SMALL HYDROPOWER, BIG POTENTIAL: CONSIDERATIONS FOR RESPONSIBLE GLOBAL DEVELOPMENT

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I. INTRODUCTION

To say that energy is a complicated subject would be an understatement. Access to energy provides economic, social, and health benefits, while its abuse results in social, economic, environmental and climate detriments. How we meet our global energy needs may be one of the most critical issues facing people today.[1] World economies are currently looking for ways to either increase energy production (such as those in emerging countries without sufficient electricity supply) or shift to cleaner and more sustainable energy (such as those in industrialized countries).[2] Small hydropower is one opportunity that has presented itself to meet some of these growing energy needs. This article will examine: (1) what small hydropower is, including a case study from Scotland; (2) its potential role in rural electrification and climate adaptation; and (3) considerations and legal reforms that could allow responsible small hydropower development to occur.

Nearly 160 countries generate electricity from some form of hydropower, accounting for approximately 16% of the world's electricity generation.[3] Large, conventional hydropower makes up the vast majority of the world's hydropower.[4]

1. U.N. INDUS. DEV. ORG. [UNIDO] & INT'L CTR. ON SMALL HYDRO POWER [ICSHP], WORLD SMALL HYDROPOWER DEVELOPMENT REPORT 1 (2013), http://www.smallhydroworld.org/fileadmin/user_upload/pdf/WSHPDR_2013_Final_Report-updated_version.pdf [hereinafter UNIDO & ICSHP].

2. *See generally* Juscelino F. Colares, *The Dynamics and Global Implications of Sub-global Carbon-Restricting* Regimes, 25 GEO. INT'L ENVTL. L. REV. 417 (2013) (discussing European and Australian carbon control reforms); JOHNATHAN M. HARRIS ET AL., GLOBAL DEV. & ENV'T INST., THE ECONOMICS OF GLOBAL CLIMATE CHANGE (2015), http://www.ase.tufts.edu/gdae/education_materials/modules/The_Economics_of_Global_Climate_Change.pdf (discussing the economics of global climate control policies); Steven Ferrey, *Cubing the Kyoto Protocol: Post-Copenhagen Regulatory Reforms to Reset the Global Thermostat*, 28 UCLA J. ENVTL. L. & POL'Y 343 (2010) (discussing international legal carbon control schemes).

3. INT'L ENERGY AGENCY [IEA], TECHNOLOGY ROADMAP: HYDROPOWER 9 (2012), https://www.iea.org/publications/freepublications/publication/2012_Hydropower_Roadmap.pdf.

4. *See generally id.*

"Unlike large conventional hydropower, small and low flow hydropower facilities require less water flow"[5]—making them attractive for rural electrification in less traditional hydropower areas.[6] Further, they can be placed in or on existing conduits, canals, locks, and even on existing small, unpowered dams.[7] Importantly, these small facilities are less likely to negatively impact human and wildlife environments because they take up less physical space, do not require a reservoir, and in many instances can be located on waterways free of wildlife or natural habitat.[8] This low-cost distributed form of renewable energy generation—with responsible development—can benefit industrialized and emerging countries alike.

For small hydropower to meet its full potential, however, legal and policy guidance will be necessary. Specifically, policymakers will need to consider—at the very least—factors such as the need for detailed site-specific information, a stable and flexible governance permitting scheme, and incentives that encourage investment in this renewable source.

5. Gina S. Warren, *Hydropower: Time For a Small Makeover*, 24 IND. INT'L & COMP. L. REV 249, 249 (2014).

6. While outside of the scope of this article, it is important to note that large conventional hydropower in some parts of the world may be a risky investment given the decrease in river flows due to climate change. *See generally* Dan Tarlock, *The Legal-Political Barriers to Ramping Up Hydro*, 86 CHI.-KENT L. REV. 259 (2011). In fact, large hydropower dams around the world have seen declines in generation over the last few years due to a lack of rainfall and snowpack. For example, California and Pacific Northwest, United States have seen a decrease in hydropower generation due to a lack of snowpack. Steve Scauzillo, *Drought is Killing California's hydroelectric Power. Can Solar Make Up the Difference?*, SAN GABRIEL VALLEY TRIBUNE (Sep. 8, 2015), http://www.sgvtribune.com/general-news/20150908/drought-is-killing-californias-hydroelectric-power-can-solar-make-up-the-difference. Additionally, Brazil has seen a significant drop in generation due to lack of rainfall. Sue Branford, *Brazil Climate Change Report Warns of Failed Hydropower and Crops*, MONGABAY (Nov. 9, 2015), https://news.mongabay.com/2015/11/brazil-climate-change-report-warns-of-failed-hydro-power-and-crops/.

7. Warren, *supra* note 5, at 255.

8. *Id.* at 255–56.

II. WHAT IS SMALL HYDROPOWER?

"Small hydropower is a well-developed small-scale renewable energy technology" that can provide safe and clean electricity to rural and urban areas.[9] Untapped small hydropower potential exists worldwide and could deliver upwards of 173 gigawatts (GW) of new energy.[10] To put this in context, the current US small hydropower capacity is 21.6 GW, where the average residential home consumes around 901 kilowatt-hours (kWh) per month.[11] Hydropower is created by the flow of water over a turbine or water wheel that is connected to an alternator or generator, which in turn generates electricity.[12] The electricity can be used onsite, directed into the transmission grid for utility-scale distribution, or stored in batteries for later use.[13] While there is no international definition of small hydropower, most concur that small hydropower generators are those that produce up to 10 megawatts (MW); however, this threshold is by no means a universal consensus. For example, for regulatory purposes, India draws the line at 25MW, China at 50MW, and the United States at 30MW.[14]

A facility producing less than 1MW is generally labeled mini-hydropower; less than 100 kilowatts (kW) is generally labeled mi-

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9. UNIDO & ICSHP, *supra* note 1, at 1. After studying 152 countries and their potential for small hydropower, the authors concluded: "It can be concluded that small hydropower is a suitable renewable energy technology in the context of rural electrification efforts, energy diversification, industrial development and exploration of existing infrastructure." *Id.* at 10.

10. *Id.* at 1. This report utilizes a 10MW cutoff for small hydropower. As such, the potential for medium hydropower (up to 50MW) was not addressed.

11. *Frequently Asked Questions*, U.S. ENERGY INFO. ADMIN. (Oct. 21, 2015), https://www.eia.gov/tools/faqs/faq.cfm?id=97&t=3.

12. *Small Scale HydroPower*, SMALL HYDRO INT'L. GATEWAY, http://www.small-hydro.com/about/small-scale-hydrpower.aspx (last visited Sept. 22, 2016).

13. *Id.*

14. IEA, *supra* note 3, at 15; EUROPEAN SMALL HYDROPOWER ASS'N [ESHA], SMALL HYDROPOWER FOR DEVELOPING COUNTRIES 4, https://kunaifien.files.wordpress.com/2008/12/small-hydropower-for-developing-countries1.pdf (last visited Dec. 29, 2016).

cro-hydropower; and less than 5kW is generally labeled pico-hydropower.[15] Small and mini facilities usually contribute electricity to the regional or national grid, while pico and micro facilities are generally used for isolated individuals and villages.[16] This article will focus on mini, small, and medium hydropower up to 30MW, referring generally to them as "small hydropower."

Small hydropower is flexible and can be located on rivers, in canals, locks, pipes, lakes, or just about any running waterway without the need to install elaborate or expensive dams.[17] It can also be placed on existing infrastructure, such as an existing dam or other flood-control mechanism.[18] This specific placement maximizes efficiency and minimizes environmental harm.[19] The following project from Scotland provides a good example.

