Integrating Wind Generation on Northwest Power Grids: Learning by Doing.
风电接入西北电网： 在实践中学习

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西北电力与节能委员会
Presented December 2010

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Northwest Power and Conservation Council
西北电力与节能委员会

- Established by federal legislation to provide regional guidance on energy issues.
  通过联邦立法成立，提供有关能源问题的区域性指导
  - Council members are appointed by the governors of the four Northwest states: Oregon, Washington, Idaho, and Montana.
    委员会成员分别由西北四州的州长指定：俄勒冈州，华盛顿州，爱达荷州和蒙大拿州。
- Reviews regional power plan at least every five years.
  至少每五年进行一次区域性电力规划评审
- Recommends funding for fish and wildlife programs to mitigate effects of hydro power development.
  建议为鱼类和野生动物保护项目提供资金，以减轻水电发展的影响。
- Encourages broad public participation in regional energy issues.
  鼓励公众广泛参与区域能源问题的讨论。

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Northwest Region
西北地区

- The four Northwest states of Oregon, Washington, Idaho, and western Montana.
  西北的四个州：俄勒冈，华盛顿州，爱达荷州和蒙大拿州西部。
  - Population ~13,000,000　　人口约13,000,000

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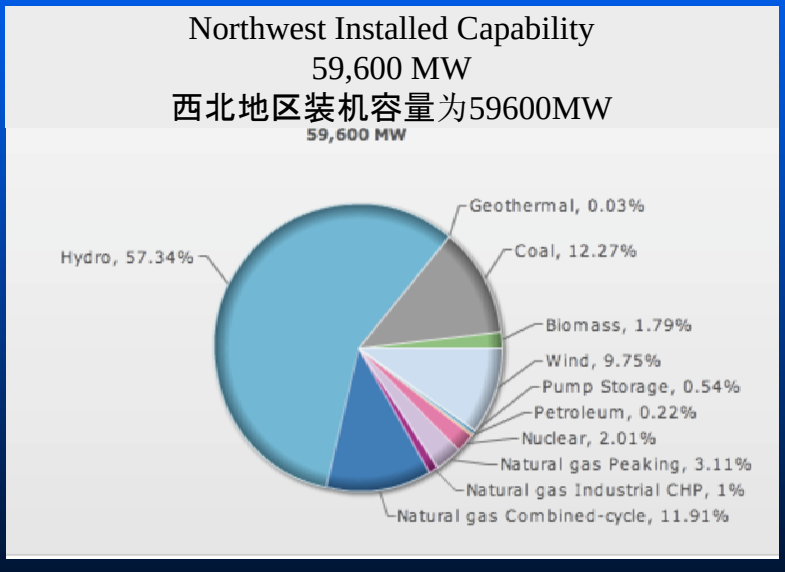
Northwest Region Electric Resources
西北地区电力资源

- Dominated by hydro with fast growing wind and natural gas sectors.
  主要由水电构成，同时风电，燃气发电快速发展，



水电：57.34%
地热：0.03%
煤电：12.27%
生物质发电：1.79%
风电：9.75%
抽水蓄能：0.54%
燃油：0.22%
核电：2.01%
天然气调峰：3.11%
天然气工业热电联产：1%
天然气联合循环：11.91%

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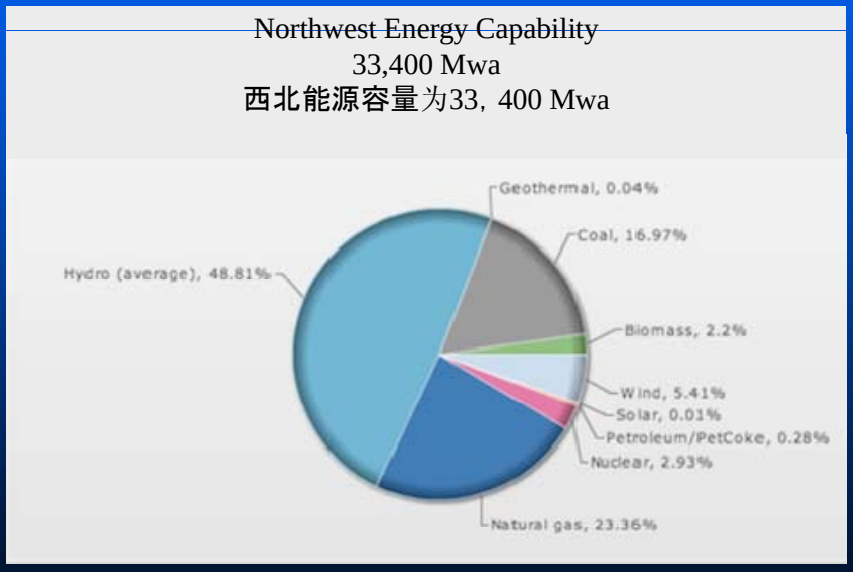
Northwest Region Electric Resources
西北地区电力资源

