A New Paradigm for Collaborative Development of Small Hydropower Projects

A White Paper

Developed by American Rivers,
Community Hydropower Consulting
and Bradley Florentin

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Executive Summary

Dating from the world's first hydroelectric power plant constructed on the Fox River in Appleton, Wisconsin in 1882; through the development of the Hoover Dam power plant in the 1930's; and leading to the complex system of hydropower facilities that exist today, the basic development process for large and small hydropower projects has remained the same.

Predicated on obtaining the maximum power available from a given resource, this established process has become increasingly complex during the past four to five decades with the advent of governmental regulations that include a project's potential impact on water quality, wildlife, and fish. In addition, a myriad of other stakeholders, each with their own focus and agenda, are customarily involved in the permitting process, often complicating or even obstructing progress toward the realization of a project. Some of these stakeholders offer binding conditions based on legislative mandates. As a result, developers often have to navigate through a myriad of competing interests from various (sometimes unknown) stakeholders. This process can potentially result in unexpected conflicts, often in an adversarial atmosphere, late in the development of a proposed hydropower project.


Photo Courtesy of Canyon Hydro

In response to a renewed interest in small hydropower development, American Rivers, Community Hydropower Consulting and Bradley Florentin envisioned the need for a new process for developing responsible, ecologically sustainable hydropower, while reducing as much conflict from the process as possible. Following a period of informal discussion, American Rivers procured the funding needed to formally develop and document this process. They issued a Request for Proposals (RFP) to identify the parameters and outline a process for a collaborative approach to developing smaller, usually decentralized hydropower projects. Richard Smart of Community Hydropower Consulting and hydrologist/engineer Bradley Florentin responded to the RFP. This white paper is the result of their joint effort and collaboration with Matt Rice of American Rivers and is intended as a first step toward a workable model of such a process.

Our shared goal is to develop and promote a positive small hydropower development model that is based on collaborative, sustainable relationships between all stakeholders, including project developers, community interest groups, environmental groups, other non-profits, land owners, power and water utilities, resource agencies, and other impacted parties. It is our hope that developers will come to understand the advantages of this approach, will adopt this transformative approach, and further refine it as they work within this new paradigm.

History of Development of Hydroelectric Power

Hydropower is a mature technology and although several innovative new products are entering the market, the underlying process is the same: the production of power from falling water. In the 1700's, mechanical hydropower was used extensively for milling and pumping. The world's first hydroelectric power plant began operation on the Fox River in Wisconsin in 1882, and by the early 1900's, hydroelectric power accounted for more than 40% of the United States' supply of electricity, according to the Bureau of Reclamation.

Prior to the 1930's many cities and towns had developed small hydroelectric plants to provide power for their communities. These plants were widely distributed around the country, diverse in production capabilities and locally focused. They were efficient due to their proximity to power users, and usually did not use an extensive power grid since they did not need to deliver the power over long distances. However, not all areas of the country had sites for hydropower development or access to other fuels for generating electrical power, and in particular, rural areas were typically underserved.

As part of Roosevelt's New Deal, in the 1930's and 40's many of America's large scale hydroelectric projects were developed that, in turn, were able to deliver large amounts of affordable electricity from a centralized location. This resulted in the formation of Rural Electric Cooperatives (REA) and they played a major role in delivering power to rural areas that developed connectedness, improved irrigation and farming yields and prevented flooding. Their construction and maintenance also provided a stimulus at a time when the county was in need of an economic boost following the Great Depression.

Hoover Dam was built from 1930 to 1935 to provide water and power for the growing west and southwest portion of the country and provided 20,000 construction jobs. Grand Coulee Dam on the Columbia River was started in 1933 and by 1941 was providing the Northwest with large amounts of water and power. This project, along with parts of the Tennessee Valley Authority that served the southern U.S., was also a major contributor in developing the vast high voltage transmission grid needed to produce aluminum for WWII's military equipment needs.

As large scale hydropower projects were developed, along with an electric grid that economically delivered power over long distances, many smaller communities reassessed whether it made economic sense to continue to produce their own power. As a result, many local hydropower plants were decommissioned in the late 1940's and early 1950's, despite the fact that their infrastructure was still usable.