While in Edinburgh for the 2015 World Water Congress, I had the opportunity to visit the Harlaw Hydropower Project, which is a small hydro facility located in the Pentland Hills Regional Park, approximately seven miles south of Edinburgh.[20] The reservoir is surrounded by a lovely walking path patronized by locals out for a stroll, walking their dogs. Birds and butterflies buzz about, and in the spring, the adjacent fields are full of blooming brassica flowers

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15. Jose Luis Carrasco et. at., *Hydropower (Small-scale)*, SUSTAINABLE SANITATION AND WATER MGMT., http://www.sswm.info/content/hydropower-small-scale (last visited Sept. 22, 2016).

16. ESHA, *supra* note 14, at 4.

17. *See* U.S. DEPT. OF ENERGY, WATER POWER FOR A CLEAN ENERGY FUTURE 10 (2013), http://www1.eere.energy.gov/water/pdfs/wp_accomplishments_brochure.pdf; U.S. DEPT. OF ENERGY, AN ASSESSMENT OF ENERGY POTENTIAL AT NON-POWERED DAMS IN THE UNITED STATES vii (2012), http://www1.eere.energy.gov/water/pdfs/npd_report.pdf [hereinafter ASSESSMENT].

18. ASSESSMENT, *supra* note 17, at vii.

19. UNIDO & ICSHP, *supra* note 1, at 10 ("Small hydropower technology has gradually adapted to meet environmental concerns while technical innovators aim to explore the use of existing infrastructures"); *see also* Warren, *supra* note 5, at 249.

20. For more information about the Harlaw project, *see generally* HARLAW HYDRO, HTTP://WWW.HARLAWHYDRO.ORG.UK/ (LAST VISITED Dec. 31, 2016).

(the flowers used to make vegetable oil), as shown in the photograph below.

Field of brassica flowers at the Pentland Hills Regional Park.[21]

The Harlaw reservoir, as shown in the photograph below, was created over 100 years ago as a catchment for rain runoff from the hills, to prevent flooding and to provide a steady water supply for downriver water mills.[22] In the early 1900s, the dam was powered and provided electricity to the nearby water bailiff's cottage.[23] Engineers unearthed old rusted-out turbines near where the new

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21. Photograph taken by author during trip to Scotland in May 2015.

22. *Water Powers Industry*, HARLAW HYDRO, http://www.harlawhydro.org.uk/background-3/the-resevoirs/#.V9Bx9GU4S-I (last visited Sept. 22, 2016) [hereinafter *Water Powers Industry*]. According to the website:

> The Harlaw and Threipmuir Reservoirs were constructed by the Edinburgh Water Company, around 1847, as compensation reservoirs to regulate the flow of water into Bavelaw Burn and from there into the Water of Leith. On its way from Harlaw to Leith the water still flows over many of the weirs that were created to manage the water and enable it to be used by up to 70 water wheels.

Id.

23. *Hydro at Harlaw*, HARLAW HYDRO, http://www.harlawhydro.org.uk/background-3/hydro-electric-and-fit/#.V9ByeGU4S-I (last visited Sept. 22, 2016) [hereinafter *Hydro at Harlaw*].

pump house was erected.[24] However, it was not a functioning hydropower facility in recent memory.[25]

Harlaw Reservoir [26]

In 2009, the local community became interested in using the existing structure to produce green energy and to make a profit by selling the energy to the grid.[27] In 2010, a feasibility study was prepared for the site, confirming the practicality of adding hydropower to the existing dam.[28] Over the next four years, the community undertook licensing, along with litigation, until it obtained the final

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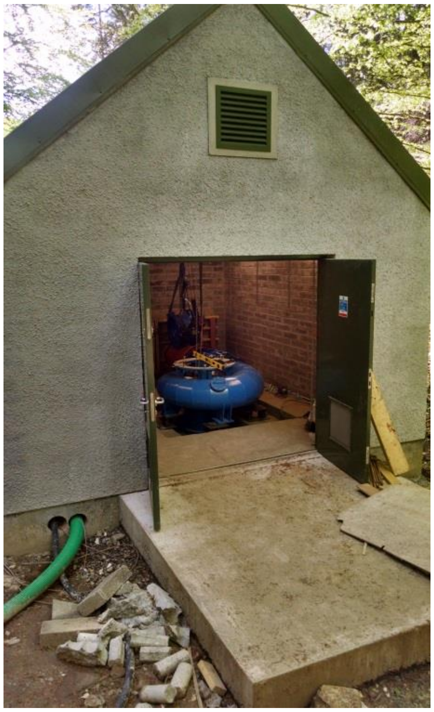
24. *What to do with the Old Wheel*, HARLAW HYDRO, http://www.harlawhydro.org.uk/what-to-do-with-the-old-wheel/#.V9BzR2U4S-I (last visited Sept. 22, 2016).

25. *Hydro at Harlaw*, *supra* note 23; *Water Powers Industry, supra* note 22.

26. Photograph taken by author during trip to Scotland in May 2015.

27. *Project Life Cycle*, HARLAW HYDRO, http://www.harlawhydro.org.uk/project-life-cycle/#.Vtr2tvkrLIU (last visited Mar. 1, 2016) [hereinafter *Project Life Cycle*]. Interconnection through feed-in tariffs is very helpful for communities looking to develop, connect to an existing grid, and sell energy at a set price. Felix Mormann, *Enhancing the Investor Appeal of Renewable Energy*, 42 ENVTL. L. 681, 693 (2012). As explained by Professor Mormann, "[t]he 'feed-in' element guarantees renewable electricity generators the right to connect to the power grid. The 'tariff' element requires local utilities to purchase the power that these generators feed into the grid at subsidized rates above market prices for an extended period of time." *Id.*

28. *Project Life Cycle*, *supra* note 27.



New Harlaw pumphouse [1]

paperwork needed to begin construction.[29] Through the use of volunteers, a new pump house, as shown in the photograph below, was constructed and a new turbine was installed.[30] The turbine power has an installed capacity of 92kW,[31] but engineers expected the efficiency to be approximately 82kW of electricity,[32] given the downstream water flow needs.[33]

Based on conversations with volunteer engineers, by July 2015, the turbine was running twenty-four hours a day, seven days a week, and generating enough electricity to power around 177 homes.[34]

The Scottish government highly values hydropower and uses hydropower as a means to reach its target of "supplying 50%

29. *Id.*

30. *Id.*

31. See generally HARLAW HYDRO, supra note 20.

32. It appears from the Harlaw Hydro website that the turbin is currently being run at 85kW. *See Power Meter*, HARLAW HYDRO, http://www.harlawhydro.org.uk/power-meter/#.V9B2AGU4S-J (last visited Sept. 22, 2016) [hereinafter *Power Meter*].

33. *CEC Reservoirs Technical Information*, EDINBURGH: THE CITY OF EDINBURGH COUNCIL, https://www.edinburgh.gov.uk/site/custom_scripts/proxy.php?file=/documents/9282/EDIR%209282%20CEC%20Reservoirs%20TECHNICAL%20INFORMATION.pdf (last visited Sept. 22, 2016).

