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Hydrokinetic Development within Irrigation District Canals Provide a Unique Opportunity to Lessen the Dependence on Carbon-Based Energy Sources

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HYDROKINETIC DEVELOPMENT WITHIN IRRIGATION DISTRICT CANALS PROVIDE A UNIQUE OPPORTUNITY TO LESSEN THE DEPENDENCE ON CARBON-BASED ENERGY SOURCES

DIXON S. HAMMER

ABSTRACT

Hydrokinetic technological advancements have significantly increased the feasibility of energy extraction within low flow water body applications. These advancements have made applications within irrigation districts' canals more enticing due to the potential energy they contain and the inherent advantages that canals have over their natural counterparts. Additionally, with the loose restrictions on hydrokinetic projects within the FERC licensing and permitting process, there are additional incentives for their development. Therefore, it is up to states to implement similarly relaxed water rights processes to remain consistent with FERC and to not create obstacles within their overlay of federal law. Idaho serves as one example of a state water right process that imbues no disincentivizing overlays that should serve as a model for other states to follow.

TABLE OF CONTENTS

I. INTRODUCTION

The push to decrease carbon-based fuel and energy dependence has led to technological advancements in hydrokinetics, particularly with low flow applications, leading to possible energy extraction from previously overlooked sources. The unlocking of these new sources, particularly in irrigation systems, presents energy production opportunities, but requires thorough analyses of the legal implications stemming from federal licensing procedures and exemptions while also maintaining state water law compliance.

Irrigation districts should consider the implementation of feasibly integratable hydrokinetic technology as an alternative to carbon-based energy production. Part II will discuss the advancements of hydrokinetic technologies enabling it to become a feasible consideration for the extraction of energy from low flow water bodies. This section will not only detail the advancements in the technology, but also note a specific characteristic of irrigation canals that makes irrigation districts especially primed for integration. Next, Part III will expand upon the multitude of benefits and incentives that exist within the FERC licensing process. This will entail detailing of the available exemptions and operation categories along with the unique benefits that they confer. Finally, Part IV will demonstrate the simplified process for water rights that Idaho has adopted and the interplay between state's laws and those of the federal government.

II. THE ADVANCEMENT OF HYDROKINETIC TECHNOLOGIES PRESENT ENERGY EXTRACTION OPPORTUNITIES IN PREVIOUSLY OVERLOOKED APPLICATIONS

When contemplating the development of hydrokinetic projects within areas such as irrigation districts, it is important to consider the advancement of the technology. A lack of understanding of the technology, and its benefits, has led to applications, such as in irrigation districts, to be largely overlooked. Modern hydrokinetic technology as we know it has been studied since 1979.[1] That incredibly simple design eventually evolved into numerous applications of significant increases in efficiency.[2] The vertical axis hydroelectric turbine (VAHT), one of the most efficient iterations of the '79 design, had its first adaptation introduced by way of patent in 1995.[3] The drastic increase in efficiency of the modern hydrokinetic technologies is what has made it a more viable option in irrigation canals than

1. Anurag Kumar & R. P. Saini, DEVELOPMENT OF HYDROKINETIC POWER GENERATION SYS.: A REVIEW, 4 INT'L J. OF ENGINEERING SCI. & ADVANCED TECH. 464 (2014), https://www.researchgate.net/publication/271655650_DEVELOPMENT_OF_HYDROKINETIC_POWER_GENERATION_SYSTEM_A_REVIEW.
2. *See generally id*.
3. U.S. Patent No. 5,451,137 (filed Sept. 19, 1995).

preexisting devices.[4] The earlier technologies could only increase their power output to a certain point before there were diminishing returns.[5] The modern advancements and the corresponding increases in efficiency have allowed devices, such as those incorporating VAHT technology, to reach near maximum extraction without compromise.[6]

A. The Origins of Hydrokinetic Energy Production and the Contrast Between Traditional and Newly Developed Technologies

Hydrokinetic energy can be described as the energy associated with the movement of a body of water.[7] This type of energy can be contrasted with most other forms of hydroelectric energy where hydrokinetic is the energy of free flowing water bodies without the need for damming.[8] Hydrokinetic energy, in-stream, can be derived from a number of different sources, including, "rivers, inland waterways, irrigation canals and other man-made conduits."[9] Of this non-comprehensive list of sources, irrigation canals will be the primary source of discussion. The use of irrigation canals as a hydroelectric source of energy will allow for the dual purposing of these canals and the capture of the free-flowing energy that they contain.

Traditionally, in-stream hydrokinetic devices have largely been in the form of water wheels.[10] A basic water wheel will have its power derived from the following equation[11]:

$$P = 0.5 * (\eta * \rho * A * v^3),$$

Where,

P = Power

η = Efficiency of the Turbine

ρ = Density of the Water

A = Turbine Area

v = River Velocity

The importance of this equation is that it shows the limiting factor for these traditional hydrokinetic devices. Where power generation is concerned, nearly all

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4. Anurag Kumar & R. P. Saini, *supra* note 1.

5. R. Hantoro et al., Innovation in Vertical Axis Hydrokinetic Turbine–Straight Blade Cascaded (VAHT-SBC) Design and Testing for Low Current Speed Power Generation, J. Phys. Conf. Ser. 1022 (2018), https://iopscience.iop.org/article/10.1088/1742-6596/1022/1/012023/pdf.

6. *See generally id.*

7. *Hydrokinetic Energy*, U.S. FISH & WILDLIFE SERV.: ENERGY DEVELOPMENT (May 2, 2018), https://www.fws.gov/ecological-services/energy-development/hydrokinetic.html.

8. Kit Eaton, *Hydroelectric Power Goes Greener, With In-River Turbine*, FAST COMPANY (Dec. 23, 2008), https://www.fastcompany.com/1119288/hydroelectric-power-goes-greener-river-turbine.

9. *Hydrokinetic Energy*, *supra* note 7.

10. *See generally* John Saavedra, *Innovative, New Approach to Low-Head, Low-Flow Water Power*, CLEANTECHNICA (Aug. 30, 2011), https://cleantechnica.com/2011/08/30/innovative-new-approach-to-low-head-low-flow-water-power/.

