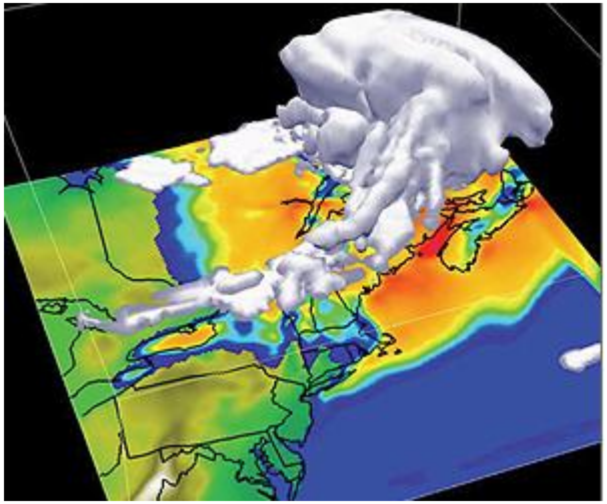
Power System Seminar Presentation
Wind Forecasting and Dispatch
7th July, 2011

Wind Power Forecasting tools and methodologies

Amanda Kelly
Principal Engineer
Power System Operational Planning
Operations
EirGrid

Contents

- The Eirgrid Journey
- Present System and Applications
- Service received from suppliers
- Supplier Forecast Modelling
- Future / Research



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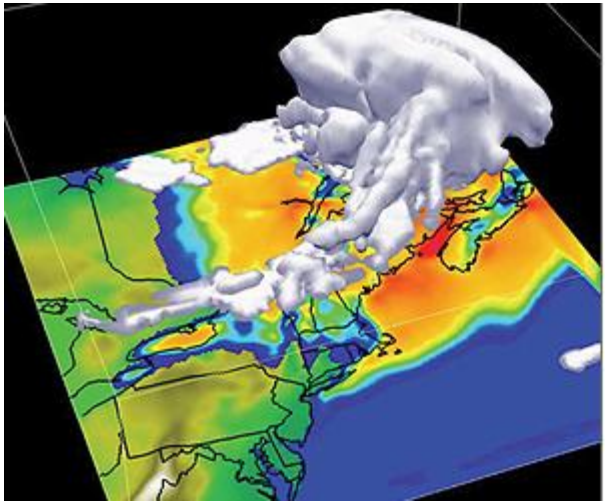


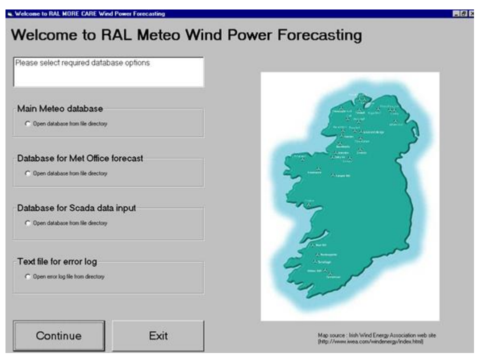
The EirGrid Journey

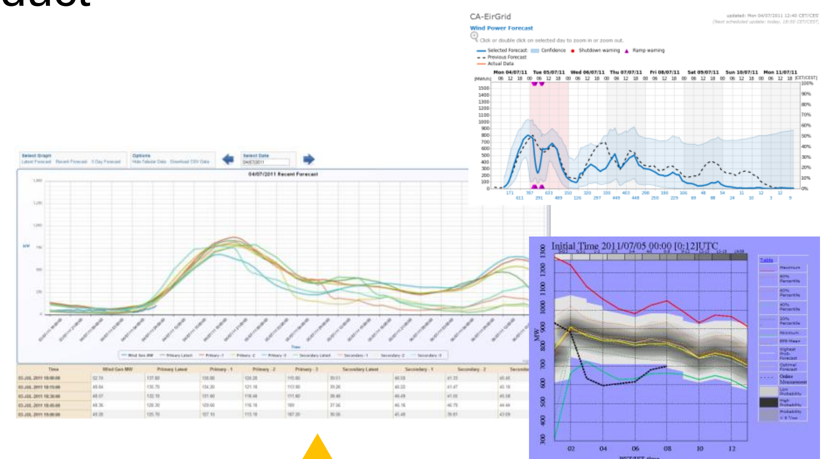
2000	Pilot project Danish university and UCC research project
2001	Developed first Irish system Model operates in Denmark
2002	UK research project, developed first forecast tool for NCC
2006	Tool upgrade GPW + research product
2010	Tool upgrade, Tender with SONI

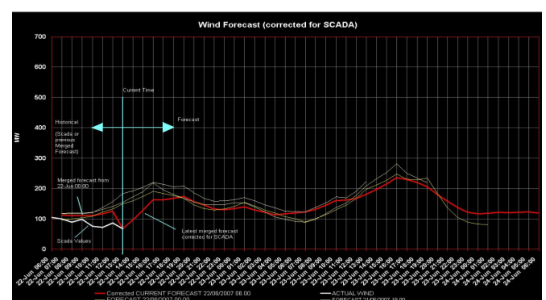
Prognosis ID: HIRLAM/Met Eirann

TOTAL PRODUCTION:

Time	Prod	Error	Runtime
02081400	10750	9908	2002081400
02081401	14791	9908	2002081400
02081402	23196	9908	2002081400
02081403	36551	9908	2002081400
02081404	41013	9908	2002081400
02081405	49992	9908	2002081400
02081406	67061	9908	2002081400
02081407	65305	9908	2002081400
02081408	68346	9908	2002081400
02081409	70409	9908	2002081400
02081410	76594	9908	2002081400
02081411	83046	9908	2002081400
02081412	88556	9908	2002081400
02081413	96409	9908	2002081400







GPW : Grid Predict wind
SONI: System operator Northern Ireland
UCC: University College Cork

The EirGrid Journey – during 2010

Transfer of expertise from EirGrid to Service provider core competencies in weather prediction modelling and wind power forecasting

Reasons:

- Development with range of commercial tools now available
- Expertise in Wind Power Forecasting

EirGrid focus

- Performance Incentive Scheme on Forecast accuracy

(% total contract price)

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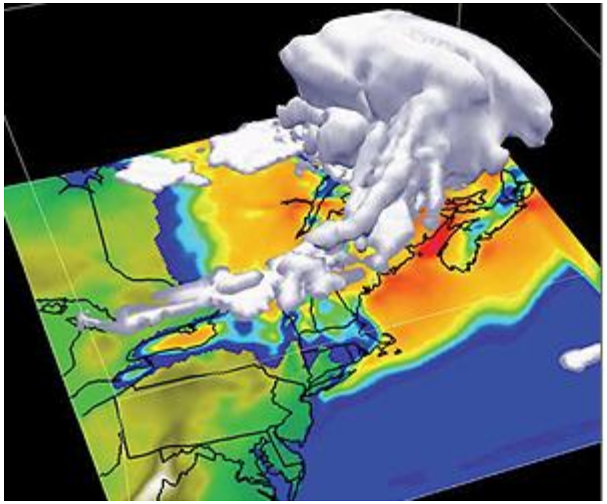
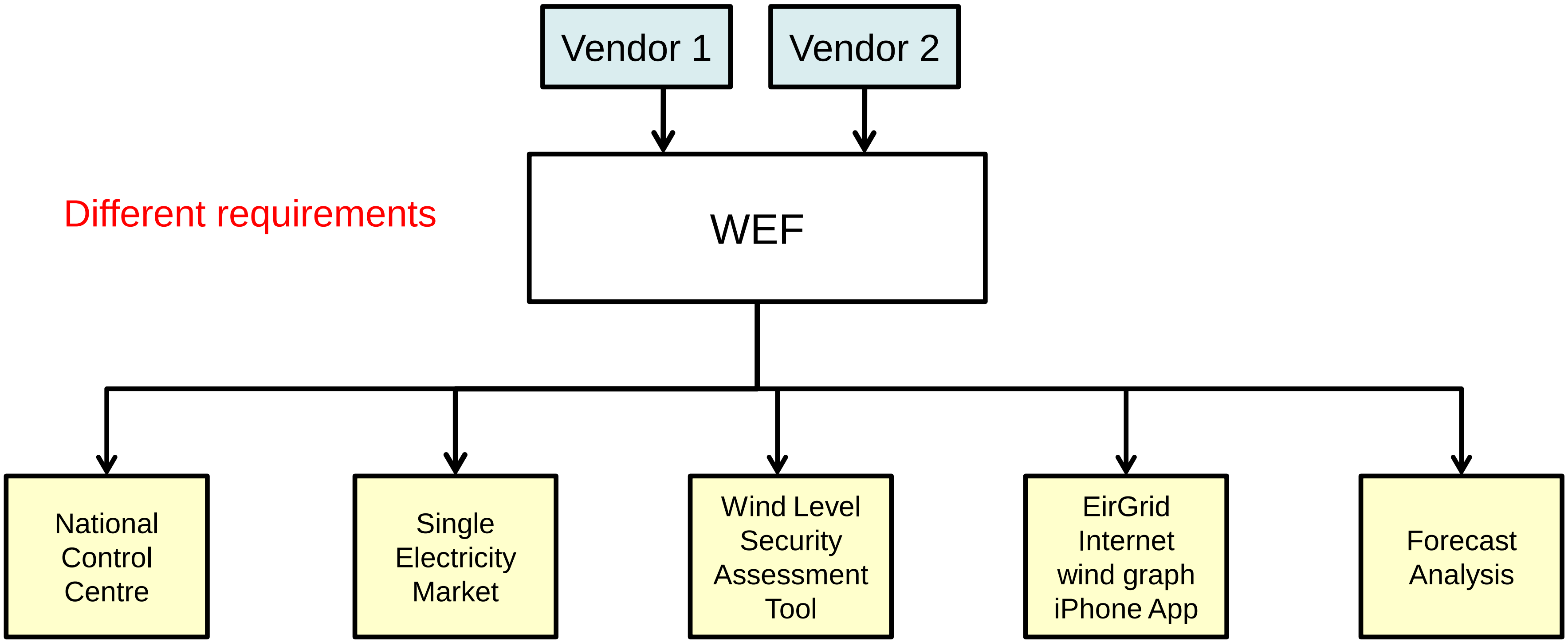
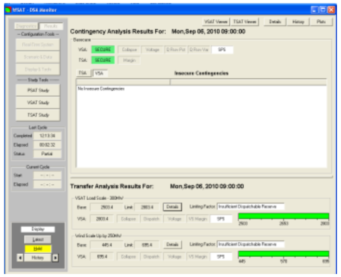
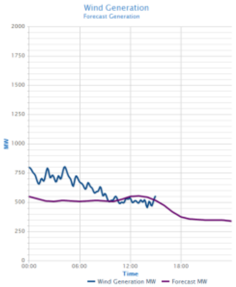


