



## Possible future strategies to limit extend and impact of major system disturbances

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# Possible future strategies to limit extend and impact of major system disturbances

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Leader of iTesla WP6 – Defense and restoration

# Background

- Reasons to revise / upgrade defense and restoration:
  - Pan European trading: increased loading of transmission / interconnection
  - Increased penetration of renewables
  - Increased distributed generation / flexible consumption
  - Improved technology
    - Power: Facts ...
    - Communication: WAMS ...

# Defense and restoration supplement to iTesla platform

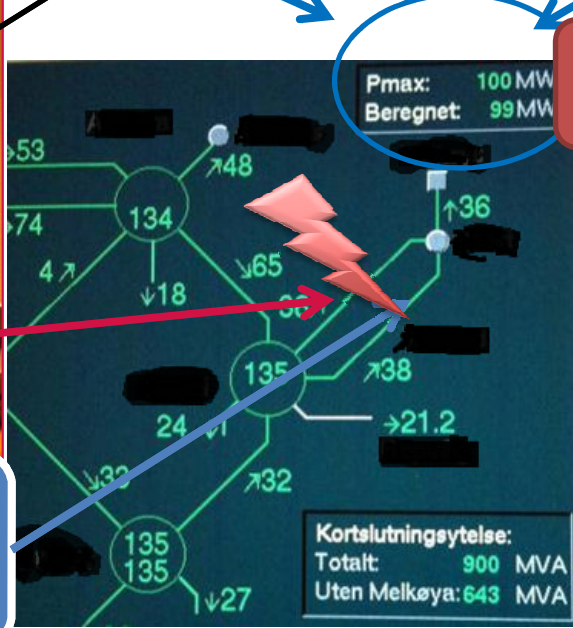
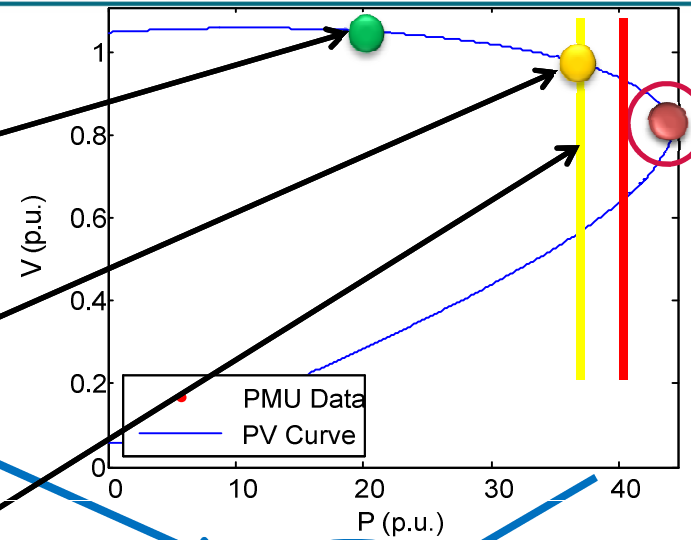
**Monitor the Operating Point:**  
Tools for Pan-European Observability help to identify the system's state

**Identify Problems:**  
*iTesla* platform allows to perform **Security Assessment** to determine challenging dynamic problems

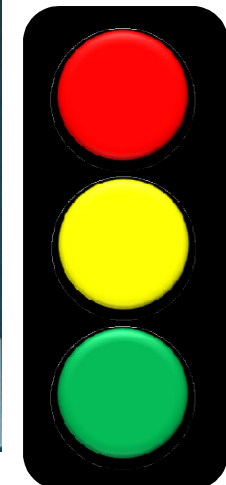
**Determine Dynamic Limits:**  
Security assessment in *iTesla* platform also allow to obtain **REALISTIC LIMITS** of stability boundaries

**Defense Plan and Actions:**  
In a dangerous operating state, "Defense Plans" need to act to maintain system integrity.

