Water Power R&D in the Department of Energy

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Office of Energy Efficiency and Renewable Energy

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Tulsa, OK, June 10, 2009

DOE' new Water Power Program started in 2008

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- DOE authorized to reestablish a water power program:
  - EPAct 2005 addressed both conventional hydro (CH) plus marine and hydrokinetic technologies (MHK)
  - EISA 2007 emphasizing MHK
- $10 million Appropriated in FY08 for both CH and MHK (zero requested)
- $40 million Appropriate in FY09 ($3M requested)
- $30 million requested in FY10 Budget
- Recover Act funds also possible

EERE is the key DOE office for Hydropower

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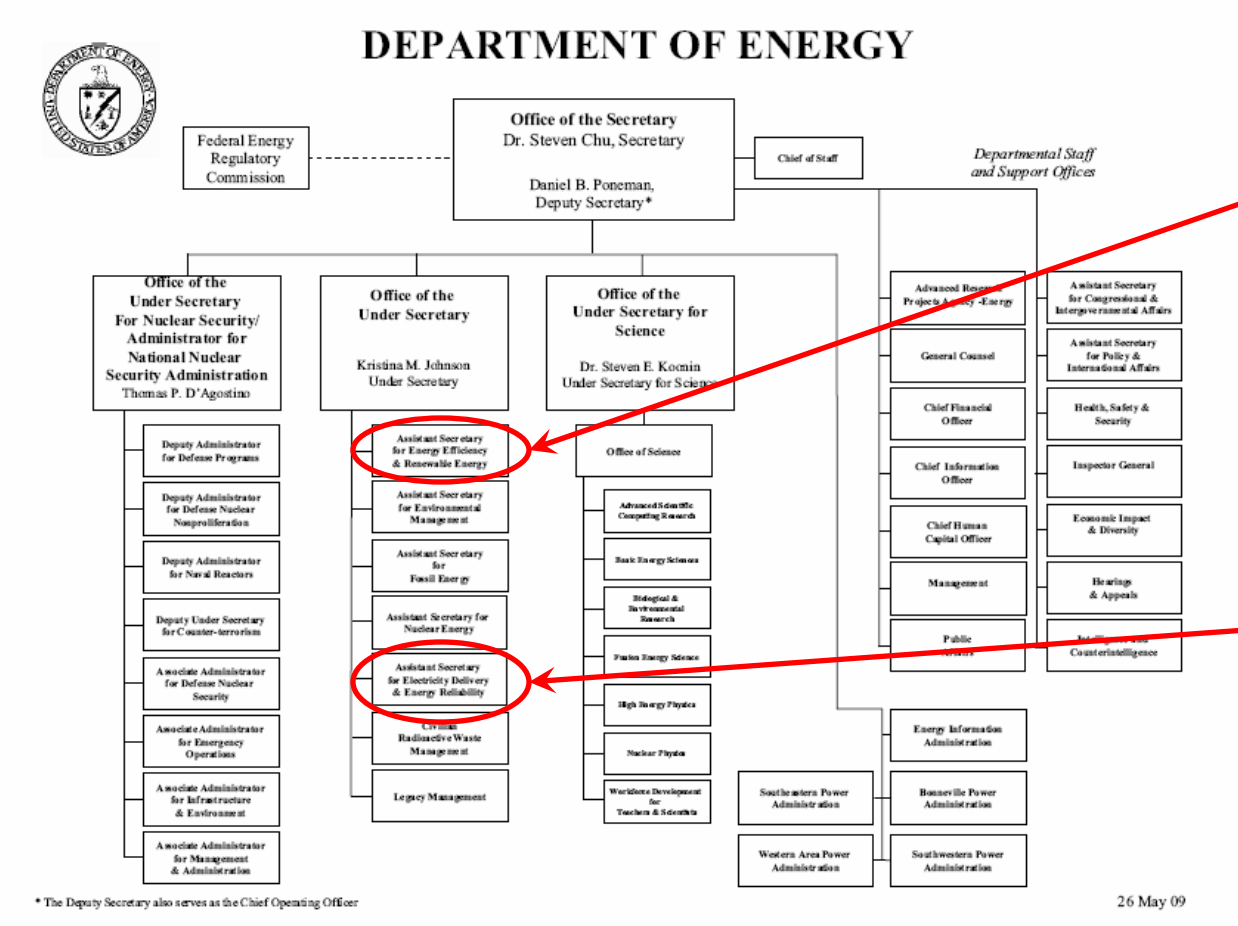