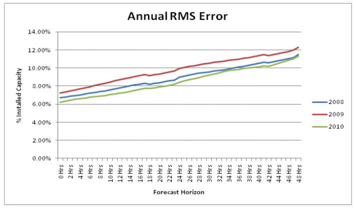
Present System and Applications

Different requirements









WEF : Wind Energy Forecast

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- The Eirgrid Journey
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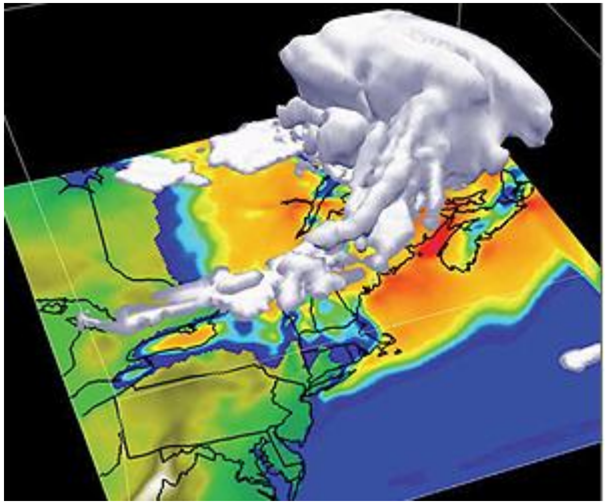


Service received from suppliers – What do we acquired from our service providers

1. <u>Long term forecasting</u>
   - Unit level wind power forecast
   - 15 minutes resolution, 5 days ahead
   - Updates 4 times daily
   - Irish DST correction
   - GUI
     - High speed shutdown
     - Ramp warnings
     - Icing warnings
     - Confidence band
   - Forecast training (metered data)

2. <u>Short term forecasting</u>
   - Updates every 15 minutes, 12 hours ahead
   - Real time SCADA correction from EMS

DST: Daylight saving Time
GUI: Graphical user interface

Service received from suppliers – Our time horizons

Market :

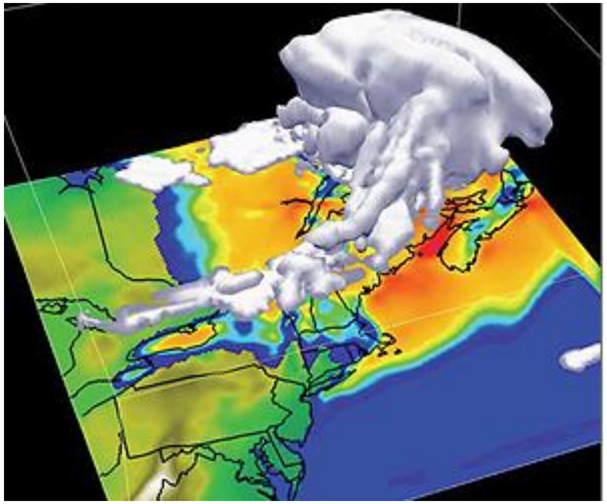
- SEM - 10 am, Day ahead forecast
  - Unit level forecast
  - Ex-Ante run (D-1) at 10am
  - Ex-post “perfect hindsight” settled with metered generation

Operation:

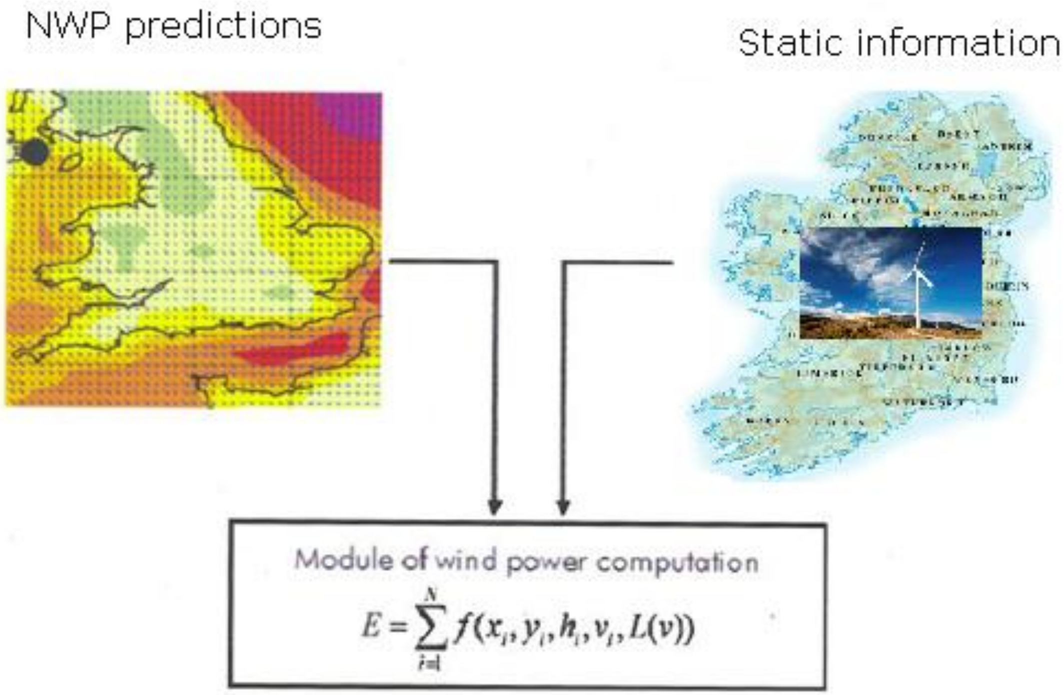
- RCUC run - day ahead from 6am to 2 days ahead 12pm
  - Aggregated total
  - In day
  - Day ahead
- NCC – Anytime (night valley), scheduling day ahead 14 – 48 hours
  - Aggregated total
  - Real time

RCUC: Reserve constrain unit commitment

Contents



Supplier Forecast modelling



Multi – scheme weather ensemble prediction system.

- Multiple numerical predictions are conducted using slightly different initial conditions that are all plausible given the past and current set of observations, or measurements

OPTIMAL FORECAST

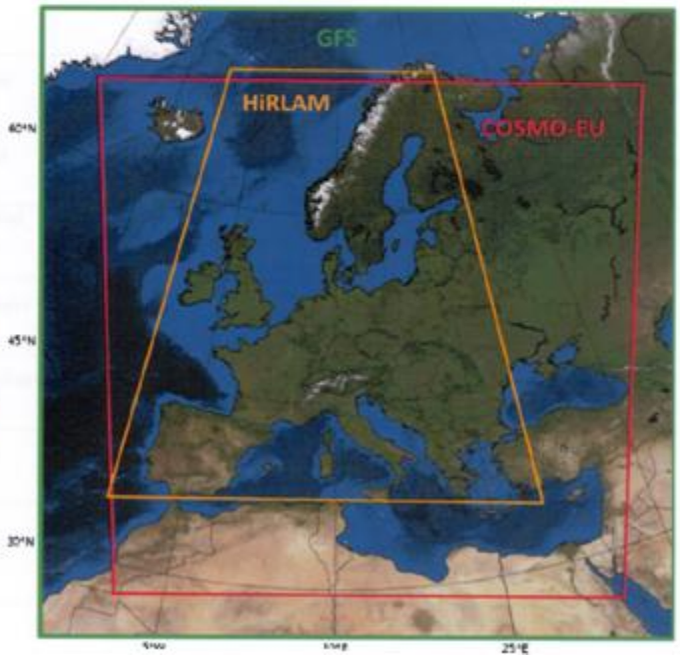
NWP: Numerical Weather Prediction

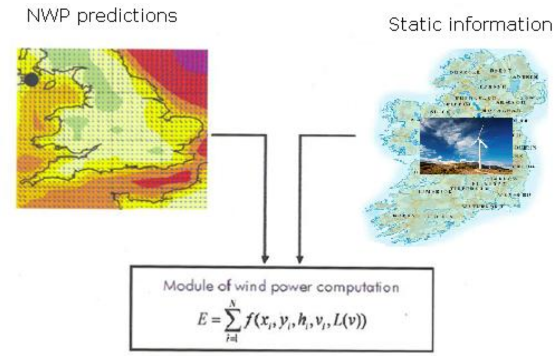
Supplier Forecast modelling – Underlying Numerical Weather model