With the growth of large scale projects came a growth in regulation. The Federal Power Act in 1920 established the Federal Power Commission (FPC) with authority to issue licenses for hydroelectric power development on public lands. The FPC became the Federal Energy Regulatory Commission (FERC) in 1977 with expanded responsibilities for regulating and enhancing the nation's energy supply.

History of Development of Hydroelectric Power

In the 1950's, the 60's and 70's, other interests that impacted the hydropower development began to come into play. Federal government entities, such as the Environmental Protection Agency (EPA), the Fish and Wildlife Service (FWS), the Bureau of Land Management (BLM) and the Forest Service (NFS), added layers of environmental approvals that were necessary for hydroelectric power development. In addition, many states added project review and oversight duties to development of these plants. Each piece of legislation reflected a shifting consciousness within the wider community concerning the impacts of hydroelectric plants beyond merely providing megawatts of power. Compliance with the Clean Water Act, the Endangered Species Act and other environmental concerns became fiery points of contention both among governmental agencies and between government and private development companies.

The "snail darter controversy" at the Tellico Dam in Tennessee typifies the most bellicose of these fights. Regardless of the fact that over $100 million had been spent by 1978, and the dam was 95% finished, the Supreme Court declined to allow the TVA to finish the project.

The complexity, time and expertise, and capital needed to develop large scale hydroelectric plants often resulted in these projects being prohibitively costly. By the mid 1980's most of the sites for large hydropower were either developed or unavailable due to environmental and other concerns. As a result, other sources of energy were developed along with a few small hydropower projects.


Photo Courtesy of Community Hydropower Consulting

In recent years, local interest groups have become more diverse. They are often small and not recognized as valid stakeholders in the approval process for new sources of power development. However, national organizations, such as Trout Unlimited, Sierra Club, American Rivers, Environmental Defense Fund, Wilderness Society, Audubon Society, Defenders of Wildlife and others have helped frame and articulate the environmental impacts of hydropower development that are regulated by respective governmental agencies. Tribal, recreational and social interests have a growing and often high level of representation to articulate their perspectives on potential hydropower development. The concerns of stakeholders in agriculture, flood control, water storage, and site aesthetics are often in the hands of local groups who may not have the expertise and resources necessary to participate in the traditional model of energy development.

Low Impact Hydropower Institute

The Low Impact Hydropower Institute (LIHI) is a relatively recent organization that promotes sustainable hydropower development. Currently, only existing hydropower projects can apply for certification. There is no process for certifying a developing project.

Projects that have avoided or reduced their environmental impacts can apply for certification as a low environmental impact facility. Established in 2001, LIHI has certified 109 hydropower projects as low impact facilities, and currently there are eight more applications pending.

LIHI's mission, as stated on their website is:

> "...to reduce the impacts of hydropower dams through market incentives. LIHI does this through its Hydropower Certification Program, a voluntary certification program designed to help identify and reward hydropower dams that are minimizing their environmental impacts. Just as an organic label can help consumers choose the foods and farming practices they want to support, the LIHI certification program can help energy consumers choose the energy and hydropower practices they want to support."

To earn LIHI certification, hydropower facilities must meet a fairly rigorous set of criteria. These criteria are based on:

- River flows
- Water quality
- Fish passage and protection
- Watershed protection
- Threatened and endangered species protection
- Cultural resource protection
- Recreation
- A site not recommended for removal

Meeting these criteria is based on established mitigation measures, as recommended for the project by the appropriate state and federal resource agencies. Today, LIHI certification is becoming an increasingly useful tool for marketing power.

Photo Courtesy of Community Hydropower Consulting

Current State of Small Hydropower Development

There has been a recent resurgence of interest in developing small, localized hydropower projects. Many of these projects, although small in terms of installed capacity, can potentially have significant environmental impacts. These projects, therefore, often face permitting issues similar to those facing larger projects. Because of the small size of the projects, developers typically have fewer resources for addressing these issues and, when they do, the time and expense results in many projects being cost prohibitive.

There is potential for small hydropower development at existing diversions and impoundments. This includes increasing the efficiency of existing plants and adding hydropower to existing dams. Today, approximately 3% of America's existing dams have hydropower equipment installed. Hydropower generation accounts for approximately 8% of the nation's electric power but, in contrast, supplies about 65% of the nation's renewable energy.

Several factors have led this resurgence in small hydropower development. Among these are the following:

1. There is a growing interest in all types of renewable energy, although the most visible interest has been in wind and solar energy resources. Currently, thirty seven states and the District of Columbia have legislation mandating renewable energy portfolio standards for utilities.

