

MAY 18, 2022

Utilizing PI System for TSO Analytics

(holistic monitoring approach for TenneT asset management)

Pilot Project with Siemens Energy on Vibrations Monitoring in HVDC Converter Stations

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AVEVA

Part 1: TSO Analytics (holistic asset monitoring approach)

AVEVA

A grid operator's tasks

Main tasks

Transmission services

Ensure a robust and efficient high-voltage grid



Market facilitation

Facilitate an efficient and stable electricity market



System services

Maintain the balance of electricity, 24/7



TenneT at a glance



2021



Workforce

6,620
Employees



EBIT

801
EUR million



Assets

32
EUR billion



Investments in 2021

3.9
EUR billion



Grid

99,99%
Availability



Grid length

24,500
Km



Dutch State

100%
Shareholder



Footprint

69%
Greened

Investments

Investments 2021

3.9 EUR billion

- 1/3 in The Netherlands, and
- 2/3 in Germany
- Towards at least 6 EUR billion annually in 2025

TenneT TSO GmbH

The Netherlands and Germany

- Facts & figures

- Employees

3,210

- Assets

EUR 9,651 billion

- Total grid length

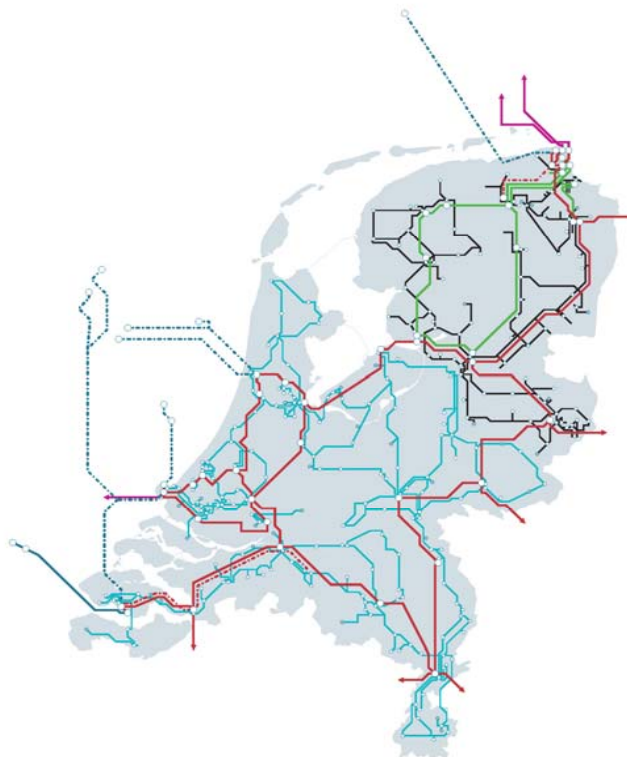
10,959 km

- Transformer substations

339

- Number of end-users

17 million



- Facts & figures

- Employees

3,410

- Assets

EUR 12,525 billion

- Total grid length

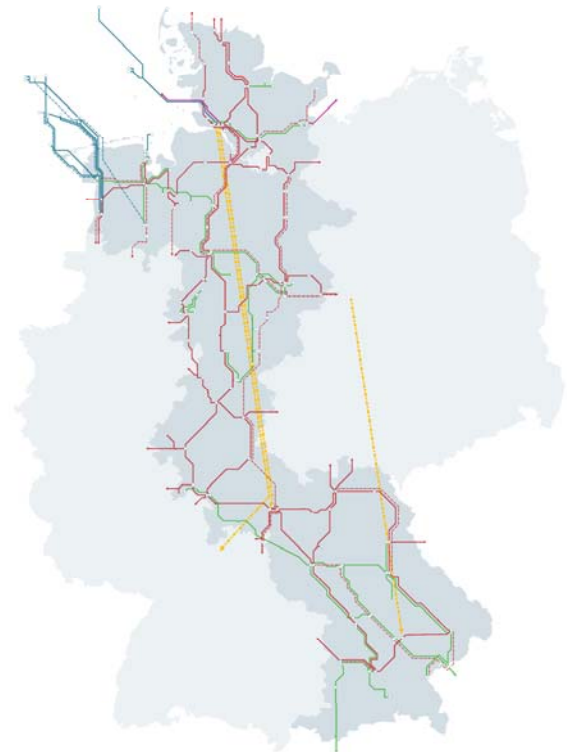
13,559 km

- Transformer substations


136

- Number of end-users

25 million

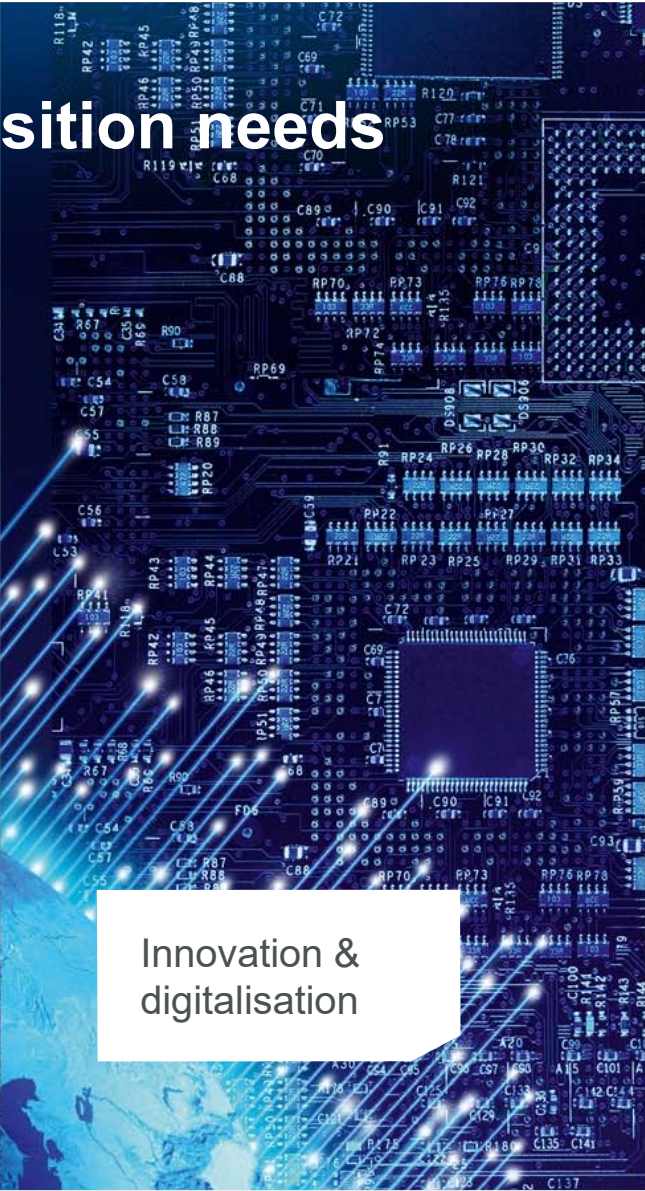


What the Energy transition needs




Large scale
grid expansion

The image shows a large offshore oil platform with a yellow lattice structure and a white upper section, situated in the ocean. In the background, several wind turbines are visible on the horizon under a blue sky.



Innovation &
digitalisation

The image is a close-up of a blue circuit board with various electronic components. Overlaid on the board are glowing blue lines and dots, suggesting a digital or technological theme.



System
Integration &
Maintenance

