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

Djordje Atanackovic, BC Hydro

Valentina Dabic, BC Hydro

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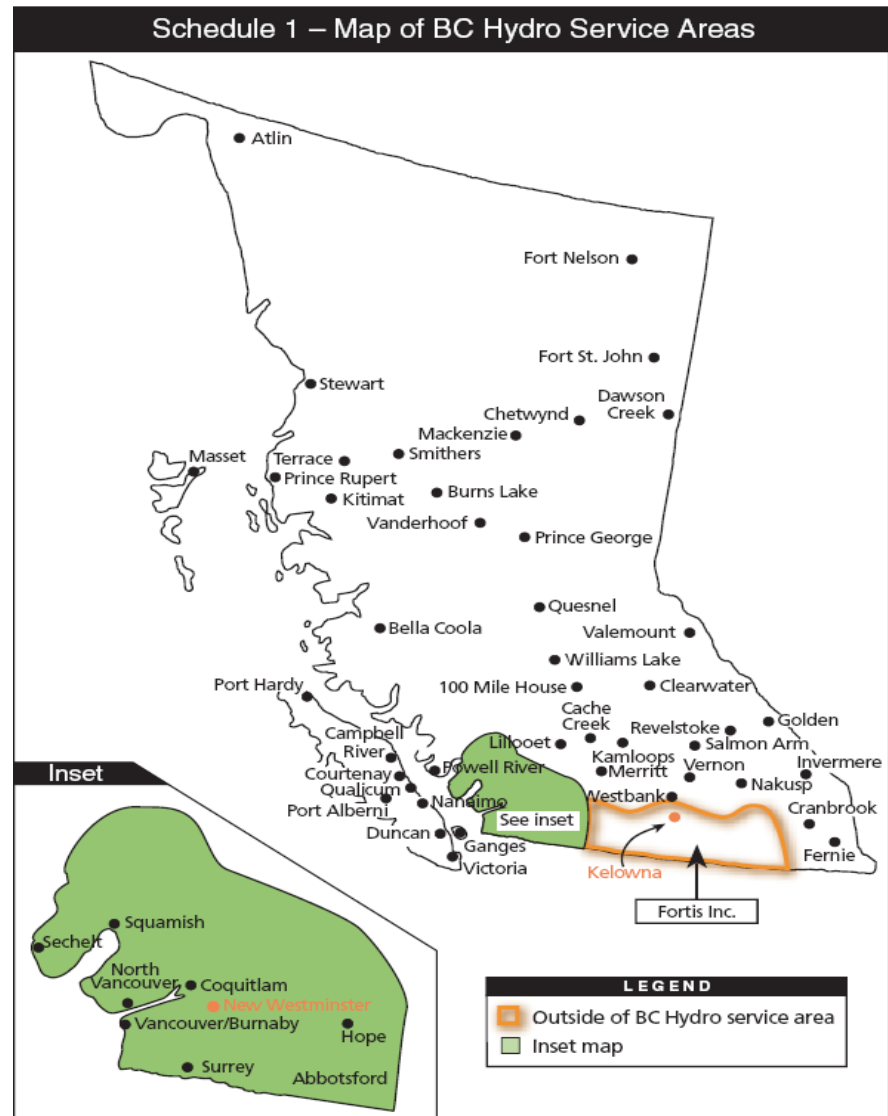
FOR GENERATIONS

