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ENERGY 3.0

Inrush Current Mitigation
a Must to Meet Grid Code Requirements

AGENDA

- What is a **Grid Code** ?
- Impact of Inrush Current on Transmission and Distribution Network
- VOLT/VAR Controller (Power Plant Controller)
- Actual Examples
  - Mont-Rothery 74MW Wind Farm in CANADA
  - Todmorden Moor Wind Farm - UK
  - Luchterduinen Wind Farm - Netherlands
  - ERDF / Enercon - France

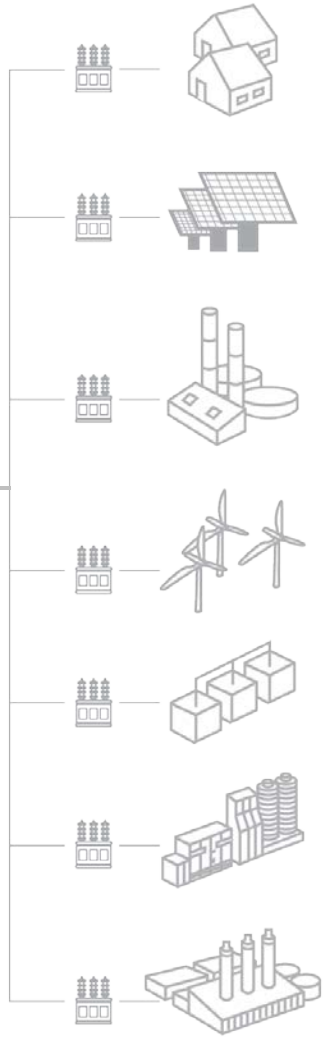
What is a Grid Code ?

- It’s a technical specification which defines the parameters a facility connected to a public electric network has to meet
- to ensure safe, secure and economic proper functioning of the electric system
- The grid code is specified by an authority responsible for the system integrity and network operation
- Typically a grid code will specify the required behavior of a connected generator during system disturbances.
  - voltage regulation
  - power factor limits
  - reactive power supply
  - response to a system fault (short-circuit)
  - response to frequency changes
  - requirement to "ride through" short interruptions of the connection.

Thanks to Wikipedia

DER Integration

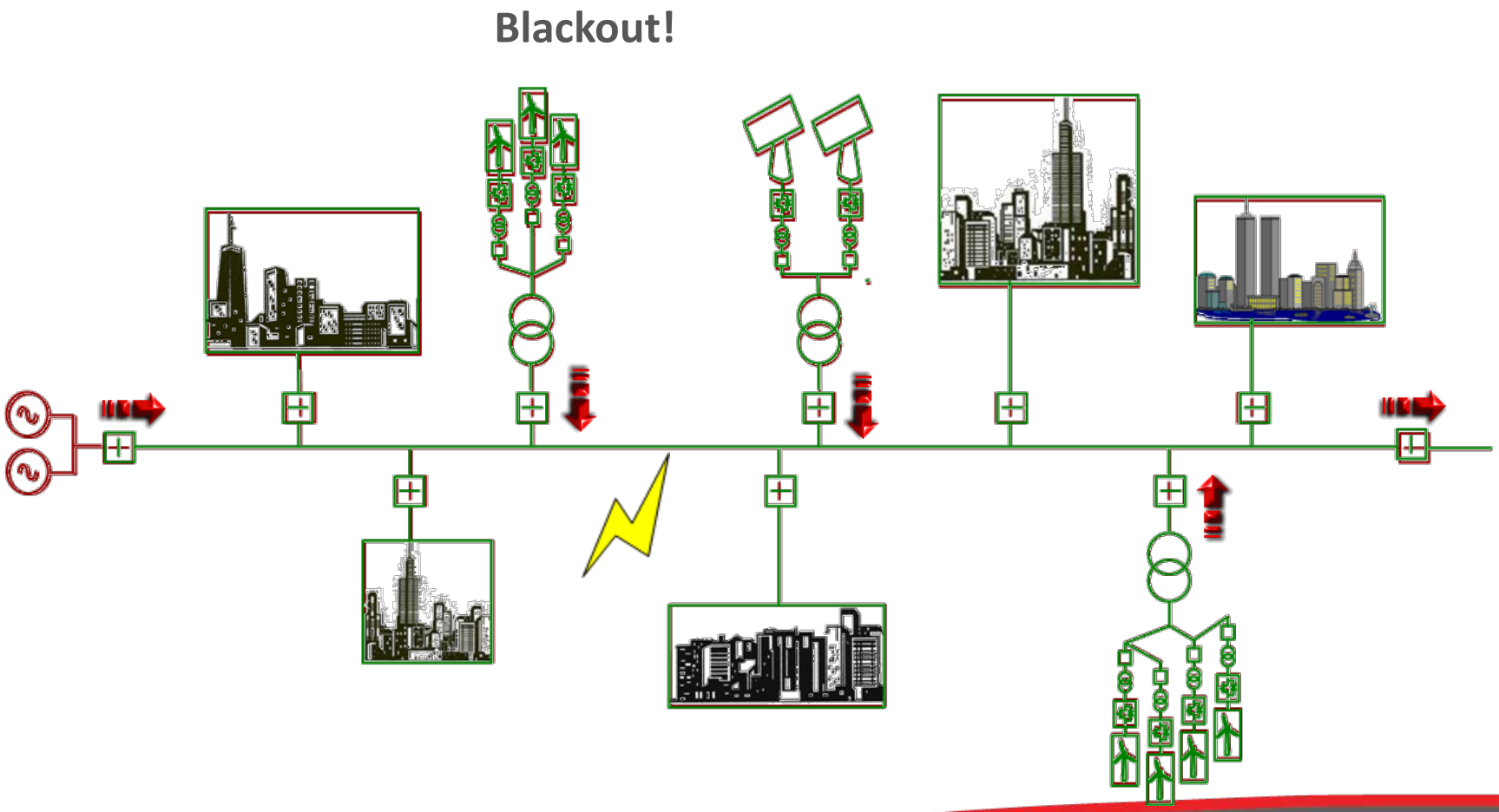
Many Distributed Energy Ressources to be connected to the power system



