Wind Integration

Presentation to Stakeholders

June 6, 2007

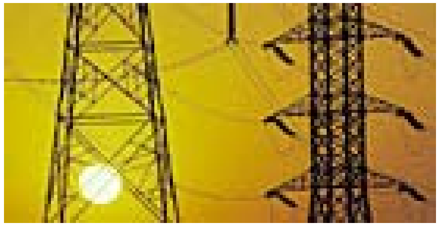
Sol Friedman

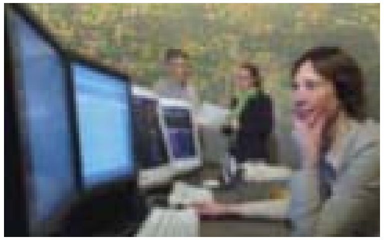
What does wind integration mean ?

“Wind Integration” means different things to different people involved in utility operations and planning.

To a:

- Transmission engineer - it is primarily about ensuring that the transmission infrastructure is able to transfer the wind energy output to the loads
- Control area operator - it is primarily about maintaining the load-resource balance, net of any additional system variability created by wind generation
- Power system dispatcher - wind variability adds uncertainty about how much generation will available to serve load during time periods ranging from the next hour to the next day and beyond
- Power system planner – key areas of interest are in how much energy will be provided to the system during different times of the year, as well as capacity values for planning reserve purposes

