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The Regulatory Noose: Logan City's Adventures in Micro-Hydropower

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Abstract: Recent growth in the renewable energy industry has increased government support for alternative energy. In the United States, hydropower is the largest source of renewable energy and also one of the most efficient. Currently, there are 30,000 megawatts of potential energy capacity through small- and micro-hydro projects throughout the United States. Increased development of micro-hydro could double America's hydropower energy generation, but micro-hydro is not being developed at the same rate as other renewable sources. Micro-hydro is regulated by the Federal Energy Regulatory Commission and subject to the same regulation as large hydroelectric projects despite its minimal environmental impact. We studied two cases of micro-hydro projects in Logan, Utah, and Afton, Wyoming, which are both small rural communities. Both cases showed that the web of federal regulation is likely discouraging the development of micro-hydro in the United States by increasing the costs in time and funds for developers. Federal environmental regulation like the National Environmental Policy Act, the Endangered Species Act, and others are likely discouraging the development of clean renewable energy through micro-hydro technology.

Keywords: hydropower; regulation; renewable energy; micro-hydropower

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1. Background

In this paper, we explore how the federal regulatory process affects the development of micro-hydro energy systems in the United States. This paper focuses specifically on the direct effects of federal regulations, not whether micro-hydro was the proper solution.

Over the past half-century, a substantial amount of literature has been published on the effects of federal regulation in the economy. Some of this literature identifies the political process as an obstacle to passing effective regulation. Tullock (1967) first presented the idea, now known as rent-seeking, that interest groups willingly expend economic resources to obtain regulatory preference, such as tariffs or monopoly power, from public officials [1]. Similarly, Stigler (1971) presented theories of regulatory supply and demand, wherein special interest groups demand public resources and protection supplied by public officials [2].

Once a regulation is instituted, it can be onerous to reverse. Arthur (1989) proposed the idea of technological lock-in, arguing that once a technology is initially adopted, there are increasing returns to its use [3]. The longer that technology is in use, the more it is improved, the more experience is gained with it, and the lower the likelihood of it being replaced because of the increased costs of switching over to something new. Once this occurs, it is referred to as path-dependence. Economists have applied Arrow's theory to institutions, noting the parallels of increasing returns in the costs of setting up and maintaining an institution with those of technology (North (1990) [4], Foxon (2002) [5]). Political institutions are especially susceptible to path-dependence (Pierson (2000) [6]). Once a bureaucracy is created, bureaucrats have the incentive to grow. More regulations lead to increased authority and increased budgets, creating bureaucratic bloat and complicated webs of regulatory standards. McClaughlin and Williams (2014) [7] (pp. 7–8) observe that as bureaucracies react to new situations they add new layers of regulation without removing the old, further increasing regulations that entrepreneurs and developers must navigate. This regulatory web stifles innovation and development due to the increased costs in both time and money.

Yonk, Simmons, and Steed (2013) examine the environmental regulatory web facing green energy producers in their book *Green vs. Green*. The book, after outlining the development of many of the environmental regulations in place today, presents numerous examples of green energy projects halted by green legislation. The case studies we present in this paper contribute to the ideas set forth by Yonk, Simmons, and Steed by showing that regulations intended as green policy vastly increased the costs of green micro-hydro energy projects [8].

1.1. Micro-Hydro Potential

Exploring alternative energy sources is important for the future of the environment and economy in the United States. Diversity in energy production provides opportunities for new industries to form and improves the environmental effects of energy production. Small-scale hydropower is a promising source of clean power. Small cities like Logan, Utah (the city is referred to as Logan, Utah, or Logan City based on local custom), and Afton, Wyoming, are taking advantage of the opportunity to develop green energy in their own backyards by installing micro-hydropower systems.

Unlike traditional large-scale hydropower, small-scale and micro-hydropower systems rarely require dams, reducing the technology's environmental impacts. Micro-hydro turbines take advantage of the kinetic energy in flowing water by converting that energy into usable electricity. Micro-hydro systems most commonly work through a "run-of-the-river" system in which water from a river is diverted to a pipeline. This water then flows through a turbine or waterwheel, powering a generator and producing electricity. A system generating only ten kilowatts can power a large home, small resort, or hobby farm [9].

Collectively, small- and micro-hydropower systems have high energy-generation potential. The term "low-power hydropower" (also known as micro-hydro) includes systems less than one megawatt, while "small hydropower" includes systems between one and thirty megawatts [10] (p. iii). According to the Idaho National Laboratory feasibility assessment of small- and low-power hydroelectric plants, there are 30,000 megawatts of potential energy capacity through small- and low-power hydroelectric projects (small- and low-power hydroelectric projects are defined as generating 30 megawatts or less) throughout the United States [10] (p. 1). This potential energy is enough energy to power more than 65,000 homes on an annual basis (based on average household consumption of 30 kWh per day/24 h = 1.25 kW). If developed, small- and micro-hydro systems would more than double total hydroelectric generation in the United States [10] (p. v).

The complicated nature of hydropower regulations often discourages city officials from developing micro-hydropower. Without complicated regulations, cities would be more likely to take advantage of micro-hydropower's economic and environmental benefits. After installation, maintenance and operational costs are low and the environmental impact is low. Hydropower generates electricity very efficiently, with a conversion rate of ninety percent compared to an average of only fifty percent for other types of renewable power generation [11] (p. 450).