34. *Power Meter*, *supra* note 32; *see also The Kilowatts are Flowing Bring on the Rain!!*, HARLAW HYDRO (July 23, 2016), http://www.harlawhydro.org.uk/the-kilowatts-are-flowing-bring-on-the-rain/#.V-LwlJMrLfY.

of its energy from renewable resources by 2020."[35] In 2008, the government commissioned a study and report to look at the feasibility of additional hydropower development.[36] The study found that Scotland has about 201MW of financially viable hydropower potential that has yet to be developed.[37] The report noted that one barrier to expedient development was the current permitting process,[38] which can be lengthy and expensive. This was the case with the Harlaw project, which took six years and significant money to reach fruition – though most of the folks working on the project were volunteers.[39] A quick look at the Scottish hydropower licensing framework sheds light on why the process was a lengthy one.

The Scottish Environmental Protection Agency ("SEPA") regulates the development of hydropower.[40] SEPA issues water-use licenses in accordance with the Controlled Activities Regulations ("CAR"), which regulate water-related activities like hydropower developments.[41] All hydropower developments require a CAR water-use license no matter the size.[42] The one license will cover all

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35. NICK FORREST ASSOC. LTD. ET AL., SCOTTISH HYDROPOWER RESOURCE STUDY 10 (2008), http://www.gov.scot/resource/doc/917/0064958.pdf.

36. *Id.*

37. *Id.* at 25–26.

38. *Id.* at 25–26, 28 (concluding in part that "[m]arket forces, which have a stronger effect, can be influenced to some extent by providing a stable support and permitting regime as these affect the investor's perception of risk and hence the discount rate that they will require").

39. *See generally* HARLAW HYDRO, *supra* note 20.

40. *Hydropower*, SCOTTISH ENV'T PROT. AGENCY [SEPA], http://www.sepa.org.uk/regulations/water/hydropower (last visited Mar. 1, 2016).

41. *Id.*; *The Waters Environment (Controlled Activities) (Scotland) Regulations 2011 (as Amended): A Practical Guide*, SEPA 5 (July 2016), http://www.sepa.org.uk/media/34761/car_a_practical_guide.pdf.

42. SEPA, *supra* note 40.

associated activities.[43] To issue a license, SEPA gathers detailed information about the proposed project, including site and technical specifications.[44] Several levels of consultation are required before it performs a cost-benefit analysis to determine whether the scheme's potential benefits outweigh its potential to cause environmental harm.[45] Following this process, small hydropower (less than 35MW) will generally be approved so long as the facility does not have any adverse impact on the water environment.[46] This approval, however, can come years later after several levels of consultation and it can be very costly—potentially outweighing the cost of the project itself, which discourages investment.[47] According to one Scottish energy consultant, the process "is often long-winded and presents further risks for developers and investors should delays make the projects less financially viable."[48] This licensing scheme is not unlike the licensing scheme in the United States,

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43. *License Applicant Guidance: General Guidance Notes*, SEPA 4 (June 2015), http://www.sepa.org.uk/media/34540/car_licence_applicant_guide.pdf. Even though all hydropower schemes are required to obtain the same type of license, they are screened against different criteria based on their annual output. *Id.*

44. *Id.* at 5.

45. *Guidance for Developers of Run-of-River Hydropower Schemes*, SEPA 3 (Nov. 2015), http://www.sepa.org.uk/media/156800/guidance-for-developers-of-run-of-river-hydropower-schemes.pdf.

46. *Id.* at 5.

> Likely acceptable schemes include those:
>
> - situated in degraded parts of the water environment (other than those planned to be improved);
> - situated in small, steep streams;
> - delivering an overall improvement to the ecological quality of the water environment;
> - using only that proportion of flow that can be abstracted from the river or stream without breaching river flow standards.
>
> Proposals not satisfying the criteria in the checklists may still be able to obtain authorisation if they would deliver additional and significant social or environmental benefits.

Id.

47. Barry Cowell, *Why hydro energy still offers hope to Scotland*, HERALDSCOTLAND (Oct. 22, 2013), http://www.heraldscotland.com/business/opinion/13128354.Why_hydro_energy_still_offers_hope_to_Scotland/.

48. *Id.*

which has been noted as a legitimate barrier to small hydropower investment and development in the United States.[49]

III. SMALL HYDROPOWER'S POTENTIAL ROLE IN PROVIDING SUSTAINABLE ENERGY

In September 2015, the United Nations adopted the 2030 Agenda for Sustainable Development.[50] The Agenda includes seventeen Sustainable Development Goals ranging from ending poverty, inequities, and injustices, to addressing climate change and protecting our natural resources by 2030.[51] Goal Seven seeks to "[e]nsure access to affordable, reliable, sustainable and modern energy for all."[52] Small hydropower could be one of many ways to supply affordable, reliable, and sustainable energy to people living in more remote areas.

A. Rural Electrification

Approximately 1.2 billion people (17% of the world's population) live without access to electricity today.[53] The overwhelming majority of these people (approximately 95%) live in the developing regions of Asia and sub-Saharan Africa.[54] In addition, about 2.7

49. *See* UNIDO & ICSHP, *supra* note 1, at 181*; Capacity Concerns for the Democratic Republic of Congo*, REEGLE (2012), http://www.reegle.info/policy-and-regulatory-overviews/CD (last visted Sept. 21, 2016) [hereinafter REEGLE]; *see infra* p. 12 and note 82.

50. *See generally* G.A. Res. 70/1, Transforming Our World: The 2030 Agenda for Sustainable Development (Sept. 25, 2015), http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E.

51. *Id.* at 14.

52. *Id.* at 19.

53. IEA, WORLD ENERGY OUTLOOK 2015 3 (2015), http://www.iea.org/publications/freepublications/publication/WEB_WorldEnergyOutlook2015ExecutiveSummaryEnglishFinal.pdf.

54. *World Energy Outlook: Energy Access Database*, IEA, http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/ (last visited Sept. 21, 2016).

billion people—38% of the world's population—burn biomass (usually wood) to prepare meals.[55]

Governments benefit when their citizens have reliable electricity.[56] Electricity can help alleviate poverty and bring jobs that increase a country's gross domestic product.[57] Statistically, people living in developing countries pay a higher percentage of their income (12%) for energy than those in developed areas.[58] Traditional energy sources (biomass and diesel) can be very expensive, so having a reliable and consistent source of energy such as small hydropower can reduce energy costs.[59] As people become less dependent on expensive energy sources, funds are freed up to spend in other industries.[60] Reliable and less costly energy can also provide jobs in both the short and long term.[61] Small hydropower projects use

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55. IEA, *supra* note 53.

56. Rural electrification, as a means to an end, has its own pitfalls, which are beyond the scope of this article. It should be noted, however, that concerns have been raised about either "going too far" or "stopping short." Catherine Wolfram, *Are We Too Fixated on Rural Electrification?*, BERKELEYHAAS (Sept. 14, 2015), https://energyathaas.wordpress.com/2015/09/14/are-we-too-fixated-on-rural-electrification/. The concern with stopping short is that once a household is connected to any form of small renewable, even if it is a temporary one, they will be proclaimed as "electrified" and no future advancements will be made. *Id.* The concern with overreaching is that it may create a myopic view of the issues in developing countries. *Id.* Meaning electricity will solve everything. *Id.* If the sole focus is on financing electrification, other needs such as "better health services" will go unmet. *Id.*

57. U.N. DEP'T OF ECON. & SOC. AFFAIRS [UNDESA] DIV. FOR SUSTAINABLE DEV., A SURVEY OF INTERNATIONAL ACTIVITIES IN RURAL ENERGY ACCESS AND ELECTRIFICATION 1 (2014), https://sustainabledevelopment.un.org/content/documents/1272A%20Survey%20of%20International%20Activities%20in%20Energy%20Access%20and%20Electrification.pdf [hereinafter UNDESA].

