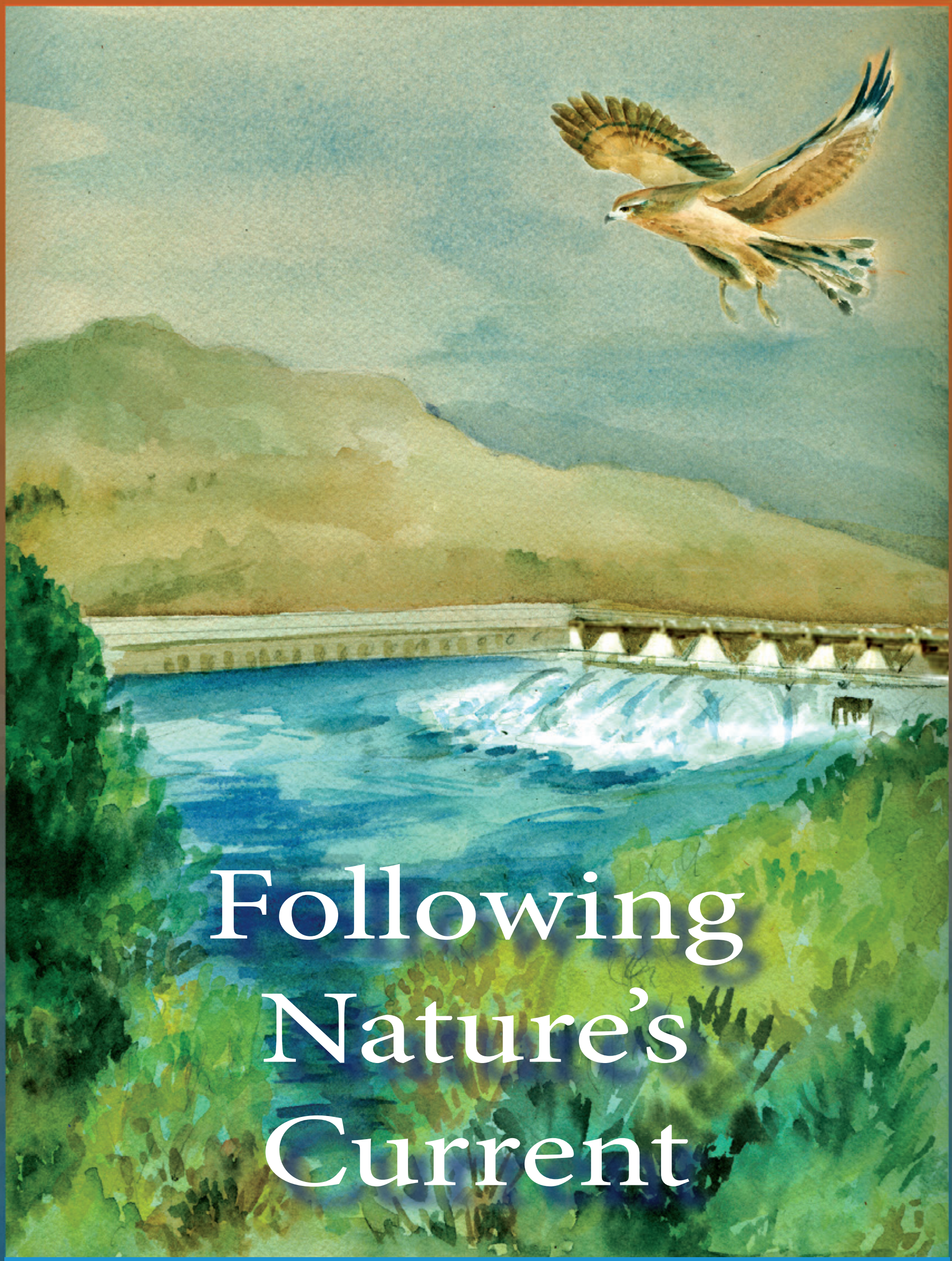

Following Nature's Current

HYDROELECTRIC POWER IN THE NORTHWEST

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PROVIDING BALANCED INFORMATION FOR USING WATER AS A RENEWABLE ENERGY RESOURCE IN THE NORTHWEST

The Foundation for Water and Energy Education (FWEE) is a non-profit organization whose mission is to provide balanced information about the use of water as a renewable energy resource in the Northwest.

FWEE meets our mission by providing materials and outreach activities that help the general public, opinion leaders, teachers, students of all ages and other groups make informed choices about hydropower and the Northwest's energy future. These choices are fundamental to meeting our environmental, cultural, economic and quality of life desires.

Join over 100,000 others who visit our web site annually to find:

- hands-on, interactive materials that can be used in classrooms, science fairs and other settings,
- resource information and tours that explain complex issues with language that is easy to understand,
- links to related information and organizations,
- and news stories from throughout the region.

The information in this publication was developed and reviewed by FWEE members and others with a deep understanding of how hydropower and other power resources contribute to our Northwest energy future. The on-line version also has links to related reference material. Although developed collaboratively, the content is solely the responsibility of FWEE and does not necessarily represent the view of a FWEE member or contributor.

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Illustrations by Janet Hess

Hydropower: The Northwest's Renewable Bounty

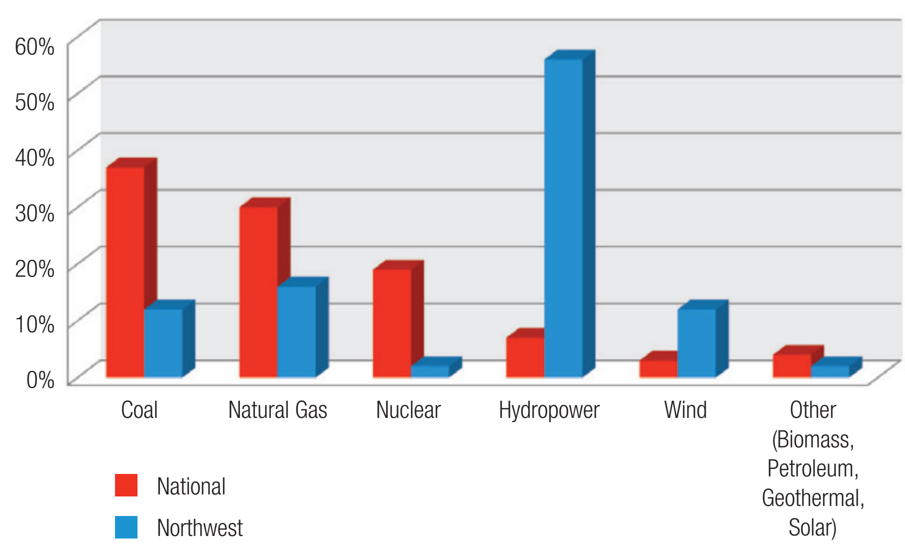
Living in the Northwest means, on average, you pay 28 percent less for electricity than the rest of the nation.

It also means our carbon footprint from generating electricity is about half that of the rest of the nation. This is great news for those who are concerned with low cost, clean, renewable power that is reliable, minimizes our contribution to climate change and supports energy independence.

Why are we so fortunate in the Northwest? In a word, hydropower. Hydropower, combined with energy conservation, wind power and emerging technologies, are the keys to powering our renewable Northwest energy future.

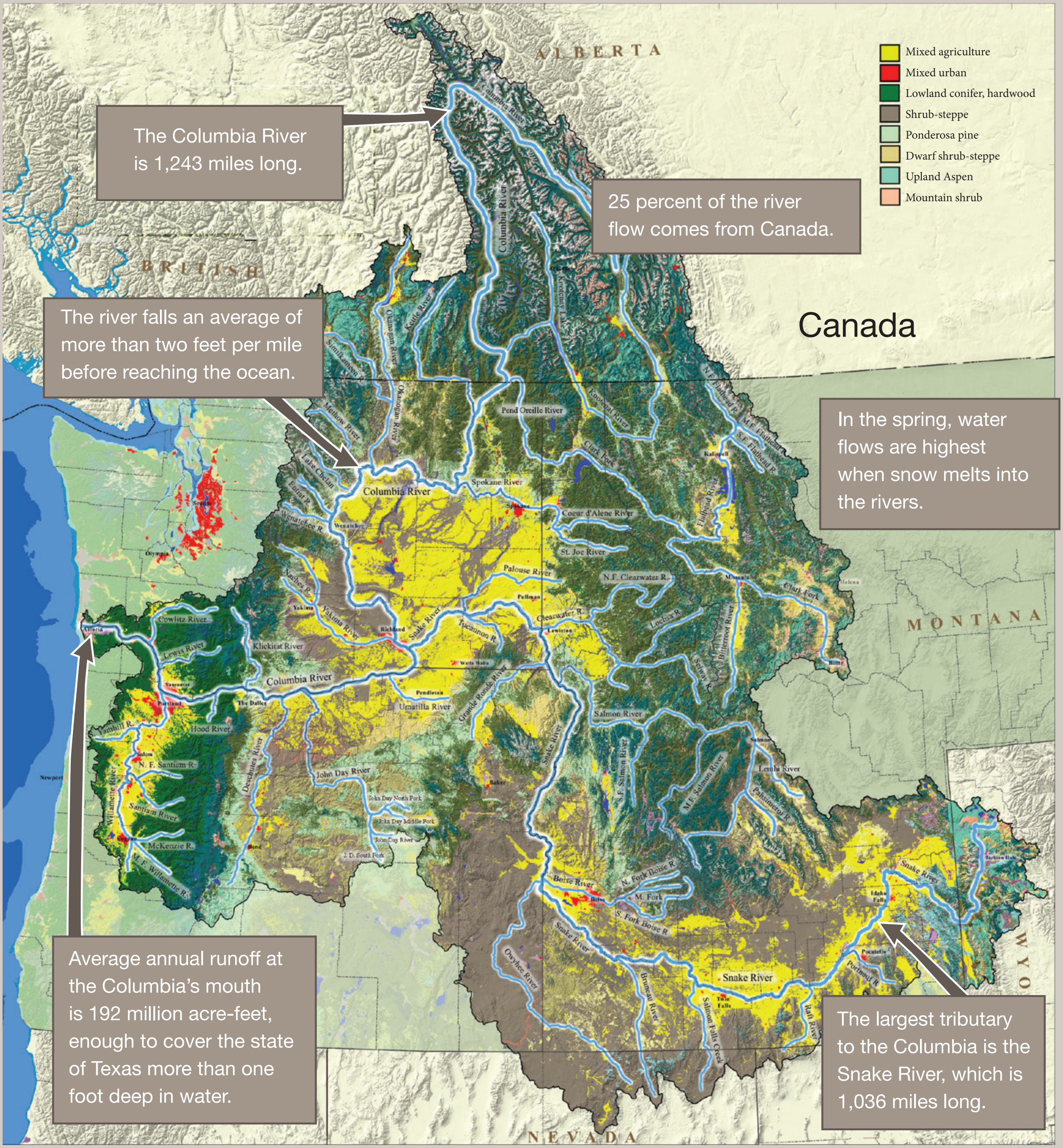
Following Nature's Current provides you an overview of why our mountains and streams provide this unique hydropower bounty, the daily actions taken to be good stewards of this resource and what the future holds for clean, renewable energy in the Northwest.