Office of Energy Efficiency and Renewable Energy (EERE or EE)

Office of Energy Delivery and Energy Reliability (OE)

Hydropower is combined with Wind in one Office

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WHTP Program Manager

Megan McCluer

Water Power Team Lead

Alejandro Moreno

DOE HQ Staff

Technology Development
Vacant

Market Acceleration
Vacant

Project Sitimg and Environmental Impacts
Patrick Gilman (.5)

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Water Competitive Solicitation Project Manager
Curtis Framel

Water Contracts
Tim Ramsey

Contracting Support
Jeff Rieks

Supporting Contractors

Marine and Hydrokinetic Technologies Support
Michael Reed (New West/IS)

Hydropower Technologies Support
Michael Sale (New West/IS)

Technical Characterization & Industry Relations
Robert Whitson (Sentech)

Budget, Planning & Communications
Laurel Winkenwerder (BCS)

Hydropower is the foundation of renewables in the U.S.

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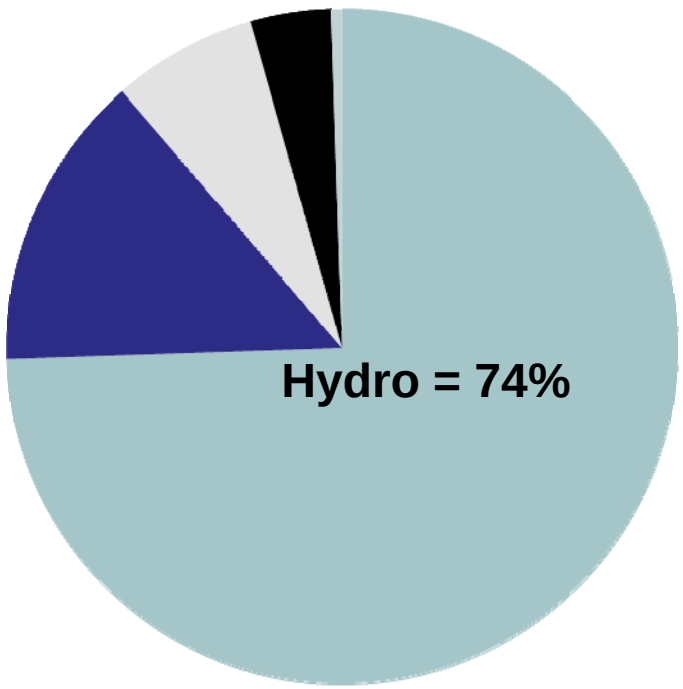
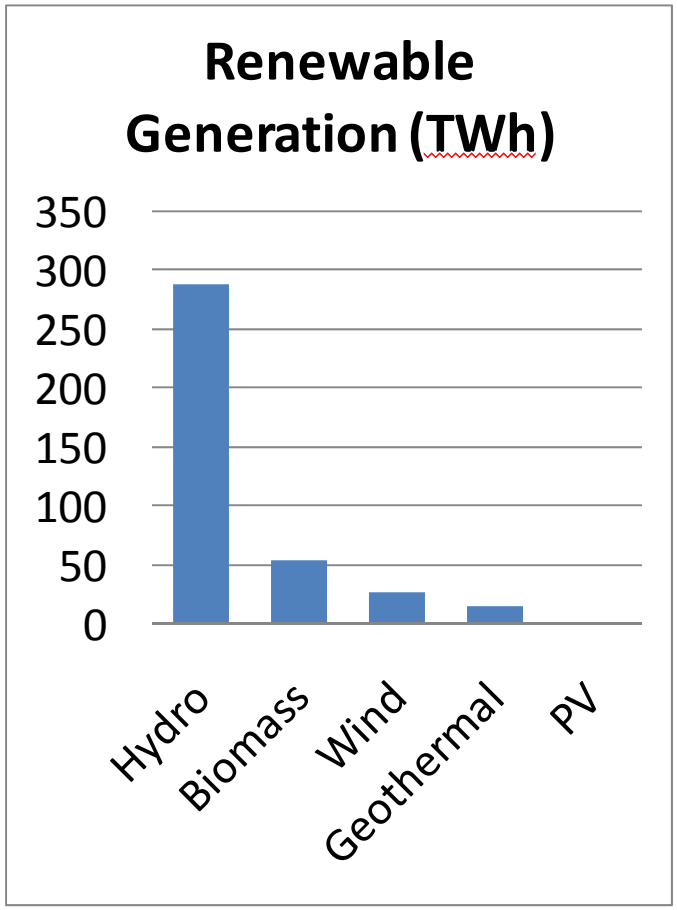
EIA generation data from 2006



