Alberta Wind System Impact Study & Dispatch Simulation Model

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About the Alberta Electric System

- Load
  - Historical peak load: ~9,600MW in 2005 winter, ~9000 summer
  - Annual load factor: ~80%
- Generation
  - ~11,500MW installed capacity
    - Coal: ~5,800GW (~50%)
    - Gas: ~4,300GW (~37%), in which about half are co-generation
    - Hydro: ~900MW (~8%)
    - Wind: ~300MW (~3%)
    - Others: ~200GW (~2%)
- Interconnection
  - 1000 MW to BC
  - 150 MW to SPC (DC)

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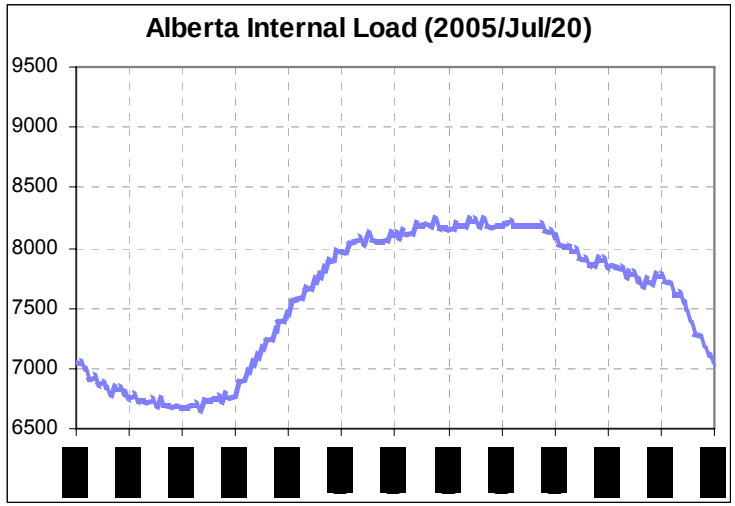
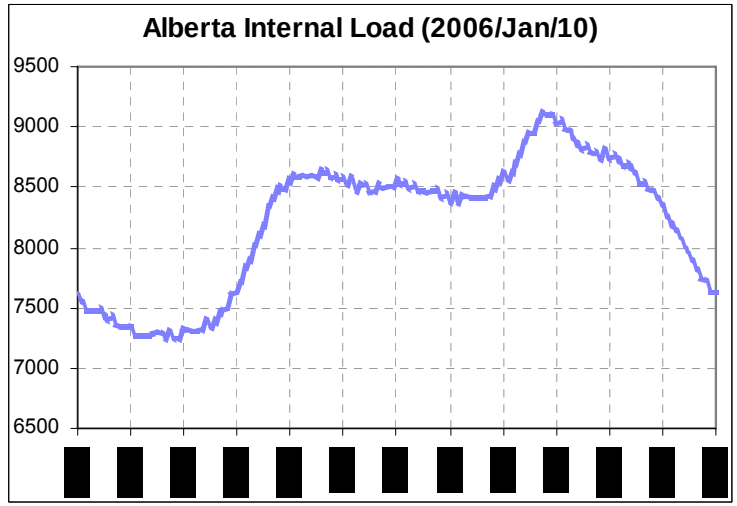
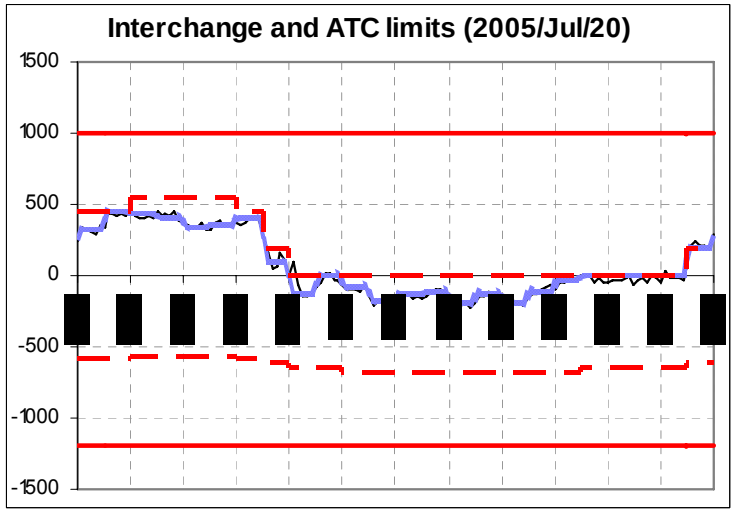
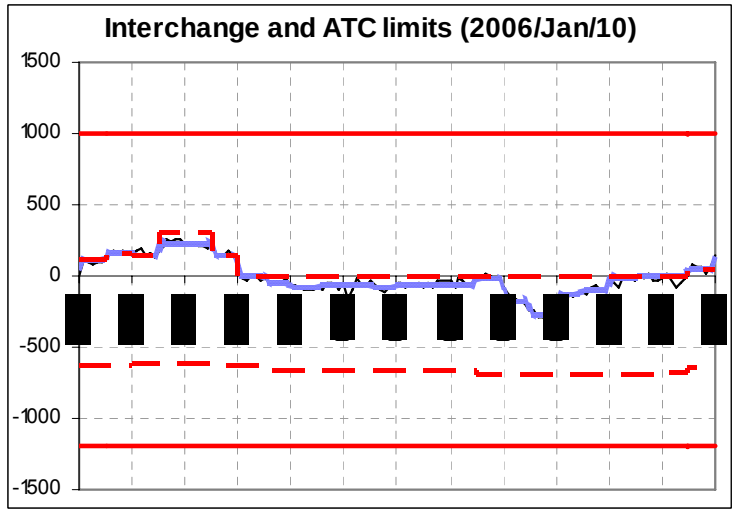
Example Daily Load and Interchange