Comparing National vs. Northwest Electricity Generation Capacity 2012



Source: Northwest Power and Conservation Council, 2013 & U.S. Energy Information Agency, 2013

The Columbia River Basin



Source: Northwest Power and Conservation Council, 2013

The Dalles Dam

Tapping the Power of Water

About 40 percent of the nation's hydropower is located in the Northwest, and in the Northwest over 60 percent of our electricity comes from hydropower in a normal precipitation year.

Harnessing hydropower to generate electricity starts with the water cycle, also called the hydrologic cycle, bringing rain, snow, sleet and hail to our communities, mountains and countryside. Rivers, lakes and streams serve as collectors, carrying the water back to the ocean for the cycle to begin again.

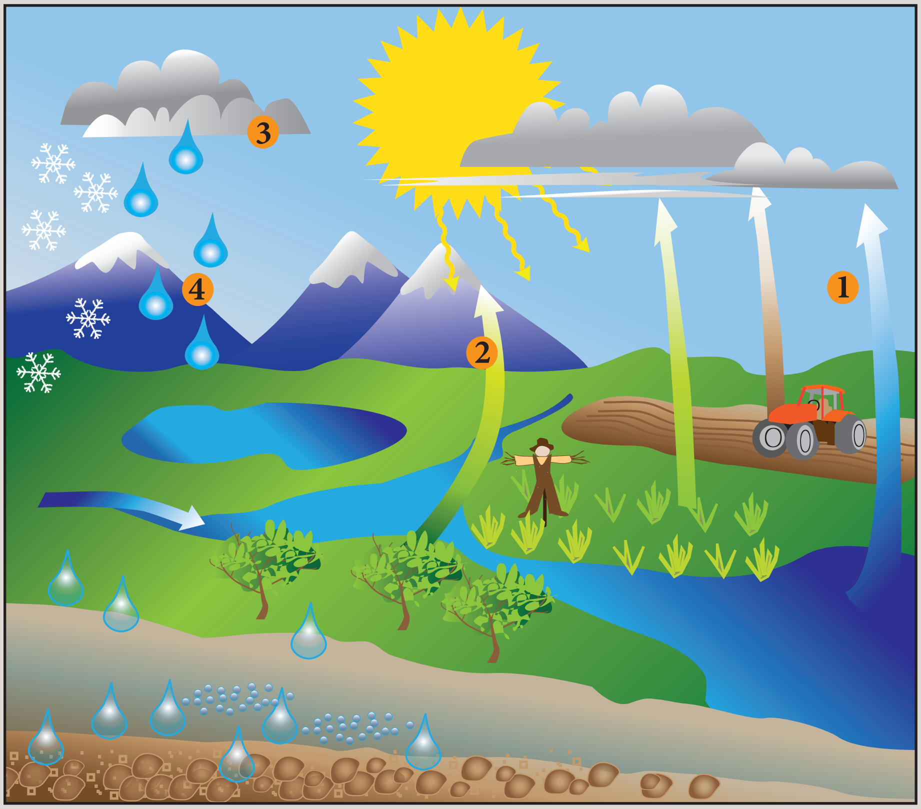
The water cycle in the Northwest interacts with the Columbia Basin in unique ways. The basin covers 259,000 square miles, an area the size of France, draining parts of seven states and Canada into the Columbia River.

From a hydropower perspective, water flow and elevation drop are what make this bountiful resource possible. The Columbia, for instance, is 1,243 miles long and is 2,690 feet above sea level at its headwaters. It has the greatest flow of any North American river draining into the Pacific, dropping an average of two feet per mile.

To think about the "force," or potential energy of this water flowing downstream, imagine you are on the Columbia River. Average stream flow at The Dalles Dam is about 190,000 cubic feet per second (cfs). That's like taking a football field and filling it with over three feet of water (or 1,421,000 gallons) and passing it by an imaginary line across the river each second. When the river flow peaks in spring, over twice this amount of water flows by The Dalles Dam.

The Water Cycle

Energy from the sun powers the water cycle. It causes water to: **1** EVAPORATE from oceans, rivers, lakes and even puddles. "Evaporate" means water turns from liquid to gas, or "vapor," and then rises into the atmosphere. Another form of evaporation is **2** TRANSPIRATION, which is when water given off through the pores of plants and animals joins the atmosphere. **3** CONDENSATION happens when the water vapor condenses around and clings to fine particles of air. As the air gets moister, droplets that form clouds get larger and larger. Eventually, **4** PRECIPITATION returns these droplets to earth as rain, snow, sleet or hail. The cycle begins again.



Powering the Northwest: Yesterday, Today and the Future

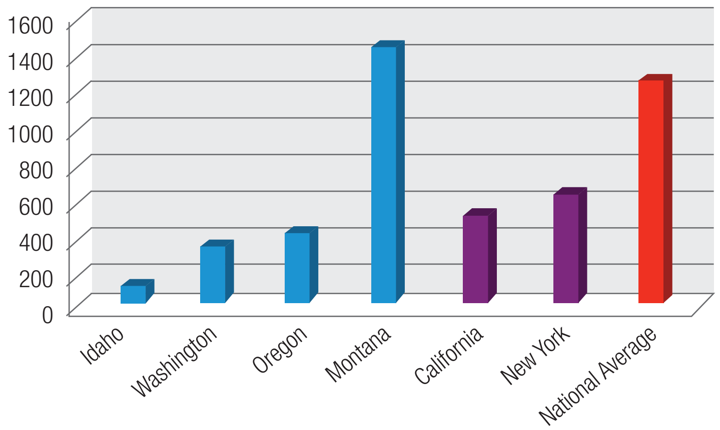
The Northwest's population and capacity to generate electricity has more than doubled since 1960.

The 20th century story of low cost, clean and renewable electricity in the Northwest is intimately tied to the development of hydroelectric projects, the largest of which serve multiple purposes. Hydropower spurred economic development by attracting energy-intensive industries such as aluminum, food processing, aerospace and national defense; navigation locks on Columbia River dams support a 465-mile corridor to ship millions of tons of cargo annually; irrigation uses reservoirs and diverts 6 percent of yearly runoff to grow crops on almost 8 million acres of land; and 55 million acre feet of water storage in reservoirs provide flood control, saving billions of dollars in property damage.

Success also stimulates growth, new opportunities and new needs. Energy-intensive demands for today's power include massive data centers to meet the Internet and data storage needs of people located around the world. In 2012, power used by data centers in the Northwest was the equivalent of powering about 239,000 Northwest homes. By 2030, data centers are expected to use about 4 to 7 times more power.

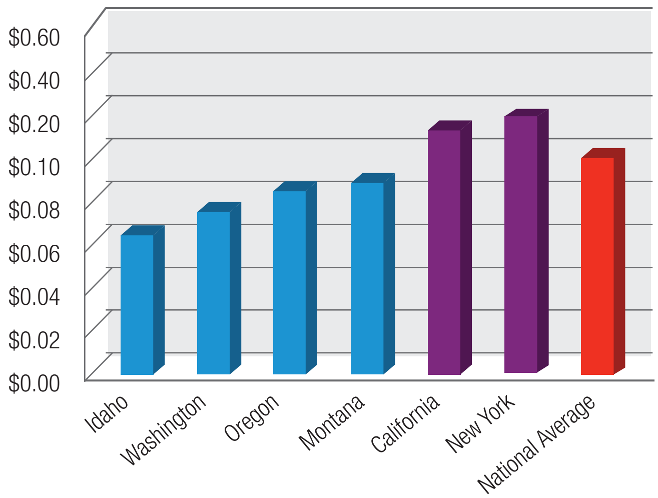
Further, people now use many electronic devices to make them more comfortable and connect them to a wired world. Currently, U.S. households own nearly 3 billion electronic devices, or about 26 per household. Powering information age needs while maintaining navigation, agricultural, flood control and environmental commitments is the focus of planners throughout the region.

State Carbon Dioxide Emissions Rate, 2010
(Pounds per megawatt hour)



Source: Environmental Protection Agency, 2014

Average Electricity Rate, 2011
(Cents per kilowatt hour)



Source: Nebraska State Government, taken from U.S. Energy Information Agency, 2013

Powering the Northwest Cont.

The Northwest's mix of power generation resources continues to evolve. In 1960, hydropower provided almost all of the region's generation capacity; in 2012, it provided about 54 percent. One reason for this change is integrating fossil fuels like coal and natural gas; and part of the story began in 1980 when Congress passed the Northwest Power Act and the Northwest Power Planning Council was formed.

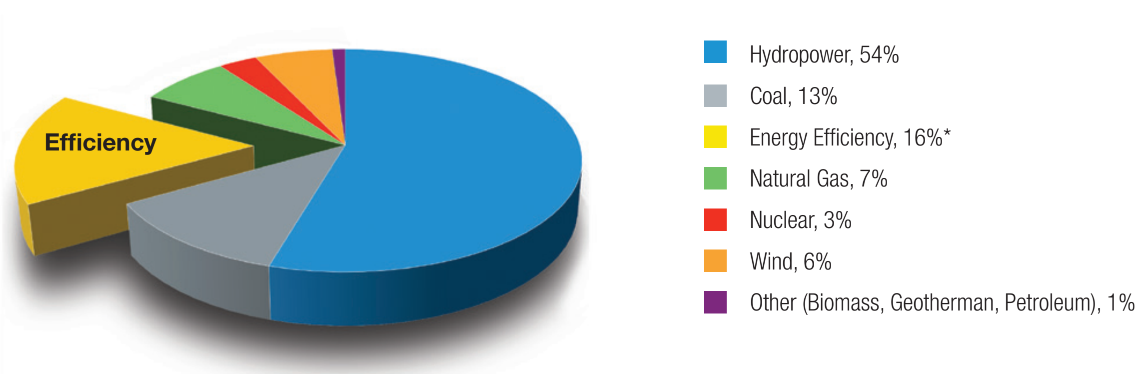
People in the Northwest committed to, invested in and embraced conservation and efficiency far beyond other regions of the country. Conservation means turning things off to reduce the amount of electricity used, and efficiency means using less power to accomplish the same task. Since 1980, conservation and efficiency have met 50 percent of the Northwest's additional power needs.

As we look toward 2030, up to 85 percent of the Northwest's increased power demands may be met through conservation and efficiency. That power savings is equivalent to meeting almost all the power needs of the state of Oregon. At the same time, planners are integrating thousands of megawatts of wind energy. This, combined with technologies described later, is the backbone of ensuring low cost, clean power that provides energy independence and a small carbon footprint for another generation.

As our energy resource mix evolves, hydropower remains as important as ever. It provides what's called "base load," the foundation of power supply that other generation resources build from and rely on. It is also provides "peaking," the ability to increase power supply quickly when demand is highest.

