

# MEMORANDUM OF UNDERSTANDING FOR HYDROPOWER

TWO-YEAR PROGRESS REPORT

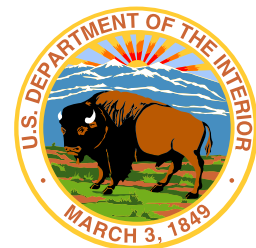
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US Army Corps  
of Engineers®



U.S. DEPARTMENT OF  
**ENERGY**



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## LIST OF ACRONYMS

AHS	Archimedes Hydrodynamic Screw
ANL	DOE's Argonne National Laboratory
BPA	Bonneville Power Administration
BSOA	Basin Scale Opportunity Assessment
CEATI	Centre for Energy Advancement through Technological Innovation
DOA	Department of the Army
DOE	Department of Energy
DOI	Department of the Interior
FERC	Federal Energy Regulatory Commission
FIHWG	Federal Inland Hydropower Working Group
FY	Fiscal Year
FOA	Funding Opportunity Announcement
GIS	Geographical Information System
GW	Gigawatt
HAP	Hydropower Advancement Project
HMI	Hydropower Modernization Initiative
LIHI	Low Impact Hydropower Institute
LOPP	Lease of Power Privilege
MOU	Memorandum of Understanding
MW	Megawatt
MWh	Megawatt Hour
NGO	Nongovernmental Organization
NHAAP	National Hydropower Asset Assessment Program
NPD	Non-powered dams
NREL	DOE's National Renewable Energy Laboratory
ORNL	DOE's Oak Ridge National Laboratory
PG	Pump Generator
PMA	Power Marketing Administration
PNNL	DOE's Pacific Northwest National Laboratory
R&D	Research and Development
Reclamation	DOI's Bureau of Reclamation
RFI	Request for Information
USACE or Corps	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

## EXECUTIVE SUMMARY

Since the U.S. Department of the Army (through the U.S. Army Corps of Engineers), U.S. Department of Energy, and U.S. Department of the Interior signed the Memorandum of Understanding (MOU) for Hydropower two years ago, these agencies have endeavored to advance their mutual goals for the development of clean, reliable, cost-effective, and sustainable hydropower generation in the United States. The MOU for Hydropower contains 13 high-level goals and 17 specific action items that are specifically targeted to help meet those goals. Through collaboration and partnerships with other federal agencies, the hydropower industry, the research community, and numerous stakeholders, these agencies have been able to succeed in the majority of their efforts. From March 2010 to March 2012, the three agencies have succeeded in accomplishing the following:

- Complete numerous publically available assessments of different hydropower resources, including the construction of a database for all existing U.S. hydropower infrastructure.
- Collaborate to develop tools for optimizing the operation of hydropower facilities and evaluating the potential for state-of-the-art upgrades and modernizations.
- Fund several research projects that aim to develop and demonstrate new hydropower generation technologies and minimize the environmental impacts of hydropower facilities.
- Work together to produce a report that examines the potential effects of climate change on water available for hydropower generation at federal facilities.
- Coordinate a stakeholder-driven, basin-scale opportunity assessment in the Deschutes River basin in the Pacific Northwest, with the goal of identifying opportunities for increasing both hydropower production and environmental services.
- Establish a Federal Inland Hydropower Working Group, including staff from 15 federal entities that are involved with hydropower in order to share information and increase collaboration.
- Host research and development workshops on key areas for the development of new hydropower generation.
- Initiate several new studies on pumped storage and the ancillary grid services that can be provided by hydropower.
- Improve the licensing process for the development of new, privately owned hydropower generation at existing federal dams and water infrastructure.

## INTRODUCTION

As the largest source of renewable electricity generation in the United States, hydropower provides a wide range of benefits to the country. Hydropower is a minimal emission, low-cost source of energy that can be relied upon for long-term, stable production of domestic electricity. Hydropower also provides consistent, reliable generation that can be quickly adjusted and dispatched to meet the various needs of the electric grid.



**Figure 1:** Jo-Ellen Darcy, Assistant Secretary of the Army for Civil Works; Steven Chu, Secretary of Energy; and Ken Salazar, Secretary of the Interior signing the Memorandum of Understanding for Hydropower on March 24, 2010.

On March 24, 2010, the Department of the Army (DOA) through the U.S. Army Corps of Engineers (USACE or Corps), the Department of Energy, and the Department of the Interior signed the Memorandum of Understanding (MOU) for Hydropower. The purpose of the MOU is to “help meet the nation’s needs for reliable, affordable, and environmentally sustainable hydropower by building a long-term working relationship, prioritizing similar goals, and aligning ongoing and future renewable energy development efforts.” Additionally, the MOU aims to “(1) support the maintenance and sustainable optimization of existing federal and non-federal hydropower projects, (2) elevate the goal of increased hydropower generation as a priority of each agency to the extent permitted by their respective statutory authorities, (3) promote energy efficiency, and (4) ensure that new hydropower generation is implemented in a sustainable manner.” To accomplish its purpose and aims, the MOU has 13 goals:

## MEMORANDUM OF UNDERSTANDING FOR HYDROPOWER

1. Enhance environmentally sustainable hydropower development and operation at federally owned hydropower generation facilities in order to provide clean, reliable, and affordable energy to American consumers.
2. Focus on a new approach to development of hydropower which increases hydropower generation and improves ecosystem function through environmentally sustainable, low-impact, or small hydropower projects.
3. Identify specific federal facilities and lands owned or controlled by the United States that are well-suited as sites for environmentally sustainable hydropower energy development, and collaborate on efforts to implement projects at these locations, including joint studies, demonstration projects, and other mutually supported partnership arrangements with private entities, Indian tribes, and state and federal agencies.
4. Coordinate efforts to assess the potential additional hydropower capacity available at federal hydropower facilities that is environmentally sustainable, including fostering an understanding of the potential effects of climate change on future generation capability.
5. Collaborate with Indian tribes, the environmental community, the owners of non-federal hydropower facilities, federal and state agencies, and other stakeholders to identify river basins where integrated basin-scale hydropower opportunity assessments could help facilitate the move to a low-carbon future, including both environmental sustainability and the delivery of renewable energy.
6. Emphasize the critical role that hydropower can play in helping to integrate other renewable energy technologies into the U.S. electric grid.
7. Promote an environmentally responsible approach to enhancing hydropower development that recognizes the need to preserve biological diversity, ecosystem function, our natural and cultural heritage, and recreational opportunities, and also recognizes that some geographic locations are not appropriate for new hydropower development.
8. Conduct research and disseminate results from environmental studies, and encourage development of specific standards for and certification of environmentally sustainable hydropower.
9. Work to integrate energy and water policies at the federal level not only to address the development of hydropower resources, but to also evaluate the use of non-hydropower renewable resources with water management operations, and promote water conservation as a means to realize species conservation, environmental and energy efficiency goals.
10. Investigate ways to responsibly facilitate the permitting process for federal and non-federal hydropower generation and other renewable energy projects at federally owned and Indian tribe facilities by increasing coordination among the agencies that have jurisdiction and reducing unnecessary delay, while ensuring that environmental impacts are fully considered.
11. Share information on renewable energy research and development (R&D) efforts being conducted by each agency along with any results obtained. Prevent the duplication of efforts and highlight potential areas of collaboration and/or joint funding.
12. Apply collective knowledge and lessons learned from conventional hydropower development, deployment, and management to the emerging in-river hydrokinetic technologies.
13. Increase levels of both formal and informal communication and coordination between officials and staff at multiple levels of each agency.

To address these goals, the MOU is organized into seven main topic areas, each with its own specific initiatives and action items. To distinguish how the 13 high-level goals are addressed by the various action items, see Table 1.

The seven organizational topic areas of the MOU are as follows:

- A. Federal facility energy resource assessment
- B. Integrated basin-scale opportunity assessments
- C. Green hydropower certification
- D. Federal Inland Hydropower Working Group (FIHWG)
- E. Technology development and deployment
- F. Renewable energy integration and energy storage
- G. Regulatory process.

**Table1:** MOU on Hydropower goals and associated action items.

Goal No.	MOU Goal	Associated Action Items
1	Enhance environmentally sustainable hydropower development and operation at federally owned hydropower generation facilities.	A.1.1, A.1.2, B.1.1, B.1.2, B.1.3, C.1.1, C.1.2, D.1.1
2	Investigate a new approach for river, basin-scale hydropower development that increases generation and improves ecosystem function.	B.1.1, B.1.2, B.1.3
3	Identify specific federal facilities and lands owned or controlled by the United States that are well-suited for environmentally sustainable hydropower development, and collaborate on efforts to implement projects at these locations.	A.1.1, A.1.2, B.1.1, B.1.2, B.1.3, C.1.1, C.1.2
4	Coordinate efforts to assess the potential additional hydropower capacity available at federal hydropower facilities that is environmentally sustainable, including fostering an understanding of the potential effects of climate change on future generation capability.	A.1.1, A.1.2, A.2.1, A.3.1, C.1.1, C.1.2
5	Collaborate with Indian tribes, the environmental community, the owners of non-federal hydropower facilities, federal and state agencies, and other stakeholders to identify river basins where integrated basin-scale hydropower opportunity assessments could be conducted.	B.1.1, B.1.2, B.1.3
6	Emphasize the critical role that hydropower can play in helping to integrate other renewable energy technologies into the U.S. electric grid.	F.1.1, F.2.1

Goal No.	MOU Goal	Associated Action Items
7	Promote an environmentally responsible approach to enhancing hydropower development that recognizes the need to preserve biological diversity, ecosystem function, our natural and cultural heritage, and recreational opportunities, and also recognizes that some geographic locations are not appropriate for new hydropower development.	A.1.1, A.1.2, A.2.1, A.3.1, B.1.1, B.1.2, B.1.3, C.1.1, C.1.2
8	Conduct research and disseminate results from environmental studies, and also encourage development of specific standards for and certification of environmentally sustainable hydropower.	C.1.1, C.1.2., E.2.1, E.2.1, E.2.2
9	Work to integrate energy and water policies at the federal level for energy and environmental goals.	D.1.1
10	Investigate ways to responsibly facilitate the permitting process for federal and non-federal hydropower generation and other renewable energy projects at federally owned and Indian tribe facilities.	G.1.1, G.1.2
11	Share information on renewable energy R&D efforts being conducted by each agency, along with any results obtained. Prevent the duplication of efforts and highlight potential areas of collaboration and/or joint funding.	A.2.1, D.1.1, E.1.1, E.2.1, E.2.2
12	Apply collective knowledge and lessons learned from conventional hydropower development, deployment, and management to the emerging in-river hydrokinetic technologies.	D.1.1, E.1.1
13	Increase levels of both formal and informal communication and coordination between officials and staff at multiple levels of each agency.	D.1.1

Over the past two years, the MOU agencies have strived to make progress toward these goals. The following sections describe the specific action items from the MOU and the progress that has been made on each between April 2010 and March 2012.