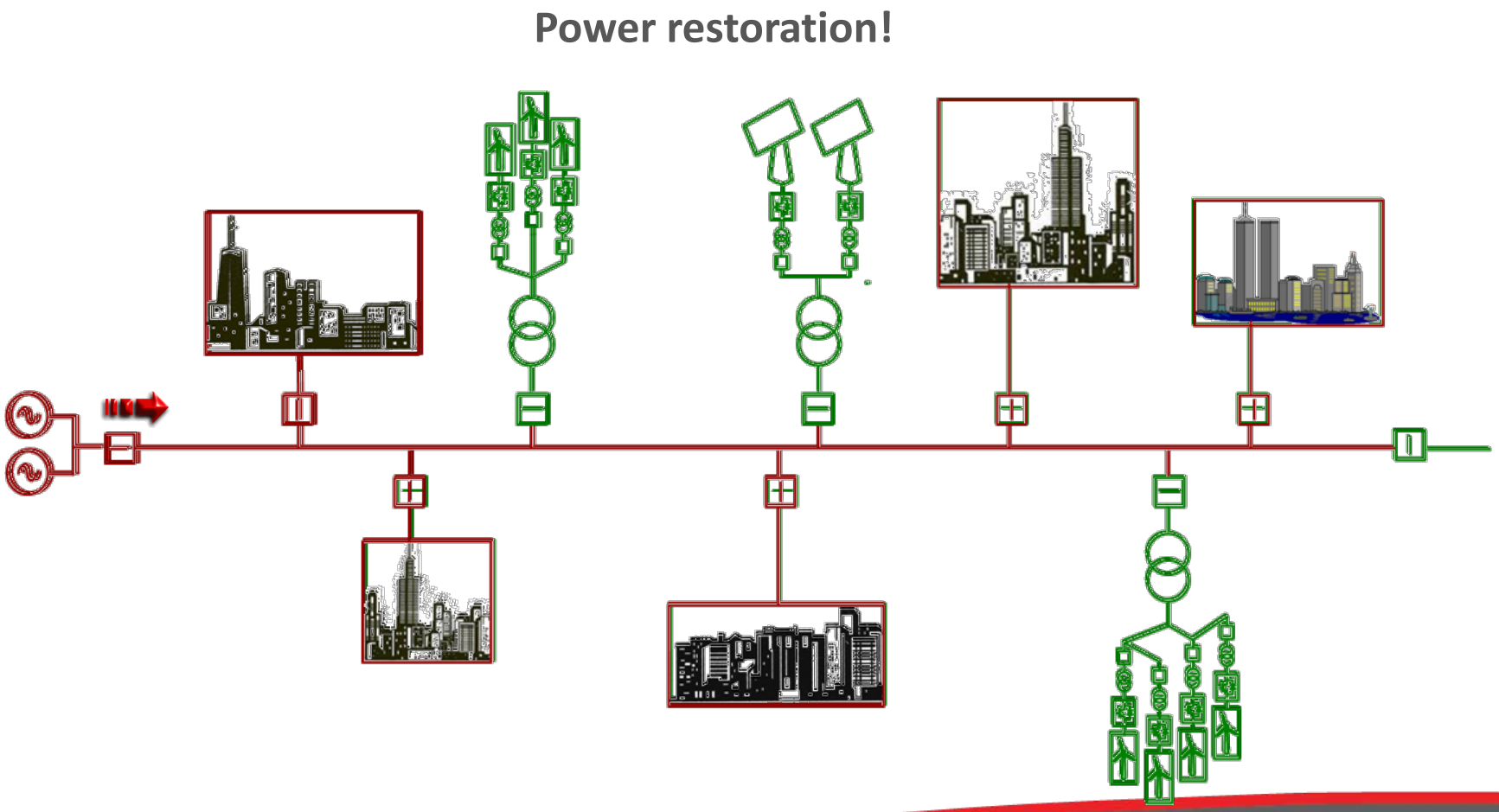
- Utilities' need for flexible power generation capability
- Integration of clean and renewable energy in compliance with green energy policies
- Increase energy production capacity to match demand
- Integration of IPP to reduce capital investment of public utilities
- Onsite energy production

Impact of Inrush Current on Transmission and Distribution Network

Reducing the risks of network collapsing after black out by mitigating power transformer inrush current