Despite its advantages, hydropower potential is not being developed at the same rate as other renewable energy technologies. Since 2011, hydropower production has decreased due to droughts in the western United States. Although wind energy constitutes the majority of non-hydro renewable energy, a forty-five percent increase in solar power drove most renewable growth in 2015 [12] (p. 23). Hydropower is unique because it requires a Federal Energy Regulatory Commission (FERC) proceeding before generation of any size can take place [13]. Other renewable energy sources do not face FERC proceedings for small-scale projects like rooftop solar and private wind turbines. Although micro-hydro projects usually have limited environmental effects, the federal permitting process is extensive and overly complex for such simple projects. With fewer complicated regulations, small hydropower could potentially see the same growth as solar energy and help the United States increase clean energy production through a more efficient renewable source.

1.2. Current Micro-Hydro Regulation

The current licensing process for small micro-hydro projects can be long and costly. Those seeking a license through FERC may have to obtain permits from as many as twenty-five different regulatory agencies. Meeting mitigation requirements for the project's impact on endangered species, water quality, and other environmental concerns can take years [14] (p. 8). Our study is confined to federal regulation and omits state regulations that must also be met before micro-hydro development can occur. The strictness of state regulation varies widely and is therefore more difficult to study.

Of the numerous federal agencies and laws involved in the micro-hydro process, we observe those that proved to be the largest barriers during our case studies. Any micro-hydro process begins with the preliminary notification and three rounds of consultation directed by FERC. Developers must also satisfy the requirements of the National Environmental Policy Act through an analysis of the environmental impact of their project, which generally involves the Environmental Protection Agency (EPA). A 404 Clean Water Act permit must also be obtained from the Army Corps of Engineers adding another federal agency to process. The National Historic Preservation Act (NHPA) requires a section 106 analysis and document submission to the State Historic Preservation Office (SHPO), a state agency required by NHPA. In addition, the General Wildlife Consultation (GWC) and Endangered Species Act (ESA) require consultations and biological assessments on the effect that the project might have on wildlife. Both laws involve the Fish and Wildlife Service (FWS) in the project. These federal agencies and laws constituted the greatest barriers according to information gathered during our case studies.

1.2.1. Federal Energy Regulatory Commission (FERC)

FERC is responsible for deciding what level of analysis will be required for a given energy development project. FERC's responsibilities include implementing and ensuring compliance with an extensive list of legislation, including the Energy Policy Act of 2005, the Federal Deepwater Port Act of 1974, the Clean Air Act, the Clean Water Act, the Coastal Zone Management Act, the Endangered Species Act, the Fish and Wildlife Coordination Act, the National Environmental Policy Act of 1969 (NEPA), the National Historic Preservation Act, the Rivers and Harbors Act, and the Wild and Scenic Rivers Act [15]. Navigating this regulatory process can be complicated, time-intensive, and costly.

In applying for a license with FERC, even a minimal-impact hydroelectric installation must comply with the full process for hydropower projects. Small-scale, low-impact projects are subject to the same level of regulation and scrutiny as large projects that would require dams and cause substantial environmental impacts. In addition to applying to new projects, these requirements apply to expanding the capacity of an existing project, nearly any construction around an existing project, and addition of new water turbines to an existing structure. The FERC process begins with preliminary notification and pre-filing consultation with any "relevant Federal, State, and interstate resource agencies" [16]. In addition to all relevant agencies, contact and consultation with Indian tribes and members of the public are also required [8]. The time required to comply with, contact, and consult with all of these entities could require a full-time employee for any given project, regardless of size. Among the requirements which follow the preliminary steps, full maps (requiring the services of surveyors and engineers) of the potential project and surrounding area must be completed and submitted, annual flow rates estimated (requiring the services of a water engineer), and a thorough examination of potential environmental impacts (requiring a specialist in that area) must also be conducted [16].

These steps are only the beginning of the licensing process. After completion of the preliminary process, applicants are required to hold a joint meeting, including opportunities for on-site visits, with all applicable federal agencies and the public. Written or audio transcripts of the meeting must then be provided by the applicant to FERC [16]. After the meeting, the application enters the second stage of consultation, receiving comments from all parties and resolving any disagreements with concerned parties as directed by FERC. The applicant must also conduct further studies as requested by agencies and directed by FERC. After further studies are conducted according to the objections of concerned parties, the applicant must resubmit new results and revised plans and submit a new request for comment to all concerned agencies and moves to a third round of consultation [16]. Whether the project is the installation of a turbine in an already existing pipeline or a project the size of Hoover Dam, applicants face the same licensing process and the same level of scrutiny.

FERC allows exemptions from certain licensing requirements for municipal projects under forty megawatts where the existing pipeline or canal was not originally built for power generation and where the project is not located on federal lands. FERC's conduit exemption gives exempt projects perpetually issued licenses, rather than having to reapply in fifty years [17]. The exemption is also meant to streamline the process by relieving in-conduit projects from the National Environmental Protection Agency (NEPA) requirement that an environmental assessment (EA) or environmental impact statement (EIS) be prepared. As the FERC website notes, however, "this does not mean that the Commission cannot require an EA or EIS to be prepared if your project appears to have adverse effects on the environment" [18].

