Transmission Products
Offering system integration for grid solutions

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Transmission Products
Market leader in innovation

Key information

- Worldwide #2 position
- ~13,300 employees
- 30 factory locations in 14 countries
- Transmission Products has the competence of building all product and system elements of HV substations
  - a trusted and reliable partner
  - comprehensive portfolio
  - driving technology innovations
  - highest quality standards
Transmission Products
Major backbone of the Energy Value Chain

Our functionality offer

- Transmission products & systems for:
  - Efficient power transformation
  - Reliable protection
  - Precise measurement
  - Safe switching & operation
  - Power quality
  - Future built in connectivity & intelligence
  - Improved grid resilience & sustainability

Conventional power generation

Renewable power generation

Transmission Products & Systems

Industry & infrastructure

Distribution network

single source for products & systems from generation via transmission to distribution
TP comprising all products of HV substations including their electrical integration to systems

Sensors and connectivity; control, protection and automation; medium voltage; parameterization, system engineering; HV connection between AIS/GIS and transformers
Our portfolio – Reliable & sustainable for all applications (I/IV)

**Gas-insulated switchgear**

- **8VM1** up to 72.5 kV
- **8VN1** up to 145 kV
- **8DN8** up to 170 kV
- **8DN9** up to 245 kV
- **8DQ1** up to 550 kV

- Very reliable: Less than 25% of failures compared to GIS Cigre failure average
- Very compact
- For indoor and outdoor installation, also in environmentally sensitive areas
- Low operating costs with the first inspection required after 25 years of operation

**Circuit Breaker**

- **Live Tank Circuit Breaker** from 72.5 kV up to 1200 kV
- **Dead Tank Circuit Breaker** from 72.5 kV up to 1200 kV
- **Disconnecting Circuit Breaker** for 145 kV and 420 kV
- **Dead Tank Compact** for 145 kV and 245 kV

- Very reliable: Less than 10% of failures compared to Cigre failure average through self-compression interrupter unit and stored-energy spring mechanism
- Reliable product life time of up to 50 years
- Low installation and maintenance costs
- Market leader with >100 years of operational experience
Our portfolio – Reliable & sustainable for all applications (II/IV)

Disconnectors & Earthing Switches

- Delivery of pre-assembled and pre-adjusted disconnector & earthing switch poles and main components
- Easy erection and final adjustment according to the operating instructions
- No special tools necessary
- Dry-lubricated contact systems

Surge Arrestors & Long rod insulators

- One of the leading manufacturers with 90 years of operational experience in standard and special applications
- Superior sealing system that reliably prevents moisture ingress to ensure the highest possible degree of overvoltage protection and decades of trouble-free service
Our portfolio – Reliable & sustainable for all applications (III/IV)

Instrument Transformers

- Complete product portfolio for AIS & GIS applications in all technologies
- Excellent insulating stress control using fine graded bushings, increasing safety & reliability
- We meet and exceed our customers’ specifications and some of the industry’s most rigorous standards, with designs available in compliance to ANSI/IEEE, IEC and other major standards

Coils

- Highest mechanical and short-circuit strength
- Low noise levels are maintained throughout the life of the reactor
- Weatherproof construction, with minimum maintenance requirements
- Product lifetime of 30 years and more
- Designs available in compliance with ANSI/IEEE, IEC and other major standards.
Our portfolio – Reliable & sustainable for all applications (IV/IV)

Transformers and Reactors

- Full portfolio tailored to meet specific customer needs
- Designed to maximize grid availability
- Extreme high reliability
  (“excellent” mean time between failure rates)
- Comprehensive Pretact® and Ester solutions
- Long-lifecycle solutions with maximum efficiency
- Connectivity & optimized operation by Sensformer® technology

<table>
<thead>
<tr>
<th>Power Transformers</th>
<th>HVDC Transformers</th>
<th>Reactors</th>
<th>Phase Shifting Transformers</th>
<th>Transformers for Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 1200 kV</td>
<td>up to 1100 kV</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Bushings

- HSP & Trench, two world market leaders in high-voltage bushing technology share their knowledge in terms of development, design and production of AC & DC bushings
- Highest quality and customized solutions
- Technologies have been successfully in service for more than 65 years

<table>
<thead>
<tr>
<th>Transformer Bushings</th>
<th>Wall Bushings</th>
<th>GIS Bushings</th>
<th>Generator Bushings</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 - 1200 kV</td>
<td>24 - 1000 kV</td>
<td>73 - 550 kV</td>
<td>up to 50,000A</td>
</tr>
</tbody>
</table>