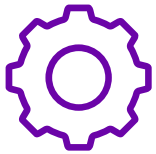
The image shows a complex industrial system with large, white, curved pipes and various valves and fittings. The system appears to be part of a large-scale infrastructure project.

2 June, 2022

TenneT corporate presentation

 **TenneT**

TenneT TSO Holistic Monitoring Approach



Challenge

- Complex and geographically widely distributed systems
- Plan maintenance measures based on evaluation of process and plant data
- Collect, store and transfer data in a cyber secure manner



Solution

PI System deployment as **common data infrastructure** brings together **immense quantities of data** from the individual sub-systems in a structured and systematically normalised way **to make new information available** for process monitoring, condition-based maintenance (CBM), advanced analytics



Benefits

- Improved asset availability
- Significant cost savings can be realised compared to the classical methods of cyclical, preventive maintenance
- Centralised centre for process monitoring, condition-based maintenance & advanced analytics

Holistic Monitoring Approach

Why TSO Analytics?

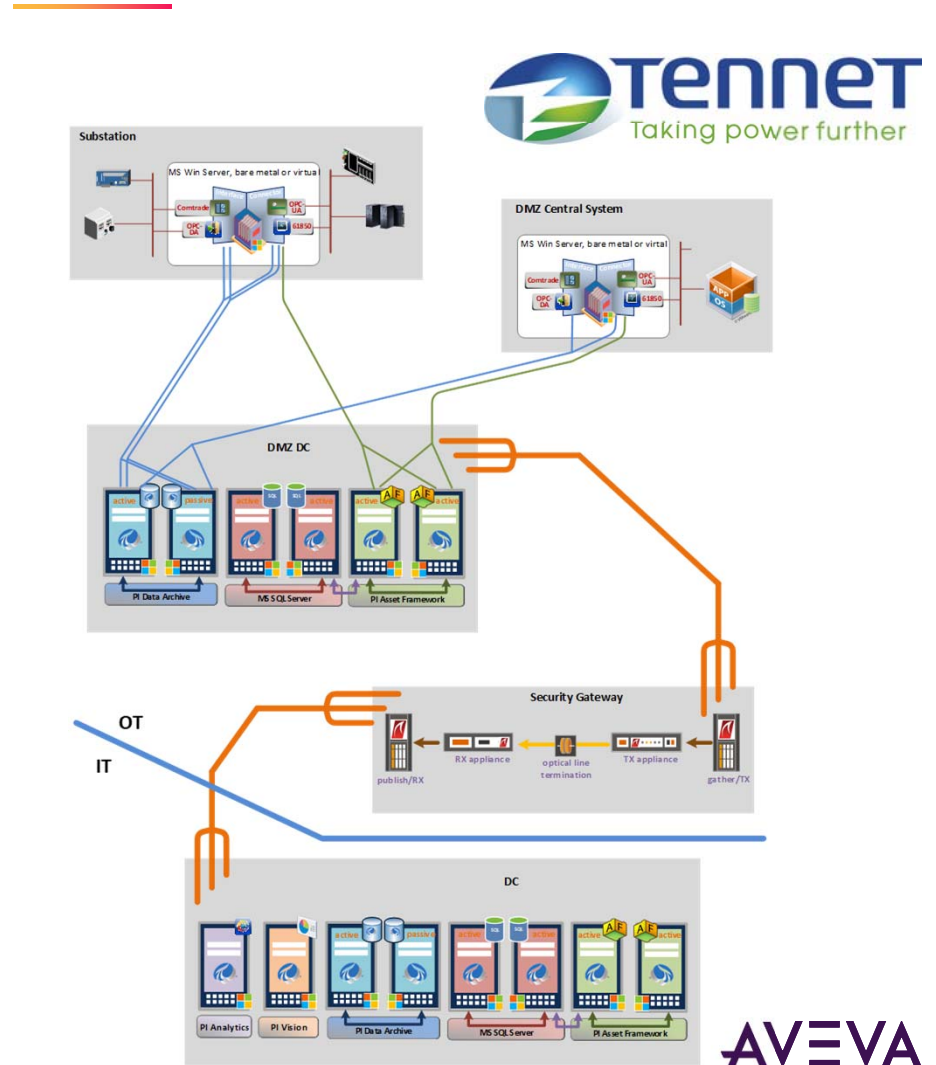
- Majority of data required for process monitoring, condition-based maintenance & advanced analytics are currently stored decentral in the plants themselves, or within the departments in the specialized management systems.
- Until now, the necessary maintenance measures, some of which are prescribed by law or by the manufacturers, were **carried out on a purely rotational basis** and do not consider the *actual* plant operating conditions. (scheduled procedures versus “smart” operational-data-based decision-making)
- Open questions to answer in the organization:
 - Who is condition monitoring business owner
 - Who is condition monitoring data owner
 - Who are condition monitoring custodians
 - Who is condition monitoring system owner
 - Who are condition monitoring data controllers and data processors
 - **Enabling data sharing with diverse stakeholder (internal & external)**