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Alberta Market Operation

- Energy Market
  - AESO creates a day-ahead load forecast (MAPE of 1.3% (~100MW))
  - Generators submit day ahead offers to supply in up to 7 price/MW pairs
  - AESO creates an hourly merit order from the offers and provides a 7 day price forecast by matching offers to forecast load
  - Generators are allowed to restate offers right up to the operating hour, AESO enforces dispatch compliance in the operating hour
  - Operators dispatch the merit order in real time to match supply with load, meet interconnection schedules and maintain regulating margin in both directions.
  - System Marginal Price is calculated every minute, the market is settled on the ex-post hourly average pool price
  - No day ahead energy market or unit commitment, no capacity market
  - No transmission rights within Alberta
  - We areconsidering changes to several elements of market design (T-2 lock down on offers, must offer must comply rules, RUC)

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Alberta Market Operation

- Ancillary services market
  - Operating reserves requirements (regulating, spinning and supplemental) are forecasted and reserve may be purchased up to 5 days ahead of the operating day
  - Generators coordinate their energy market offers with operating reserve commitments
  - AESO purchases between 120-225MW of regulating reserves each hour (depending on forecast load change), ~160 MW on average
  - Standby reserves are also purchased to cover contingencies (~120MW on average)

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Alberta Market Operation

- Interconnections
  - Interchange scheduling with BCTC (and Sask) according to NERC/WECC rules (TTC/ATC/TRM calculations, OTC limits, e-tagging), maximum hourly ramps are enforced
  - Imports and exports are not permitted to set SMP since they are not able to be dispatched like generators in our market. Rather, they must decide whether they want energy to flow prior to T-20 minutes and then accept the pool price
  - TRM is set 65MW to prevent load swings from causing an OTC violation (most conditions)
  - Alberta exports are constrained during higher load periods due to north to south transmission limitations.
  - There are many hours where schedules are at export OTC limits (i.e. even at 0 export)
  - Therefore we must maintain good CPS2 performance in order to avoid OTC violations
  - Currently do not have dynamic scheduling capability

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Wind Power Development and Concerns

- Significant interest in Alberta to develop wind facilities (~3000 MW)
- While we can build wires, we needed to study the impact on system reliability from a control area perspective
  - Control performance (CPS2, OTC violation)
  - Short term adequacy
  - Can performance issues be mitigated?
- How does wind participate in the existing market or with the proposed market changes?
- If the performance issues can be mitigated, who pays the cost of mitigation?
- In June 2006, AESO declared a 900MW reliability threshold to ensure that we can continue to operate reliably while we continue to address the issues
  - We know that some mitigation will be necessary to get to 900MW

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The Wind System Impact Study