2. Many communities, especially those with municipal electric utilities, as well as rural REA's, have expressed interest in developing new small hydropower projects or redeveloping plants that had earlier provided power to the local area. This interest is often driven by the historical significance of a facility or a desire to increase the renewable energy in their portfolio.

3. As part of a renewable energy initiative, the 2009 Colorado legislature requested a renewable energy resource assessment. A task force, created by SB07-091, reported that about 782 MW of undeveloped hydropower is available at existing impoundments and diversions. This assessment was based on a larger water resource study by the Department of Energy's Idaho National Engineering and Environmental Laboratory (INEEL).

4. As follow-up to this renewed interest, the Colorado Governors Energy Office (GEO), now the Colorado Energy Office (CEO), along with the Colorado Small Hydro Working Group (SHWG) identified project permitting as one of three significant barriers to rapid development of small hydropower resources.

5. In response to an increased interest in permitting small hydropower projects, FERC hosted a one day seminar in December 2009. The purpose was to explore issues related to small hydropower and identify potential opportunities to expedite the permitting process.

6. Following this FERC seminar, the State of Colorado entered into a Memorandum of Understanding (MOU) with FERC to explore ways to streamline the permitting of small hydropower projects in Colorado.

7. Following implementation of the MOU in Colorado, two federal bills relating to small hydropower were introduced into the U.S. Congress and signed into law in the summer of 2013. As a result, the formal permitting burden for certain types of small hydropower projects will be reduced.

   These bills are:

   Hydropower Regulatory Efficiency Act of 2013, House Resolution 267. This bill increases the small hydropower exemption to 10 MW; removes conduit projects under 5 MW from FERC jurisdiction; increases conduit exemptions to 40 MW; allows FERC to extend preliminary permits; and requires FERC to evaluate a two-year licensing process for non-powered dams and closed-loop pumped-storage.

   Bureau of Reclamation Small Conduit Hydropower Development and Rural Jobs Act, House Resolution 678. This bill encourages development of small conduit hydropower at all Reclamation-owned canals, pipelines, aqueducts and other waterways.

8. Perhaps the most telling indicator of small hydropower opportunities is a recent study by DOE's Oak Ridge National Laboratory. This updated report indicates that about 12.6 GW of hydropower potential is available at about 12,000 existing non-powered dams.

Given the current awareness of small hydropower as a renewable energy resource, the following factors summarize the activities that are expected to further this development:

- State legislation establishing renewable energy standards for utilities
- FERC's continuing activities to streamline permitting
- Legislative initiatives that reduce FERC's oversight of certain projects
- The increasing types of financial initiatives that promote renewable energy
- Reclamation's interest in small hydropower development
- National resource assessments that confirm large numbers of small hydropower opportunities

Taken together, these factors strongly suggest there will be continuing interest in developing and redeveloping small hydropower projects will continue into the foreseeable future.

The new development paradigm presented in this white paper is designed to provide a roadmap for developing small hydropower in an environmentally sound manner that is coupled with local community interest and support.

Challenges Facing Small Hydropower Development


Photo Courtesy of Canyon Hydro

The challenge facing our nation is how to develop, and thus increase, the availability of affordable and reliable sources of power, in a manner that is both sustainable and that meets the often competing needs of diverse communities and stakeholders. This challenge is compounded by the risks associated with large centralized plants and the need to transmit power over long distances. These issues are coupled with the interest in other renewable energy resources and the often lower costs of energy from other fuels such as coal and gas.

The scope of this paper is to outline a new development paradigm that will make small hydroelectric projects more cost effective. A core feature of this model is the process of engaging stakeholders in a manner that creates ongoing partnerships, and therefore, a development process that is easier and more likely to be successful.

Along with the issues of technical feasibility, such as proper equipment, site selection, available head and flows and operational issues, it is essential to address the multiplier effects of environmental impacts and benefits that can often result from small hydropower development.

The choices and subsequent decisions of whether to develop a new hydropower site, refurbish or reactivate an existing site, or add power to existing dams or diversions become problematic without addressing the needs of multiple stakeholders. Contentious permitting delays often preclude what otherwise could have been an opportunity to effectively address the "how" and "why" of options for a project.