Setup / Installation



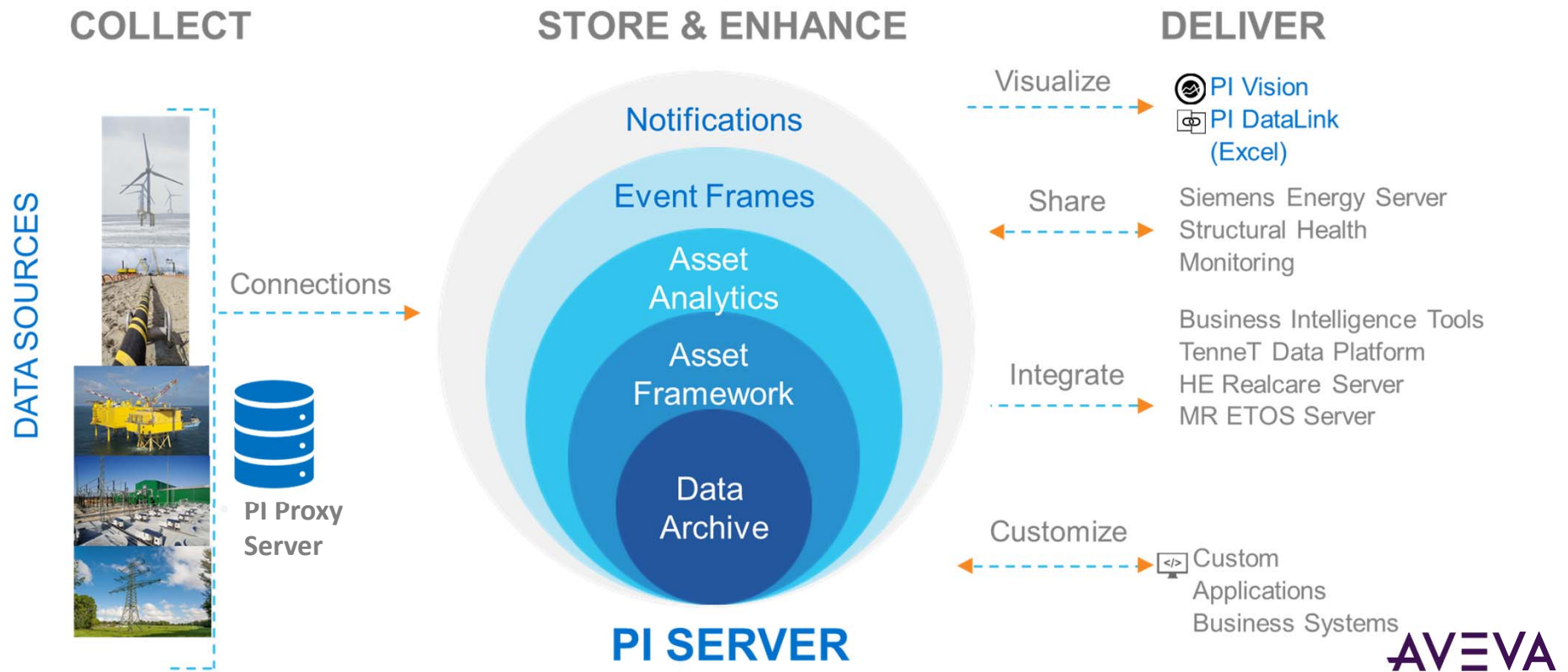
- **PI Connector**
 - Collects operationally relevant data and status information as well as their history in an interdisciplinary way
- **PI Server (PI AF, PI Vision)**
 - Store operationally relevant data into a structure, which makes the individual information assignable to concrete assets
- **Data Diode for Cybersecurity**
 - Secure transfers of information from the restrictively isolated area of OT (operational technology) to the IT area of office communication.