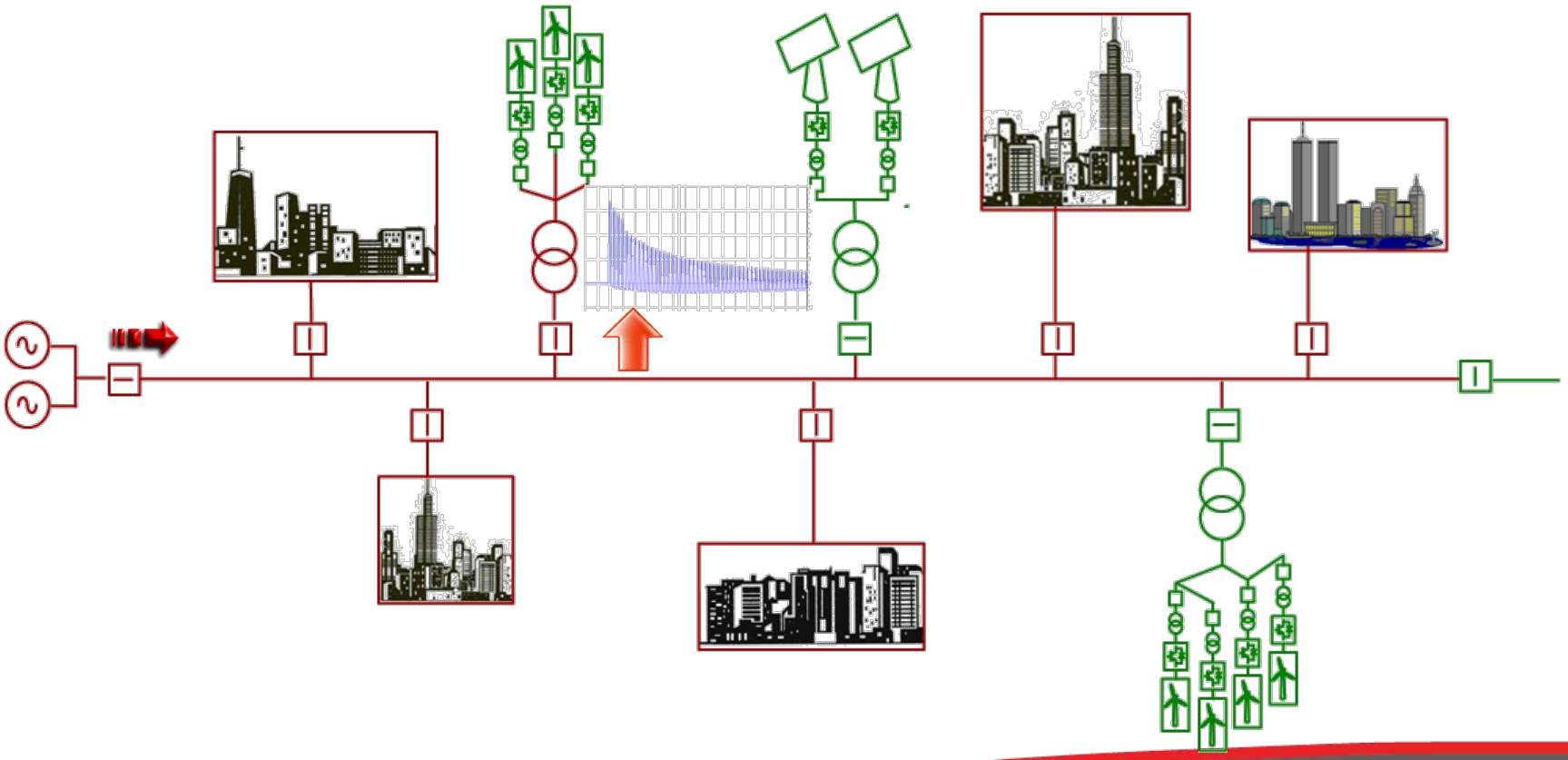
POWER RESTAURATION OF LOADS



EXCESSIVE INRUSH CURRENT FROM DER TRANSFORMER ENERGIZATION

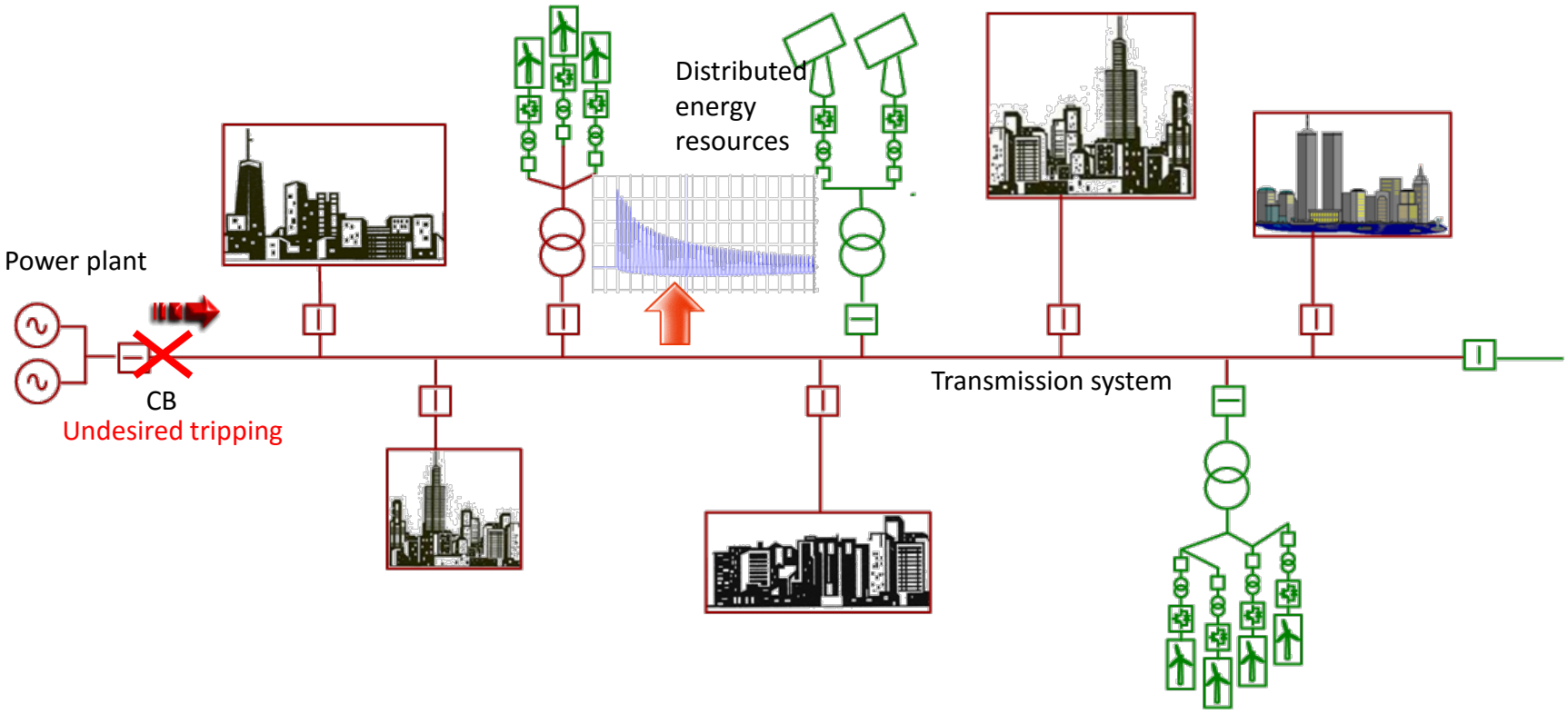
2 possible effects : **Voltage flicker** (grid code violation)

or **black out** from protection trip!!