Hydro
Biomass
Wind
Geothermal
PV
CSP



Trends in Hydropower are troublesome

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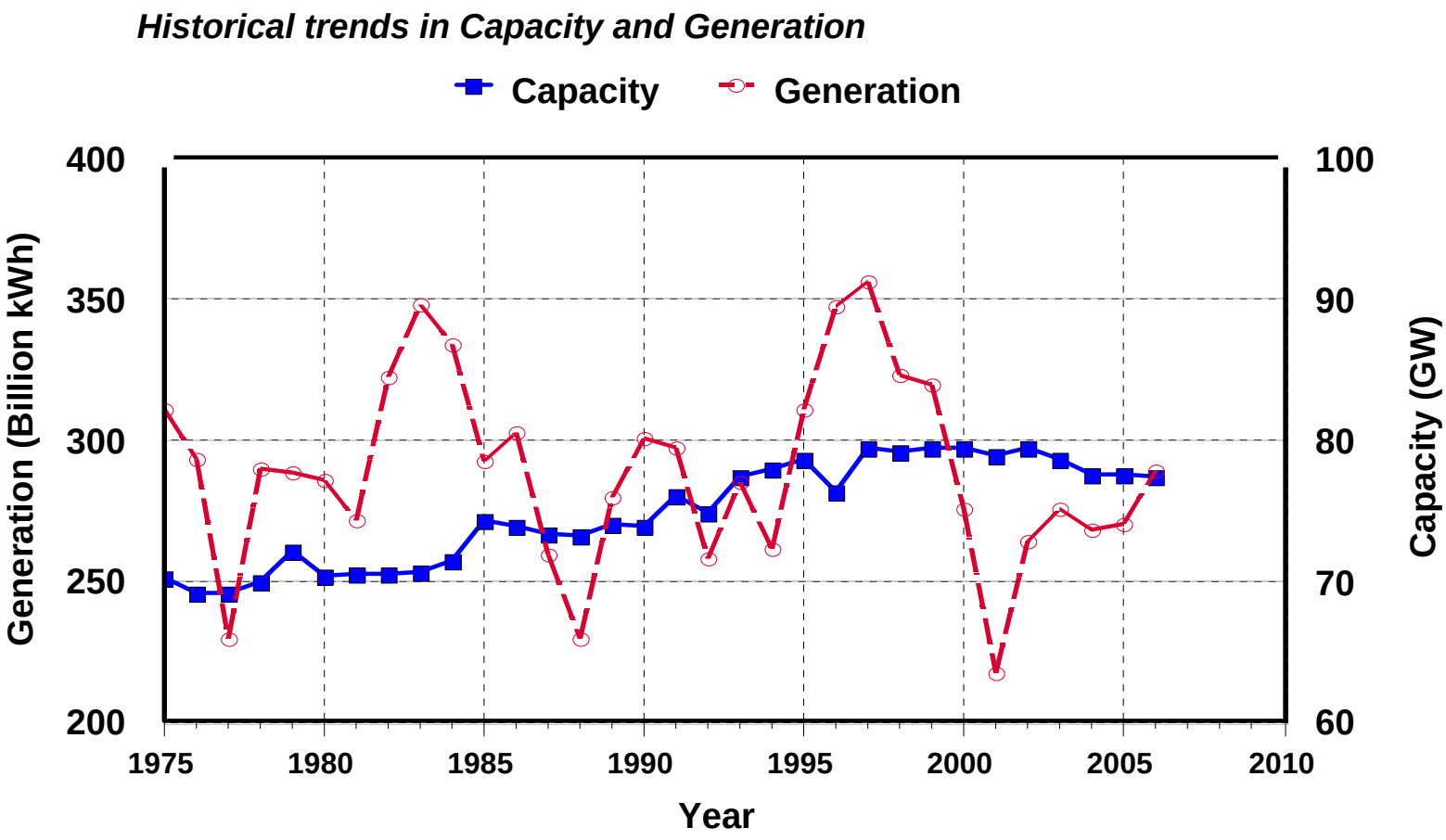