In the case of wind, which doesn't blow all the time, a renewable dance is at play. When wind turbines are operational, more water can be stored in the reservoirs of hydropower projects for future electricity generation. Likewise, when the wind is blowing poorly, water from these reservoirs can be used to generate more electricity.

Northwest Energy Resources 2012



***Efficiency**, like appliances and light bulbs needing less electricity to operate, translates into less power generation needed to meet demand. If you count each megawatt saved because of efficiency as the equivalent of a megawatt generated, 16% of the Northwest's electricity demands are met through energy efficiency.

Source: Northwest Power and Conservation Council, Staff Presentation

Hydropower Uses the Force of Falling Water to Generate Electricity

Hydroelectric projects take an unpredictable resource, rainfall and snowpack, and turns it into a reliable source of electricity.

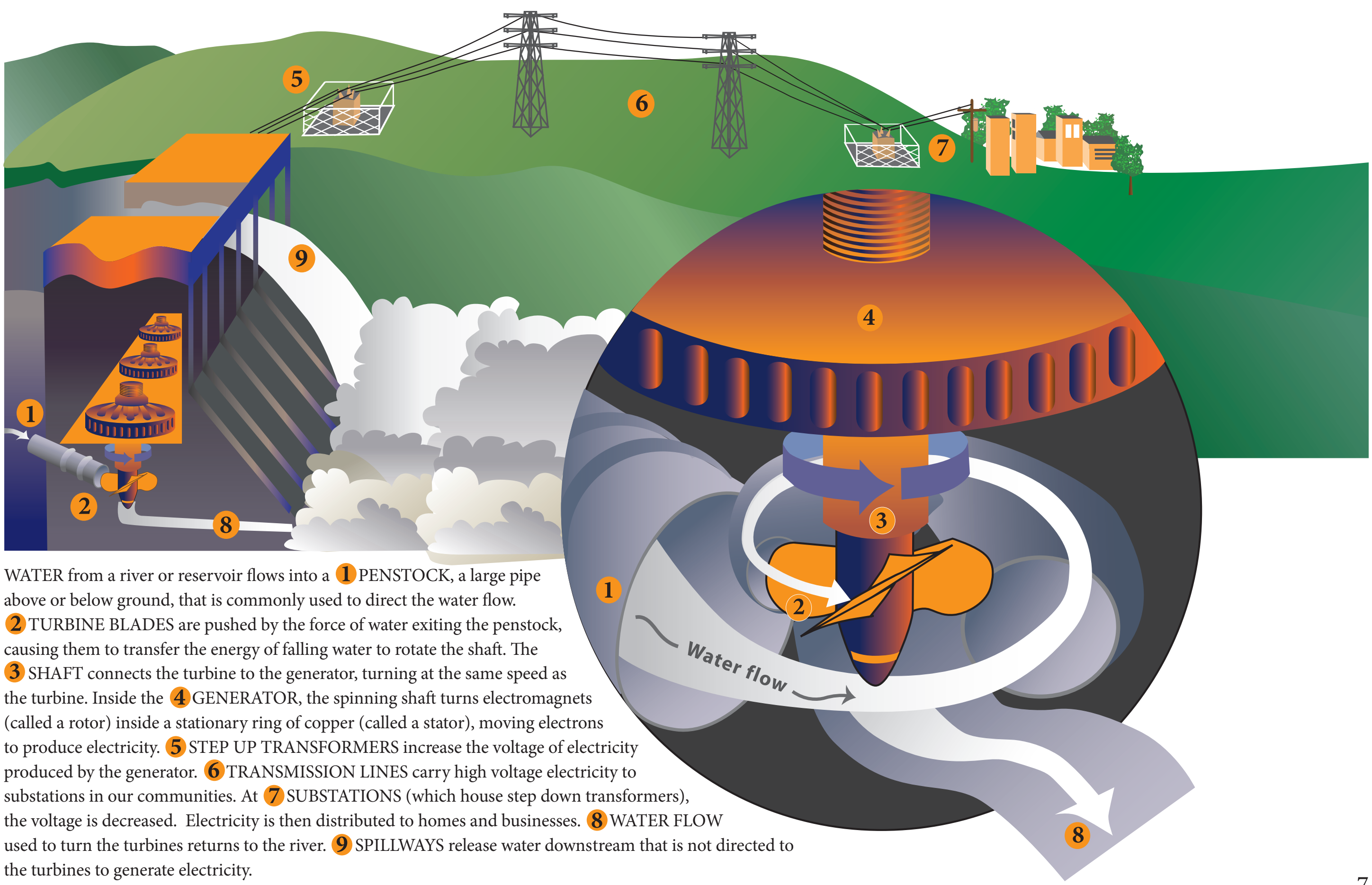
Each hydroelectric project is unique. The equipment and design reflect when it was built, the particular landscape and the geologic character of the location. And like our homes, equipment and designs are regularly updated. Hundreds of millions of dollars have been invested since the 1990s to replace turbines and rewind generators. These investments are used to help projects generate more power, use less water to generate the same amount of power, improve water quality and/or increase juvenile fish passage downstream.

From a power generation perspective, the other big difference between projects is “run-of-river” vs. “storage” projects. Storage projects have a reservoir, sometimes called a lake, behind the dam. By “storing” water, operators can adjust the river’s natural water flow to meet one or more needs. For instance, releasing water when more electricity is needed, capturing runoff to assist with flood control and having water for irrigation.

Storage between May and July also helps equalize river runoff over the course of the year. In fact, in the Northwest 60 percent of runoff occurs during this time. By storing water in U.S. and Canadian reservoirs, it can be released when supply is less plentiful during the late summer, fall and winter months. By comparison, the Columbia has similar available reservoir storage to the Colorado and Missouri rivers. But the Columbia has over 5 times the average annual runoff and over 7 times the hydropower generating capacity of the Missouri and Colorado rivers combined. Further, over half of the Columbia’s reservoir storage is in Canada.

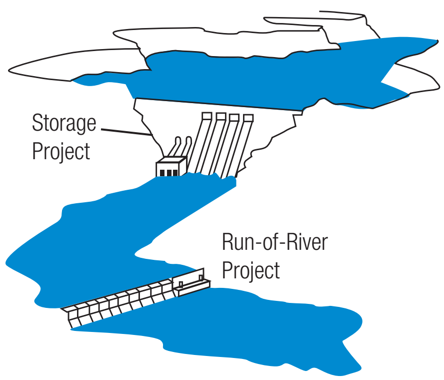
Run-of-river projects, on the other hand, allow water to pass through a facility at about the same rate the river naturally flows.

Take a Walk Through a Hydroelectric Project



WATER from a river or reservoir flows into a **1** PENSTOCK, a large pipe above or below ground, that is commonly used to direct the water flow. **2** TURBINE BLADES are pushed by the force of water exiting the penstock, causing them to transfer the energy of falling water to rotate the shaft. The **3** SHAFT connects the turbine to the generator, turning at the same speed as the turbine. Inside the **4** GENERATOR, the spinning shaft turns electromagnets (called a rotor) inside a stationary ring of copper (called a stator), moving electrons to produce electricity. **5** STEP UP TRANSFORMERS increase the voltage of electricity produced by the generator. **6** TRANSMISSION LINES carry high voltage electricity to substations in our communities. At **7** SUBSTATIONS (which house step down transformers), the voltage is decreased. Electricity is then distributed to homes and businesses. **8** WATER FLOW used to turn the turbines returns to the river. **9** SPILLWAYS release water downstream that is not directed to the turbines to generate electricity.

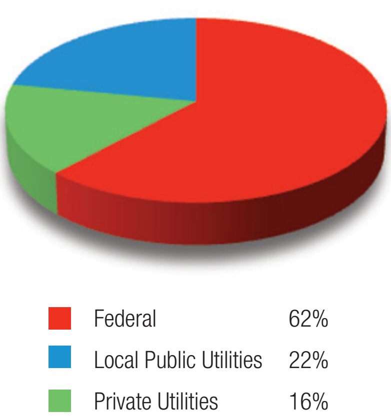
Storage vs. Run-of-River



In the Northwest, 60 percent of runoff occurs from May through July. Storage projects allow water to be released when supply is less plentiful during the late summer, fall and winter months. Storing water is helpful in meeting flows for fish, irrigation and flood control needs. It also enables intermittent resources such as wind and solar to be used on the power grid.

Run-of-river projects allow water to pass through a project at about the same rate the river naturally flows.

Northwest Hydropower Generating Capacity by Owner 2011



Source: Foundation for Water And Energy Education, 2013

The Who and How of Hydropower Generation

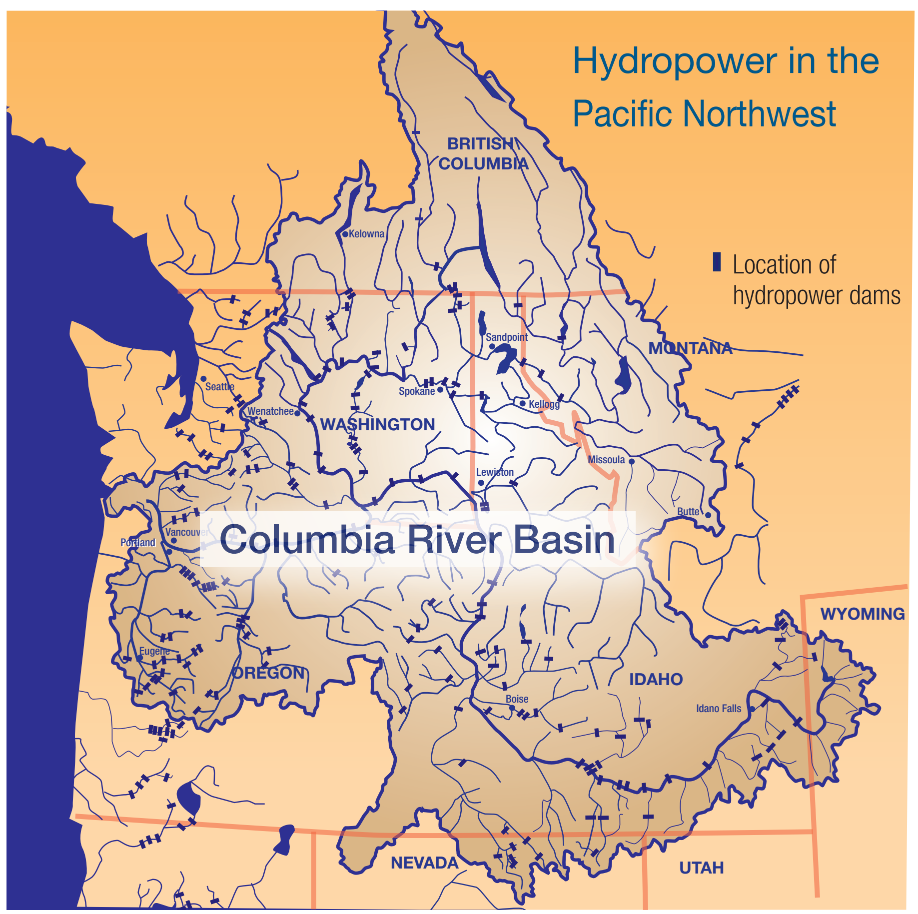
There are more than 370 hydroelectric projects in the Northwest's Columbia River Basin.

