Ancillary Services Adequacy Study

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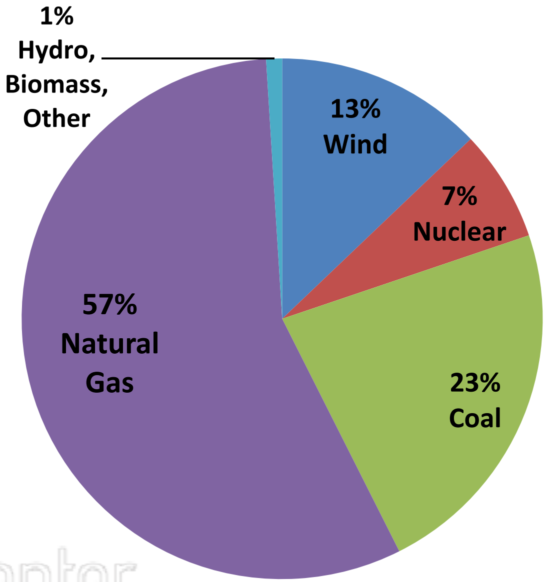
Overview of ERCOT generation mix

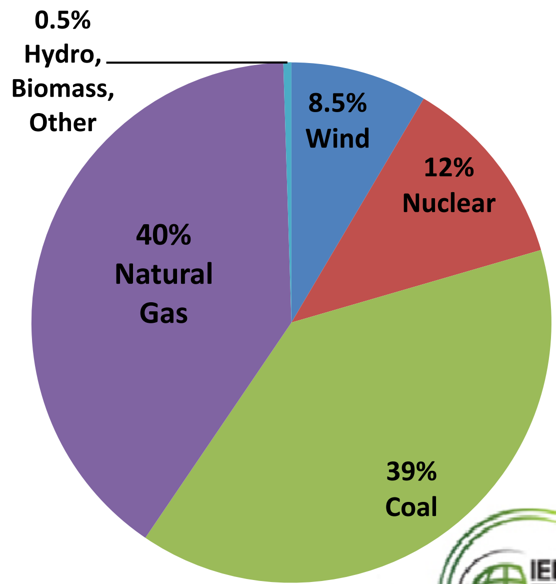
Wind Generation in the ERCOT Market

- 2011 Total ERCOT Generating Capacity: ~84,000 MW
- 2011 Installed Wind Power Capacity: 13%
- 2011 Wind Energy Produced: 8.5%
- More wind and solar capacity is probable in the future

2011 Installed Capacity*



2011 Energy Produced*



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Considerations for variable resources

- Production forecast error
- Production variability

This issues may result in:

- Frequency excursions
- High Area Control Error (ACE), or frequency deviation (in case of ERCOT system)

