On-Line Dynamic Security Assessment: Its Role and Challenges for Smart Control Centers

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Powertech

A very simple version of Smart Grid

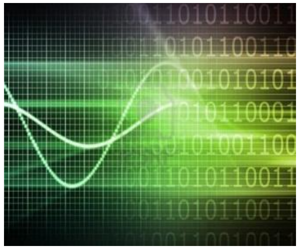
Hardware / software added to a power system to achieve:

- A more autonomous responsiveness to events that impact the electrical power grid
- Optimal day-to-day operational efficiency of electrical power delivery

Focused areas:

Demand management

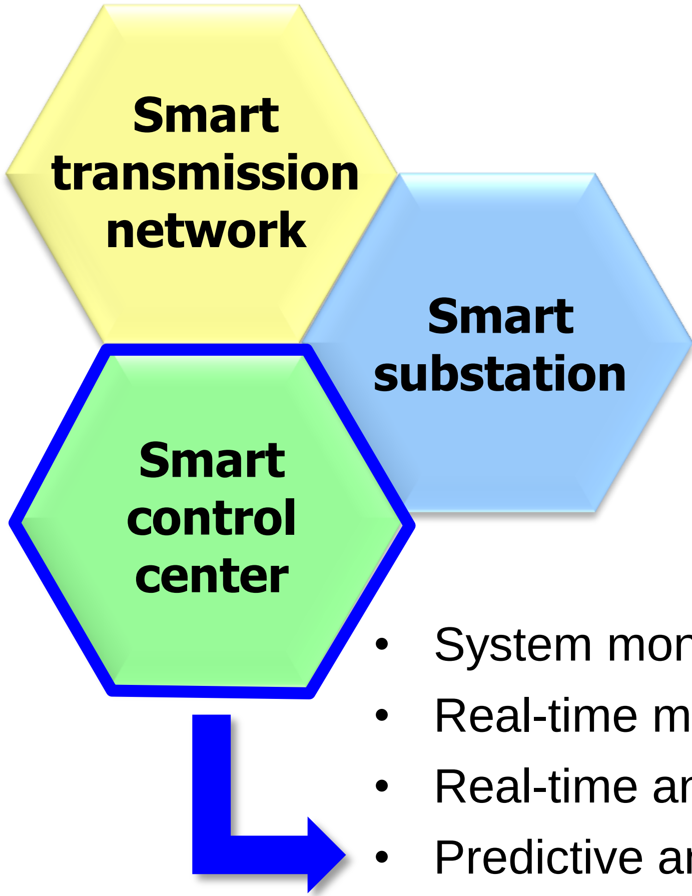
Renewable-based systems



Information technologies

Transmission grid

Smart Transmission Grid



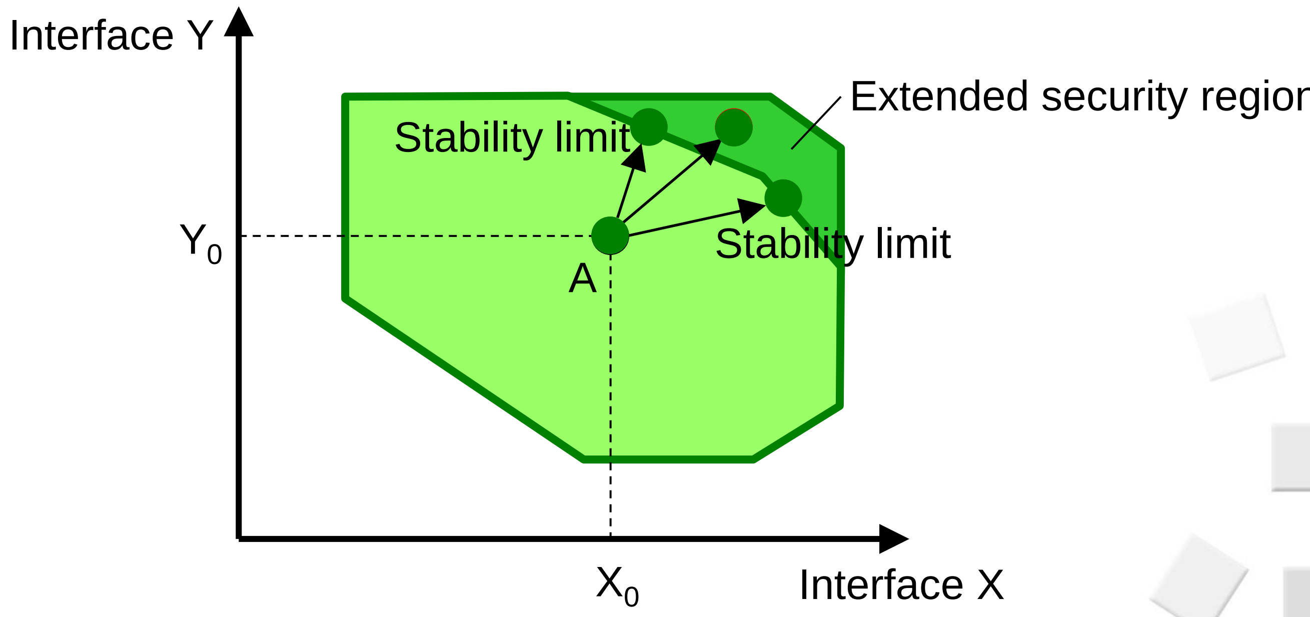
- System monitoring and visualization
- Real-time modeling and validation
- Real-time analyses
- Predictive analyses
- Controllability
- Information for dispatchers/operators
- Interactions with power market

Smart Control Center

- Modernization of control centers involves development and application of technologies in many areas
- One of these that is critical to the grid operation: **Dynamic Security Assessment (DSA)**
- This is to answer three basic functions:
  - How well a system condition can withstand credible contingencies (**degree of stability**)
  - What is the maximum secure power transfer under these contingencies (**stability limits**)
  - What can be done to prevent possible insecurity (**remedial control actions**)

What does this mean?

- Assume that a system is operating at a point A
  - Measured by some system parameters (e.g. interface flows)
  - Determined to be secure for all credible contingencies
- We need to know what is the secure region within which the system can move
- If the system needs to move to an insecure point for some reason, what needs to be done to ensure the system security
  - For example, special protection system settings



Analysis and computation requirements

- Need to work with **models** of an interconnected power system
  - The full Eastern US/Canada interconnected system models have more than 60,000 buses and 8,000 generators
- Use various **mathematical techniques**
  - Powerflow
  - Time-domain simulations
- Examine a set of **contingencies** over a range of **system conditions**
  - N-1, N-2, N-G outages, etc.
  - Different load levels, generator dispatches, power transfers, etc.
- Ensure that a set of **security criteria** are met
  - Steady state (thermal, voltage)
  - Dynamic (voltage, transient, small signal, frequency)

