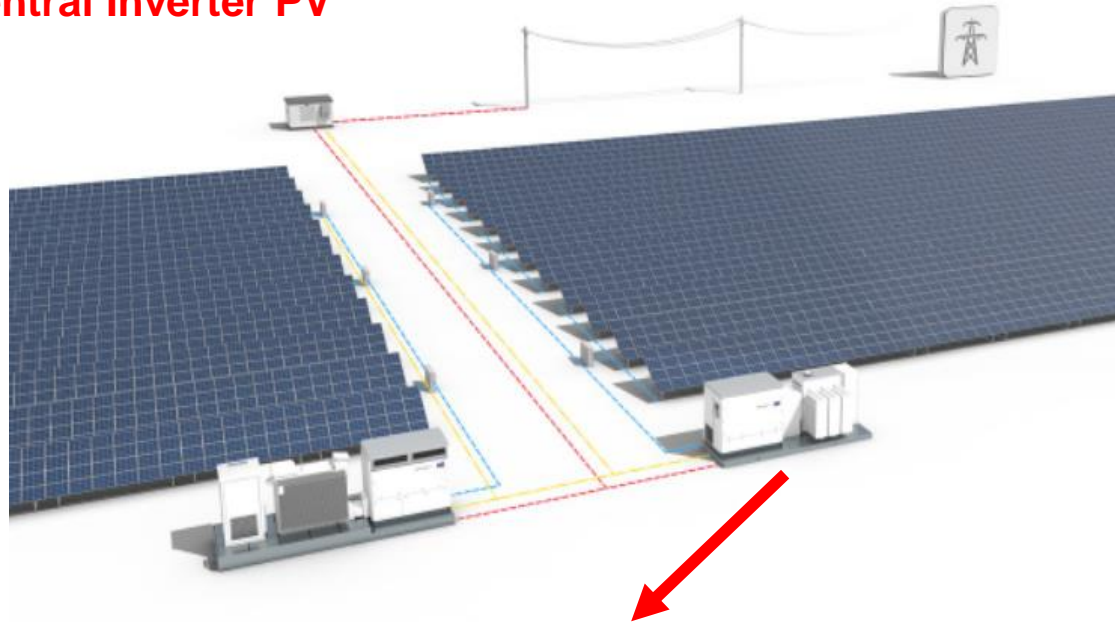
- Balancing fluctuating demand and a changing generation mix, without over sizing equipment

System Components

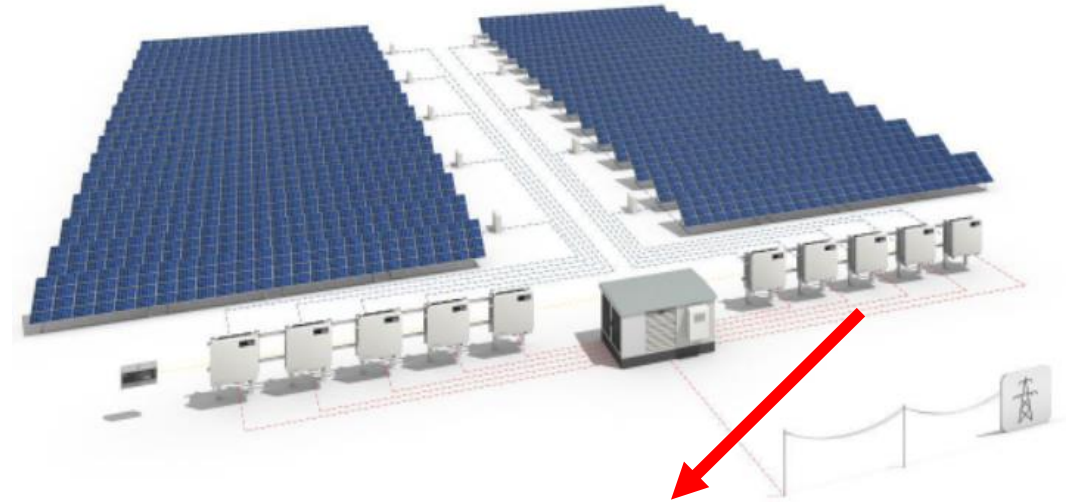
- Bi-directional inverters
- Energy storage batteries
- System controller (EMS)
- Distribution transformer