1) Including Generator step-up transformers and System-interconnecting transformers
Global factory network for highest performance & customer intimacy

- Clear global product responsibility in Lead Factories for highest performance of entire factory network

Factory Network

Air Insulated Switchgear

- Jakarta, ID (in set up)

Gas Insulated Switchgear

- Wuxi, CN
- Shanghai, CN
- Hangzhou, CN
- Guangzhou, CN

Power Transformers

- Wuxi, CN
- Shanghai, CN
- Hangzhou, CN
- Guangzhou, CN
Key innovations for high-tech performance and sustainability

**Sensformer® – Born Connected**
- Sensformer® enables our customers to get digitalized and optimize its operations

**Grid Resilience – Pretact®**
- Mobile Resilience Units for easy and fast replacement / bypassing

**Ester – alternative fluid for transformers**
- Fully biodegradable insulation fluid produced from renewable sources

**Blue Clean Air / Vacuum portfolio (SF₆ free)**
- "Blue" portfolio combines high-tech performance, easy operation, maintenance and sustainable
- No CO₂e emissions

**UHV equipment <=1200 kV (AC) / 1100kV (DC)**
- State-of-the-art technology for efficient longest distance transmission

**Low power instrument transformer**
- Compact combined eCT/eVT solution suitable for wide range of applications
Reference: Gas Insulated Switchgear and Transformers for groundbreaking Megaproject in Egypt

**Power Transformers**
- 86 Power Transformers delivered in total, therein step-up transformers and auto transformers with ratings from 165 to 485 MVA
- Utilizing factory network to meet tight delivery schedule

**Gas-insulated switchgear**
- Six 500 kV gas-insulated substations and six 220 kV gas-insulated substations to enable a reliable and resilient energy delivery
- Provision of training and employment

**Key facts**
- Customer: Egypt government
- Local partners: El Sewedy Electric and Orascom Construction
- Siemens gas successfully managed to connect 14.4 gigawatts to the Egyptian national grid
- Ordering year: 2015
Reference: Product supply for world’s first 1100 kV UHVDC transmission line

HVDC Transformers
- Design and manufacturing of 4 different transformer types
- World’s first 1100 kV UHVDC transformer
- Utilizing factory network to develop & produce 28 units

Bushings
- First bushing worldwide for ±1100 kV UHVDC transmission in RIP dry technology

Key project facts
- UHVDC transmission line from Changji to Guquan in China
- Operator: State Grid Corporation of China (SGCC)
- Distance of 3,284 kilometers with a transmission capacity of twelve gigawatts
- Ordering Year: 2016
Reference: World’s first SF6-free high-voltage switchgear with clean air insulation

Circuit Breakers
- Installation of two SF₆-free 3AV1 Blue circuit breakers
- Vacuum interrupter technology
- Clean air insulation

Instrument transformers
- Six SVAA voltage and current transformers with clean air insulation

Key information
- Customer: Netze BW GmbH, Germany
- Modernization of a 110 kV substation in Noerdlingen
- Operation requires no SF₆ insulating gas anymore
- Ordering year: 2017
Transmission Products – benefiting from experience and innovation power

Total cost of ownership
- Short delivery and commissioning times
- Highest overall value through predictable revenue stream and lowest costs of operation driven by energy efficient solutions

Reliable & resilient
- Lowest failure rates
- Long product life times
- Over 100 years of operational experience
- Global Resilience concept to Protect, Prevent and React

Leading in innovation
- State-of-the-art technology
- UHV equipment up to 1200 kV (AC) and 1100 kV (DC)
- Several world first solutions

Cost efficient

Connectable & intelligent
- Digitalized products to optimize operations
  - Secure data transmission
  - Data storage on cloud solutions

Sustainable
- High efficiency products
  - Minimal SF₆ volume and best in class leakage rate
  - Blue products with no greenhouse gas impact
  - Ester technology

Comprehensive & global
- Global footprint operated as factory network
- Most comprehensive portfolio for all high voltage applications
- Single source opportunity
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Blue Clean Air / Vacuum portfolio combines high-tech performance, easy operation and sustainability

Customer benefits of the blue portfolio

- **High reliability**
  due to the hermetically tight vacuum interrupter, eliminating any influence caused by decomposition products

- **High performance**
  Perfect for frequent switching applications: Higher number of short-circuit interruptions 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