1.2.2. The National Environmental Policy Act of 1969 (NEPA)

The NEPA process requires analysis of the environmental effects of a proposed action, usually in three stages. First, a project may be categorically excluded if it is expected to have no significant environmental impacts and a brief Categorical Exclusion (CATEX) document is prepared to meet the requirements of NEPA. Second, a federal agency may require an environmental assessment (EA) to help determine the expected impact of a project. If the EA results in a finding of no significant impact, then the process stops here. If the EA, however, finds expected environmental impacts to be significant, then an environmental impact statement (EIS) may be required to evaluate in detail the effects of the proposed action, along with any viable alternatives. This is the third stage of the process. An EIS is more extensive than an EA and includes the opportunity for outside parties to provide input [19]. In the case of micro-hydro power generation, NEPA increases the costs for smaller developers through redundancy, the cost of analysis, timeframes, and mitigation.

Many of the FERC permitting requirements are redundant with those of NEPA. However many of the requirements must be separately prepared and submitted as separate documents to FERC, causing duplication of effort, increased costs, increased delays, and frustration for cooperating agencies as they spend substantial amounts of time dealing with the bureaucracies of other agencies.

The procedural requirements of NEPA are costly in terms of time. While a CATEX can generally be completed within a couple of months (depending on the complexity), an EA generally takes from six months to two years. A full-blown EIS often takes between three to five years and complications can extend this timeframe to up to ten years if significant controversy or substantial issues arise. Additionally, extended timeframes often complicate projects as industry and agency personnel turnover or maintain various levels of engagement in project affairs. Extended timeframes increase costs as consultants and contractors must be paid to produce the analyses and documents to satisfy the various agencies involved in the NEPA process. Additionally, the time and salary of involved city personnel add to the overall costs. Even after satisfying the requirements in the NEPA process, FERC can deny the permits necessary to move forward. These timeframes serve to discourage investment from entrepreneurs in the energy industry, which significantly reduces the rate of adoption for micro-hydro projects.

The procedural requirements of NEPA can be extremely costly, particularly for the small entities that typically undertake micro-hydro projects. These entities, such as small cities, individuals, or organizations generally lack expertise to deal with the intricacies of federal legislation or perform the required analysis. Direct costs with NEPA consultants can be upwards of $100 per hour for a single person and can be much more for specialized expertise as shown in the below case study of a micro-hydro project in Afton, Wyoming where costs were $250 per person per hour [20]. In addition, the costs of equipment must be considered as well as the salaries for town personnel, power company employees, and resource agencies. Over the time-frames discussed above, these consultant costs, coupled with the direct costs of equipment and travel, can easily be in the hundreds of thousands of dollars for an EIS, tens of thousands of dollars for an EA, and thousands of dollars for a CATEX. For the smaller entities that participate in micro-hydro projects, these costs are substantial and can easily dissuade micro-hydro development due to budgets.

As potential impacts are disclosed during NEPA analysis, compensation for those impacts in the form of mitigation are sought by various organizations and agencies that are concerned with the resources that may be impacted. For example, if a micro-hydro project occupies a stream-bed where salmon potentially spawn, project proponents may be required to enhance spawning habitat elsewhere to help offset and mitigate for the impacts of the project. Mitigation further adds to the costs that small entities must face in their attempt to develop cleaner energy.

1.2.3. Clean Water Act (CWA)

Unlike NEPA, which is primarily procedural, the Clean Water Act (CWA) is a more substantive regulation with specific guidelines and must be met in order to fully comply with the law. Because some aspect of a micro-hydro project generally involves affecting jurisdictional waters of the United States, a 404 CWA permit is required. The 404 permit regulates the discharge of any dredge or fill material into waters of the United States [21]. Among a variety of requirements, the necessity that a specific alternative must be chosen for implementation only if it is the "least environmentally damaging practicable alternative" (LEDPA) is likely the hardest to overcome. The LEDPA determination, as discussed in Section 404 of the CWA, has been called "the steepest hurdle" in obtaining a clean water permit. Jon Shutz provides a good overview of how crucial and tenuous a Section 404 Permit can be:

> "To construct any project involving the discharge of dredged or fill material into U.S. waters, one must obtain a 404 permit from the United States Army Corps of Engineers (Corps). An applicant for a 404 permit must demonstrate to the Corps that, among other things, the proposed project is the least environmentally damaging practicable alternative (LEDPA) to achieve the project's purpose. To determine the LEDPA, an applicant conducts a 404(b) (1) Alternatives Analysis. Though the LEDPA determination is only one of many determinations the Corps will make for a project and that the applicant must pass, the LEDPA determination is often the "steepest hurdle" in obtaining a 404 permit. Practitioners should be aware that where a proposed project is not the LEDPA, the Corps may not approve the project or grant the applicant a 404 permit. In other words, the LEDPA determination can be fatal to the project [22]."

Although there is overlap in NEPA and Section 404, many of the requirements still require separate concurrences and documentation, further increasing costs and delays for micro-hydro proponents. In addition, compliance with Section 404 introduces an additional governmental bureaucracy creating demands and insisting on mitigation of different degrees for potential impacts. Additional studies for the Environmental Protection Agency, proof that the project meets the LEDPA requirements, additional costs for mitigation, and increased time to meet these requirements increase costs and delays for micro-hydro developers. Most significantly, however, is the fact that Section 404 requires protection of the very resource that must be exploited to make micro-hydro function, namely water.