- By energy contribution.
  按能源贡献算



水电(平均):48.81%
地热:0.04%
煤电:16.67%
生物质发电:2.2%
风电:5.41%
太阳能:0.01%
燃油/焦煤:0.28%
核电: 2.93%
天然气:23.36%

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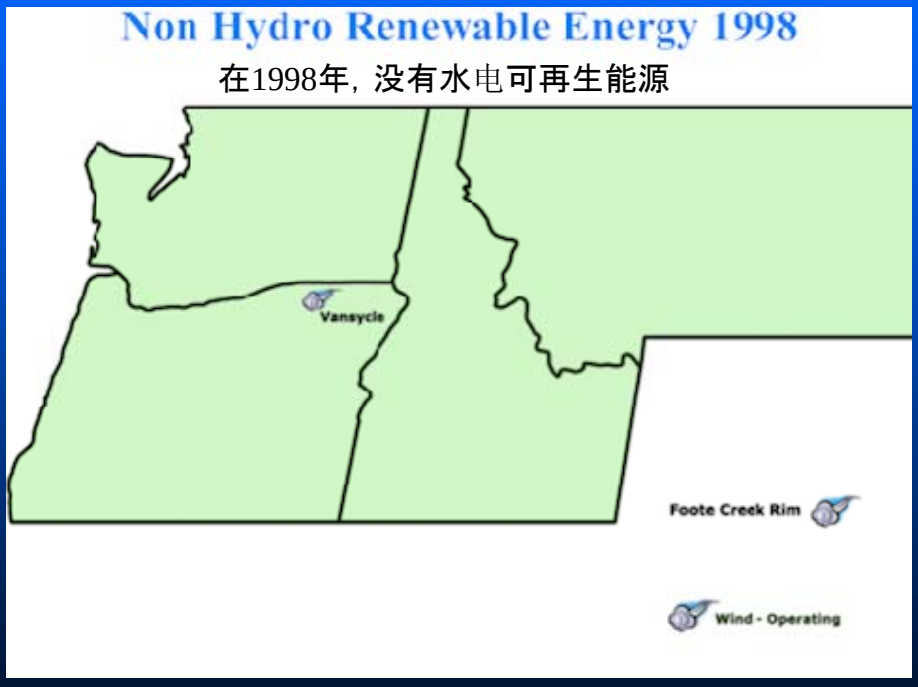
Rapid Growth of Wind in Northwest
风电在西北地区迅速发展



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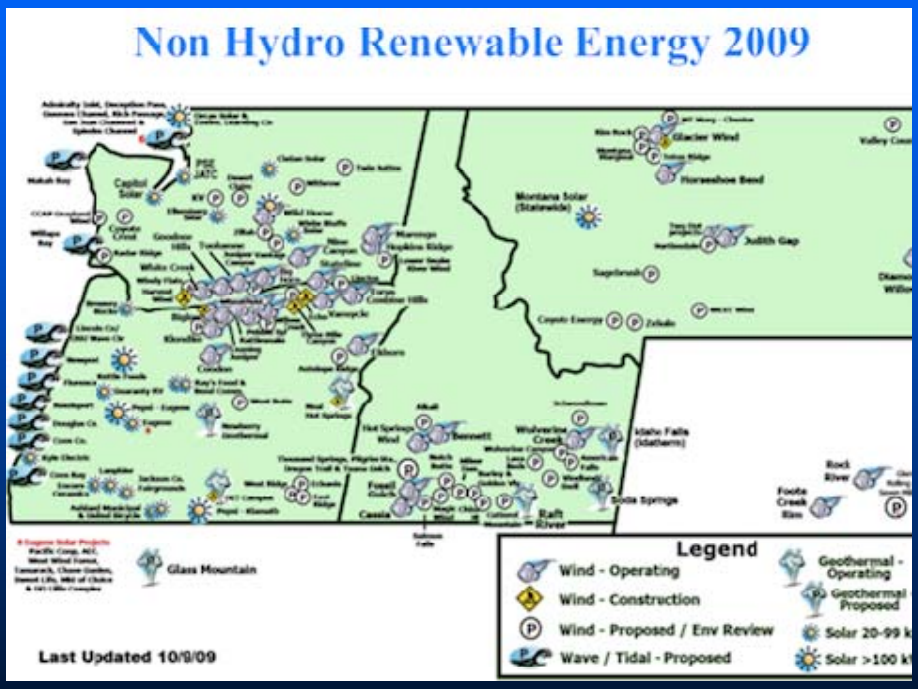
Rapid Growth of Wind in Northwest
风电在西北地区迅速发展



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Promoting Renewable Energy: State and Federal Policies
促进可再生能源发展:州和联邦政策