- Phase-1 (2005/Nov):
  - Simulate system dispatch based on recorded 2004 system operation data (actual and forecast l*oad, interchange, ATC, and regulating reserve*) and recorded wind power data to validate the model
  - Combined with 2004 actual system operation data with different wind scenarios' data provided by wind industry
    - Scenario A: existing wind level 254MW
    - Scenario B: existing wind level ~900MW
    - Scenario C: existing wind level ~1500MW
    - Scenario D: existing wind level ~2000MW
  - Examine the incremental effects of wind power penetration on system operation
  - Provide a more accurate assessment on operational impact: (CPS2, OTC)
- Phase-2 (2006/May):
  - Sensitivity analysis of key assumptions
  - Investigate possible mitigation solutions

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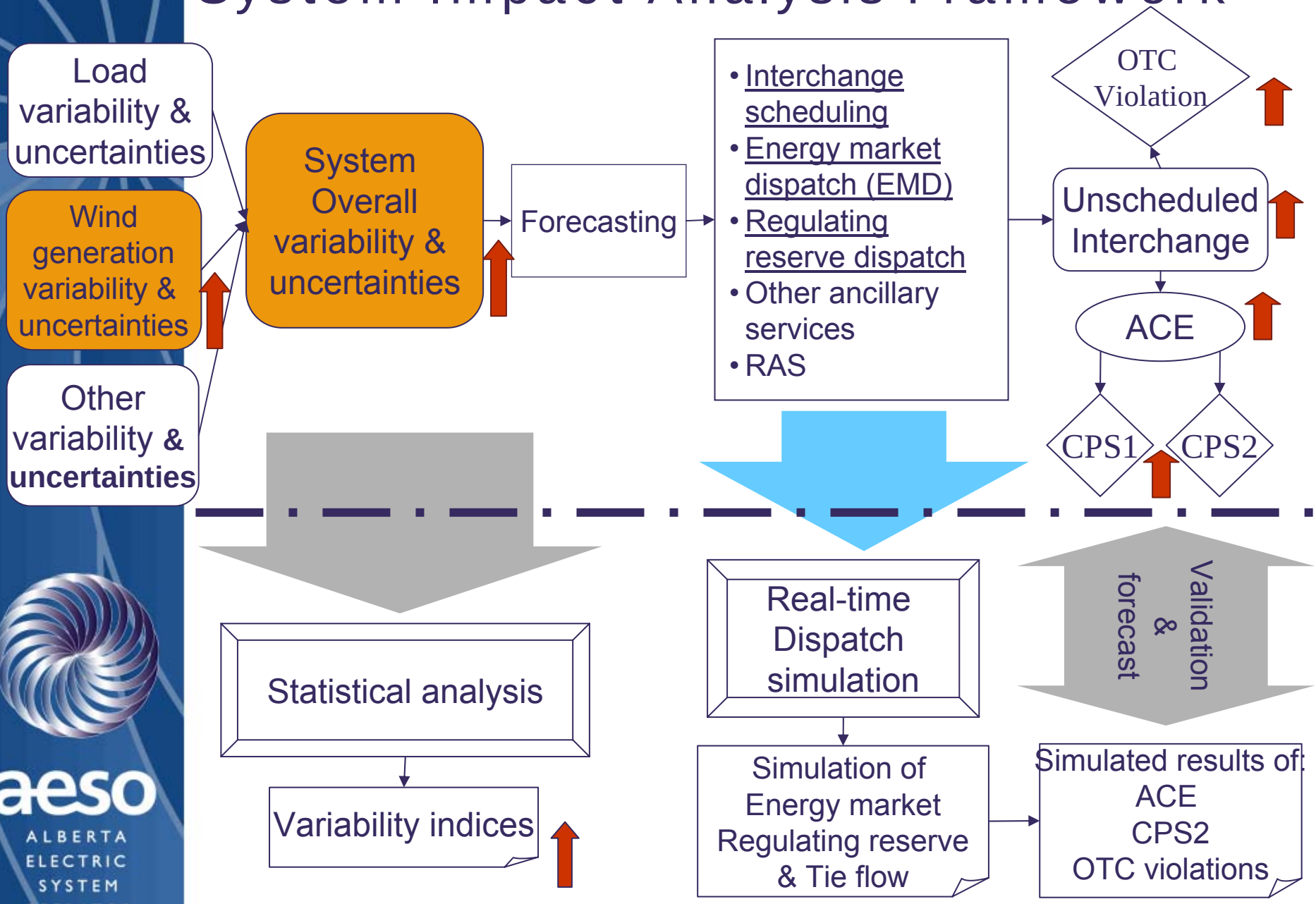
System Impact Analysis Framework



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Why do we need to do a Real-time Dispatch Simulation?

