Large-Scale Automated Model Builder

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Outline

• Load Flow Model Builder Concepts

• Automated Model Builder Applications

• Overview of Model Building Process

• Future Directions
Applications

• Future Chronological Power flow models are required for many tasks/applications:
  – AFC/ATC calculations
  – Outage analysis
  – Transmission planning
  – Market applications
  – Near term operations tasks
Model Building Concepts/Overview

• Start from static “all-in” model as a starting point
  – Typically MMWG or NERC IDC seasonal model for planning
  – EMS based for market applications and near term applications

• Apply dynamic events – incremental changes for selected time window
  – Generation and transmission outages
  – Load forecast
  – Additional subsystem-based transfers

• Dispatch generation

• Solve AC load flow
Model Building Complexities

• Past experience says it is not that simple. Why?
  – Developing models manually or via user developed scripts requires significant effort and can be the most time consuming part of the study. Not a reliable approach for large scale projects that need to be repeated regularly.
  – Problem is in capturing details, making and tracking numerous small changes
  – Difficulty using “pure database” approach involving in-service and out-of-service dates, particularly with dynamic data inputs such as outage schedules

• Handling of external areas
  – Require/desirable to use data for multiple control area
  – Typical transmission modeler concerns:
    • If it is a lot of effort to develop a model for my control area, can it be done for external control area?
  – Would that external area “bless” that dispatch?
Initial AMB Application:
AFC/ATC Calculations for OASIS Posting

• FERC orders 888-890, 729
  – Mandate a calculation and posting of Available Transfer Capabilities on economically viable paths that is consistent, transparent, reproducible, and representative of the most current system forecast data available
  – AMB is the backbone of AFC/ATC solution

• Joint Reliability Coordination Agreement
  – Initially between MISO and PJM, now includes several other entities

• Data sharing and coordination makes it feasible
  – NERC SDX for load forecasts and outages
  – External OASIS reservation information
  – NERG tags for energy schedule information
  – External flowgate AFCs via Coordinated flowgates
Status and Implementation details

• Used by many major Eastern Interconnection companies for several years now
  – PJM, TVA, MISO and others with combined peak exceeding 400,000 MW of load, 3 times zones

• Automatically builds
  – 48 hourly models every hour
  – 168 hourly/35 daily models multiple times per day
  – 18 monthly models
  – **Totals more than 1,800 LF models per day**, all models are AC solved

• Computed flowgate AFCs and sensitivity factors directly feed into PowerGEM AFC/ATC process
AMB Applications: Reliability/System Security Analysis

- Reliability Analysis of Approved outages
  - Example – One AMB user creates Eastern Interconnection wide models for next 35 days and performs full AC N-1 analysis – daily
  - By-product of AFC/ATC process
- Near-term what-if scenarios
- With proper data, setup can be used to build transmission planning growth scenarios
- The AMB process can build models from an online EMS ‘seed’ case, allowing breaker-level detail for contingencies and evaluating outages
AMB Applications: Automated Outage Evaluation Analysis

- Build models for various future time periods. Examples:
  - Next day hourly models or just peak/off-peak model
  - Near term 35 daily models
  - 90 daily models representing months 6 through 9
- Automatically evaluate all outages occurring in the study time window
- Evaluate outages
  - One at a time
  - In order of submission
- Decline or approve based on reliability impacts
- Find new outage opportunity window
Common Requirements

• Models should represent multiple control areas
  – MMWG/IDC load flow models represent the best available Eastern Interconnection wide load flow models for planning applications
    • Up to 60,000 buses, 100+ control areas

• Created models should be AC solved
  – Reliable and high performance is critical

• Constructed in an automate-able and reproduce-able/auditable manner

• Time horizons
  – Hourly
  – Daily (representative peak and off-peak models)
  – Monthly peak
TARA AMB Process

Starting Point - Base Input:
- Seasonal MMWG derived
- or EMS based models

NERC SDX Files
- for Load Forecast
- And Outage Information

NERC SDX-Type inputs
- For providing Gen/Load
- Direct Dispatch,
- Shunt Outages

CA Generator
- Block Dispatch
- And Load Profile
- Definition Files

Standard-Format
- Flowgate
- Definition Files

Standard-Format
- POR/POD, Gen, Load
- Subsystem definitions
- For Dist. Factors

Reservation/Schedule
- Inputs for building
- Into Snapshots

TARA Model Builder
- Script file driven
- By Period Type
- Run in batch mode
- or TARA Viewer

Power Flow Snapshot Models
- 60,000 buses

DCCont, ACCont
- Output reports

N-1 Analysis
- Distribution Factor
- Reports

Flowgate Base
- (Initial) AFCs

TDF Information
- By Flowgate
- For each POR/POD
- Including Gen, Load

Transmission Outage
- Request Analysis

Offline System
- Analysis And
- Reliability Studies

Other Applications:
- Case creation for
- Planning Studies
- using SCED, etc.
Where to Get Input Data?