Setup / Installation



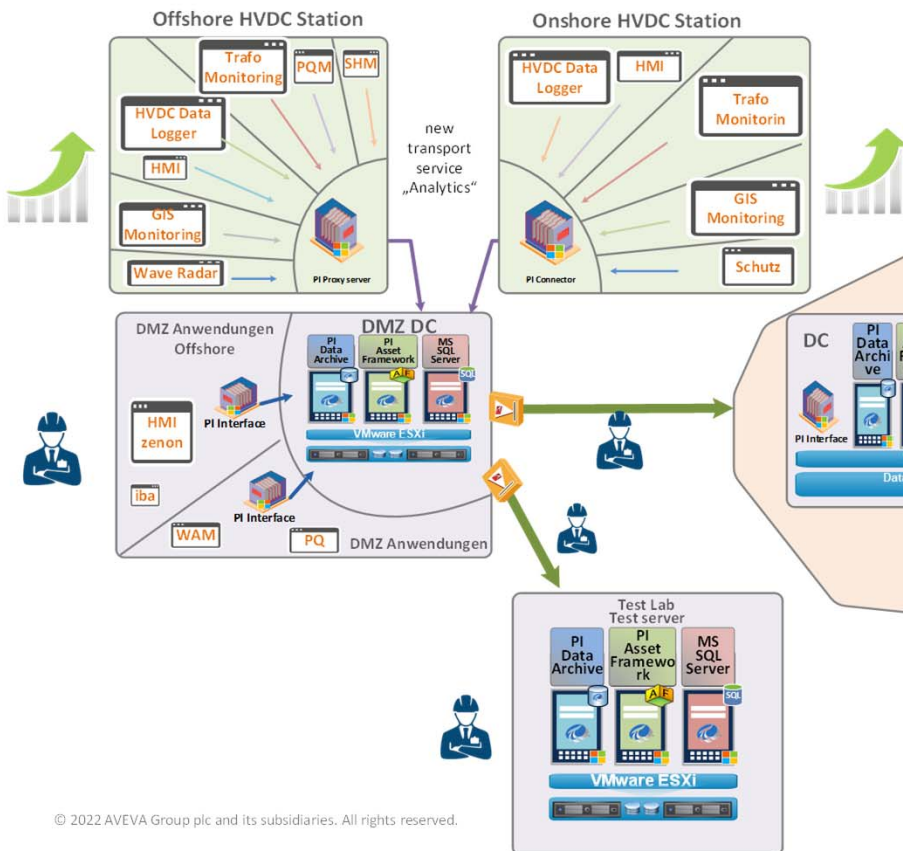
TSO Analytics Approach and Roll-out Status



Setup / Installation



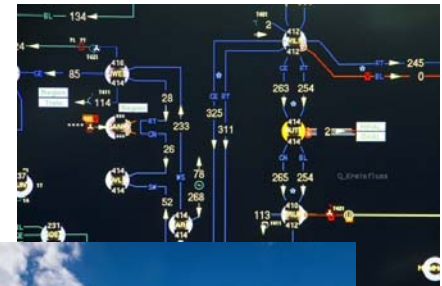
TSO Analytics Approach and Roll-out Status



TenneT Data Platform

Control Room of Future

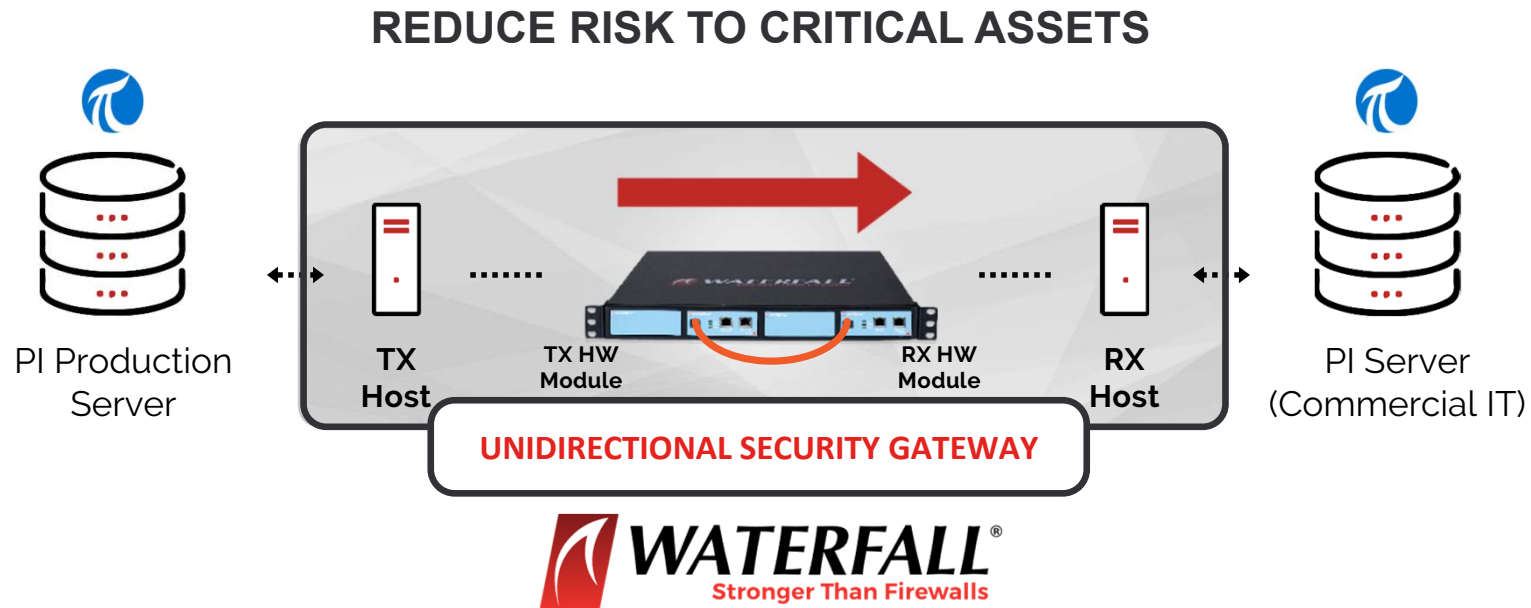
Siemens Energy Server
Structural Health Monitoring