- Federal government offered ~$20/MWh tax credit for first ten years of production. 联邦政府在首个十年运行期内提供 $20/MWh的税收抵免。
- States developed renewable energy targets. 各州开发可再生能源的目标
  - Montana as part of state legislature market restructuring.
    蒙大拿州议会将其作为市场重组计划的一部分
  - Washington by ballot initiative of the people.
    华盛顿州通过投票表达人民的意愿
  - Oregon by state legislative action. 俄勒冈州通过州立法实行
  - No action in Idaho. 爱达荷州没有任何举动
- State tax incentives. 各州的税收激励政策
  - Oregon tax credit (50% of investment up to $10 million).
    俄勒冈州税收抵免政策(50%的投资可高达1000万美元)
  - Washington sales tax exemption . 华盛顿免征营业税政策
  - Montana property and energy transaction tax exemptions.
    蒙大拿州的财产和能源交易税豁免政策

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Leaders Became Concerned
领导人开始关注

- The growth in wind generation began to concern regional leaders in the power industry.
  风电的发展使得地区领导人开始关注电力行业
- The "Wind Integration Forum" was established to determine whether reaching 6,000 MW of wind generation was technically feasible.
  "风电接入论坛"的举行就是为了讨论开发6000MW的风力发电在技术上是否可行。

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Wind Integration Definition
风电接入定义

- Wind Generation is inherently variable and not completely predictable.
  风力发电有着固有的波动性，不能够完全被预测。
  - ***Wind integration means changes in power system operations that foster the efficient and reliable operation of the electric grid.***
    风电接入意味着电力系统运行的改变，而电力系统运行必须确保电力网络的经济与可靠运行。

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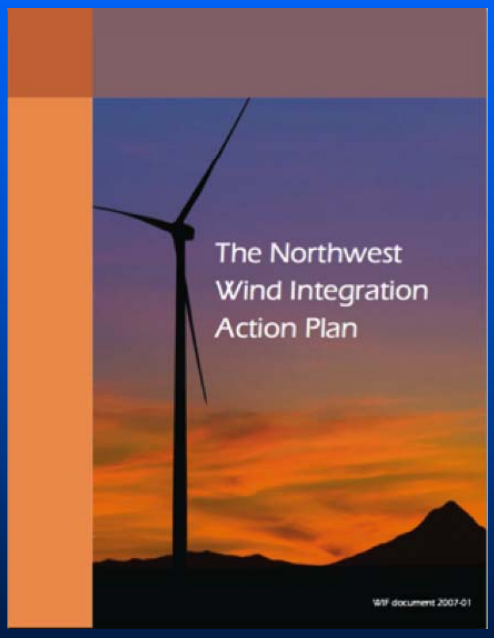
The Answer Was Yes!
答案是：对！

- Resulted in a report recommending 16 Action Items to support the efficient and economic development of wind generation.
  形成这样一份报告，推荐16项措施来支持有效与经济地发展风电。
- The report observed that the primary value of wind is in displacing fossil fuel consumption and emissions.
  该报告指出，风电的主要价值在于替代化石燃料的消耗和排放。



http://www.nwcouncil.org/energy/Wind/library/2007-1.pdf

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Market Conditions Matter
市场条件情况

- The Northwest is divided into 17 grid operators or "Balancing Areas," each one separately responsible for reliability within its service territory.
  西北地区被分为17个电网运营机构或平衡区域。每个运营机构分别对自己服务区域的可靠性负责。
- Balancing areas trade with one another under various contractual arrangements and through bilateral trades for hour-long operating periods.
  平衡区域之间在各种协议安排的规则下进行交易，在小时级运营周期进行双边交易。
- Balancing Areas are for the most part on their own for the duration of each operating period.
  平衡区域主要从自身角度考虑每个运营周期的持续时间。
- It is clear that sharing resources and variability across Balancing Areas is a huge benefit.
  很明显，平衡区域间的共享资源和共同承担风电波动性会带来巨大收益。

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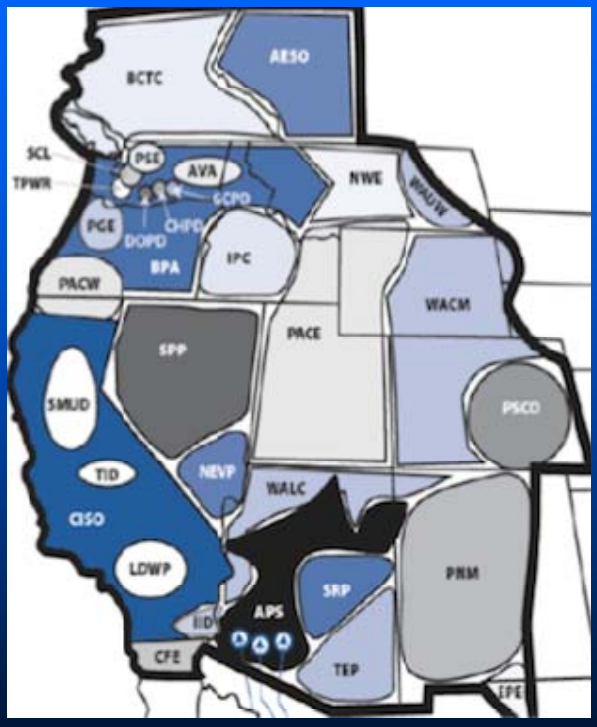
Multiplicity of Balancing Areas
平衡区域的多样性



- As a result of historical development, and possibly cultural preferences, the west developed around many, relatively small balancing areas.