For small hydropower projects, common factors limiting development include large up front capital costs, complex and sometimes expensive permitting processes, inadequate power purchase agreements (PPA's) and grid interconnection requirements.

Often overlooked, early in the development process, is the societal value of rivers and watersheds and the oftentimes competing uses of these resources. Beyond the early focus on navigation, trade, manufacturing and transportation, rivers are now valued for aquatic habitat, recreation, boating, tourism, waste disposal, flood protection, water storage, energy production, cooling and urban development needs.

Thus, the permitting process is often a point of contention in the development of both large and small hydropower projects. Each government agency, and each set of regulations with the intent of protecting an environmental resource, often have their own internal review process and associated timeline.

Historically FERC has served as an oversight and coordinating agency for the process of "getting through" the necessary permitting requirements. However, recent federal legislation has removed FERC from this role for certain projects, thus leaving developers to navigate their own way through regulatory agencies and local and national stakeholder groups.

The Case for a New Collaborative Hydropower Design and Development Process

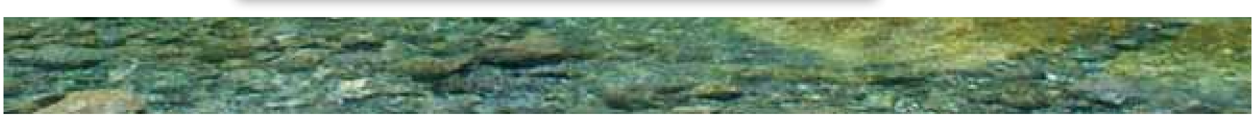
We believe there is a need for a new transformative approach to developing small hydropower projects. It should be noted that the following sustainable development process is not merely a rearrangement of traditional development stages, but rather a fundamentally different set of assumptions about what a successful project is, and role of other water users, public interest groups and communities in the process.

It is usually assumed that the goal of a project is to develop the largest amount of power available from a given site, consistent with available resources and engineering considerations. The biggest risks to project development usually lie within the public or community context, that include competing environmental, social, recreational, and other uses of water as objections to projects. Unfortunately, little attention is typically paid to, or information gathered from, a community until large amounts of time and money has been expended on the technical design of a project. Non-engineering issues, raised by project stakeholders, often delay, or sometimes even derail a project. This, then, leaves developers scrambling to overcome the objections, including proposed mediation, and thus insufficient time to determine if a level of consensus exists for a project to continue.

In contrast, one of the major goals of this proposed development paradigm is to reduce the uncertainty regarding a project early in the conceptual design stage – and before significant investments of time and capital have been made in a detailed design. Additional goals of this new paradigm include resolving as much conflict as possible, creating a focus on broader economic and community benefits versus purely financial returns of the project, identifying and promoting ancillary benefits and generally easing the permitting process or identifying "show stoppers" early in the process. This new collaborative process represents, and requires, a true paradigm shift in the way small hydropower projects are conceived, designed, and developed.

The following page shows a side by side comparison of the two development processes. Keep in mind, however, the differences and similarities illustrated here are only part of the new paradigm.