1.2.4. National Historic Preservation Act (NHPA)

Section 106 of the NHPA requires that a federal agency take into account effects to historic properties resulting from implementation of a project. For micro-hydro projects, this is a requirement during both the NEPA process and the Section 404 permitting process, and must also be documented independently, adding both cost and delay [23].

During the Section 106 compliance process properties, structures, and cultural resources of all kinds are evaluated (usually by a specialized consultant) to determine if historic properties are present within a project area. Historic properties are basically any man-made object that is fifty years old or more. However, in practice, historic properties are evaluated that are at least forty-five years old in order to accommodate the project time frame and the possibility that it could take five years or more to work through the various permitting processes. For micro-hydro projects, the historic properties involved are often dam structures, canals, headgates, and other water works structures. These structures are designed to have long lifetimes with little maintenance and are often in good operating condition despite their "historical" nature.

After identifying historic structures, project proponents must pay for an analysis and evaluation of the project's potential impacts to the structures. This analysis is forwarded to the State Historic Preservation Office (SHPO) to concur with the findings. If no properties are affected, then the process can be completed pending a concurrence letter from the SHPO.

If historic properties are affected (and this is very likely when utilizing existing infrastructure), then project proponents (and their consultants) must design specific plans for minimizing harm to historic properties and mitigating for potential impacts. The Section 106 process also requires public input and specialized advice and ideas from industry leaders and professionals. This extensive coordination takes time and money, further expending the resources of small or micro-hydro project developers and potentially making them unprofitable and unsustainable.

1.2.5. Endangered Species Act (ESA) and General Wildlife Consultation (GWC)

Although ESA Consultation is required if a project could potentially impact protected species or their designated critical habitat, wildlife agencies often request expensive and long-term studies in areas that are close to an endangered species' critical habitat areas, but are not themselves designated as critical to the survival of a species. Costs and delays become particularly acute when surveys are requested to take place during specific seasons (i.e., bird migration or nesting) and project proponents must wait months for that time to occur.

In cases where threatened or endangered species could be present in the area, Section 7 of the ESA also requires a separate Biological Assessment of the action on the species. This assessment is generally prepared by specialized consultants at high costs to project proponents. Further, the ESA requires "consultation" regarding the Biological Assessment to ensure that the Fish and Wildlife Service (FWS) and state wildlife agencies concur with its findings [24]. Consultation and negotiations can be both expensive and time consuming for even small projects like micro-hydro.

Although it is tempting to point to one specific regulation as the root cause of today's impediments to small hydropower development, a federal web of regulation is currently increasing the difficulty for small projects. The prevalent issue for these projects is not simply an over reaching bureaucratic agency or one specific piece of legislation, but rather a complicated regulatory process that includes numerous agencies and regulations that affect hydropower development.

2. Methods

We use two specific case studies to examine how federal regulations affected the installation of micro-hydro projects when they appeared to be a straightforward project to city personnel. One case study looks at Logan, Utah, and the other examines Afton, Wyoming. For our case studies, we interviewed the project managers in both Logan and Afton who were the sole city employees to work with the federal agencies and navigate federal regulations. In each project, the project managers dealt directly with the Federal Energy Regulatory Commission and other federal agencies when installing micro-hydro systems. Both project managers could present us with the most realistic view of the actual effects of federal regulation. Our interest in using these specific case studies stems from the fact that they both occurred in rural cities with staff that were able to actively engage in the development process of micro-hydro. In both cases, the city personnel were interested in generating their own power by retrofitting existing projects.

Logan's approach to micro-hydro was slightly different than Afton. Logan officials retrofitted a municipal water pipe with a hydroelectric turbine, and Afton officials restored a small dam, penstock, and powerhouse. Both case studies show that federal regulations increased the monetary and time costs of micro-hydro development, regardless of the form of micro-hydro electricity generation. We find that federal regulations are discouraging the development of micro-hydro generation by raising costs, thus defeating the regulatory purpose of a cleaner environment.

3. Case Studies and Results

The selected case studies present clear examples of how the unintended consequences from federal agencies and regulation increased the delay and costs in developing micro-hydro power. Small-scale, low-impact projects are subject to the same level of regulation and scrutiny as large projects that would require dams and cause substantial environmental impacts. This level of scrutiny drives up costs and discourages small projects that would otherwise be likely to actively participate in programs to improve their environmental impact and reap the economic and environmental benefits of micro-hydro power. In both case studies, city personnel saw micro-hydro as a simple solution and expressed the belief that current regulation is far too strict for simple projects that could produce substantial environmental and economic benefits if not for the federal regulatory nexus.

3.1. Logan, Utah

In 2004, Lance Houser saw an opportunity. As assistant engineer for Logan City, Houser was put in charge of managing the municipal water system and handled oversight and all of the planning for Logan's micro-hydro project. Houser had previously worked on several large-scale projects including the Hoover Dam and Bonito Pipeline in New Mexico, therefore he recognized the potential for the city's culinary water system to generate clean, low-cost electricity. All the system needed was the installation of a micro-hydro turbine within an existing pipeline, which Houser believed would face few regulations because it would require no new construction, but rather would modify an existing pipeline within an existing building. The project would have no additional environmental impacts and would create enough energy to power 185 local homes. It would solve a problem with water pressure while providing extra benefits to the city. Houser clearly saw the benefits that this seemingly small and simple project could bring to Logan City.