## PROGRESS ON ACTION ITEMS

### Category A—Federal Facility Energy Resources

**Goal:** : Focus on opportunities at federal facilities by assessing the potential of additional hydropower generation available at USACE and DOI Bureau of Reclamation (Reclamation) facilities and collaborate on joint projects to increase generation at identified facilities. Projects considered or undertaken are intended to complement, and not compete or conflict with any ongoing activities or projects at federal facilities, and will need to involve all affected stakeholders throughout the planning process. Opportunities for increased generation include efficiency and/or capacity upgrades to existing facilities, improvements in water management practices, powering currently unpowered dams or other constructed waterways, and the addition of new pumped storage capacity. Opportunities for increasing generation while improving ecosystem function, such as hydropower production from bypass flows, will also be assessed. Also, the agencies will assess the potential effects of climate change on federal hydropower facilities and generation.

#### *Initiative A.1—Resource Assessments*

Coordinate ongoing efforts at all three agencies to improve resource data and identify specific federal facilities or sites as good candidates for projects to increase hydropower generation (including in-river hydrokinetic projects). Ongoing efforts include, but are not limited to:

- DOE Office of Energy Efficiency and Renewable Energy’s National Hydropower Asset Assessment Program (NHAAP) to identify the current state of the hydropower infrastructure in the United States (age, type, ownership, etc.), generation patterns from these assets, and effects of varying hydrologic conditions on generation.
- DOI Reclamation’s efforts to survey its facilities and update the report on Potential Hydropower Development at Existing Federal Facilities under Section 1834 of the Energy Policy Act of 2005. The Section 1834 report will identify potential environmental concerns. Future development on any federal facility identified in the Section 1834 report will include coordination with the U.S. Fish and Wildlife Service, the National Park Service, and other entities with jurisdiction.
- DOA USACE’s/DOI Reclamation’s Hydropower Modernization Initiative (HMI) to survey their facilities, quantify the potential additional generation available, and identify the most suitable locations for upgrades. Actual implementation of the HMI will be in consultation with DOE and the federal Power Marketing Administrations (PMA) and their power customers.

#### Action Item A.1.1 – National Hydropower Asset Assessment Program (NHAAP)

Establish an advisory committee for DOE’s NHAAP and include USACE and Reclamation representatives as members; hold regular meetings to exchange available data/research from all ongoing efforts.

Deliverable	Lead Agency	Due Date	Status
Hold meetings twice a year	DOE, Reclamation, USACE	Hold first meeting in April 2010	Ongoing

## Details

**NHAAP:** The NHAAP launched in fiscal year (FY) 2010, starting with gathering, organizing, and validating the stream network, facility configuration data, historic generation, and water availability data necessary to trend the production and capacity of U.S. hydropower for DOE's Water Power Program.

These data are derived from federally chartered database efforts and include the Reclamation/USACE HydroAmp, Federal Energy Regulatory Commission (FERC) eLibrary and DamSafety Database, Energy Information Administration Forms 860/923 Powerplant and Generation Database, USACE National Inventory of Dams, U.S. Geological Survey (USGS)/Environmental Protection Agency National Hydrography Dataset, and USGS National Water Information Service.

The NHAAP is designed to integrate these data at various scales and serve as a tool for strategic planning and decision-making to assess the current value of the nation's hydroelectric infrastructure, quantify the amounts of energy that could be feasibly extracted, and provide an environmental attribution resource. Both formal meetings and informal communication are taking place between Reclamation, DOE, and the Corps regarding these activities. <http://nhaap.ornl.gov/>

**Non-Powered Dams:** DOE recently completed an assessment of the country's non-powered dams (NPD) under the NHAAP and found approximately 12 gigawatts (GW) of potential, which is roughly equivalent to increasing the size of the existing conventional hydropower fleet by 15%. A majority of this potential is concentrated in just 100 NPDs, which could contribute 8 GW of clean, reliable hydropower; the top 10 facilities alone could add up to 3 GW of new hydropower. Eighty-one of the top 100 NPDs are Corps facilities, many of which—including the top 10—are navigation locks on the Ohio, Mississippi, Alabama, and Arkansas Rivers. Corps and Reclamation staff members played a key role in providing information about federally owned NPDs and helping to review the results of this effort. <http://nhaap.ornl.gov/content/non-powered-dam-potential>

**Table 2:** Summary of NPD assessment by state totaling 12.1 GW of potential. Note, Alaska and Hawaii were not assessed.

State	Potential Capacity (MW)	State	Potential Capacity (MW)	State	Potential Capacity (MW)	Potential Generation (TWh/yr)
AL	922	ME	19	OH	288	1.249
AZ	80	MD	48	OK	339	1.065
AR	1136	MA	67	OR	116	0.446
CA	195	MI	48	PA	679	2.865
CO	172	MN	186	RI	13	0.061
CT	68	MS	271	SC	38	0.089
DE	3	MO	489	SD	12	0.039
FL	173	MT	88	TN	40	0.150
GA	144	NE	7	TX	658	1.474
ID	12	NV	16	UT	40	0.108
IL	1269	NH	63	VT	17	0.078
IN	454	NJ	33	VA	50	0.193
IA	427	NM	103	WA	85	0.328
KS	92	NY	295	WV	210	0.864
KY	1253	NC	167	WI	245	1.356
LA	857	ND	31	WY	45	0.149

## Future Activities

**New Site Assessment:** DOE recently began work on a new task under the NHAAP that involves assessing new sites for potential hydropower development across the country. Both Corps and Reclamation representatives are helping to develop the methodology and will continue to be involved throughout the assessment process. This assessment is expected to be completed and released during FY 2013.

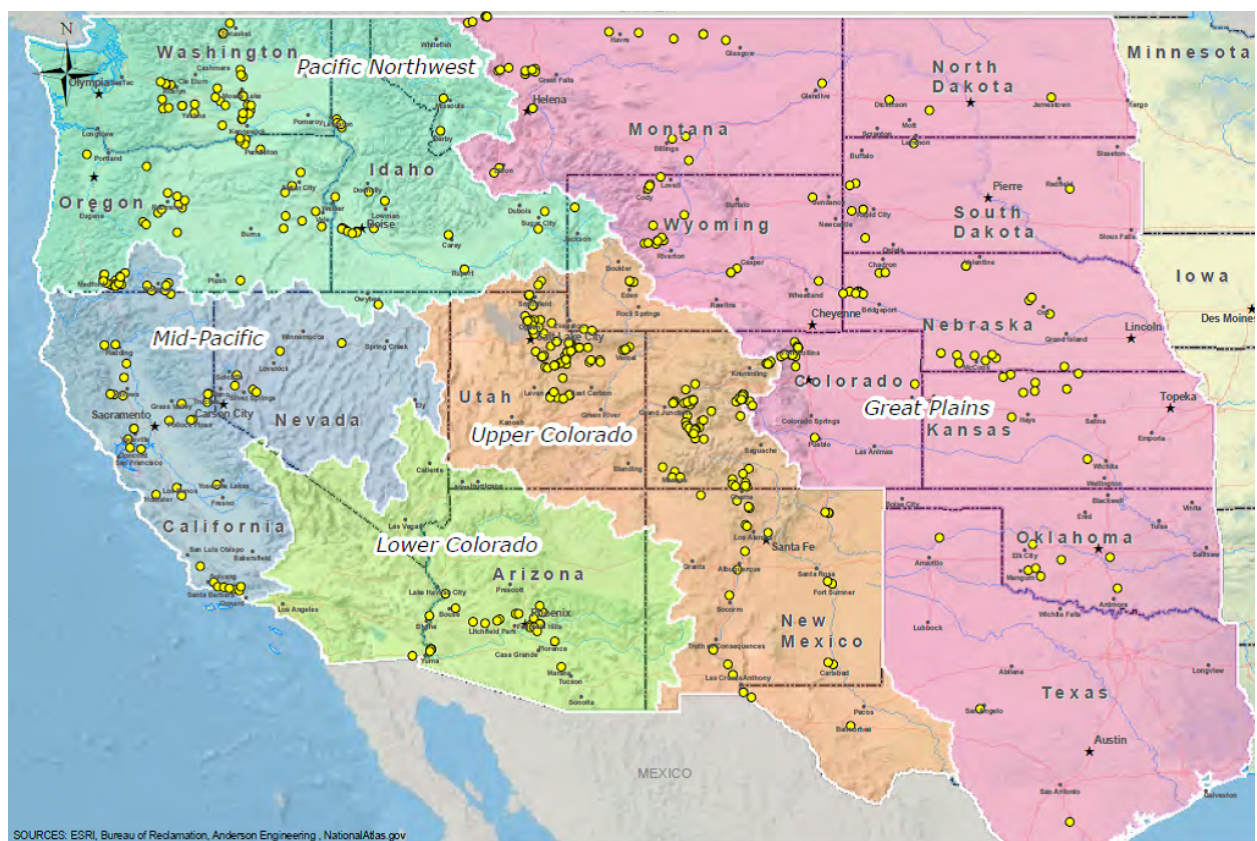
### Action Item A.1.2 – Hydropower Potential at Existing Federal Facilities

DOI Reclamation's efforts to survey its facilities and update the report on Potential Hydropower Development at Existing Federal Facilities under Section 1834 of the Energy Policy Act of 2005; produce a list of USACE and Reclamation facilities and sites best suited for upgrades or projects to increase generation in a sustainable manner.

