What is A Wind Integration Study?

何谓风电并网研究

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Wind Integration Workshop

December 7, 2010

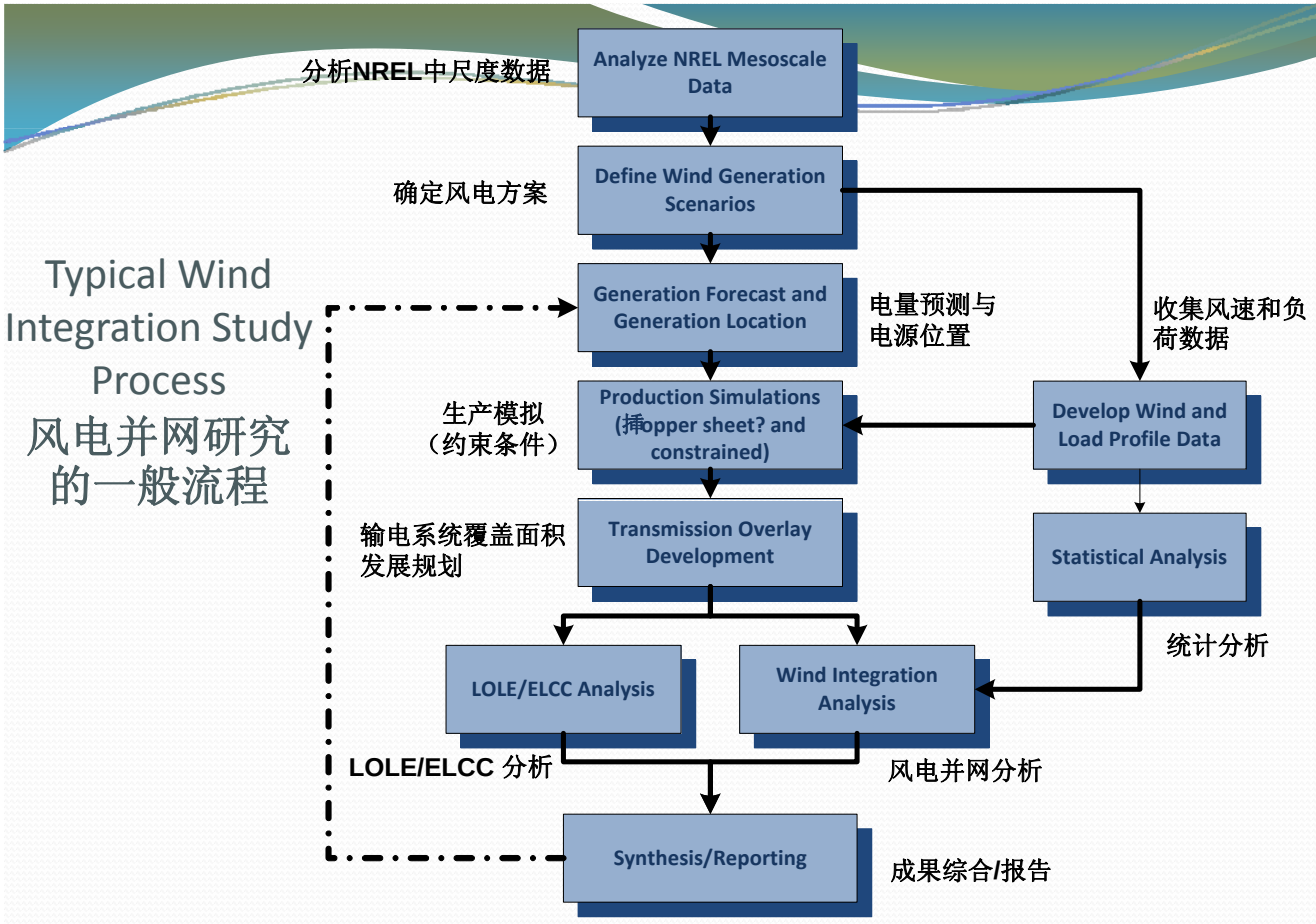
What is a Wind Integration Study?
何谓风电并网研究？

