# Transmission and Integration of Renewable Energy and System Operations
# 可再生能源电力输送和并网以及系统运行

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# Transmission 输电

- Integrating new generation is not only an issue for wind resources. Large coal and nuclear generation have integration costs, too
- Proactive transmission planning on large-scale clearly necessary
  - The wind resource is distant from load in China and U.S.
  - 1/3 of wind capacity installed in China is reportedly not grid-connected, but this is temporary condition
  - 10+ GW/yr additions require planning
- Transmission expansion may support other generation, but dispatch and curtailment policies are needed to deliver emissions reductions
- The US has much to learn from China about how to plan and build transmission for wind

- 并网问题不仅仅是风电面临的问题，大规模煤电和核电也同样存在并网成本问题
- 现阶段明显需要积极主动的大规模输电规划
  - 中国和美国的风能资源都远离负荷中心
  - 报告显示，中国三分之一的风电装机容量没有并网发电，但这只是暂时的情况
  - 每年超过千万千瓦的新增风电装机需要输电规划
- 输电网扩展可以支持不同类型的发电，但是需要制定合理的调度和限发政策，以减少排放
- 中国在规划和建设风电输电网络方面有很多经验值得美国借鉴

# Wind Forecasting Critical
# 风功率预测很重要

- Consider establishing a central wind forecasting system that would cover the entire country (or, at least multiple provinces)
- Will need multiple time levels of wind forecasts (e.g., hourly, day-ahead, week-ahead and month-ahead)
- Will likely need ramp forecasts as well (more difficult to do and should be in addition to regular wind forecast)
- Consider using an ensemble of multiple wind forecasts
  - Some wind forecasts more tuned to certain wind patterns than others
  - Increase in accuracy may offset higher costs

- 考虑建立一个覆盖全国（至少覆盖多个省份）的中央风功率预测系统
- 需要多个不同时间层次的风功率预测（如每小时、提前一天、提前一周和提前一个月）
- 很可能也需要爬坡预测（难度更大，应在常规风功率预测基础上，增加爬坡预测）
- 考虑采用多种风功率预测的组合办法：
  - 某些风功率预测更侧重某种风力类型
  - 预测准确性的提高可以抵消额外成本

# Grid Codes and Other Items
# 并网标准和其它事项

- Strong and continually updated grid code will encourage advanced wind turbines
  - Can provide reactive power or frequency reserves
  - Can ride through low-voltage faults or other grid events
  - Newer wind turbines can also contribute to system inertia
- None of this is free and will not be part of standard wind turbine installations unless required, through grid code, or encouraged through extra payments

- 加强并不断修订并网标准，促进风机技术进步
  - 可提供无功或频率备用
  - 可以在低电压或其它电网故障下维持运行
  - 新一代的风机也有助于系统惯性
- 上述技术需要资金投入，开发商不会主动增加这些技术，除非并网标准有所规定或有额外的补偿机制

# Grid Codes and Other Items
# 并网标准和其它事项

- Larger regional operations will smooth wind output and make accessing needed balancing flexibility resources easier
- Encourage geographic diversification of wind power
  - Will make operational issues easier
  - Smooth wind output

- 在更大区域范围内运行，可以平滑风电出力的不稳定性，也可以获得更多的灵活发电资源来平衡风电
- 鼓励风电场在地理分布上更加分散
  - 易于系统运行
  - 可以平滑风电出力

# Flexible Generation / Ancillary Services 灵活的发电资源 / 辅助服务

- High levels of wind generation will require more flexible generation / ancillary services, primarily load following
- Revise existing payment mechanisms for conventional generation to encourage flexible generation
- Consider providing incentives (such as higher payment) for generators that can operate at lower levels, start up quickly, or respond quickly to operator signals
- Consider increasing non-spinning reserves to track wind ramps
- FERC has a pending investigation on these issues

- 大规模风电发展需要更多的灵活发电资源/辅助服务，尤其是负荷跟踪
- 修改对常规发电的支付方式，鼓励灵活发电
- 考虑对低水平运行、启动快或对系统运营商信号反应迅速的发电机组提供奖励（如支付更高电价）
- 考虑增加非旋转备用，追踪风速变化
- 联邦能源监管委员会即将对上述问题进行调查

# Consider a Wind Integration Study
# 考虑开展风电并网研究

- International studies show integration is not difficult or costly
- Grid companies have data to perform study
- International expertise is available
- Data needs are immense
  - Time-synchronized hourly generation and load data
  - Meso-scale wind data for high penetration wind scenarios
  - Wind energy forecasts
  - Periods of sub-hourly generation and load data to analyze "interesting periods" (i.e., high wind/low load, low wind/high load, etc.)

