Deployment of Real-time State Estimator and Load Flow in BC Hydro DMS - Challenges and Opportunities

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Summary

- Overview of BC Hydro distribution system
- DMS model requirements
- Distribution application sequence
- State estimator tuning and commissioning
- Results
- Next steps
BC Hydro System

- As one of the largest electric utilities in Canada, BC Hydro serves customers in an area containing over 94% of British Columbia’s population.
- 1.8 million customers
- Reliable Power, at Low Cost for Generations
- 11.3 GW generating capacity
  - 90.3% hydroelectric
  - remainder diesel or thermal
- Operating Area is 68,201 km²
BC Hydro Quick Facts

• 18,500 km transmission (500kV to 60kV)
• 1,000,000 poles, 300,000 transformers
• 47,000 km overhead primary (85%)
• 7,600 km of underground primary (14%)
• 400 km of D submarine cable (<1%)
• 212 distribution substations
• 75 transmission substations
• 1500 + feeders
  – <1% - 35 kV, 47% - 25 kV, 50% - 12kV, 3% - 4 kV
DMS Model Requirements
Data Sources

- Distribution substation data – Energy Management system (EMS)
- Distribution network data (outside of substation fence) – Asset Management GIS
- Real-time data (SCADA)
- Load profiles (customer care and conservation)
- Plant alterations and system design - GIS
- Weather data (Environment Canada)
- Supplemental technical information related to distribution equipment
DMS Model Development

- Conversion of substation model from EMS into CIM format
- Conversion of distribution network model from GIS into CIM format
- Addition of supplemental substation and feeder data during model build including load profiles
- Stitching of EMS and GIS CIM models into a cohesive DMS model in proprietary phase connectivity format
- Export of SCADA model from EMS to cover all substation real-time measurements
- ICCP definition for integration real-time SCADA models of EMS and DMS. All substation controlled via EMS as a conduit
- Creation of SCADA model for measurements and statuses outside of substation fence in DMS SCADA subsystem.
Distribution Applications Sequence

- Analog measurement trigger
- Periodic trigger
- Topology trigger
- Periodic trigger

- SE
- LF
- VVO

[Image of software interface for triggering and alarm settings]
Distribution State Estimation – BCH Implementation

- Integration with EMS – energy source data transferred from EMS state estimator
- Summed measurements representation
- Utilization of field measurements including SMI
- Archiving and tracking of state estimator solution (PI)
- State estimation of meshed distribution networks (includes complete low voltage networks)
- Customized reports – violations and performance indices
Distribution State Estimation – Integration with EMS

Substation 1
Energy Source
\( \sum \)
\( V \theta \)

L L L L L

Substation 2
Energy Source
\( a \)

L L L L
Distribution State Estimation – Meshed Networks
Distribution Load Flow – BCH Implementation

- Two tier algorithm to enable solution for meshed networks including low voltage
- Customized solution reports for violations and performance indices
- Secondary networks equivalent – to optimize performance for validation purposes
Distribution Load Flow – Reports

- Tabular reporting of selected LF results
- Graphical presentation of LF flow along distribution network
State Estimator Tuning

- Tuning performed in five phases
- Phases 1-3 model validations
- Phase 4 measurement error tuning
- Phase 5 Benchmarking against real-time
Preparatory network tuning for SE Phase 1

- Topology validation for substations and connected distribution system
- Utilization of Topology reports from DMS and comparison with source data
- Validation of substation transformer attributes
- Validation of LTC controller model
- Validation of substation transformer impedance
- Validation of a proper “stitching” between feeder and feeder head
- Validation of equipment models: capacitor, voltage regulator, generator etc.
- Validation of number of elements imported from source GIS system
- Validation of catalogs assigned to equipment
Preparatory network tuning for SE
Phase 1
Preparatory network tuning for SE Phase 2

- SCADA model & validation of ICCP points
- Display validation for LF&SE
- Analysis of Load flow and State Estimation results on selected area
Preparatory network tuning for SE Phase 3

- Analysis of overloaded service transformers – each individual case was looked to determine source of problem:
  - Connectivity issues – incorrect association of customers and transformers
  - Legitimate overload
  - Incorrect transformer size
  - Incorrect load profile

- Analysis of overloaded sections – determination of probable cause:
  - Data issue (e.g. incorrect association of wire/cable catalog)
  - Legitimate overload

- Analysis of low voltage problems at customer location – determination of probable cause:
  - Incorrect association of customer to service transformer
  - Undersized transformer and/or service wire for the customer connection
  - Incorrect association of load profile (e.g. customer consumption doesn’t follow typical assigned load profile)
Preparatory network tuning for SE Phase 3

- Violation report – overloaded transformers

- Overall Load Flow distribution on selected domain
Preparatory network tuning for SE Phase 3

Overloaded section
State Estimator Tuning – phase 4

- Validation of SE results quality
State Estimator Tuning – phase 4

- Job dashboard – monitoring of real time sequence
Results and experiences

- PI tracking
- Job dashboard
- State estimator report
- Violation report
- Performance indices
- Benchmarking results
Next steps

- Release to production (staged) – large amount of work to tune one station (time it takes, people impact, skill set, relation to data sources etc.)

- Error detection (measurement redundancy, se reports, quality indices etc.)

- Violation report

- Performance indices

- Benchmarking results (against recorded SMI data from real-time)
QUESTIONS ?