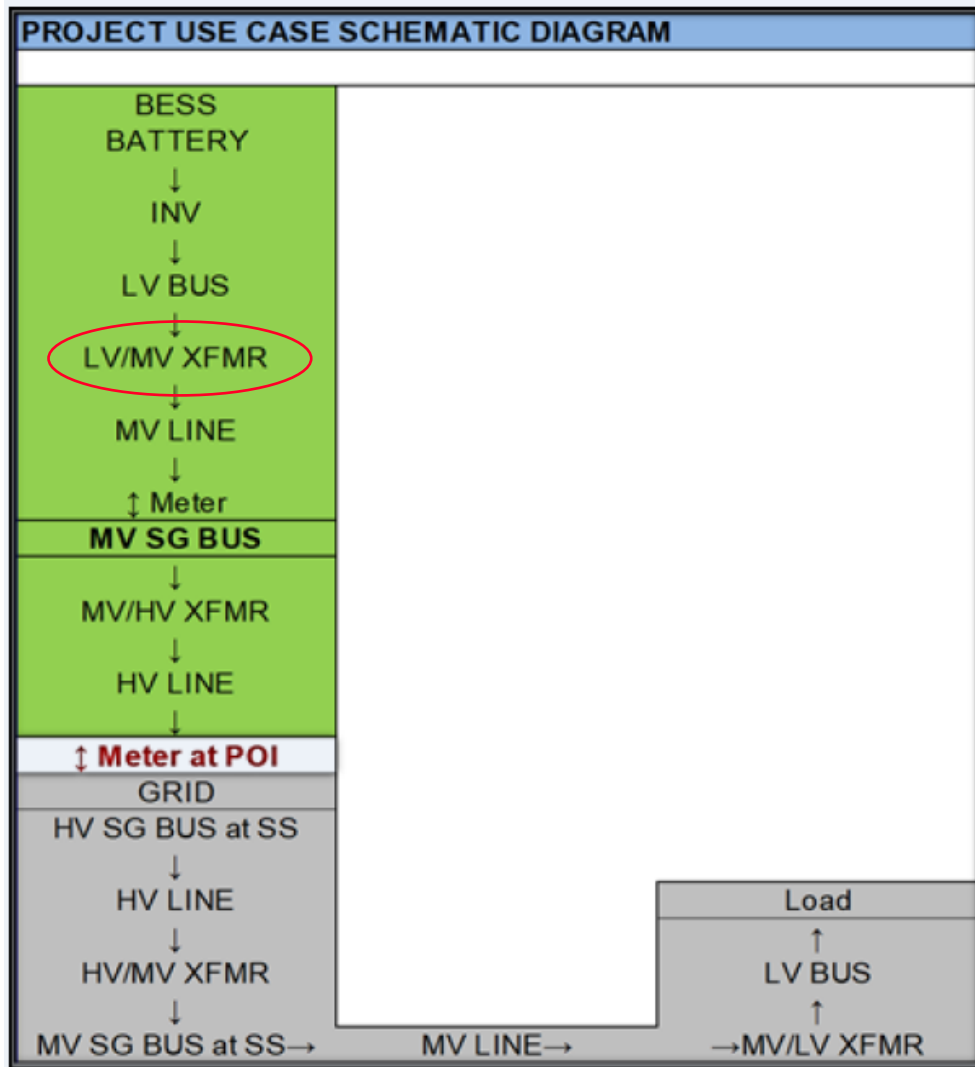
Central Inverter PV



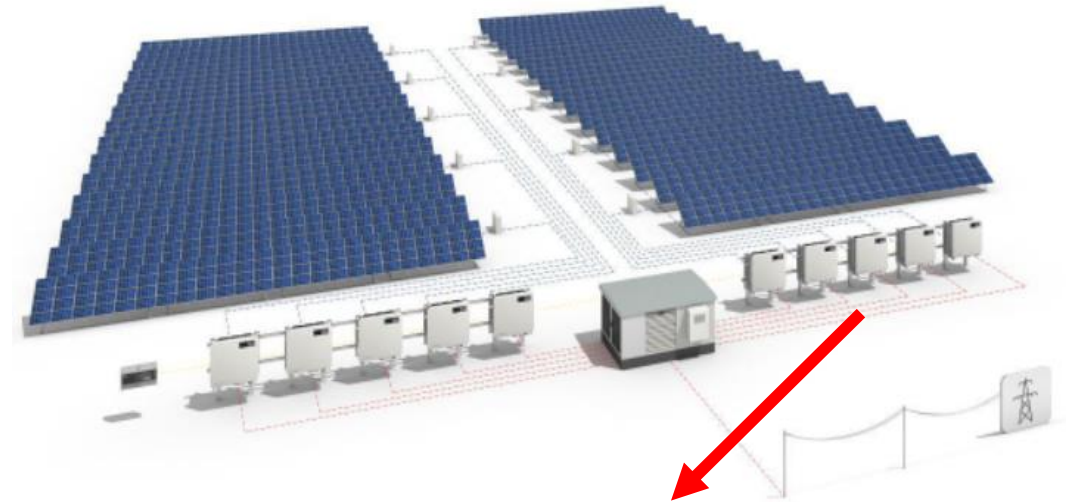
String Inverter PV



Type of solar inverters: Central & String