Challenges

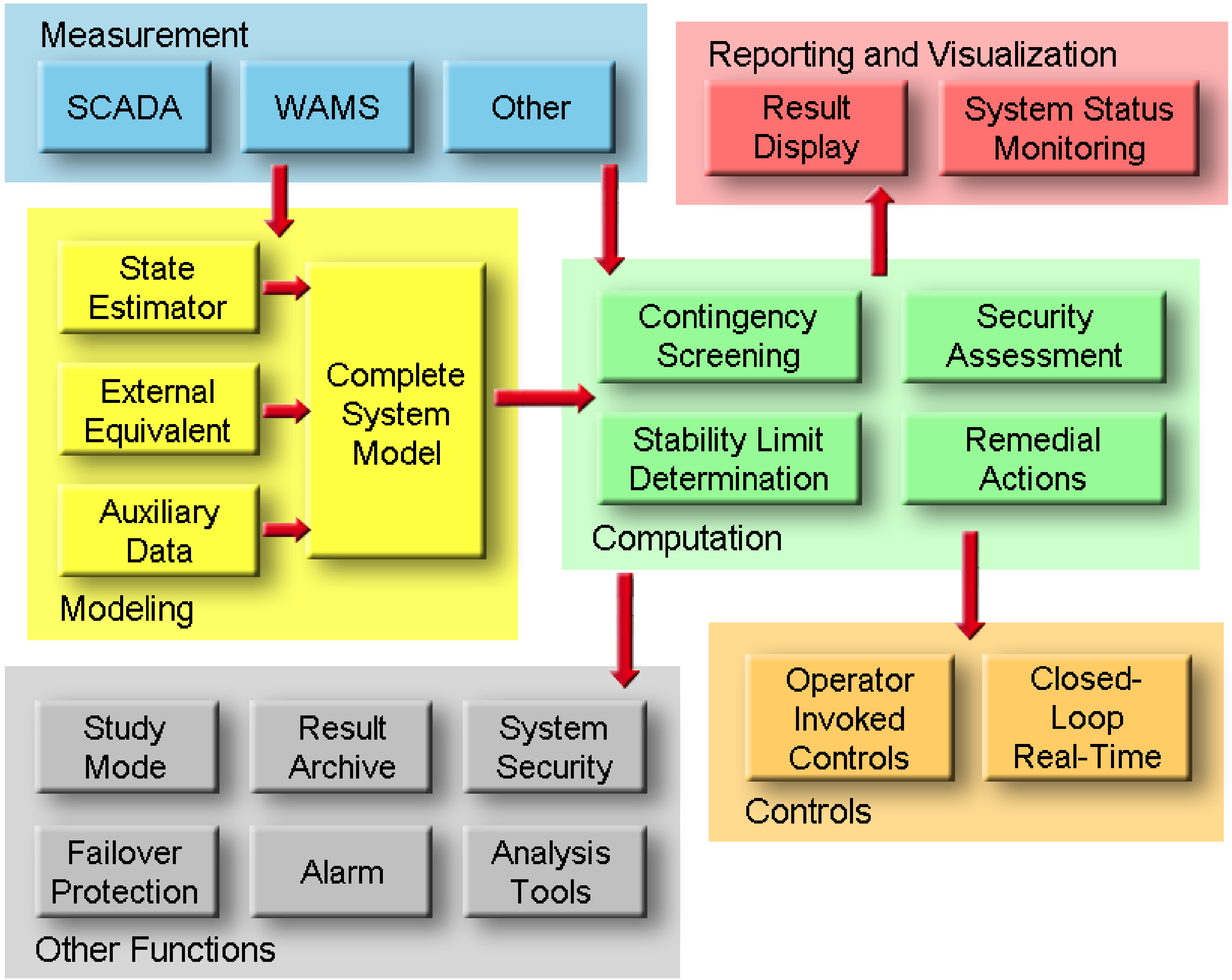
- DSA has been traditionally performed using **off-line studies**
- Problems with this approach:
  - Number of possible conditions and contingencies becomes **unmanageable** as system complexity increases
  - Exact system state is **rarely accurately** captured by forecast
  - Most study results are never used resulting in **high wastage**
  - Conditions which usually cause problems are **often not studied** off-line (such as an N-1 event evolving into N-3 event)