11. *Flow of River Hydro—Using Only Stream Velocity to Drive a Turbine*, BUILD IT SOLAR, https://www.builditsolar.com/Projects/Hydro/FlowOfRiver/FlowOfRiver.htm (last updated Aug. 25, 2012).

of the factors are either constant or generally constant except for the turbine area (A).[12] This means that the only way to increase power generation is to increase the size of the wheel. However, this increase in power due to size is proportional meaning that doubling the area will yield a doubling of the original power generation. Thus, efforts to increase energy production will quickly lead to diminishing returns as construction costs will outweigh extraction increases, the size is necessarily limited by the canal dimensions, and the obtrusion created will have adverse downstream effects. Advancements in hydrokinetic energy generation units have led to designs, such as blade turbines enclosed in ducting, that can "generate more electricity per unit of rotor area" making these devices a more efficient alternative to traditional means.[13] Since efficiency is an independent variable, equivalent increases in swept area between the two technologies will see a greater return in the newer technology. The equations below will illustrate the point:

Old Technology
$P = 0.5 * (\eta * \rho * A * \boldsymbol{v^3})$,
Where,
$\boldsymbol{v^3}$ is a constant variable equaling 20 units,
ρ is a constant variable equaling 1 unit,
A is a constant variable equaling 10 units,
And,
η is an independent variable equaling 45% efficiency,[14]
$P = 0.5 * (.45 * 1 * 10 * 20) = 45$ units of power

New Technology
$P = 0.5 * (\eta * \rho * A * \boldsymbol{v^3})$,
Where,
All constant variables remain the same,
And,
η is an independent variable equaling 93% efficiency,[15]
$P = 0.5 * (.93 * 1 * 10 * 20) = 93$ units of power

Where a hydrokinetic facility is contemplated at one location, the limiting factors include water density, water velocity, and maximum swept area.[16] Thus,

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12. *See generally Hydroelectric Power*, Electropaedia: Battery and Energy Technologies, https://www.mpoweruk.com/hydro_power.htm.
13. *Hydrokinetic Energy*, *supra* note 7.
14. Dendy Adanta et al., *Effect of Blades Number on Undershot Waterwheel Performance with Variable Inlet Velocity,* (Nov. 2018), https://www.researchgate.net/publication/328979758_Effect_of_Blades_Number_on_Undershot_Waterwheel_Performance_with_Variable_Inlet_Velocity.
15. Innovation in Vertical Axis Hydrokinetic Turbine, *supra* note 5.
16. *See generally* Hantoro et al., *supra* note 5.

implementing a technology with the greatest efficiency is the only way to maximize potential energy output.

B. The Technology Improvements for Low Flow Applications Regarding Their Efficiencies

Hydrokinetic generation devices have seen a dramatic improvement since the water wheels of old. Currently, there are three general types of hydrokinetic turbines.[17] These are vertical-axis hydrokinetic turbines, horizontal-axis hydrokinetic turbines, and oscillating-foil hydrokinetic turbines.[18] The following diagram will illustrate the different vertical-axis hydrokinetic turbine designs:

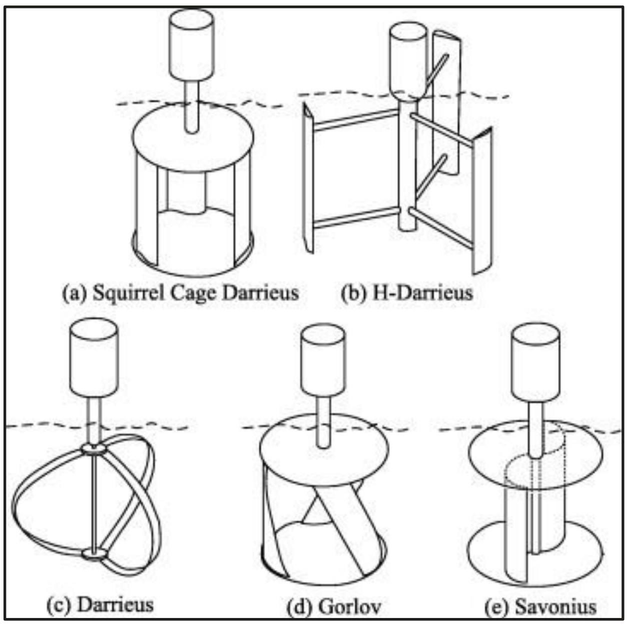

Figure 1: Various Vertical-axis Hydrokinetic Turbine Designs[19]

There are also the differing horizontal-axis hydrokinetic turbine designs:

17. *A RENEWABLE ENERGY OPTION: HYDROKINETIC POWER*, Hydro Quebec 5 (2015), https://www.hydroquebec.com/data/developpement-durable/pdf/file-hydrokinetic.pdf.

18. *Id.*

19. M.J. Khan et al., Hydrokinetic Energy Conversion Systems and Assessment of Horizontal and Vertical Axis Turbines for River and Tidal Applications: A Technology Status Review, 86 APPLIED ENERGY 1823 (2009).

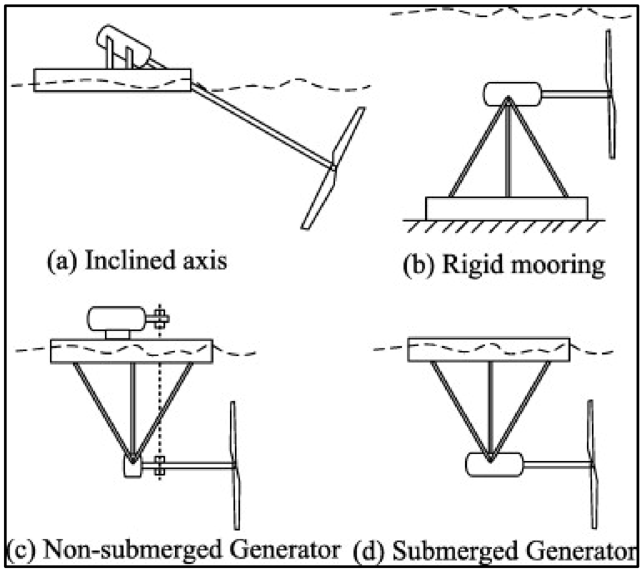

Figure 2: Various Vertical-axis Hydrokinetic Turbine Designs[20]