Hydropower is mix of federal and non-federal projects

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	Number of Projects	Number of Units	Total Capacity (GW)	Average Project Size (MW)	Average Units per Project	Average Unit Size (MW)
Corps of Engineers	74	350	20.4	276	4.7	58
Bureau of Reclamation	58	194	14.8	255	3.3	76
TVA	29	109	3.9	134	3.8	36
Total Federal	***161***	***653***	***39.1***	***243***	***4.1***	***60***
FERC Licenses *	1012	n/a	53.5	53	n/a	n/a
FERC Exemptions	595	n/a	0.8	1.4	n/a	n/a
Total Nonfederal *	***1607***		***54.3***	***34***		

*** Includes approximately 18 MW of pumped storage projects.**

The whole portfolio must be understood to reach a unified understanding of national trends.

DOE Goals are to increase generation and value

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Federal investment is necessary to overcome issues confronting hydropower, as well as improve energy efficiency and environmental performance.

Water Program Priorities Include:

Understand Assets and Resources	Improve Environmental Performance	Increase Power Generation	Maximize Ancillary Benefits
• Describe resources, generation patterns, water availability, cost of development and economic impacts of existing hydro fleet • Identify full range of undeveloped incremental hydro resources and opportunities to update/modernize facilities	• Technological advancements to improve fish passage • Understand GHG emissions from reservoirs • Assess cumulative impact and reduce stresses on wildlife and environment	• Develop and demonstrate technologies to modernize hydro facilities, including pumped storage • Expand incremental hydropower	• Assess and quantify value of existing hydro/PS fleet to support grid stability and further integrate variable generation • Identify opportunities to increase ancillary value, including the development of new technologies and processes, and policies

Program activities are divided into two focus areas

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Technology Development

1. **Technology Development and Deployment**

   Examples:

   - ***Advanced technologies development and deployment***
   - ***Basic and materials research***
   - ***Sensors and controls to improve power system performance, flexibility and reliability***

Market Acceleration

1. **Environmental impacts and mitigation**

   Examples:

   - ***Improved fish passage***
   - ***Water use optimization***
   - ***GHG reservoir emissions***

2. **Asset management**

   Examples:

   - ***Resource/industry assessments***
   - ***Asset upgrades***
   - ***Economics and employment***

3. **Integrated Power Systems**

   Examples:

   - ***Wind/hydro integration***
   - ***Grid Services modeling***

Pumped-hydro technologies do fit among priorities

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- ***Driving question:*** What are the availability, cost, and value of hydro flexibility to transmission systems?
- **Water Power Grid Services R&D (EE-Water)**
  - Development and testing of new methods to quantify ancillary benefits of conventional and pumped-storage hydro
  - Competitive solicitation out now for new, industry-led project
- **Renewable Systems Interconnection (RSI) Program (EE-Wind plus OE)**
  - Major element of the DOE Wind Program (Stan Calvert)
  - Address barriers to expanded use of wind energy with high technological and institutional focus -- beyond wind turbine design

Current RSI activities focus on Wind Energy first

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- ***Wind Plant Performance Characterization***
  - Resource assessment
  - Forecasting
  - Generator and wind farm modeling
- ***Grid System Operations***
  - Analysis methods and tools
  - Interconnection studies
  - Mitigation strategies
- ***Grid System Planning***
  - System expansion studies
  - Planning assistance
  - Increasing existing line usage
- ***Communication, Policy, Education and Outreach***