**Restoration Plan and Actions**  
Perform actions that allow to bring the power system to safe operating state.



**Operational State!**



- Defense plans
  - Strengthes and weaknesses in existing plans (AIA)
  - Pan-European coordination (KU Leuven)
  - Use of PMUs (Statnett / KTH)
  - Use of renewable generation plants (DTU)
  - Use of distributed energy resources (Imperial Col.)
- Restoration
  - Coordinated restoration (AIA)
  - Use of renewable generation plants (INESC)

# Coordination control actions and power flow control

Steven De Boeck, Dirk Van Hertem  
KU Leuven

- Different influences on the energy flows:
  - Liberalisation which resulted in unbundling of the power sector
  - Strong increase of renewables in certain regions in Europe
  - Working closer to the limits

→ Cross-border operation of the power system is more **complex** and **international**, and thus there is a need for more **coordination** of power system operation and control of flows.
- Coordinated defence plans:
  - Based on “strengthes and weaknesses in existing plans” – inputs through harmonisation
  - Based on ENTSO-E recommendations for defence plans
  - Ex. Adequate under frequency load shedding schemes : Which Set points, principle of solidarity, Load shedding in each step, disconnection delay,...

- Power flow control:
  - Exploring the use of power flow controlling devices such as PST, FACTS and HVDC
  - Ex. HVDC connection between zones. In case of loss of generation in one zone: increase power injection from the other zone to this zone.
  - Looking at control parameters and how they can be set to let the system return faster to a secure state.
  - How can power flow controllers be used to reduce risk and avoid system collapse



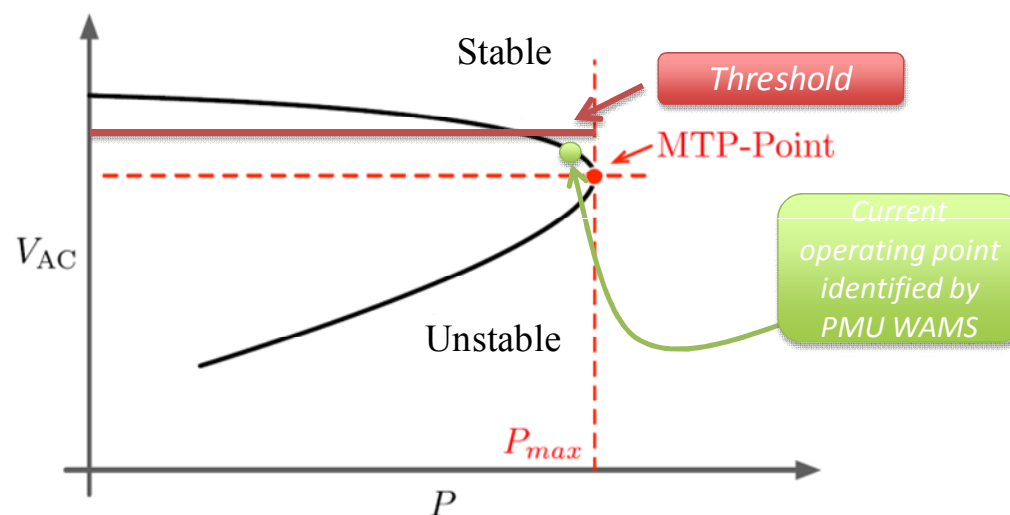
# Defensive and restorative Wide Area Control Use of PMUs in defense plans