String Inverter PV



Central Inverters Solar, BESS & EV: MV + TR + Inverter

String inverters Solar: MV + TR + LV



Twin



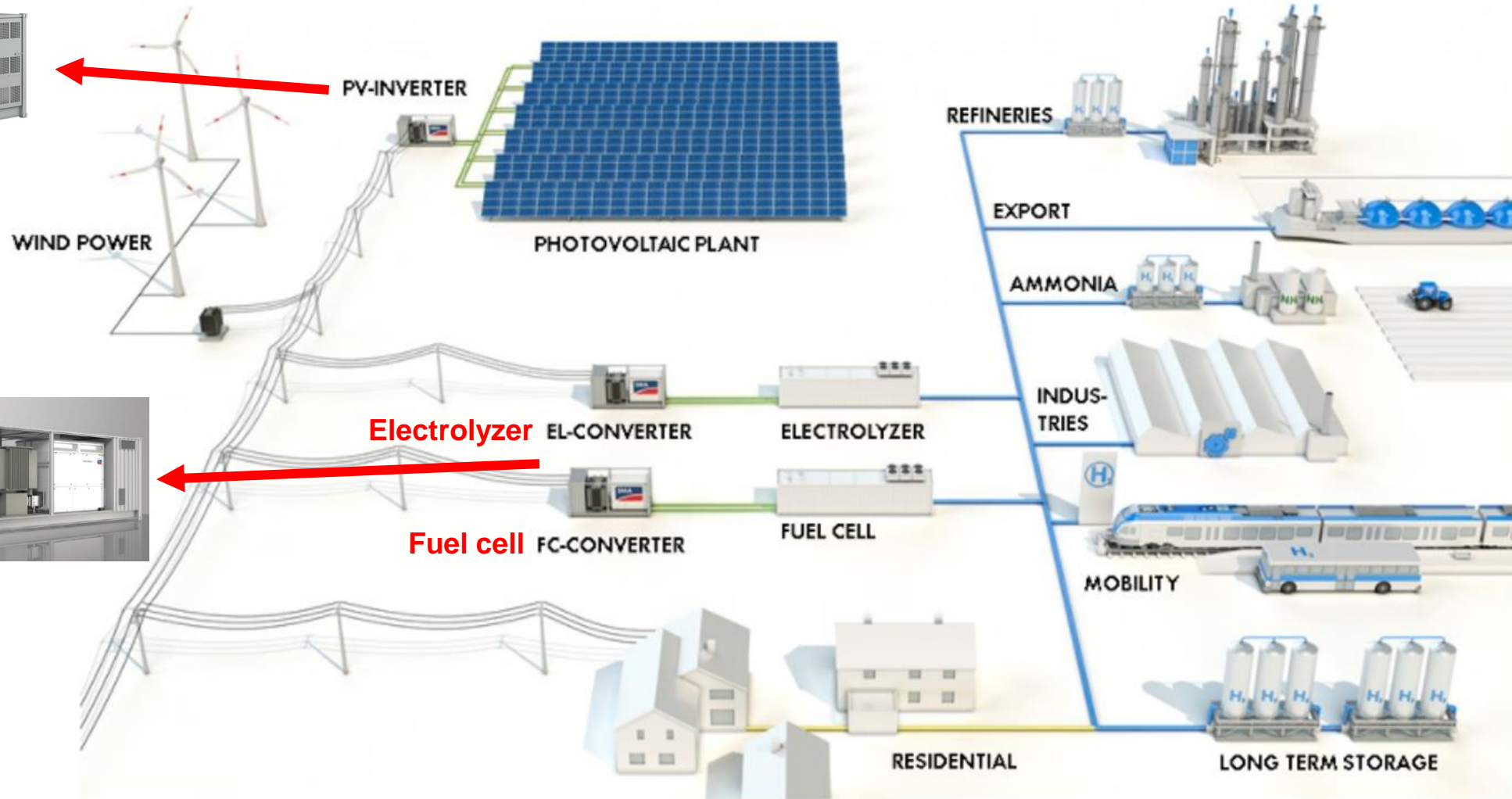
Skid Compact



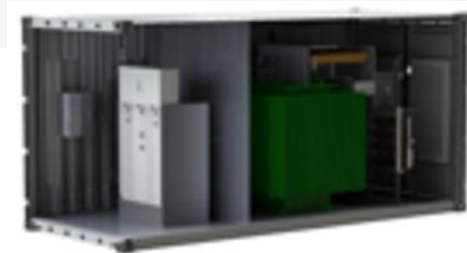
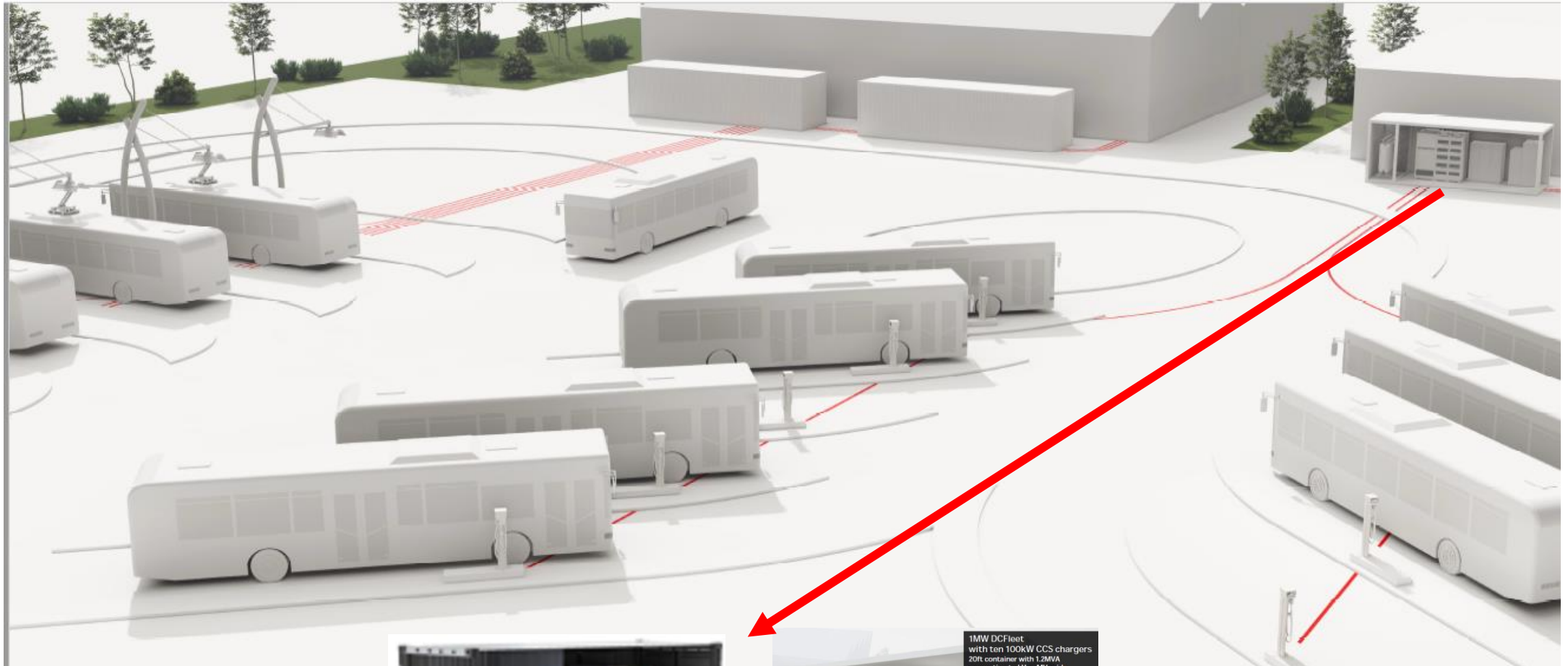
Containerized solutions: BESS