Hydropower tends to be a constraint in RSI modeling

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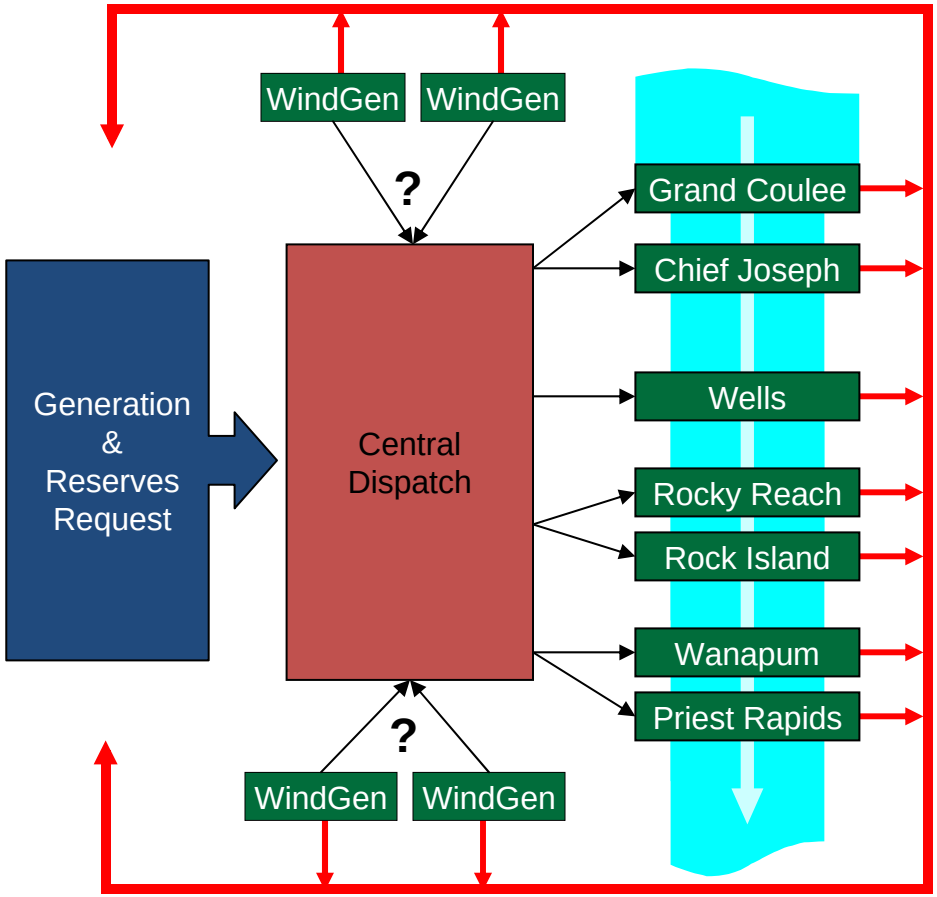
- **Aggregation of wind resource: hydro generation and reserve requirements depend on how load-net-wind is aggregated**
- **What is overall increase in energy availability (hydro + wind) with wind integration?**
- **How do environmental constraints limit wind integration?**
- **How are sub-hourly optimization gains affected by inclusion of wind - - phase 2**
- **Individual utility impacts**
  - which hydro projects are impacted most and why?
  - integration costs or changes in value of hydro?
  - changes in hydro damage costs
- **Explicit inclusion of transmission constraints?**

Pacific Northwest Virtual Balancing Area Wind Integration Analysis



Non-federal developers see a future in pumped-storage

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FERC licensing proceedings as of January 2009:

- 23 preliminary permits issued for 15 GW
- 15 applications pending for 16 GW more