Deliverable	Lead Agency	Due Date	Status
Updated report	Reclamation, USACE	Not identified	Reclamation report completed March 2010; Corps report underway with an expected completion of July 2012

## Details

**Hydropower Resource Assessment at Existing Reclamation Facilities:** This resource assessment, published by the Bureau of Reclamation in March 2011, provides information about whether or not hydropower development at existing Reclamation facilities would be economically viable and possibly warrant further investigation. The Resource Assessment is mainly targeted toward municipalities and private developers who are seeking to add power to their load area (or for investment purposes) in order to further evaluate the potential to increase hydropower production at Reclamation sites. Developers could use this information to focus more detailed analysis on sites that demonstrate a reasonable potential for being economically and financially viable. The Resource Assessment is not intended to provide feasibility level analyses for the potential sites but does provide information necessary to determine if further investigation is warranted. Out of the 530 sites analyzed, the resource assessment report identified 70 sites, (potentially comprising 225 megawatts (MW) of capacity and 1 million megawatt hours (MWh) of generation) with a benefit/cost ratio greater than 0.75. Several of the sites identified are currently being developed through a FERC license or a Lease of Power Privilege (LOPP). A LOPP is a contractual right of up to 40 years given to a non-federal entity to use a Reclamation facility for electric power generation. It is an alternative to federal power development where Reclamation has the authority to develop power on a federal project. There have been 10 LOPP projects initiated and 18 FERC applications filed since this study was published. <http://www.usbr.gov/power/AssessmentReport/USBRHydroAssessmentFinalReportMarch2011.pdf>



**Figure 2:** Reclamation sites assessed as part of Hydropower Resource Assessment at *Existing Reclamation Facilities Report*.

**Site Inventory and Hydropower Energy Assessment of Reclamation-Owned Conduits** (supplement to the Hydropower Resource Assessment at Existing Reclamation Facilities Report): This report builds off the March 2011 Resource Assessment, identifying potential hydropower sites on Reclamation-owned conduits and determining those sites' capacity and energy potential. The report includes conduit sites that were identified in the March 2011 Resource Assessment, but not fully analyzed. It also analyzes additional conduit sites that have been identified since the publication of that study.

The results of this study show that more than 100 MW of potential capacity and more than 365,000 MWh of potential generation are available at the 373 identified sites on Reclamation's existing canals. At present, this report has been made available for internal review. Public release of the study is expected in April 2012 and will be available at [www.usbr.gov/power](http://www.usbr.gov/power).

**Table 3:** Findings of potential capacity and annual energy by state from the Reclamation study, *Site Inventory and Hydropower Energy Assessment of Reclamation-owned Conduits*.

State	Canal Sites	Potential Installed Capacity (kW)	Potential Annual Energy (kWh)
AZ	26	5,061	28,464,753
CA	20	1,570	4,802,925
CO	28	27,286	100,230,315
ID	9	2,771	11,451,814
MT	32	9,885	26,316,565
NE	30	5,501	13,793,995
NM	8	1,427	3,573,029
NV	16	1,533	8,671,966
OR	68	20,404	75,943,044
SD	1	131	572,000
UT	12	3,552	5,965,031
WA	2	1,047	2,885,357
WY	121	23,460	82,548,053
<b>Total</b>	<b>373</b>	<b>103,628</b>	<b>365,218,846</b>

**HMI**—This report, completed by the Bureau of Reclamation in October 2010, assesses the potential for capacity and efficiency increases at Reclamation's 58 existing hydroelectric plants. The report confirmed that Reclamation has had an active uprate program and—as a result—has sized the majority of the hydropower plants to their optimum proportions. The report determined that there is potential for approximately 67 MW of additional capacity at 10 of Reclamation's 58 power plants. It also shows that additional generation could be realized through the installation of newer and more efficient turbines. A total of 36 plants could potentially increase their annual generation by more than 3% through turbine replacements. This increase would represent an average of an additional 388,357 MWh per year. <http://www.usbr.gov/power/AssessmentReport/USBRHMICapacityAdditionFinalReportOctober2010.pdf>

**Table 4:** Top 10 Reclamation capacity opportunities ranked by benefit-to-cost ratio. In the Assessment of Potential Capacity Increases at Existing Hydropower Plants, capacity opportunities were also ranked by net present value, efficiency gain opportunities, and greenhouse gas reductions.

Rank <sup>1</sup>	Plant	Region	Existing Installed Capacity (MW)	Maximum BCR Percent Increase	Maximum NPV Percent Increase	Maximum BCR Capacity Increase (MW)	Maximum BCR	Maximum NPV (\$M)
1	Shoshone	Great Plains	3.0	50%	50%	1.5	3.50	\$12.2
2	Black Canyon	Pacific Northwest	10	50%	50%	5.1	2.52	\$19.6
3	Boise Diversion	Pacific Northwest	3.5	40%	50%	1.4	2.48	\$7.8
4	Palisades	Pacific Northwest	177	20%	50%	35	2.28	\$123
5	Canyon Ferry	Great Plains	50	10%	40%	5.0	1.53	\$13.4
6	Guernsey	Great Plains	6.4	50%	50%	3.2	1.52	\$4.6
7	Nimbus	Mid-Pacific	13.5	20%	50%	2.7	1.39	\$5.8
8	Minidoka	Pacific Northwest	28	10%	20%	2.8	1.21	\$2.6
9	Deer Creek	Upper Colorado	5.0	10%	20%	0.5	1.04	\$0.1
10	Crystal	Upper Colorado	31.5	30%	30%	9.5	1.00	\$0.1

<sup>1</sup> Plants are ranked based on the capacity addition increment with the highest BCR for each plant  
BCR - Benefit on Cost Ratio

USACE is in the implementation phase of its HMI effort, which seeks to prioritize modernization activities at its facilities. A total of 54 plants are included in the initiative across three PMA regions. Agreements have been finalized in two regions to fund the recapitalization of HMI projects. These projects will result in efficiency improvements and/or capacity upgrades at most of the 54 plants without any increases in streamflow. Efficiency and capacity gains will be quantified on a project by project basis. There is a tremendous amount of interest from the private sector to provide capital for improvements of USACE hydropower facilities. Efforts to acquire the authority for USACE to accept private investments are ongoing.

USACE has also initiated a hydropower potential resource assessment study at its non-powered facilities, which will be much more rigorous than a previous study completed in May 2007 ([http://www.usbr.gov/power/data/1834/Sec1834\\_EPA.pdf](http://www.usbr.gov/power/data/1834/Sec1834_EPA.pdf)). This effort is expected to complete in July 2012.

**Hydropower Advancement Project:** Currently, more than half of the hydropower facilities in the United States are using major equipment, such as turbines, that were designed and installed more than 50 years ago. Over time, the efficiency and capacity of turbine units declines, primarily due to deteriorating physical conditions. Many facilities in the U.S. hydropower fleet are operating under a different set of constraints than those existing at the time of commissioning, resulting in reduced energy production and ancillary services for the electric power system. In addition, newer technologies that improve the efficiency and performance of turbines and other components of hydropower projects are not being taken advantage of. DOE developed the Hydropower Advancement Project (HAP) to support additional generation from existing hydropower facilities. <http://hydropower.ornl.gov/HAP/>

**Table 5:** Distribution of turbine ages for the U.S. hydropower fleet. Developed by DOE under NHAAP

Turbines	Median Age	Older than 50 Years	Older than 75 Years		
Non-Federal	58	54.6%	18.4 GW	41.9%	8.1 GW
Reclamation	49	49.8%	4.1 GW	8.2%	0.058 GW
Army Corps of Engineers	49	51.0%	12.4 GW	0.3%	0.002 GW
TVA	18	23.3%	0.8 GW	4.3%	0.061 GW
Total	53	52.5%	29.5 GW	36.8%	8.2 GW

Through HAP, DOE is establishing a systematic and standard approach to evaluate and assess existing hydropower facilities and identify potential improvement opportunities. DOE will utilize HAP results to establish a baseline of the U.S. hydropower fleet's current condition and estimate the potential for increased generation through improvements and expansions at existing hydropower facilities. Additionally, DOE will develop a better understanding of the real-world opportunities for plant improvements, the process used in making investment decisions, and the current barriers to achieving plant improvements. DOE will use this understanding to manage its R&D investments, and other stakeholders may use it to improve their investment decisions. HAP does not include financial support for upgrading existing hydropower facilities.

DOE, Reclamation, and USACE are collaborating to ensure that HAP aligns well with USACE and Reclamation HMI efforts, and that it is not a duplicative effort. Both Reclamation and USACE are participating in HAP by providing access to their projects (Flaming Gorge and Center Hill) for demonstration assessments.



**Figure 3:** Flaming Gorge Dam (Reclamation) <http://www.usbr.gov/uc/rm/crsp/fg/index.html>. For information on the USACE Center Hill project, visit <http://www.lrn.usace.army.mil/centerhill/pdf/center%20hill%20brochure.pdf>.

## Future Activities

**Hydrokinetic Canal Systems:** Reclamation is working with other utilities through its membership with the Centre for Energy Advancement through Technological Innovation (CEATI) to identify promising hydrokinetic technologies that could be installed in canal systems. The study will also assess the systems' technical and economic characteristics, which includes identifying potential impacts to the operations of canal systems and determining the desired characteristics of sites that would be viable locations for the technologies in both natural and constructed waterways. Finally, the study will outline a test evaluation plan that could be used for pilot testing of the most promising technologies.