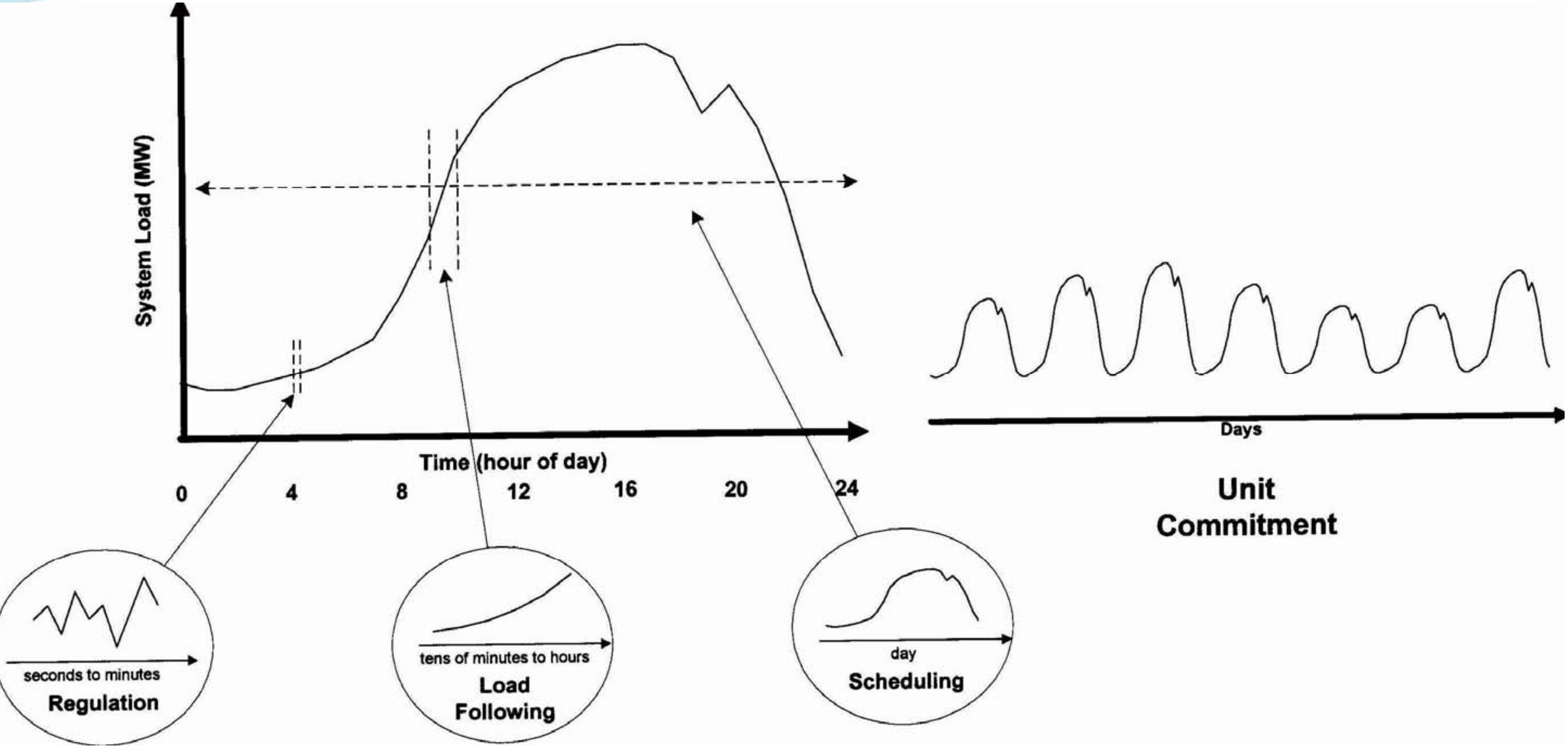




Key Questions Relating to the Integration of Wind Energy

- What are the transmission system requirements to integrate wind resources?
- What capability does the power system have to integrate intermittent wind resources from a system operations perspective ?
- How does wind energy impact the system flexibility to supply load and undertake trade ?
- What are the associated costs of integrating wind energy ?
- What forecasting standards and equipment and what wind farm design methods can be used to reduce the integration impacts / costs ?

Time Scales of Interest



Source: UWIG

Time Scales of Interest

Regulation
- Seconds to 10 minutes
- Similar to variations in load
- AGC and LVRT capability are used to keep the system frequency and tie line flows within desired levels

Load following
- Tens of minutes to a few hours
- Load follows predictable patterns, wind less so
- Hour ahead forecasting and plant active power management are used

Scheduling and unit commitment
- Hours to several days
- Aims to optimize the mix of generating units to supply the hour-by-hour forecasted load at minimum cost (additional reserve units are also optimally scheduled)
- Good day-ahead and multi-day forecasting is key

Resource and capacity planning
- Time frame of one or more years
- Based on a reliability metric such as ELCC (Effective Load Carrying Capability)

"System flexibility" refers to the power system's ability to provide regulation, load-following and energy storage services

The Different Time Frames

"Ultimately, wind energy, with its variability characteristics, must be integrated into all phases of system operation, from the sub-second level of voltage stability to within-hour control area operations, to hour-ahead and day-ahead unit commit - ment and finally to the process of long-term planning"

(Source: BPA)

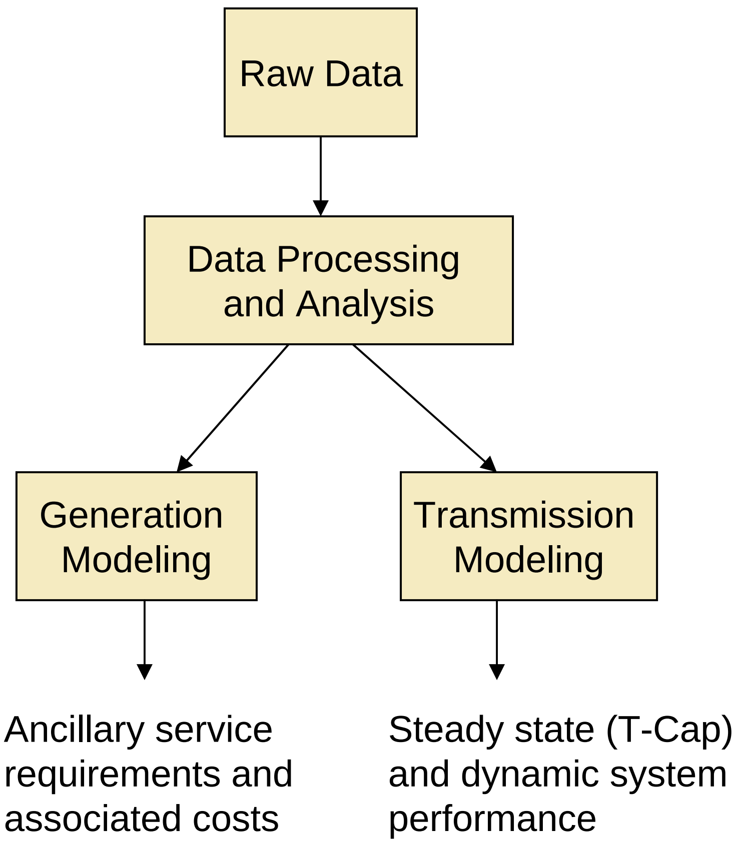
Basic Components of a Wind Integration Study