With the encouragement of federal policies, cities like Logan are implementing renewable energy projects such as small- and micro-hydropower. The American Recovery and Reinvestment Act (ARRA) of 2009, commonly known as the Recovery Act or the stimulus bill, officially provided $16.8 billion for "Energy Efficiency and Renewable Energy" [25]. Part of that funding went to renewable energy projects like Logan City's micro-hydro project. In total, the city planned to spend up to $1.4 million to complete the project, of which half was local funding and half was the ARRA-supported grant.

Logan City's micro-hydro project would generate electricity from a renewable source, reducing the city's reliance on energy generated from higher-emission coal and natural gas. As of 2012, over half of the city's electricity generation came from coal and about six percent came from gas [26]. As the National Hydropower Association notes, "Hydropower is a climate-friendly energy source, generating power without producing air pollution or toxic by-products." [27]. If Logan City's project were to run constantly for one year, and if all of the energy it replaced came from coal-powered plants, the project would offset approximately three and a half million pounds of carbon dioxide [28] (based on average CO_2 emissions of 2.14 lbs. per kWh of electricity generated from coal; a 200 kW project would produce 1.75 million kWh per year, if run constantly).

Despite the project's small size and its environmental benefits, Logan City had to navigate a complex regulatory web before its micro-hydro plant, known as the Dewitt Springs Pipeline Project, could be completed. Because of this, the project ended up taking four years and costing almost $3 million. By comparison, experts at Natural Resources Canada estimate that the total cost of a similar project in Canada would have been between $290,000 and $485,000 [29] (p. 31) (cost per kilowatt multiplied by the total kilowatts of the Logan project and converted from 2004 Canadian dollars to US dollars, adjusted for inflation from 2004 to 2016).

Dewitt Springs, a naturally flowing fountain of pure water in Logan Canyon, provides about seventy percent of Logan City's water supply. The city obtains the rest of its water from wells. Water from Dewitt Springs is diverted to a control vault used to remove pressure, and is then distributed among storage tanks until it is released according to demand. In 2008, the city updated its Dewitt Pipeline, increasing both the water supply to the city and the pressure on the system. The city's pressure-reducing valves soon proved ill-equipped to handle the new load [30] (p. 18). Rather than simply replacing all the valves, which would provide a costly, short-term fix, the city decided to place a micro-hydro turbine within the Dewitt Springs pipeline [31]. The turbine would help reduce pressure and would generate low-cost, renewable energy for the city.

What was perceived to be an inexpensive and economically feasible idea ended up well over budget. Logan City will not be starting any new projects of a similar size or scope, because the costs of this project outweighed the benefits. Houser told us that because of "the cost of the permitting headache and the nightmare and the frustration of the process, there is no economic benefit to doing a project that size again" [32].

The Recovery Act provided the initial stimulus for Logan City's project by allocating billions of dollars to renewable energy development. The Dewitt Pipeline project received approximately $700,000 in Recovery Act money as a cost-match grant through the Utah Division of Drinking Water [32] (we attempted to confirm this funding on the Recovery.gov tracking website, but were unable to do so; which may be because specific information is self-reported by recipients of ARRA money). In passing the act, the federal government sought to "preserve and create jobs and promote economic recovery" and to "invest in transportation, environmental protection, and other infrastructure that will provide long-term economic benefits" [33]. Unfortunately, Logan City's micro-hydro project did not create any new jobs, but rather increased the workload of existing city employees. Although the project is environmentally friendly, it will most likely not lead to significant economic benefits.

In completing the Dewitt Pipeline project, Houser worked closely with FERC, which oversees all permitting of hydropower plants. Logan City applied for and was granted a conduit exemption in January 2011 [34]. According to Houser, "the irony of the whole thing is that you get the exemption but all it saves you is about three to four months" [31]. Although the conduit exemption categorically exempts qualified projects from completing a formal EA, FERC still requires such projects to complete an environmental report in the form of a draft preliminary EA. This report must include "a description of the project's environmental setting, the expected environmental impacts, and proposed measures to protect the environment" [35] (Section 6.3). FERC required this environmental analysis even though the water used in the turbine comes from Dewitt Springs, not from the river [31]. The project would only affect an existing pipeline.

Although federal stimulus money provided the impetus for Logan City's project, this funding came with strings attached. The Recovery Act contains a "Buy American" stipulation, requiring that no funds be provided through the act "unless all of the iron, steel, and manufactured goods used in the project are domestic [produced in the United States]" [36]. According to Houser "under that definition of American-made, that meant there was only one turbine manufacturer in the entire world that met that definition" [31]. This ban on importing turbines prevented Logan City from buying less-expensive foreign alternatives and allowed one manufacturer to hold a monopoly and artificially high prices, contributing further to the cost of Logan City's experiment in micro-hydro.

Many of the same regulations designed to protect the environment created obstacles for Logan City's environmentally friendly micro-hydro project. The Endangered Species Act (ESA) required Houser to show that the project would not adversely affect any species or habitat listed under the act "on a project that disturbed nothing outside of an existing building" [31]. FERC requires permit applicants to complete a draft biological assessment to "address project effects on federally listed or proposed species or critical habitat in the project vicinity" [37] (p. 11). In Logan City's case, this requirement meant conducting analysis to show that the county's four animal species listed as "candidate" species, one as in "recovery," and three as "threatened," would not be harmed by the project [38]. Although the ESA was intended to protect the environment, in Logan City's case it ended up creating obstacles for cleaner energy production.