Finally, there is the more theoretical and less put to use oscillating-foil hydrokinetic turbine design:

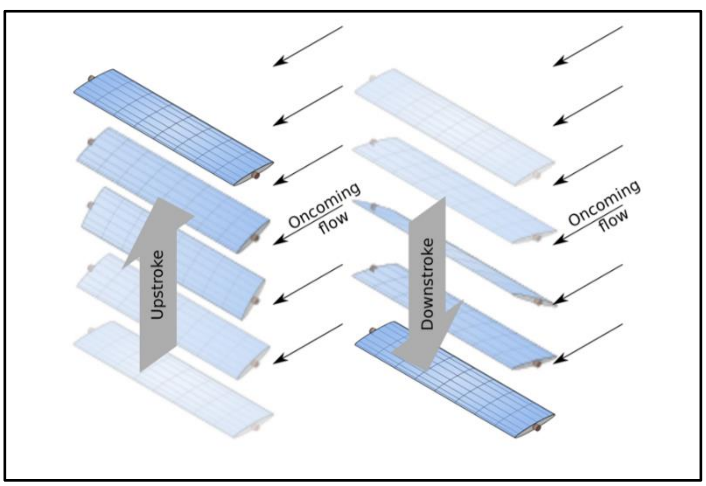

Figure 3: Various Vertical-axis Hydrokinetic Turbine Designs[21]

20. *Id.*

21. Jennifer Franck, *Introduction to Oscillating Foil Technology*, LEADING EDGE MARINE HYDROKINETIC ENERGY, http://leadingedge.engin.brown.edu/wordpress/?page_id=1 (last visited Feb. 12, 2020).

Vertical-axis hydrokinetic turbines, or VAHTs, consist of a vertical axis with a variable number of rotatable blades that extract energy from water passing by the blades perpendicularly.[22] This type of turbine has the benefit of being able to harness energy from flow traveling in any direction unlike traditional methods.[23] This is particularly important in applications that might see variable water flows as a result of seasonal changes. Additionally, this type of turbine has been seen to achieve a C_P, the value of turbine efficiency, of 93% of the theoretical maximum.[24] Therefore, with hydrokinetic technologies approaching 100% theoretical efficiency, the advancements have made these systems an increasingly viable option of energy extraction from low flow waterways.

C. The Effect of River Profiling and the Inherent Advantages of Irrigation Canals for Hydropower

Irrigation districts pose another advantage to rivers and other natural flowing water sources when considering their respective bathymetries. Bathymetry, "the foundation of the science of hydrography[,] . . . measures the physical features of a water body."[25] These features include things such as the cross-sectional area of the canal, the material of canal linings and their corresponding friction gradients, and canal uniformity with its effect on the presence of flow turbulence.[26] What sets irrigation canals apart from natural flowing waterways is that irrigation canals are man-made and are constructed with uniform geometry and a consistent slope.[27] This consistency makes predicting hydroelectric energy output more accurate than natural sources, and this is especially true taking into account the ever changing channel profiling of natural waterways as a result of sediment deposition and erosion.[28] This is not to say that irrigation districts are immune from the principles of sediment deposition or erosion, but that they are less susceptible than their natural counterparts.[29]

The predictability of waterways for energy extraction becomes even more important when surveying locations, and optimizing at the settled location, for the construction and implementation of a generation device. The following diagram can highlight the difference between natural and man-made waterways:

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22. Hantoro et al., *supra* note 5.
23. *Id.*
24. *Id.*
25. NOAA, *What is Bathymetry?*, NAT'L OCEAN SERV. (December 4, 2020), https://oceanservice.noaa.gov/facts/bathymetry.html.
26. *See generally id.*
27. *See generally* Budi Gunawan, Assessing and Testing Hydrokinetic Turbine Performance and Effects on Open Channel Hydrodynamics: An Irrigation Canal Case Study, U.S. Dep't of Energy: Energy Efficiency & Renewable Energy at 4 (2017), https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2017/174925r.pdf.
28. *See generally id.*
29. *See generally id.*

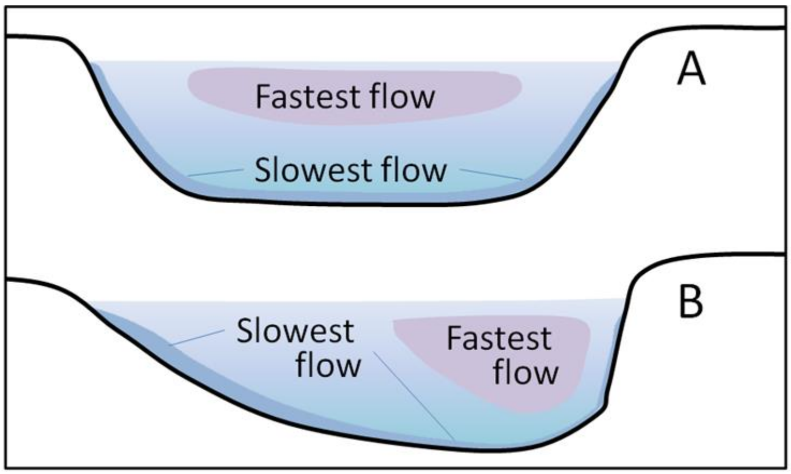

Figure 4: River Cross-Section Demonstrating Variable Flow Velocities[30]

The cross-section in Figure 1 of "A" arguably more closely represents the uniformity of an irrigation canal while "B" likely represents the variance seen in nature. The figure demonstrates the optimal location for a generation device to be implemented where the fastest flow rate is at a location furthest from the bottom and sides where friction creates a slowing effect.[31] The flow velocity is, additionally, fastest just under the surface as the friction present between the water and air, however minimal, exerts a slowing effect.[32] Therefore, the consistent nature of man-made waterways presents an ideal and predictable medium for energy extraction.