- 国际研究显示，风电并网并不困难，成本也不高
- 电网公司拥有开展研究需要的数据
- 国际上有现成的专业知识
- 巨大的数据需求
  - 时间同步的每小时发电量和负荷数据
  - 对于高风电情景，需要中尺度风资源数据
  - 每小时发电周期和负荷数据，分析“有趣的周期”，如疾风/低负荷或低风/高负荷

# Demand Response and PHEVs
# 需求响应和插电式混合动力车

- Demand response could help integrate higher levels of wind generation at a lower cost than adding new generation or ancillary services
  - Particularly true for extreme wind events that may happen for only a few hours per year
- Introduction of Plug-In Electric Vehicles can also help with high levels of wind power
  - PHEV charging at night coincides with timing of higher levels of wind production

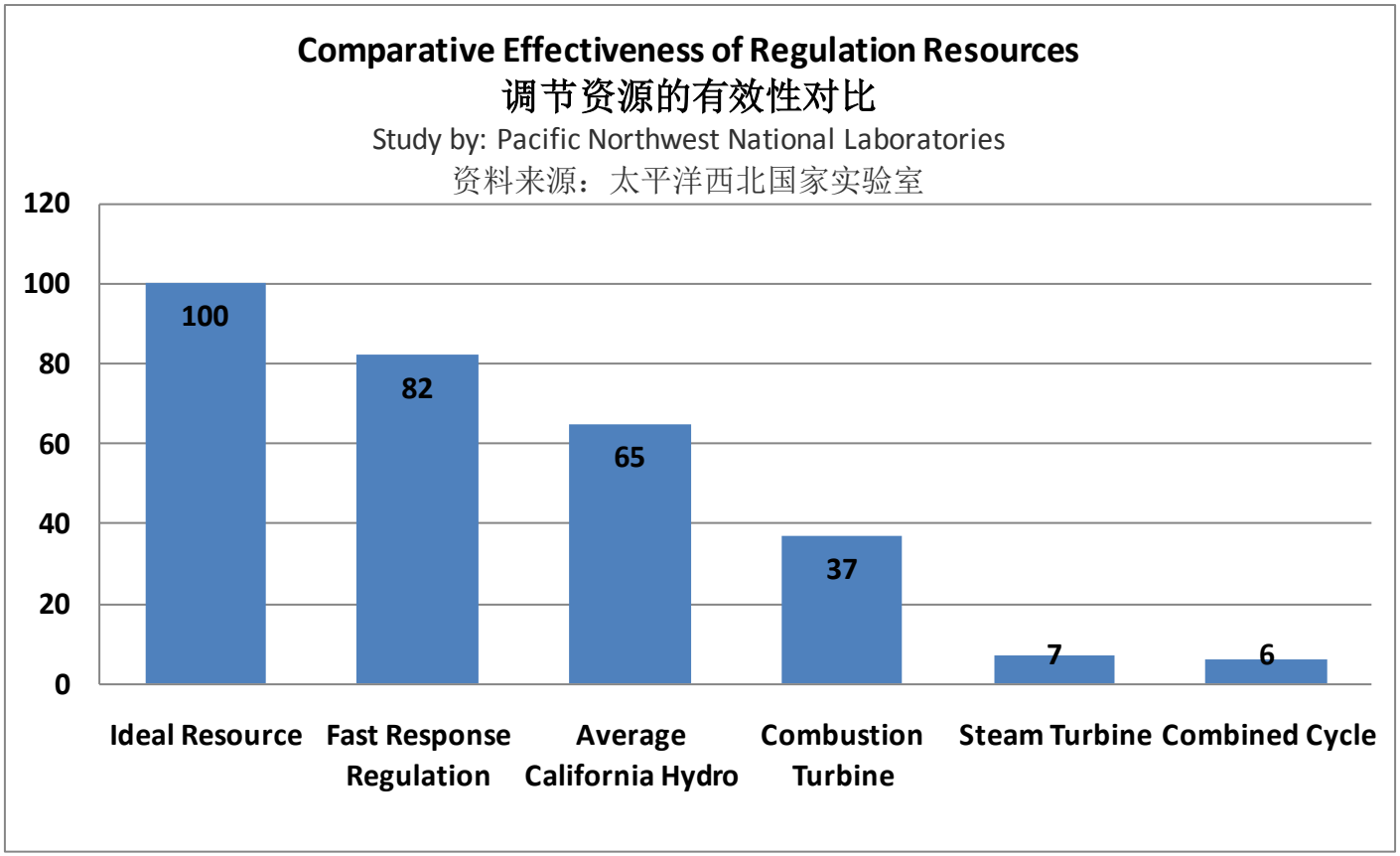
- 需求响应有助于吸纳更多风电，且较增加发电容量或辅助服务成本更低
  - 对解决极端风况下的并网问题更为成本有效，这种情况一年可能仅发生几个小时