Wind and Load Data is collected

Data is processed

Different models are used depending on the focus of the study

The outputs generated will depend on the focus of the study



Results of Wind Integration Analyses done by other Jurisdictions

Study	Year finished	Duration of Study (months)	Wind Penetration (%)	Regulation Cost ($/MWh)	Load Following Cost ($/MWh)	Unit Commitment Cost ($/MWh)	Total Cost ($/MWh)
Xcel-Mn	2004	12	15	0.23	0	4.37	4.60
Minnesota	2006	15	15				3.00
			20		0.11		4.11
			25				4.50
Idaho	2007	12	20				11.72
Xcel – PSCo	2006	18	10	0.20		2.26	3.72
			15	0.20		3.32	4.97
			20	0.20		6.57	8.87
Manitoba Hydro	2006	18	6.25				4 - 6
			12.5				5 - 7
			18.75				6 - 8
			25				6 - 10

Learnings from Wind Integration Analyses performed in other Jurisidictions

- Accurate, validated data is crucial to wind integration analysis
- Accurate forecasting is key to wind power absorption, reduced ancillary costs and system operations
- Wind farm requirements to meet grid codes, forecasting, and power management requirements should be specified in advance
- Lack or cost of transmission availability has been a barrier to wind farm development
- There are wind integration costs, and typically the higher the wind power penetration levels*, the higher the cost. Other cost influencers include:
  - Forecasting accuracy
  - Size of the control area
  - Geographic diversity of wind sites
  - Amount of flexibility available to the power system
  - Access to robust markets for control area services, storage & shaping products

* usually expressed as a percentage of peak load

Drivers for BC Wind Integration Project

- 2006 Open Call for Power : Contracts awarded for 325 MW of wind energy
- 2007 BCTC Generator Interconnection Queue : 700 MW of wind power
- Recent public announcements from companies planning to bid hundreds of MW of wind power into future Calls
- PG&E Application : In August 2006, an application was filed with the CPUC requesting rate recovery authorization up to $14 million for studying the feasibility of obtaining power generated from renewable sources in BC
- The provincial government's 2007 Energy Plan, with its focus on climate change
- Lack of operational experience as no utility scale wind projects are in service yet in BC

What BC Hydro / BCTC have done

- BC Hydro ran a wind monitoring program from 2000 to 2003
- Elsam Engineering compiled a report for BCTC & IPPBC (2004)
- BC Hydro organized a wind workshop in January 2005
- ABB compiled two high-level reports for BCTC (2005)
- Garrad Hassan compiled two reports for BC Hydro (2005)
- Powerex are part of the Northwest Wind Integration Action Plan
- BC Hydro met with BCTC in February 2005 and agreed that wind integration needs to have further study
- Project teams have been formed and a high level work plan developed

BC Hydro Wind Integration Project - Task Assignments

Task	Objective
1) Data	To determine the data needs and source this data
2) Forecasting	To determine the appropriate methodologies, tools, standards and responsibilities for new wind farms
3) System & Generation Operations	To determine the operations impacts and associated costs of wind variability and methods to reduce these
4) Transmission	To determine transmission expansion planning criteria to deliver wind power efficiently, reliably and cost effectively from production to load

Data for Wind Integration Study

Data Sources/ Model Inputs

- Satellite
- Doppler Sodar
- Doppler Lidar
- Global weather data
- Regional weather data
- High resolution surface data
- Wind farms (SCADA)
- Met. towers
- Load data
- Power curves