58. ESHA, *supra* note 14. This is not just the case in developing countries. In a recent U.S. study, the bottom quartile of income earners paid nearly 10% of their income to electricity and transportation costs, where the top quartile paid only 1.38%. Julian Spector, *Where America's Poor Pay the Most for Electricity*, CITY LAB (Apr. 14, 2016), http://www.citylab.com/housing/2016/04/electricity-bills-by-city-low-income-costs/478155/. The study points out that this is not simply due to low income earners paying more as a percentage of their income, but that they are paying more per square foot, because they do not have access to energy efficient home or auto technologies or low cost energy. *Id.*

59. ESHA, *supra* note 14.

60. *Id.*

61. *Id.*

local labor for construction and repairs.[62] In addition to employment created by the project itself, small hydropower can provide a village grid enough reliable energy to support small local industries and agriculture.[63]

However, creating reliable electricity is not just an economic concern, it is a humanitarian one. Electricity can prevent illnesses and save lives. Without electricity, people are forced to cook with whatever will burn – usually wood – which then causes indoor air pollution that is a significant cause of acute respiratory infections,[64] and a prominent cause of death of children in developing areas.[65] Electricity also brings other health benefits, such as temperature control. In the summer of 2015, with no electricity to cool them, over one thousand people died in India because of excess heat and humidity.[66] Substituting small hydropower for biomass can provide people a reliable source of clean energy that they can use to cook, and heat, cool, and light their homes without harm.[67]

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62. *The Potential of Small Hydro for Rural Electrification*, ALLIANCE FOR RURAL ELECTRIFICATION 6–7 (2014), http://ruralelec.org/sites/default/files/are_small_hydropower_position_paper_2014.pdf.

63. ESHA, *supra* note 14, at 6. An example of this comes from rural Wales, United Kingdom where 23 new micro hydropower facilities have recently been put into place. James Meadway, *Small Scale Hydropower Can Provide Stream of New Jobs to Rural Regions*, THE GUARDIAN (July 16, 2015), http://www.theguardian.com/sustainable-business/2015/jul/16/community-hydropower-schemes-under-threat-at-expense-of-local-jobs. Communities have banded together to own these small facilities "unlocking the economic potential of hard-to-reach rural areas." *Id.* According to research by the Cardiff Business School, small hydro can provide an "economic windfall" because it relies on local materials and supplies, as well as local knowledge of the geography. *Id.* This reliance creates local jobs. *Id.* When feed-in tariffs are in place, it can also generate a revenue stream for community owners selling the power into the grid. *Id.*

64. *See generally*, Kirk R. Smith et al., *Indoor Air Pollution in Developing Countries and Acute Lower Respiratory Infections in Children*, 55 THORAX 518 (2000), http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1745777/pdf/v055p00518.pdf.

65. *Id.*

66. Harmeet Shah Singh & Rishabh Pratap, *Heatwave Kills More than 1,100 in India*, CNN (May 28, 2015), http://www.cnn.com/2015/05/25/asia/india-heatwave-deaths/.

67. ESHA, *supra* note 14, at 3, 6.

What follows is a brief look at rural electrification rates in three different countries—the Democratic Republic of the Congo, Argentina, and China—and their opportunities to access small hydropower as a potential solution. In each of these countries, millions of people live in rural locales that are isolated from the main grid, or they are connected to grids that are not supplied with adequate energy to meet the demand.[68]

The Congo has an 11.1% electrification rate, with 65.7% of the population living in rural areas.[69] As a result, 58.7 million people live without access to electricity.[70] Power sources are located far from the end users and the transmission infrastructure is old, in need of repair, and unreliable.[71] About 95% of the population relies on burning biomass, such as wood and charcoal, for energy to cook food.[72] These sources produce pollution and negatively impact human health.[73]

The Congo's overall goal is to promote rural electrification, and it has an opportunity to do so through small hydropower development.[74] By some estimates, it contains 66% of central Africa's potential and about 8% of the global hydropower potential.[75] Congo

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68. For an in-depth look at the benefits of renewable power generation in developing nations, *see* STEVEN FERRY & R. ANIL CABRAAL, RENEWABLE POWER IN DEVELOPING COUNTRIES: WINNING THE WAR ON GLOBAL WARMING (Steve Hill ed., PennWell Corp. 2006). For a discussion on hydropower specifically, *see id.* 37–39.

69. UNIDO & ICSHP, *supra* note 1, at 65, 75.

70. *Id.* at 75.

71. *See generally id.*; REEGLE, *supra* note 49.

72. REEGLE, *supra* note 49, at Energy Efficiency. "The vast majority (over 95%) of the population continue to use traditional biomass fuels for domestic energy needs." *Id.*

73. *Id.*

74. *See generally* UNIDO & ICSHP, *supra* note 1; REEGLE, *supra* note 49.

75. REEGLE, *supra* note 49, at Renewable energy ("DRC has large hydroelectric resources, estimated at 774 GWh, i.e. 66% of central Africa's potential, 35% of the continent's potential and 8% of world annual potential. This corresponds to a minimum exploitable power capacity of 88,400 MW. A truly vast potential exists for development of further hydroelectric resources, and estimates put potential hydropower export capacity at 51.9 TWh/year, which would create revenues for the country of over 6% of current GDP.").

has a current installed capacity of 25.6 MW, but a potential to generate 100 MW from 350 sites identified through a previous study.[76] A lack of a formal licensing scheme, as well as instabilities within the country's democratization process, however, has led to a lack of funding and structure for small hydropower development.[77]

In comparison, Argentina has an electrification rate of 97.2%.[78] Despite this high rate, 2 million Argentinians still live without electricity.[79] Most of Argentina's population lives connected to one grid, but many of the people without electricity live in small villages that are isolated from the main grid.[80] Argentina receives 30% of its energy from hydropower,[81] but most of it is large conventional hydropower. All too often, rural communities do not receive the energy from large hydropower even though they bear much of the burden of its development. Argentina has a small hydropower installed capacity of 66 MW but has the potential to generate 430 MW.[82] Unfortunately, a lack of a stable energy policy and licensing scheme makes investment in Argentina risky.[83]

Similar to Argentina, China has a very high electrification rate of over 99%.[84] Its remaining less than one percent, however, affects more than 8 million people who live in remote locations.[85] China has increased its electrification over the last several years by developing many different forms of energy generation, including

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76. UNIDO & ICSHP, *supra* note 1, at 76.

77. *Id.*

78. *Id.* at 178.

79. *Id.* at 180.

80. *Id.*

81. *Id.*

82. UNIDO & ICSHP, *supra* note 1, at 181.

83. *Id.* at 182.

84. *Id.* at 230.

85. *Id.*

hydropower.[86] By some estimates, China has the highest capacity for hydropower in the world (the 2030 projection is 400 GW).[87] Over the last decade, it has installed several damaging large conventional dams with the goal of rural electrification.[88] However, it has also utilized small hydropower (installed capacity of 65,680 MW) to reach people who are isolated from the grid.[89] China is such a vast country with a variety of terrain that transmission of energy to remote regions is not feasible.[90] Small hydropower was originally state funded, but more recently foreign and private investors are taking advantage of tax breaks and a profitable market.[91] Small hydropower potential in China is 128,000 MW.[92] This potential offers low-risk investment of far less capital than other projects, as well as steady, reliable profits.[93] Still, one significant barrier to small hydropower development in China is its reliance on macro-policy decisions, which is not conducive to the smaller, more localized hydropower projects.[94]

The Republic of Congo, Argentina, and China are all good candidates for rural electrification through the use of small hydropower. Unfortunately, they all suffer from a lack of an established and reliable licensing and regulatory scheme. As will be discussed, this is a disincentive to investment where stakeholders are risk adverse.