TRANSFORMER ENERGIZATION INRUSH CURRENT EFFECTS

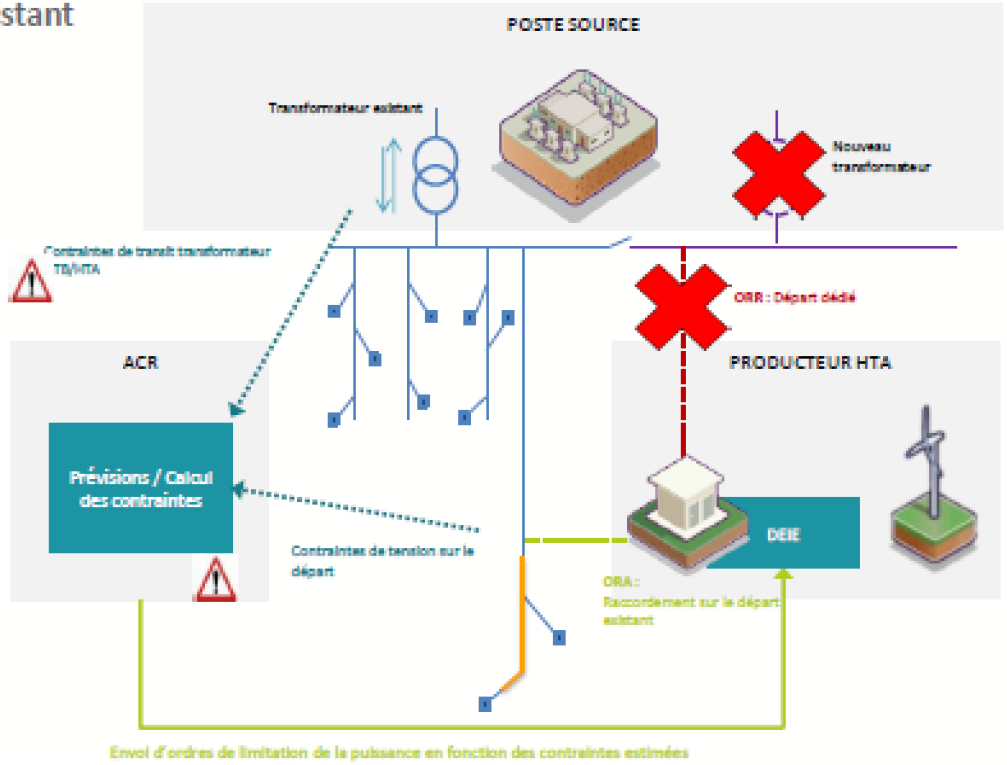
- Voltage dip/flicker/overvoltage (grid code violation)
- Undesired tripping of the recloser due to inrush created by the re-energization of the DER Transformer