**Hydropower and Renewable Geographical Information System:** In late 2011, Reclamation began to develop a plan to utilize advanced geographical information system (GIS) technology to build a comprehensive power system and water delivery database that can be used cross-functionally for more accurate and consistent renewable energy development planning and research. The system will initially provide critical information on existing Reclamation renewable energy development. The second phase will involve inputting information about potential development and overlaying that information with development opportunities for other renewable resources. This effort is being coordinated with the DOE NHAAP project (details provided above).

## Initiative A.2—Generation Increases at Federal Facilities

Explore opportunities for all the agencies to jointly fund or solicit projects to increase generation at the identified federal sites and facilities.

### Action Item A.2.1 – Proposal for Joint Funding

Develop a proposal with details for how projects identified in the Federal Facilities/Sites List could be funded. Options will include both federal and non-federal development at USACE and Reclamation sites and facilities.

Deliverable	Lead Agency	Due Date	Status
Finalized proposal	DOE, Reclamation, USACE	October 2010	Ongoing

## Details

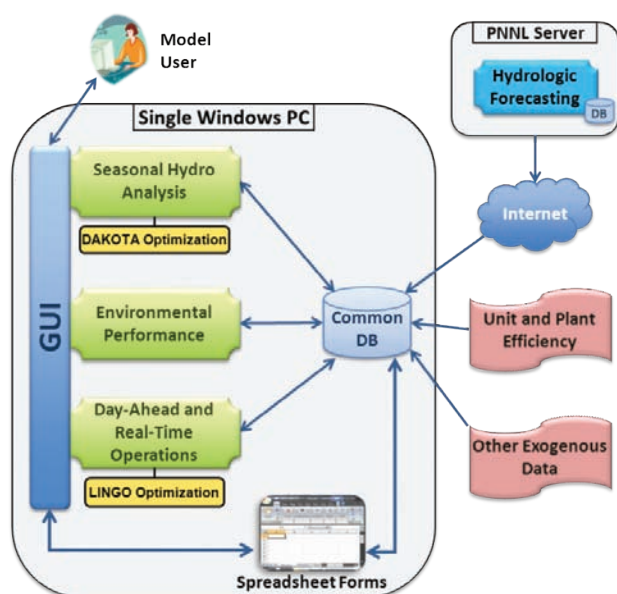
**Advanced Hydropower Technology Development:** In April 2011, DOE and DOI announced a joint funding opportunity announcement (FOA)—the Advanced Hydropower Technology Development FOA (<https://www.fedconnect.net/FedConnect/?doc=DE-FOA-0000486&agency=DOE>)—which offered financial assistance to projects that develop and demonstrate innovative hydropower technologies that can produce power more efficiently, reduce costs, and increase sustainable hydropower generation at sites not previously considered practical. Sixteen projects totaling nearly \$17 million were selected for award (<http://energy.gov/articles/16-projects-advance-hydropower-technology>). Of those awards, two grants were for technology testing and demonstration at Reclamation sites, and DOE and Reclamation have partnered to co-fund and monitor the work occurring through those projects. Deliverables include testing to demonstrate energy cost reductions that could be replicated at other Reclamation sites.



**Water Use Optimization Toolset:** The major challenge facing hydropower suppliers today is how to operate conventional hydropower plants more efficiently, increasing electricity generation and power sales while dealing with an increasingly uncertain, water-constrained operating environment and complex electricity market.

DOE has commissioned a team of national laboratories, led by Argonne National Laboratory (ANL), to develop and demonstrate a practical suite of advanced integrated analytical tools to improve hydropower operational efficiency and inform environmental performance decisions. [www.anl.gov/renewables/research/hydro\\_advanced\\_convent\\_hydropower.html](http://www.anl.gov/renewables/research/hydro_advanced_convent_hydropower.html)

In collaboration with Reclamation, the toolset is being demonstrated in the Gunnison River basin, which is part of the Reclamation Colorado River Storage Project. [www.usbr.gov/uc/rm/crsp/index.html](http://www.usbr.gov/uc/rm/crsp/index.html) The demonstration at Reclamation facilities provides a necessary integration and testing environment for this complex toolset, and it will identify potential operational and planning changes that could increase energy and grid services from the available water while enhancing environmental benefits from the Reclamation Gunnison River hydropower projects.



**Figure 4:** Water use optimization toolset integration diagram.



**Figure 5:** Colorado River Storage Project mainstream units map.

## Future Activities

**Future Joint Funding Opportunities/Hydro Generator Optimization:** DOE and the Corps are discussing options for partnering on innovative technology demonstration projects at USACE facilities.

Reclamation will continue to encourage non-federal hydropower development at its facilities through the Lease of Power Privilege (LOPP) process and will continue to look for opportunities at existing plants to increase capacity and generation through generator rewinds and turbine replacements. In addition, Reclamation is currently working on a project to develop and implement a standardized hydro generator optimization system for its facilities. The objective of this system is to provide an increase in the power production efficiency (MWh per acre feet) at multi-unit plants without using additional water or sacrificing plant reliability. It is envisioned that this optimization system could be deployed across Reclamation power facilities. It is estimated that a 1% efficiency improvement across Reclamation from optimization could produce 16.2 MW of additional power at all times, resulting in extra power that is worth approximately \$5.7 million annually. In 2013, Reclamation will begin installing new optimization systems in its power plants. It is expected that Reclamation will complete the installation of these systems by 2015. All three MOU agencies intend to make use of the data collected on efficiency improvements gained from these new optimization systems.

### *Initiative A.3— SECURE Water Act Section 9505 Studies*

Coordinate efforts to complete the Hydropower Power Assessment called for in Section 9505 of the Omnibus Public Lands Act of 2009, P.L. 111-11. Evaluate the effects and risks associated with global climate change to water supplies available for hydropower power generation at federal water projects, in consultation with each of the federal PMAs, USGS, and other federal and state authorities as appropriate.

#### Action Item A.3.1 – Interagency Cooperation on 9505 Reports

Complete a report on the effects of global climate change on water available at federal hydropower facilities and on power sales of the PMAs, based on best available scientific information. The report will include recommendations from the PMA administrators on potential changes in operation or contracting practices that could address the effects and risks of climate change.

Deliverable	Lead Agency	Due Date	Status
Establish an interagency working group to plan and implement the required assessment and to provide long-term coordination for subsequent reports every five years	DOE, Reclamation, USACE	April 2011	Interagency Working Group formed; Draft of 9505 assessment report completed in September 2011; Report to Congress in DOE concurrence review

## Details

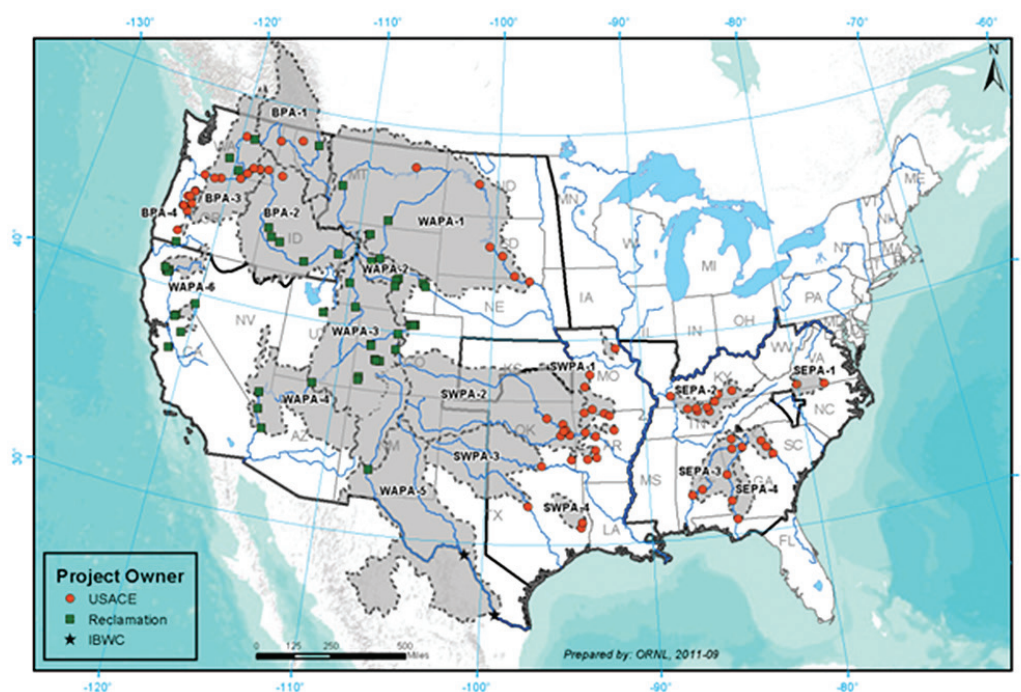
**Section 9505 Assessment:** Pursuant to Section 9505 of P.L. 111-11, DOE, in consultation with the federal PMAs and other federal agencies—including federal dam owners—prepared a comprehensive assessment that examined the potential effects of climate change on water available for hydropower generation at federal facilities and on the marketing of that power. The Section 9505 assessment included: (1) a historical analysis of the sensitivity of federal hydropower operations to climate variables, (2) a climate modeling analysis that projected possible climate conditions and impacts to hydropower into the future, and (3) a literature review of other related climate studies for comparison to the Section 9505 assessment’s modeling results. Results from the full assessment were condensed into a Report to Congress that also included recommendations from the PMA administrators on adaptation and mitigation strategies.

Reclamation and USACE supported DOE in conducting this assessment by providing the following technical assistance:

- Reclamation hosted several coordination meetings with DOE staff, USACE, and PMAs at Reclamation’s Denver offices in 2010 and 2011.
- Reclamation and USACE provided extensive written comments on the draft technical report of the Section 9505 assessment in June 2011.