  由于历史发展或文化偏好的原因，西部只发展了一些相对小的平衡区域

  - Not conducive to fostering efficient integration of wind energy.

    不利于培育风电的有效接入

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Wind Concentrated in One Balancing Area
风能集中在一个平衡区域

- The federal Bonneville Power Administration (BPA) owns 75% of the Northwest high voltage transmission system, and about 75% of wind generation interconnects with them.

  美国邦那维尔电力局(BPA)拥有75%西北高压输电系统，和与其联网的约75%的风电。

  - Most of the wind is sent across the BPA system to other regional Balancing Areas.

    大部分风电是通过BPA的电力系统输送到其他平衡区域的。

  - BPA has begun to charge a wind integration fee for providing balancing services.

    美国邦那维尔电力局已经开始为提供平衡服务对风电接入收取费用。

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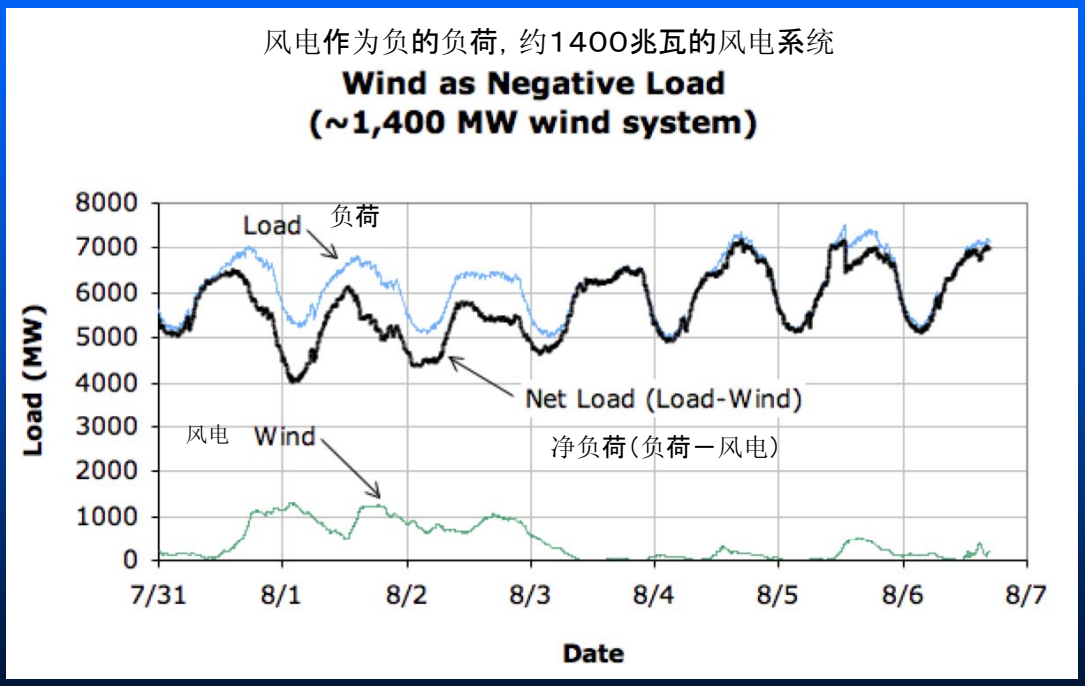
Dispatching Wind First
首先，对风电调度



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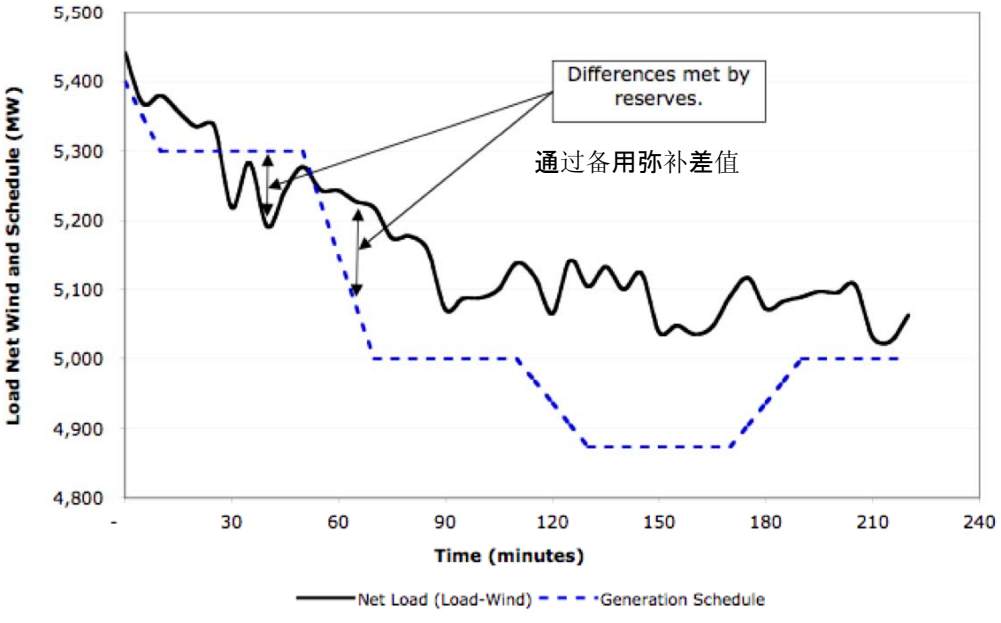
Balancing Act and Reserve Generation
平衡措施和备用发电