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86. *Id.* at 232.

87. *Id.*

88. UNIDO & ICSHP, *supra* note 1, at 233.

89. *Id.* at 232–33.

90. *Id.* at 232.

91. *Id.* at 232–33.

92. *Id.* at 233.

93. Zhao Jianda & Zhu Xiaozhang, *Private Participation in Small Hydropower Development in China–Comparison with International Communities*, UNITED NATATIONS 2 (2004), http://www.un.org/esa/sustdev/sdissues/energy/op/hydro_zhao_english.pdf.

94. UNIDO & ICSHP, *supra* note 1, at 234.

B. Climate Incentives

With energy demand rising alongside climate concerns, small hydropower may provide opportunity to provide reliable, clean energy where none previously existed, or to replace existing damaging fuel sources.[95] For emerging nations, governments may be incentivized to use clean energy to meet their growing needs because it is their climate that is most affected by carbon emissions.[96] For industrialized countries, governments are incentivized to minimize fossil fuel use to meet internal and external standards for decreasing carbon emissions.[97]

Scotland, for example, has a goal of generating 50% of its electricity from renewable energy by 2020.[98] While most of Scotland's output from hydropower derives from large-scale facilities, the government has acknowledged that small run-of-river hydropower,[99] will also play a role "in Scotland's renewable energy mix and help tackle climate change and contribute to economic growth."[100] Similarly, in the United States, many of the states have renewable energy standards that look to increase renewables within a set period

95. UNDESA, *supra* note 57, at 1 ("To address the skyrocketing growth in demand and, in particular, to fill the electrification gap that is especially large in rural areas, which are often most distant from national electricity grids, a global transformation is needed in the way energy sources are produced and consumed in order to truly achieve sustainable energy for all.").

96. *IDA at Work: Climate Change and Development*, INT'L DEV. ASS'N [IDA] 3–4 (July 2009), http://siteresources.worldbank.org/IDA/Resources/IDA-Climate_Change.pdf [hereinafter IDA].

97. *Id.* at 6.

98. THE SCOTTISH GOV'T, 2020 ROUTEMAP FOR RENEWABLE ENERGY IN SCOTLAND 97 (2011), http://www.gov.scot/resource/doc/917/0118802.pdf; NICK FORREST ASSOC. LTD. ET AL., *supra* note 35, at 10.

99. Run-of-river hydropower does not require use of a dam. Instead, it diverts a portion of the river through a penstock, which then turns a turbine, which turns a generator to produce electricity. *Types of Hydropower Plants*, U.S. DEPT. OF ENERGY, http://energy.gov/eere/water/types-hydropower-plants (last visited Sept. 22, 2016).

100. THE SCOTTISH GOV'T, *supra* note 98, at 97.

of time.[101] For example, Connecticut has a 27% requirement by 2020; California has a 50% requirement by 2030; and Hawaii has a 100% requirement by 2045.[102] Many states, though not all, count small hydropower as qualifying renewable energy.[103]

Emerging countries not only need to replace inefficient diesel and wood-burning as energy sources, they need to increase their electricity generation to meet their growing needs.[104] Current projections are that overall energy demand will grow "nearly one-third between 2013 and 2040, with all of the net growth coming from non-OECD countries and OECD demand ending 3% lower."[105] Moreover, demand for electricity specifically, is estimated to increase by more than 70% by 2040.[106]

Furthermore, many of the countries that are most susceptible to changes in climate patterns are those with significant demand,

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101. While this article does not specifically address feed-in tariffs, they are an important part of incentivizing renewable energy development. Feed-in tariffs allow small power producers to interconnect into an existing grid and to be a paid a set price for supplying excess energy. Some have debated whether renewable portfolio standards or feed-in tariffs supply the most benefit for renewable energy development. In a recent article, Professor Lincoln Davies argues that they are not mutually exclusive and utilizing a combined renewable portfolio standard plus feed-in tariff model could be the most optimal method. Lincoln L. Davies, *Reconciling Renewable Portfolio Standards and Feed-in Tariffs*, 32 UTAH ENVTL. L. REV. 311 (2012); *see also* U.S. DEP'T OF ENERGY & DSIRE, RENEWABLE PORTFOLIO STANDARD POLICIES, (2015), http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2014/11/Renewable-Portfolio-Standards.pdf.

102. U.S. DEP'T OF ENERGY & DSIRE, *supra* note 101.

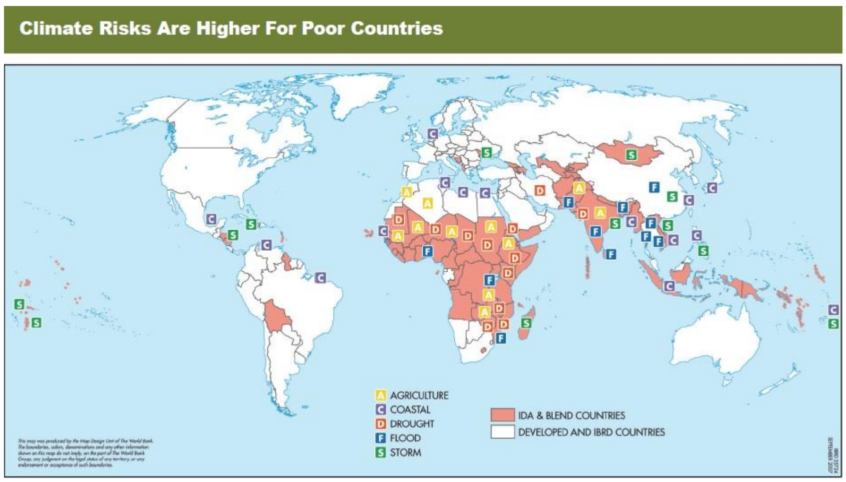
103. *See generally* Database of State Incentives for Renewables & Efficiency, DSIRE, http://www.dsireusa.org/resources/detailed-summary-maps/ (last visited Sept. 21, 2016). Not all U.S. states allow small hydropower to count toward their renewable energy requirements. *Id.*; *see also* Mark James, et al., Comment, *Undamming the Federal Production Tax Credit: Creating Financial Incentives for Dam Removal*, ___ IDAHO L. REV. (forthcoming 2017).

104. IDA, *supra* note 96, at 3.

105. *World Energy Outlook 2015 Factsheet*, IEA, http://www.worldenergyoutlook.org/media/weowebsite/2015/WEO2015_Factsheets.pdf (last visited Sept. 21, 2016).

106. *Id.* As noted in a United Nations report, most modern utility-scale energy efficient technologies are too costly for people in emerging countries, which is particularly concerning, "because most of the harmful effects of climate change in large part result from fossil fuel combustion affecting developing countries, where populations largely depend on the planet's natural systems for survival." UNDESA, *supra* note 57, at 3.

but without sufficient electricity generation.[107] As is illustrated in the following map, they are susceptible to hotter temperatures, increased drought, increased flooding, and increased storm activity.[108] As a result, their governments not only have an incentive to



increase electrification rates, but also to do so in a manner that will not increase carbon emissions.[109]

Distributed off-grid or micro-grid renewable energy technologies have increasingly become more accessible to people living in developing countries.[110] These technologies, including small hydropower, provide an opportunity to meet economic growth while still mitigating the impacts of climate change.[111] According to the European Small Hydropower Association, "One GWh of electricity pro-

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107. IDA, *supra* note 96, at 3.