Containerized solutions: Hydrogen



Containerized solutions: EV-chargers



→ **Hitachi Energy
Grid Integration (PGGI)**

Massive volume in a really competitive environment

- **Reliability**: failure means NO generation (**change the mindset**)
- Competitive market: 10-12 USD/KVA and 12 weeks lead time → **Standard quote, never PO (Demand & supply full coordination)**
- Activated factories: **know-how + production capacity + competitiveness**
- **Electrical & mechanical requirements: Coordination**
 - **Inverter Central or string: LV insulation level, screen, THD..**
 - **Connections: HV & LV terminals requirements (set up & type)**
 - Dimension restrictions **EXPORT: skid & container limitations**
 - **Thermal behavior**
 - **Increase along with the inverter**
- New technologies, new requirements: **Floating PV** (acceleration & corrosion)



Direct supply, not long homologation required

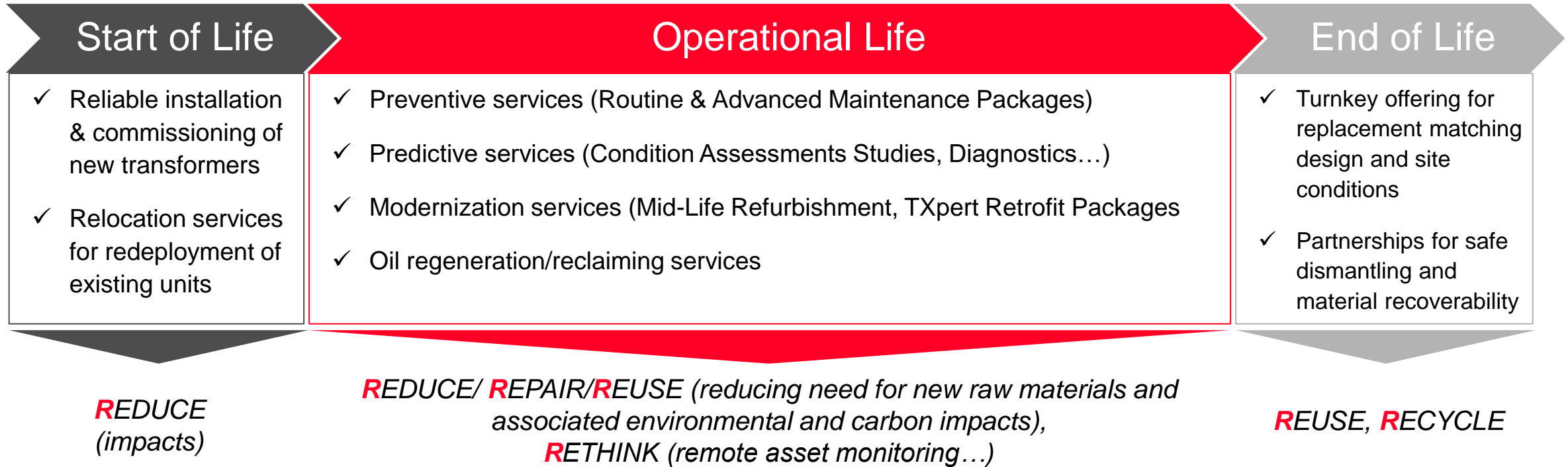
- Equipment usually supplied as **stand-alone solution**
- **No homologation** required, site delivery usually requested
- **Early engagement:** Key winning factor to avoid pure price competition
- **Price and delivery**, challenging.
- **Global footprint** key driver: Logistics & service
- Mapping from substation transformer level (coordination)
- Optimal solution to reduce CAPEX & OPEX



New Innovations in Transformers

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Enhancing resource and material efficiency: Our solutions – Services packages for Circularity and Lower Impacts