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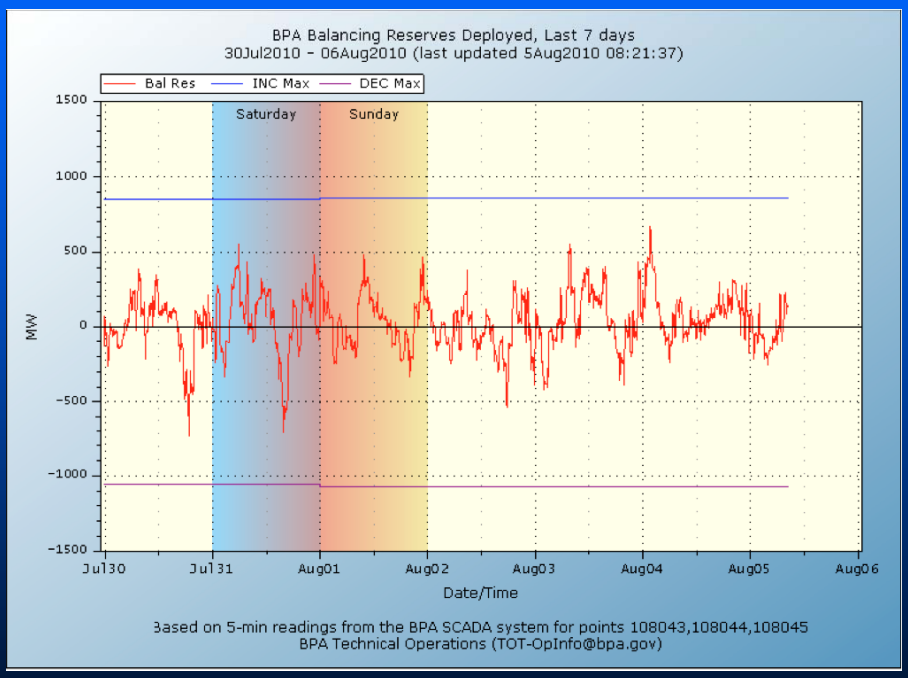
Balancing Reserve Burden
平衡备用负担



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Reserve Requirements
备用需求

- Chief among power system operators concerns--having sufficient capability to increase or decrease generation levels as the combination of wind and load vary.

  电力系统运营商主要关心的是:综合考虑风电和负荷的变化，拥有足够的容量增加或减少发电量。

- Larger impacts to balancing areas transmitting wind to meet demand outside their territory.

  输送风电以满足其区域外的需求对平衡区有更大影响。

  – For example, Montana has lots of wind but little balancing generation or native load.

    例如： 蒙大拿州有很多风电，但只有很少的平衡电源和本地负荷。

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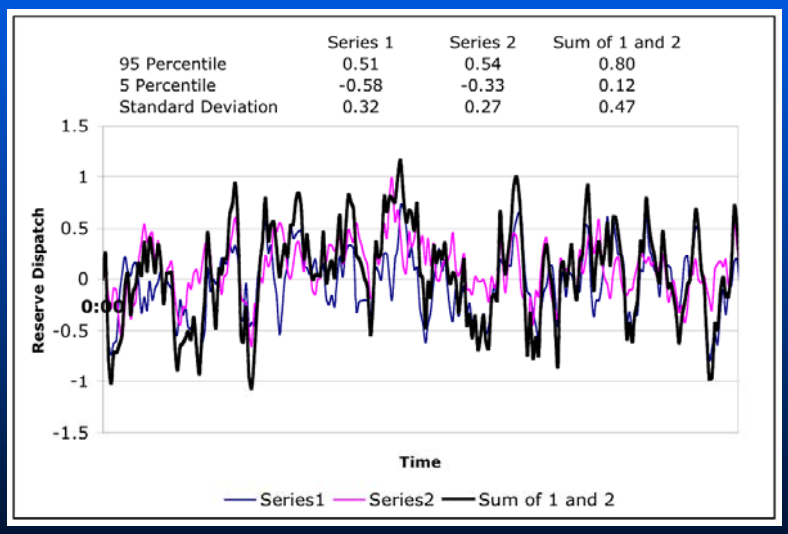
Sharing Balancing Burden Across Balancing Areas
跨平衡区域分担平衡负担