GFS:
Global model

HiRLAM:
Driven by global model ECMWF

COSMO-EU:
Driven by global model GME

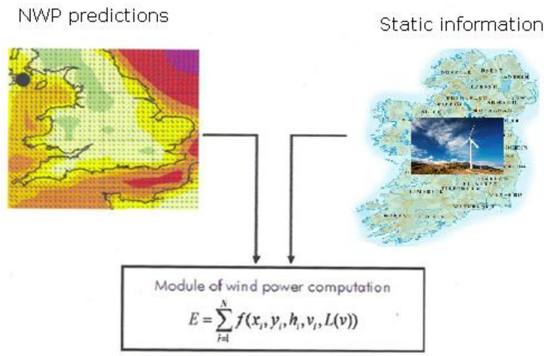




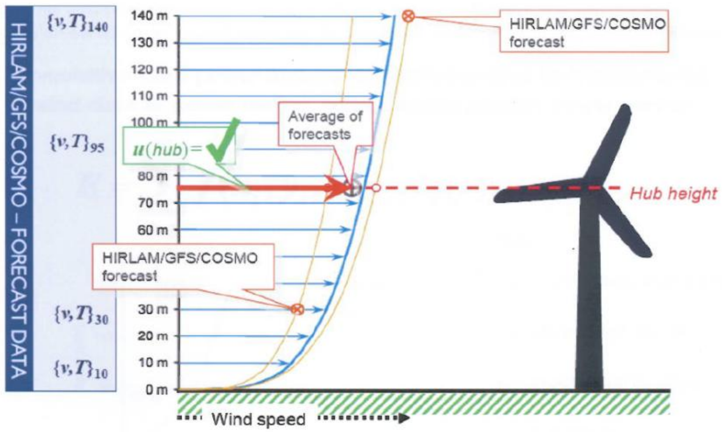
	GFS	HiRLAM	COSMO-EU
Starting time	00, 06, 12, 18 UTC	00, 06, 12, 18 UTC	00, 06, 12, 18 UTC
Published at	04:40, 10:40, 16:40 & 22:40 UTC	03:20, 09:20, 15:20 & 21:20 UTC	04:30, 09:45, 16:30, 21:45 UTC
Horizontal grid resolution	1°	0.1°	0.0625°
Forecast horizon	180 h	48 h	78 h
Forecast resolution	Up to 15 min	Up to 15 min	Up to 15 min
Grid points	64.800	145.000	436.905
Available forecast data	Wind speed, direction & temperature in10 and 30 m	Wind speed, direction & temperature in10, 30 and 95 m	Wind speed & direction in 10, 34, 68, 115 m; Temperature in 2, 34, 68, 115 m

Wind farm static information for forecasting

- Wind farm ID
- Turbine information
  - Type
  - Manufacturer
  - Size
  - Model
  - Hub Height
- Installed capacity
- Maximum Export Capacity
- Nearest connecting stations
- Grid co ordinates
- Effective date



More accurate information = Better forecast



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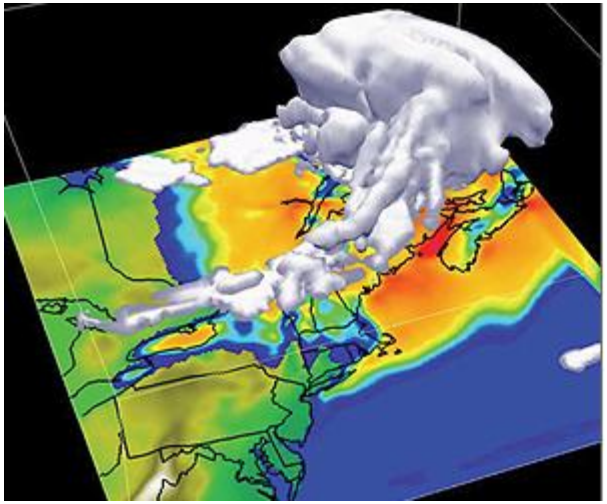


Future / Research –
European Research Projects

EIRGRID

WIND POWER FORECASTING ANEMOS

Development of A NExt generation wind resource forecasting systeM

for the large-scale integration of Onshore and offShore wind farms

Resarch project supported by the European Commission under the 5th framework Program

SafeWind

The aim of SafeWind is to substantially improve wind power predictability in these challenging or extreme situations. Going beyond this, wind predictability is considered as a system parameter linked to the resource assessment phase, where the aim is to take optimal decisions for the installation of a new wind farm.

ANEMOS.plus

ANEMOS.PLUS

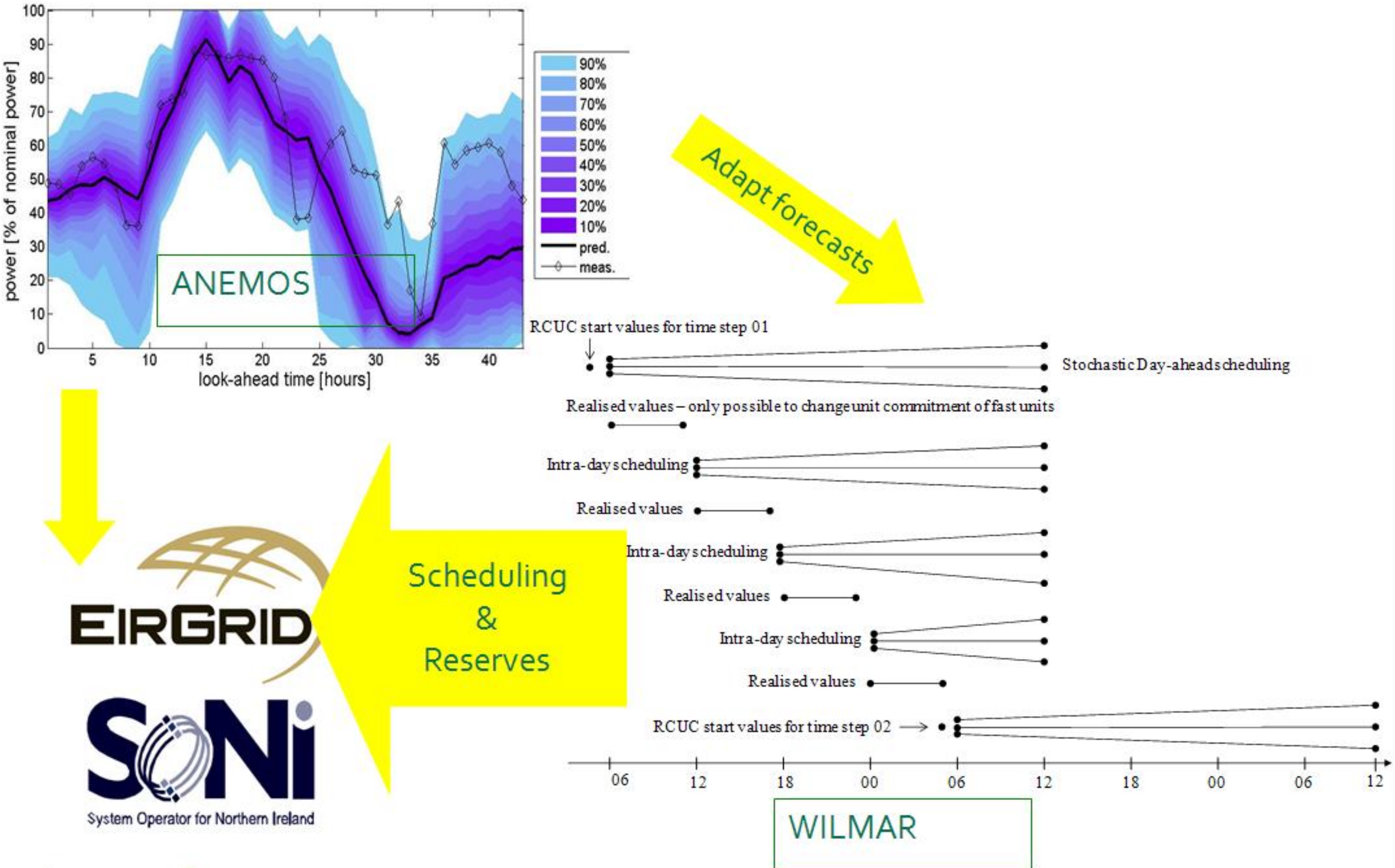
Project no.: 038692
Advanced Tools for the Management of Electricity Grids with Large-Scale Wind Generation

STReP
Thematic Priority: Priority 6.1 "Sustainable Energy Systems"

Start date of project: 01-01-2008

Duration: 42 Months

Concept



power [% of nominal power]
look-ahead time [hours]
90%
80%
70%
60%
50%
40%
30%
20%
10%
pred.
meas.
ANEMOS
Adapt forecasts
RCUC start values for time step 01
Stochastic Day-ahead scheduling
Realised values – only possible to change unit commitment of fast units
Intra-day scheduling
Realised values
Intra-day scheduling
Realised values
Intra-day scheduling
Realised values
RCUC start values for time step 02
06 12 18 00 06 12 18 00 06 12
WILMAR
Scheduling
&
Reserves
EIRGRID
SONI
System Operator for Northern Ireland

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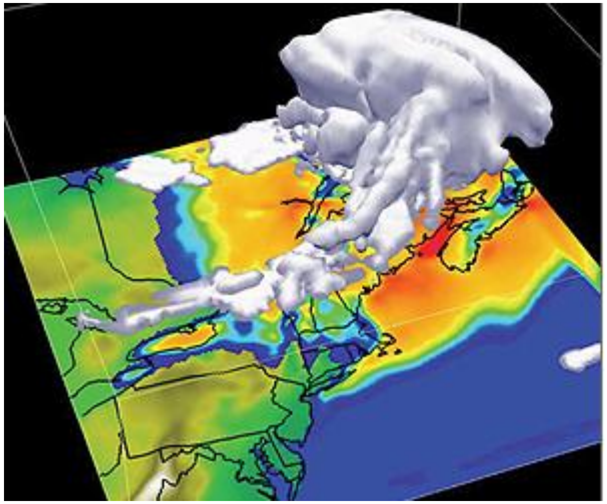
Accuracy of Wind Forecasts

Michael Coone
Power System Operational Planning
Operations
EirGrid

Contents

- Benchmarking
- Wind Forecast Inaccuracies
- Error Types
- Improvement Initiatives