- In real time system operation, there are aspects that are difficult to be modelled statistically or mathematically
  - Resources limits such as:
    - Energy market dispatch ramping limits
    - Regulating reserve dispatch ramping limits
  - Human activities such as:
    - Control strategy
    - Time delay associated with decision making, dispatch, and plant operator action
    - Threshold level where no action may be taken
- To assess the impacts of the required system control performance
  - ACE (Area Control Error)
  - CPS2 (Control performance 2)
  - Tie flow and OTC violations
- Provide analytical tools that can be used to evaluate appropriate mitigation solutions

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Real-time Dispatch Simulation

- On a minute to minute basis, maintain balance between demand and supply
  - [Load + Scheduled Interchange – Wind Generation] ⟶ system demand & variability
  - [Energy Market Dispatch + Regulating Reserve] ⟶ system supply & control
  - Ignore frequency deviation and contingencies
- The simulation is intended to model a 'general' system operator behaviour and strategy
  - Looking ahead 20-minute
    - Current dispatch deviation (ACE)
    - Load change based on day-ahead hourly load forecast
    - Interchange schedule changes
    - Expected regulation range set-point
    - Wind forecast, the default is persistent or persistent ramping forecast
  - Threshold for control action (+/-20MW for AIES)
  - Time-delay of control action (1-10 Minutes, 5 minutes)
  - Ramp-limit of energy market dispatch (10MW/Min for on-peak, 5MW/Min for off-peak)
  - Ramp-limit of regulating reserve dispatch (10% of the range per minute)
  - Wind power ramp rate limiting (WRRL)

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Simulation Model Logic

Control decision every 20 minutes

Existing control deviation
- Current ACE
- Deviation from expected RR range set-point

Expected Load change
- Based on day-ahead forecast

Interchange Schedule change

Expected wind generation
- Persistent wind forecast (no change in next 20 minute)
- Persistent ramping
- Perfect hourly
- Perfect 20-minute

Control decision for next 20 minutes

control instruction validation
MW threshold, if within +/- 20MW, no instruction is made

1-minute simulation

Calculate the Energy market dispatch level for each minute
Energy market starts ramping after 1-10 Minutes (5 minutes is used as default)
Subject to ramping limit:
- 10MW/Min for on-peak
- 5MW/Min for off-peak

Calculate the mismatch after EMD
between the energy market dispatch and net demand
(Load + ScheduledInterchange – WindGeneration)

Calculate required regulating reserve dispatch level
To balance the mismatch, subject to:
- Available regulating reserves (up & down)
- Ramping limit (10%_of_range/Min)

Calculate the remaining mismatch after regulating reserve dispatch
(mismatch between [energy market dispatch + regulating reserve dispatch] and [Load + ScheduledInterchange – WindGeneration] as **ACE** and the simulated interchange

Other wind power forecast

Calculate related operation reliability index of simulation result
- CPS2
- OTC violation