Environmentally friendly execution with highest safety standards (protecting your & our people & assets)

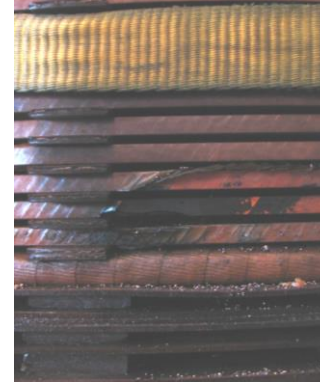


Assessment of life-cycle environmental, carbon, circularity impacts/benefits (on demand)



Mechanical Stresses

- Forces between winding conductor, leads and windings
- Due to over current caused by short circuit or inrush currents



Dielectric Stresses

- System overvoltage
- Transient overvoltage or internal resonance of windings



Thermal Stresses

- Local overheating
- Overload currents
- Eddie & stray losses
- Malfunction of cooling equipment



Accessory Fault

- Poor maintenance
- Harsh environments

•Paper Aging

- Cellulose life measured by the **Degree of Polymerization (DP) value** – can range from 1100 (new) – 200 (end of life)
- Cellulose aging is accelerated by temperature, moisture and oxygen

•Oil Degradation

- Poor quality oil also can increase dielectric failure risk
- Maintaining oil in excellent condition can reduce cellulose aging

•Bushings

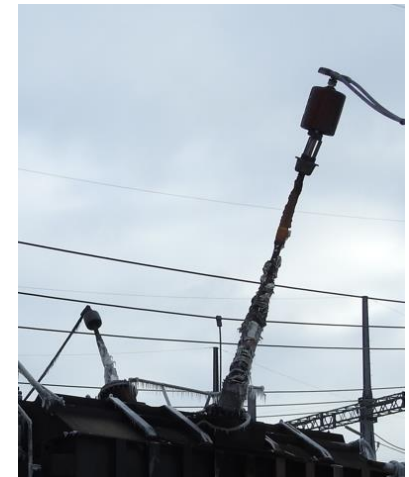
- Can degrade due to moisture, contamination, short circuited layers, voids and lead to failure, Failure of a bushing can cause total loss of the transformer

•Tap-changers (on load and off load)

- Overheating of contacts, In worse case, improper operation can cause winding failure

•Cooling system

- Overheating of the transformer due to cooling deficiencies, out of calibration winding temperature indicator
- Can lead to premature paper aging