## Future Activities

After the Report to Congress is approved and delivered, DOE will begin development of longer-term plans for subsequent Section 9505 studies, including coordination with Reclamation, USACE, and the PMAs. A possible venue for future collaborations could be the federal Climate Change and Water Working Group, an informal interagency body that has been meeting since 2008. <http://www.esrl.noaa.gov/psd/ccawwg/>



**Figure 6:** Regions and hydropower projects evaluated in the 9505 assessment.

## Category B—Integrated Basin-Scale Opportunity Assessments

**Goal:** A new basin-scale approach to hydropower and related renewable development that emphasizes sustainable, low-impact, or small hydropower and related renewable energies could identify ecosystems or river basins where hydropower generation could be increased while simultaneously improving biodiversity, and taking into account impacts on stream flows, water quality, fish, and other aquatic resources. The agencies will collaborate with the environmental community, the owners of federal and non-federal hydropower facilities, potentially affected federal land management agencies, Indian tribes, and other stakeholders to identify river basins where renewable power generation and environmental sustainability could both be increased, with appropriate consideration of other values. These basin-scale studies will also evaluate whether there are opportunities in the basin to retrofit existing dams to increase generation while improving environmental conditions. The agencies will build on the existing basin study programs and other ongoing research activities of all participants to investigate how such opportunities could potentially be developed. Activities within this section are intended to complement current initiatives or existing agreements pertaining to facilities and river-basins by providing additional tools, information, and/or research for stakeholders.

### *Initiative B.1—Collaborative Pilot Projects*

Collaborate with appropriate agencies and stakeholders to: (1) develop methodologies, (2) identify suitable river basins, and (3) select one or more basins for a basin-scale opportunity assessment pilot project. Develop consensus on specific actions that could be taken within that basin to achieve an increase in hydropower and related renewable generation and improve environmental sustainability.

#### Action Item B.1.1 – Design of Basin-Scale Assessments

Plan and hold an expert workshop to identify methodologies, tools, and strategies for conducting basin-scale hydropower opportunity assessments. Workshop participants will: (1) identify basins suitable for a basin-scale approach with significant hydropower potential and environmental restoration opportunities, and (2) select and prioritize one to three basins for basin-scale assessment pilot projects.

Deliverable	Lead Agency	Due Date	Status
Organize and conduct first design workshop; Produce initial report three months after first workshop	DOE	May 2010	Complete. Steering committee established and workshop held during the National Hydropower Association Conference in April 2010; Second methodologies workshop held in September 2010; Summary report provided to DOE and participants

## Details

In the first quarter of 2010, MOU agency partners formed a steering committee made up of agency staff, hydropower industry members, and environmental nongovernmental organizations (NGO) to develop the vision and goals of the Basin-Scale Opportunity Assessment (BSOA) initiative.<sup>1</sup> The steering committee met by phone and in person six times in FY 2010. National laboratory staff supported the steering committee by conducting literature reviews and research, in addition to organizing two workshops. The first was an internal workshop to identify basins where opportunity assessments would be most appropriate, and the second was a national experts workshop to refine assessment methodologies for stakeholder interaction and system-scale analysis.

The national workshop—held in Denver, Colorado, in September 2010—completed FY 2010 activities and was attended by nearly 60 representatives from agencies, national laboratories, the hydropower industry, environmental NGOs, and other interested parties. Workshop participants developed a three-step process for carrying out opportunity assessments and identified potential basins that would be appropriate for initial case studies. A report summarizing workshop findings was prepared and distributed to participants.

By the end of FY 2010, the steering committee and MOU agencies had defined high-level participation in BSOA activities, articulated goals, solicited input from hydropower experts (through presentations at conferences and workshops), identified priority basins for an initial pilot opportunity assessment, and defined an approach for carrying out opportunity assessments. Several basins were selected as likely locations for a pilot project by the end of 2010. Starting in 2011, Pacific Northwest National Laboratory (PNNL) and Oak Ridge National Laboratory (ORNL) staff and the steering committee began reaching out to these basins to determine whether they would be willing to participate in a pilot assessment. Following, the Deschutes Basin in Oregon was selected as the BSOA's first pilot; assessment activities commenced in the second quarter of FY 2011.

## Future Activities

Follow-on assessment activities are underway in the Deschutes Basin in Oregon. Results of the Deschutes pilot will be used to inform MOU agency discussions on whether expansion of this initiative to additional basins will be useful and feasible in FY 2013 and beyond.

### Action Item B.1.2 – Pilot Study

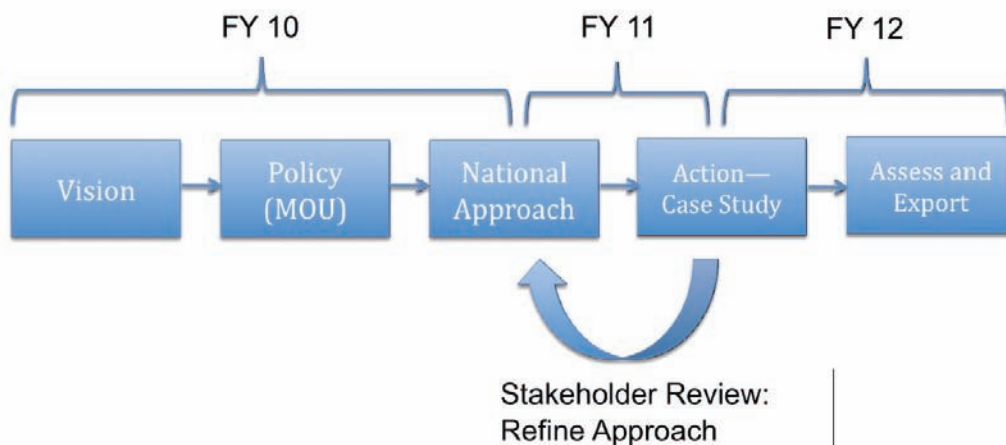
Conduct one or more basin-scale assessment pilot studies consistent with the findings of the workshop described above, in partnership with representatives of the hydropower industry and other relevant stakeholders.

Deliverable	Lead Agency	Due Date	Status
Deliverables and milestones defined in detailed work plan were submitted to DOE in the first quarter of FY 2011	DOE	See work plan schedule and details below	On schedule

<sup>1</sup> Steering committee participation has evolved throughout the course of this initiative. Core members of this group are Jeff Leahey and Linda Church-Ciocci (National Hydropower Association); Richard Roos-Collins (Hydropower Reform Coalition); Julie Keil (Portland General Electric); Jeff Opperman (The Nature Conservancy); Fred Ayer (Low Impact Hydropower Institute); Dave Sabo, Kerry McCalman, CJ McKeral, and Mike Pulskamp (Reclamation); Kamau Sadiki and Lisa Morales (Corps); and Alejandro Moreno and Hoyt Battey (DOE). The steering committee was supported by national laboratory staff, including Mike Sale, Brennan Smith, and Bo Saulsbury (ORNL), and Simon Geerlofs (PNNL).

## Details

During FY 2011, BSOA efforts focused on moving from policy and initiative design at the national level (through MOU and steering committee activities) to outreach and application of an assessment approach through a pilot study at the basin scale. The Deschutes Basin in Oregon was selected and a two-year pilot study process was developed and funded through DOE's Water Power Program.



**Figure 7:** Overarching process for the first two years of the Integrated BSOA Initiative.

The overarching goal for FY 2011 was to work within the pilot basin to develop an approach for integrated hydropower and environmental opportunity assessment at the basin scale. This approach is intended to achieve national goals, as described in the MOU, as well as provide value to local stakeholders to identify and explore promising opportunities. The approach is to identify and apply appropriate analytical tools, as well as enable stakeholder participation, feedback, and review of assessment documents. Collaborative application of analytical assessment tools is intended to initiate dialogue about specific actions within basins that are achievable and how to best meet the goals of the BSOA initiative—to increase both hydropower generation and environmental health within the river basin, within the context of existing uses.

Early in FY 2011, the following objectives were identified to allow for development of the opportunity assessment approach:

- **Select Pilot Basin:** Completed in February 2011.
- **Develop Opportunity Assessment Toolbox:** Completed in March 2011.
- **Initiate Basin-Scale Pilot Assessment:** Completed in October 2011.

FY 2011 activities in the Deschutes Basin pilot consisted of the following:

- Aggregating existing data and literature in the Deschutes Basin.
- Conducting outreach to local stakeholders and forming a local stakeholder advisory committee (called the Logistics Committee).
- Forming the PNNL/ORNL Technical Team.

- Executing a Technical Team and Steering Committee site visit and developing a report on compilation of stakeholder-identified opportunities.
- Identifying appropriate tools for system-scale integrated assessment of hydropower and environmental opportunities.

Developing a project website where assessment tools are catalogued and described.

<http://basin.pnnl.gov/>

- Refining stakeholder-identified opportunities through focused interviews.
- Holding a public workshop in Bend, Oregon, to describe the project and solicit information from stakeholders and basin experts. Results of the workshop culminated in the development of a final list of stakeholder-identified opportunities and an outline of the research needed for an integrated analysis of those opportunities.
- Producing an interim report that described these activities and identified opportunities, as well as an action plan for analysis of opportunities in FY 2012 (further described in Action Item B.1.3).



**Figure 8:** Map of project area showing Upper Deschutes and Crooked River sub-basins, existing hydropower projects, dams, and major irrigation canals.

## Future Activities

In FY 2012, the BSOA team will complete the Deschutes River Basin pilot study and produce tools that can be used by stakeholders for collaborative opportunity analysis. Specific activities underway in FY 2012 further describe and analyze opportunities presented in the FY 2011 preliminary opportunity assessment. These analyses were selected based on stakeholder input during the Deschutes Basin Workshop—held in Bend, Oregon, in July 2011—and are fully described in the FY 2011 preliminary assessment report (described in Action Item B.1.3 below).

The technical approach to opportunity assessments relies on use of existing tools and models, strives for transparency and the collaborative application of tools with stakeholders, and provides information and analyses to inform creative dialogue among stakeholders without making specific recommendations. The BSOA Initiative plans to complete development of water balance models, modeling scenarios, and data visualization tools by the end of FY 2012. Final presentation of project results to Deschutes Basin stakeholders will likely occur near the end of calendar year 2012.