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Cybersecurity

Architecture Design with Data diode



How TSO analytics (PI System) solved TenneT condition monitoring business challenges



Past

- No pervasive security model for condition monitoring solutions
- Local security millstones for condition monitoring solution implemented
- Historic measured data and data models available local
- OEM supplier leader of innovation and development of condition monitoring solutions and needs

Present

- Pervasive security model implemented via TSO analytics
- Central security millstones for condition monitoring solution implemented
- Historic measured data and data models available central for analyses and quality check
- TenneT is the leader of innovation and development of condition monitoring solutions and needs

Part 2: Pilot Project with Siemens Energy on Vibrations Monitoring in HVDC Stations

Dr. Marcus Zeller (Siemens Energy Global GmbH & Co. KG)

AVEVA

Our set up

The leading pureplay energy company



Our offering

Products
Solutions
Services

Across the value chain

Generation
Transmission
Storage

Broad technology portfolio

From
Conventional
to Renewables

Siemens Energy AG

Gas and Power ("GP")

Generation



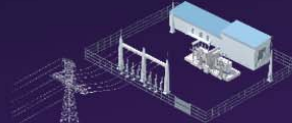
Central

Distributed

Industrial Applications



Transmission



Starting now...

New Energy



Siemens Gamesa Renewable Energy ("SGRE")

67% owned

Onshore

Offshore



High Voltage Grids

March 2022

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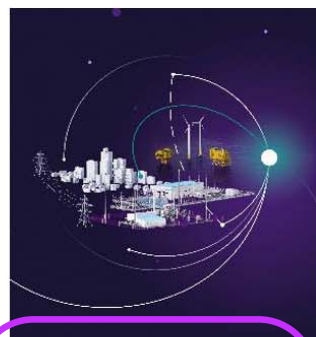
Unrestricted © Siemens Energy, 2022

Overview of Transmission Business

Our portfolio



"Data & Insights Partnership"



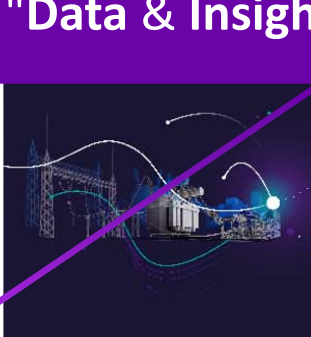
High Voltage Grids

- Onshore HVDC grid connections
- Offshore HVDC and HVAC grid connections
- Offshore electrification



Grid Stabilization

- Substation solutions
- FACTS
- MVDC



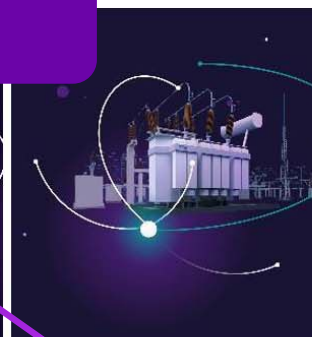
Grid Automation Technology

- Network consulting
- Sens-X
- Automation and future grid lab



Switching Products

- Substation systems
- Gas-insulated switchgear
- Circuit breakers, surge arresters, disconnectors



Non-switching Products

- Power and distribution transformers
- Bushings, instrument transformers, coils
- Bundles and systems



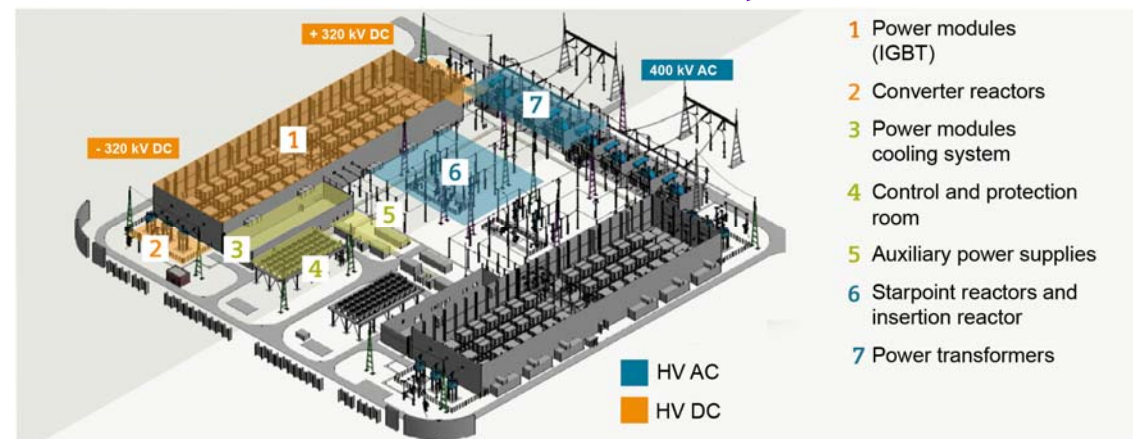
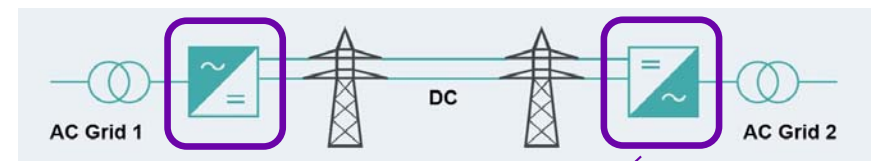
Service