- Replacement of a transformer is more than procurement of a new transformer
 - May require civil planning and extensive site work (new pad & containment)
 - Transportation of a new unit to site (might have changed from the original installation)
 - Outage planning
 - Removal of old unit, disposal, install new unit
 - Planning, approvals, impacts on other equipment
- Lead time of the new transformer
- Environmental benefits with extending the life of a present asset rather than replace
- Repair of the transformer is often a lower effort option



- Bushing Replacement
- Leak repairs / gasket replacement
- Oil reconditioning (filter, vacuum treat)
- Oil replacement or reclaiming
- Biodegradable fluid retro fills
- Transformer insulation dryouts
- Internal Inspections / internal repairs
- Cooling replacement / upgrade
- Control system upgrade
- Conservator tank modifications
- Tap Changer Replacement
- Field Induce Test
- Transformer winding replacement at site
- Transformer winding replacement at factory



Bushing Replacement



Cooling can be modified for increased MVA (10 – 20% is possible) or to fix thermal issue

Thermal design study

Options = replace fans, add radiators, replace with coolers

Example - design study showed unit could be uprated from 67 to 83MVA, addition of 16 fans, new nameplate



Cooling change allowed re-use of a transformer for a critical application

Before



After

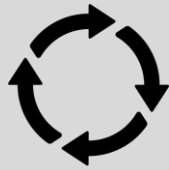


Four customizable packages to fit customers needs



Rapid Response

Fast and flexible service to maximize equipment availability



Lifecycle Management

Knowledge and expertise to optimize and extend equipment life



Performance Improvement

Increasing productivity through powerful tools and asset utilization



Nursing (short-term)

Extend the operation of a sick transformer with online monitoring & expert reports

Leverage the largest service organization to support your customers

+25
Countries with transformer service units










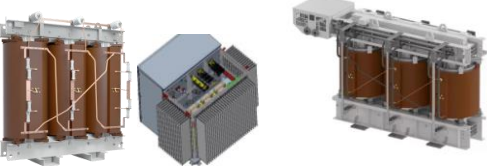



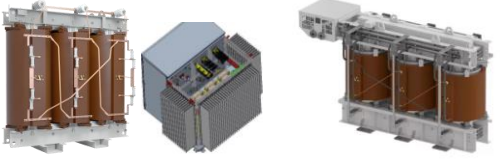



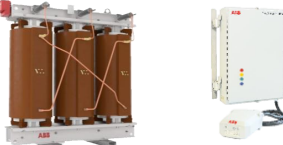


~1,300
Employees dedicated to customer services

24/7
Remote support with our Customer Connect Center

>100k
Transformer installed base

Service Contracts are customizable to match each customer's needs, leveraging:

Keeping Pace with concepts that are transforming future of Energy

Segment	Digitalization	Reliability	Decarbonization	Decentralization
<p>Utilities</p> 	<p>TXpert™ Ecosystem</p>   <p>APM Edge Transformer only</p>	<p>Hi Dry</p> 	<p>EconIQ TXpand</p>  	<p>Line Voltage Regulators</p> 
<p>Renewables</p> 	<p>TXpert™ Ecosystem</p> 	<p>TVP CompactCool</p> 	<p>Fit for Purpose” (F4P) Step-up collector transformers</p>	<p>Containerized Solutions</p> 
<p>Infrastructure Dtc / Building / Trans</p> 	<p>TXpert™ Ecosystem</p> 	<p>TVP CompactCool</p> 	<p>Dry TRs Ester Filled</p>  <p>FR3 DIELECTRIC FLUID</p>	<p>Containerized Solutions</p> 
<p>Industries O&G / F&B / METAL</p> 	<p>TXpert™ Ecosystem</p>  <p>CoreSense M10 DGA Multi-GAs</p>	<p>TVP</p> 	<p>K-Factor TRs Life Cycle Analysis Dry Type TRs</p>	<p>Remote Monitoring & Services</p> 

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HITACHI
Inspire the Next 