Photo Courtesy of Canyon Hydro



A Comparative Look at the Traditional and Collaborative Processes

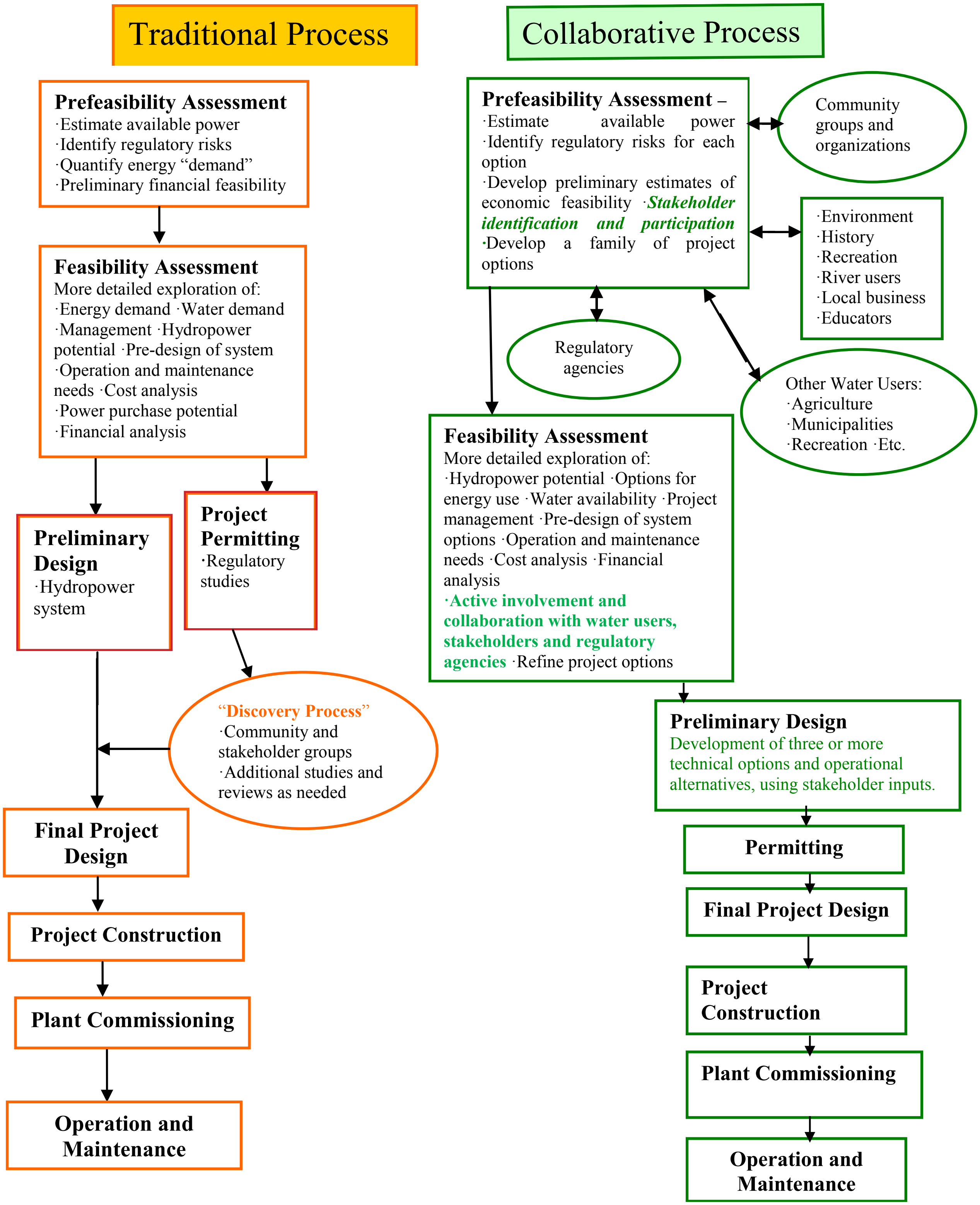
Traditional Development Process

1. Prefeasibility Assessment – estimate of available power, identify regulatory risks, quantify energy "demand" and preliminary financial feasibility
2. Feasibility Assessment – a more detailed exploration of project parameters including: energy demand, water demand, management capabilities, hydropower potential, pre-design of system, plant operating factors, operation and maintenance needs, cost analysis, power purchase potential, and financial analysis
3. Preliminary Design – a design of hydropower system and more refinement of the elements listed above
4. Project Permitting – Often done in parallel with design and usually includes additional studies for regulatory agencies to quantify, eliminate, minimize and mitigate project impacts. This tends to be a discovery phase for regulatory agencies and community groups in which they "learn about" the project. Typically, major elements of the project have been determined prior to the permitting stage and often commitments are made regarding project size, financial return and energy production.
5. Final Project Design – additional requirements from the permitting stage are incorporated into the detailed project design
6. Project Construction
7. Plant Commissioning
8. Operations and Maintenance

Collaborative Development Process

1. Prefeasibility Assessment – estimate of available power, identify regulatory risks, develop preliminary estimates of economic feasibility and ***identify additional water users/stakeholders. Outline a "family of technical solutions" in addition to the maximum available power solution.***
2. Feasibility Assessment – a more detailed exploration of prefeasibility including: actively ***engaging additional water users to determine what they need/want*** (not just good faith inclusion – ***but inviting active involvement and project collaboration***), energy demand, water needs, project management options, ***potential project flexibility***, proposed system pre-design, expected plant operating factors, operation and maintenance requirements, cost analysis, options for power use, and an updated economic analysis.
3. Preliminary Design – preliminary system design of ***three or more technical options***, describe ***operational alternatives***, more refinement of the elements listed above incorporating the needs/wants of the user groups
4. Permitting – often done somewhat in parallel with design. However, this process in the new paradigm would ***NOT be a discovery process*** for regulators and community groups but rather, ***a confirmation of the work and efforts in previous stages.***
5. Final Design – incorporates the requirements determined through the development process into the detailed design of the best hydropower system for the project
6. Project Construction
7. Plant Commissioning
8. Operations and Maintenance