Wind Forecast Analysis - Benchmarking

- Mean Absolute Error – M.A.E

$$\frac{1}{n}\sum_{j=1}^{n}|y_j - \hat{y}_j|$$

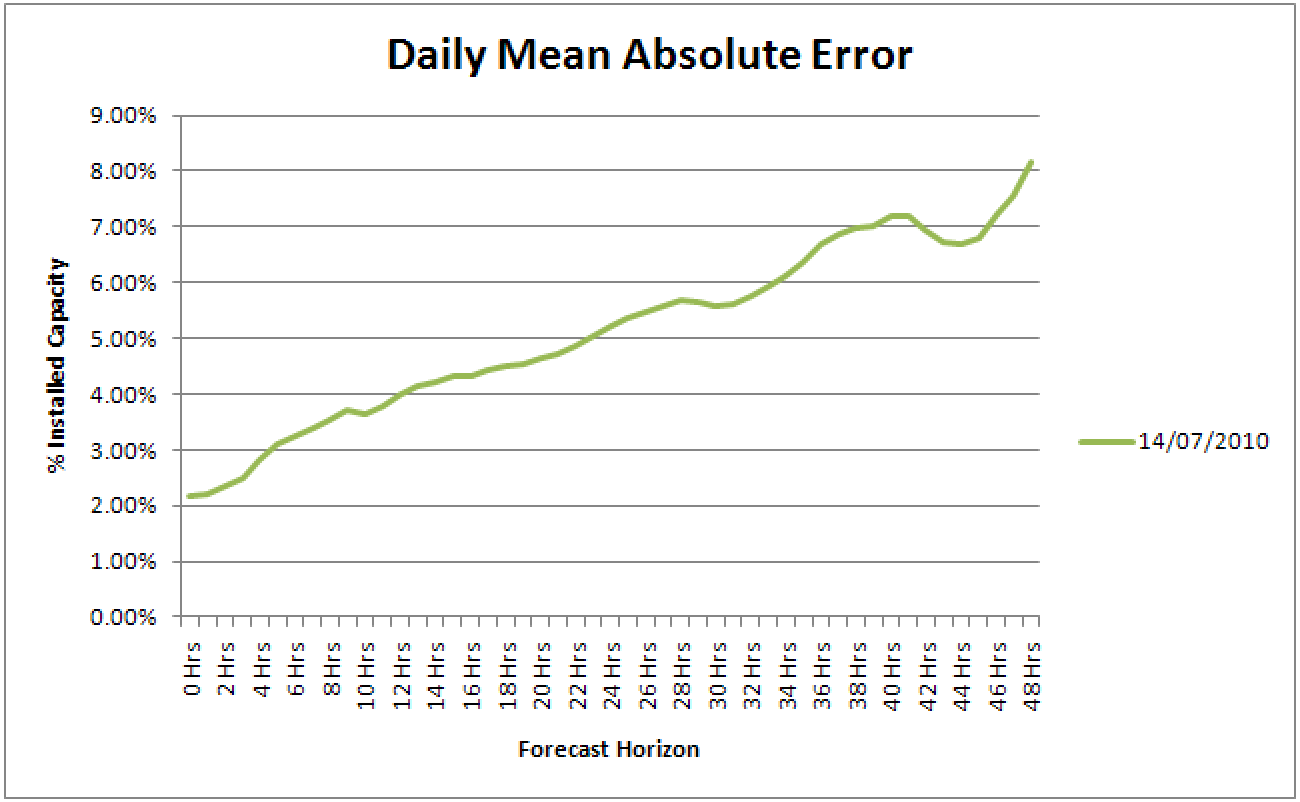
  - The Average Absolute Error Averaged Over Days, Months, Years
  - Normalised to Installed Capacity
  - For 0 – 48Hr Forecast Horizons.

- Root Mean Square Error – R.M.S.E

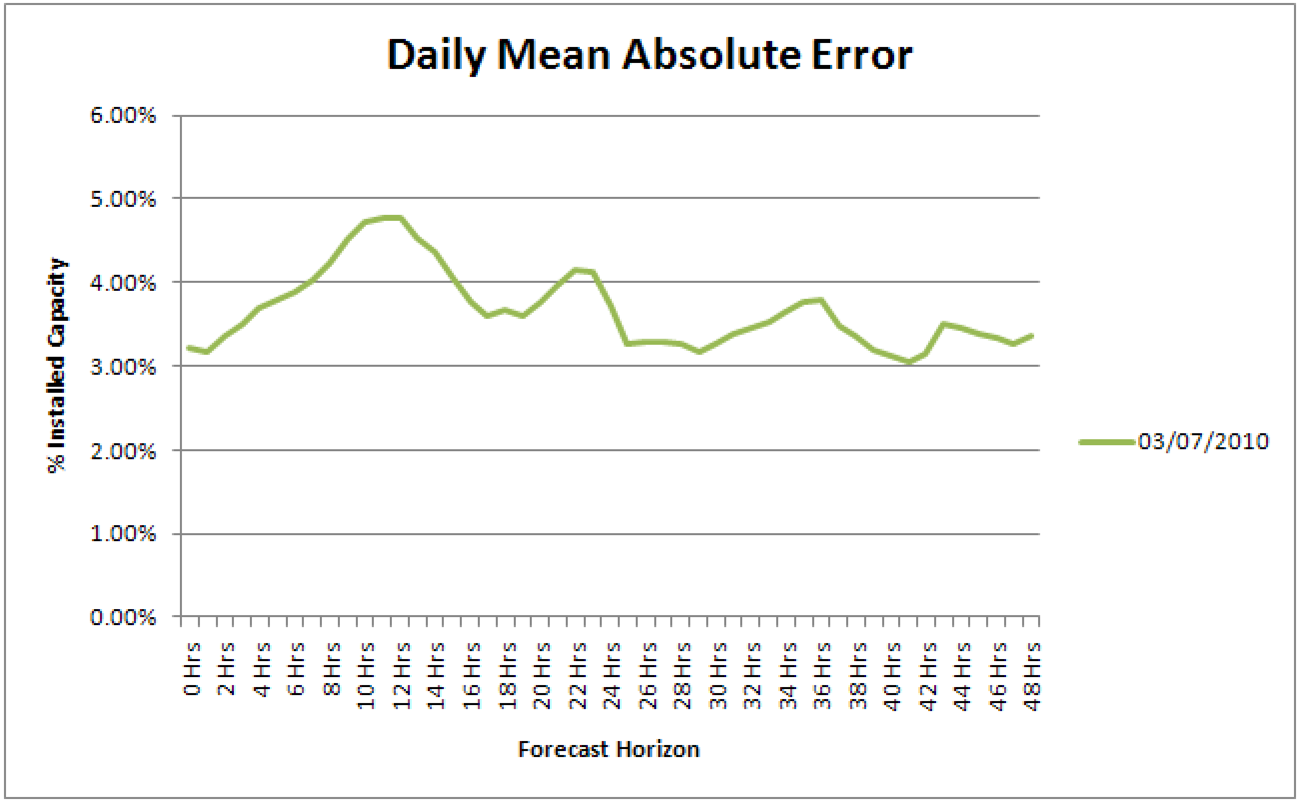
$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N} e_i^2}\ .$$

  - The Root Mean Square Error Summed Over Days, Months, Years.
  - Normalised to Installed Capacity
  - For 0 – 48Hr Forecast Horizons.

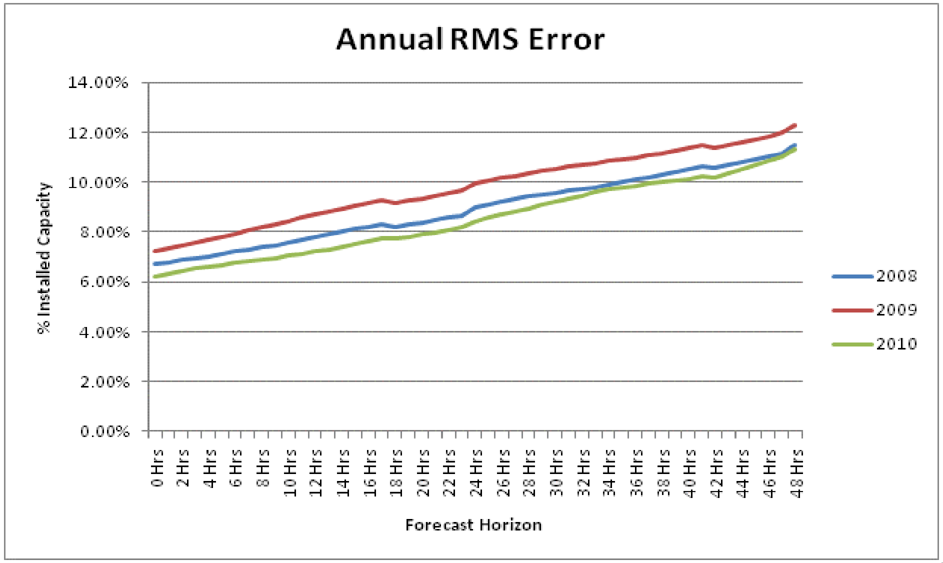
Wind Forecast Analysis - Unpredictability



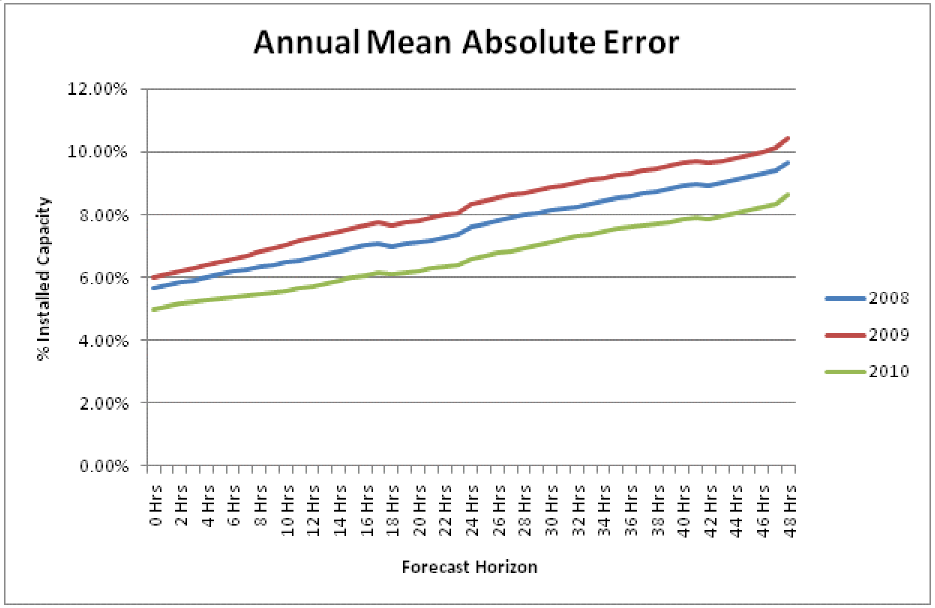
Wind Forecast Analysis - Unpredictability