- Product related services
- Modernization, upgrades
- Long term programs incl. operations

HVDC Transmission in a nutshell

HVDC = High-Voltage Direct Current

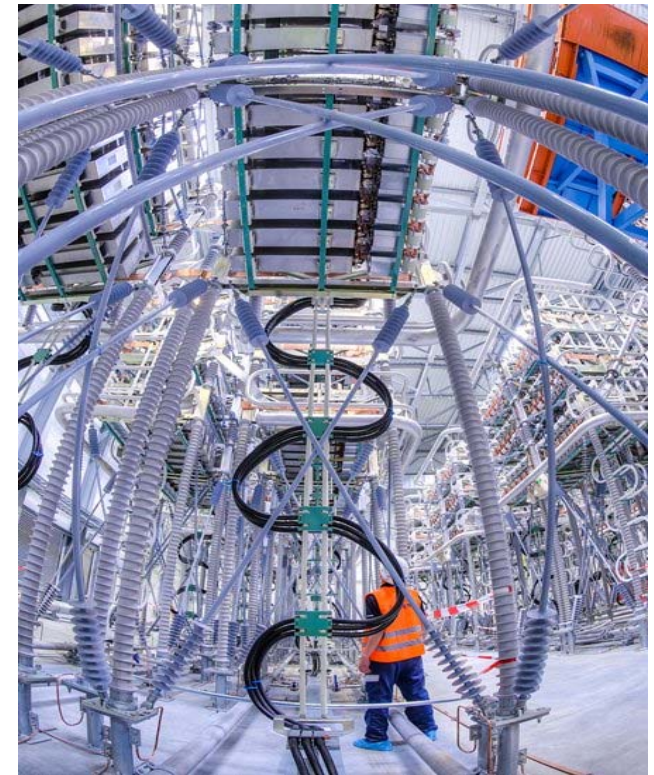
- Efficient transmission of energy:
 - Long distance bulk power
 - Low losses and no reactive power provisioning required
 - Integration of renewable energy sources (e.g. offshore wind)
- HVDC stations:
 - AC/DC conversion process required at each end of the HVDC link
 - Siemens Energy's HVDC PLUS® technology enables controlling both active & reactive power
 - Internal power electronic modules incl. capacitors (VSC technology, 1)
 - The cooling system (3) plays an important role to guarantee for a long equipment life



Why monitor vibrations in HVDC stations?

Converter Water Cooling (CWC) system

- Crucial assets for HVDC Station:
 - Task: Continuously provide sufficient cooling power, i.e. lower heat dissipated by power electronics
 - Required to be fully operational during long periods of high-load power transmission, otherwise...
 - ...significant loss of power capability / outage in case of failures! ☹️
- Spatially extended system comprising pipes, pumps, heat exchangers, filters, water treatment and various instrumentation
- Main component = motor/pump combinations (on skid)
- Vibrations monitoring:
 - Confirm normal "health" conditions
 - Detect arising misalignments or abnormal behaviour early on
 - Schedule service interventions properly while minimizing visits → **Condition-based Maintenance**



Which plant was chosen as a pilot?

Landstation vs. Platforms vs. Age

- Since a couple of years, TenneT & Siemens Energy have numerous HVDC stations successfully in operation!
- Condition monitoring is typically most important for offshore platforms:
 - Unmanned operation (per design)
 - Remote location, i.e. high costs of transfer / spare parts mgmt
- Selection of existing landstation (onshore) due to...
 - ...ease of access for installation
 - ...faster availability of data (i.e. no new project)
 - ...higher age of pumps → better view into aging also for future stations still under construction 😊