ERDF DSO France

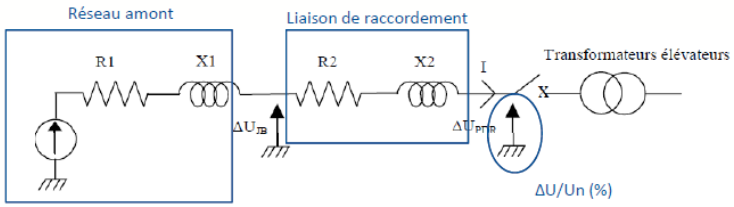
6- Des solutions « Smart » pour aller plus loin (2)

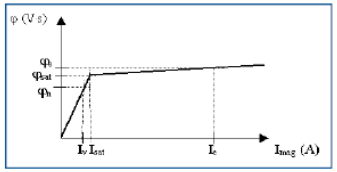
- Des écrêtements de puissance pour de nouveaux gisements dans le réseau existant



Transformer Inrush Current Mitigation Study ERDF France

Etude de raccordement : A-coup de tension à l'enclenchement du (des) transformateur(s)





Rappel du principe de l'étude :

- Détermination de la courbe de magnétisation du transformateur (à partir de ces caractéristiques fournies dans les fiches de collecte : courant d'enclenchement, puissance …)
- Détermination de l'instant d'enclenchement le plus contraignant et enclenchement des transformateurs
- Détermination de l'à-coup de tension (rapport tension initiale/tension minimale)
- L'étude tient compte :
  - du flux rémanent dans le transformateur
  - de la composante capacitive des câbles
  - du réseau amont et du transformateur

En cours d'implémentation :

Nouveau

- L'ensemble des simulations sont menées afin de déterminer l'à-coup de tension maximal (au moment le plus contraignant)
- Afin d'atténuer, cette position très sécurisante (faible probabilité d'occurrence) et les contraintes qu'elle représente pour les producteurs, **ERDF minimise la valeur du flux résiduel des transformateurs à hauteur de 70%.**

Transformer Inrush Current Mitigation Study

Etude de raccordement : A-coup de tension à l'enclenchement du (des) transformateur(s)

- Constat : des transformateurs de forte puissance (>2,5 MVA) peuvent amener quasi-systématiquement une contrainte d'à-coup de tension supérieur à 5%Un au niveau du PDL

➔ nécessite des enclenchements séquentiels voir un changement de transformateur

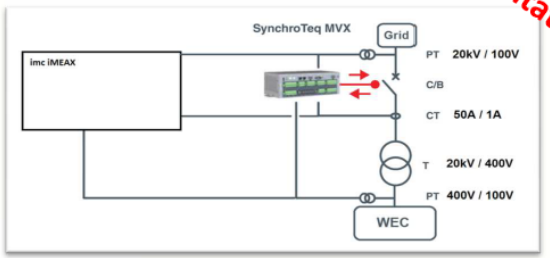
- Etude en cours : **limiteur de courant d'appel du transformateur** (Inrush current limiter) : solution permettant de contrôler l'instant d'enclenchement su transformateur

➔ minimiser le courant d'appel et donc le creux de tension généré sur le réseau (Ie/In ≈ 1 au lieu de 6 ou 7 pour un enclenchement non contrôlé)

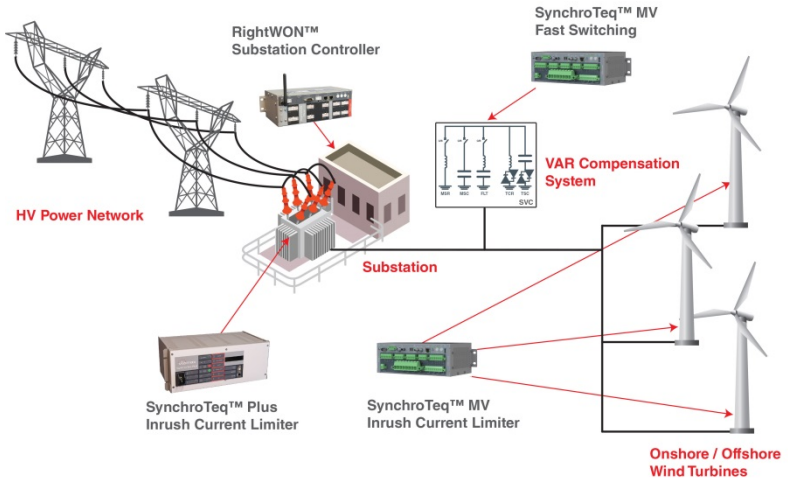
- **En cours d'expérimentation sur un site éolien**

- **Si résultats positifs, l'utilisation de ce type de matériel sera autorisée et son impact pris en compte dans les études de raccordement**

