RENEWABLE ENERGY MANAGEMENT SYSTEM

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Renewable Energy is growing at an exponential rate since the last decade.

In some of the countries like Denmark, the share of renewable generation is higher than the demand during some part of the time.

This is possible with interconnection with other countries.

Power System Operators face challenges in operating the system with large renewable energy due its intermittency and variability.
Curtailment of generation from wind and solar is a growing concern across the world.

There is a need for operating the Renewable Energy as a Virtual Power Plant which should behave similar to the conventional power plants in its operational characteristics.
Technical issues with RE

Technical requirements

- For system flexibility, predictability, variability (and intermittency);
- For optimizing the technical design and management of generation and network to facilitate and guide the development of emerging technologies, so that they function effectively as components of a single machine when integrated into conventional power systems.
- for metering, communication and remote control.
- scope for geographical and technological aggregation to manage variability

Boundary issues, including interconnection design operation & flow constraints, and compatibility with other decision-making regimes

Technical challenges of distributed generation, intelligent grid control, demand side management and Smart Grid
Wind Generation

Long-term economic sustainability of wind energy requires improving the wind energy business model.

Energy maximization – generating more energy over the low-to-medium operating wind spectrum.

- Development of new control systems, materials, blades, electro-mechanics, and power systems for the wind turbine, and
- Automatic low-cost blade and tower manufacturing systems for mass production

- Smart blades with advanced airfoils, new sensors and actuators, and specific control systems;
- New rotor configurations; variable-diameter rotors, which could significantly increase the efficiency of the turbine by presenting a large area to capture more energy in low winds and a reduced area to protect the system in high winds;
- Advanced control strategies to damp out tower motion by using blade pitch and generator torque control are critical.
Large multi-megawatt machines need very large rotor diameters.

- new active and independent pitch control and torque control systems must be developed to reduce tower top motion, power fluctuations, asymmetric rotor loads, mechanical fatigue, and individual blade loads, achieving higher reliability and lower maintenance

Large-scale wind energy scenario, the wind farms will have to support the grid by providing

- fault ride-through capability; voltage regulation and reactive power control; primary frequency control; oscillation damping; low harmonics content; and avoiding power flickers and carrying a share of power control capability for the grid.
Wind Generation

"maximum" level of wind penetration will depend on the particular grid

- existing generating plants, wind turbine technology, wind turbine control systems, grid demand management, pricing mechanisms, grid capacity and topology, storage type and availability, and wind resource reliability and diversity

There is increasing scope for offshore applications with large machines

- new ideas to reduce the cost;
- remote, intelligent turbine condition monitoring and self-diagnostic systems;
- analytical models to characterize wind, ocean currents, tides, ice, and ocean waves;
- Ensure high reliability and predictive maintenance techniques; and
- grid technologies for electricity transmission back to shore.
Grand Challenges today is to make solar energy economical: “Overcoming the barriers to widespread solar power generation will require engineering innovations in several arenas—for capturing the sun’s energy, converting it to useful forms and storing it for use when the sun itself is obscured”
Advanced control can help reduce operating costs and increase solar plant performance. The main control challenges are:

- Optimal robust control techniques able to maintain the operating temperature as close to optimum as possible despite disturbances such as changes in solar irradiance level (caused by clouds), mirror reflectivity, and other operating conditions.
- Optimal and hybrid control algorithms that determine optimal operating points and modes and take into account the production commitments, expected solar radiation, state of energy storage, and electricity tariffs.
- Modes and methods for forecasting solar radiation using heterogeneous information (cameras, satellites, weather forecasts).
Algorithms to estimate main process variables and parameters from heterogeneous and distributed measurements (oil temperature and solar radiation at different parts of the field, mirror reflectivity, thermal losses).

Automatic mirror cleaning devices. The main factor degrading the optical performance of concentrating mirrors is accumulation of dirt on the mirror surface.

Heliostat self-calibration mechanisms. Heliostats need to be retuned periodically because of errors in the sun model, latitude and longitude of the site, heliostat position in the field, mechanical errors, optical errors, and the like.

Fault detection and isolation in solar power plants. Algorithms are needed to detect and isolate faults and malfunctions in power plants, such as detection of hot spots, receivers with broken glass covers or vacuum losses, and heliostat faults.
Several strategies have been in vogue in many countries for integrating large scale RE generation.

- RE forecasting
- Grid code
- RE modeling & dynamic interaction
- Demand response
- Adequate transmission planning & development
- REMS
Managing Intermittency

The intermittency is managed by

- Better geographical integration
- Diversity of wind generation across States or regions
- Diversity of Wind and Solar
- Real power balancing by flexible generators
- Smart Grid and Storage

The intermittency is managed by these strategies.
Wind Generation from a Turbine

Power generation in kW

Power generated for a day in July
Wind Generation in Wind Farm

Power generation in MW

Power generated for a day in July
Actual Solar Generation on 2\textsuperscript{nd} March
Solar Generation

Graph showing solar generation over time for two different dates, 2-Apr and 5-Apr. The graph indicates a peak around 13:00 for both dates, with fluctuations throughout the day.
The main functional components in REMS are:
1. Wind/Solar Farm Data Acquisition and Management System, to collect real time data from all the wind farms
2. Centralized short term wind/solar power prediction tool,.
Why REMS

- REMS will co-exist with the traditional EMS system
- REMS would be based on the probabilistic approach and designed to predict / control / operate the variable energy sources
- Centralized / Regional forecasting of renewable are preferred for system operation and it would be integrated as part of REMS
RENEWABLE ENERGY MANAGEMENT SYSTEM

Tools Used in REMS:

✓ Wind/Solar Farm Data Acquisition and Management System
✓ Short term Wind/Solar Forecasting
✓ Centralized renewable forecasting
✓ Wind/Solar Scheduling
✓ Wind/Solar Ramp Power Forecasting
✓ Dispatch Decision Support System
✓ Curtailment and Re-dispatch Systems
✓ Security Assessment tools with Renewables
REMS

- Measured Wind & Solar Data
- Real Time Data (From RE)
- Outage Plans (of RE’s)
- Metered RE Generation

Meteorological Data

Data Analysis and Database

RE Data Acquisition and Management System

RE Forecasting Engine

Generation Forecast to SLDC Day ahead, 12hr ahead and further time slicing
Resources
- Energy Market Merit Order
- Generator ramping characteristics
- Load Supply Following
- Wind Power Management (Optional)

Present Status
System Status
- What supply has been dispatched
- What is the Actual generator output

What Is Going to Change
System Change
- Load forecast
- Actual and forecast Interchange Schedules
- 3 Modes for Wind power forecast (Optional)
  - Input External Wind Power Forecast
  - Persistence Forecast
  - Persistence Ramp Forecast

Heart of DDSS
Provide 1 hr forecast of supply demand balance and a 6 hr outlook

What If?
System Controller can toggle up and down the merit order to see the impact of the dispatch on the forecast imbalance
View of Spanish Renewable Energy Control Center

Courtesy : Strategies and decision support system for integration variable energy resources in control centers for Reliable Grid operations - DoE report
Thank you

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