The Case for a New Collaborative Hydropower Design and Development Process



The overall process of collaborative hydropower development appears to have many steps in common with the traditional process. However, the difference is a fundamental shift in the end goal and, therefore, the development process contained within each step. The end goal for the traditional development process is to "develop the maximum available power." The end result, in contrast, of the collaborative development process is an economically feasible hydropower project that balances community uses of the water and the river corridor along with other ancillary benefits. This approach is designed to be a sustainable process that enhances public trust by making the community a valued partner in the early stages of design.

Why Community is Key to Creating a Sustainable Development Process

All projects exist within a social context – not just a pure engineering environment. The social/cultural context is the framework within which all development and operations occur. Therefore, in the collaborative model, it is essential to recognize that water user issues and community benefits are as much of a driver for a given project as the kWhs the project will produce.

Photo Courtesy of Creative Commons

In the collaborative model, stakeholders are identified and engaged in the first two steps of the process. This synergistic approach is the key to creating a sustainable process. Early focus on the "people issues" expands the dialog, respects the valid interests of multiple water users, establishes trust among developers and stakeholders, and thus becomes a major consideration in the design phase of the process. These early steps therefore, become a major driver of how the project size, location, operation and use of the power are determined.

Individuals and groups representing special water use interests can become active participants in this process and, thus, potentially allies rather than opponents to the project.

Financial Benefits Versus Economic and Other Synergistic Benefits

Note that, in the side-by-side comparison, the traditional model addresses financial viability in the prefeasibility and feasibility steps while the collaborative model addresses economic viability. While financial viability is a factor in most projects, there are often significant synergistic benefits to small hydropower development and distributed generation resources – not just financial returns, but community, environmental, and economic benefits that can be realized.

The Case for a New Collaborative Hydropower Design and Development Process

The proposed development process assumes that the largest benefits for small hydropower may actually be realized in the synergistic benefits and not necessarily in the financial aspects alone. Potential synergistic benefits can add weight to community perception of a project's value, enhancing public understanding and support. The community participates as a genuine partner in the design, development and operation of the project – and realizes some of the ancillary benefits.

Sustainability

In the context of small, low-impact hydropower projects, sustainability can be defined as:

A solution that takes multiple uses of the river into consideration, meets current community and environmental needs, and becomes an integral part of the future of the river corridor.

Assumptions

This collaborative development process is based on the following assumptions and attributes:

1. Existing infrastructure is adequately abundant in streams and waterways to allow hydropower to be developed with no new significant diversions.
2. There are many engineering solutions for a given site – not just the one that develops the most power through maximum resource utilization.
3. A project generally must be economically viable and provide a reasonable financial return.
4. More hydropower projects will be developed if the associated risks can be appropriately identified and quantified early in the process.
5. Genuinely engaging stakeholders and the public early in the process can better identify and highlight opportunities for synergistic benefits to become part of the project.
6. Incorporating these concepts and benefits early into the feasibility assessment has the potential to identify issues that are project "showstoppers."
7. Alternatively, a collaborative approach can develop support for a project, resulting in the formal permitting process becoming a confirmation procedure rather than, at times, a nerve-wracking exploration process.

Next Steps

The current high level of interest in small hydropower parallels the convergence of interest in sustainable and renewable energy sources; the need to develop reliable domestic energy; and concern for long-term environmental impacts. The time is ripe to make the most of the opportunities available now and in the future.

As American Rivers states on their website:

> "To get hydropower right, we must consider both sides of the power/river health equation: we need to pursue better environmental performance and new [hydropower] generation together, as two goals that can be achieved together rather than an either-or, zero-sum game. We must take equally seriously the promise of hydropower and the risks of hydropower development."