Summary

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

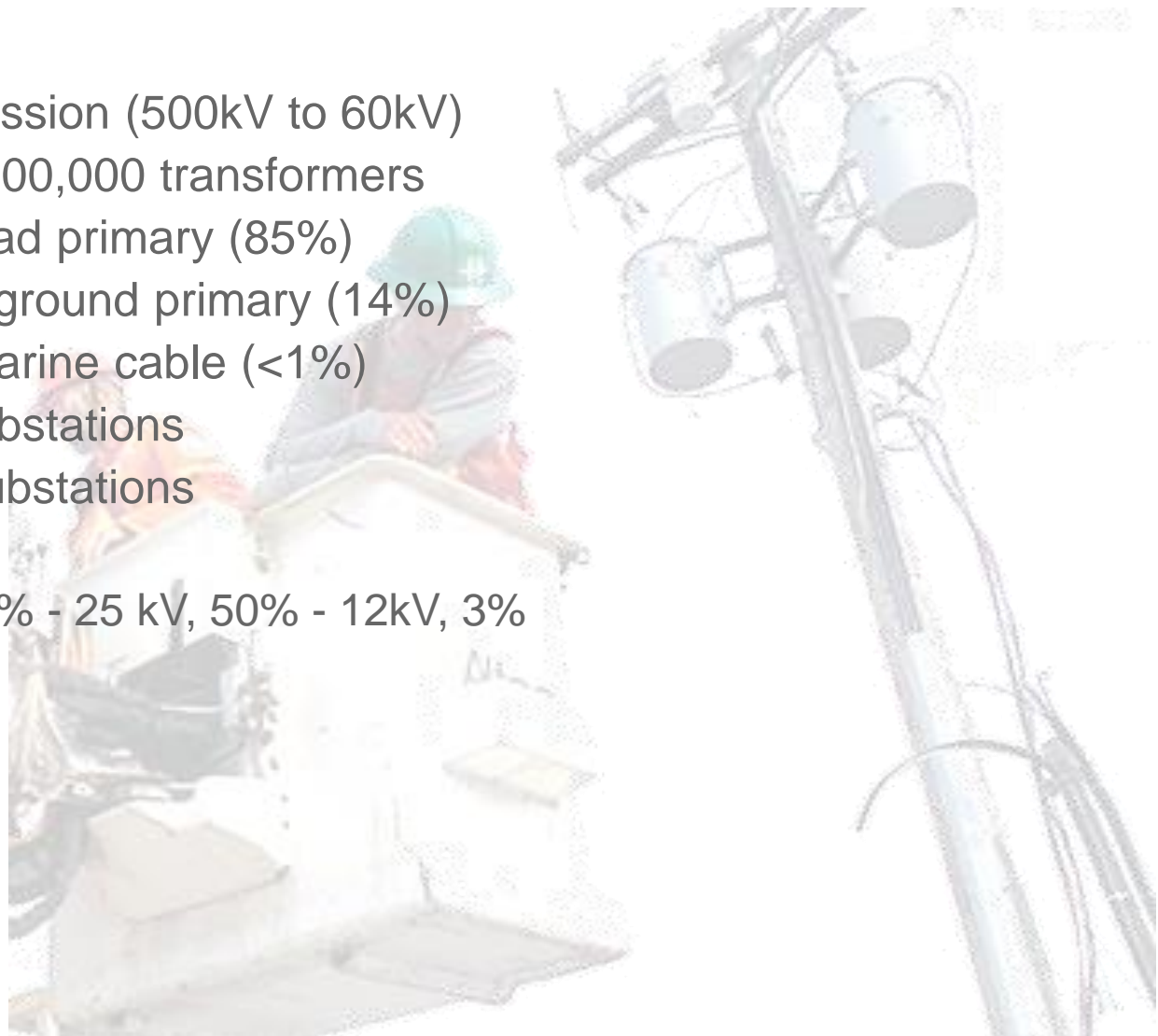
BC Hydro System