Much work to be done in modernizing hydropower

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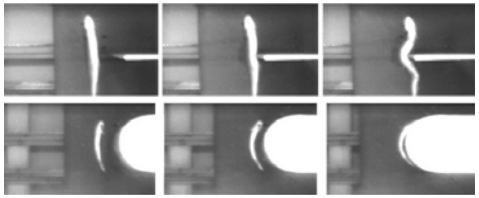
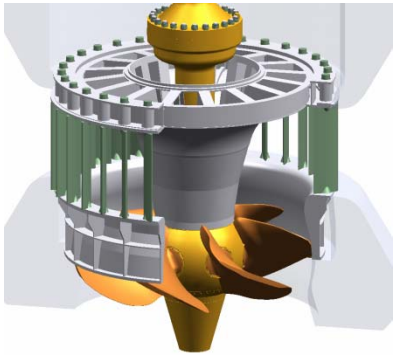
- **Dichotomy of federal and non-federal projects is artificial and counterproductive**
- **Areas of opportunity:**
  - Resource assessment, modeling, and climate change impacts
  - Technology development and testing, for energy and environment
  - R&D to find more cost-effective solutions
  - Regulatory streamlining and policy options
- **Cooperative studies could be organized under a new Interagency Hydropower Taskforce**





EPRI estimates large blocks of new water power by 2025

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Water Power type	Most-Likely Scenario	Aggressive Scenario *
New, Large Hydro	500	2,500
Small, Low-Power Hydro	3,375	5,400
Capacity Gains at Existing Plants	2,875	3,000
New Hydro at Existing Dams	7,000	8,000
In-River Hydrokinetic Projects	3,000	3,000
Tidal-Current Hydrokinetic Projects	3,000	3,000
Ocean Wave Projects	10,000	12,000
Pumped Storage Projects	10,000	12,500
TOTALS	**39,750**	**49,400**

* Aggressive scenario involves strong policy and investment strategies at federal and state levels.

Source: *Updated Edition of Assessment of Waterpower Potential and Development Needs. EPRI, Palo Alto, CA: 2009.*

Data used to predict future directions need updating

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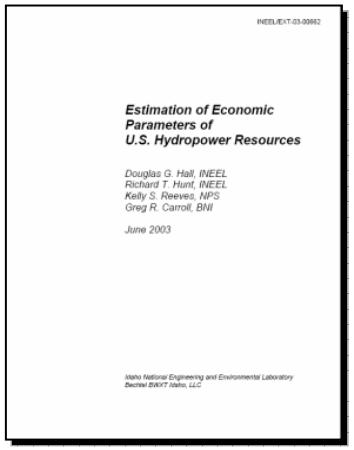
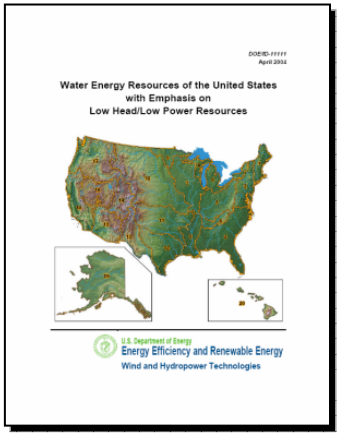
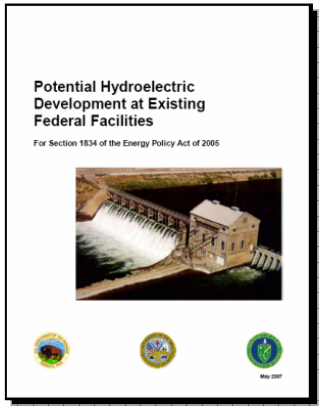
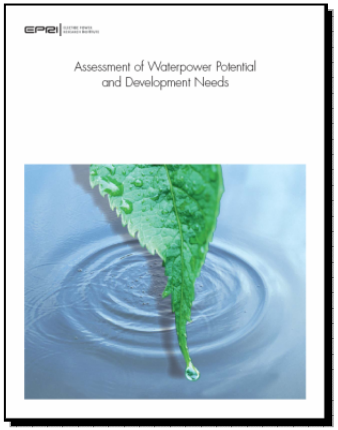
- EPRI studies of potential resources fall back to studies from early 2000s, which are based on FERC HPRA and NPS data of 1990s
- NREL carbon abatement study and new NHA/Navigant study rely on cost data from 2003
- EPAct Section 1834 study needs to be updated









NHAAP started with building a better database

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Initial scope: Describe all existing federal and nonfederal facilities

- Project characteristics
  - *Power plants and equipment*
  - *Dams, diversions and reservoirs*
  - *Connectivity in river basins*
- Generation patterns for at least 10 years
- Water availability and competing water uses