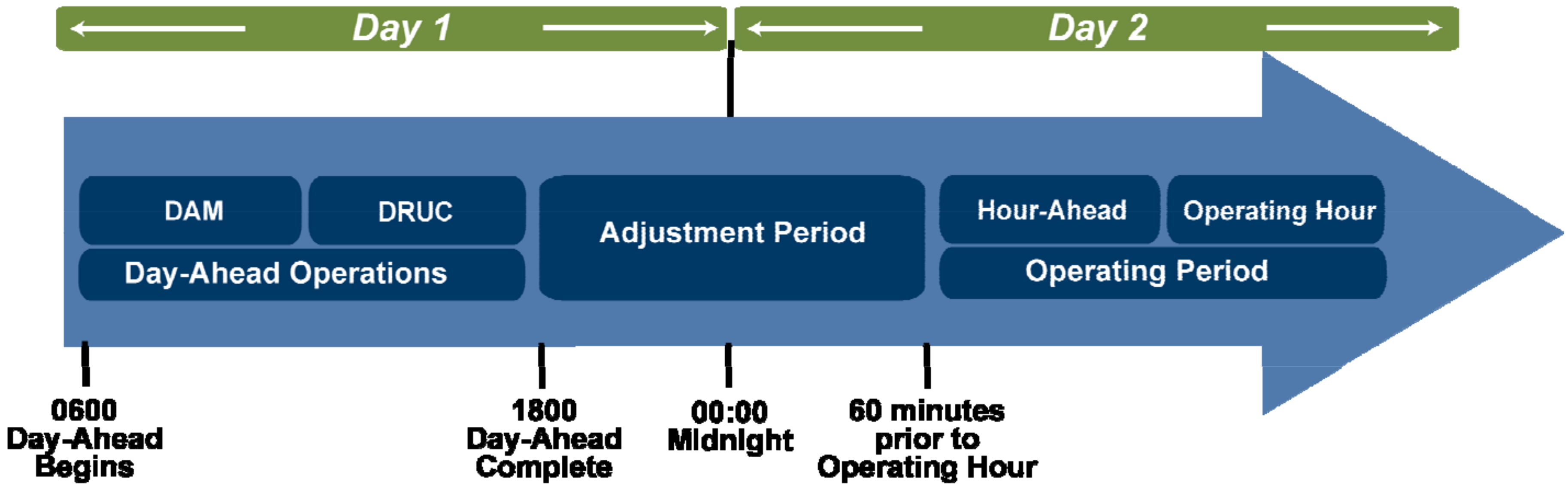
$$ACE = (I_A - I_S) - 10B\,(F_A - F_S) - I_{ME}$$

Previous Integration Studies

Usually wind integration studies:

- Consider one time resolution (e.g. hourly)and neglect variability within each time step;
- Assume perfect forecast of variable resource or only one forecasting activity per day (e.g. day-ahead forecast);
- Neglect intra-day and intra-hour commitment and scheduling activities based upon system changes;
- Are “off-line” analysis of renewable resource variability (e.g. at minute-minute resolution) without consideration of impacts of variability on the system;
- Neglect second-to-second balancing horizons.

ERCOT Electricity Market



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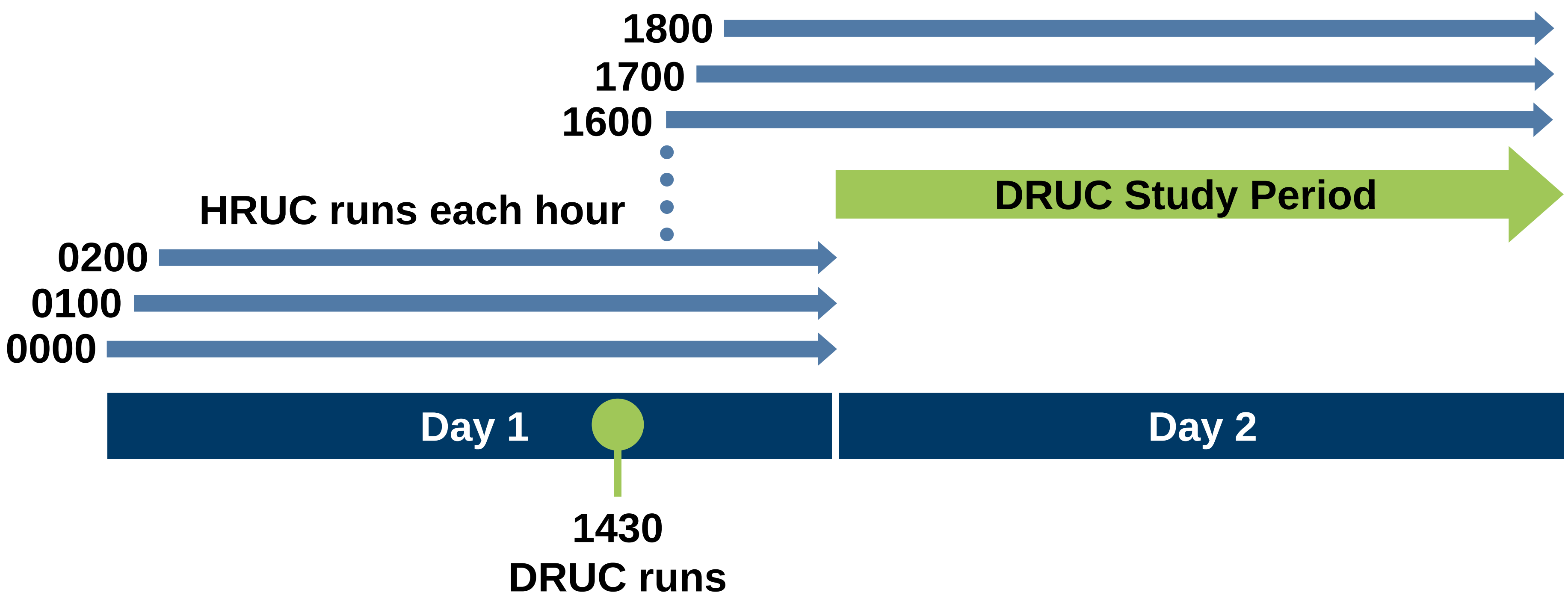
DRUC and HRUC