Solutions

Avoid using forecasted system conditions for DSA

. . . perform the calculations ***on-line*** *in* ***real time***

On-line DSA functional overview



Main benefits

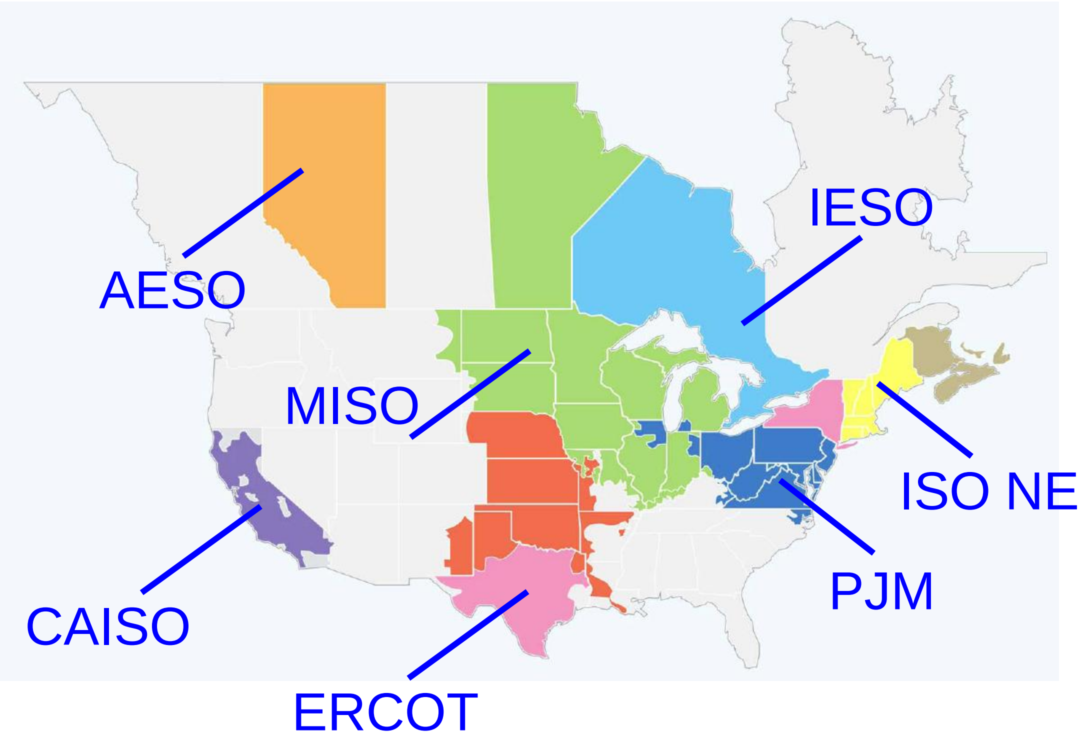
- System security status monitoring
- Stability limit determination
- Recommendations for preventive/corrective control actions
- Impact assessment of renewables on system security
- Verification of Special Protection Systems (SPS)
- Transaction settlements in power market
- Determination of active and reactive power reserves
- Scheduling of equipment maintenance
- Support to PMU/WAMS applications
- Calibration and validation of power system models
- Preparation of models for system studies
- Post-mortem analysis of incidents
- System restoration

State-of-the-art

- On-line DSA is not new; it has been proposed, discussed, and developed for **over 40 years**
  - It has matured in the past decade
- This technology has been increasingly included as one of the **advanced network applications** in EMS
- Performance
  - Real-time models with 13,500 buses and 2,500 generators
  - Processing of 3,000 contingencies and 40 stability limits
  - Computation cycle within **20 minutes**

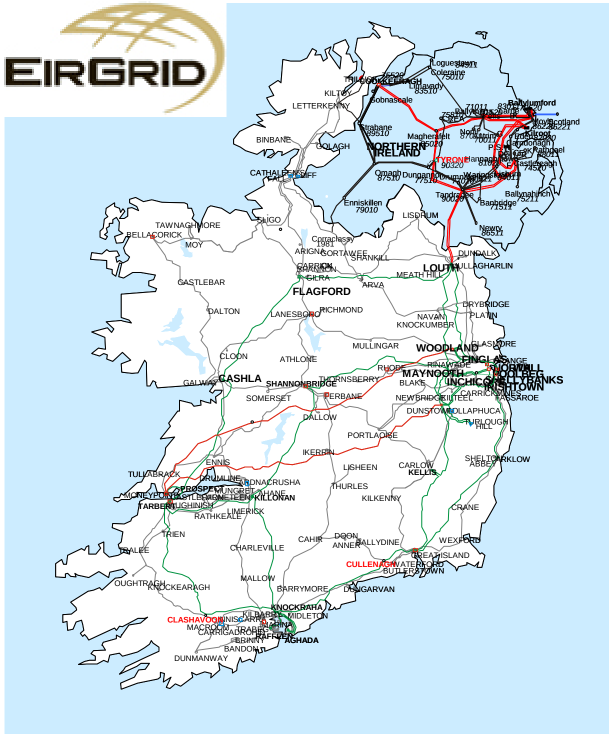
Applications of on-line DSA

- At least **7** out of **10** ISO/RTO in North America have, or are implementing, on-line DSA systems