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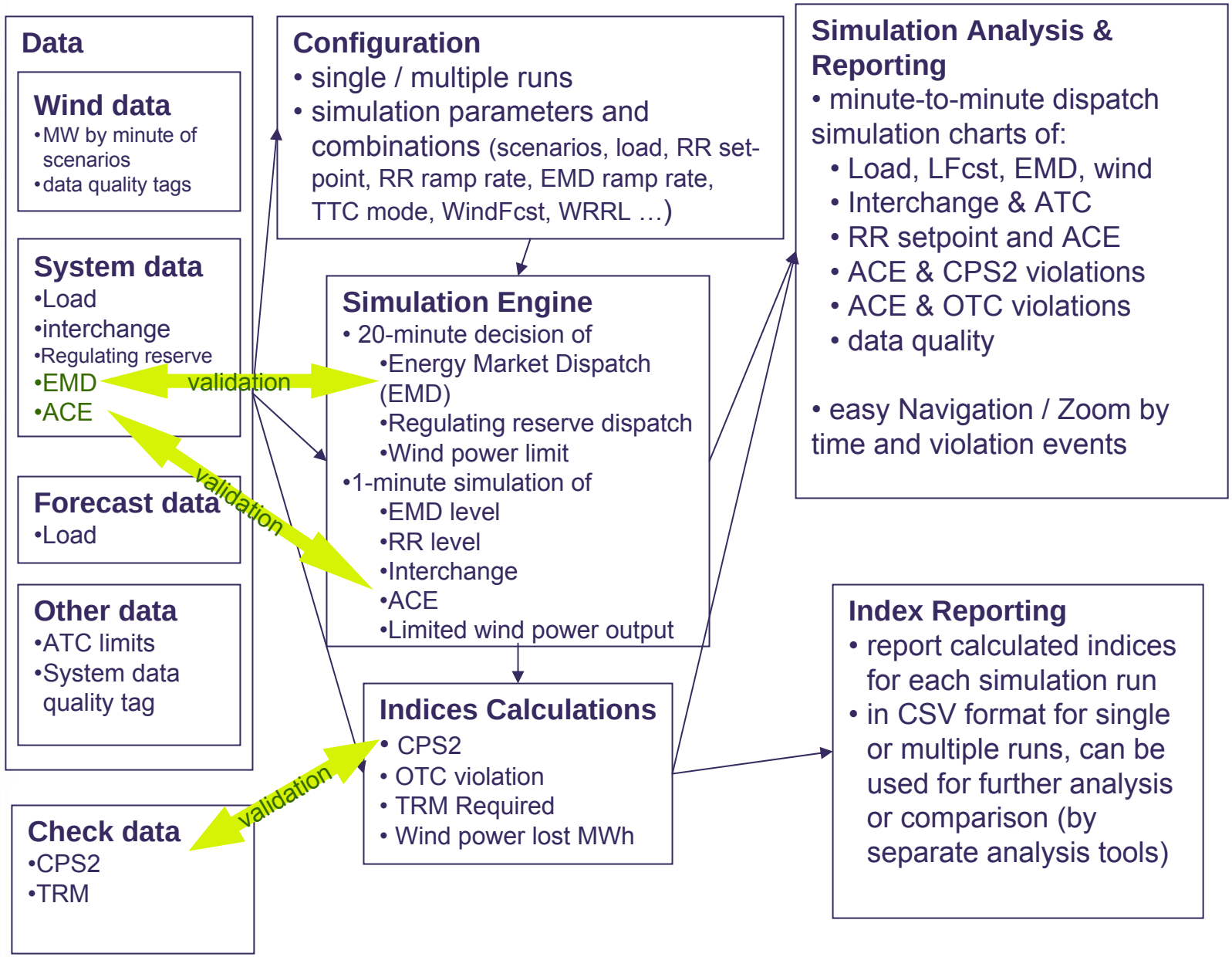
Model Architecture



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Data

- Wind data and system operation data are in CSV format
- ATC limits data and system data quality tags is in excel format
- Load forecast data is directly from market system database (ODBC)
- Different wind forecasts are currently calculated inside model and is not modeled as input data. It may have to be modeled as input data if the forecast is fed by third-party.
- All data is read in memory as MatLab arrays
- Different data inputs are combined and synchronized by timestamp

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Configuration

- Due to the limitation of MatLab, the model is currently designed to handle only one scenario of data in a single run, The multiple simulation configuration mechanism is built to efficiently handle the multiple simulation runs for different model parameters and their combinations

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Simulation Engine

- All algorithms are 20-minute based
  - Regulating Reserve biasing decision
  - Wind forecast
  - Wind power limit decision, there is an iteration between the wind forecast and the WRRL decision
- As we believe Montana (NWE) uses 1 hour as the decision interval, it is likely that they have to go through some of the detailed algorithms and make corresponding changes to make sure the model works at other time intervals. This may be necessary, as a shorter time interval for decision making could be a mitigating solution.