Real Time Operation

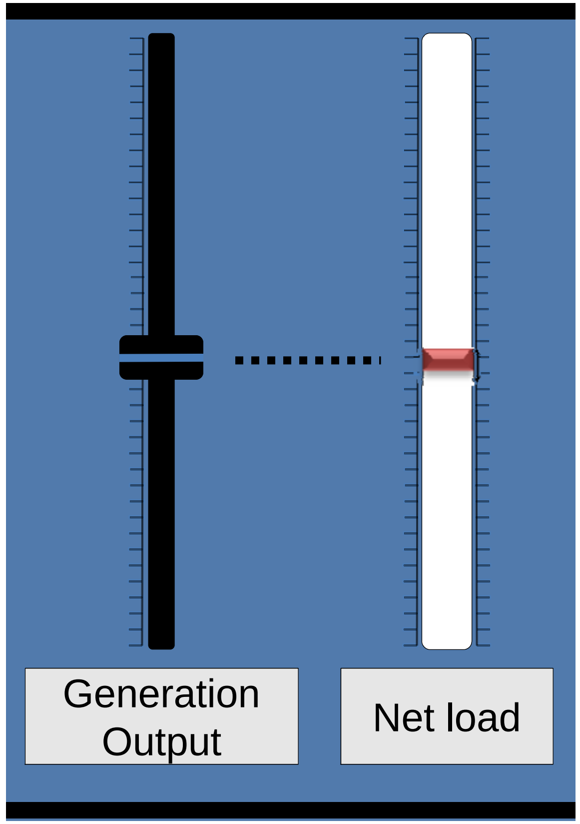
- Security constrained economic dispatch (SCED), runs at least 5 minutes in operating hour;
- Evaluates transmission constraints and submitted energy offers to determine least cost dispatch solution;
- Goal: Meet intra-hourly variations in load/wind. Minimize use of regulation service
- Telemetered output and resource limits are used as input data to SCED

Slide 7

g1 Do we minimize? or co-optimize? I think the intent is to preserve availability of the service, rather than minimize the use of it.
gthurnher, 9/18/2012

System balancing (within 5 mins)

To balance variability of load and renewable generation and compensate for generation outages Ancillary Services are procured through day-ahead and current day markets and deployed in real time



<u>Three types of reserves, ERCOT</u>

- Regulation up and down (4 second service, AGC)
- Responsive reserve, disturbance reserve (governor response, automatic load disconnection)
- Non-spin (30 minute service)

Goal of ERCOT's AS study

The Department of Energy has provided ERCOT with funding to improve tools and processes used in Long Term Transmission System Planning as well as to increase planning horizon up to 20 years ahead. As a part of the DOE project, ERCOT :

- Studies future scenarios of renewable and conventional generation mix,
- Assesses the ability of the ERCOT market and system to manage inherent variability and uncertainty in renewables at multiple timescales
- Using a tool(s) that integrate ERCOT's multiple scheduling sub-models:
  - DRUC
  - HRUC