With an understanding of the information above, one can more effectively utilize previously untapped resources and navigate the legalities associated. This largely comes from the development of technologies as a result of their physics, the rapidly increasing efficiencies of modern technologies, and the inherent benefits of using structures such as irrigation canals. It is with this fundamental understanding of hydrokinetic technology that there can be effective implementation and more efficient extraction. Knowing the benefits that can be derived allows for the utilization of advantageous resources and informs decisions regarding the implementation or creation of laws to govern. Among the laws already codified to deal with hydrokinetic energy development, the Federal Energy Regulatory Commission regulations should be a first stop to the development of any projects.

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30. STEVEN EARLE, PHYSICAL GEOLOGY, ch. 13.3 (2015), https://courses.lumenlearning.com/physicalgeology/chapter/13-3-stream-erosion-and-deposition/.
31. *Id.*
32. *Id.*

III. THE FERC PROCESS AND THE INCENTIVES IT PROVIDES FOR HYDROPOWER DEVELOPMENT

While understanding of the fundamental physics, technology, and inherent benefits of proposed locations is an important step in the development of hydrokinetic generation, it is equally important to understand the underlying federal regulations and their impact. Federal regulations, developed at a time when low flow applications were an infeasible pursuit, could present significant obstacles for those now enabled to develop small scale energy projects. However, regarding hydroelectric development, FERC has prescribed a set of rules and regulations that seem to indicate encouragement for such development. Through an analysis of the pertinent regulation promulgated by FERC, entities interested in developing facilities to extract energy, such as in irrigation canals, can better navigate the legal process to obtain the most benefit possible.

Knowledge of the incentives provided by the Federal Energy Regulatory Commission will allow entities to optimize their projects for the greatest benefit. Development of this knowledge will require examination of the conduit exemption, 10 MW exemption, qualifying conduit exemption, and pilot program. Through examination of these individual processes, entities will be better suited to determine the subsequent course of action in their pursuit of energy extraction.

A. Conduit Exemptions for Power Generation up to 40 MW

The Federal Energy Regulatory Commission (FERC) first provides an exemption to conduit hydroelectric facilities.[33] This exemption is premised upon generation up to 40 MW, by a small hydroelectric facility, within a man-made conduit that's being primarily operated for non-hydroelectric purposes.[34] Additionally, pursuant to 18 CFR 4.31(b)(2), the applicant needs to have the "real property interests necessary to develop and operate the project or an option to obtain the interests."[35] Since all irrigation districts are developed for the primary purpose of irrigation, they are especially primed for this FERC exception. The conduit exemption, specifying that hydroelectric projects incidental to the primary purpose of the waterway, seems to incentivize the integration of generation devices in order to extract energy from these types of untapped resources. What is more is that applications for these types of conduit generation projects are "categorically exempt from the requirement for an Environmental Assessment (EA) or Environmental Impact Statement (EIS) to be prepared by the Commission."[36]

33. *Small/Low-Impact Hydropower Projects*, FED. ENERGY REG. COMM'N, https://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact.asp; *How to File a Notice of Intent to Construct a Qualifying Conduit Hydropower Facility*, FED. ENERGY REG. COMM'N., https://www.ferc.gov/industries-data/hydropower/overview/industry-activities/how-file-notice-intent-construct-qualifying.

34. *Id.*

35. *Id.*

36. *Id.*

However, the Commission retains the discretion to require an EA or EIS if the project raises a reasonable belief that it is causing adverse environmental effects.[37]

The exemption from EAs and EISs removes a significant barrier to develop hydroelectric generation projects that fall within this exemption category. Environmental assessments can be defined as "identifying, estimating, and evaluating the environmental impacts of existing and proposed projects, by conducting environmental studies, to mitigate the relevant negative effects prior to making decisions and commitments."[38] The preparation of this type of report is a time consuming and costly process. Understanding this helps to draw the inference that FERC has eliminated this step in the pursuit of encouraging energy development. Now, while information on the costs associated with preparing EAs are not readily determinable, the DOE (Department of Energy) has kept track of those pertaining to the preparation of EISs.[39] They note that their median cost of an EIS, prepared between 2003 and 2012, is between $250,000 to $2 million.[40] Additionally, it has been determined that EISs can take anywhere from fifty-one to 6,708 days to prepare.[41] While hard figures associated with the preparation of EAs could not be sourced, this is not the case regarding EISs. The sheer costs and time necessary in compiling an EIS, for a facility capable of generating power at a mere 2% of that of the Hoover Dam, presents a significant obstacle for the development of low-capacity hydrokinetic power generation facilities.[42] Thus, it would seem that these obstacles were outweighed by the limited potential for adverse environmental impacts and desire to develop more hydroelectric extraction projects.

B. Incentives to Hydropower Facilities That Are Not Federally Owned

The Federal Energy Regulatory Commission also provides, and incentivizes, the development of particular hydropower facilities which are located on conduits that are not federally owned.[43] In such instances, the hydropower facility capacities are not to exceed 5MW.[44] Where a proposed facility meets these parameters, FERC has provided that they are both exempted by the Commission and are not required to obtain a license.[45] This is significant since the traditional licensing process entails