Expérimentation en cours

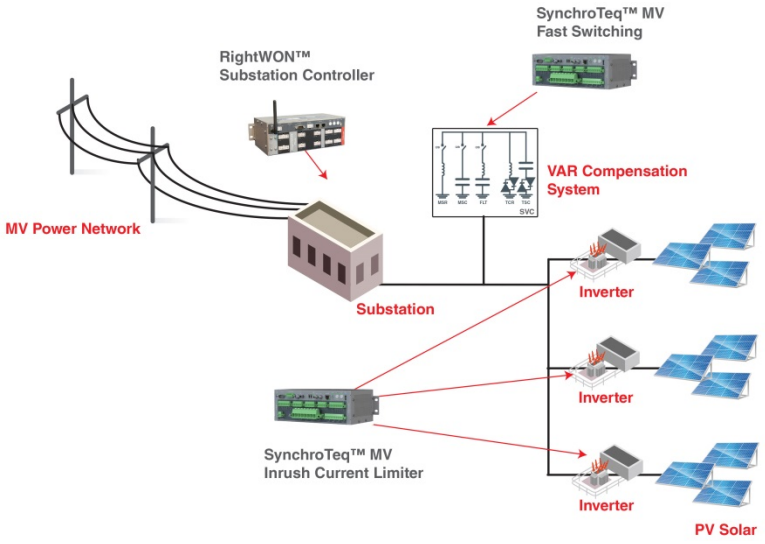


Conclusion of the Study – Wind and Solar



- Secure data aggregators and gateways
- Substation automation
- Remote operation, monitoring

- Seamless connection to MV-HV grids
- Advance VAR compensation techniques
- Avoid risks of voltage depression



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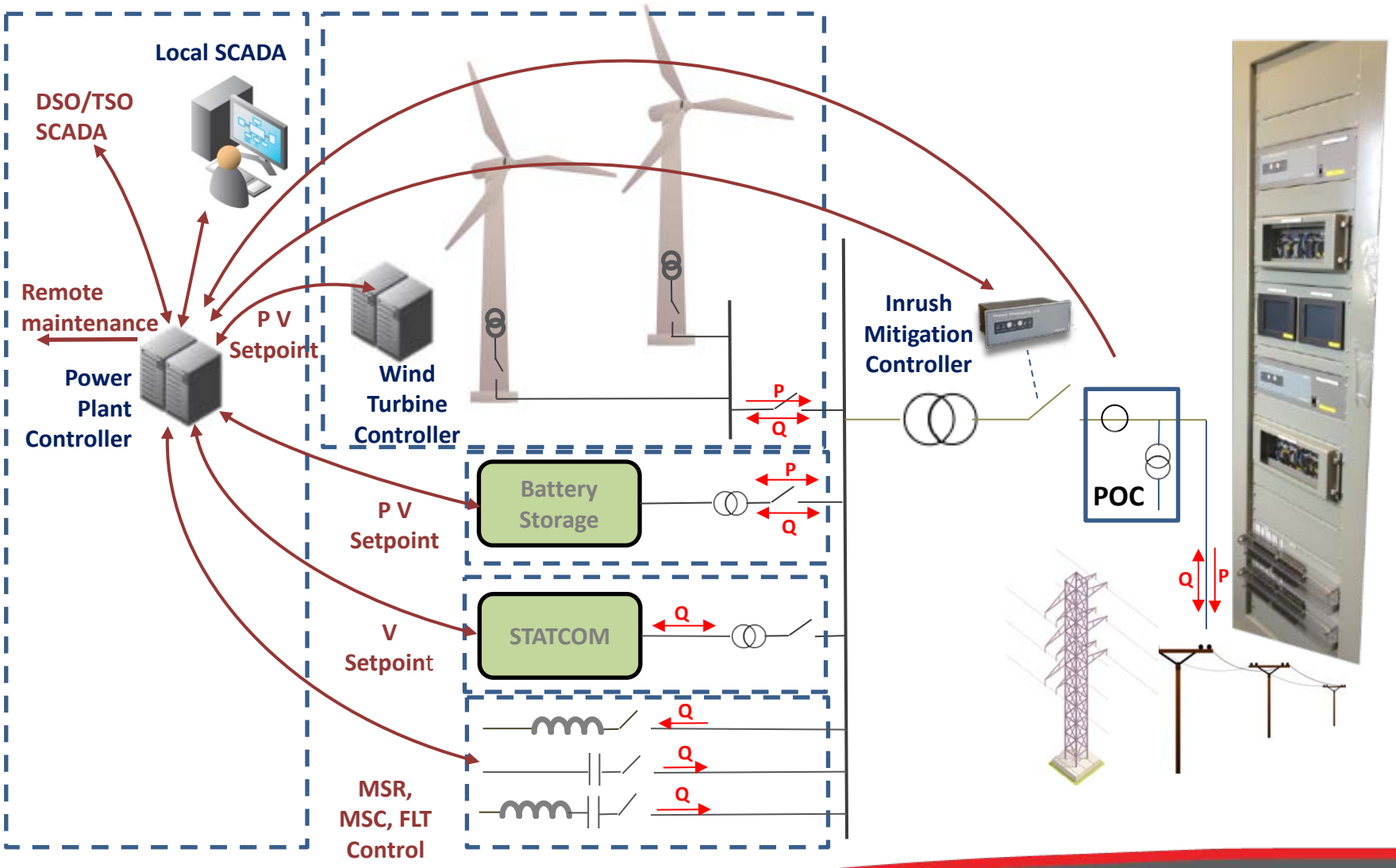
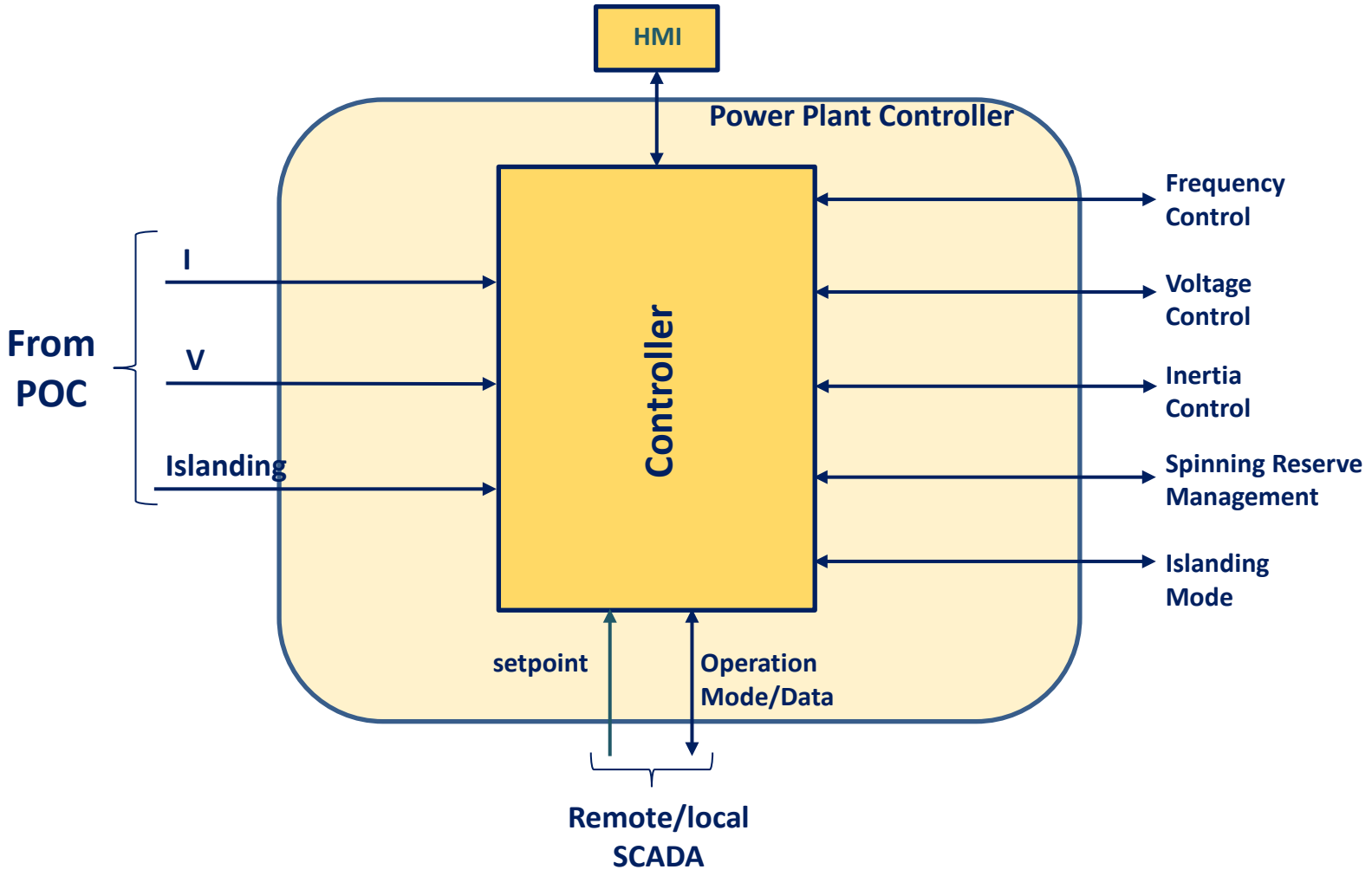
Power Plant Controller Architecture