108. *Id.* at 1. These changes in climate can also have a negative impact on the use of large conventional hydropower to generate electricity, which needs a consistent flow of large volumes of water.

109. *Id.*

110. UNDESA, *supra* note 57, at 3.

111. *Id.*

duced by Small Hydropower (SHP) means a reduction of CO_2 emissions by 480 tonnes."[112] Small hydropower does not contribute to emission of greenhouse gasses.[113]

Over three-quarters of the world's population currently relies on biomass (often wood) to properly prepare their food, with that number increasing to 80% in Sub-Saharan Africa.[114] Isolated rural populations rely on diesel generators and kerosene lanterns to cook their food, pump water, and light their homes.[115] These sources are bad for climate change and bad for the environment.[116] Their substitution with local small hydropower can help curb CO_2 emissions while simultaneously meeting growing energy demand.[117]

IV. CONSIDERATIONS FOR RESPONSIBLE SMALL HYDROPOWER DEVELOPMENT

If small hydropower is to become a larger part of our clean energy future, a stable, but flexible, development model is needed.[118] A proper framework would include, at the very least: competent and thorough information gathered about the proposed site, facility, and output; and a simple, yet flexible, governance structure that utilizes the principles of subsidiarity.

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112. ESHA, ENVIRONMENTAL INTEGRATION OF SMALL HYDROPOWER PLANTS 3, http://www.studiofrosio.it/images/pubblicazionieng/%20Brochure%20EN.pdf (last visited Sept. 21, 2016).

113. *See generally* ESHA, *supra* note 14.

114. IEA, *supra* note 54.

115. ESHA, *supra* note 14, at 3, 6.

116. *See generally id.*

117. *Id.* at 3.

118. Rural electrification through integration of small renewable energy sources requires "enabling and supportive legal, administrative, and regulatory frameworks" as well as "a comprehensive strategy that will attract investment and developers, grow markets, raise awareness, as well as encourage public private partnerships to leverage public resources in the private sector." UNDESA, *supra* note 57, at 3.

A. Information

To reliably develop small hydropower, stakeholders will need an accurate and thorough understanding of multiple factors, including the feasibility of the specific site and the technological advancements available to generate a sufficient amount of electricity to offset any potential human or nature impacts of development at the location.

1. Site Feasibility Studies

Through years of mistakes in hydropower development, we now understand that not all sites can or should be developed.[119] Instead, it is important to study potential sites, looking for locations with the highest energy value[120] and the least environmental and human impacts. For example, in 2006 the U.S. Department of Energy conducted a series of feasibility studies for small hydro development within the United States.[121] It determined that 500,000 sites exist that are suitable for small or low-flow hydropower.[122] Of those 500,000 sites, roughly 130,000 sites were determined to be feasible for immediate development.[123] Of those 130,000 sites, how-

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119. *See generally* Gina S. Warren, *Hydropower: It's a Small World After All*, 91 NEB. L. REV. 925, 936 (2013); Robin Craig, *Of Fish, Federal Dams, and State Protections: A State's Options Against the Federal Government for Dam-Related Fish Kills on the Columbia River*, 26 ENVTL. L. 355 (1996) (discussing the devastation of Columbia River dams to fish populations in the U.S. Pacific Northwest).

120. *See* Thomas Mosier, Kendra Sharp, David Hill, *The Hydropower Potential Assessment Tool (HPAT): Evaluation of run-of-river resource potential for any global land area and application to Falls Creek, Oregon, USA*, Renewable Energy 97 (2016) 492-503 (outlining a computer modeling system that can assess small hydropower potential at specific locations).

121. U.S. DEP'T OF ENERGY, FEASIBILITY ASSESSMENT OF THE WATER ENERGY RESOURCES OF THE UNITED STATES FOR NEW LOW POWER AND SMALL HYDRO CLASSES OF HYDROELECTRIC PLANTS (2006), http://www1.eere.energy.gov/water/pdfs/doewater-11263.pdf.

122. *Id.*

123. *Id.*

ever, 5,400 sites were determined to yield the highest potential output, potentially increasing United States' hydropower generation by 50%.[124]

The feasibility study looked at criteria such as land and environmental sensitivities, existing infrastructure, access, transmission proximity, customer base proximity, financial viability, and hydropower potential.[125] The vast majority of the best sites are those that can be located on existing infrastructure, near transmission and a customer base—like the Harlaw project previously discussed.[126]

More recently, in July 2016, the U.S. Department of Energy's (DOE's) Wind and Water Power Technologies Office issued a report of its comprehensive study of the United States' hydropower potential.[127] According to the report, the Department's focus was on "continued technical evolution, increased energy market value, and environmental sustainability."[128] The study concluded that the United States could increase hydropower from 101 GW to 150 GW by 2050.[129] While it is unclear how much of this new hydropower would be "small" hydropower,[130] of the nearly 50% increase, 13 GW

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124. *Id.*

125. *See generally id.*

126. *Id.* For an in-depth discussion of the study see also Warren*, supra* note 5.

127. U.S. DEP'T OF ENERGY, HYDROPOWER VISION: EXECUTIVE SUMMARY (2016), http://energy.gov/sites/prod/files/2016/07/f33/Hydropower-Vision-Executive-Summary.pdf.

128. *Id.* at 1.

129. *Id.*

130. The report does state that facilities less than 500 kilowatts (kW) for non-powered dams, and less than 1 MW for new streams were not included in the calculation, because they are "uneconomical to deploy" in the U.S. under most conditions. It states:

> These project size thresholds effectively remove 0.5 GW of NPD [non-powered dams] and many of the 53,000 existing dams, as well as over 20 GW of NSD [new stream reach development] and approximately 220,000 reaches, from the technical potential estimates to achieve the modeled resource. The final NPD modeled resource contains 5 GW from 671 dams, while the final modeled NSD resource contains 30.7 GW from nearly 8,000 reaches. So while hundreds of thousands of potential projects have been removed, thousands of the most economic projects remain. The intent is not to dismiss the potential from responsible hydropower projects below

could come from upgrading existing facilities, powering unpowered dams and canals, as well as some new in-stream facilities.[131] To reach fruition, the report notes five areas that will require action: technological advancement; enhanced revenue and market structures, optimization of the regulatory process, sustainable development and operation, and enhanced collaboration education and outreach.[132]

For a global look, the United Nations Industrial Development Organization (UNIDO) and the International Center on Small Hydro Power (ICSHP) studied small hydropower potential around the world and published its World Small Hydropower Development Report in 2013.[133] The purpose of the study was to identify global small hydropower capacity and potential, identify barriers to its development, and to make recommendations for future action at a national level.[134] This report is a good start for nations interested in development and could provide investors with incentive to contribute to more specific studies within nations with the greatest hydropower potential, such as those in Asia, Africa, and Europe.[135]

> these size thresholds, but instead to allow the ReEDS model to more easily identify economically competitive hydropower capacity.

U.S. DEP'T OF ENERGY, HYDROPOWER VISION: CHAPTER 3: ASSESSMENT OF NATIONAL HYDROPOWER POTENTIAL 247 (2016), http://energy.gov/sites/prod/files/2016/07/f33/Hydropower%20Vision_Ch-3_07-25-2016.pdf.