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37. *Id.*
38. ŞEBNEM Y. BALAMAN, DECISION-MAKING FOR BIOMASS-BASED PRODUCTION CHAINS (2019), https://www.sciencedirect.com/topics/earth-and-planetary-sciences/environmental-assessment.
39. U.S. Gen. Accountability Office, NEPA: Little Information Exists on NEPA Analyses 12 (2014), https://www.gao.gov/assets/670/662543.pdf.
40. *Id.*
41. Piet deWitt & Carole A. deWitt, *How Long Does It Take to Prepare an Environmental Impact Statement?*, 10 ENV'T PRACTICE 164 (2017), https://www.tandfonline.com/doi/abs/10.1017/S146604660808037X.
42. U.S. Dep't. of the Interior: Bureau of Reclamation, Grand Coulee Dam Statistics and Facts, https://www.usbr.gov/pn/grandcoulee/pubs/factsheet.pdf (last revised Feb. 2019).
43. *Id.*
44. *Id.*
45. *Id.*

three stages.[46] The first stage comprises various notice and resolution requirements to be met pertaining to the public, agencies, and tribes.[47] The second stage requires conducting various environmental and impact studies, disseminating the results to agencies and tribes, and engaging in resolutions upon disagreement.[48] Finally, the third stage entails filing a final application and sends them to the agencies and tribes for approval.[49] Similar to the conduit exemption previously expanded upon, the conduit here must not be used, primarily, for the purpose of power generation.[50] Again, conduits for irrigation will necessarily satisfy the primary purpose requirement. The exemption and elimination from licensing requirements are not the only incentives that FERC provides to encourage hydroelectric development. FERC also categorically exempts the applicant from this type of facility from having to prepare an environmental document pursuant to 18 C.F.R. § 380.4(a)(3).[51]

Expanding upon the exempt environmental documents, 18 C.F.R. § 380.4 specifies that these documents include environmental assessment and environmental impact statements.[52] Again, the elimination of having to prepare and provide environmental documents seems to indicate a clear incentivizing, by FERC, for the development of hydroelectric generation in places such as irrigation canals. This assertion is further supported by the large benefits derived as a result of not requiring these documents. The saving of between $250,000 to $2 million associated with the preparation of an EIS, especially pertaining to a project netting only up to 5 MW, seems to likely indicate significant encouragement.[53] FERC seems to promote the development of hydroelectric generation in places such as irrigation districts, and this contention is further supported where they encourage the development of experimental technologies.

C. Exemptions for Lower Capacity Projects Generating up to 10 MW

Another exemption provided by the Federal Energy Regulatory Commission pertains to hydroelectric projects generating up to 10 MW.[54] Regarding this exemption, the proposed power generation project mentions applicable locations including at an "on-federal, pre-2005 dam, or at a natural water feature."[55] This exemption can be contrasted with the conduit exemption which directly implicates waterways such as those of irrigation districts. However, this particular exemption also includes locations on federal lands, so long as it is not located at a federal dam, or on any non-federal lands provided the applicant has, or has the option to obtain,

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46. *Id.*
47. *Id.*
48. *Integrated, Traditional and Alternative Licensing Processes*, FED. ENERGY REG. COMM'N., https://www.ferc.gov/industries-data/hydropower/licensing/licensing-processes.
49. U.S. DEP'T OF INTERIOR, *supra* note 42.
50. U.S. DEP'T OF INTERIOR, *supra* note 42.
51. Projects or actions categorically excluded, 18 C.F.R. § 380.4 (2014).
52. 18 C.F.R. § 380.4(a) (2014).
53. *See generally* U.S. GEN. ACCOUNTABILITY OFFICE, *supra* note 39.
54. SMALL/LOW-IMPACT HYDROPOWER PROJECTS, *supra* note 33.
55. SMALL/LOW-IMPACT HYDROPOWER PROJECTS, *supra* note 33.

the applicable real property interests.[56] The flexibility of this exemption seems to likely arise from the relatively minimal amount of allowable power generation and the expanse of applicable locations necessarily includes irrigation districts and irrigation canals alike. Thus, FERC seems to continue to incentivize power generation, by providing exemptions, with this particular exemption further expanding the applicable locations.

D. Pilot Program for Projects with the Primary Purpose of Developing and Testing New Hydrokinetic Technologies

Eligible developers interested in a short-term license to test new technologies may use the Hydrokinetic Pilot Project Licensing Process.[57] The goal, as stated by FERC, is to encourage the development of new hydrokinetic technologies while collecting data pertaining to ideal locations of development, any environmental impacts, and all while maintaining a close relationship with FERC and any applicable agencies.[58] Eligibility for this short-term license requires the ability for the project to be closed and removed with relatively short notice while also avoiding environmentally sensitive locations.[59] Thus, the overarching goal for this particular program is to encourage the development of new hydrokinetic technologies rather than the permanent installation of active facilities. While the previously mentioned exemptions provided incentives such as the elimination of the preparation of environmental documents, this pilot program necessarily includes strict procedures and monitoring of the environment.[60] Rather than viewing this as a de-incentivization, it should be understood that this is a necessary corollary to the allowance of experimental development.

While the parameters of the pilot program specify that the project must be readily removable, this is not an absolute.[61] The program stipulates that projects may be able to be transitioned to a build-out project if such a proposal to do so is adopted by the Commission.[62] This ability to transition presents a significant incentivization to develop hydrokinetic projects within places such as irrigation districts. Irrigation canals are an especially attractive option for this type of pilot program. This is due to the program's intense environmental focus and irrigation canals' relatively low impact as a pre-built structure. Thus, this program likely creates indirect encouragement for the development of new hydrokinetic technology developments within irrigation canals.

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56. SMALL/LOW-IMPACT HYDROPOWER PROJECTS, *supra* note 33.

57. *Hydrokinetic Pilot Project Licensing Process*, FED. ENERGY REG. COMM'N., https://www.ferc.gov/industries-data/hydropower/licensing/hydrokinetic-pilot-project-licensing-process.

58. HYDROKINETIC PILOT PROJECT LICENSING PROCESS, *supra* note 57.

59. HYDROKINETIC PILOT PROJECT LICENSING PROCESS, *supra* note 57.

60. HYDROKINETIC PILOT PROJECT LICENSING PROCESS, *supra* note 57.

61. Federal Energy Regulatory Commission Licensing Hydrokinetic Pilot Projects, FED. ENERGY REG. COMM'N 12 (Apr. 14, 2008), https://www.ferc.gov/sites/default/files/2020-04/white_paper.pdf.