Though the Dewitt Pipeline project would require no construction except for the modification of an existing structure that had no historic value, FERC required Houser to show that no historical structures were being negatively impacted by Logan City's project [31]. Section 106 of the National Historic Preservation Act requires FERC to consider the potential impact of a project on "historic properties" that are "included in or eligible for inclusion in the National Register of Historic Places." This consideration may require consultation with "the Advisory Council, State Historic Preservation Officer, National Park Service, Tribal Historic Preservation Officer, members of the public, and affected Indian tribes," all of which must be documented in the FERC license application [37] (p. 15). This requirement led to more studies, paperwork, further delays, and added costs.

How did such a small, simple project end up costing almost $3 million? Table 1 shows the financial costs and benefits of the Dewitt Pipeline project. Houser estimates that an additional $110,000 could be added to the total if his time were included. He also estimates that the city spent about $400,000 just dealing with FERC [31]. The financial benefit generated in 2012 will be an annual benefit; however, the specific amount will vary each year since the amount of power generated depends on flow rates and how often the micro-hydro project is run.

Table 1. Financial Costs and Benefits of Dewitt Pipeline Project to Logan City Taxpayers.

Fiscal Year	Start-Up Costs	Power Generated	Financial Benefits
2010	$0.370 million	0 kWh	$0.00
2011	$1.025 million	0 kWh	$0.00
2012	$0.700 million	1,121,401 kWh	$67,284.06 (avg. rate of $0.06 per kWh)
Totals	$2.095 million	1,121,401 kWh	$67,284.06

Note: These costs do not include the $700,000 of federal grant money provided through ARRA. Sources: [39,40].

The numbers in Table 1 are based on both financial statements and firsthand interviews with city employees. The start-up costs in column 2 come from Logan City's financial statements, which can be found online. We then sat down with Houser to confirm that these costs were associated with the Dewitt Springs project and that they included ARRA grant money.

How long will it take Logan City to break even on its investment? The city's electric-meter foreman, Chris Niemann, estimates that if the project were to constantly run, it would take thirty-seven years for the project to break even. Since the project is usually operating under capacity, Niemann told us, "it's gonna take more like fifty years" [40].

According to our own calculations, Logan City's project will not reach the break-even point until the beginning of its thirty-second year of operation. This undiscounted break-even point calculation includes only Logan City's contribution to the project and excludes the $700,000 received from ARRA. If those funds are included, the project reaches the breakeven point in the 42nd year. We calculate the net present value (NPV) of Logan City's project, the difference between the present value of benefits from the project and costs of the project, as negative $650,000. This calculation is based on an interest rate for the project of four percent and assumes that every year the project would produce the same financial benefit as its first year [41]. The four percent interest rate is based on the rate Logan City is currently paying for a bond it issued in 2008, and is likely to be a conservative estimate of an appropriate discount rate for a project with fairly high risk. Because the NPV is significantly negative, if a business were deciding whether to take on this project, it would likely decide against it. Since the micro-hydro system is expected to last about fifty years, Logan City will be lucky if it can break even, let alone generate financial benefits [24]. Finances, however, do not take into account the project's real costs in terms of time and effort. The city will never be able to recoup the time it spent dealing with FERC and meeting the list of federal regulatory requirements.

Houser believes the high cost of regulations is also deterring other local cities from developing their micro-hydro potential. Cities like Hyrum, Millville, and Providence are all located within ten miles of Logan, and each has the potential to develop micro-hydro energy. These cities are also smaller than Logan. "Where are they gonna get the economic backbone in their community to handle all the regulatory compliance requirements?" Houser asked [31]. Because of costly regulations, potential green-power generation will likely not be developed in these small cities. Houser has experience working on hydropower projects all over the world and he believes that, "in other countries a project like this would have been considered a gold mine" because the regulatory environment is comparatively much less burdensome [32].

Using comparisons from other G7 countries with major developed economies, we can estimate what a similar project would have cost in an economy similar to the United States. According to a study by Natural Resources Canada, total costs, including construction, installation, and regulatory compliance, for a typical micro-hydro system range from $1500 to $2500 per kilowatt (Canadian dollars 2004) [29] (p. 31). This means that, in Canada, a 200-kilowatt project like Logan City's would cost between $290,000 and $485,000 U.S. dollars (converted from Canadian dollars 2004 and adjusted for inflation from 2004 to 2016). In addition, a study by the International Renewable Energy Agency (IRENA) estimates that, in Great Britain, total costs for micro-hydro below one megawatt range from $3400 to $10,000 U.S. dollars per kilowatt. The costs of a 200-kilowatt micro-hydro project in Great Britain would be between $708,631 and $2 million U.S. dollars [42] (p. 20) (dollars were adjusted for inflation from 2012 to 2016). Logan City's final cost amounted to nearly $3 million, or $15,000 per kilowatt (total cost of $3 million was divided by the 200 kilowatts). Logan City has identified multiple other locations where in-conduit micro-hydro could be added, but will not implement them due to the complex regulations and permitting costs.

3.2. Afton, Wyoming

Afton is a small town on the south end of Star Valley situated in the mountains of southwest Wyoming. Star Valley is just south of Yellowstone Park and the Grand Tetons; therefore, it is often used as a bedroom community for the high-priced recreational town of Jackson, Wyoming.