Data Processing/ Validation

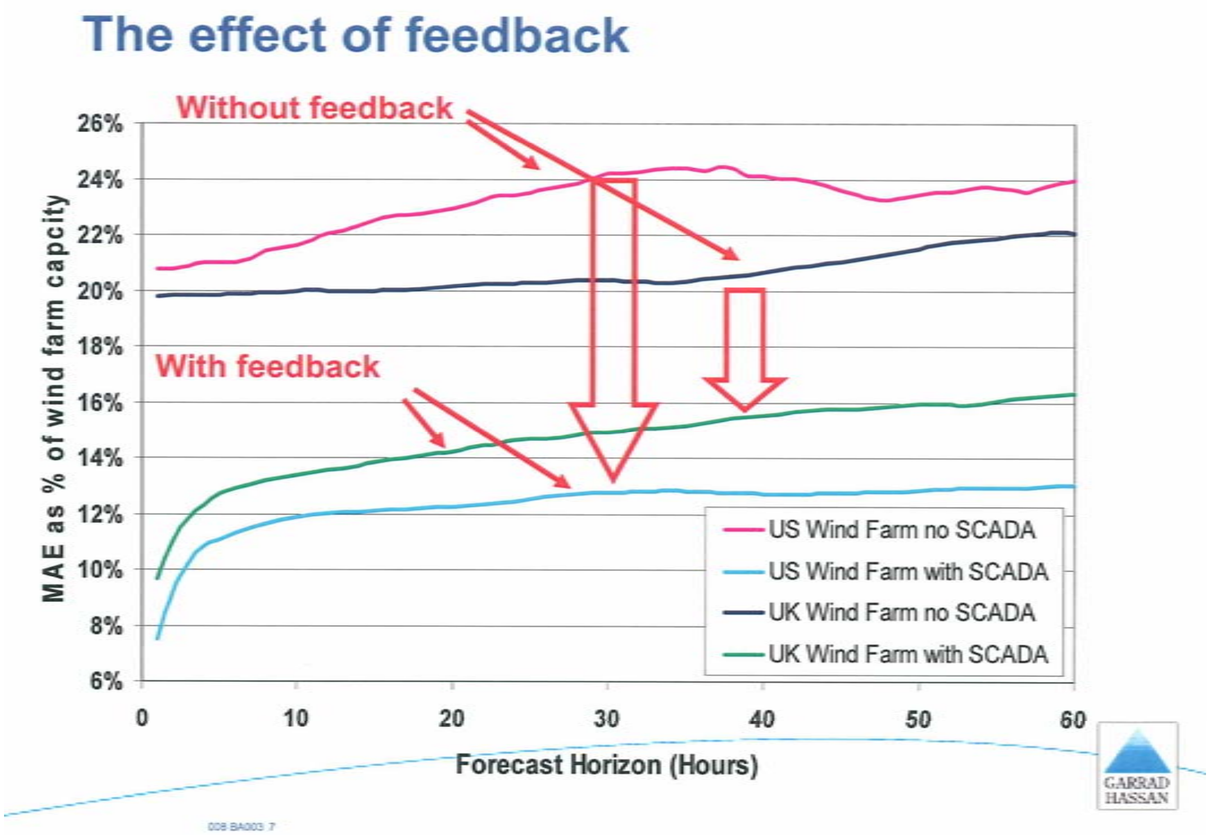
Processing and Validation

Data Outputs/ Uses

- Capacity calculations
- Reliability studies
- Transmission system planning and stability studies
- System integration studies
- Forecasting

Benefit of SCADA in Wind Power Forecasting

The diagram below and the three following slides come from presentations at the CanWEA / AWEA Seminar on wind integration and forecasting held in Calgary in April 2007



MAE = Mean Absolute Error

From the UWIG presentation

How Do You Deal with the Uncertain Nature of the Wind ?

> Wind forecasting provides the answer

> Wind plant output can be forecast within some margin of error, and forecasts are getting better

	Currently	5-10 Years
Hour Ahead	4-6%	3-5%
Day Ahead	15-20%	10-15%

From the AWEA Presentation

> Wind Forecasting in the Operational Environment

- Referenced or made as a recommendation in almost every Wind Integration Study to date
- Benefits are significant (NYISO Study: <u>$125 million benefit annually</u> to adopting wind forecasting)

> AWEA is committed to supporting Wind Forecasting adopted into the Control Room

- By ISOs and RTOs
- By individual utilities

From AWS Truewind's Presentation

> State-of-the-art site-specific wind forecasts are made with a combination of physics-based and statistical models

> Forecast ensembles (sets of forecasts) are used to estimate and compensate for uncertainty (data and model) in a forecast system

> Nature of forecast problem and the solution depends on the forecast time horizon (look-ahead time period)

> In general, quantity and quality of data limits forecast accuracy more than accuracy of forecast models

> New remote sensing technology will supply better data in the future --> improved forecasts will result.

BC Hydro Project Two-Phase Process

Short Term:

A jurisdictional review and high level study is being used to inform the following:

- 2007 NITS (Network Integrated Transmission Service) application
- 2007 Call
- 2008 LTAP (Long Term Acquisition Plan)

Longer Term:

In the longer-term, a detailed wind integration study will address or inform:

- Ability to absorb large volumes of wind energy into the system
- System upgrade requirements to accommodate additional wind
- Benefits of geographic diversity
- Benefits of integrating wind operations into the WECC region
- Potential impacts of other jurisdictions acquiring BC wind resources

Next Steps

- BC Hydro and BCTC will continue with work on Phases 1 and 2 of the wind integration analysis
- Stakeholders will be involved and play a key role
- We want to spend the time required to get the scope of the wind integration study correct