Power Plant Controller Functions



Power Plant Controller

Power Quality:

- Inrush Current Limitation (MV-HV transformers) and Voltage Drop Mitigation
- Disturbance-free switching of Harmonic filters and Capacitor banks
- Waveform recording

Reactive Power Management:

- Multi channel control: WTGs, Hybrid-Statcom, Storage, Mechanically switched loads
- VAR / PF control
- Advanced switching and fast-switching of Reactive Loads

Voltage Control

Frequency, ROCOF and Phasor monitoring:

- Time synchronization
- Ultra-fast and accurate measurement
- Reliable data source for Synthetic Inertia Management

Multi-protocol broadcast:

- IEEE-Certified C37-118 PMU for PDC/Open PDC at TSO and DSO central sites
- IEC61850, IEC61400-25, IEC60870-5-104, DNP3, ModBus TCP for WTG controllers and equipment manufacturers

Grid Connection of RES -GRID VOLTAGE REGULATION/VAR COMPENSATION

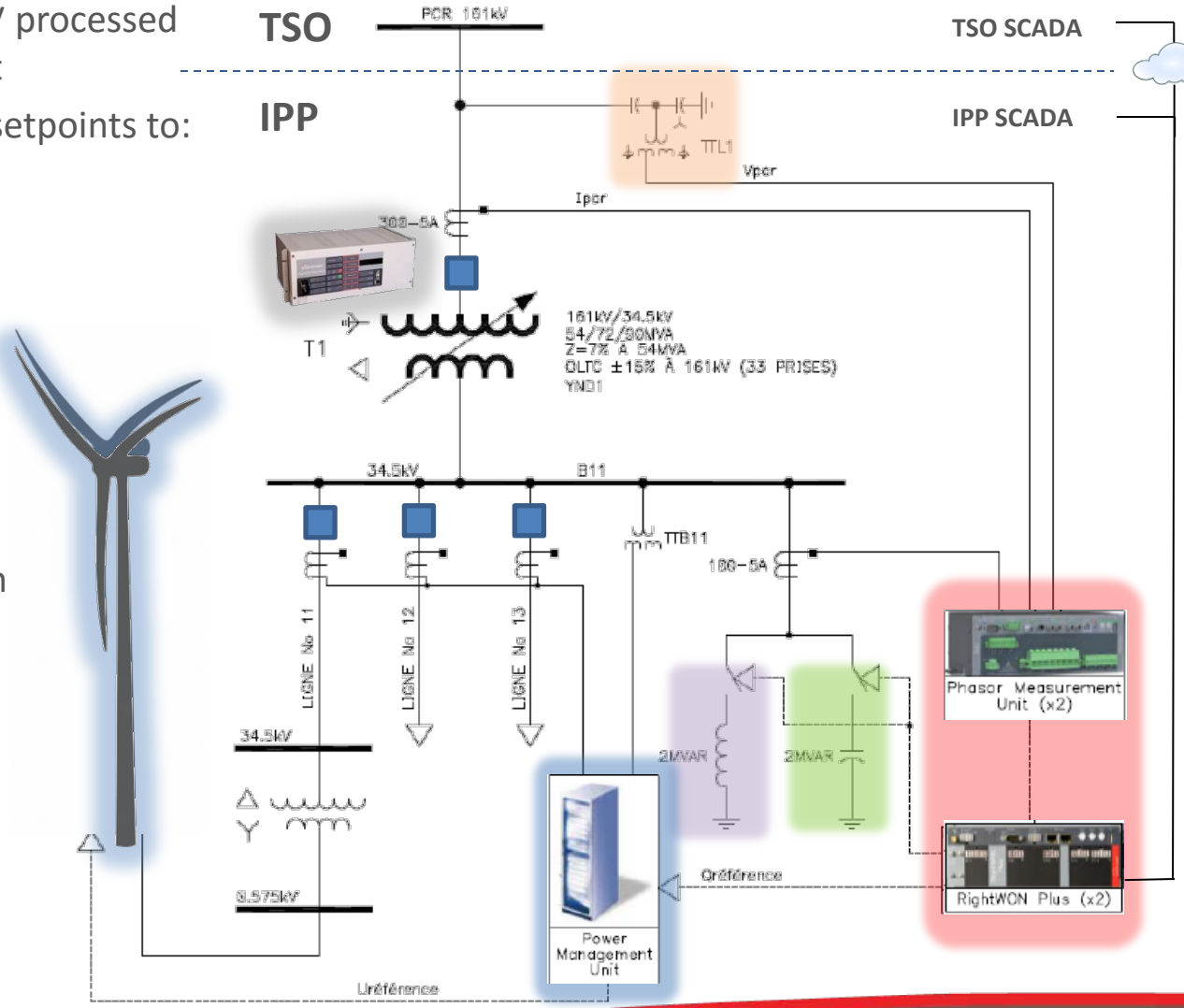
Mont Rothery Wind Farm - Canada

- 37 x 2 MW WTGs, 34.5 kV collector system
- 2 MVAR cap bank and 2 MVAR Shunt Reactor
- Energizing a 90 MVA / 34.5-161 kV step-up transformer
- Control mode (voltage, power factor or MVAR)
- Voltage/PF/MVAR Setpoint
- Droop Gain Septoint 0-10%
- Min. MW Start-up/Shutdown Ramp (2-60 min)
- Max. MW

Grid Connection of RES – Volt/VAR/PF Control

Mont Rothery Wind Farm - Canada

- Voltage error on 161kV processed by RightWON Plus Unit
- RightWON Plus sends setpoints to:
  - WTG Controller
  - Cap Bank
  - Shunt Reactor
- 16 ms control loop
- Measuring and filtering by Fast Processing PMU
- ± 0.5 p.u., (± 37 MVAr)
- Ultra-fast ROCOF: within 1.2 ~2 cycles typ. (3.25 max)
- IEC61850, ModBus output



Switching of TFO also controlled by SynchroTeq Plus

Grid Connection of RES – MV Power Transformers

Todmorden Moor Wind Farm - UK

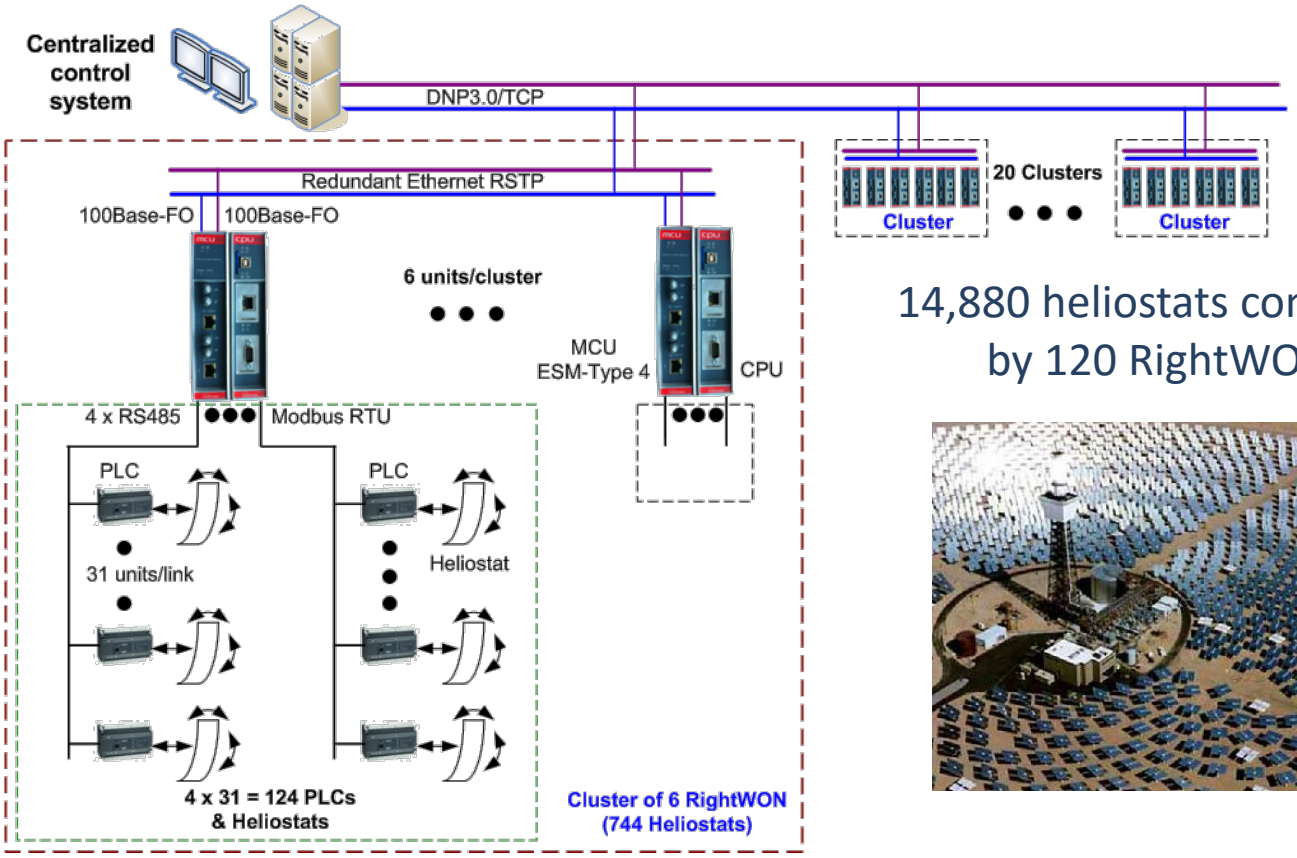
- 12.5 MVA on-shore wind farm
- Integration of RES in 36kV grid
- SynchroTeq MVX