On both the west and east sides of Afton there are multiple creeks and streams. Although many creeks are seasonally higher in the spring and summer months, most have continuous and predictable flows throughout the year, making them perfect for micro-hydro application. Small hydropower projects have been present in Afton since the early part of the 20th century with a small dam, penstock, and powerhouse developed on Swift Creek. In the late 1960s, a snow avalanche destroyed a portion of the infrastructure and the project was abandoned [43].

There were several attempts to rehabilitate the project in the 1980s and 1990s, but the project was never finished due to costs and Afton's inability to conform to the complex regulations. In 2008, cooperation between the town of Afton and the local power company, Lower Valley Energy, resulted in renewed efforts to bring the renewable energy from Swift Creek back online [20]. The project has a 1.4 megawatt capacity [43] and is capable of offsetting almost twenty-six million pounds of carbon dioxide if the project were to run constantly for one year, and if all of the energy it replaced came from coal-powered plants [28] (based on average CO_2 emissions of 2.14 lbs. per kWh of electricity generated from coal; a 200 kW project would produce 1.75 million kWh per year, if run constantly).

Despite having an existing license from FERC for the project, the permitting and regulatory jungle proved a substantial challenge for city officials. Frustrated with the delays inherent in the project, the project manager for engineering commented that the "process is more complex and burdensome than it needs to be" and that "the federal red tape makes things take longer than it should" [44]. Another project manager noted that "for many micro-hydro projects it is often five years until you're breaking ground" because of the stringent federal permitting requirements [45]. Although project personnel recognized the need to follow procedures and have environmental oversight, the consensus was that current regulations "have gone too far in the wrong direction" [20,44,45].

Reflecting on the costs involved with micro-hydro projects, Tony Allen estimated that "three-quarters of the costs is regulatory" [45]. Environmental and engineering personnel from consultants can be particularly expensive for small projects. Costs for the prime consultant on the project were $250 per person per hour and the project costs totaled approximately $7.5 million [20]. Using Tony Allen's estimate, this indicates approximately $5.6 million was required just to navigate regulation and satisfy federal agency requirements. For small cities like Afton, an investment of this size for little to no short-term return is unsustainable on budgets and discourages development. With less restrictive regulation, Afton could have potentially used the estimated $5.6 million spent adhering to regulation to build up to three additional projects. With complex regulations in place, the natural result is that hydropower capacity is going unmet all over the country as regulation discourages small communities from accessing the green energy potential of micro-hydro.

Despite the regulatory hurdles, the project was able to obtain a permit and was constructed within two and a half years, a somewhat accelerated pace compared with many other micro-hydro projects. According to project management, this was primarily because the "stars were in alignment" for things to go well [20,45]. Because the Swift Creek project had previously been operational and several attempts had been made to bring it back online, many of the most costly and time-consuming aspects of micro-hydro development had already taken place. These aspects included the following:

- A current FERC license was already in place.
- Existing infrastructure (Dam, powerhouse, transmission lines, etc.) were already in place (but needed refurbishing).
- Past failed attempts at the project produced some submissions and permits that were able to be "piggybacked" by this project.
- The project was on Forest Service land and they were requiring that the project be re-instated or cleaned up, so money had to be spent either way.
- There was little interference from non-governmental organizations who usually oppose power projects.
- The project was "Greentagged" and qualified for state and federal governmental subsidies.
- An unusually positive and cooperative relationship between the Forest Service and city personnel.
- The power was to be sold to users in Jackson, Wyoming who generally place a premium on "green" power from local sources and are willing and able to pay higher prices.

Although the Swift Creek project had numerous advantages over an average micro-hydro project and required little construction due to existing infrastructure, it still took two and a half years to complete and cost an average of $5400 per kilowatt (divided total of $7.5 million by 1.4 megawatt project size, adjusted for inflation from 2013 to 2016 dollars) to bring back online. Some of the greatest hurdles for Afton were the requests for more studies and more mitigation from resource agencies. For example, an expensive Lynx survey was required despite the project not occurring in critical habitat for Lynx. It was also noted that the project would go smoother if the project provided a parking lot desired by the Forest Service. Tony Allen noted, "agencies have "wish lists" that are part of "buying" your permitting, like parking lots or other pet projects" that allow projects to go through [45].

Even after a project is completed, the costs of federal regulations continue on a regular basis. Review of the FERC website for the Swift Creek hydro project indicates that following the construction of a project, federal requirements continue to place financial and temporal burdens upon micro-hydro power producers. Examples include multiple requests from federal agencies to update information, conduct surveys, provide certifications, disclose operational details, and more [46]. Cumulatively, these requests result in additional costs that are difficult to bear for micro-hydro producers like the City of Afton, even after the initial permitting and construction costs are realized. Although the Swift Creek micro-hydro project was completed and is operational, it was not without substantial costs and delays resulting from federal regulatory processes.