- 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

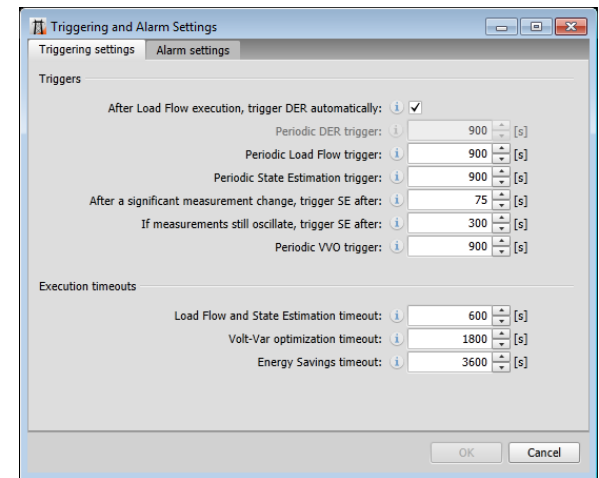
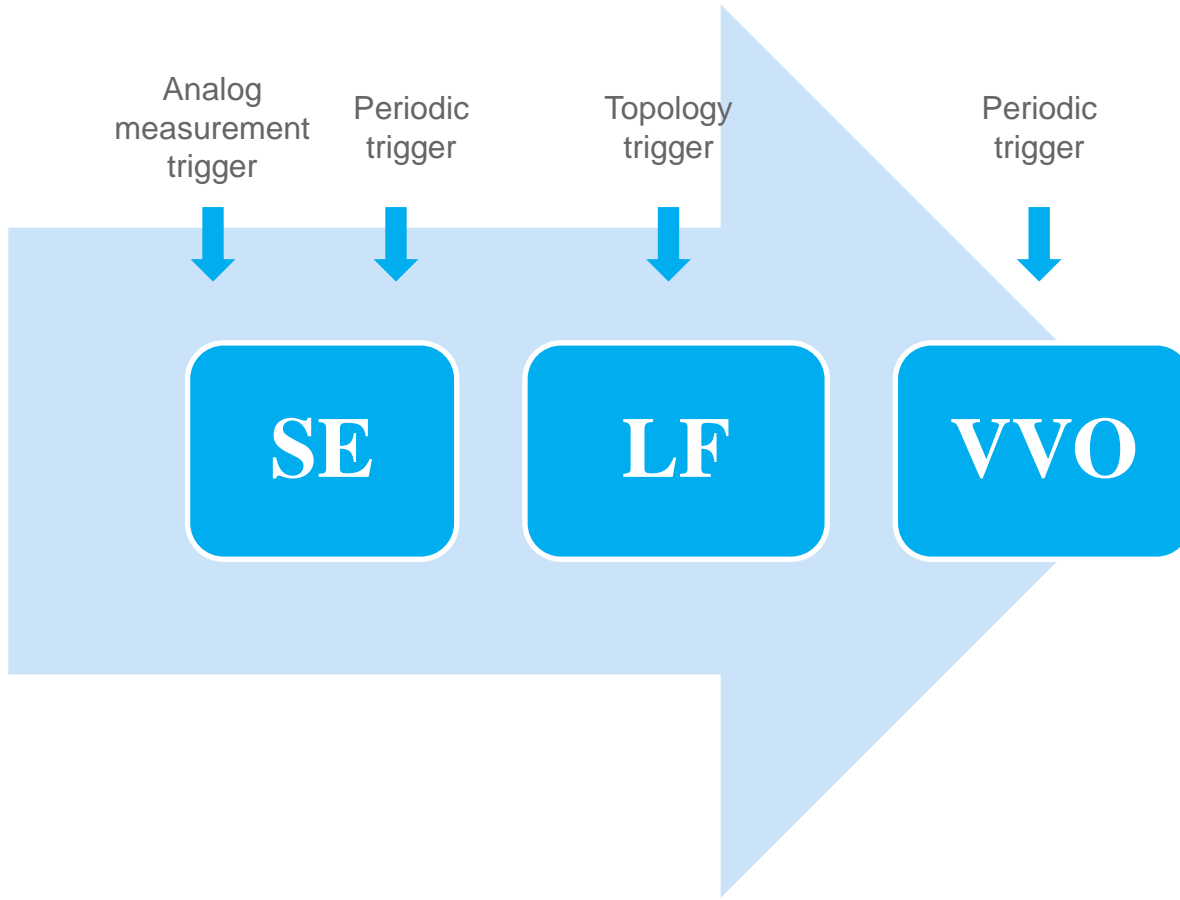
Data Sources