Northwest hydroelectric projects range from serving the needs of less than one hundred homes to Grand Coulee Dam, with a generating capacity that can meet the needs of over 4 million homes. The 16 largest projects account for 62 percent of the Northwest's hydropower generating capacity. All but one of the largest projects is located on the Columbia or Snake rivers.

A diverse group of public and private entities own and operate hydroelectric projects. The 48 federal government projects account for the majority of the Northwest's hydropower generating capacity. They are operated by the U.S. Army Corps of Engineers and Bureau of Reclamation. Many of these also serve flood control, navigation and/or irrigation needs as well. The Bonneville Power Administration markets this power, with proceeds going toward financing construction, operations and maintenance costs.

Public ownership also exists at the local level, primarily via public utility districts (PUDs), cooperatives and municipal governments. These projects are owned and operated by the local citizens they serve. There are 61 such projects that contribute 22 percent of the Northwest's hydropower generating capacity.

Private utilities, often called independent or investor-owned utilities, also own and operate projects. There are 264 private projects that contribute 16 percent of the Northwest's hydropower generating capacity.



Hydropower and the Environment

All forms of generating electricity affect the environment, including hydropower.

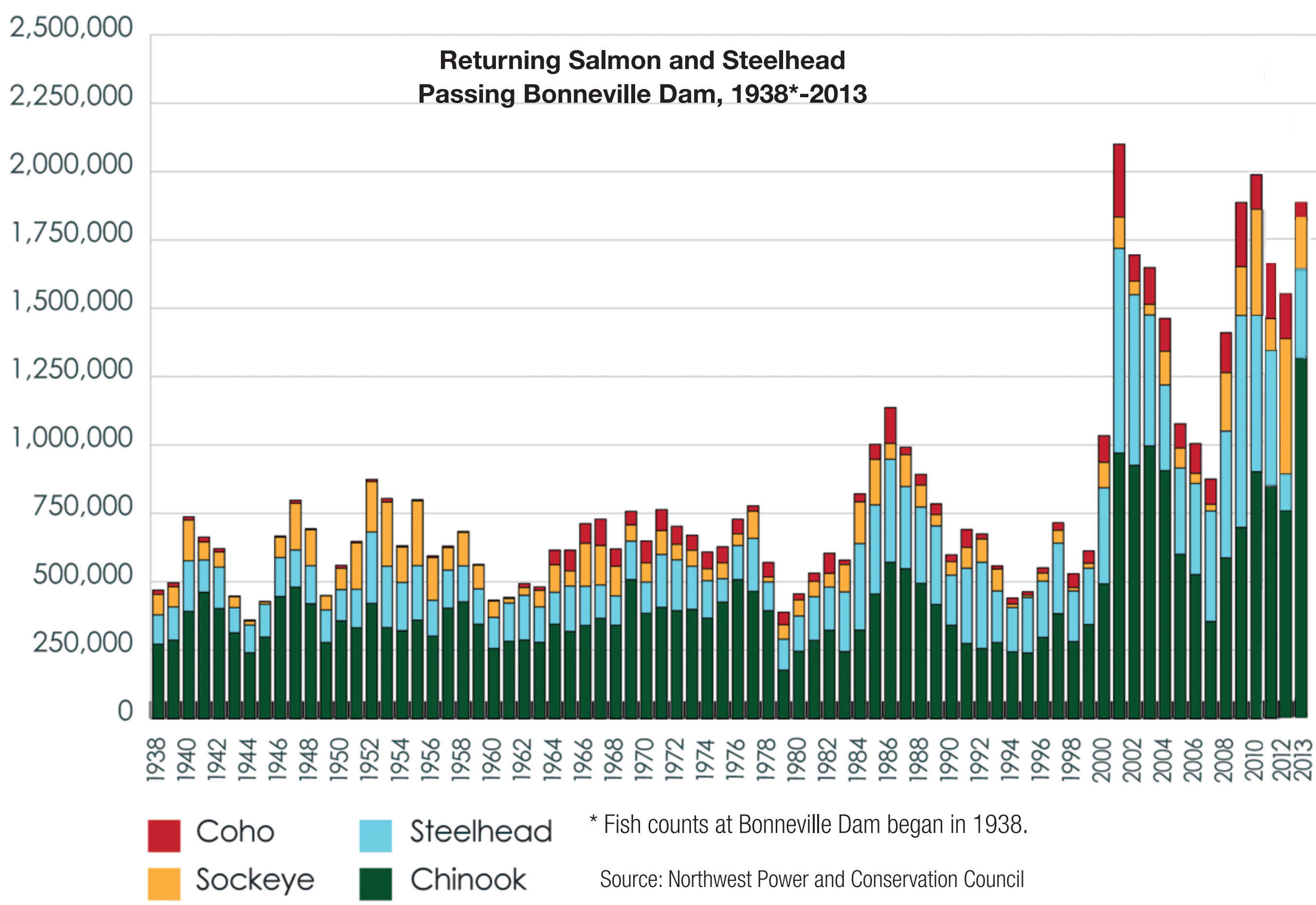
Environmental effects from hydroelectric projects largely stem from changes to river conditions and/or riparian areas, which is the land and vegetation bordering a body of water.

Depending on the type, size and location of a project, the most common effects relate to changes in river flows, water quality, erosion and sedimentation. Water quality concerns stem from things like changes in temperature, or water content with too much nitrogen or too little oxygen. While critically important, these projects are not a source of contaminants or toxins polluting the water.

The environment affects all manner of plant and animal species, from the top of nature's pyramid to the bottom. The complexity of successfully addressing these effects is made that much more complicated by other human practices like farming, logging, cattle grazing, mining and land development occurring adjacent to or upstream of a project. This is one reason natural resource managers often take a watershed planning approach to characterize conditions, prioritize needs, create management objectives and implement protection and restoration strategies.

Fishery issues (particularly salmon and steelhead) are a leading concern for many people. In the Northwest, there are 13 species of salmon and steelhead listed as threatened or endangered. In addition, Kootenai River white sturgeon and bull trout (a resident fish that migrates only within freshwater) are also listed as threatened. Most bull trout populations are now found in headwater areas of tributaries to the Columbia, Snake, and Klamath rivers.

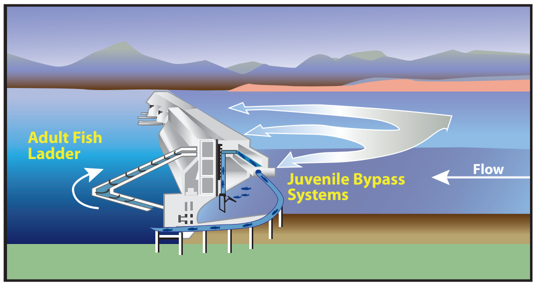
After years and hundreds of millions of dollars of investment, salmon and steelhead populations are beginning to improve. Since the 1990s, on average, chinook salmon have more than tripled in abundance and steelhead more than doubled. Further, in that period the abundance of 47 of 49 Interior Columbia Basin wild adult fish populations increased.



* Fish counts at Bonneville Dam began in 1938.

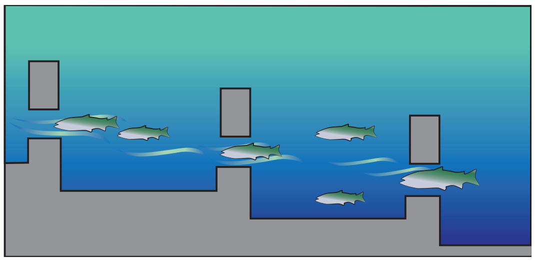
Source: Northwest Power and Conservation Council

Fish Passage Tour



When young salmon (smolts) migrating downstream encounter a hydroelectric project, they will either pass over a SPILLWAY, through the TURBINE area, be TRANSPORTED around a dam or enter a BYPASS SYSTEM.

Upstream Migration, Fish Ladder



Adult salmon migrating upstream will most often use a fish ladder as they journey to their spawning grounds.

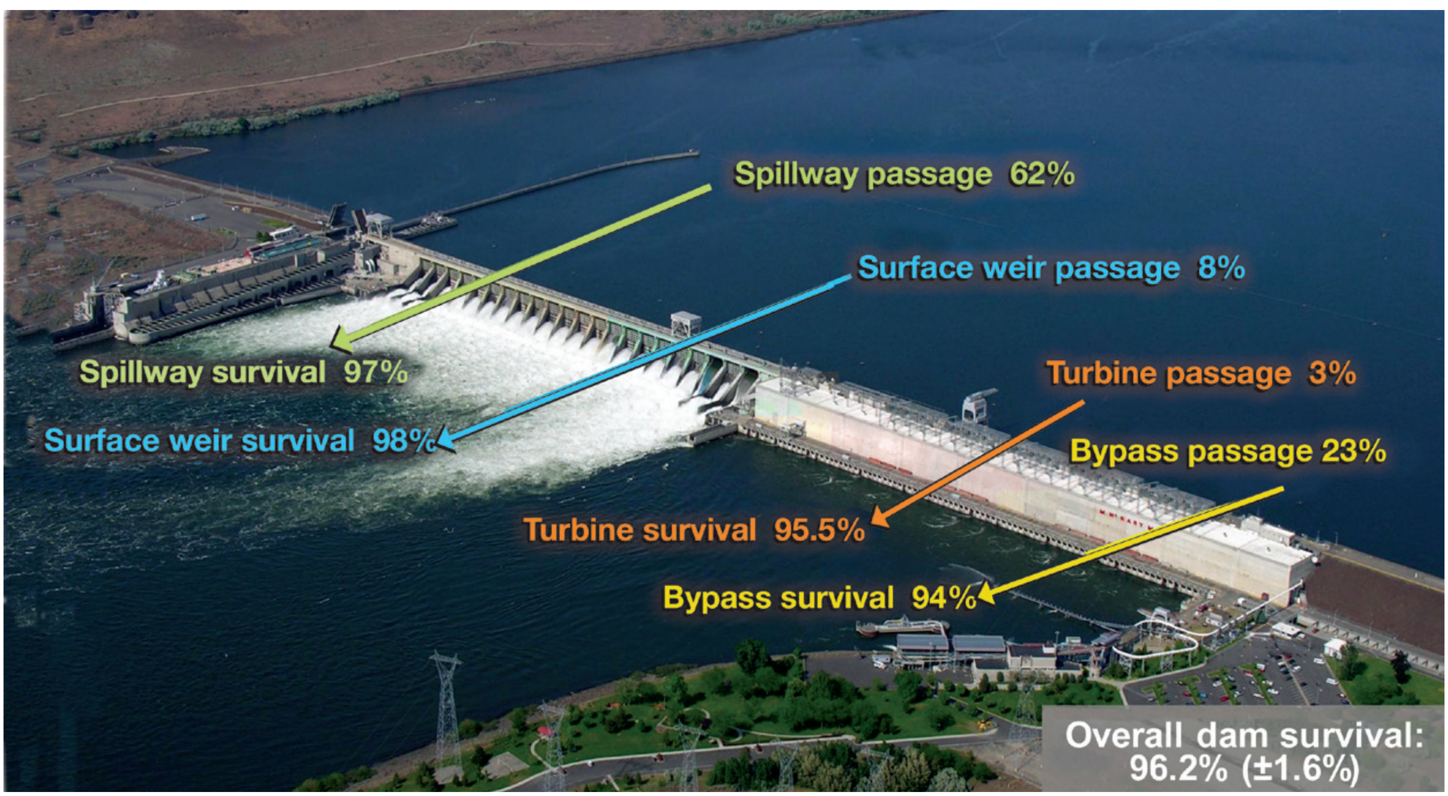
Environmental Protection, Mitigation and Enhancement at Hydroelectric Projects

Hundreds of millions of dollars are spent annually by federal, public and private operators of hydroelectric projects to offset or minimize adverse environmental effects. Since 1978, federal investments to support fish and wildlife needs are more than 6.6 billion dollars.

