Ensuring the Reliability and Security of Large Synchronous Networks

Ways to Limit the Extent of Blackouts

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Deregulation Questions
(Off-Hand Replies)

The Free Market Mantra
Deregulation is Market-Based – So it Must be Good!
Good for Reliability and Security?
Not Really, but those are Just Externalities
Is Reliability and Security Improved
with the Separation of Generation from Transmission?
No, But Market-Based Congestion Management
and Ancillary Services will Manage Somehow
Is Operation for Reliability and Security Improved
with Ever-Larger Synchronous Networks?
No! More Transmission Lines Should be Built!
Large Synchronous Networks

- Larger and Tighter Networks
  - Mergers and Acquisitions On the Rise
    - Deregulation Followed by a Wave of Consolidation; Less Instead of More Competition;
      - M&A Dictum: It’s Cheaper to Buy than to Build
    - M&A Results in Larger and Tighter Networks
  - Centralized Operation of Large and Tight Networks
    - Internalize Congestion Problems
    - Aversion to Decentralized, Hierarchical Control
    - The Bigger the Better
    - Huge Real-Time Database
      - 10,000+ Bus Network Models
    - Inadequacy of Decision and Control by the Human-Computer Operator
Problems of Large Synchronous Networks

- The Larger and Tighter the Network
  - the Greater the Interplay of System Dynamics among All Parts of the Network
  - the Greater the Likelihood of a Widespread Blackout

- Adding New Transmission Lines Does Not Necessarily Improve Reliability and Security;
  But it Makes the Network Larger and Tighter and so it goes ----
The Grid Has Been Improved

Excerpts from an article in the March 28, 2005 issue of BusinessWeek

“----- the U.S. needs an energy plan -- one that goes beyond the compromises and pork-trading that Congress will resort to in Energy Bill, Act III. Here's what the nation should do: IMPROVE THE GRID. Remember the August, 2003, blackout? The transmission grid has been improved since then, reducing chances of another outage."

How has the grid been improved?
How have the chances of another outage been reduced?
The article continues:

“---- the U.S. needs to invest far more in infrastructure -- a "smart", digitally controlled grid that would boost reliability and efficiency. It would save tens of billions of dollars a year and eliminate the need for dozens of power plants."

Save Billions of Dollars a Year?
Eliminate Need for Dozens of Power Plants?
Get More Information

Reliability Coordination Agreement

MISO, PJM with TVA will “share more information about daily power flows which will allow grid controllers at MISO and PJM, which already operate jointly, to ‘see’ power flows in the TVA system. The information should prevent widespread blackouts”

--- From Wire Services, 4/23/2005

What do we do with more information?
How do we process more information to prevent widespread blackouts?
The Decision-Making and Control Riddle

What’s Inside?

What’s the Application Software?

How are Automatic Controls Executed?
Problems of Operating Large Synchronous Networks

- The Human-Computer Operator is Overwhelmed with More and More Information but is not Provided with Manual or Automatic Decision and Control Processes
- Software Still in the Making; Real-time Automatic Control Functions Not yet Formulated and Developed
- No Direct Control Access to Generation, Controllable Loads, or Substations in Other Operating Areas
Limiting Synchronism Problems
- Approach I -

DC-Islanding:

- Break Up Large Synchronous Networks into Small Network Islands Interconnected via Back-to-Back (BTB) HVDC

*HVDC is a Mature Technology. Do it Now!*
Limiting Synchronism Problems
- Approach II -

Voltage and Dynamic Stability Control:
Detect Instability Conditions and Execute Manually and/or Automatically Preventive and Emergency Control

Real-Time Voltage Stability Analysis and Control Being Implemented in Several Control Centers;
Off-Line Dynamic Stability Analysis Used for Operation Planning
Limiting Synchronism Problems
- Approach III -

Adaptive AC-Islanding:
Temporarily Split an Intact Synchronous Network or Dynamically Create Islands To Prevent or Control an Emergency

On-Going Research and Development Using WAMS
Some Conventional HVDC Links

- Europe: 6 Nordel-UCTE cable links
- North America: 12 BTB, 7 lines
- India: 4 BTB, 5 lines
- Japan: 4 BTB, 2 lines
- Itaipu-Furnas, 6300 MW, 800 km, 600 kv link
  - Participates in Primary & Secondary Frequency Control of Brazilian system
- Thailand (EGAT)-Malaysia (TNB) link
  - Forerunner of ASEAN Grid
DC-Islanding Preferences

- **BTB zero-distance interconnection**
  - reduced real estate and maintenance
  - no need to convert existing AC transmission
  - simpler converter; DC voltage level can be much lower than that of overhead line or cable
  - no need for communication link between 2 converters

- **HVDC cable for a new tie-line**
  - Minimal right-of-way problems and delays
  - Lower construction cost
Benefits of DC-Islanded Networks

- Control of generation and loads confined to an island
- Steady-state and dynamic problems confined to an island
- Reduces need for real-time information from all interconnected operating areas, i.e., SAMS instead of WAMS
- No uncontrolled loop flows; market-contracted loop flows do not flow through networks of bystander parties
- Precise and rapid control of magnitude and direction of power flow in the link
- Islands can have different frequency standards
Deregulation & DC-Islanding

- Deregulation Jeopardizes Reliability and Security
- Reliability and Security of Operation Improved by DC-Islanding
- DC-Islanding Enhances Deregulation
  - Power Transfers Maintained at Contracted Values
  - Congestion Management Simplified
  - Ancillary Services Facilitated
SUMMARY

Three Approaches to Ensuring Reliability and Security of Large Networks

- DC-Islanding
- Implementation of Software for Detection, Analysis, and Real-Time Control of Voltage and Dynamic Instability
- Realization and Application of Adaptive AC-Islanding
References for HVDC


2. G. C. Loehr, *And There will be Blackouts --*, Keynote Address, T&D World Expo 2000 Cincinnati, Ohio, [www.ameredinst.org](http://www.ameredinst.org)