Wind Power Forecast Annual Performance



RMSE forecast error
MAE forecast error



Wind Forecast Analysis - Inaccuracies

- Process Time - Weather Observation Made Hours Before Forecast Delivery

- Inaccuracies Associated with the Weather Model
    - Strength of Pressure Systems
    - Location of Weather Fronts
    - Hub Height Wind Speeds

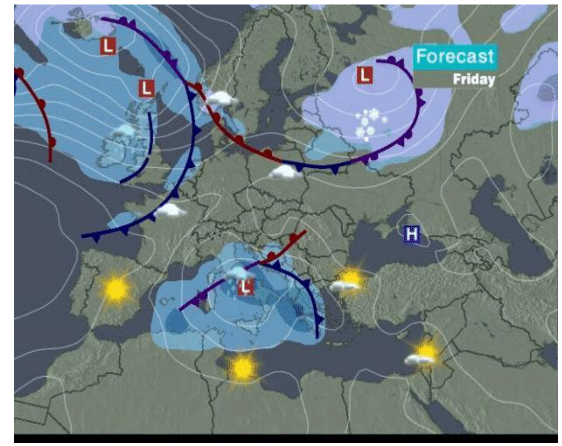
- Inaccuracies Associated with the Weather to Power Conversion

- Forecast Model Assumes Wind Farms Are at all Times Fully Available Without Taking Maintenance Schedules into Account.

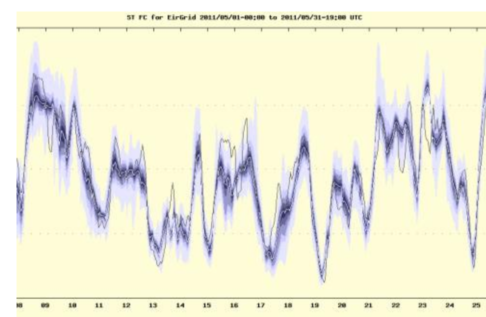
- Forecast Model Does Not take into Account Wind Farm Constraint or Curtailment

Consequences – Types of Error

- Phase Error – The timing of ramping events
- Peak Error – Strength of Low Pressure
- Uncertainty in Location of Weather Fronts
  - North/Southward (Peak Sensitive)
  - East/Westward (Phase Sensitive)



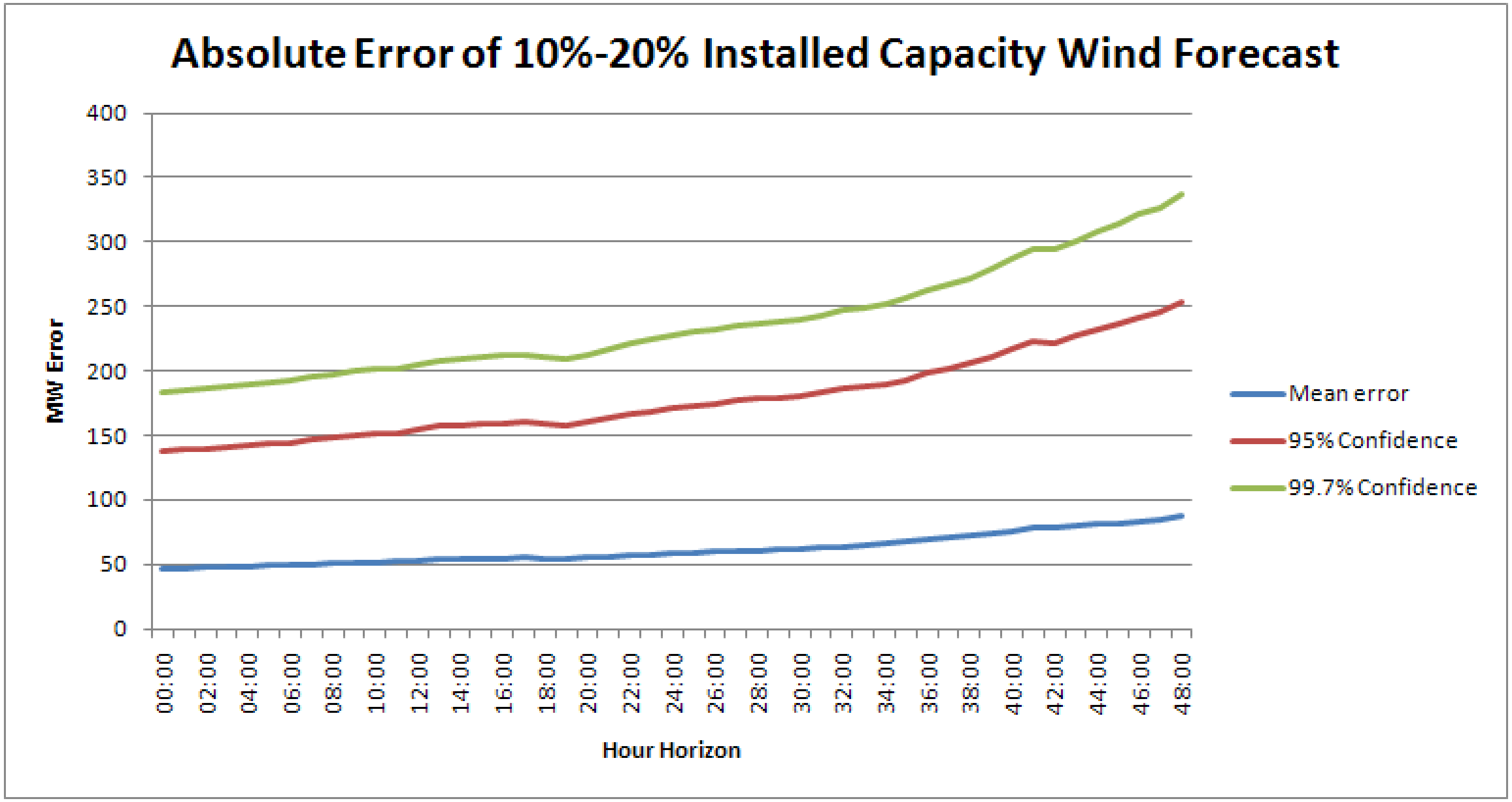
- Ramping Between 6 m/s-12 m/s – Short Ramps Up and Down
- Cut-Off – High Speed Shut Down Events
- Large Ensemble Spread Forecasts – Large Uncertainty



Improvement Initiatives

- Monthly Accuracy Review
- Vendor Performance Incentive
- Constant Wind Forecast Training
- More Information to Vendors;
  - More reflective Installed Capacity and MEC Values
  - Outage Information
  - Real Time Metered Data
  - Real time Wind Speed data
  - Wind farm Static Data: Hub Height, Orientation, Topography etc.
- Planning for Error

Wind Forecast Analysis – Confidence Graphs



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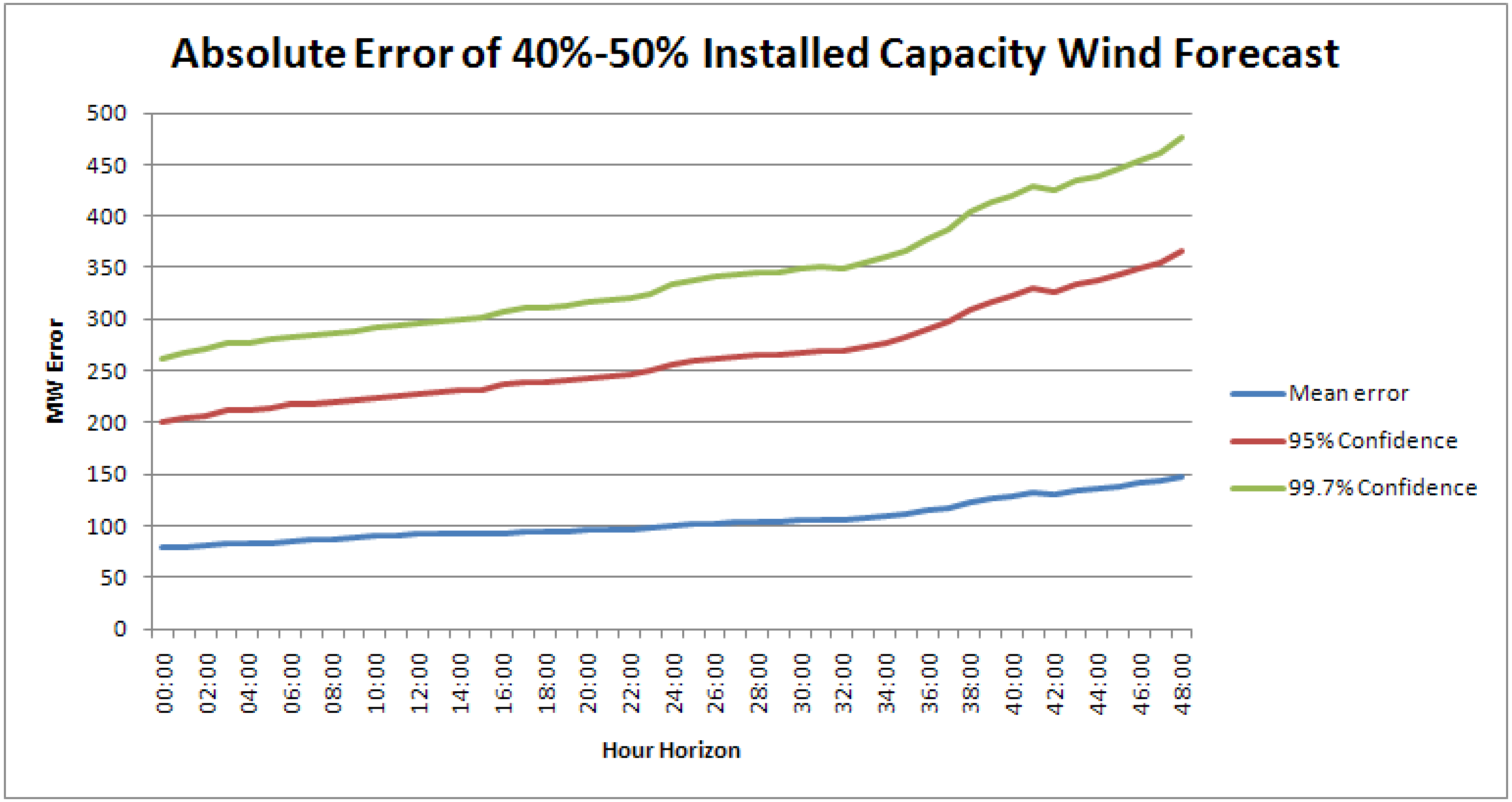