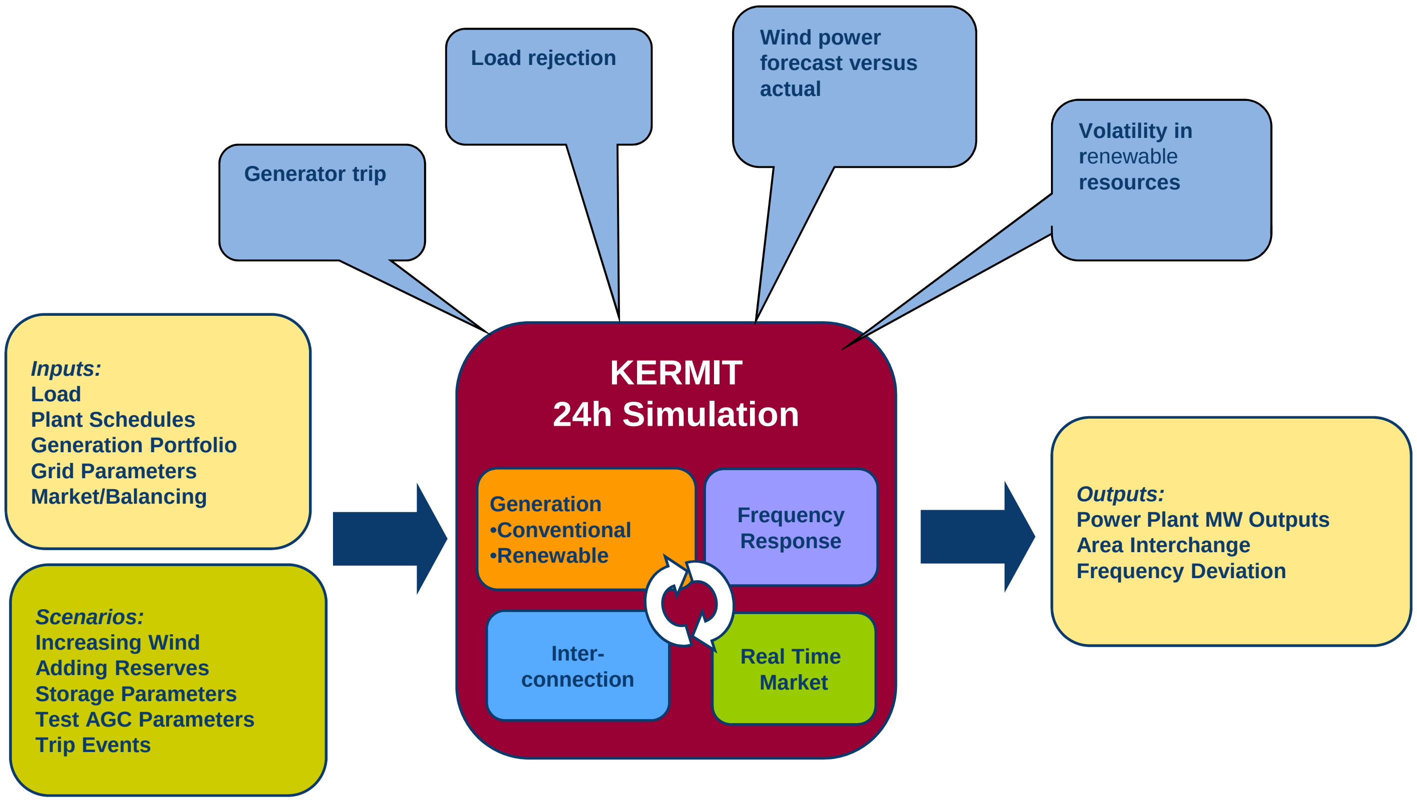
  } Production cost simulation tools (PROMOD, Plexos, UPLAN)