In finding the balance between promise and risk, following a collaborative pathway will lead to a greater likelihood that a project will make it successfully through the permitting process. In addition, this transformative approach can help fill the gap as new federal legislation reduces FERC oversight for some small hydropower projects. In these cases FERC will no longer function as a moderator between developers, community interests, and regulatory agencies. When enacted, these changes will make it more important than ever for developers to identify community and regulatory issues early in the development process and include these considerations a part of the design. And, by arriving at a go/no-go decision early in the feasibility stage rather than during the formal permitting process, developers can save time, money, and frustration.

A pilot project is needed to field test this new collaborative model and create a roadmap for others to follow when initiating small hydropower projects. The authors are currently developing the methodologies and tools needed for such a field test.

Photo Courtesy of Community Hydropower Consulting

Glossary of Terms and Measures

Cfs
A unit of measurement for water flow. Flow equals the volume of water (cubic feet) passing through an area in a given time period (per second). 1 cfs = 7.48 gallons per second.

Diversion
A water diversion redirects a flow of water from its natural course. Diversions can either be open like a canal or ditch, or a closed like a pipeline.

Dynamic pressure
The water pressure in a pipeline while the water is flowing. It is equal to the static pressure (measured in a closed pipeline) minus the pressure loss from friction, turbulence and cavitation in the pipeline and fittings.

Flow
Flow is the volume of water passing through an area in a given time period. It is most often measured in cubic feet per second (cf/s) or gallons per minute (GPM).

Flume
Open and closed flumes serve to channel water into a water turbine.

Forebay
A closed tank at the top end of a hydropower diversion pipeline. It allows the water to settle before entering the penstock. Usually where the primary filter/trash-rack is installed.

Francis Turbine
A type of reaction turbine. Francis turbines have a series of fixed vanes on the runner. Water enters the runner from the side (through the vertical vanes), and exits out the bottom of the turbine (a 90 degree change in direction). Francis turbines operate with 4 to 2000 feet of head, and can be as large as 800 megawatts of output.

Generator
A device that produces electrical power from a rotating shaft.

GPM
Gallons per Minute is a common measurement of the flow velocity of water.

Grid
The electric power grid or utility grid. This refers to the utility power system. If you get a monthly electric bill, you are "on the grid."

Head
The total vertical distance between the beginning of a hydropower system diversion and the hydro turbine. The amount of power a turbine produces is proportional to the total available head.

Head Loss
Obstructions to the flow of water to a hydro turbine. Anything from the friction on the inside of the pipeline, to water turbulence in the pipe or fittings which change the pipeline direction can slow the water flow, causing head loss.

Impoundment
Impoundment refers to a type of hydropower facility, where a dam is used to back up water in a pond or reservoir.

INEEL
The Idaho National Engineering and Environmental Laboratory is a Department of Energy (DOE) science and applied engineering laboratory located west of Idaho Falls, Idaho.

Impulse Turbine
Impulse turbines produce power when a jet of water from an enclosed diversion pipeline 'shoots' through a small nozzle directly onto the turbine runner. Impulse turbines are best for 'high head' sites (with 20 feet of head or more), but they do not require high flow rates. Pelton and Turgo turbines are two of the most common impulse turbine families.

Intake
The point at which water is diverted from a river or stream to the turbine via a diversion system. A trash rack or filter and settling tank are often installed at the intake point to prevent debris and sand or silt from reaching the turbine.

kW
The kilowatt (symbol: kW), equal to one thousand watts, is typically used to state the power output of engines and the power consumption of tools and machines. A kilowatt is approximately equivalent to 1.34 horsepower. An electric heater with one heating-element might use 1 kilowatt.

kW hour
A measure of energy equal to the use of one kilowatt in one hour.

Kaplan Turbine
The Kaplan turbine is a propeller-type water turbine that has adjustable blades. It was developed in 1913 by the Austrian professor Viktor Kaplan. The Kaplan turbine was an evolution of the Francis turbine. Its invention allowed efficient power production in low head applications that was not possible with Francis turbines.

Kinetic Energy
Energy developed due to motion. Moving water has kinetic energy, which is converted to electrical energy by a hydroelectric turbine.

Glossary of Terms and Measures

LIHI
The Low Impact Hydropower Institute is a non-profit organization that certifies hydropower projects as low impact based on an established set of environmental criteria.

Load
Electrical loads or power loads. Any item or series of items that use electrical power.

MGD
A measurement of the flow of water in Millions of Gallons per Day.