### Action Item B.1.3 – Report on Methods and Applications

Draft and disseminate a report on the results of the pilot studies that includes a feasibility analysis for expansion of the basin-scale assessment model to other appropriate river basins.

Deliverable	Lead Agency	Due Date	Status
Interim and final report on pilot assessment activities	DOE	Preliminary report due at the end of FY 2011; final assessment due at the end of FY 2012 (see details below)	Report detailing the preliminary assessment of the Deschutes Basin pilot with details on methodologies and analytical approach completed in September 2011; Final report with results of analysis due October 1, 2012

## Details

The FY 2011 preliminary assessment report can be accessed at <http://basin.pnnl.gov/>. This report details all BSOA activities since the MOU was signed (including workshop reports and the FY 2012 technical work plan). Additionally, it catalogs preliminary environmental and hydropower opportunities identified by Deschutes stakeholders. A final report detailing the results of the analyses of opportunities in the Deschutes Basin will be complete by the end of FY 2012. All results of modeling and information analysis activities will be presented on the BSOA website through a Web-based data visualization tool, currently under development.

## Future Activities

Following completion of the Deschutes pilot project, MOU agencies will discuss expansion of this initiative to other basins in FY 2013 and beyond.



## Category C—Green Hydropower Certification

**Goal:** Identification of new hydropower development projects that avoid or reduce environmental impacts. Collaborate with private companies, states, tribes, NGOs, and other federal agencies to explore the benefits of the certification of environmentally friendly hydropower projects, and identify types of hydropower projects that could be included under state or national renewable energy portfolio standards, or could be given other credit for clean energy produced.

### *Initiative C.1—Identification of Sustainable Hydropower*

Work with multiple stakeholders and other agencies to review potential criteria and/or other evaluation methods for identifying sustainable, environmentally friendly hydropower projects.

#### Action Item C.1.1 – Stakeholder Meetings

Initiate a series of stakeholder meetings with state and tribal governments, and environmental and other interest groups to gather information on concerns regarding environmental impacts of hydropower generation, and possible solutions/mitigation options. Meetings would be led by DOE with participation and involvement by USACE, Reclamation, the PMAs, the U.S. Fish and Wildlife Service, the National Park Service, other federal agencies, and other industry representatives.

Deliverable	Lead Agency	Due Date	Status
Hold three to four meetings with various stakeholder groups	DOE	FY 2010	Ongoing

### Details

Certification of “green” hydropower is a process that identifies projects that have avoided or reduced their environmental impacts, and that are compatible with the riverine ecosystems in which they are located. Consumer choice is informed by such “eco-labeling” in many different ways, including qualification of hydro projects for state renewable energy portfolios and for renewable energy credits. The Low Impact Hydropower Institute (LIHI; <http://www.lowimpacthydro.org/>) is one of the more active hydro certifying organizations in the United States, but there are others, such as Green-e (<http://www.green-e.org/>). Since its inception in 2000, LIHI has certified approximately 85 hydropower projects with a total installed capacity of more than 3 GW.

Standards for eco-labeling, such as those used for hydropower, have been evolving over the past decade. This is largely due to the markets in which they are applied to developing. In 2009, LIHI began a programmatic review of its certification methods to determine if improvements could be made to make its decisions more transparent and objective. LIHI's review is still ongoing.

This MOU initiative on green hydropower certification used the FIHWG (see Initiative D) as the venue for meetings and information exchange. Since 2010, there has been a significant amount of ongoing discussion about the content and procedures associated with green hydropower certification within the hydropower industry and the certifying entities. Accordingly, the working group agencies chose to wait until the LIHI programmatic review was complete before conducting more work on this topic. A status report was presented by LIHI to FIHWG in October 2011.



**Figure 9:** Vine Street Hydroelectric Project, Albany, Oregon. Certified by LIHI on February 23, 2012. LIHI's 84th certification.

### Future Activities

The MOU agencies have proposed that an independent workshop be conducted on the topic of hydropower certification to exchange updated information and compare alternative certification approaches that have been proposed in the US and other countries.

#### Action Item C.1.2 – Criteria Development

Based on stakeholder meetings, jointly develop a list of recommended criteria or processes that could be used to certify sustainable and environmentally friendly hydropower generation facilities, including conventional or hydrokinetic hydropower developments and/or pumped storage facilities.

Deliverable	Lead Agency	Due Date	Status
Develop a list of recommended hydropower certification standards or criteria	DOE	Initiate in FY 2010	Ongoing

### Details

See Action Item C.1.1.

### Future Activities

The possibility of organizing an independent workshop on hydropower certification will be considered under the Federal Inland Hydropower Working Group (FIHWG). The development of any recommended certification criteria which could be endorsed by the MOU signatory agencies or those participating in the FIHWG would likely be a lengthy process with ample opportunity for stakeholder input.

## Category D—Federal Inland Hydropower Working Group

**Goal:** Convene and participate in a FIHWG composed of DOE, USACE, DOI, and all other federal agencies involved in the regulation, management, or development of hydropower assets (including in-river and other emerging hydrokinetic technologies) in rivers and streams in the United States.

### *Initiative D.1—Quarterly Meetings*

Hold quarterly, staff-level meetings via teleconference in order to update federal agencies on the status of all initiatives, efforts, and projects related to hydropower. Also utilize these meetings to update project leads from DOE, USACE, and DOI on the status of projects and define ongoing action items necessary to complete individual tasks listed in these guidelines.

#### Action Item D.1.1 – Implementation

Involve other federal agencies in the working group, and schedule first meeting

Deliverable	Lead Agency	Due Date	Status
Hold teleconference once every three months	DOE, Reclamation, USACE	Initiate in FY 2010	Ongoing. Meetings were held 6/10, 10/10, 1/11, 4/11, 7/11, 10/11, and 1/12; Next meeting is scheduled for 4/12

### Details

The FIHWG is made up of 15 federal entities (listed below) involved in the regulation, management, or development of hydropower resources (including hydrokinetics) in rivers and streams of the United States. The working group convenes quarterly, staff-level meetings to update federal agencies on the status of initiatives, efforts, and projects related to hydropower. Although the working group was only required to hold teleconferences, it was decided that in-person meetings would be beneficial. As such, every other working group meeting is held face-to-face.

**FIHWG Member Agencies:**

- Army Corps of Engineers
- Bonneville Power Administration
- Bureau of Indian Affairs
- Bureau of Reclamation
- Department of Energy
- Environmental Protection Agency
- Federal Energy Regulatory Commission
- Fish and Wildlife Service
- Forest Service
- National Oceanic and Atmospheric Administration
- National Park Service
- Southeastern Power Administration
- Southwestern Power Administration
- U.S. Geological Survey
- Western Area Power Administration.

**Future Activities**

The working group will continue to meet once per quarter as directed by the MOU. During 2012, the working group intends to finalize a set of goals to help shape future interactions and publish a series of fact sheets that detail the missions, areas of expertise, and interests of each agency in relation to hydropower. Future activities will attempt to achieve goals laid out by the working group.

## Category E—Technology Development and Deployment

**Goal:** Share information on R&D efforts being conducted by each agency along with any results obtained. Prevent the duplication of efforts and highlight potential areas of collaboration and/or joint funding.

### *Initiative E.1—R&D Workshops*

Conduct yearly renewable energy R&D workshop to highlight current initiatives, results of past efforts, and future goals of each agency.

#### Action Item E.1.1 – R&D Workshops

Convene a renewable R&D workshop to discuss ongoing federally funded efforts, initiatives, and technology R&D.

Deliverable	Lead Agency	Due Date	Status
Hold annual workshops to exchange information on R&D topics	DOE, Reclamation, USACE	Initiate in FY 2010	Ongoing. Workshops held 4/10, 6/10, 9/10 and 5/11

### Details

Four workshops on technology development issues related to hydropower have been held in Washington, D.C., in 2010 and 2011. All three MOU agencies participated in the planning and implementation of these workshops, and the workshops have been very well-attended by federal agencies, stakeholders, and members of the hydropower industry. Following are the topics and dates of the workshops held to date:

- Environmentally Enhanced Turbine Technology, May 19–20, 2011
- Pumped Storage Hydropower, September 20–21, 2010
- Environmental Mitigation Technology, June 2–3, 2010
- Small Hydro Technology, April 7–8, 2010.

Summary reports on the 2010 workshops can be accessed at [www.esd.ornl.gov/WindWaterPower/2010HydropowerWorkshop.shtml](http://www.esd.ornl.gov/WindWaterPower/2010HydropowerWorkshop.shtml). Results from the 2011 workshop are accessible at [www.epriturbinesworkshop.com](http://www.epriturbinesworkshop.com).



**Figure 10.** Glenn Cada of ORNL, speaking at the Environmental Mitigation Technology Summit Meeting in Washington, D.C., on June 2, 2010.

## Future Activities

In 2012, one or more workshops will be held on topics that are still to be determined. Topics under consideration include hydropower certification (see Initiative D), development of federal non-powered dams, and hydropower systems optimization.

Also, DOE will host a meeting of the International Energy Agency Implementing Agreement for Hydropower Technologies and Programmes in Washington, D.C., at the end of May 2012. One day of this meeting will be dedicated to a workshop on hydropower optimization in which Reclamation and USACE staff will participate. This workshop on optimization R&D will be an important opportunity to exchange information on technical advances in operational aspects of hydropower.

## Initiative E.2—Joint R&D Projects

Identify potential R&D deployment sites at or near USACE or Reclamation facilities for DOE or jointly funded technology development projects (including in-river and other emerging hydrokinetic technologies).

### Action Item E.2.1 – Solicit Potential R&D Deployment Sites

Initiate a public process to identify facilities.