- A wind integration study typically identifies the operational and reliability issues from increasing levels of wind penetration
  一般来说，风电并网研究是针对风电并网容量增加所带来的电力系统运行及可靠性问题进行的分析与研究。
  - Usually multiple scenarios of base, 10%, 20%, 30%
    研究通常基于多种方案进行，如风电容量占10%，20%，30%。
- Identify changes in production costs from higher levels of wind penetration
  分析确定由于风电并网容量增加导致的生产成本变化。
- Identify changes in requirements for reserves over multiple time frames
  分析确定多时间尺度下系统所需备用容量的变化。
- Consider whether existing generating resources (i.e., coal, natural gas, hydro) can accommodate higher levels of wind generation
  分析现有发电资源（如煤炭、天然气和水力）能否接纳更多的风电容量。

Wind Integration Studies Generally Have Multiple Parts
风电并网研究的组成部分

- Production cost modeling (for hourly simulations of power flows, costs and dispatch)
  生产成本建模（用于进行潮流、成本和调度的小时级仿真）。
- Statistical analysis (for determining hourly deviations in net load from adding wind, and for determining sub-hourly changes)
  统计分析（用于确定风电增加后等效负荷的小时级偏差，确定小时内的变化）。
- Capacity value and reliability analysis 容量置信度和可靠性分析
- Load flow analysis 潮流分析
- Transmission planning and siting 输电规划和选址
- A Technical Review Committee that is comprised of grid operators, government energy officials, renewable energy companies, renewable energy experts and/or consultants
  技术审查委员会，通常由电网运营商、政府能源部门、可再生能源公司、可再生能源专家和/或顾问组成。

Typical Wind Integration Study Process
风电并网研究的一般流程



Source: Eastern Wind Integration & Transmission Study - Study Overview

Organizational Set-Up
组织建立

- Study time-consuming and labor-intensive 研究需要消耗大量时间和工作量
  - Typical study time 1 year, and can take longer
    一般来说研究时间是1年，或更长时间
- Need single organization to lead and take responsibility
  需要单独的组织负责领导，并对项目负责
  - With help from other organizations and from Technical Review Committee
    需要其他组织和技术审查委员会协助
- Consider who does the work 考虑谁来承担相关研究工作
  - Could be done in-house but hard to juggle wind integration study with other responsibilities
    虽然可以内部完成，但就很难与其他相关部门同时参与开展风电并网研究；
  - Work typically is outsourced to multiple consultants
    研究工作通常会委托给多个顾问，包括：
    - Power systems consultant 电力系统顾问
    - Transmission/load flows consultant 输电/潮流顾问
    - Wind resource and forecasting consultant 风资源和预测顾问

Sensitivity Studies
灵敏度研究

- Different natural gas and coal prices 不同的天然气和煤炭价格
- Different fuel mixes 不同的燃料组合方案
- Higher or lower projected electricity demand 过高或过低的计划电力需求
- More demand response 更多的需求侧响应
- Plug-in electric vehicles 即插式电动汽车
- Different turndown capabilities for coal units 火电机组的不同降出力能力
- Differing levels of hydro flexibility 水电不同程度的灵活性
- Varying accuracy levels of wind power forecast 风功率预测的不同精度水平

Assumptions to Make
假设条件

- Projected future fuel costs for natural gas and coal
  未来天然气和煤炭燃料的预计成本
- Expected future load growth
  预计的未来负荷增量
- Projected future transmission grid
  规划的未来输电网结构
- Projected generating capacity additions
  预计的未来新增发电量
- Whether to include $/ton carbon dioxide adder or not
  是否需要在分析中包含美元/吨二氧化碳的信息

Data Needs
所需数据

- Multiple years (usually three) of time-synchronized wind and load data to capture inter-annual variability of load and wind
  多年（通常为三年）时间同步的风速和负荷数据，用于确定负荷和风电的多年变化规律。
- Use Numerical Weather Prediction models to recreate historical weather data
  运用数值天气预报模型重建历史天气数据。

Data Needs (2)
所需数据（2）

- Sub-hourly load and generation data (minute-by-minute, 10-minute) for analysis of interesting periods (high wind, high load, high wind/low load, etc.)