- 引进插电式电动车也有助于吸纳更多风电
  - 插电式混合动力车在晚间充电，刚好与风电产量高的时段吻合

# System Benefits of Fast Regulation
# 快速调节的系统效益

MW of Regulation Displaced by 1 MW Fast Response Resource

**1兆瓦的快速响应资源替代的调节资源**




*Fast Response resources reduce the amount of necessary Regulation*
*快速响应资源减少了必要的调节资源*

# System Benefits of Fast Regulation
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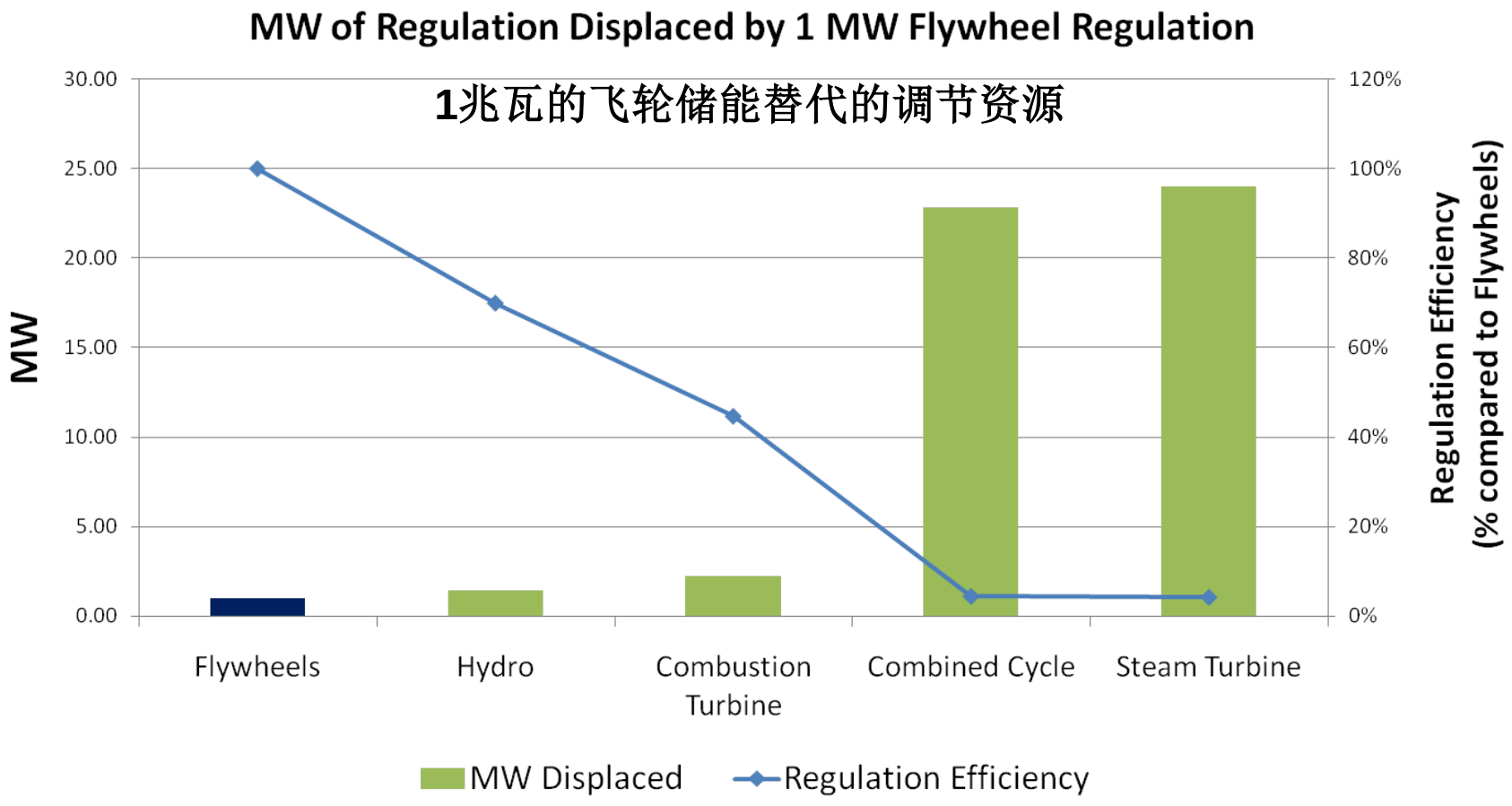


Thank you
谢谢大家！