The latest products in the blue portfolio

- 8VM1 blue GIS up to 72 kV (for wind turbines)
- 8VN1 blue GIS up to 145 kV
- 3AV1 blue 145 kV circuit breaker
- Blue instrument transformer up to 420 kV
Ester technology - Benefits of alternative insulation fluids for Power Transformers *)

Higher fire safety

- Higher flash and fire point
- Fire point above 300° C
- K class rating (IEC 61100 / 61039)
- Lower gas conversion factor
- Tank rupture prevention

Lifetime extension

- Slower decrease in the degree of polymerization
- High capability to take water from cellulose
- Dielectric strength unaffected by water
- Higher temperature limits

Smaller Footprint

- Eliminate rocks, grating, and support steel
- Change containment size
- Shorter bus duct length

Cost savings (example)

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost/Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings from design difference</td>
<td>$ 655,494</td>
</tr>
<tr>
<td>Bio-oil transformer extra costs</td>
<td>– $ 275,450</td>
</tr>
<tr>
<td>Total savings</td>
<td>$ 390,044</td>
</tr>
</tbody>
</table>

OPEX savings

- Lower annual insurance premiums
- Lower losses during operation due to shorter bus duct length

*) up to 420kV in operation – higher values on request
Pretact® – Increase grid resilience at any time
Minimizing unplanned outage and blackout risks

Risk factors for safe power supply

- **Operational issues**
  - Network failure
  - Aging fleet
  - Load balancing
  - Incorrect operations

- **Natural disasters**
  - Storms
  - Flooding
  - Fire
  - Earthquakes
  -Geomagnetic storms

- **Other forced outages**
  - Vandalism
  - Cyber attacks

<table>
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<th>Common protection</th>
<th>Game changing concept</th>
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<tr>
<td><strong>PREVENT</strong></td>
<td><strong>PROTECT</strong></td>
</tr>
<tr>
<td>operational issues</td>
<td>against natural disasters and forced outages</td>
</tr>
</tbody>
</table>

Benefits:

- Maximize energy availability at reasonable efforts vs. blackout impacts
- Increased personal safety in combination with ecofriendly design (e.g. ester filled, clean air)
- Minimized outage risk from months to a minimum e.g.
  - 300 MVA transformer-bank exchange in 30 hours (within three working days)
  - Mobile GIS
- Optimized outage management costs
- Outage recovery plan definable
Pretact® – Increase Grid Resilience at any time
Modular feature architecture to protect, prevent and react

**PROTECT**
against natural disasters and forced outages

- Bullet resistance, composite insulators and bushings
- Protection equipment like surge arresters and coils
- DC compensation, GIC- and tank rapture safe transformers

**PREVENT**
operational issues

- Alternative Fluids, Blue products: vacuum switching and clean air technology
- Monitoring, Life Time Management, Service concepts
- Reliable products, state of the art design tools

**REACT**
to emergencies and temporary outages

- Mobile Plug & Play concepts for transformers, reactors, Power VT, RIS and RIP bushings
- DCB, Hybrid insulated switchgear / Deadtank CB, Mobile GIS
- Spare product concepts at customer sites for AIS, GIS equipment

**GENERAL**

- Financing

**Abbreviations:**
- DC: Direct Current
- GIC: Geomagnetically Induced Currents
- RIS: Resin Impregnated Synthetic
- RIP: Resin Impregnated Paper
- DCB: Disconnecting Circuit Breaker
- GIS: Gas-insulated Switchgear
- AIS: Air-insulated Switchgear
- VT: Voltage Transformer

Transmission Products
Pretact® – Reference
REACT Transformers for emergencies and scheduled maintenance

- Multiple Rating units
- Flexible EPR cable connection
- Single phase units with optimized geometry
- Plug In Bushings (HV & LV)
- Sensformer® Cloud connection
- Alternative Insulation fluid (e.g. Ester)
- Optimized for transportation
- Cable Plug In connections Neutral / LV
Sensformer® – Born Connected
Future is in managing and learning from the data

- Sensformer® equipped to provide following direct measurements per default:
  - Oil Level Alarm
  - Top Oil Temperature
  - LV Winding Current
  - GPS Location
  - Local weather information

- Secure data transmission through GSM or Ethernet with state-of-the-art cyber security measures
- Data storage on cloud solution with graphic interface tool for data analysis
- Software applications for further value creation and operational enhancement
Sensformer® App…
Stay on-grid even when you're off-site

- Secure mobile connectivity
- Instant overview of asset status with real-time data
- Enhanced asset life cycle management
- Key KPIs at a glance
- Optional push messages in case of alarms
Thanks for your attention!