62. *Id.*

This concludes the discussion of the various processes offered by the Federal Energy Regulatory Commission for the development of hydroelectric energy producing developments. Each of the three exemptions likely indicate a desire to encourage development of such facilities by FERC's removal of potentially significant barriers such as those associated with the preparation environmental documents and the financial burdens of licensing. Additionally, FERC provides an additional incentive through the pilot program whereby entities are provided with an effective avenue for the testing of new technologies. Through the examination of the FERC process as it pertains to hydropower, entities may better understand the incentives provided and more effectively develop their individual projects. By taking this understanding and pairing it with that of hydrokinetic technology, these entities can better see the advantages of such development within irrigation districts and that these canals can serve a dual purpose. The analysis, however, does not end with federal regulations as such projects will be developed within a state and thus states may have their own set of regulations which may be layered upon that of FERC.

IV. THE STATE WATER RIGHT PROCESS AND ITS POTENTIAL TO CREATE A DETRIMENTAL OVERLAY UPON THE FERC PROCESS

Finally, after understanding the technology of hydrokinetics and the approach taken by the federal government in regulation and incentivization, it is important to focus on state water laws as they often overlay those of the federal government. In light of the likely federal incentivization for the development of hydrokinetic energy development, analysis of the possible state law overlays will demonstrate those most closely aligned with FERC and provide a model for other states to follow. Where states may adopt policies similar to those espoused by FERC, they will incentivize the development of hydroelectric projects within places such as irrigation districts and thus limit the country's overall dependence on fossil, and other non-renewable fuels.

In order for states to develop laws that are consistent with those of FERC, it is helpful to evaluate states whose current laws track similarly, such as those of Idaho. The next thing to consider will be the possible adverse effects of the development of such facilities. In light of these potential negative effects there should also be an evaluation of other states who heavily engage in irrigation and their legal parameters surrounding hydro power generation projects. Finally, evaluation of projects which have seen success are important to be able to more fully make a cost benefit analysis regarding incentivizing laws and policies.

A. Idaho's Water Right Process and How It Presents No Restrictive Overlay

Idaho, rather than promulgating laws that would be layered upon FERC, has removed any barriers that may have been created through a new process in obtaining water rights seemingly to incentivize the development of such projects. This contention is likely supported where the Idaho Code states that anyone "operating a canal or conduit for irrigation . . . shall not be required to obtain an additional water right for the incidental use . . . to generate hydroelectricity in the canal or conduit."[63] Here, Idaho similarly emulates the incidental use exemption employed by FERC. This type of regulation likely encourages the development of hydrokinetic projects that will provide additional benefits from an already existing canal. While this type of codification focuses on the incidentally derived benefits of such canals, it remains the responsibility of the canal owners to work closely with the developers of such projects to account for possible flow disruptions that could impact the primary use and operation of the irrigation canals.

B. The Considerations for the Development of Hydrokinetic Projects as They Pertain to Possible Detrimental Effects

Now, the implementation of hydrokinetic structures within any free-flowing water body necessarily entails impeding its flow in the effort of energy extraction. Hydrokinetic turbines create a wake, which is defined as "a deficit in the mean flow due to the drag produced by the turbine structure and due to energy extraction," among other considerations, including the resulting, downstream turbulence and the interaction of this artificial turbulence with naturally existing turbulences.[64] This phenomenon can be observed in the following diagrams:

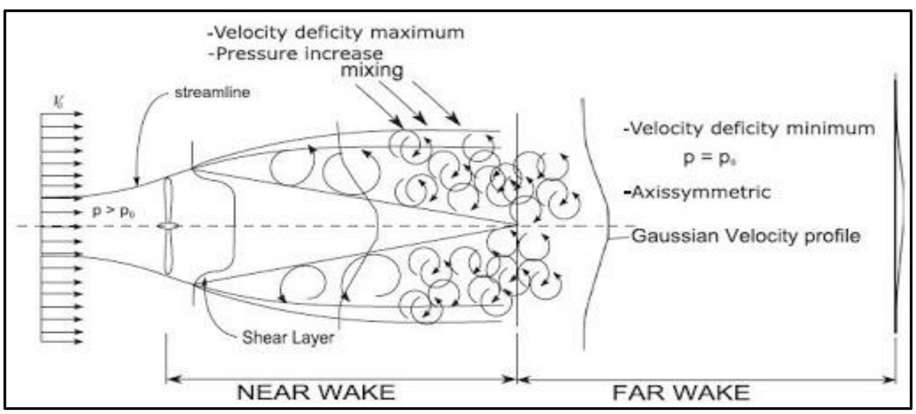

Figure 5: Energy Deficit Process Resulting from Energy Extraction and Turbine Drag.[65]

63. IDAHO CODE § 42-201(9).

64. Maricarmen Guerra & Jim Thomson, *Wake measurements from a hydrokinetic river turbine*, 139 Renewable Energy 483, 483–95 (2019).

65. Paulo A.S.F. Silva et al., *Numerical Study of Wake Characteristics in a Horizontal-Axis Hydrokinetic Turbine*, 88 AN. ACAD. BRAS. CIÊNC 1, 3 (2016), http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0001-37652016000602441.

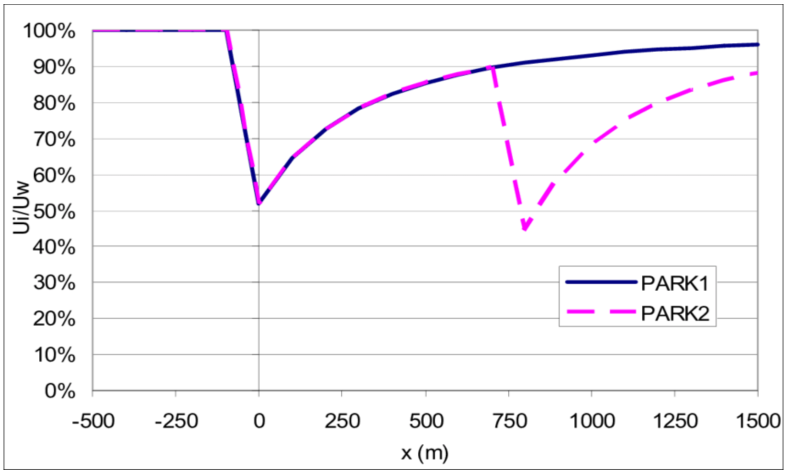

Figure 6: Downstream Recovery Effect with Multiple Turbines.[66]