Expanded scope in FY09

- Add pumped storage projects
- Add cost of development data
- Link to Regional Energy Deployment Systems Model (ReEDS) at NREL
- Import new resource data collected in FOA-2009

Analysis Team:

EnergyWorks, ORNL, NREL, other private sector advisors and contractors, plus agencies

Hydropower values are more than capacity and energy

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- GHG offsets
- Price on short-term markets (ancillary benefits)
- Contributions to grid stability (e.g., spinning reserve and voltage regulation)
- Enabler of other non-dispatchable renewables

Loss of hydropower negates gains in other renewables

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- Examples:
  - Loss in hydro capacity since 2000 (-2.5 GW) is equal to all existing geothermal capacity
  - Annual variability in hydro generation (± 70 TWh) exceeds total generation from other renewables
- Other troubling trends in Hydropower:
  - Availability of Corps projects is steadly dropping
  - Capacity factors drop in relicensing
- Bottom line: when we need more, we are getting less, because of neglect of the sector

Decrease in hydropower affects total GHG emissions

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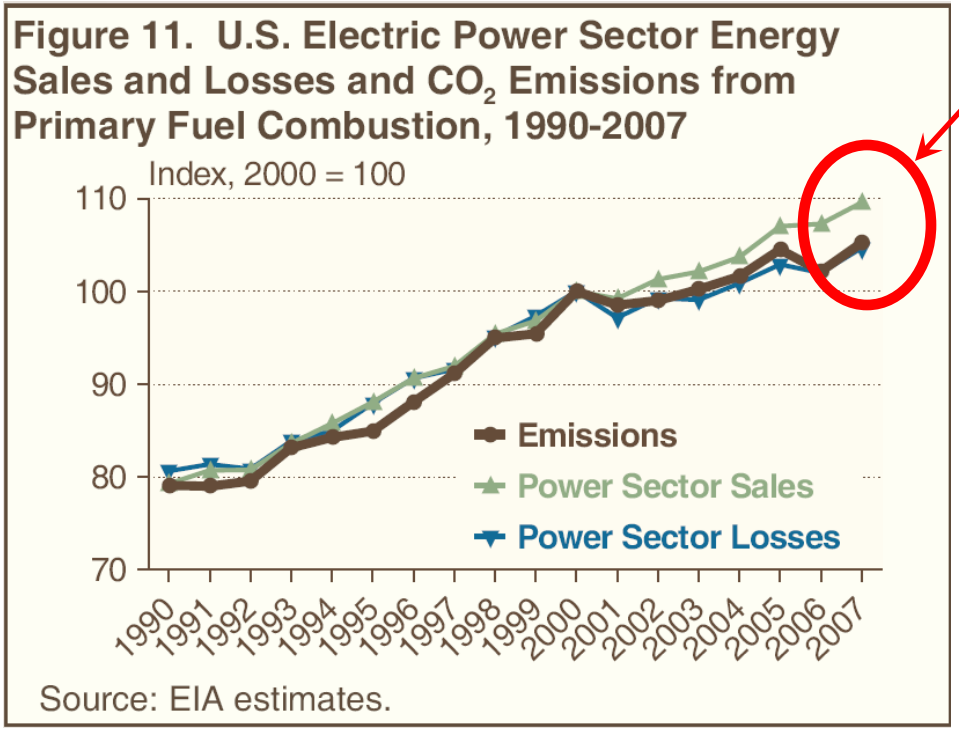

0.4% increase in carbon intensity in 2007 was due to a 40-TWh drop in hydropower generation, which offset increases in wind and nuclear

EIA 2008

***Source: Emissions of Greenhouse Gases in the U.S. 2007*, DOE-EIA-0573(2007), December 2008.**

Hydropower is no longer the cheapest renewable

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	Capacity (GW) by Scenario			Cost ($/kW or kWh)		
Development Type	***Low***	***Medium***	***High***	***cost now***	***2030 cost***	***life time***
New small hydro at new dams	0	5	12	3,125	2,900	50
New hydro at existing dams	8	15	21	2,010	1,810	30
Capacity upgrades	5	5	5	1,340	1,205	25
Efficiency upgrades	3.5	5.7	7.1	0.042	0.038	25
	16.5	30.7	45.1			