  小时内的负荷和发电数据（每分钟或每10分钟），用以对某些典型时段进行分析（高风速、高负荷、高风速/低负荷等等）。
- Load forecasts for multiple years

  多年负荷预测
- **This step always takes the longest, and wind integration studies cannot proceed without data**

  本步骤用时最长，没有这些数据风电并网研究就无法进行。

Wind Forecasts
风功率预测

- Techniques for simulating wind power forecasts not well developed

  风功率预测模拟技术还有待进一步发展和提高。
- Two basic methods

  风功率预测的两种基本方法
  - Impose random error on top of wind generation profiles

    在风力发电曲线中叠加随机误差
  - Match up with another wind forecast (covering same time frame)

    与其他风功率预测方法配合（覆盖同一时间尺度）

Transmission
传输系统

- Need current and projected load flows for planned scenarios

  针对计划的研究方案，需要当前的和规划的系统潮流。

- Also need to decide whether to do detailed transmission study for low-voltage and high-voltage transmission levels, or do high-voltage schematic and assume low-voltage issues away

  还需要决定是否针对低电压和高电压等级传输系统做详细输电研究，还是只针对高电压电网而不考虑低电压等级电网。

Wind Integration Costs
风电并网成本

- In general, defined as the increased system costs imposed by higher levels of wind generation, but different viewpoints on how to calculate wind integration costs

  一般来说，风电并网成本定义为因风电并网容量增加所引起的新增系统成本，但在计算风电并网成本的问题上存在不同观点。

- Two common methods: 两种常见方法：
  - Flat block, where a power system with wind is compared to a system with an energy-equivalent flat block, and the cost difference is the integration cost

    固定模块（Flat Block），比较含风电的电力系统与不含风电但能量等效电力系统的成本，其成本之差就是风电并网成本。
  - System, focusing on wind's impact on commitment and dispatch and wind's net value from fuel savings and reduced wholesale prices

    系统方法（System），着眼于风电对开机安排和调度的影响、以及风电在节约燃料和降低趸售价格方面的净价值角度。
- Newer, but still relatively untested, is using an "ideal wind block" (perfectly forecasted) instead of a flat block

  更新的方法，但尚未经测试，是使用一个"理想的风电模块"（功率预测非常准确）取代一个固定模块（flat block）。

Study Assumptions and Results
研究假设和结果

- Inputs, assumptions, data should be public and transparent

  输入、假设和数据应该是公开与透明的。

- Study results should also be made public

  研究结果也应该是公开的。

- Non-disclosure agreements may be required to get access to sensitive data

  在获取一些敏感数据时可能需要签订保密协议。

Summary
总结

- Wind integration studies are a useful means of studying the potential market and reliability impacts of higher levels of wind generation

  风电并网研究是研究大规模风力发电的潜在市场和可靠性影响的一种重要手段。

- These studies are time- and data-intensive and typically involve meso-scale modeling, load flow modeling, production cost model, and statistical analysis

  这些研究需要大量时间和数据，且通常涉及中尺度建模，潮流建模，生产成本建模和统计分析。

- A Technical Review Committee can be very helpful, if not essential, in helping design the study, to provide critical review, and to build stakeholder support and confidence in the study results

  技术审查委员会作用重大，可以帮助设计研究方案，提供关键性意见、建立各利益相关方对研究结果的支持度和信任度。

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