131. U.S. DEP'T OF ENERGY, *supra* note 127, at *iii*.

132. U.S. DEP'T OF ENERGY, HYDROPOWER VISION: CHAPTER 4: THE HYDROPOWER VISION: A PATHWAY FORWARD (2016), http://energy.gov/sites/prod/files/2016/07/f33/Hydropower%20Vision_Ch-4_07-25-2016.pdf.

133. UNIDO & ICSHP, *supra* note 1, at 1.

134. *Id.*

135. Researchers at Oregon State University have developed a software modeling program, the "Hydropower Assessment Tool," to identify the most efficient locations for run-of-the-river small hydropower, without the need for extensive data, which is often unavailable in developing countries. David Stauth, *New Technology Could Improve the Use of Small-Scale Hydropower in Developing Nations*, OREGON STATE UNIVERSITY (June 30, 2016), http://oregonstate.edu/ua/ncs/archives/2016/jun/new-technology-could-improve-use-small-scale-hydropower-developing-nations.

2. Technology and Project Design

Smaller hydropower projects can be designed in a way to cater to the specifications of the exact location.[136] Engineers can study the site and determine maximum generation output depending on the design of the turbine and the desired water flow.[137] Because of technological enhancements and the nature of small hydropower, it can be designed so that it does not kill all aquatic creatures.[138] For example, there are a variety of fish bypass systems available for small hydropower as well as turbine alternatives like the Archimedic screw, which does not require a fine trash rack.[139]

Furthermore, small hydropower can be flexibly located on waterways *without* indigenous fish species, thereby significantly reducing environmental harm. For example, the Harlaw reservoir discussed above does not contain any native fish. Instead, it is periodically stocked with fish for sport fishermen. According to the engineers who worked on the project, this stocking results in all of the reservoir's fish being within a certain size-range, allowing the engineers to employ fish wires that prevent the stocked fish from entering the turbine.[140]

B. Governance Structure

In addition to understanding and utilizing site-specific information and technology, regulatory agencies must establish stable licensing schemes that reduce risk and encourage sustainable development.[141] While many nations lack any formal regulatory

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136. *See generally* ESHA, *supra* note 112.

137. *Id.*

138. *Id.* at 14.

139. *Id.*

140. HIGHLAND ECO-DESIGN LTD., HARLAW RESERVOIR MICRO-HYDRO PRELIMINARY DESIGN REPORT 3 (2011), http://www.harlawhydro.org.uk/wp-content/uploads/2013/04/Harlaw-Design-Report.pdf; RD ENERGY SOLUTIONS, DETAILED ENVIRONMENTAL OVERVIEW FOR HARLAW HYDRO-ELECTRIC SCHEME 11, (2010), http://www.harlawhydro.org.uk/wp-content/uploads/2013/04/1154003D1062010_Harlaw_Hydro_Detailed_Environmental_Overview.pdf.

141. The word "sustainable" has been seriously overused lately. When I use the word, I mean sustainable development which "meets the needs of the present without compromising the ability of future generations to meet their own needs." World Comm. on Env't and Dev.,

structure for small hydropower development,[142] others have convoluted schemes that do little to acknowledge differences between small projects and large conventional dams. For example, in addition to the Harlaw case study,[143] the United States, which currently generates between 6–8% of its electricity from hydropower,[144] provides a good example of a licensing structure in need of review. Its current licensing scheme is administered through the federal government and requires, with few exceptions, that small hydropower projects undergo the same permitting and licensing process as large conventional hydropower projects.[145] The process can be cost-prohibitive and lengthy,[146] taking several years to complete.[147] One reason for the length and cost is the complex nature of the licensing, which requires multiple levels of consultation, often with dozens of parties.[148] As a result, small hydropower has been slow to

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Report of the World Commission on Environment and Development: Our Common Future, UN DOCUMENTS ¶ 27 (1987), http://www.un-documents.net/our-common-future.pdf.

142. *See* UNIDO & ICSHP, *supra* note 1, at 76, 180 (discussing Democratic Republic of the Congo and Argentina's lack of formal regulatory structures).

143. *See generally supra* Section II.

144. In 2015, hydropower made up 6% of the total U.S. electricity generation. *Frequently Asked Questions*, EIA (Apr. 1, 2016), https://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3. According to the EIA, conventional hydropower generated a high of 319,355 MW in 2011 to a low of 249,080 MW in 2015. *Electric Power Monthly*, EIA (Aug. 24, 2016), http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_01_a. These numbers do not include small-scale hydropower. *See id.*

145. 18 C.F.R. §§ 4.30(b)(29), 4.101 (2012); *see also* Warren, *supra* note 119 (analyzing the complexities of the current regulatory and licensing scheme for hydropower); Lea Kosnick, *The Potential for Small Scale Hydropower Development in the US*, 38 ENERGY POL'Y 5512, 5518 (2010) (discussing in detail the regulatory restrictions to the current U.S. licensing system).

146. *See generally* U.S. GEN. ACCT. OFF. [GAO], GAO-01-499, REPORT TO CONGRESSIONAL REQUESTERS, LICENSING HYDROPOWER PROJECTS (2001), http://www.gao.gov/assets/240/231349.pdf.

147. Kosnick, *supra* note 145.

148. *See* Federal Power Act, 16 U.S.C. §§ 791a-823 (2012); KELSI BRACMORT ET AL., CONG. RESEARCH SERV., HYDROPOWER: FEDERAL AND NONFEDERAL INVESTMENT 15 (2012), http://www.fas.org/sgp/crs/misc/R42579.pdf.

develop in the United States because it has historically been seen as cost-prohibitive.[149]

The following offers guidance with two specific areas to alleviate some of the barriers and to potentially increase the viability of small hydropower development. First, the lowest form of centralized government should be in charge of licensing. Second, the licensing should be sufficiently flexible to allow developers and regulators to monitor the new facilities and make changes to address unforeseen negative externalities.

1. Local Governance

For effective development, small hydropower needs a flexible, but stable, information-based governance structure. The framework should be simple, expeditious, and economically viable so that the costs and complications do not outweigh the benefits. One way to help ensure this is through subsidiarity—by granting authority for licensing to the least (or lowest) centralized authority capable of undertaking the licensing.[150]

In the United States this means that states and local governments would oversee licensing of more small, qualifying facilities. States could then screen the projects; ensuring the applications are complete by identifying any necessary consultations and studies so as to satisfy all licensing requirements, and finally, issuing the licenses if all requirements have been met. For other nations, their local and regional governing units could do the same. If properly implemented, this bottom-up approach could decrease costs, increase efficiency, and provide incentive for local governmental units to promote small hydropower development while still empowering them to protect their natural resources, fish, wildlife,[151] and

149. *See* Kosnick, *supra* note 145 (discussing in cost and length of licensing process as a barrier to development in the U.S.); *see also* Warren, *supra* 119, at 962–63, 968.