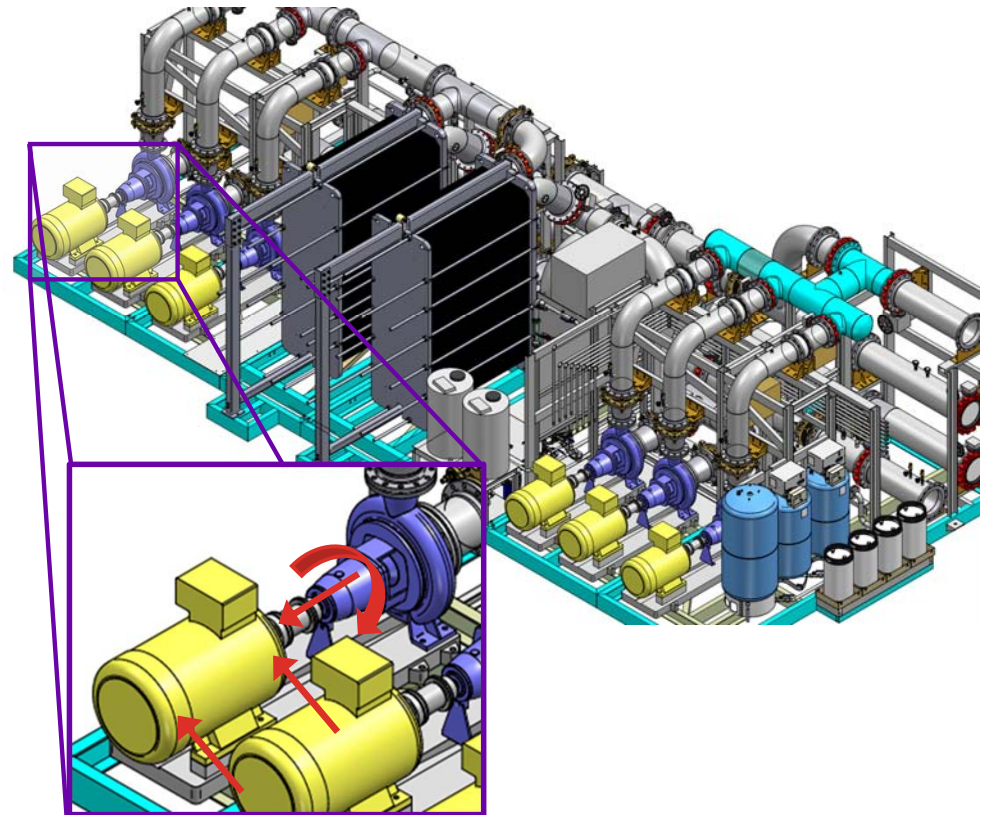


Setup / Installation

- All motor/pump combinations of the plant's CWC will be equipped with sensors
 - 3 x primary / 3 x secondary circuit = 6 in total
- Which locations & sensors?
 - 1 x NDE, 1 x DE (45° in load zone, L/R direction)
 - 1 x axial
 - 1 x rotational speed
 - Accelerometers IEPE* (combined x/y behaviour) + inductive sensor
- How to install?
 - Fixation by glued plates with threadings for sensors
 - Only possible during annual maintenance campaign

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SIEMENS
energy



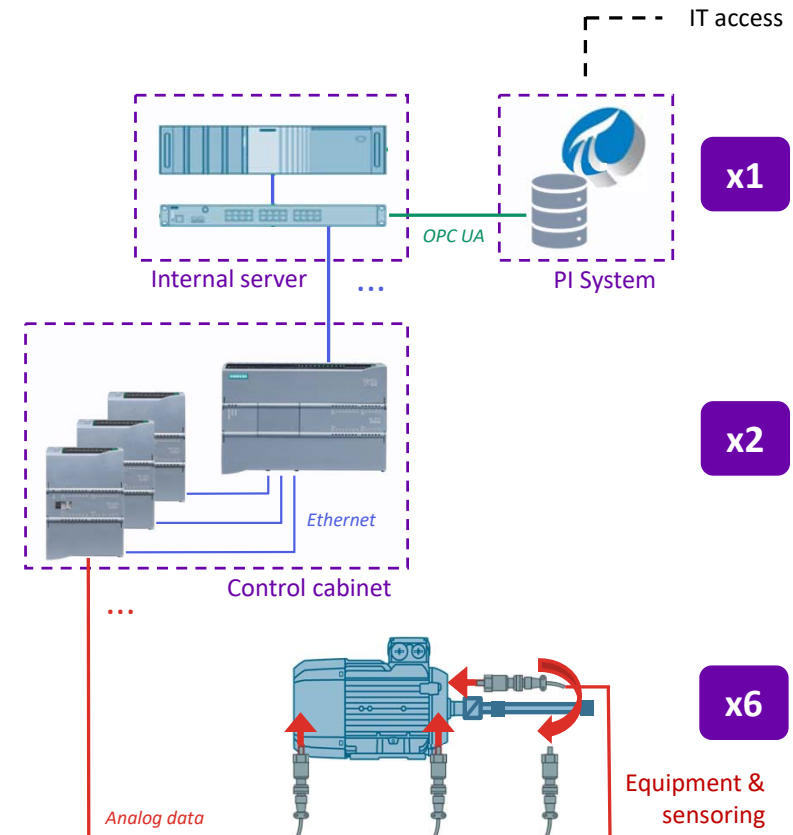
* IEPE = Integrated Electronics Piezo-Electric