  - SCED
  - AGC

  } KEMA's Renewable Integration Tool (KERMIT) or NREL's FESTIV
- with multiple time resolutions, relevant to ERCOT:
  - hours
  - 5 minutes
  - seconds

Overview of KERMIT Architecture

- KEMA's Renewable Market Integration Tool
- Developed by DNV KEMA

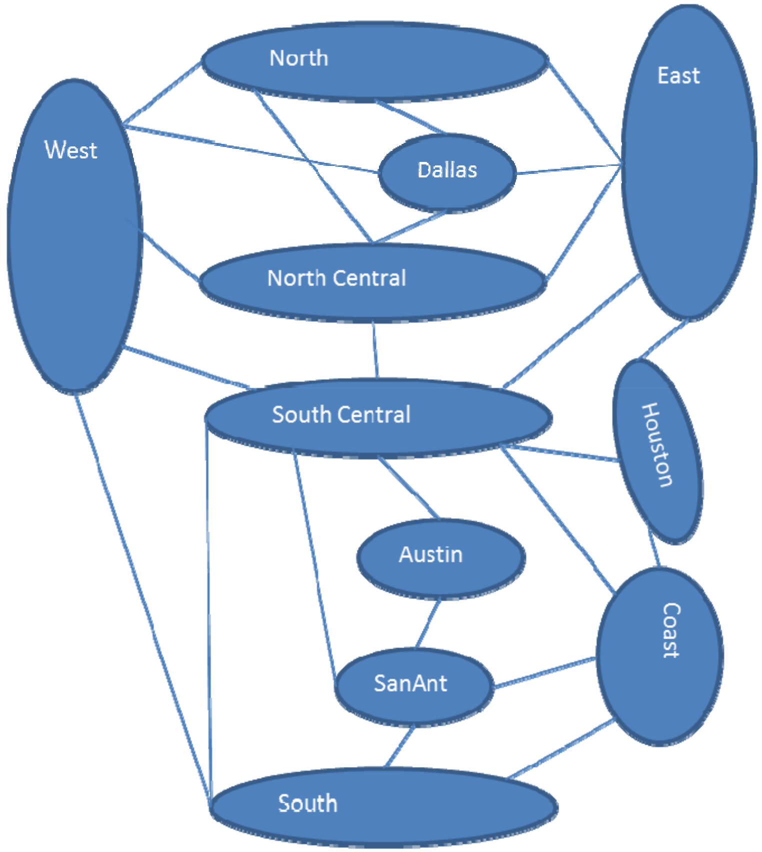


Key Features of KERMIT, general

- Detailed IEEE standard dynamic models of a variety of generation types;
- Representation of generator governors and generator controls for primary frequency response and response to dispatch/regulation controls;
- Representation of the dynamic frequency response of system load and second by second load and variable energy resource volatility;
- No reliability unit commitment (DRUC and HRUC). Commitments from production cost simulations (e.g. in PROMOD, Plexos, UPLAN) can be used as input to KERMIT;
- Model of real-time dispatch (e.g. SCED) and AGC systems;
- Model of various types of storage;

Features specific to ERCOT's AS study

- Demand Response (DR) model: price responsive or frequency responsive; with probabilistic adjustment to randomly vary a level of re
- Simplified ERCOT network representation ("Pipe and bubble" model)
- Calibration of the existing ERCOT system model (generation fleet, SCED, frequency control, etc.) to the historical operation data (2011) before simulation of future scenarios;



Benefits for ERCOT's AS study

The primary benefits of KERMIT for ERCOT's AS study include the ability to:

- examine and verify adequate ancillary service performance and ability of the future generation fleet with high share of renewables to meet applicable reliability metrics (e.g. Control Performance Standard (CPS1) and Disturbance Control Standard (DCS));
- ensure that future resource portfolios will provide sufficient flexibility for ERCOT's system dispatch and operations, considering uncertainty and variability of renewable resources.
- test future scenarios with alternative ERCOT market products such as DR, storage, etc. and their effect on the system's ancillary service requirements;

ERCOT is also evaluating other applications for the KERMIT platform