- Working together is best
  协同工作是最好的。



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Actions to Reduce Impacts
减小影响的措施

- Balancing Areas working to unify trading practices to allow half-hour trading.
  为进行半小时级交易，平衡区域间应统一交易行为。
- Implementing automated market (e.g., “bulletin board”) within-hour trading.
  实施自动化市场以进行小时内交易（例如，设置“公告栏”）
- Balancing Area sharing of energy imbalances on sub-hourly timescales.
  在次小时级时间尺度上，平衡区域间共同承担能源的不平衡。
- Consideration of Balancing Area Consolidation.
  考虑平衡区域的联合合并。

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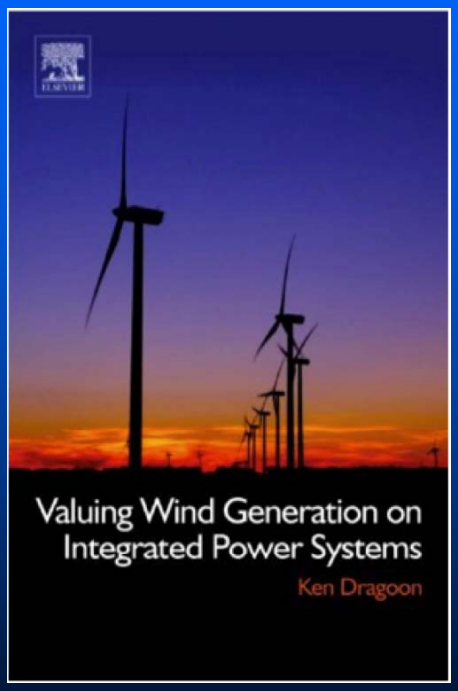
Wind Integration Studies
风电接入研究

- Calculating reserve requirements is usually done in complex wind integration studies.
  在综合的风电接入研究中经常会计算备用需求。
  - Relatively complex calculations that many balancing areas may not be prepared to undertake.
    很多平衡区域还没准备好去承担这相对复杂的计算
- Northwest utilities have tended to over-estimate amounts and cost of reserves.
  西北公用事业公司往往过高估计备用量和备用成本。
- Many wind integration studies have been undertaken, and there is even a book on the subject.
  风电接入的研究已有很多，关于这个题目已有相关书籍。



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Growing Pains
日益增加的烦恼

- June 2010 high unpredicted river flows, nearly full reservoirs… and high wind at times.
  2010年6月未预测到河流的大流量，水库几乎全满...，同时有强风。
  - Hydro system operator did not want to pay wind generators to stop generating, and had limited ability to spill additional water due to environmental concerns.
    水电运营商不想为风电的停发而支付费用，同时由于对环境的考虑，也只有有限的弃水能力。
- Primary operational issue with respect to wind relates to large amounts of generation when little ability to use it (e.g., at night).
  风电的主要运行问题是在负荷较小的时候有大量的风电（比如，在夜晚）。

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Going Forward
进一步

- State targets require increasing levels of demand to be served by renewable energy-- variously 20-25% over the next 15 years or so (California targets 33% by 2020) .
  各州发展目标要求可再生能源提供电力占负荷需求的比例不断增加——在接下来的15年中达到20-25%（加州的目标是2020年达到33%）。
- Actions to improve ability to efficiently absorb wind energy will continue.
  实施提高有效消纳风电能力的措施
  - Changes in markets.
    市场的改变
  - Considering changes in tax incentives (to relieve some negative pricing).
    在税收优惠中考虑一些改进（减轻一些负定价）
  - Technological solutions, especially thermal storage.
    技术解决方案，特别是储热。

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Technological Solutions
技术解决方案

- Increase transmission capability among Balancing Areas.
  增加平衡区域之间输电能力
- Actively manage wind generation (especially under wind ramp conditions).
  主动管理风力发电（特别是风电爬坡情况）
- Improve forecasting capability.
  提高预测能力
- Increase storage capability to capture night time generation and relieve negative pricing events (likely thermal storage).
  增加储能能力以捕获夜晚的发电量，减少负定价（如储热）。

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Energy Storage for Balancing
用于平衡的电能存储

- Irish Grid study found energy storage not to be necessary.
  爱尔兰电网研究发现电能的存储不是必须的。
  - Less expensive to actively limit wind generation and ramp rates.
    主动限制风力发电和其爬坡率是经济的。
- To the extent energy storage is economic, thermal storage is likely to be the least cost opportunity.
  一定程度上储能是经济的，储热可能是最经济的做法。

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Danish Model
丹麦模型

- Denmark uses "waste" energy from power plant cooling systems to heat 60% of all buildings in district heating systems.
  丹麦用电厂冷却系统中的"废弃能量"对小区供热系统中60%的建筑物供暖。
- Large insulated hot water storage facilities
  大型绝热热水存储装置
- decouple electric generation from building space and water heating needs.
  将建筑物用电和建筑物空间与水供热需求分离
- At times when wind generation exceeds load and export capability, power can be used to heat water in storage facilities.
  当风电超出了负荷和外送容量时，多余的电力可用于加热储能设备中的水。
- Henrik Bindslev, Risø Director:
  The Danish power system will move from one where supply responds to demand, to one where demand responds to supply.
  丹麦的电力系统将从供给响应需求转换为需求响应供给。