Micro Hydropower
Micro hydropower is usually defined as a subdivision of small hydropower. A generally accepted definition is a project with an installed capacity of up to 100 kilowatts (kW).

ORNL
The Oak Ridge National Laboratory is a Department of Energy (DOE) science and technology laboratory located in Oak Ridge, TN.

PSI
A measure of pressure. Pounds per square inch (psi) or, more accurately, pound-force per square inch is a unit of pressure based on avoirdupois units. The pressure resulting from a force of one pound-force applied to an area of one square inch:

Pelton Turbine
A type of impulse turbine with one or more jets of water hitting the buckets of a runner. The runner resembles a miniature water wheel. Pelton turbines are used in high head sites (20 - 6000 feet), and can be as large as 200 megawatts.

Penstock
A closed pipeline through which the water flows to a hydro turbine.

Potential Energy
Energy in a stored form. Batteries store potential electrical energy. Water behind a dam also has potential energy, because the stored water can be released for future power production.

PPA
A Power Purchase Agreement is a contract between a party who generates electrical power and the party that purchases the power.

Reaction Turbine
Reaction turbines produce power from the pressure of water 'falling' on the runners after flowing through the guide vanes. Reaction turbines can operate with heads as low as two feet, but require much higher flow rates than impulse turbines.

SCADA
Supervisory Control And Data Acquisition. It generally refers to an industrial control system: a computer system monitoring and controlling a process.

SHWG
Small Hydropower Working Group. An informal group of small hydropower developers, owners and operators, power company representatives and state and federal officials formed to promote small hydropower development in Colorado.

Small Hydropower
The definition of small hydropower varies. A generally accepted definition is a project with an installed capacity of up to 10 megawatts (MW).

Static Pressure
Pressure produced by an unmoving column of water. (See also: static head) There are no friction/head losses when water is not moving, so static pressure is determined only by the vertical height of the water column. The static pressure on a 10 foot tall vertical pipe full of water would be the same as a 1000 foot long pipeline with 10 foot of head over its entire distance.

Tail Race
The open channel or pipe that delivers water from a hydroelectric turbine outlet back to the stream/river.

Volts
The “pressure” of electrical flow. Volts can be compared to the pounds per square inch (psi) of water flow through a pipe.

Watts
A measure of electrical power. Watts = Volts x Amps

Contributors

Richard Smart is the owner of Community Hydropower Consulting. He has worked in the hydropower industry for more than 35 years in both industry and academic settings. He has conducted numerous feasibility assessments for utility developers, government and private organizations. He served on the Colorado Governor's Energy Office team that developed a pilot project with FERC to streamline the hydropower project permitting process. Dr. Smart has served as a consultant with the U.S. Department of Energy, the Bureau of Reclamation, and holds membership in the National Hydropower Association and the Colorado Renewable Energy Society. His interests include sustainable hydropower development and the impacts of engineering projects on community social systems. He holds a B.S. in Electrical Engineering from the University of Kansas and M.A. and Ph.D. degrees in Sociology from the University of Colorado. Richard may be reached at: richard@communityhydro.com.

Bradley Florentin has been an independent consulting civil engineer for twenty years with extensive experience in the evaluation of stream and fish habitat restoration. He served on the Colorado Governor's Energy Office team that developed a pilot project with FERC to streamline the hydropower project permitting process. He has managed and directed large, multi-disciplined teams and projects. Brad's technical expertise blends knowledge and training in wetland delineation and creation with a passion for riverine hydraulics to produce hard scientific solutions with a soft edge. He holds a B.S. in Civil Engineering and an M.S. in Hydraulic Engineering from Colorado State University and is an avid fly fisherman. Brad may be reached at: bradflorentin@gmail.com.

Matt Rice is the Colorado Director of American Rivers. He directs large scale, high profile, complex water projects under FERC jurisdictional authority in Colorado. He provides policy recommendations and performs project reviews including designation of high value rivers in Colorado under the Wild and Scenic Rivers Act. . His work protecting and enhancing the natural and recreational values of rivers and ecological flows benefitting fish and floodplains serves as a national model for responsible hydropower operations. He holds a B.A. in History from Montana State University and an M.A. in International Studies from the University of Denver. Matt may be reached at: mrice@americanrivers.org.

Cover photo courtesy of Community Hydropower Consulting.

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