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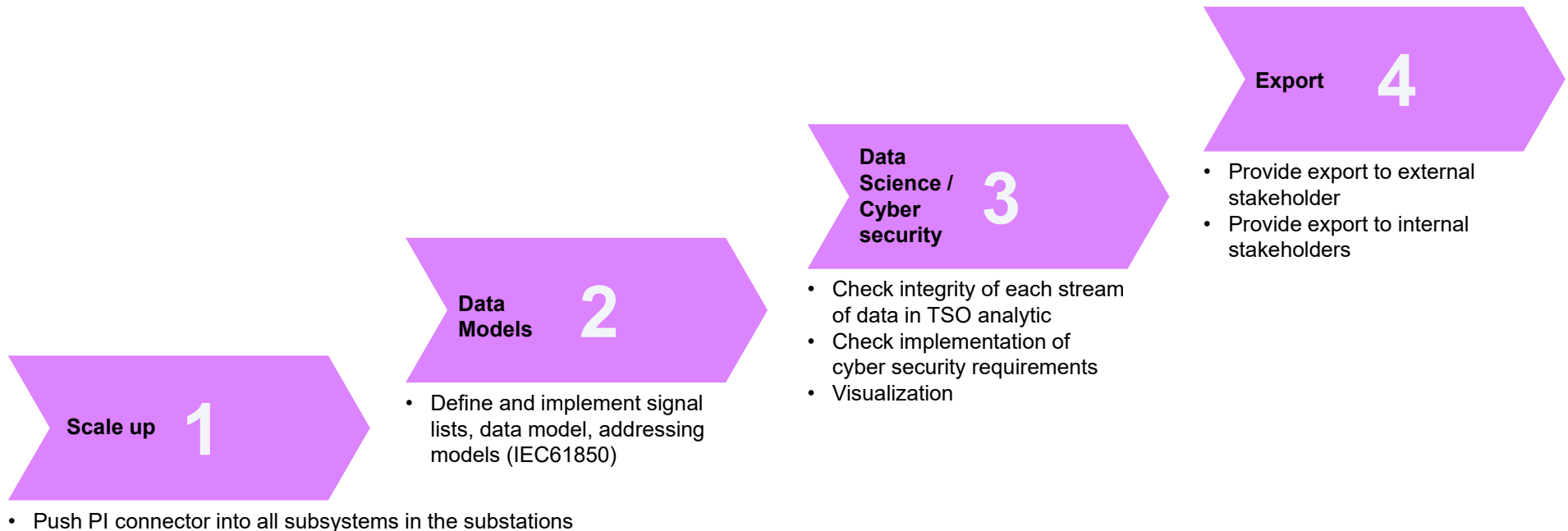
How do measurements get into the PI System?

Processing chain from sensors to database

- Acquisition of sensor data
 - A/D conversion by 3 CM modules (3 IEPE sensors + 1 rot. speed)
 - Aggregation by S7 CPU, high-resolution channels (~24kHz sampling)
 - 2 packages in pre-configured control cabinets (attached to wall)
- Storage to internal server (file-based)
- Processing capabilities
 - Filtering/smoothing, RMS, spectral analysis
 - Other sophisticated modeling? → **Collaborative learning**
- Forwarding to PI System (e.g. via OPC UA) for long-term storage
 - Convenient data access "from TenneT's offices"
 - Regular provision of data for Siemens Energy personnel manually (due to strict IT security regulations) → **Data sharing**



Next Step for TSO Analytics (PI System)



Several pilot project are in progress with Siemens Energy, Hitachi Energy, Maschinenfabrik Reinhausen, ...

Conclusions



TenneT TSO

- PI system supported TSO analytics to define a Pervasive solution for condition monitoring in a cyber secure manner
- Internal alignment between different departments are simpler and less confused due to the existing architecture
- TSO analytics (PI system) resulted in:
 - Central condition monitoring
 - Central monitoring for cyber security millstones and security model's implementation for condition monitoring
 - Central monitoring for quality of services (purchased or provided)

Siemens Energy

- Bringing added-value to our Customers by proper sensoring/evaluations for a specific Use Case
- We are committed to further improve as OEM and EPC by **learning from data** in real-world applications
- In this constellation, the PI system enables tracking of data & shared access in a controlled way
- Our goals:
 - Continuous learning & **joint insights with partners**
 - Offer optimized maintenance concepts & digital consulting services



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Asset Management - Control Systems Monitoring

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- Siemens Energy Global GmbH & Co. KG, Gas and Power, Transmission, High-Voltage Grids, Grid Access
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THANK YOU

謝謝

DZIĘKUJĘ CI NGIYABONGA TEŞEKKÜR EDERIM DANKIE TERIMA KASIH SPASIBO GRAZIE MATUR NUWUN ХВАЛА ВАМ MULTUMESC PAKMET CIZGE 고맙습니다 GRAZIE شكرا FAAFETAI ESKERRIK ASKO HVALA HVALA TEŞEKKÜR EDERIM OBRIGADO MERCI DI OU MÈSI ĎAKUJEM

KÖSZÖNÖM GO RAIBH MAITH AGAT БЛАГОДАРЕА ТИ БЛАГОДАРАМ ТАК DANKE RAHMAT HATUR NUHUN CẢM ƠN BẠN WAZVIITA

GRACIAS TI БЛАГОДАРАМ ТАК DANKE RAHMAT HATUR NUHUN CẢM ƠN BẠN WAZVIITA


MAHADSANID DANKJE EΥΧΑΡΙΣΤΩ GRATIAS TIBI AČIŮ SALAMAT MAHALO IĀ 'OE TAKK SKAL DU HA GRAZZI PAKKA PÉR SIPAS JI WERE TERIMA KASIH UA TSAUG RAU KOJ ТИ БЛАГОДАРАМ СИПОС


TAPADH LEIBH KEA LEBOHA MISAOTRA ANAO WHAKAWHETAI KOE DANKON TANK TAPADH LEAT SALAMAT

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