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Avedøre District Heating 小区供热设施
Hot Water Storage Units 热水存储

- About 12 hours @570 MW of storage from the CHP plant serving Copenhagen.
  热电联产厂的12小时@570MW的储热容量为哥本哈根服务。
- Nearly 50,000 cubic meters of storage capacity.
  大约50000立方米的存储容量
- No electric heating elements… yet.
  至今还没有电加热设备

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Water Heater Storage Capability
热水器存储容量

- In the Northwest: 在西北部
  - More than 2,000 MWa electric water heating load
    大于20，000兆瓦的电热水器负荷
  - 4,000 MW of coincidental peak demand.
    4，000兆瓦同时发生的峰值负荷需求

Unit	Maximum Power (kW) 最大功率	Energy Storage Capacity (kWh) 能量存贮容量
50-gal water heater 50加仑热水器	4.5	13.2†
100-gal water heater 100加仑热水器	4.5	26.4†
2102 room heater 2102 房间供热器	3.6	13.5
2106 room heater 2106 房间供热器	10.8	40.0
4140 residential furnace 4140 住宅炉	45.6	240.0
8188 commercial furnace 8188 商业炉	160.0	960.0

†Assumes 60°F incoming water

Source: Steffes Corporation

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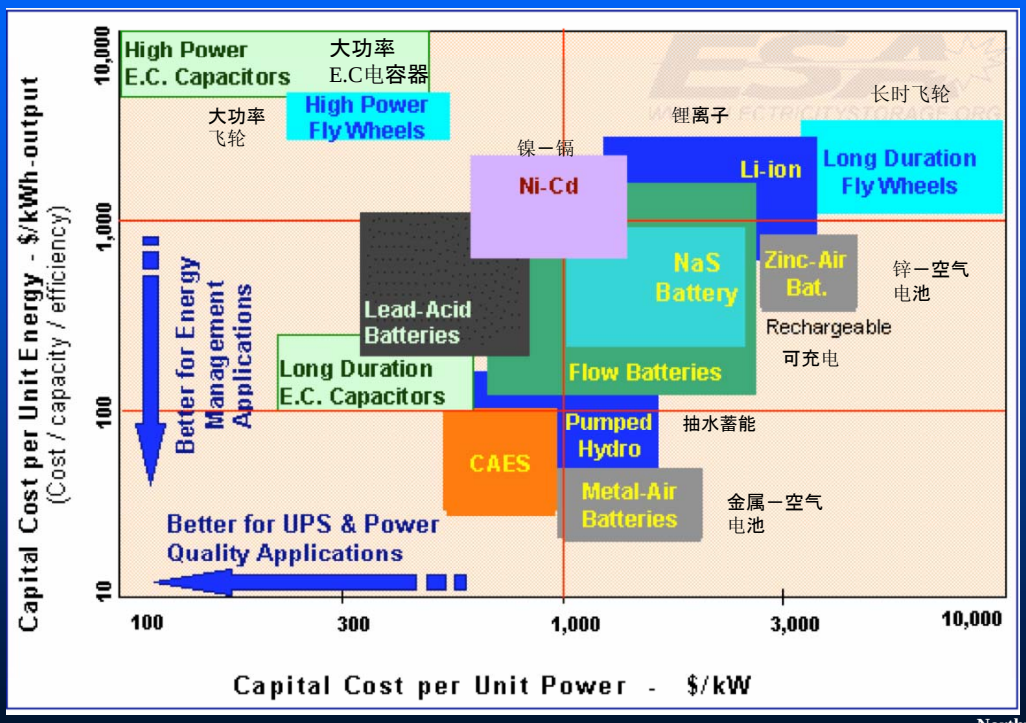
Thermal Storage-- Low Cost Source
热能存储 —— 低成本资源