Using comparisons from Canada and Great Britain, both G7 countries with well-developed economies, a project similar to Afton's of 1.4 megawatts would cost significantly less. In Canada, a project similar in size to Afton's would cost on average between $2 million and $3.4 million [29] (p. 31) (converted from Canadian dollars 2004 and adjusted for inflation from 2004 to 2016). In Great Britain, projects greater than one megawatt cost between $3400 and $4000 per kilowatt [42] (p. 20). A 1.4-megawatt system on average would cost between $4.9 million and $5.8 million total (adjusted for inflation from 2012 to 2016 dollars). In less developed countries, which tend to have less stringent environmental regulations, the breakdown of costs for micro-hydro shows that the planning and permitting process is a small fraction of total costs. According to IRENA's estimates, a project similar in size to Afton of 1.4 megawatts would have faced costs in the range of 0–5% for the planning and permitting [42] (p. 22), which would equal a maximum of $375,000 rather than the project manager Allen's estimate of $5.6 million. IRENA shows that the costs for micro-hydro can vary significantly according to the project, but even at its highest planning only reached about twenty percent of total costs [42] (p. 22). Although some developing countries may not have stringent enough regulation, the costs incurred by the regulatory jungle in the United States can substantially increase the burden on micro-hydro developers and clean energy. Comparisons show that the average cost per kilowatt in the United States is higher than other developed countries and developing countries.

Other cities across the United States have tried to implement micro-hydro systems and have seen similar results as Logan and Afton. Barre City, Vermont, spent seven years meeting regulatory requirements and securing federal funding for a micro-hydro project of only fifteen kilowatts that installs turbines within already existing city piping [47] due to the delays caused by regulation. Eric Jacobson of Telluride, Colorado spent six years navigating the federal regulatory nexus before he could bring the recently purchased Bridal Veil Falls' micro-hydro power plant back online. The Bridal Veil Falls plant was an already existing structure that produced hydropower, but was shut down in the 1950s. Jacobson purchased the plant in 1981 and between the purchasing process, navigating regulation, obtaining permits, and getting the plant back online, ten years had passed when the plant began producing power in 1991 [48]. Jacobson found the regulations too severe in the case of Bridal Veil observing that the water supply lake has no fish in it, meaning "there are zero deaths per kilowatt hour . . . it's hard to be any greener than Bridal Veil." Jacobson continued with the following, "FERC has made compliance costs so high it absolutely shuts down small projects. There's a direct correlation between size of the project and size of its impact...Yet some say that every project ought to have the same environmental review" [49].

Many communities have been dissuaded from attempting the development of clean micro-hydro energy due to environmental regulation. An entity in New Mexico has identified one hundred and fifty potential micro-hydro sites on a single waterway, but has shelved the idea after FERC communicated its intention to require a NEPA document for each site [50]. In Colorado alone there are hundreds of undeveloped megawatts of electric energy available at "existing impoundments and diversions as well (as) existing municipal water systems" [51]. This means that very little infrastructure, if any at all, would have to be built to utilize this energy, yet these sites remain undeveloped. Holding micro-hydro developers to a less complicated standard could solve many of the barriers that are now discouraging clean energy development in the United States. By simplifying the regulatory process, the incentives to develop clean energy can increase, which will produce a cleaner environment.

4. Conclusions

There is consensus in Congress to make it easier for small hydropower projects that will have minimal environmental effects to obtain a federal license. Washington State Representative

Cathy McMorris Rodgers and Colorado Representative Diana DeGette co-sponsored H.R.267, the Hydropower Regulatory Efficiency Act of 2013, which was signed into law by the president on 9 August 2013 [52]. The legislation is intended to streamline the permitting process for small hydropower projects and to increase the scope of projects eligible for licensing exemptions [40]. It is still too soon to tell whether this law will have its intended effects, but the direction taken is one that could increase micro-hydro projects and clean energy throughout the United States.

In a report presented to the Department for International Development and the World Bank, London Economics outlined the best means by which governments throughout the world could promote the development of micro-hydro energy. Included in this outline are suggestions on how best to regulate micro-hydro [53] (p. 52).

- Regulation should be free from political interference and encourage competition.
- Regulation should be steady and not subject to sudden change as well as clear and transparent concerning requirements.
- Regulation should be appropriate to both the cost of the project and the financial capacity of the involved parties.
- Regulation should be structured to avoid encouraging "rent seeking behavior" by federal agencies and officials.
- Regulation should create incentives for developers in a way that consumers' needs are met in a cost-effective manner.
- Standards for both safety and quality should be enforced to protect developers and consumers.

The current regulatory jungle that American micro-hydro developers face does not achieve many of the points outlined above. When regulation fails to encourage these ends it is unlikely that micro-hydro will be developed. Extensive and complex regulations produce unintended consequences. Although the federal government attempts to encourage renewable energy production by providing funding through legislation like the ARRA, federal regulations enforced by FERC suffocate many green-energy projects. Many of these regulations, like the ESA and NEPA, are meant to protect the environment, but instead they end up discouraging small renewable energy development.

Evidence of minimal environmental impacts and substantial economic benefits from small hydro power projects shows that the U.S. could increase the output of hydro energy, which is currently the largest source of renewable power, by fifty percent. If the United States wants to see more green energy, then one of the simplest paths is by simplifying licensing requirements and regulation for small hydropower projects. Micro-hydro could justifiably face less stringent regulations than large hydropower projects because they do not have the same impact on the environment, they utilize existing infrastructure, and generate clean renewable energy. Cities and organizations would save money and building more hydropower facilities could create jobs. If the federal government amended current legislation to make development of small hydro more accessible, affordable, and timely then America could see substantial environmental and economic benefits.

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