Using Forecasts and Dispatching Wind from NCC

Marie Hayden
Manager Power System Operational Planning

Contents

- Accounting for Forecast Errors in Unit Commitment
- Planning for the sudden loss of a lot of wind generation
- Dispatching Wind / Priority Dispatch

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Accounting for Forecast Errors in Unit Commitment

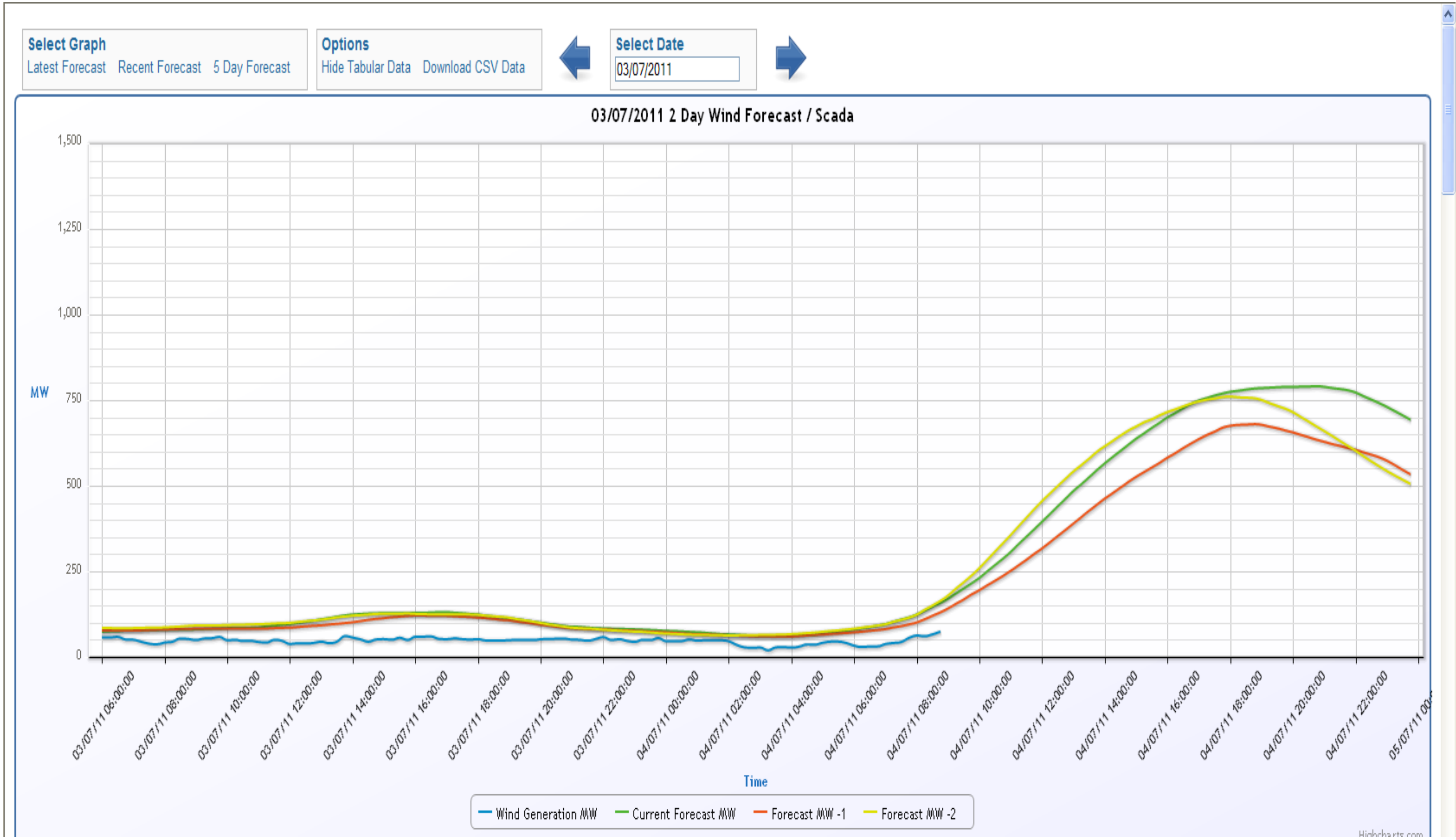
- Previous Seminars have covered the topic of Unit Commitment
- EirGrid performs day ahead scheduling on completion of the Market Ex-Ante run
- Scheduling is based on forecast values for:
  - Availability
  - Demand
  - Wind
- Scheduling must take account of changes in any of these key inputs
  - Unexpected changes in Generation Availability are accounted for by scheduling operating reserve
  - Accounting for Wind Forecast errors is more of an art than a science at the moment

Accounting for Forecast Errors in Unit Commitment

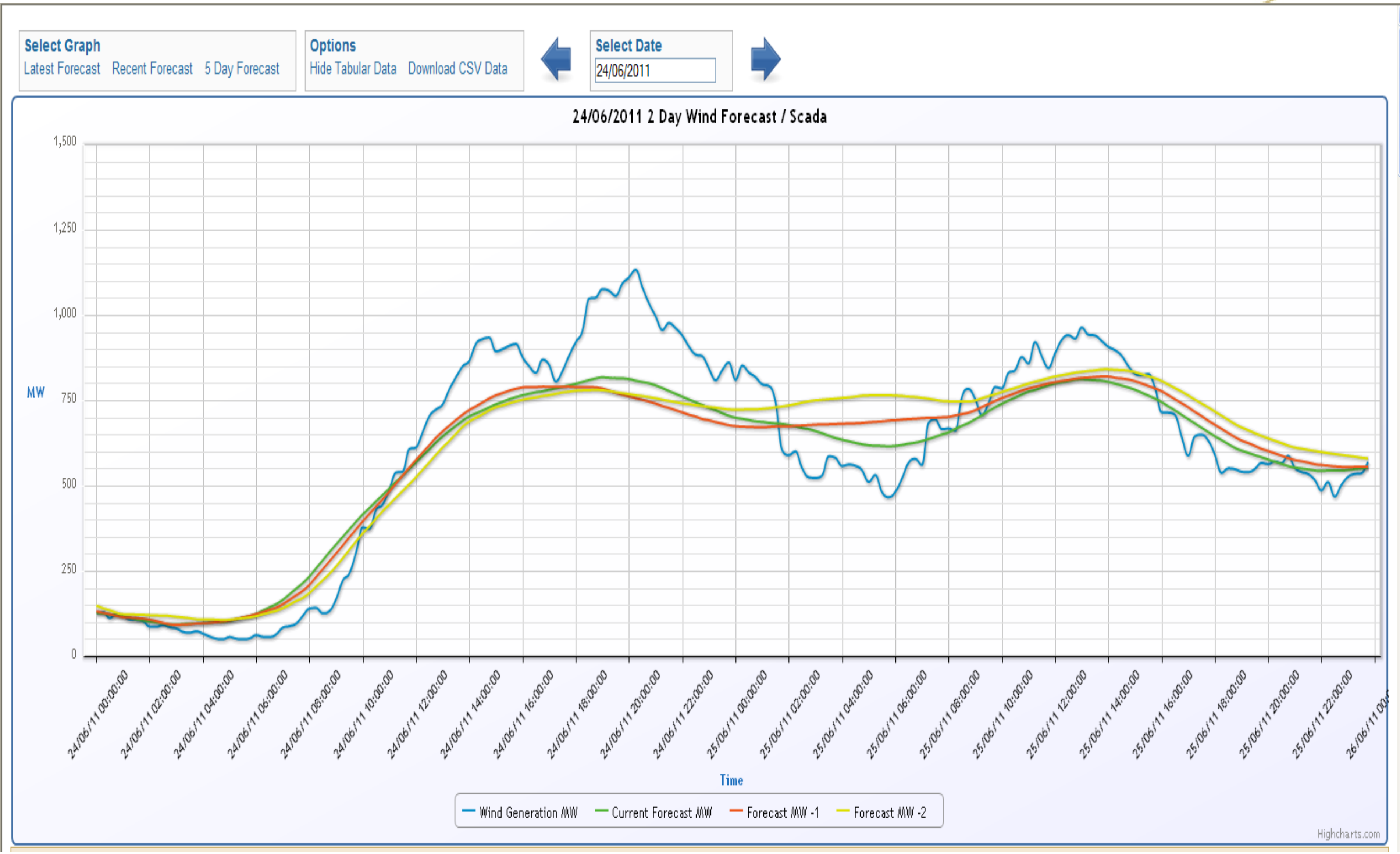
- Before running the Scheduling Software schedulers review the Wind Forecast
- They often adjust it taking account of :
  - Is the forecast for high, medium or low wind?
  - Is it a flat or variable forecast?
  - Is the confidence interval narrow or wide?
  - Which direction is the weather front coming from?