Dr. Luigi Vanfretti, Rujiroj Leelaruji, KTH

Jan Ove Gjerde, Senior Vice President, Statnett

## Restorative Wide-Area Control

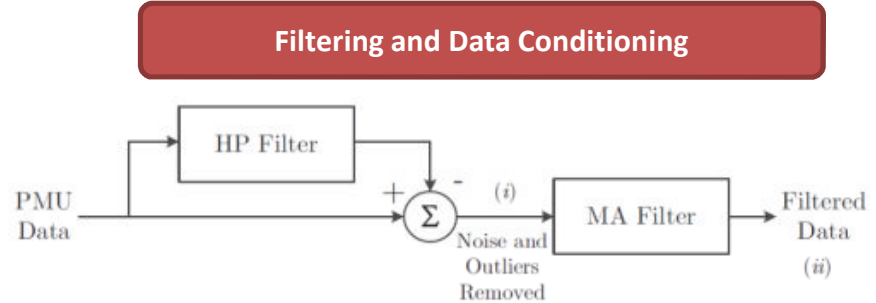
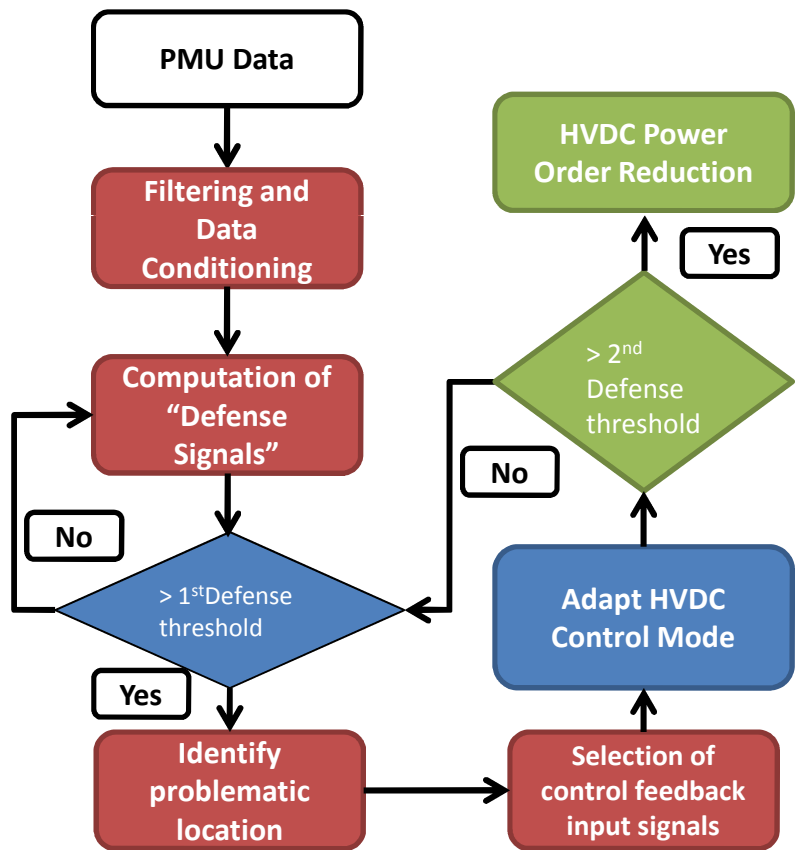
*A two layer approach for Defense Plans using PMU Data and Controls*



Approaches to prevent a voltage instability in "defense mode" and "restorative" mode:

- **Activate an specific HVDC control mode** using a "defense signal" obtained from sensitivities computed from PMU data.
- **Coordinate with internal HVDC controls:** Reduce Power Order of HVDC when surpass MTP-Point.

## Generating “Defense Signals” and Activating 2-level Control To use for modifying HVDC control modes and arming/disarming internal stabilization controllers



Approaches to compute “Defense Signals” obtained from sensitivities computed from PMU data:

- *Centralized WAMS system to generate global “defense signals”*
- *Decentralized Real-Time Controllers to activate each control level of the HVDCs*

# Use of renewables in defense plans with large amounts of renewable energy sources

Poul Sørensen, Ioannis Margaritis

Technical University of Denmark – Department of Wind Energy

- Challenge
  - e.g. high wind / high solar / low consumption:
  - Large scale renewables displace conventional spinning reserves
  - More vulnerable system
- Tasks to study (PhD)
  - understand existing defense plans
  - down regulation or RES during over frequency
  - use positive reserve from downregulated RES during under frequency
  - voltage support during large disturbances
  - virtual inertia and/or changed ROCOF settings
  - power system damping

# Restoration procedures with large amounts of renewable energy sources

Carlos Moreira, Luís Seca, André Madureira  
INESC Porto – Power Systems Unit  
Leader of iTesla Task TWP6.7



# Restoration with RES

- Blackouts are rare but severe events
- Restoration is one of the most important and challenging tasks for power system dispatchers in the control center
  - Off-line restoration plans and available Black Start generation units or interconnections with neighboring areas are used to restore the system

# Restoration with RES

- Large scale Integration of renewables, mainly wind (onshore or offshore) 1/2
  - Available resources that can be included in the restoration plan
    - How? When? What are the control requirements?
    - Off-shore wind generators and the development of Multi Terminal DC grids with Voltage Source Converters offer flexible control functionalities that can be exploited in the restoration phase



# Restoration with RES

- Large scale Integration of renewables, mainly wind (onshore or offshore) 2/2
  - Load-frequency control during the load pick-up phase, including active participation of wind generators
  - Increase the amount of restored load and reduce the restoration times

# Thank you

- Questions?
  - Workplan defense / restoration
    - Defense plans
      - » Strengthes and weaknesses in existing plans (AIA)
      - » Pan-European coordination (KU Leuven)
      - » Use of PMUs (Statnett / KTH)
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    - Restoration
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