Fish, particularly salmon and steelhead that travel long distances between fresh and ocean waters, pass through multiple environments during their life cycle. To meet their many needs, diverse strategies are used to support up and downstream migration, improve habitat conditions and manage predation. In addition, hatcheries are used to supplement wild fish populations. Even with these supports, research indicates that changing ocean conditions beyond our local control also contribute to the variation of salmon and steelhead populations from year to year.

For salmon and steelhead on the Columbia River, federal performance standards call for 96 percent of spring fish migrating downstream to successfully pass each hydroelectric project, and 93 percent for summer migrants. Thanks to new fish bypass systems, turbine design, spillway improvements and other efforts, recent reports predict these performance measures have been or will be met by 2018.

McNary Dam
2012 Yearling Chinook Passage and Survival Estimates



The downstream fish migration passage is shown on the upper side of the dam. The survival rate for each passage point is shown on the lower side of the dam.

Source: The Columbia River Basin Federal Caucus, 2014

Protection, Mitigation and Enhancement

Protection, mitigation and enhancement are three broad strategies that can be used to help minimize possibly adverse environmental effects from a hydroelectric project.

Protection

Protection strategies focus on preserving areas in a watershed that are ecologically important, healthy and intact. Doing so often means protecting areas from human activities that can disturb the ecological functions of aquatic and riparian habitats.

For instance, wetlands provide critical wildlife habitat, assist with water purification and help store water during storms and floods. Because wetland areas may be in decline, assisting with their protection or restoration may be part of a hydroelectric project owner's efforts to assist with maintaining the overall health of a watershed. A watershed is the geographic area that drains into a common river, river system or other body of water.

Mitigation

In situations where habitat conditions are seriously degraded and impacts are unavoidable and cannot be recovered, mitigation strategies may be employed to help offset these losses.

The abundance and diversity of fish species may decline because fewer fish can successfully migrate past one or more dams to reach their spawning areas. In this instance, a mitigation strategy might include building a hatchery. Another example is purchase of land to protect and preserve sensitive wildlife.

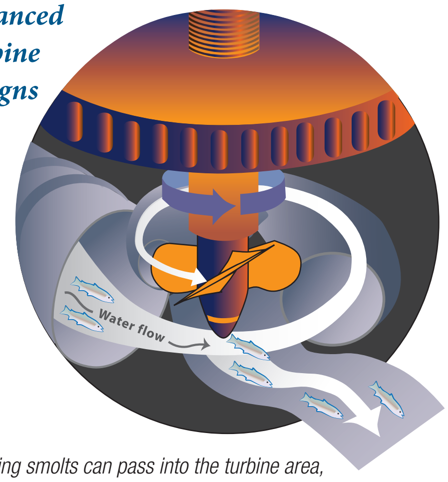
Enhancement

When a change to the environment occurs, one means of addressing the new effects is to establish enhancements that minimize or alleviate these effects. Such enhancements use technology and/or natural materials to alter or modify habitat conditions. By so doing, nondesirable habitat conditions can be offset to the greatest extent possible.

Examples of enhancements include creating fish passage, use of vegetation to control erosion and stabilize streambanks, installing screens to protect fish from irrigation facilities, and changing water flow conditions to meet habitat needs of various species.

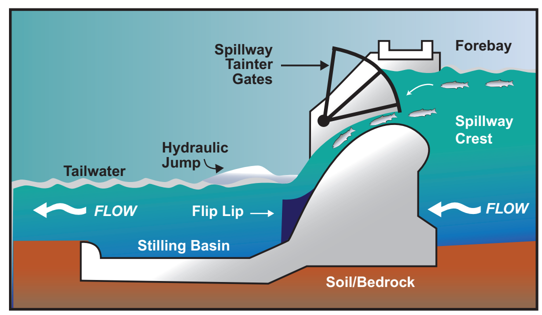
Fish Passage Tour

Advanced Turbine Designs



Migrating smolts can pass into the turbine area, and exit via the tail race. A new generation of turbines include minimum gap runners to increase turbine efficiency while decreasing the likelihood of being trapped, bruised, stressed or disoriented. This technology eliminates gaps on the turbine hub and at the tips of the blades.

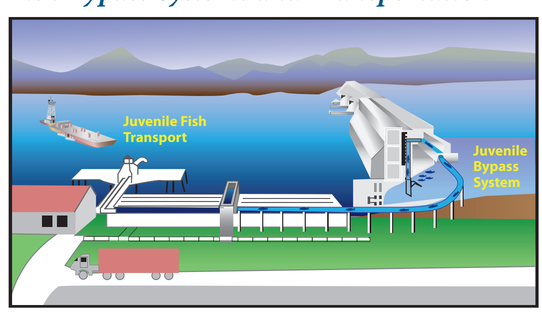
Spillway Improvements



Migrating smolts can pass over a spillway, fall into the pool of water below, and then continue their journey downstream. Some weirs now provide a water ramp that allow fish to slide down to the river below.

Flip lips, also called spill deflectors, are sometimes used to reduce the effect of total dissolved gas, or TDG, which can cause gas bubble disease in fish.

Fish Bypass Systems and Transportation



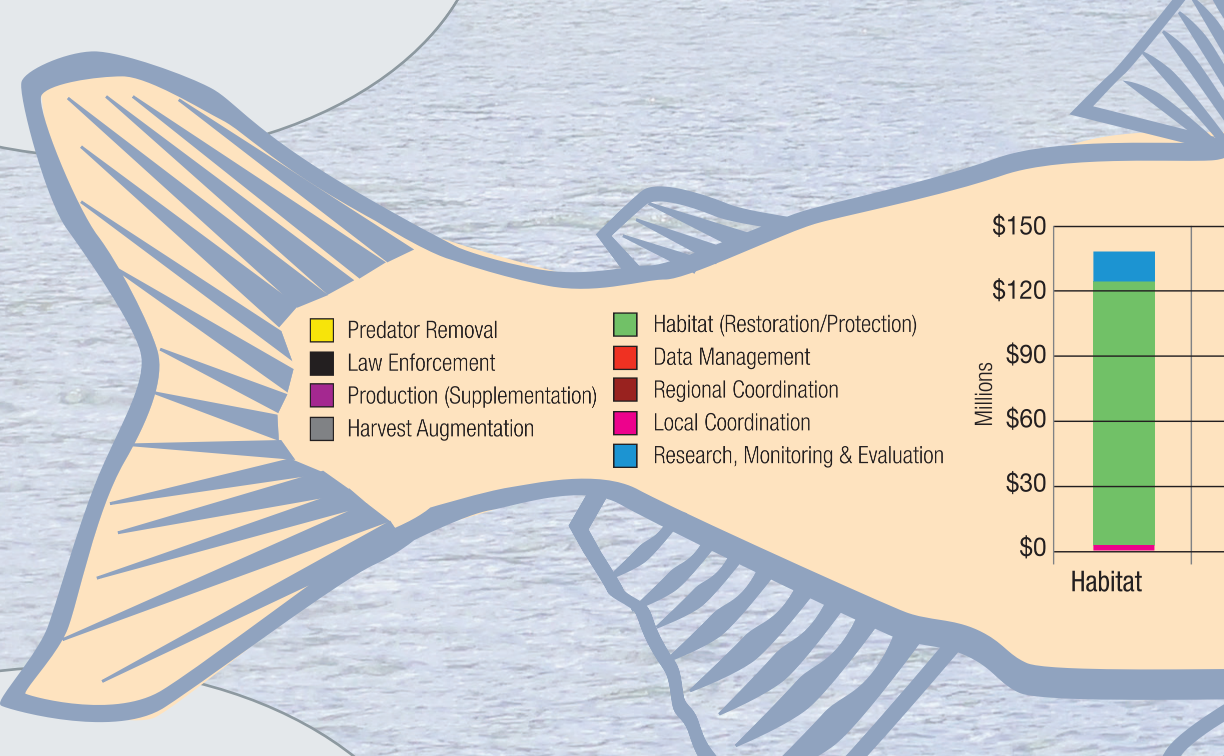
Surface collectors are a common means of guiding juvenile salmon around a project.

One method is to use fish screens to guide fish into a bypass system. Another method is to use a surface collector to channel fish into a bypass system. Along the main stem of the Columbia and Snake rivers, some migrating smolts are collected in barges and then transported up to several hundred miles downstream.

2012 Bonneville Power Administration Fish and Wildlife Program Expenditures

Chelan PUD

Hydro operations at Chelan PUD projects achieve no net impact on adult and juvenile salmon and steelhead through implementation of Habitat Conservation Plans.



Douglas PUD

Douglas PUD's unique Hydrocombine structure at the Wells Project enabled existing spillways to be used to build a fish bypass system in 1990. Using less than 10 percent of the Columbia River flow, the bypass achieves safe and effective passage for over 96 percent of the juvenile salmon and steelhead migrating downstream.