- What actions are taken
  - Forecasts for the valley are often adjusted upwards
  - Forecasts for the peak are often adjusted downwards

This forecast is flat and low so no adjustments would be made



This forecast is rising from midnight until the peak – considerable error can occur so adjustments would be made



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Operating Reserve

- Operating Reserve is carried to ensure the system remains stable following the loss of the largest single infeed

- It is carried in different time frames;
  - Primary 5-15 seconds
  - Secondary 15-90 seconds
  - Tertiary 1 90 seconds to 5 minutes
  - Tertiary 2 20 minutes
  - Replacement 4 hours

- It is expected that as wind capacity increases on the system operating reserve policy will have an explicit wind factor in it based on the wind forecast

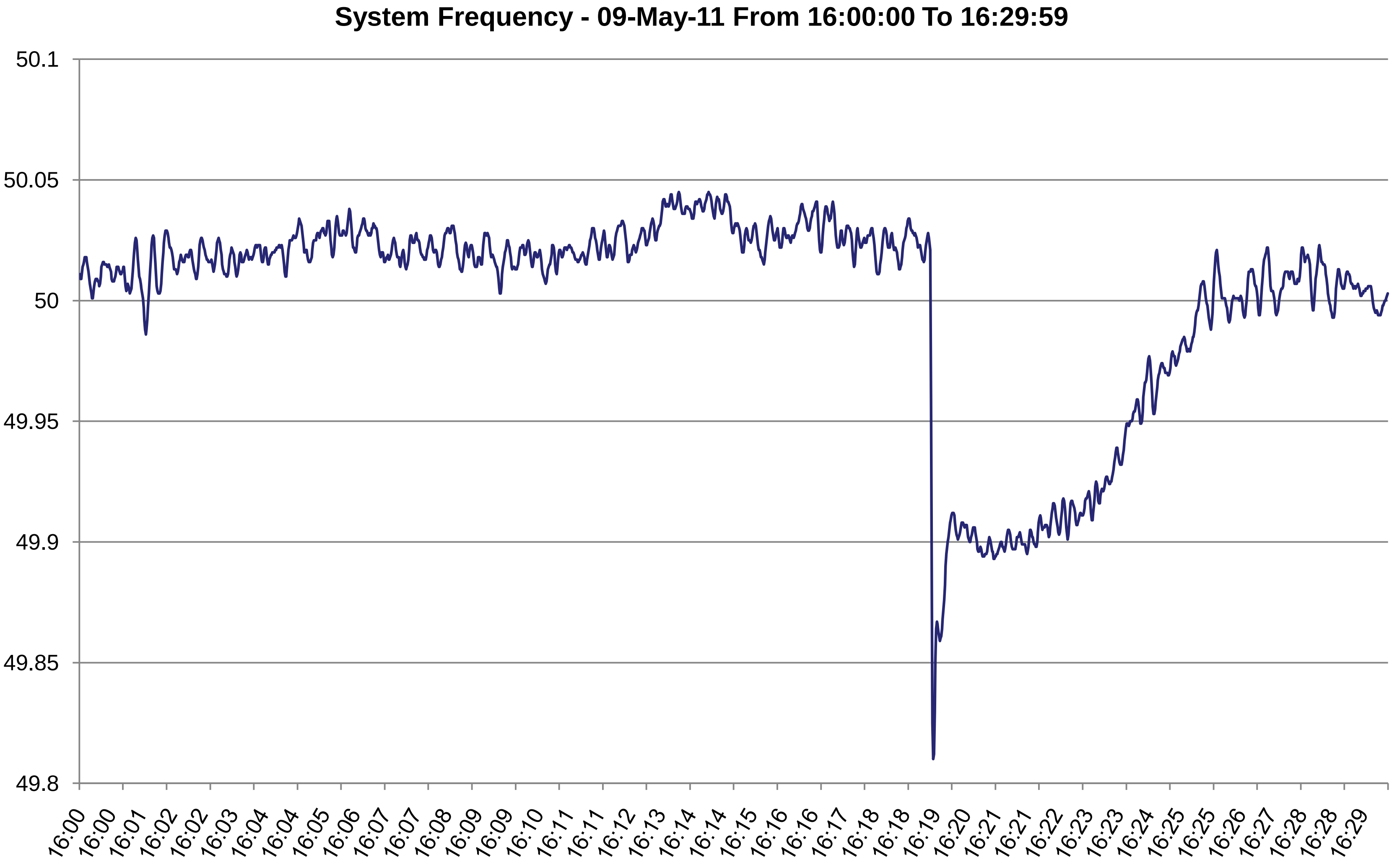
Fault Ride Through

- Refers to a generation unit's capability to remain connected to the power system during a short circuit

- Example:
  - On 9th May there was a lightening strike which resulted in a three phase fault on a 110kV line in the meshed transmission system.
  - Over 121MW and wind output tripped.
  - This represented a significant % (at least 25%) of the wind generation in the area at the time
  - It causes a frequency disturbance shown on the next slide

- We may need to account for this by dispatching wind down / off and this needs to be taken account of in the forecasts

System Frequency Impact of FRT Failure on 9th May



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NCC Wind Dispatch

- There are 130 Wind Farms connected to the transmission and distributions system

- Totalling 1530MW of capacity

- Out of 130 Wind Farms NCC Has:
  - SCADA on 65 Wind Farms ≈ 1300MW
  - Control commissioned on 42 of those Wind Farms ≈ 1000MW
  - NCC can control 66% of Wind Output

NCC Wind Dispatch Tools

- No Windfarms are staffed - Dispatch is via remote control from NCC’s Wind Dispatch Tool

- Successful control requires a number of systems to operate
  - Energy Management System Code
  - Communications Links
  - Remote Terminal Units in Stations
  - Voltage and Current Measurements
  - Control Devices to adjust power and voltage

- If remote control does not work NCC will revert to phone calls and ultimately to opening Circuit Breakers

Wind Dispatch Tool Graphical User Interface

WindFarm MW Totals	Actual Exported MW	Available MW	Available Capacity MW	Curtailment Setpoint Target	WindFarm Controller Setpoint Feedback
Curtailment Selected WF	91.3	95.7	481.0	500.8	486.2

The following windfarms are not available for Wind Dispatch:
(ref. email from MG to NCC 26-MAY-2011)

BALYMRTN	GRSLODGE
COOMACHO	KINGSMTN 1
CRGCANON	RAHENBR2

Auto Select Curtail VPT

Auto Select Curtail ALL

1. Enter Target MW for Selected WF 90.0 MW
2. Calculate Curtailment Setpoints
3. Issue Curtailment Setpoints
4. Remove Curtailments

1. Select WF, Enter Setpoints
2. Issue Constraint Setpoints
3. Remove Constraints

WindFarm Name	Region	Market Type	RC Enabled	MW Setpnt NCC Control	Available Capacity	Available MW	Actual MW	Last Setpoint Issued	WindFarm Setpoint Feedback	Last Stpnt Sccfully Implted at WindFarm	Curtail Selected	Curtail Setpoint MW	Curtailed [Y/N]	Constrain Selected	Constraint Setpoint MW	Constrained [Y/N]
BALWATER_PLC1	STH EAST	VPT	ON	OFF	42.0	6.2	6.0	42.0	42.3	OK	☑	42.0	☐	☐	42.0	☐
BEAMHILL_PLC1	NORTH	VPT	ON	OFF	14.0	2.4	2.6	14.0	14.0	OK	☑	14.0	☐	☐	14.0	☐
BINDOO_PLC1	NORTH	VPT	ON	OFF	48.0	9.8	12.1	48.0	49.0	OK	☑	48.0	☐	☐	48.0	☐
BOOLTIAG_PLC1	STH WEST	VPT	ON	OFF	20.0	4.6	0.0 s	20.0	20.2	OK	☑	20.0	☐	☐	20.0	☐
COMGRLHY_PLC1	STH WEST	VPT	ON	OFF	43.0	15.3	15.3	43.0	42.9	OK	☑	43.0	☐	☐	43.0	☐
COMGRLHY_PLC2	STH WEST	VPT	ON	OFF	9.0	3.8	3.6	9.0	9.0	OK	☑	9.0	☐	☐	9.0	☐
DERYBRIN_PLC1	STH WEST	VPT	ON	OFF s	0.0	0.0	0.0	60.0	0.0	OK	☑	60.0	☐	☐	10.0	☐
DRUMHILL_PLC2	NORTH	VPT	ON	OFF	10.0	1.6	1.5	0.0	12.5	Not OK	☑	0.0	☐	☐	10.0	☐
GARVAGH_PLC1	NORTH	AUT	ON	OFF	32.0	3.4	3.6	0.0	31.8	OK	☑	31.8	☐	☐	26.0	☐
GARVAGH_PLC2	NORTH	AUT	ON	OFF	27.0	3.6	3.9	27.0	26.9	OK	☑	27.0	☐	☐	20.0	☐
GLANLEE_PLC1	STH WEST	VPT	ON	OFF	30.0	12.2	12.2	30.0	30.0	OK	☑	0.0	☐	☐	30.0	☐
LISHEEN_PLC1	STH EAST	VPT	ON	OFF	55.0	7.8	7.9	55.0	55.2	OK	☑	55.0	☐	☐	56.0	☐
MEENTCAT_PLC1	NORTH	VPT	ON	OFF	85.0	12.0	10.4	85.0	85.7	OK	☑	85.0	☐	☐	85.0	☐
RCHFIELD_PLC1	STH EAST	VPT	ON	OFF	27.0	2.9	3.2	27.0	27.7	OK	☑	27.0	☐	☐	27.0	☐
SORNHILL_PLC1	NORTH	VPT	ON	OFF	39.0	10.2	9.2	39.0	39.0	OK	☑	39.0	☐	☐	39.0	☐