- 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

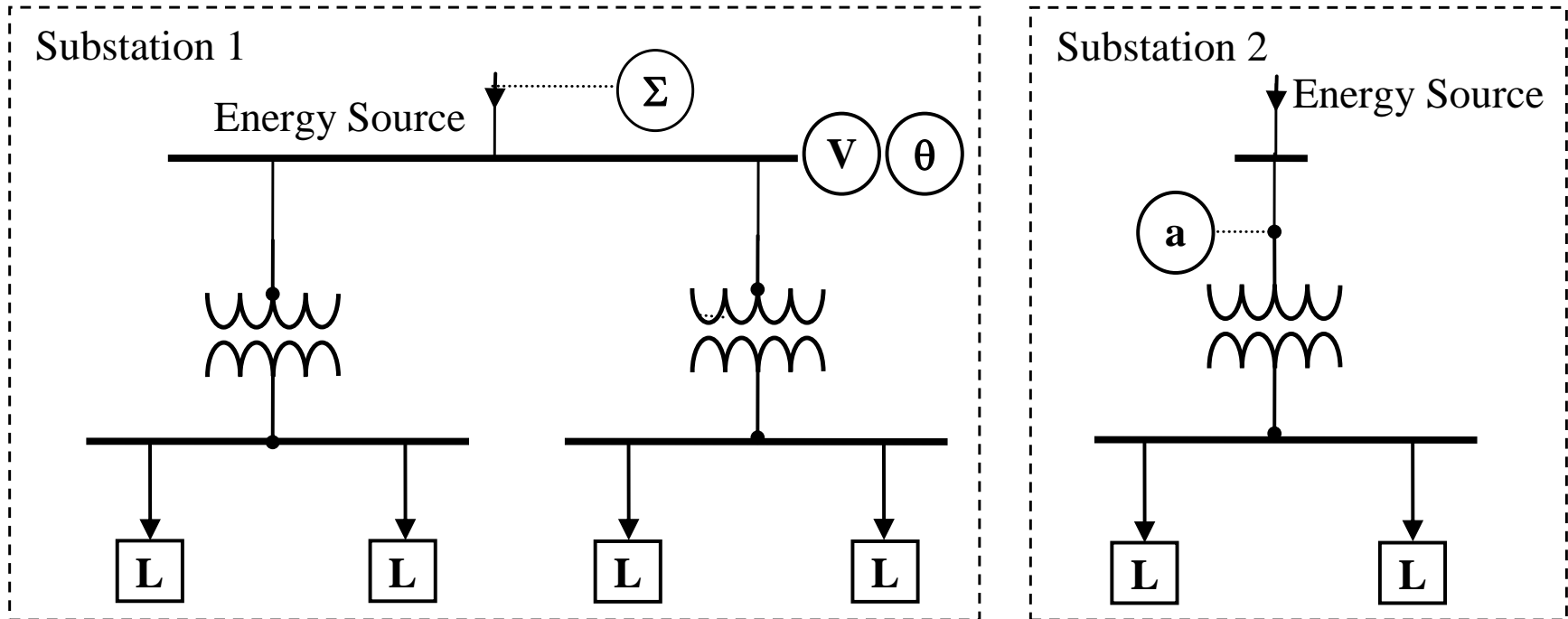
Distribution Applications Sequence



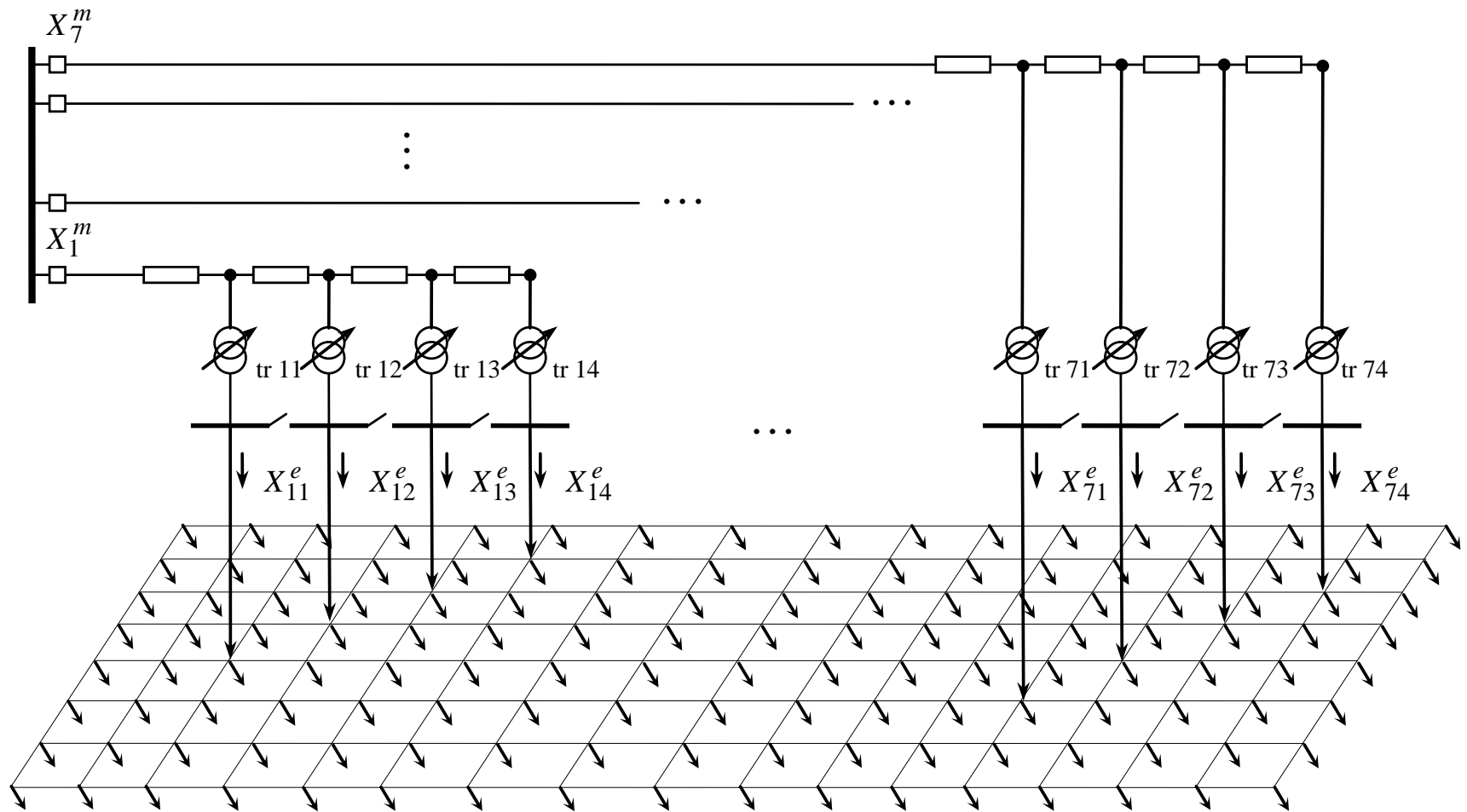
Distribution State Estimation – BCH Implementation