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Index Calculation

- Must account for bad data
- Due to the large volume of data, algorithms need to be developed to handle bad data efficiently

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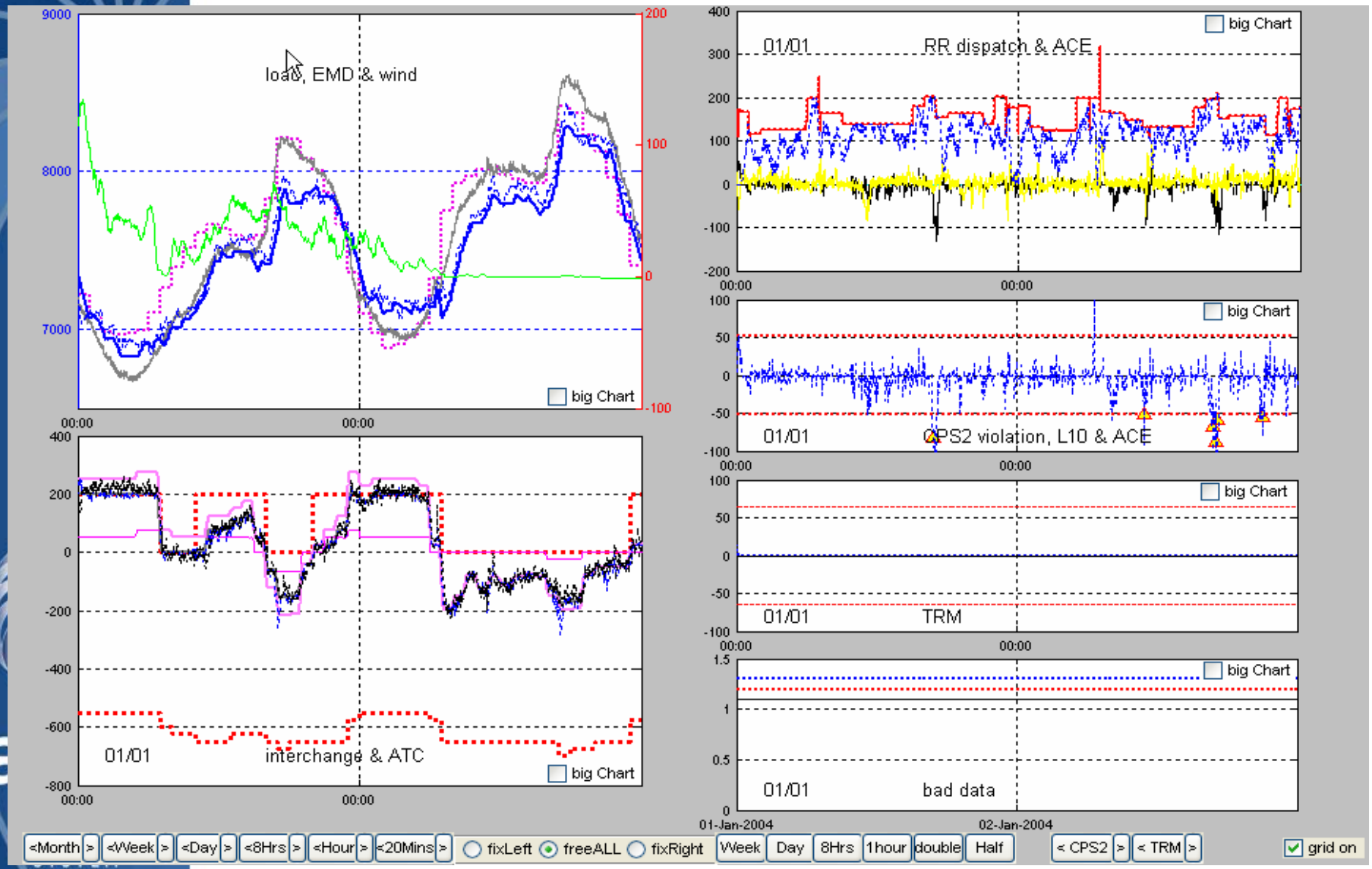
Example of Simulation Checking & Reporting



Index Reporting

- Relatively straightforward
- Designed to efficiently report simulated index results of multiple simulation runs in a consistent way
- Designed to report simulated index results in a structured format so that further analysis can be efficiently performed

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More information is available at:
http://www.aeso.ca/gridoperations/286.html