• NERC System Data Exchange (SDX)
• Eastern Interconnection control areas submit/update data several times a day
  – Data time periods range from next few hours up to several years into future
• Members can download information
  – Load forecast for various future time periods
  – Transmission outages
  – Generation outages & de-rates
• System topology in baseline model must align with NERC IDC case
• If NERC SDX data is not available
  – Load forecast and outage information provided from ‘internal’ sources can also be used
• Transactions data
  – External OASIS reservation information
  – NERG tags for energy schedule information
Modeling Outages and Scenarios

• Transmission and Generation outages
  – What to do with outages lasting a fraction of the represented time?
  – i.e. when creating daily peak case, do we include an outage that lasts one hour in early afternoon?
• TARA AMB process utilizes a ‘representative time window’ for selection of outages applied to longer time period models
• Same approach can be used to model future transmission upgrades and retirements
Generation Dispatch Methods

• Block Dispatch – variation of merit order dispatch
  – Divide generation into groups or blocks and dispatch proportionally by blocks

• Direct Dispatch – do not follow economic dispatch rules
  – Hydro, pumped storage, wind, pre-scheduled units
  – User defines output by time of day or time of year

• Dispatch plants or individual units according to bilateral transaction inputs (reservations or schedules)

• SCED (Security-Constrained Economic Dispatch)
  – Economic-based. Provides N-1 secure cases
  – Challenge – running SCED for multiple control areas, as typically each area enforces only internal constraints
Challenges Solving Load flow

- Solving power flow models involving such wide-scale changes is a challenge for fully automated applications using MMWG models.

- Using “peak conditions” seed model to create off-peak models is inherently difficult due to voltage schedules, VAR profiles, etc.

- MMWG modeling information may not be entirely correct:
  - Conflicting voltage schedules from different control devices
  - Voltage schedule ranges too narrow to arrive at a ‘satisfied’ state
  - Leads to oscillation of controls (taps, shunts, gen setpoints)

- A simple error in a remote area can “kill” the process.

- Various solution techniques have been developed to improve the solution or identify local areas causing solution problems.
EMS Trend

- Recent requests to use EMS as a base model to build future cases
- Include relevant breakers as zero-impedance lines
- TARA topology processor converts EMS equipment connection descriptions to standard load flow format
  - EMS data formats are not standard yet
- Customer’s internal outage and contingency definitions are used
  - Matches EMS equipment names
- Apply a real-time historic load profile to base
- Future work – combine MMWG with EMS model for selected area
AMB performance

• Computers and software are fast enough now
• MMWG models - 60,000 buses
  – Every hour next 48 hourly model – takes ~3-4 min
  – Advance applications using AMB models (such as large scale AC contingency analysis) take more time than AMB model creation
• EMS models
  – 12,000 buses - created 720 hourly cases with N-1 SCED applied – every hour of the month; 45 minutes run time
  – Stress test – tested full EMS model without any reduction for a large ISO
    • has ~200,000 buses, > 150,000 zero impedance lines
    • Successfully tested/AC solved/N-1
    • Normally reduced to ~40,000 buses
Future directions

• Expand usage of existing AMB features
  – Expand usage of EMS models
  – Models on demand
  – Improve/simplify usage of MMWG/IDC models

• Improve data sharing between control areas

• Standardize planning and EMS data formats

• Better integration and more standard solutions for various applications
Possible Future Direction

Centralized AMB process for the whole Eastern Interconnection

Is it feasible?

• Users?
  – All companies within Eastern Interconnection
  – Case repository at a central location
  – Accessible to all participants
Centralized AMB Process for the Eastern Interconnection

• Existing AMB process can be used with little changes
  – Well tested process for several years now
  – Models Eastern Interconnection without any reduction now
  – Someone has to administrate the process
  – Scalable and can be executed in parallel/independently at different locations

• Challenge
  – Quality – it is up to users. The more information control areas submit, the better their local models will be
  – AMB process has to dispatch multiple control areas simultaneously
  – Coordination between control areas requires further discussion

• Future - Centralized AMB with EMS - Phase 2
  – Develop capability to import EMS model for selected control area
AMB Summary

- AMB is a process to create chronological LF models for any future time interval
- Generic, yet customizable approach
  - Can be applied for any company within Eastern Interconnection with incrementally small efforts
  - Most of the information required is readily available via NERC SDX and information shared between companies
  - Can be used by Western Systems companies with a smaller scope, since adjacent company information is not yet readily available
- Tailor-made for processes requiring frequent evaluation of multiple future time horizons such as:
  - AFC/ATC calculation for OASIS posting
  - System security evaluation for facility outage requests
Questions?