- 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



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

State Estimator Tuning

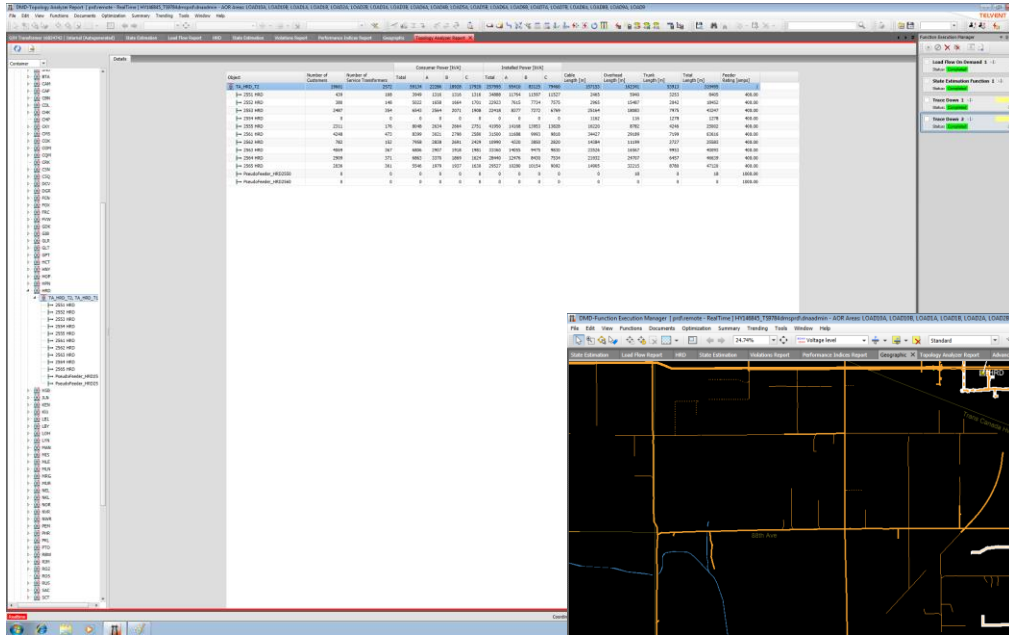
- Tuning performed in five phases
- Phases 1-3 model validations
- Phase 4 measurement error tuning
- Phase 5 Benchmarking against real-time