Eugene Water & Electric Board

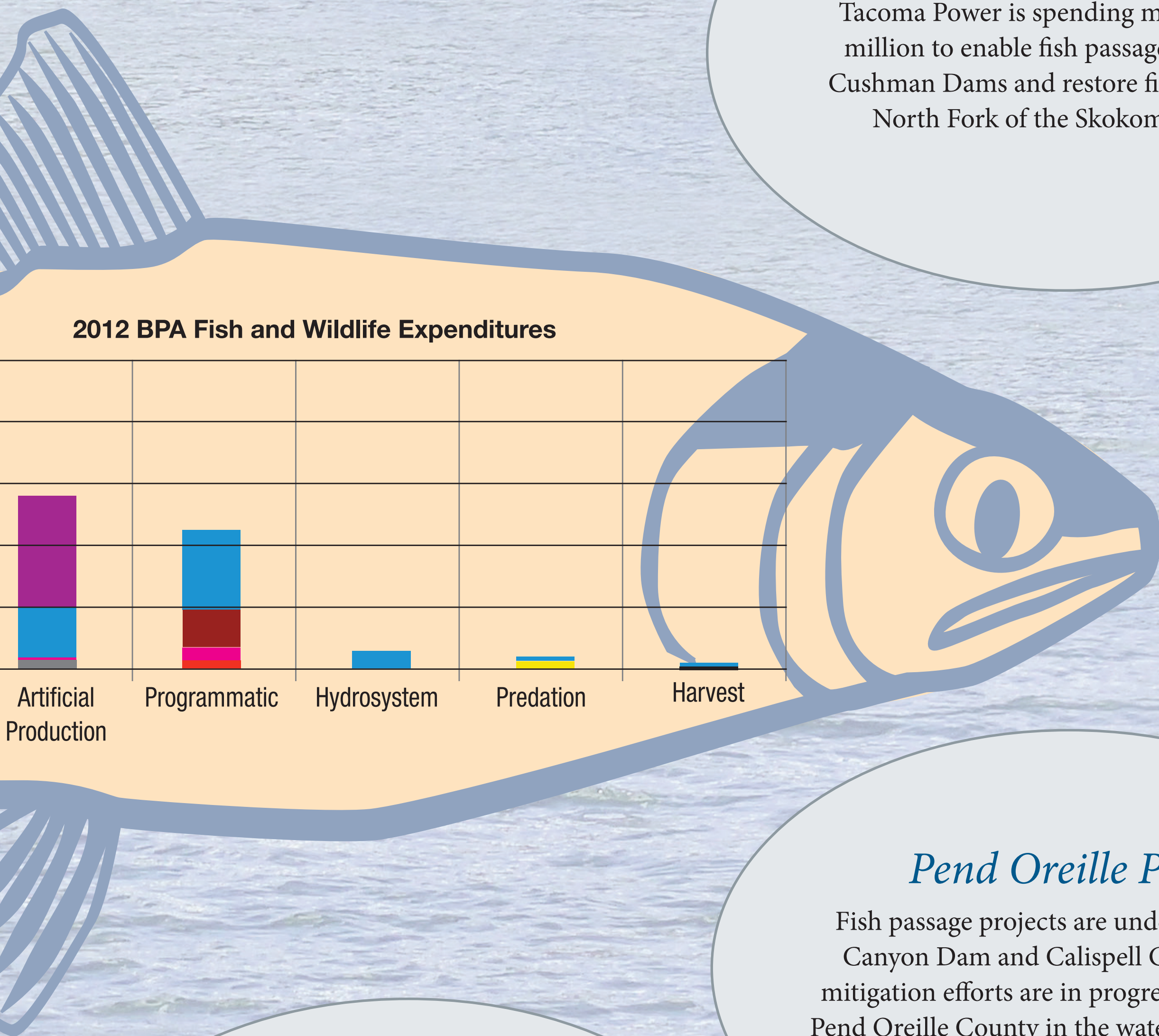
Fish passage improvements totaling more than $25 million at EWEB's Leaburg-Walterville Hydroelectric Project on the McKenzie River help ensure safe upstream and downstream passage of chinook salmon and other native species.

Source: Northwest Power and Conservation Council, 2013

In 2012, BPA invested $306.4 million dollars to address fish and wildlife needs caused by operation of the Federal Columbia River Power System. Add to this millions spent on fish and wildlife projects by private and locally owned public power utilities to meet their regulatory requirements.

Tacoma Power

Tacoma Power is spending more than $50 million to enable fish passage around the Cushman Dams and restore fisheries on the North Fork of the Skokomish River.



Pend Oreille PUD

Fish passage projects are underway at Box Canyon Dam and Calispell Creek. Other mitigation efforts are in progress throughout Pend Oreille County in the watershed streams.

Grant PUD

Grant PUD has spent more than $60 million to install juvenile fish bypass facilities at Priest Rapids and Wanapum dams, ensuring at least 95 percent successful downstream migration of salmon and steelhead past these projects.

The Future of Hydropower in the Northwest

Hydropower will continue to be the largest source of electricity in the Northwest for years to come.

As the largest source of electricity in the Northwest, hydropower provides the “base load” that other generation resources build on. In 1960, almost all of the Northwest’s generating capacity came from hydropower. By 2012, it was about 54 percent and projected to remain that way through 2025.

Our need for additional generating capacity reflects a simple truism: as our population and business needs continue to grow, so does the need for more electricity. From 1960 to 2013, the Northwest’s population grew by almost two and a half times. From 2013 to 2025, the Northwest’s population is expected to grow another 10 percent (1.6 million people).

Since the 1960s, the resources we used to generate electricity grew to include coal, natural gas, nuclear and wind. Looking toward the future, conservation and efficiency, determining new power generation resources and assuring the least environmental impact becomes ever more complex.

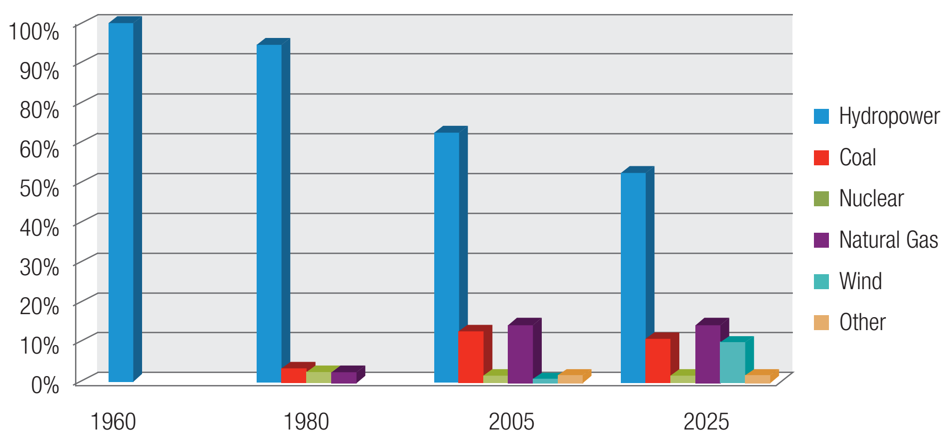
For instance, the two largest coal-fired plants in the Northwest are scheduled to be closed in 2020 and 2025. Between them, they provide enough power to meet the electricity demands of Seattle twice over.

How we approach our future has four distinct dimensions:

- Increasing energy efficiency and conservation
- Developing the Smart Grid
- Reinvesting in hydropower and integrating new power generation sources
- Balancing environmental and power generation needs

Successfully accomplishing each dimension will continue to make the Northwest home to some of the lowest cost electricity, cleanest air and smallest carbon footprint in the United States.

Generating Capacity
The Northwest’s Evolving Power Mix



Source: Northwest Power and Conservation Council

Increasing Energy Efficiency and Conservation

In many cases, the least expensive way to provide more electricity is to more efficiently use what already exists. Here's a simple example: Pretend it's 1980 and it takes 10 megawatts to meet the electricity needs of 7,000 homes in the Northwest. Imagine the Northwest builds another 700 homes by 1990, and needs another megawatt of electricity. You could build another power plant (coal, natural gas, etc.), or you could save one megawatt of electricity if everyone used less, meaning you wouldn't need to build a power plant.

Beginning in 1980, the Northwest addressed this type of choice by making a bold decision to minimize the need to build more generating resources (power plants) by investing in activities that would enable people and businesses to use less electricity. In fact, the Northwest spends about twice as much on conservation and efficiency programs than the national average. Early on, this was primarily done through conservation programs like insulating homes, replacing windows and encouraging people to turn off the lights and appliances when not using them.

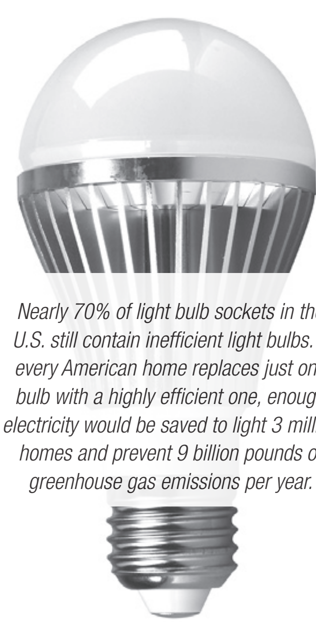
Over time, improvements in the efficiency of products provided extraordinary results. Examples include introducing appliances such as refrigerators and dryers that use less electricity, and switching from incandescent to compact florescent and LED light bulbs.

From 1978 to 2012, the cumulative savings of conservation and efficiency programs in the Northwest is 5,300 average megawatts per year. The annual savings represent enough power to serve nearly all of Oregon's electricity need, reduce carbon emissions by 19.8 metric tons and save consumers $3.1 billion.

If you think of a saved megawatt the same as you do a generated megawatt, energy efficiency met 16 percent of the Northwest's electricity needs in 2012.

Looking forward, the Northwest Power and Conservation Council plan is for 85 percent of the region's additional electricity needs from 2010 to 2030 be met through further conservation and efficiency measures. From 2010 to 2014, the council reports the region is on track to achieve the first 1,200 megawatts of the annual savings goal. The council also reports these programs continue to be far less costly than building other types of generation resources; and by 2030 an additional 17 million metric tons of carbon emissions will be saved through these efforts.