 Source: Sandia National Laboratory

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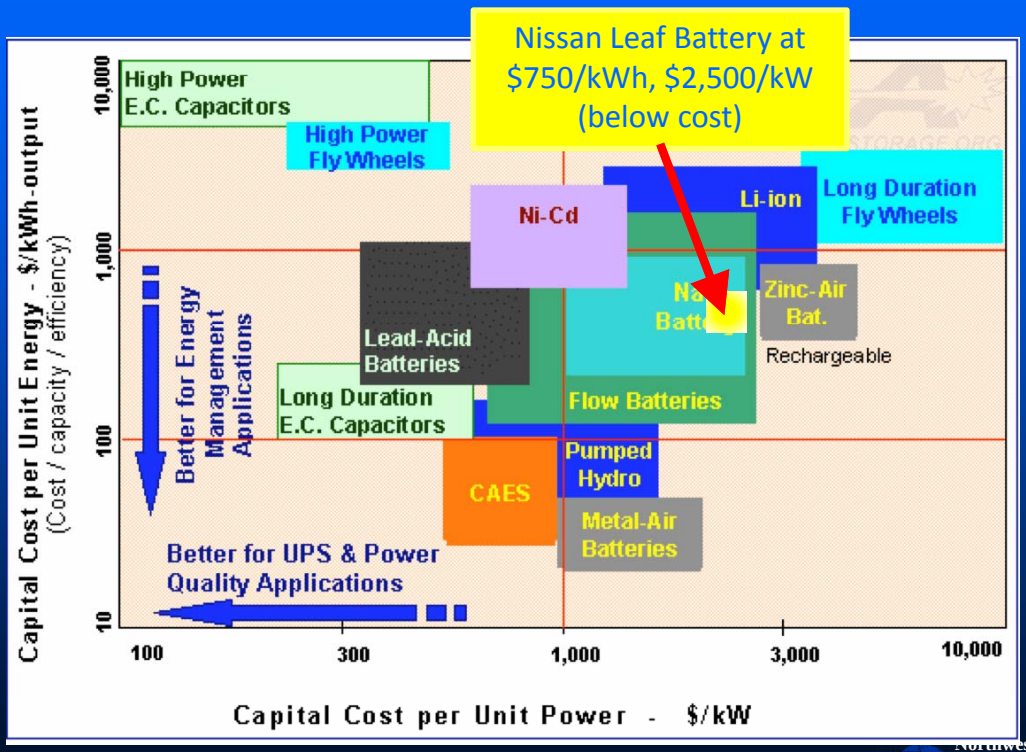
Thermal Storage-- Low Cost Source
热能存储 —— 低成本资源



 Source: Sandia National Laboratory

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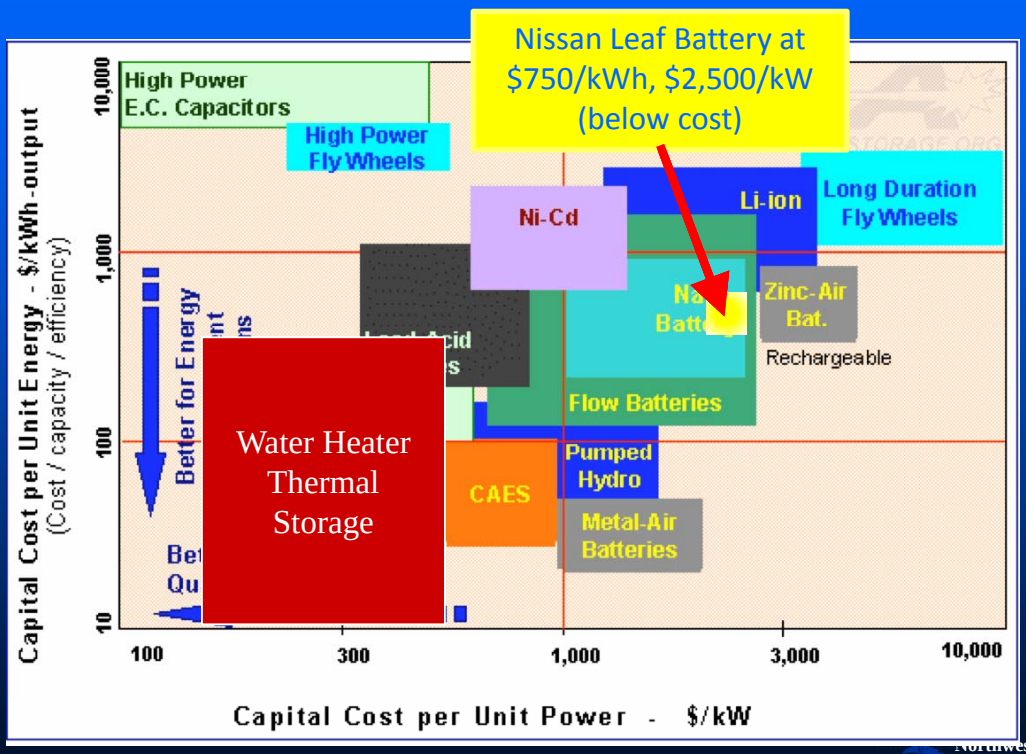
Thermal Storage-- Low Cost Source
热能存储 —— 低成本资源



Source: Sandia National Laboratory and Steffes Corporation

Thermal Storage Advantages
热能存储的优势

- Very low losses compared with most other technologies.
  与其他技术相比，损耗低。
- Very low cycling costs and long lifetimes little affected by cycling.
  非常低的循环成本和长的生命周期，受循环影响小。
- Cost mostly proportional to maximum energy storage-- not as sensitive to power levels.
  成本基本与最大存储能量成正比－对能量等级不敏感

Thank You

- Please feel free to contact me with questions.
  如有问题，欢迎与我联系
  – Kdragoon@nwcouncil.org

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