Preparatory network tuning for SE

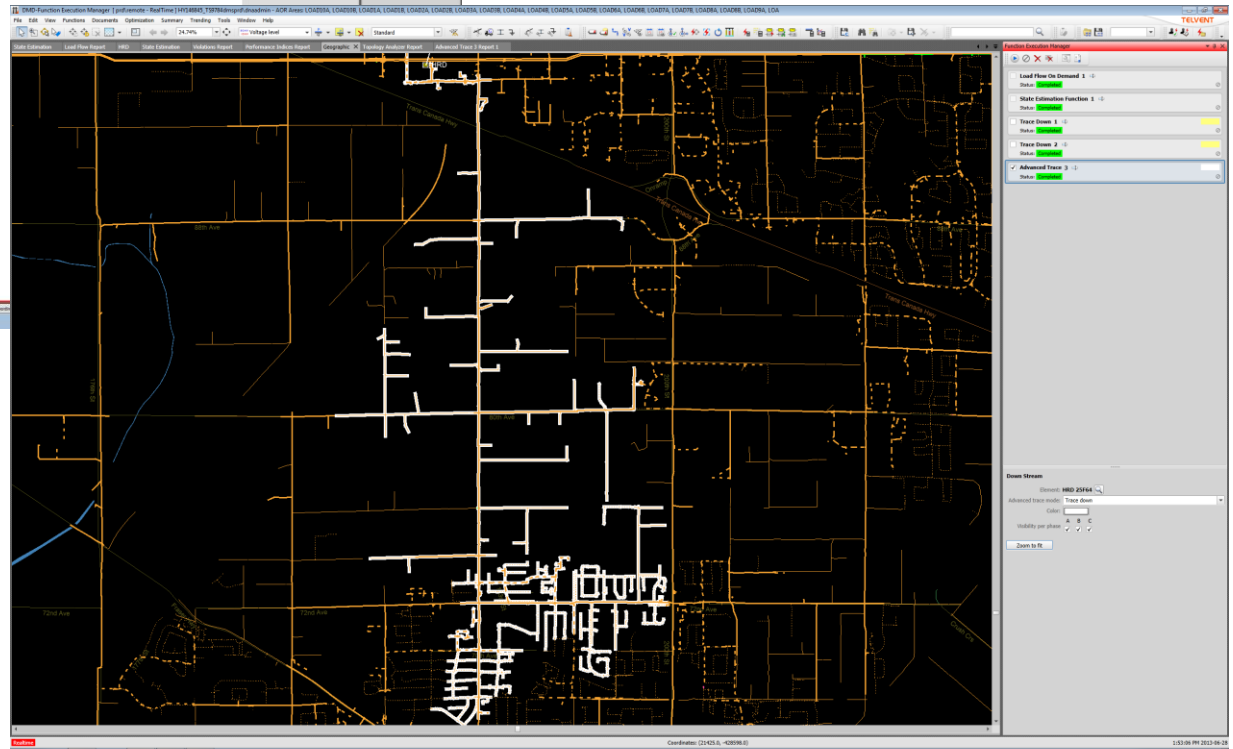
Phase 1

- 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



Class	Number of Customers	Number of Service Transformers	Conductor Type (20)			Insulator Type (20)			Cable Length (m)	Total Length (m)	Total Weight (kg)	Total Area (m ²)
			A	B	C	A	B	C				
20-200-000	400	375	2004	2208	2400	2000	2000	2000	2000	2000	2000	
20-200-001	400	375	2004	2208	2400	2000	2000	2000	2000	2000	2000	
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20-200-007	400	375	2004	2208	2400	2000	2000	2000	2000	2000	2000	
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20-200-009	400	375	2004	2208	2400	2000	2000	2000	2000	2000	2000	
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20-200-100	400	375	2004	2208	2400	2000	2000	2000	2000	2000	2000	



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

DMD-Violations Report [pdr\remote - RealTime] [H1746845_159784dmsgrd\draadmin - ADR Areas: LOAD10A, LOAD10B, LOAD1A, LOAD1B]

File Edit View Functions Documents Optimization Summary Trending Tools Window Help

Q/H Transformer 16827943 | Internal (Autogenerated) | State Estimation | Load Flow Report | HRD | State Estimation | Violations Report