Deliverable	Lead Agency	Due Date	Status
Develop an evolving list of appropriate facilities based on technologies.	DOE, Reclamation	Initiate in FY 2010	Ongoing. FOA issued and awarded

### Details

A Request for Information on available technology was jointly published by DOE and Reclamation in August 2010 (<http://www.grants.gov/search/search.do?mode=VIEW&oppld=56666>). In March 2011, an Advanced Hydropower Technology Development FOA was published, which included funding to demonstrate new technologies (<https://www.fedconnect.net/FedConnect/?doc=DE-FOA-0000486&agency=DOE>). For a full list of FOA awardees, visit <http://energy.gov/articles/16-projects-advance-hydropower-technology>.

### Future Activities

DOE and Reclamation will work together to monitor progress of their joint technology demonstration projects. DOE and the Corps are actively discussing possibilities for similar partnerships in the future.

### Action Item E.2.2 – Joint R&D Projects

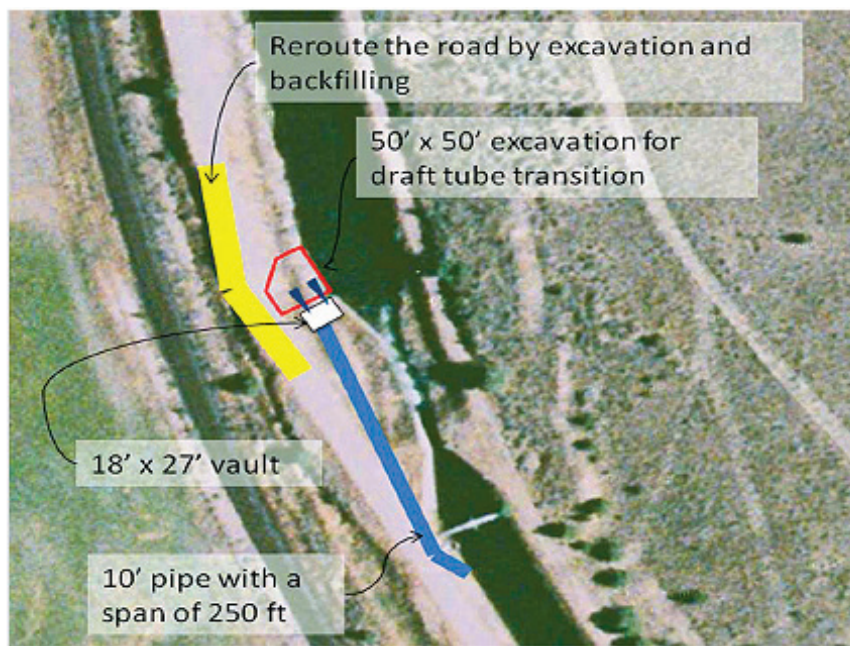
Initiate demonstration projects.

Deliverable	Lead Agency	Due Date	Status
Deploy newly developed technologies at identified facilities to increase the quantity and/or flexibility of hydropower generation	DOE, Reclamation	Initiate in FY 2011	Ongoing. FOA issued and awarded

### Details

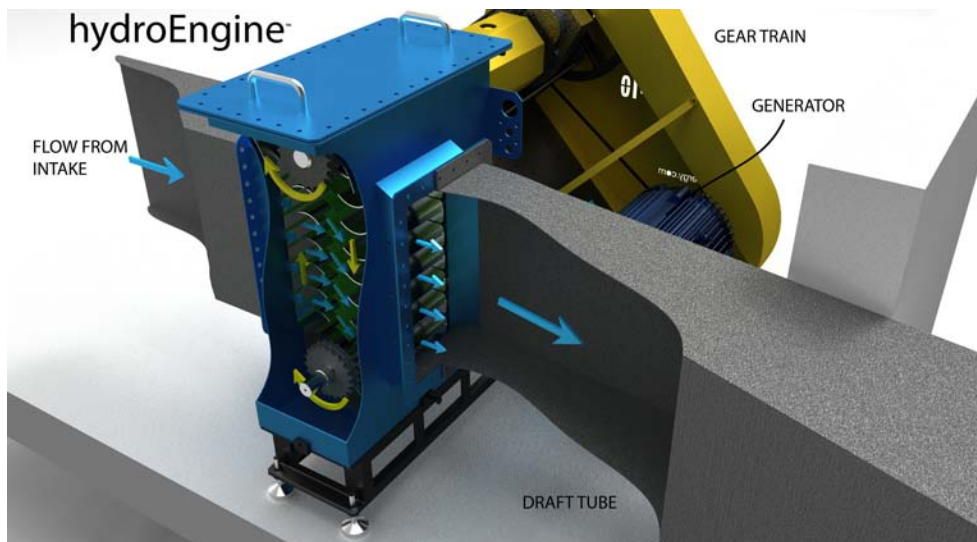
**Advanced Conventional Hydropower System Testing at a Reclamation Facility:** To support system tests of innovative, low-head hydropower technologies that can reduce capital investment costs for hydropower development at previously marginal sites, DOE and Reclamation jointly funded the following two projects for demonstrational deployment and testing via a FOA. Both projects will develop hydropower facilities on the Reclamation canal facilities.

**Installation of new hydropower technology (designed by Natel Energy) at the Monroe Canal Drop on the North Unit Irrigation District in Oregon:** As part of the 2011 joint FOA between DOE and Reclamation, Natel Energy (<http://natelenergy.com/>) was selected to demonstrate the 400 kilowatt SLH100 low-head hydropower technology on the Monroe Drop located at a Reclamation facility in North Unit Irrigation District, Oregon (<http://www.northunitid.com/>). This project will not only further the development of cost-competitive, low-head hydropower technology, but it will also set the stage for future hydropower development at existing federal and non-federal facilities. [http://www.usbr.gov/projects/Project.jsp?proj\\_Name=Deschutes%20Project#Group427530](http://www.usbr.gov/projects/Project.jsp?proj_Name=Deschutes%20Project#Group427530)



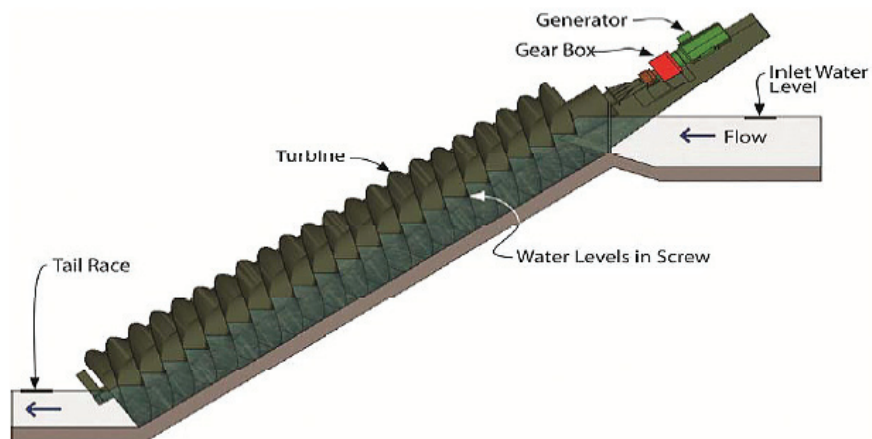
**Figure 11:** Monroe Drop project site, bird's-eye view of planned SLH installation





**Figure 12:** Natel Energy SLH component diagram

**Installation of new hydropower technology (by Percheron Power) on a Reclamation site:** Percheron Power will install and test the nation’s first Archimedes Hydrodynamic Screw (AHS) hydropower system on a Reclamation site. By demonstrating the reliability, efficiency, economic viability, and inherent simplicity of the AHS system within a federally constructed and owned irrigation system, it is envisioned that Reclamation, irrigation districts, utility companies, and others will rapidly move to deploy the AHS and similar low-head technologies at other engineered drop structures and control structures across the country.



**Figure 13:** Percheron Power graphic of Archimedes Hydrodynamic Screw

**Water Quality:** DOE has also initiated a project with the Corps (Nashville District) and Vanderbilt University to apply state-of-the-art high-fidelity hydrodynamic and water quality models to several Corps reservoirs on the Cumberland River to investigate operational changes in order to improve water quality and power generation. It is anticipated that the results of this work will be published in 2012.

### **Future Activities**

DOE has also been working with USACE and Reclamation to investigate the possible creation of an operational tool to help predict total dissolved gas concentrations below hydropower dams (particularly in the Pacific Northwest), thus optimizing power generation while maintaining environmental compliance for water quality. Depending on the results of the preliminary investigation and the availability of resources, this project may commence in 2012 or 2013.

## Category F—Renewable Energy Integration and Energy Storage

**Goal:** Emphasize the critical role that hydropower can play in working to integrate other renewable energy technologies into the U.S. electric grid.

### *Initiative F.1—Feasibility Analysis of New Pumped Storage Hydro*

Conduct a technical, economic, and environmental feasibility analysis of environmentally sustainable potential pumped storage sites that could be developed at existing USACE and Reclamation facilities (including both powered and unpowered dams). This analysis will compile and incorporate previous research on pumped storage feasibility.

#### Action Item F.1.1 – Renewable Energy Integration

Establish scope and statement of work, coordinate roles of each agency, and establish timeline for specific deliverables.