HAYDEN_MA@EGOWEB2:50 - [from egoems1]

Reasons for Dispatching Wind

- The three most commonly occurring reasons today are:
  - To manage transmission equipment loading constraints
  - To ensure that there is sufficient Inertia on the Power System
  - Because system demand is too low

- The first reason is usually called a Wind Constraint

- The latter two are commonly referred to as Wind Curtailment

- In the future we can foresee wind being dispatched down for other reasons such as:
  - To ensure the system is transiently stable
  - To provide frequency regulation
  - To provide operating reserve

Transmission Constraints

- Wind is constrained down to avoid overloads on transmission plant
- Non-firm connections driving an increase in incidents of constraint
- Transmission constraints are common during the transmission outage season which runs from the end of March until the end of October
- Donegal and West Cork / South Kerry most constrained areas

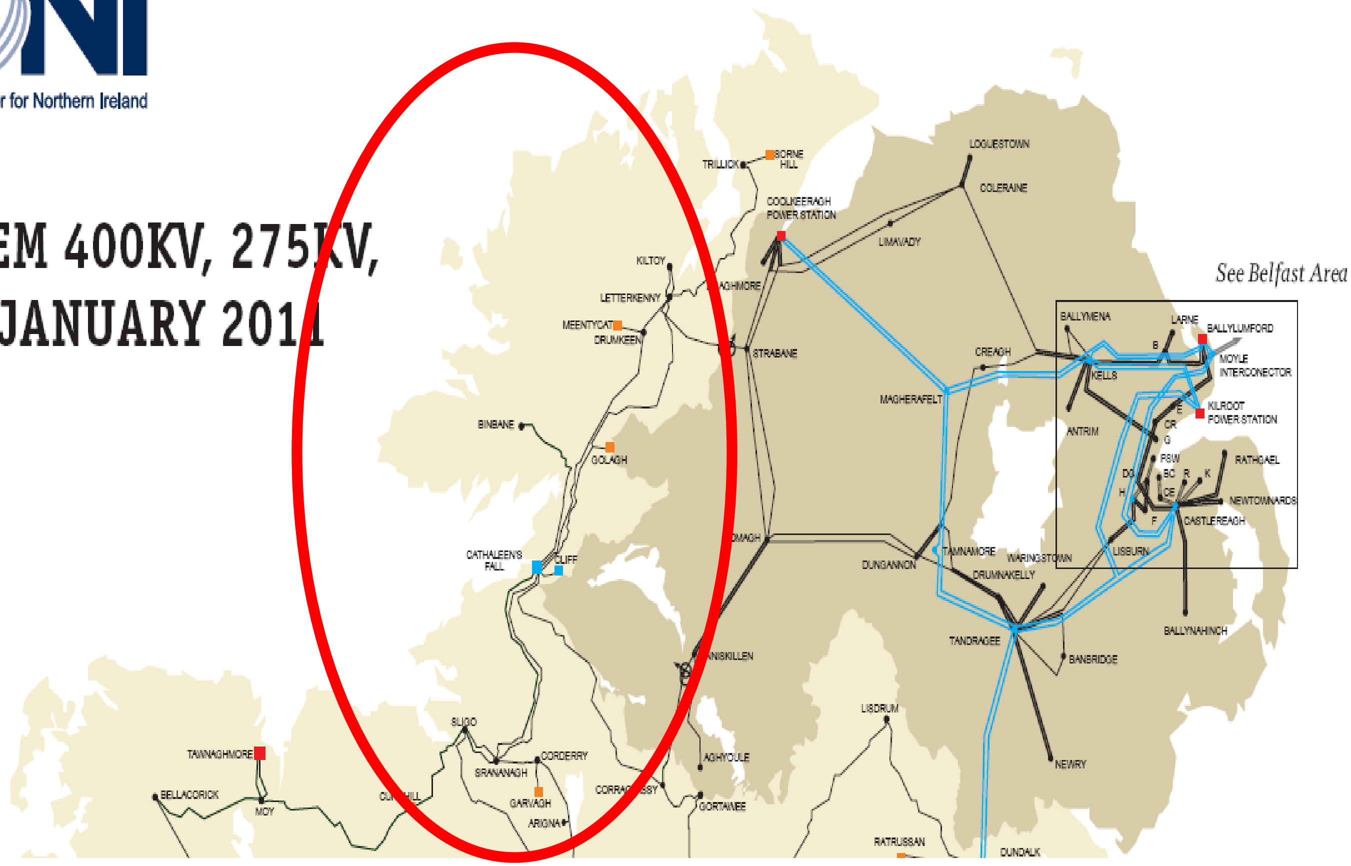
EIRGRID

SONI

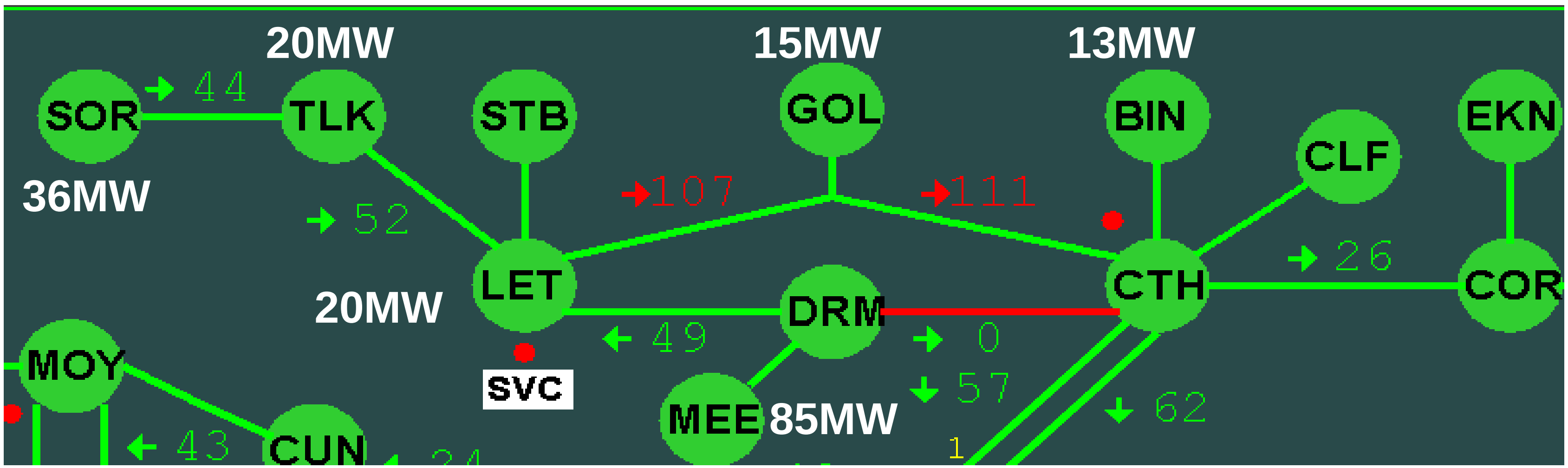
System Operator for Northern Ireland

TRANSMISSION SYSTEM 400KV, 275KV, 220KV AND 110KV - JANUARY 2011

- 400kV Lines
- 275kV Lines
- 220kV Lines
- 110kV Lines
- 220kV Cables
- 110kV Cables
- 400kV Stations



Example of Transmission Constraint



∑Installed Wind North of Cathaleen's Fall = 189MW

∑Demand at Letterkenny = Ranges 20MW (Valley) to 76MW (Peak)

Max Net Export from Region ranges from 113MW to 169MW

Lines in the area only rated for 110MW

Wind constraints range from 0 to 59MW = 0 to 31%

Wind Curtailment for Inertial Stability

- To maintain sufficient inertia one of the system rules presently in place is

"no more than 50% of (system demand + Interconnector Exports) can be supplied from non-synchronous generation (Wind/Interconnector Imports)"

	Ireland MW	Northern Ireland MW	Total MW	Max Non-sync
Peak Demand	5090	1777	6867	3433MW
Valley Demand	1685	725	2410	1205MW

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- Installed wind today on the Island is just under 1900MW

- The 50% rule does not bind very often today but is expected to more in the future

Wind Curtailment due to insufficient demand

- NCC must at all times ensure generation output = system demand

- This is done in subject to
  - System constraints
  - priority dispatch
  - merit order principles

- System constraints include
  - Provision of sufficient operating reserve
  - System inertial stability
  - Transient & Voltage stability
  - Transmission thermal overload constraints
  - Morning ramping constraints

Wind Curtailment due to insufficient demand

- NCC will first dispatch to satisfy stability constraints and then dispatch according to merit order / priority dispatch

- Units with Priority Dispatch on the system at the moment are:
    - Wind
    - CHP
    - Hydro
    - Peat

- Flows on the Moyle Interconnector are fixed day ahead and are not adjusted by the System Operators unless there is a system security issue

Example of Summer Night Valley

- System Demand = 1800MW
- Constraint 1: Voltage constraint in Dublin:
  - Constraints on Poolbeg Combined Cycle, Dublin Bay Power and Huntstown Combined Cycle
  - ∑Min Generation = 670MW
- Constraint 2: System Inertial Stability requires 5 large units on load
  - Constraints on Moneypoint 1 and 2
  - ∑Min Generation = 230MW
- Constraint 3: Operating Reserve
  - Constrains on Whitegate 1, Tynagh and one Gas Turbine
  - ∑Min Generation = 400MW
- Satisfying System Constraints requires 1230MW of plant on load

Wind Curtailment due to insufficient demand

- This leaves 1800-1230 = 570MW for other generation which will be made up of:
    - Moyle driven flows = 200MW
    - Minimum Generation on two peat units = 90MW
    - CHP Minimum Load = 80MW
    - Hydro Dispatched to 0MW
- All in all this leaves 200MW for wind

- Wind Forecast is 700MW which will drive a curtailment of 500MW over the valley period

- The continued forced outage of Turlough Hill and the reduction in system demand have both had a significant impact on the incidence of wind curtailment at night


Questions?