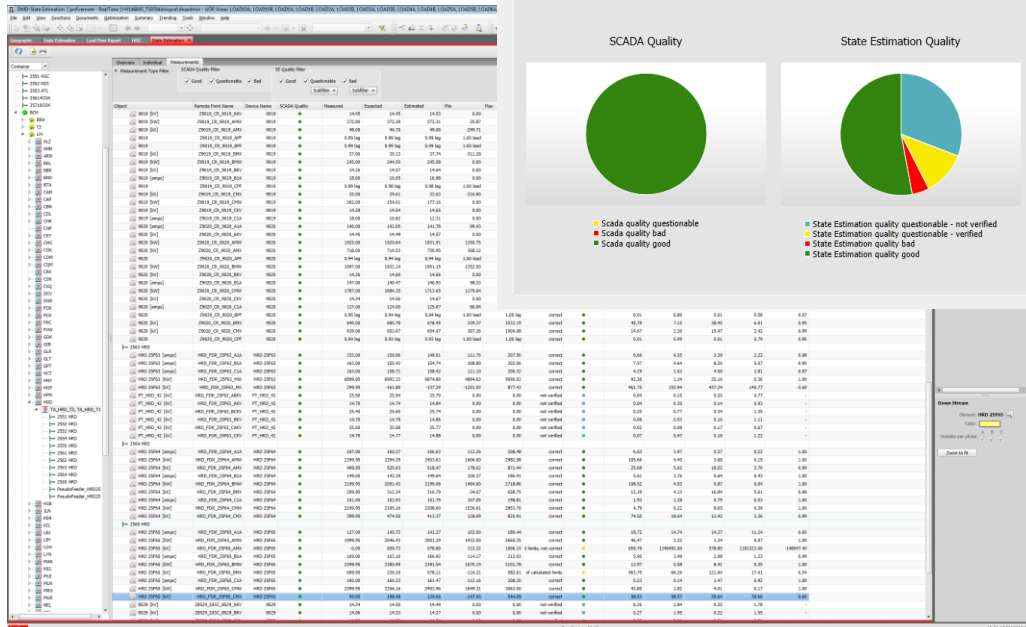
Object	Leading [%]	Loading [kVA]	Limit	Violation
TA_HP4L_T4				
12311HPN				
12314HPN				
12315HPN				
O/H Transformer 1449593135 A	134.80	67.4		
O/H Transformer 599387680 B	196.82	49.2		
12316HPN				
12317HPN				
12318HPN				
12322HPN				
C2588 Internal Transformer	130.68	2783.6		
12323HPN				
O/H Transformer 599373612 B	135.41	67.7		
O/H Transformer 599373614 B	124.28	62.1		
O/H Transformer 599373648 B	161.87	40.5		
O/H Transformer 599373654 B	108.23	54.1		
O/H Transformer 599373656 B	190.82	47.7		
12324HPN				
12325HPN				
12326HPN				
PMT 41583	131.82	197.7		
O/H Transformer 599389934 A	100.17	37.6		
O/H Transformer 599389936 C	252.13	63.0		
C2546 Internal Transformer	151.26	1512.6		
PMT 39822	128.85	193.3		
12327HPN				
O/H Transformer 599389586 C	219.74	109.9		
12328HPN				
12511 HPN				
1252 HPN				
1253 HPN				
PMT 34472	100.26	501.3		
O/H Transformer 599398514 B	113.46	56.7		
O/H Transformer 599398548 A	100.08	50.0		
O/H Transformer 599398750 A	139.99	14.0		
O/H Transformer 599398752 B	146.55	14.7		
O/H Transformer 599398754 C	145.83	14.6		
O/H Transformer 599398756 C	129.97	65.0		
O/H Transformer 599398832 A	110.63	27.7		
1254 HPN				
LPT 6161	105.62	26.4		
PMT 5169	111.46	167.2		
O/H Transformer 599374212 B	162.68	81.3		
O/H Transformer 599374222 C	101.50	25.4		
O/H Transformer 599390212 C	105.54	52.8		
O/H Transformer 599390294 A	125.89	62.9		
1255 HPN				
1256 HPN				
1257 HPN				
O/H Transformer 599372960 B	105.71	26.4		
PseudoFeeder_HPNI2320				
TA_HPNI_T3				
TA_HPNI_T4_TA_HPNI_TS				
12311HPN				
12314HPN				
12315HPN				
O/H Transformer 599397098 B	107.21	53.6		
12317HPN				
12318HPN				
12322HPN				
12323HPN				
12324HPN				
12325HPN				
12326HPN				
12327HPN				
12328HPN				
1251 HPN				
1252 HPN				
1253 HPN				
O/H Transformer 1063110535 B	244.84	24.5		
O/H Transformer 599398410 B	122.79	30.7		
O/H Transformer 599398450 B	101.34	25.3		



- Overall Load Flow distribution on selected domain

State Estimator Tuning – phase 4

- Validation of SE results quality



State Estimation Settings

Warning: Changing of these parameters affects the stability, quality and performance of all DMS functions

State estimation properties

- Use only telemetered measurements
- Verify current, power, power factor
- Verify voltage
- Use measurement quality
- Use previous estimated load as input