Source: McKinsey/NREL carbon abatement study, 2009

New hydropower can contribute to GHG reductions

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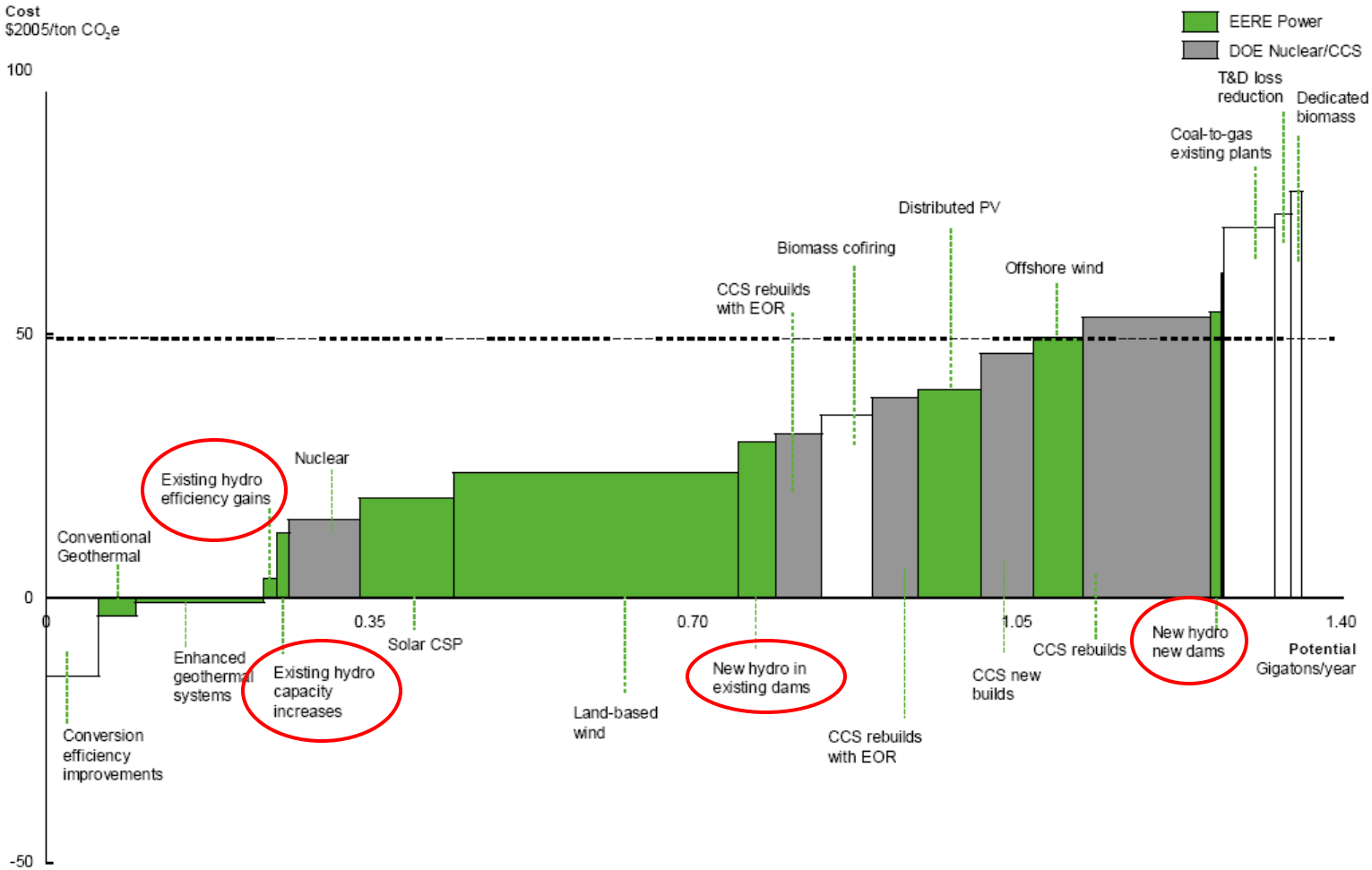
Figure 26

2030 POWER ABATEMENT CURVE – MID-RANGE CASE



Source: McKinsey analysis