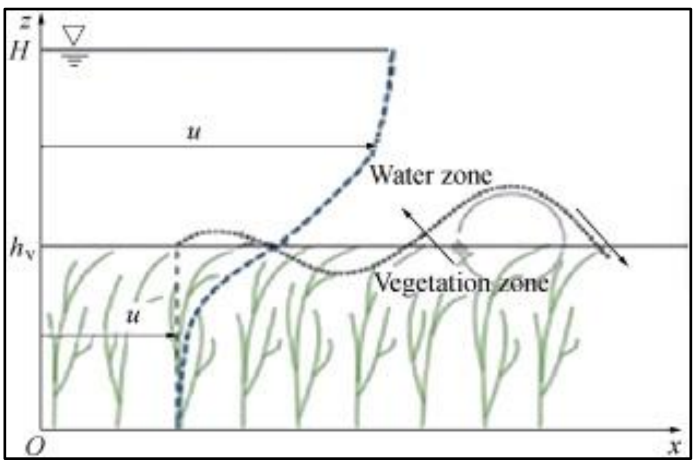

Figure 7: Velocity (u) Profile in Natural Channel.[67]

While higher blockage ratios often yield greater power extraction, they also result in a farther downstream normalization of flow velocity.[68] Where higher

66. Stuart Donovan, Wind Flow Modelling and Wind Farm Layout Optimisation, (Feb. 3, 2016), https://www.researchgate.net/figure/5-PARK-model-of-multi-turbine-wake-deficit_fig2_292881700 (unpublished Master of Engineering thesis, University of Auckland).

67. Jaan H. Pu et al., Submerged Flexible Vegetation Impact on Open Channel Flow Velocity Distribution: An Analytical Modelling Study on Drag and Friction, 12 WATER SCI AND ENG'G 121–28 (2019), https://www.sciencedirect.com/science/article/pii/S1674237019300614#fig1.

68. *See generally* Arshiya H. Chime, Analysis of Hydrokinetic Turbines in Open Channel Flows, 97 (2013), https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/25165/HoseyniChime_washington_0250O_12638.pdf?sequence=1&isAllowed=y (unpublished dissertation, Washington University).

blockage ratios equate to both higher energy production and significant downstream wakes, there is a necessary balancing.[69] While higher energy yields are desirable, disruption of the downstream users' ability to properly use their water rights is an issue and possibly renders the energy production to not merely be incidental to the irrigation operation.

C. The Contrast of Idaho's Process with the Processes of California and Washington State

Despite the potential disruption of downstream flow following hydrokinetic power generation projects, Idaho's hands-off policy pertaining to such incidental use to irrigation canals should be followed by other states. In California, their code specifies that any water used for hydroelectric power generation in irrigation canals, in excess of the appropriated water for irrigation purposes, is subject to any appropriations of prior existence.[70] This language seems to track the incidental use language incorporated by Idaho. The California state water laws also expressly state, which is implied in Idaho law, that a new water right is required where the irrigation district uses water in a way, amount, or at a time not contemplated by the original right.[71]

Washington state is another state that has imposed greater limitations upon irrigation canal hydroelectric development than Idaho. Washington's Revised Code (RCW) initially states that every entity developing hydro power shall pay an annual license fee at a predetermined rate proportional to the amount of theoretical power claimed.[72] The RCW does make an exception for irrigation districts, however, under two conditions.[73] First, projects developed by irrigation districts incidental to their irrigation operations have the annual license fee reduced to half.[74] While this reduction appears to indicate a desire to incentivize canal development, the reduction is merely to reflect the part of the year that the canal is not in operation.[75] The second condition stipulates that an irrigation district is exempt from the fees, but only provided that the produced energy be used for irrigation pumping.[76] Thus, the development of hydropower, for commercial production, seemed not to be incentivized to the same extent as development for irrigation operations.

D. Existing and Successful Irrigation Canal Applications

While the use of electric generation facilities in irrigation districts can have adverse downstream effects, there have been several applications that have yielded great successes. The first of these successes can be seen with the 27 million

69. *Id.*
70. CAL. WATER CODE § 22122 (2019).
71. CAL. WATER CODE § 1675 (2019).
72. WASH. REV. CODE § 90.16.050(1)(a-b) (2019).
73. *Id.*
74. WASH. REV. CODE § 90.16.050(1)(c)(ii)(d) (2019).
75. *Id.*
76. WASH. REV. CODE § 90.16.050(1)(c)(ii)(e) (2019).

kWh annually producing South Canal project in Colorado.[77] This project comprises two power generation sites within the Uncompahgre Irrigation Project both producing 4 MW and 3.5 MW, respectively.[78] The advantage of these capacities is that they qualify under FERC's most beneficial exemption, of facilities producing no more than 5 MW, which grants both an exemption and removal of any licensing requirements.[79] While these capacities benefit from the loose FERC regulations, they would suffer under the rule promulgated by states like Washington and their requirement for licensing fees and fees proportional to the amount of power produced up to prescribed thresholds.[80] These power generation facilities are small, powering approximately 3,000 average homes.[81] It is the desire to develop new energy production sites, in light of expensive construction costs, that FERC likely contemplated when removing costly procedures and licenses. States should mirror the un-restrictive approach taken by Idaho, which is consistent with the Federal Energy Regulatory Commission.

Another irrigation canal hydropower example can be found in California's Imperial Irrigation District. The hydro generation facilities located within this canal, however, operate more akin to traditional dams.[82] This is due to the facilities' implementation along the drops of the canal system.[83] The drops effectively provide the potential power with what is called head which alters the equation from that used for hydrokinetic generation.[84] The differences can be examined below:

Hydrokinetic Equation

$$P = 0.5 * (\eta * \rho * A * v^3)$$

Where,

P = Power

η = Efficiency of the Turbine

ρ = Density of the Water

A = Turbine Area

v = River Velocity

Hydropower Equation (Head Inclusive)

$$P = \rho * q * g * h$$

Where,

ρ = Density of the Water

77. Michael J. Sale et al., Opportunities for Energy Development in Water Conduits - Prepared in Response to Section 7 of the Hydropower Regulatory Efficiency Act of 2013, U.S. Dep't of Energy 45 (2014), https://info.ornl.gov/sites/publications/files/Pub50715.pdf.