Absolute measured - pre-estimated difference for current: 30

Relative measured - pre-estimated difference for current: 30

Absolute measured - estimated difference for current: 20

Relative measured - estimated difference for current: 20

Relative measured - estimated difference for voltage: 2

Default measurement trust factor: 80

Default load trust factor: 10

Trust factor for uncertain measurements: 10

Maximal voltage difference at the same node: 3

Maximal allowed load scaling ratio: 5

Weight for fixed measurements: 1000000

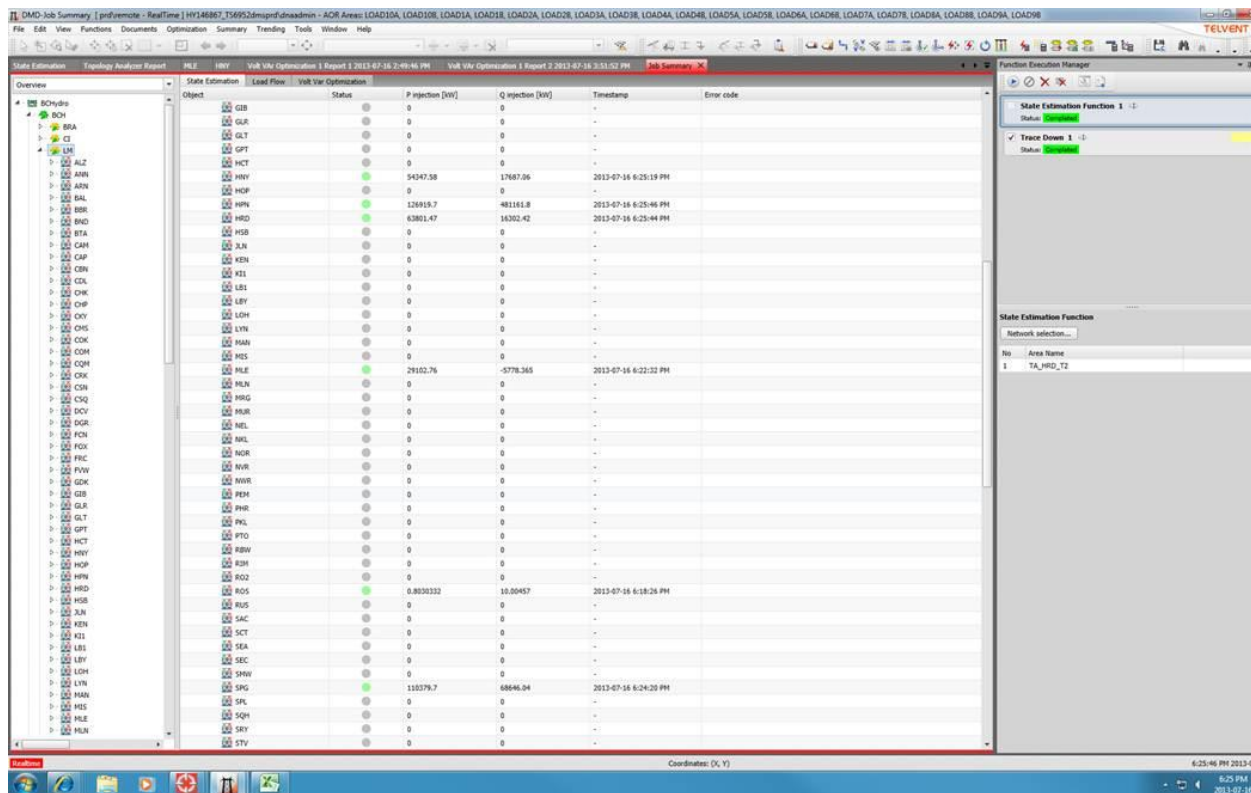
Weight for fixed consumer: 10000

Load flow properties

OK Cancel

State Estimator Tuning – phase 4

- Job dashboard – monitoring of real time sequence



The screenshot displays a software interface for monitoring a real-time sequence. The main window is titled "DMD-Job Summary" and shows a table of objects with the following columns: Object, Status, P injection [MW], Q injection [MW], Timestamp, and Error code. The table lists various objects (e.g., CBB, CBR, CLR, CLT, GPT, HCT, HNY, HOP, HSD, HSB, JLN, KEN, KXL, LBI, LBY, LCH, LYN, MAN, MES, MLE, MNL, MNR, MNS, MRS, MUR, NEL, NML, NOR, NVR, NWR, PBI, PHL, PHL, PTO, RBN, RBN, ROJ, ROS, RPS, SAC, SCT, SEA, SEC, SHW, SPG, SFL, SQH, SRY, STV) and their corresponding injection values and timestamps. The interface also includes a sidebar on the left for navigation and a right-hand panel for configuration, such as "State Estimation Function" and "Network selection".

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 ?