150. Robert K. Vischer, *Subsidiarity as a Principle of Governance: Beyond Devolution*, 35 IND. L. REV. 103, 110 (2001). Although recently adopted as furthering a conservative agenda in reducing the role of government, the principle of subsidiarity has broader origins, and has generally been intended to further individual empowerment within the context of a government that plays "a significant role in fostering the conditions for its implementation." *Id.*

151. Though the human right to control, protect and enjoy a healthy natural environment has been debated through the years, this right seems paramount to global human rights and life itself. *High Level Expert Meeting on the Future of Human Rights and Environment: Moving the Global Agenda Forward*, UNITED NATIONS ENVTL. PROGRAMME [UNEP], http://www.unep.org/environmentalgovernance/Events/HumanRightsandEnvironment (last

recreational opportunities.[152] Immediate stakeholders could look at the specific facility, its local generation potential, and its specific environmental impact potential to the surrounding area when determining whether it is the best use of the waterway.[153]

2. Flexible Licensing and Monitoring

Some countries allow large conventional hydropower facilities to receive licenses to operate for up to fifty years.[154] This long licensing period was intended to allow developers time to recover their extensive costs of construction and operation.[155] Small hydropower could and should be licensed for a shorter period of time for several reasons. One reason is that the facilities are simply not as expensive and it will therefore not take the developers a lengthy amount of time to recover their costs. Another, probably more important, reason is that technology is continuing to evolve and ten years from now the facility could be outfitted with even more efficient or even more environmentally-friendly technology.

As discussed by Professor Kibel in his recent article, all dams should undergo periodic review to ensure they are not causing damage to wild fish (or wildlife and habitats), and if they are, they

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visited Sept. 21, 2016). According to the United Nations, there is an interrelation between human rights and environmental protection. *Id.* Humans cannot enjoy life without a healthy environment, and good environmental decision-making requires access to information and participation. *Id.*

152. Gabriel Eckstein & Amy Hardberger, *State Practice in the Management and Allocation of Transboundary Groundwater Resources in North America*, 18 Y.B. OF INT'L ENVTL. L. 96 (2008).

153. While subsidiarity is a useful tool for developing small, localized projects, it is not necessarily available in all nations. *Supra* Section IV. Such is the case with China's macro-level government discussed above, and it can be limited due to a lack of funding or specialized knowledge at the local or regional jurisdiction. *Supra* Section IV.

154. Federal Power Act § 799.

155. The license can be 30–50 years, and according to FERC, the length of this term "depends on the cost of project development and environmental measures for an original license or of any developmental or environmental modifications for the relicensing of an existing project.", *Hydropower Licensing—Get Involved; A Guide for the Public*, FERC 4, https://www.ferc.gov/resources/guides/hydropower/hydro-guide.pdf (last visited Sept 21, 2016).

should be required to undergo modification.[156] Likewise, all small hydropower projects should include, within their initial licensing, the requirement for frequent facility monitoring. Once a project is licensed, it should undergo frequent inspections and monitoring to ensure it does not cause unforeseen damage. Unlike large hydropower where, once it is put into place, it is extremely difficult to change or remove (even after more information surfaces as to its potential damaging impacts), small hydropower is more flexible because of its smaller physical size and cost. Reasonable monitoring should occur to prevent unintended or unforeseen consequences.

For example, one unintended consequence can come from placing multiple small facilities on one waterway, which can heighten the potential of negative cumulative impacts. Once small hydropower facilities are put into place, any additional facilities on the same waterway will need to be studied to ensure that the cumulative impacts do not outweigh the benefits. It is possible that cumulative impacts of several small projects could be even greater than the impacts of one large facility with the same energy output.[157]

Large conventional hydropower in the U.S., as in many nations around the globe, has resulted in significant environmental and wildlife damage.[158] Certain salmon and trout species have been decimated, and large facilities and reservoirs have destroyed once pristine land.[159] It is important to use studies, technology, and monitoring to prevent this type of damage from happening again. While it is outside the scope of this article to discuss ways we can "fix" existing hydropower, new small hydropower facilities could be a good "trade" for large conventional hydropower,[160] and one that would easily accommodate any need for modifications over time.

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156. *See* Paul Stanton Kibel, *Passage and Flow Considered Anew: Wild Salmon Restoration Via Hydro Relicensing*, 37 PUB. LAND & RESOURCES L. REV. 65, 68–70 (2016).

157. IEA, supra note 3, at 31.

158. David Owen & Colin Apse, *Trading Dams*, 48 U.C. DAVIS L. REV. 1043, 1057–61 (2015).

159. *Id.* at 1074–76.

160. *See generally id.* Professors Owen and Apse recently published an article entitled "Trading Dams," in which they looked at the option of removing these damaging dams in a "trade" for development of new fish- and environment-friendly facilities. *Id.* The benefits of trading large hydropower for small hydropower facilities would depend on the specific waterway and whether the negative cumulative effects of several small hydropower facilities would

Investors are incentivized by a regulatory and permitting scheme that is straightforward, easy to navigate, and stable.[161] As discussed, hydropower licensing can be a serious issue. Whether or not a license is granted can be unpredictable, and, depending on regulations, it can take anywhere from a few months to a few decades to get a project approved.[162] In addition, the regulatory and licensing scheme needs to balance environmental restrictions so as not to singlehandedly prevent a small hydropower market on form alone. As with all sources of energy generation, some environmental impacts are likely to occur.[163] These environmental impacts, however, need to be carefully balanced with the ability to generate electricity through climate-friendly means. Because of the environmental devastation of large conventional hydropower, small hydropower has had a difficult time becoming a viable contender for renewable energy generation.[164] Restrictive regulations that do not account for the climate (and proximate environmental) benefits small hydropower offers can raise the cost of small hydropower beyond profitability.[165]

V. CONCLUSION

Small hydropower offers "access to affordable, reliable, sustainable and modern energy"[166] for citizens of industrialized and emerging nations alike. Emerging countries can utilize its low cost and flexibility to electrify rural communities that either have no electricity or that utilize diesel to generate electricity or wood burn-

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outweigh the negative impacts of one large dam. *Id.* Several small facilities would most likely outweigh one large dam if they are strategically placed on man-made waterways instead of within a single natural waterway. *Id.*

161. ESHA, SMALL HYDROPOWER ROADMAP: CONDENSED RESEARCH DATA FOR EU-27 14 (2012), http://www.tew.pl/projekty/shpstreammap/SHPRoadmap_FINAL_Public.pdf.

162. *Id.*

163. ESHA, *supra* note 112.

164. *Id.* at 24.

165. *Id.*; EUROPEAN COMM'N, *Introduction to the New EU Water Framework Directive*, EUROPEAN COMMISSION: ENVIRONMENT, http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm (last visited Sept. 21, 2016).

166. *See* G.A. Res. 70/1, *supra* note 50, at 19.

ing to cook and heat their homes. Industrialized countries can develop small hydropower on existing infrastructure such as conduits, canals, small unpowered dams, and locks to meet their climate goals and to provide clean energy to their citizens. If developed near populated areas, the facilities work as low-cost renewable energy to power local customer needs.

Governments benefit when their citizens have reliable electricity. Electricity can help alleviate poverty and bring jobs that increase a country's gross domestic product. It can also provide jobs by utilizing local labor for construction, installation, repairs, maintenance, and monitoring. Furthermore, it can curb some of the health problems that come along with a lack of electricity or the use of biomass for cooking, heating, and lighting.

If small hydropower is to reach its potential, however, policymakers need to establish a flexible, information-based licensing framework that includes site- and facility-specific information as well as adequate incentives for investment. The licensing agency should be the lowest centralized authority capable of undertaking the licensing. When local governmental units are informed local decision-makers, they are good position to protect, maintain, and ensure a future healthy natural environment. This bottom-up approach also has the ability to decrease costs of development and to provide local job creation. Furthermore, by implementing a flexible monitoring scheme, unintended damage from the project can be immediately identified and facilities be continually upgraded and outfitted with the most current environmentally-friendly technology.