78. *Id.*

79. *Id.*

80. WASH. REV. CODE § 90.16.050 (2019).

81. *Id.*

82. *See generally* Sale et al., *supra* note 77, at 45–46.

83. *All-American Canal*, IMPERIAL IRRIGATION DIST. (2020), https://www.iid.com/water/water-transportation-system/colorado-river-facilities/all-american-canal.

84. *Head and Flow Detailed Review*, RENEWABLES FIRST (2015), https://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/head-and-flow-detailed-review/.

q = Volumetric Water Flow,
g = Gravitational Force
h = Falling Height (head)

Thus, things such as canal dimensions are of a different impact on the overall generation of power. That being said, the canal is massive with widths ranging between 150-200 feet and depths from seven to twenty feet.[85] These dimensions culminate in an overall volumetric water flow ranging from 1,050X-4,000X m/s^3.[86] This level of volumetric flow coupled with a drop of 175 feet[87] culminates in a theoretical combined 58 MW of production over the five drops. This canal enjoys the unique characteristic of having head drops, thus enabling them to derive increased waterpower in a manner similar to that of a dam, but without the development and resulting increased federal and state scrutiny often attributable to dams.

Finally, there is the Roza Power Plant contained within the Roza Irrigation District.[88] This power plant operates similarly to California's Imperial Irrigation District facilities in that it too incorporates falling energy or head.[89] This particular project also has the capacity to produce 12.9 MW of power.[90] This project again highlights the success that has been enjoyed through the implementation of hydropower facilities within irrigation districts and their canals. The Roza Canal and Imperial Irrigation Canals are both examples of large capacity water bodies. This is highlighted where the Roza Canal has widths as much as 101 feet.[91] However, large applications within irrigation districts should not be the only consideration. Significant advancement has been made in the technologies capable of deriving beneficial energy returns from low flow applications.[92] Coupling these advancements with the incentives that FERC provides small production projects, these smaller canals will similarly enjoy the same success by receiving additional benefits, and have a culminating effect resulting in much greater project than the projects alone.

The development of state law pertaining to hydrokinetic energy development requires a holistic understanding of several factors. The state of Idaho presents a

85. *Id.*

86. These are my own calculations: 1,050X = 150ft width * 7ft depth; 4,000X = 200ft width * 20ft depth

87. *Id.*

88. HDR Engineering, Inc., Yakima River Basin Study - Roza and Chandler Power Plants Subordination and Power Usage Evaluation Technical Memorandum, Bureau of Reclamation 4 (2011), https://www.usbr.gov/pn/programs/yrbwep/reports/tm/4-3powsub.pdf.

89. *See Roza Diversion Dam*, BUREAU OF RECLAMATION, https://www.usbr.gov/projects/index.php?id=323. (Understanding of hydro-electric generational principles allows for extrapolation of the information on this page regarding dimensional heights to make the assertion of it being a head designed plant).

90. *Id.*

91. *System Information*, ROZA IRRIGATION DIST., http://www.roza.org/about-us/geographical-information/.

92. *See generally Low Pressure Micro Hydro*, ALTERNATIVE ENERGY TUTORIALS (2021), https://www.alternative-energy-tutorials.com/energy-articles/micro-hydro-power.html.

set of laws that incentivize, similarly to FERC, the development of hydrokinetic projects. Despite possible drawbacks from completely unregulated development, states such as California and Washington have laws that create a reduction in the overall return on investment, albeit minimally, of such projects thereby placing more obstacles before the goal of lessening nonrenewable energy consumption. This detriment is especially apparent in light of successful projects while using the South Canal project in Colorado as the general example. The foregoing presents the information necessary to craft effective law and policy that can align with FERC and establish a model for other states to follow. State laws are a further overlay upon federal regulations and laws and understanding this interconnectivity, as well as the technology as a whole, can provide the necessary knowledge to not only incentivize, but optimize their development. This holistic approach will ultimately become the necessary tools by which our carbon-based energy dependence can be loosened.

V. CONCLUSION

With the increasing interest in finding carbon-based fuel and energy alternatives, hydrokinetic applications present a unique opportunity in what have been overlooked sources of potential energy. More specifically, hydrokinetic implementation is especially poised for development within the canals of irrigation districts. This has been made the case due to recent developments in the technology that have created increasingly efficient devices. In addition to more efficient technological advancements are the encouraging federal rules and regulations that provide various exemptions and non-licensing requirements for such canals and other generation projects. Where the federal government has incentivized such development, it is important that states further incentivize hydrokinetic projects within canals through non-limiting overlays, as has been done in the state of Idaho.

Hydrokinetic technologies provide a feasible means to continue the lessening of dependence upon carbon-based energy production. The advancements in the technology provide irrigation districts with the unique ability to dually benefit from the irrigation canals that they control. In addition to the increasing efficiency of the technology, the FERC process is seemingly designed with the goal of providing incentives to such projects especially with regards to irrigation canals. States should recognize the approach taken by FERC and further implement non-limiting laws. The development and implementation of new hydrokinetic energy projects will surely assist us in lessening our carbon-based fuel dependence. However, while this technology has made great strides of advancement, these types of projects possess a number of inherent obstacles. The federal government seems to recognize this which is evident in the many incentives provided within the FERC process.[93] States should recognize the growing efforts to develop alternative energy sources and not develop obstacle inducing laws. Where state laws share the

93. *See generally Hydropowe*r, FED. ENERGY REG. COMM'N (2021), https://www.ferc.gov/industries-data/hydropower.

goal of the federal government, previously untapped and ripe energy sources will be tools that will lessen our dependence on carbon-based energy sources.