- On-line DSA systems using Powertech's **DSATools™** software have been implemented in **35** control centers around the world

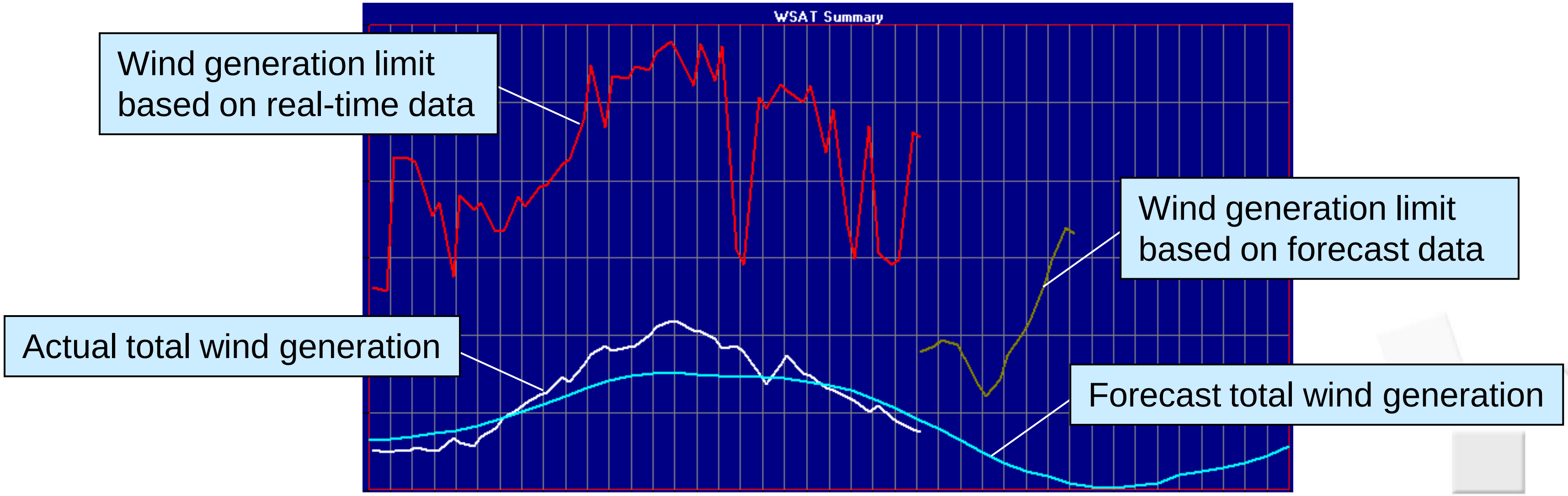
Application example – EirGrid



- The Irish national grid company
- Interconnected to Northern Ireland through AC and to UK through DC
- Small system but with high wind power penetration
  - Maximum wind generation recorded in 2009 supplied 43% of total load (this is 78% of the installed wind capacity)
  - The aim is for 40% of electricity to be produced from renewable energy sources (mostly wind) in 2020
- The question: **what is the highest amount of wind generation allowed at any given instant of time?**
  - Subject to thermal, voltage, frequency, and stability criteria

EirGrid's WSAT application

- A Wind Security Assessment Tool (WSAT) is installed in EirGrid control center as a real-time application
  - Based on Powertech's **DSATools**™ technology
- Provides max allowable wind generation for
  - Real-time condition
  - Forecast condition (integrated with wind forecast data)



Wind security assessment results for a 42-hour time window

Questions?