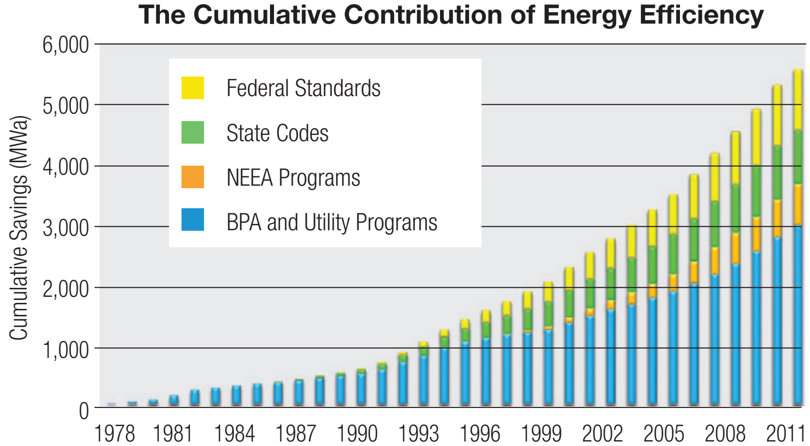
Efficiency savings one light bulb at a time



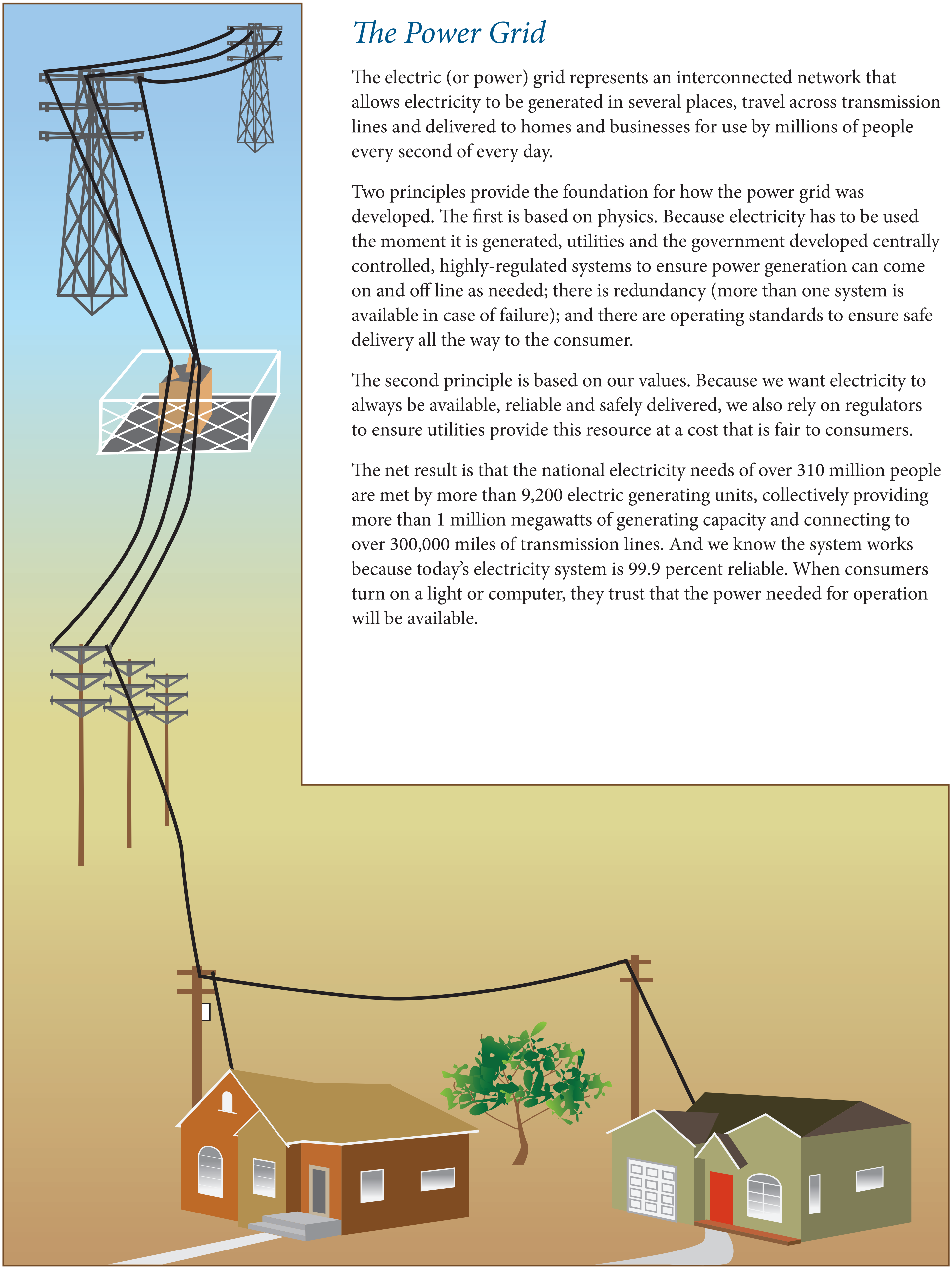
Nearly 70% of light bulb sockets in the U.S. still contain inefficient light bulbs. If every American home replaces just one bulb with a highly efficient one, enough electricity would be saved to light 3 million homes and prevent 9 billion pounds of greenhouse gas emissions per year.

Source: U.S. Environmental Protection Agency (EPA), Energy Star Program, Washington D.C., 2014.

Meeting the Northwest's Power Needs
The Cumulative Contribution of Energy Efficiency



Source: Northwest Power and Conservation Council



The Power Grid

The electric (or power) grid represents an interconnected network that allows electricity to be generated in several places, travel across transmission lines and delivered to homes and businesses for use by millions of people every second of every day.

Two principles provide the foundation for how the power grid was developed. The first is based on physics. Because electricity has to be used the moment it is generated, utilities and the government developed centrally controlled, highly-regulated systems to ensure power generation can come on and off line as needed; there is redundancy (more than one system is available in case of failure); and there are operating standards to ensure safe delivery all the way to the consumer.

The second principle is based on our values. Because we want electricity to always be available, reliable and safely delivered, we also rely on regulators to ensure utilities provide this resource at a cost that is fair to consumers.

The net result is that the national electricity needs of over 310 million people are met by more than 9,200 electric generating units, collectively providing more than 1 million megawatts of generating capacity and connecting to over 300,000 miles of transmission lines. And we know the system works because today's electricity system is 99.9 percent reliable. When consumers turn on a light or computer, they trust that the power needed for operation will be available.

The Smart Grid: Redeveloping the Power Grid for the Future

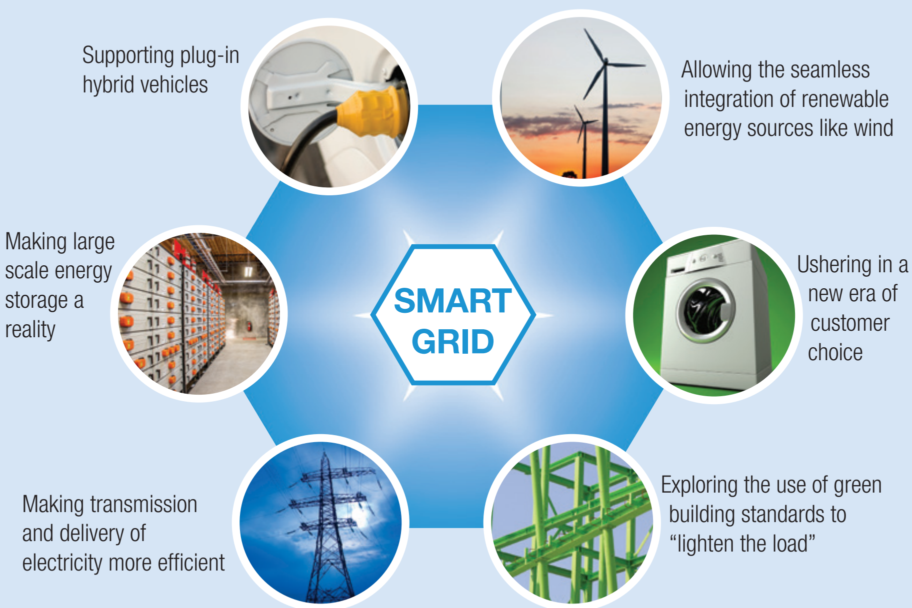
The Smart Grid represents a number of technologies that rely on high-speed communications, computing power and software to make supply and use of electricity a far different experience.

The new experience will be as profound for the operators responsible for supply and delivery as the consumers deciding how to access it. Here are some examples of what this might mean to our future.

- Imagine working with your utility provider to schedule certain power needs, e.g.—charging your computer, cell phone or car, when you will be offered a lower price (rate) to use it.
- Imagine a hybrid air conditioner that automatically interacts with your utility so it's operating with battery power when electricity is in most demand and costs more, and recharging the battery when electricity is in low demand and costs less.
- Imagine software and high-speed communications that take better account of weather patterns, demand for power and when the electric grid may get overloaded. The operator can now further optimize the available power resources (hydro, wind, etc.) to keep costs down while minimizing environmental impacts.
- Imagine smaller, distributed power systems (like solar panels on homes and businesses) that can easily be added and subtracted from the power grid to meet the community's electricity needs.

The net result of these types of innovations is providing more efficient and potentially less expensive electricity.

Building the Smart Grid in the Northwest



In 2010, five Pacific Northwest states (Washington, Oregon, Idaho, Montana and Wyoming) partnered with the Department of Energy on a five-year demonstration and research project to develop and test Smart Grid technologies. Eleven utilities, the Bonneville Power Administration and technology providers are sharing in the approximately $178 million cost. Over 60,000 customers will engage in one or more activities. Today's development and research are tomorrow's future for all.

Reinvesting in Hydropower While Integrating Wind Power

Even with savings through conservation and efficiency, the Northwest Power and Conservation Council expects an additional 7,000 megawatts of power generation will need to be developed by 2030. That's enough to meet the power needs of 4.2 million homes. Where will it come from?

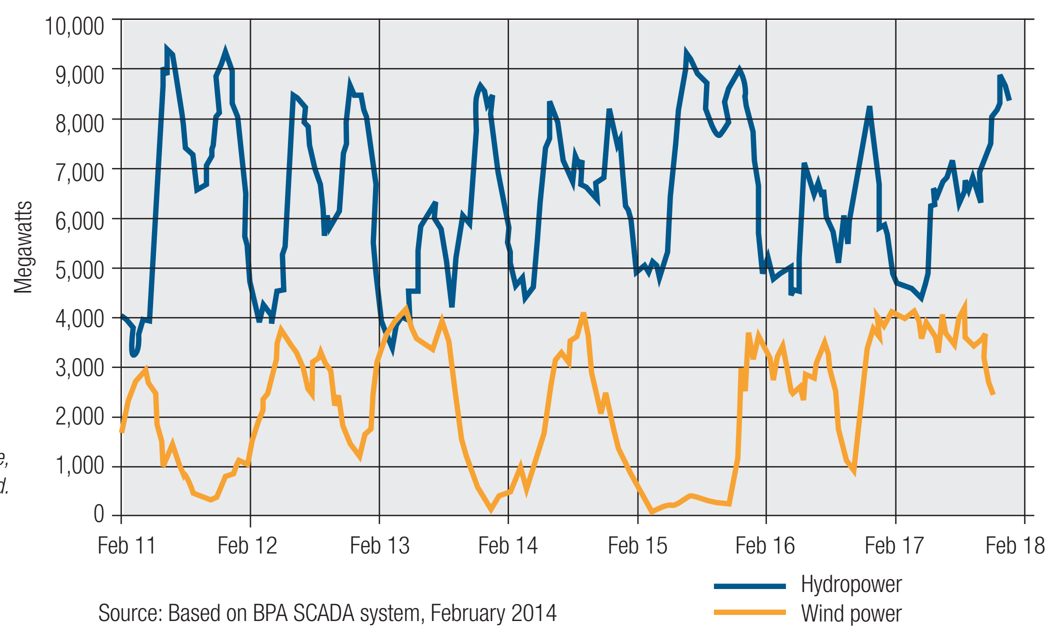
One place is the continued effort to modernize the existing hydropower system. Replacing turbines, updating generators and other efforts enable project operators to either produce more power, or produce the same amount of power more efficiently.