Grid Connection of RES – HV Power Transformers

Luchterduinen Wind Farm - Netherlands

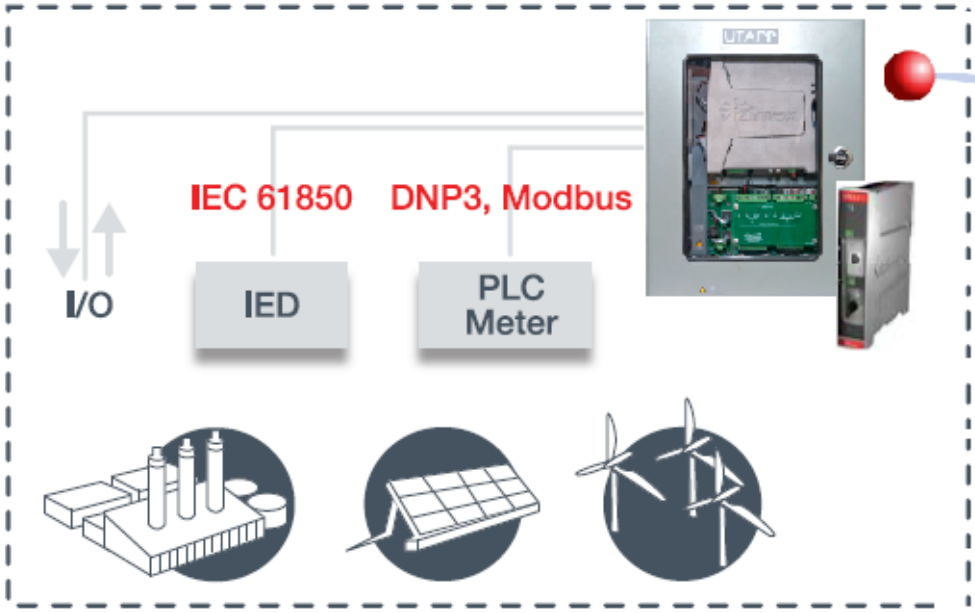
- 2x80 MVA transformers in OHVS feeding a highly capacitive 25-km long 150 kV submarine cable
- Mitigation impacted by floating neutral
- SynchroTeq Plus with residual flux management

DATA CONCENTRATOR/PROTOCOL CONVERTER



14,880 heliostats controlled by 120 RightWON!

RENEWABLES: MONITORING & CONTROL



INDEPENDENT POWER PRODUCERS

- Secure IPP Interconnection
- Remote Lock/Unlock of Circuit Breaker
- Data Acquisition, Reporting and Transmission

- **IEC61400-25 / IEC61850 / IEC60870-10x / DNP3**
- **Get a Real-time Picture of the DG site**
- **Anti-Islanding for Distributed Generation**
- **Access to Metering over DLMS**

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AVISTA Utilities
BC hydro FOR GENERATIONS
POWER GRID CORPORATION OF INDIA LIMITED
OPAL-RT
TENAGA NASIONAL
DME energética Poços de Caldas
ALSTOM
Pratt & Whitney A United Technologies Company
ERCOT
АБС Электро
KAHRAMAA
CEMIG A Melhor Energia do Brasil.
westernpower
Rte Réseau de transport d'électricité
ABB
Hydro Québec
RioTinto Fer et Titane
EDF
Manitoba Hydro
Crompton Greaves
RED ELÉCTRICA DE ESPAÑA
nationalgrid
SOLARRESERVE
CARTIER ÉNERGIE ÉOLIENNE
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SIEMENS
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Rural Areas Electricity Company S.A.O.C An ISO 9001:2008 Certified Company
Schneider Electric
CFE Comisión Federal de Electricidad
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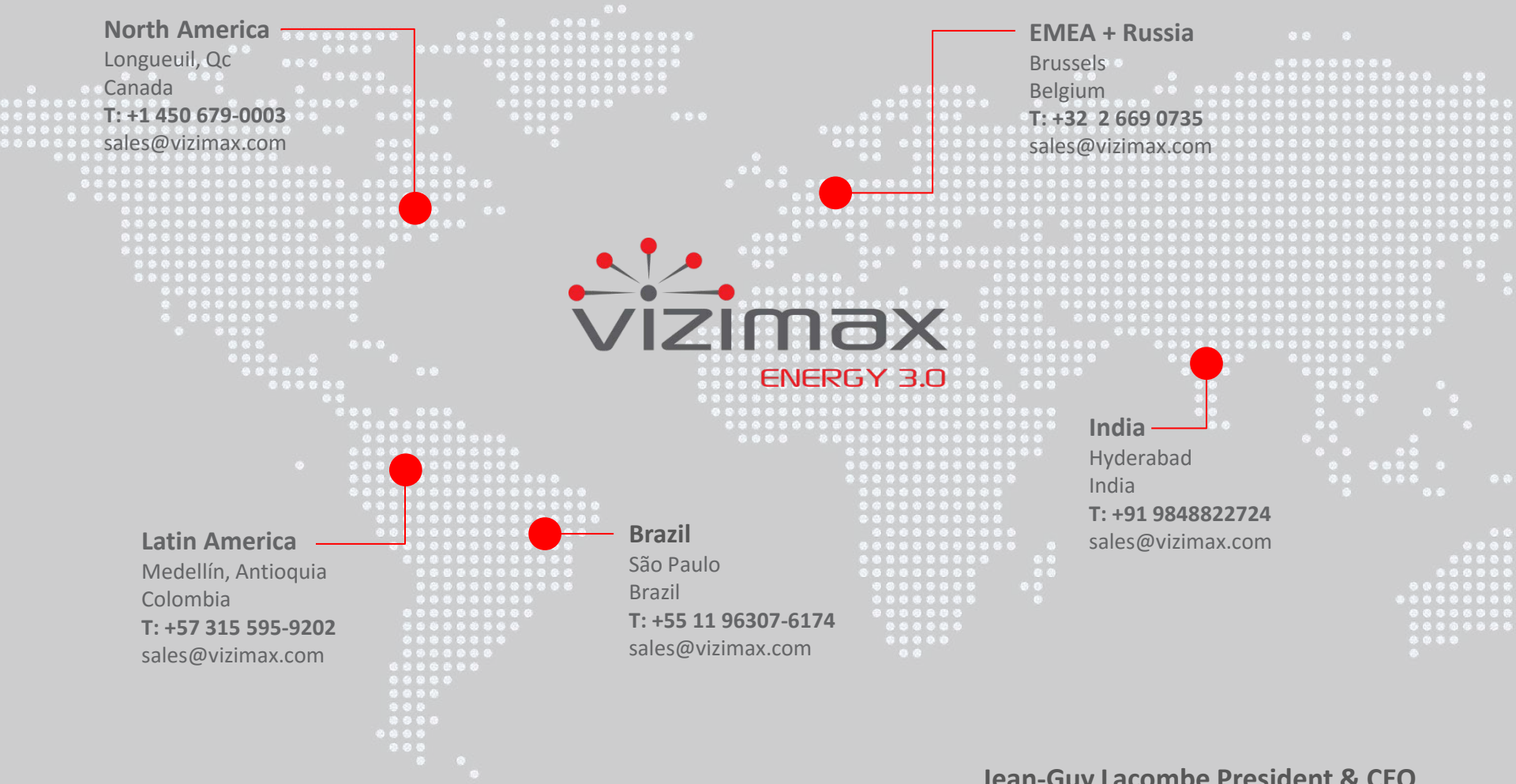
Thank You



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