Deliverable	Lead Agency	Due Date	Status
Scope of work and timeline	DOE, Reclamation	June 2010	Reclamation task complete; DOE effort redirected

### Details

**Pumped Storage Hydropower Assessment:** In 2010, DOE initiated a project through ORNL and Idaho National Laboratory to produce a report that assessed the technical development models, costs, and site characteristics of existing and planned pumped storage hydropower facilities. The report detailed areas in the United States where pumped storage hydropower facilities could be developed and analyzed the costs and potential environmental impacts of such developments. This effort was intended to focus on sites where pumped storage plants could be co-located with existing water developments (existing NPDs and hydroelectric facilities), specifically including federal infrastructure. In 2011, this project was indefinitely discontinued; a decision partially based on resource constraints, but also largely due to an evaluation of the benefits of such a study. DOE determined that site availability for the construction of pumped storage facilities was not a major limiting factor for new developments, and decided to focus efforts on analyzing and quantifying the value of ancillary services provided by pumped storage projects. [http://my.epri.com/portal/server.pt?open=512&objID=396&&PageID=241272&mode=2&in\\_hi\\_userid=2&cached=true](http://my.epri.com/portal/server.pt?open=512&objID=396&&PageID=241272&mode=2&in_hi_userid=2&cached=true)

**Reclamation-DOE-National Renewable Energy Laboratory Interagency Agreement:** Reclamation has entered into an interagency agreement with DOE to work with the National Renewable Energy Laboratory (NREL) to complete a West-Wide Utility-Scale screening and a West-Wide Facility-Scale screening. The agreement also includes site visits that will help stakeholders gain a better understanding and more details about the conditions under which renewable energy could be installed economically. The site visits will be completed in FY 2012.

NREL is also developing an assessment of replacing power from the Navajo Generating Station in Arizona with renewable power in the event that upgrading air quality controls is prohibitively expensive. An analysis was completed for the Navajo-Gallup Water Supply Project to integrate renewable energy power into the construction of that water delivery system. Finally, NREL is assisting with the evaluation of renewable energy generation to help offset high power costs for pumping water as part of the Klamath River Settlement.

**Hydrogenerator Start/Stop Cost Study:** One of the key pieces of information necessary for integrating existing hydropower with other renewable resources is the cost associated with the start and stop of generating units to support these variable resources. While numerous attempts have been made by the hydropower industry to determine start/stop costs, a definitive answer has not been determined. In 2010, under the MOU, Reclamation initiated a study to better determine start/stop costs for hydrogenerators. The study was initiated with a literature search to find all past studies and research that has been done on this subject. That literature search was completed in 2010. Also in 2010, Reclamation, in conjunction with CEATI, performed a study to identify aging and deterioration to high-voltage hydrogenerator windings from intermittent starts and stops. This study was completed in 2011 and is currently under review. Reclamation plans to complete and publish the start/stop study by December 2012.

## Future Activities

In September 2011, a project was awarded under the joint DOE/DOI Advanced Hydropower Technology Development FOA to a team led by Argonne National Lab (ANL) to update grid simulation models that will allow for much more detailed analysis of the ancillary benefits provided by advanced pumped storage systems. This effort is a follow-on activity to the DOE/Electric Power Research Institute project mentioned above. Work in support of this effort will continue over the next two years; results are expected near the end of 2013.

**Offsetting Project Load with Solar and Wind:** In 2013, Reclamation will examine the use of a competitive grant program to install wind and solar on Reclamation projects to increase the use of renewable energy in the management and delivery of water. In collaboration with an irrigation district, Reclamation will determine whether deliveries can be timed to coincide with solar or wind peaks; thereby, lending themselves to use of those renewable technologies. This would have the net effect of making more hydropower available to the grid. Reclamation will build upon the West-Wide Utility-Scale and West-Wide Facility-Scale analysis completed by NREL.

**Solar Development:** Reclamation has some experience with small solar development, primarily to run remote monitoring sites on irrigation projects and to provide local project power for offices and shops. The benefits of this development include: (1) offsetting current hydroelectric power generation, making that generation available for the grid and current federal customers' use; (2) demonstrating to the public, Reclamation's commitment to renewable energy and the environment; and (3) taking advantage of the fact that solar is an ideal power source for irrigation pumping because pumping loads are usually greater during periods of maximum solar intensity. To that end, Reclamation has identified several possible solar development projects.

With the assistance of NREL, Reclamation is currently exploring the legal structures and requirements for solar development on Reclamation lands in Imperial, California. This site is promising because of California's tax incentives and renewable energy targets.

**Demand Response Initiative:** While most of Reclamation's renewable energy efforts have focused on the development of new renewable projects and technologies, additional opportunities are available through energy conservation. Several utilities, including BPA, have programs in place to improve efficiencies on the demand side of the system. These programs include refurbishment of irrigation pumps and equipment to improve the efficiencies of that equipment. Work under this topic will include collaborating with BPA and the Western Area Power Administration to develop programs to improve efficiencies of Reclamation loads (e.g., pumping plants). The program will begin in 2012 and continue through 2014.

### *Initiative F.2—Assessment of Energy Storage Needs*

Collaborate with other federal agencies and various industry stakeholders to assess the amounts and distribution of energy storage needed to effectively integrate other intermittent sources of renewable energy into the U.S. electric transmission grid.

#### Action Item F.2.1 – Assessment of Energy Storage Needs

Assess and report on all work of this nature occurring in DOE, DOI, and DOA, and coordinate with any similar projects taking place in other federal agencies or occurring outside the federal government.

Deliverable	Lead Agency	Due Date	Status
Multiple reports	DOE	Not identified	Ongoing

### Details

This report will serve as the first major deliverable, identifying work that is occurring across the three MOU agencies in regard to pumped storage.

Topic 2.2 of the DOE/DOI Advanced Hydropower Technology Development FOA expands DOE efforts to quantify the value of ancillary grid services provided by pumped storage facilities. This work will also be useful in modeling grid requirements for these services under different possible scenarios. <https://www.fedconnect.net/FedConnect/?doc=DE-FOA-0000486&agency=DOE>

### Future Activities

**Reclamation's Pumped Storage Study:** Starting in 2012 and continuing through 2013, Reclamation will investigate the feasibility of converting existing conventional hydroelectric facilities to pumped storage facilities. Pumped storage is recognized as one of the most useful methods for regulating intermittent resources like wind and solar. Because the cost of developing these facilities is considerable, if existing conventional hydropower facilities that already have an upper and lower reservoir can be converted to pumped storage operation, it may make it more feasible to develop. If this conversion is feasible, benefits could be gained by using these resources to regulate other non-dispatchable renewable energy, such as wind and solar. Several Reclamation facilities show some initial promise of being able to be converted to pumped storage operation.

## Category G—Regulatory Processes

**Goal:** The agencies will work together and investigate ways to efficiently and responsibly facilitate the current federal permitting process for federal and non-federal hydropower projects at federal facilities, within existing authority.

### *Initiative G.1—Interagency Regulatory Process Collaboration*

Collaborate with other federal agencies to clarify the current permitting processes for projects and development occurring at federal sites and facilities, and identify the most time-intensive and resource-intensive components of each process. Work with other federal agencies to identify ways in which processes could be shortened by reducing unnecessary delay, streamlined, or simplified for appropriate projects.

#### Action Item G.1.1 – Interagency Collaboration

Hold a workshop with all federal agencies involved in the permitting process, including the U.S. Fish and Wildlife Service, the National Park Service, the Bureau of Land Management, and others.

Deliverable	Lead Agency	Due Date	Status
Collaborative workshop	DOE, Reclamation, USACE	June 2010	Complete; Held June 30, 2010

### Details

**Lease of Power Privilege (LOPP) Workshop** Reclamation and its regional offices, power and water customers, investors, and developers have conducted several meetings to identify ways to improve the LOPP process. Reclamation has developed a directive and standard to provide standardized guidance for Reclamation offices and developers in permitting under the LOPP process. The updated requirements provide a common understanding of how the LOPP process is administered and how Reclamation will enhance working relationships with project partners. To develop these revisions, Reclamation sought input from its employees, project stakeholders, and various hydropower industry parties. The revised Directive and Standard provides clearer guidance and time frames on LOPP requirements, clearly assigns roles and responsibilities within the organization for LOPP development, sets a standard methodology across Reclamation for the LOPP charge, and clearly identifies all potential charges for developers. On November 4, 2011, Reclamation posted the revised directive and standard on its website and notified stakeholders and the hydropower industry that feedback was welcome. More than 120 comments were received from federal power customers, federal irrigation customers, developers, and industry representatives. Reclamation is currently reviewing these comments and will re-issue a revised directive and standard in April 2012. Additional comments will be accepted on the revised draft.

### Future Activities

Reclamation and the Corps are planning workshops to discuss permitting issues for private development at their facilities at the National Hydropower Association Annual Conference in Washington, D.C., to be held in April 2012.

### Action Item G.1.2 – Options for Improved Regulations

Produce a report detailing the results of the workshop, and highlighting current requisite permits, overlapping areas of information required by permits, and lead times associated with each type of federal permit.

Deliverable	Lead Agency	Due Date	Status
Workshop report	DOE	Complete within three months of workshop	Ongoing

### Details

**Permitting Workshop:** After the 2010 workshop, the MOU agencies decided to conduct a series of surveys and interviews with developers who had initiated or recently completed developments at federal facilities in order to evaluate trends in time, effort, cost, and complexity of the process. This project may be able to be completed in 2012.

### Future Activities


Depending on the availability of resources and staff, it is possible that the regulatory survey will be resumed in 2012.

## MOVING FORWARD

The MOU agencies have made significant progress and intend to continue working together to improve and expand hydropower generation in the United States. Electricity from hydropower still represents the majority of renewable energy capacity and generation across the country, and the flexibility and grid services provided by hydropower can be extremely useful for the integration of other renewables as they continue to expand. Although hydropower is an extremely reliable and long-term resource, analysis shows that more than half of all hydropower turbines in the United States are more than 50 years old—35% are more than 75 years old. This presents both a challenge and an opportunity in the need to innovate and modernize U.S. facilities so that the nation can continue to rely on its hydropower resources for cost-effective and renewable electricity into the future. There are also numerous opportunities to develop new generation through research and demonstration of advanced technologies, which can further reduce the cost of energy for new hydropower and improve sustainability and environmental performance. USACE, DOE and DOI will continue work through their partnership and expect to make even more progress over the next two years as they have during the past two.

<sup>2</sup> 2010 State Renewable Electricity Profiles: <http://www.eia.gov/renewable/state/>





U.S. Department of the Army, U.S. Army  
Corps of Engineers

U.S. Department of Energy

U.S. Department of the Interior