Another renewable resource being integrated is wind power. In 1998, the first modern commercial-scale wind power plant was built in the Northwest. By 2005, about 500 megawatts of wind power capacity was available; and by 2013 over 6,000 megawatts of capacity became available. Wind, however, is considered a "variable resource" because it does not blow consistently. If it's a cold day and there's no wind, where's the additional electricity going to come from? Likewise, if there's a lot of wind but not enough demand, what electrical generating resource should be idled?

John Day Dam and Wind Point/Windy Flats Project, Columbia River

Fortunately, hydropower is an energy resource that can be brought on and off line quickly. Projects with reservoirs are now being managed to produce less or more electricity (holding or releasing water for power generation) to work in concert with wind power availability. System operators report, however, existing hydropower facilities are largely at the limit of what they can do to balance wind generation needs (called load balancing). Further load balancing will need to come through integration of new technologies like the Smart Grid and other sources of generation.

Hydropower and Wind Power Working Together



When wind power is not available, more hydropower can be used.

Source: Based on BPA SCADA system, February 2014

Future Water Power Opportunities

Pumped Storage: These projects work the same way as a conventional hydroelectric project that has a reservoir, but with a twist. Water passing through a project can be pumped up to an additional reservoir rather than flowing downstream. To do this economically, water is pumped to the additional reservoir during off-peak hours when electricity to pump the water is less expensive; and water is released back through the turbines when the demand and value of power is highest.

This technology holds particular promise for the load-balancing necessary to integrate wind, solar and other variable power generation sources into the system.

The John W. Keys III Pump Generating Plant at Grand Coulee Dam is the Northwest's only pumped-storage facility. Currently, there are eight additional prospective pumped-storage projects in the Northwest with permits enabling them to consider full development. Two of the projects actively in development, Swan Lake Project in Klamath Falls, OR and JD Pool Project in Goldendale, WA, are strategically located to potentially offer over 1,000 megawatts of electricity that would work in concert with the load balancing needs of existing and future wind power.

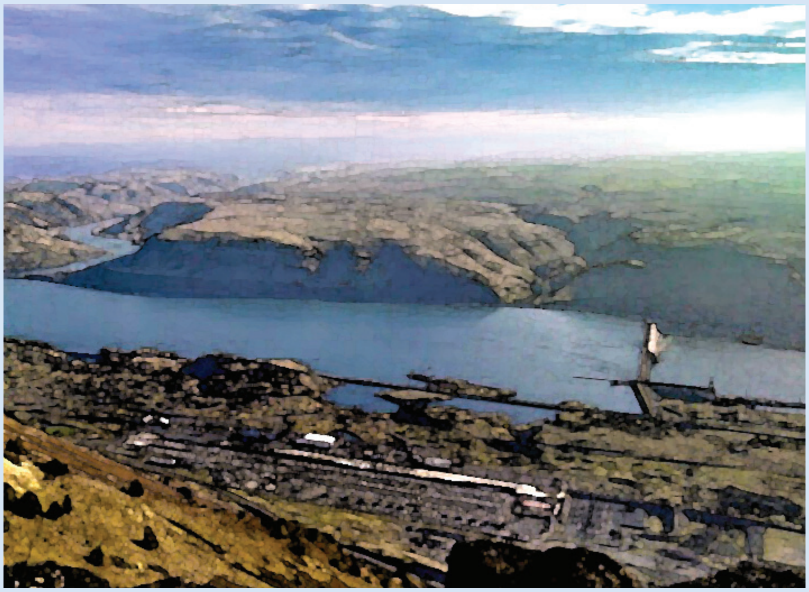
Low-Head Hydropower: These are very small projects with the potential to enable one megawatt or less of electricity to be generated at existing low-head dams (dams less than 30 feet in height) and miles of canals currently supporting irrigation needs. With only 3 percent of the nation's 80,000 existing dams set up to generate electricity, low-head hydropower may unlock hundreds of megawatts of potential electricity one small project at a time.

The Department of Energy funded grants to develop this type of technology at the North Unit Irrigation District Canal in Oregon and Washington's Potholes East Canal.

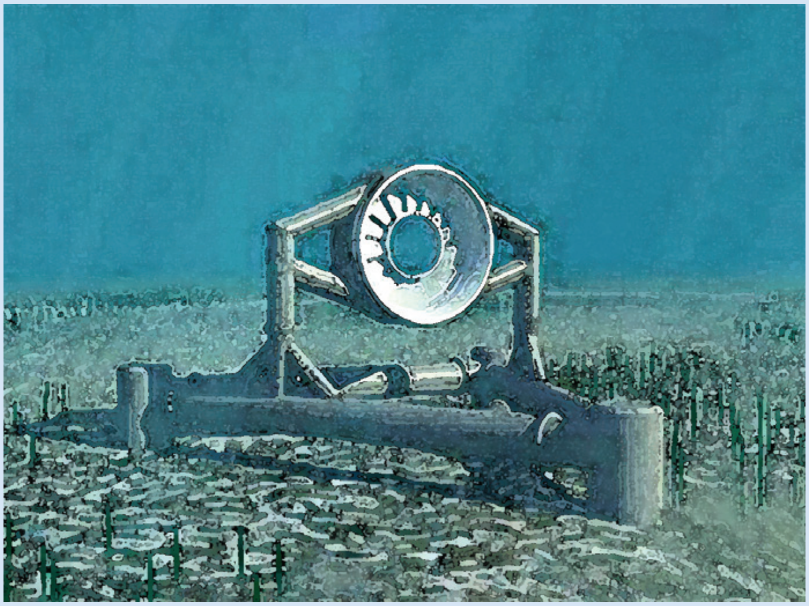
In August, 2013, Congress further encouraged this type of activity by passing two bills to streamline the regulatory process. One of these bills allows the Bureau of Reclamation to foster development of hydropower on nearly 47,000 miles of federal canals throughout the West.

Wave and Tidal Energy: The Northwest is also uniquely situated to convert tidal and wave power from the ocean into electricity. Wave technology uses the force of wind blowing across the ocean to capture the potential power of swells, while tidal energy is driven by the gravitational pull of the moon and the sun.

In October 2014, the U.S. Department of Energy announced $10 million in funding for two companies to test these type of technologies.



Klickitat County PUD is proposing a pumped storage project off-stream from the Columbia River at the John Day Dam.



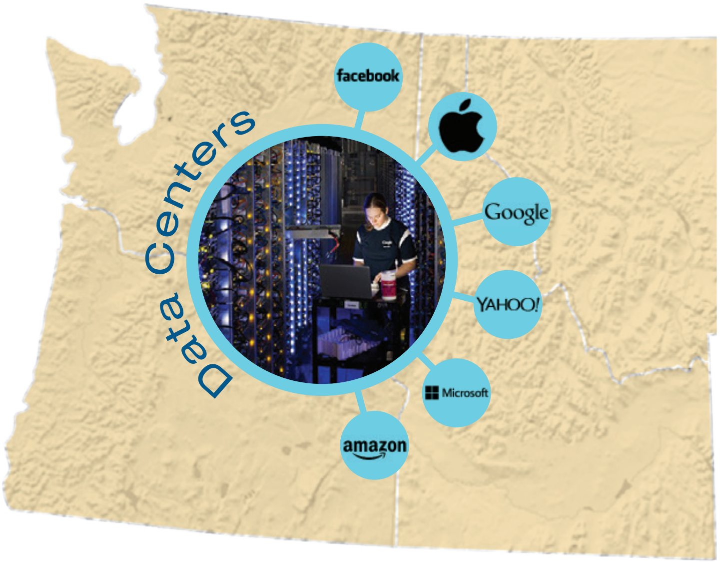
Converting tidal currents to electricity.

A Bright Future Indeed

America's desire for secure, reliable and affordable electricity that also respects our environmental values is leading us toward unprecedented innovation. The Northwest is in the fortunate position of being at the leading edge of these developments, and is well positioned to stay there.

Consider the following about the Northwest:

- Production and use of renewable sources of electricity is already ahead of any other region in the country.
- The region's carbon footprint, as measured by carbon dioxide rates, is far lower than the national average.
- The average electricity rate (cost) is significantly lower than the national average.
- The environment is being protected by a multimillion dollar annual investment, which includes ensuring the region has clean water and air, and that fish and wildlife habitat is protected.



Here are the ways that the Northwest will continue to be a leader:

- State renewable portfolio standards direct utilities to increase their use of renewable energy even further. The portfolio standard is based on acquiring new sources of renewable electricity, sources such as wind, solar or newly acquired hydropower generation. These standards are mandatory in Washington, Oregon, and Montana. Although the specifics differ from state to state, "new renewables" will make up between 15 to 25 percent of utility portfolios by 2025.
- The Northwest Power and Conservation Council plan to meet future electricity demand (which also triggers federal funding support) calls for conservation and efficiency programs to meet 85 percent of the region's additional needs between 2010 and 2030.
- Northwest utilities and government agencies are investing $178 million to develop and test Smart Grid technologies that will likely revolutionize how and when we distribute as well as consume electricity.
- Utility, government and private sector investments are piloting new renewable energy sources like harnessing tidal currents, and expanding proven technologies like pumped storage and low-head hydropower.

The Northwest's energy future is indeed bright. And the foundation for this bright future can be found by following nature's current: clean, low cost and renewable hydropower.

Recent developments underscore the enviable positioning of the Northwest

- Electricity demand from data centers, the fastest growing sector of the global information technology market, will increase 81 percent. A Greenpeace report notes the Pacific Northwest is one of three "hot spots" in the United States for rapid data center development, with companies like Apple, Facebook, Google, Yahoo, Microsoft and Amazon.com locating here because of renewable, reliable, low-cost hydropower. Indeed, Apple, Facebook and Google are among six major cloud brands committed to a goal of powering data centers with 100 percent renewable energy.
- High-tech manufacturing firms find the Northwest conducive to their energy needs. Investments by BMW in Moses Lake, WA will create the largest carbon-fiber plant in the world. According to a BMW executive, the competitive electricity cost and access to renewable power were equally important in the decision to locate here.
- Because TransAlta's coal plant in Centralia is set for closure in 2025, Washington is positioned to meet the Obama Administration's climate change goals based on reducing carbon dioxide emissions from power plants. Likewise, closure of Portland General Electric's coal plant in Boardman will greatly help Oregon reach its reduction targets.

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Hydropower Careers a Bright Spot

Up to 300,000 workers in the United States are employed by the hydropower industry, and most of these jobs are in the Northwest. The number of jobs is expected to increase as the Smart Grid comes on-line, new hydropower resources are tapped and upgrades to existing facilities and infrastructure continue. These are highly desirable engineering, manufacturing, construction and operations jobs.

The Pacific Northwest Regional Center of Excellence for Clean Energy is aggressively creating the educational and training paths necessary to fill these positions with local talent. The Center is working across state lines and creating unique coalitions between industry, labor, veterans and education to secure this tech-savvy, high-skilled future.

To learn more about educational and training opportunities or how to become a Clean Energy partner, visit cleanenergyexcellence.org.

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