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Midstream In-Conduit Hydropower for Municipal Drinking Water Pipes

Additional submitted attachment is included below.

CALIFORNIA ENERGY COMMISSION
1516 NINTH STREET
SACRAMENTO, CA 95814-5512
www.energy.ca.gov

The Energy Commission is currently soliciting ideas and stakeholder input for the 2018 – 2020 EPIC Triennial Investment Plan. For those that would like to submit an idea for consideration in the 2018-2020 EPIC Triennial Plan, we ask that you complete the form below. Submittals are due by **5:00 p.m. on February 10, 2017.**

Part 1. Initiative Description and Purpose:

1. Please provide a brief description of the proposed initiative:

Small in-conduit hydropower has the potential to convert excess energy into electricity in California municipal water pipes far beyond what can be met with conventional hyrdoturbine technologies. Much of the energy in gravity-fed water delivery pipes is unused and released through pressure reducing valves. Conventional hydro turbines extract too much pressure to allow reliable water delivery, or they only function in very limited ranges of water velocities and pressures. The proposed initative will design a midstream in-conduit small hydro turbine prototype to generate electricity within municipal gravity-fed water pipes under a wide range of flows and pressures in order to maximize the generation of unused embedded energy in water delivery pipes and produce predictive, baseload renewable energy. There is a need for mid-stream turbines that extract 10 to 40 psi of pressure from large diameter (20" and above) pipes operating between 10 to 100 CFS that can be installed anywhere midstream in water delivery pipes: next to load centers or in places where distributed energy is needed, or any place

2. What technical and/or market barriers would the proposed initiative help overcome? For scientific analysis and tools, what knowledge gaps would the proposed initiative help fill?

Conventional hyrdoturbine technologies are designed to either extract all of the pressure from a pipe or waterway (e.g. a hydro runner exiting into a river) or they operate in a very narrow range of pressures and flows, making these designs ill-suited for mid-stream water-delivery pipes. We need a midstream hydroturbine that can be tuned to extract 10 to 40 psi of pressure to make electricity over a wide range of water flows (ideally 10 to 100 CFS, depending on pipe diameter). Lucid Energy Inc. has demonstrated the market potential and proof-of-concept, but there is a need to further improve turbine design, support laboratory testing of design concepts, engineer a product to reduce civil engineering installation costs, and pilot test to reduce risk for market acceptance and bring to scale.

Part 2. Benefits and Impacts

3. If this initiative is successful, either fully or partially, what would be the expected impact? Who are the primary users and/or beneficiaries?

The potential scalability and energy production from small inconduit hydropower, if partially successful, will be greatly beneficial to provide renewable, baseload energy at key locations throughout the state, and it will be truly transformative if it is fully successful. A commercialized mid-stream hydroturbine could be installed in more than 100 locations state-wide and thousands nationwide, and generate hundreds of mega-watts of clean, renewable, baseload electricity. This is energy that is otherwise constantly wasted in pressure reduction valves. Additionally, if successfully commercialized, small in-conduit hydropower electricity would be cost competitive with both fossil and other renewable fuels, with the added advantage that the energy could be deployed as a distributed energy source, or to feed micro-grids or other innovative energy schemes.

4. Describe what quantitative or qualitative metrics or indicators would be used to evaluate the impacts of the proposed initiative:

The key metric that would be used to evaluate the impacts of a new in-conduit turbine technology is MWh of electricity generated per year from energy that would otherwise be wasted. Measuring the growth and size of the MWh captured and used would show the impacts of the successful commercialization. Growing this sector of renewable energy depends on acceptance by water agencies. NLine Energy, based in El Dorado Hills near Sacramento CA, has more than six years of experience helping water agencies implement conventional hydroturbines. They have shared the criteria that water agencies vet when evaluating in-conduit hydro. The return on investment, or net positive cash flow to the agency is the sole criteria, assuming technical risk is mitigated. The only way to commercialize hydro turbine systems to tap into this opportunity is to productize and commercialize technologies that can work in this flow and pressure regime, and make them cost effective compared to other renewable energy sources.

5. Please provide a list of peer-reviewed references that support the responses for questions 3 and 4. Proposed initiatives that include peer-reviewed references will be given stronger consideration.

Navigant 2010 Market Study found 700 likely installations
Blue Tech Research Group Market Study, Nov 2015 found 140 likely installations in CA, >700 in U.S. in states with high cost of electricity
Commericial Levelized Cost of Electricity, LCOE, NREL web site
LucidPipe System has run at Portland Water Bureau for 18 months with average of 1000MWh/yr.
Acceptance criteria for in-conduit hydro has been documented by over six years business experience, managing >90% of California in-conduit installations, by NLine Energy, Inc., based near Sacramento, CA.

6. (For technologies only) What competitive advantages does the proposed technology solution have over current benchmark technologies? If the technology is beyond the prototype stage, what strategies do you suggest to bring to scale?

Existing turbine designs, such as Francis, Kaplan, or Pelton type turbines, are restricted to limited flow and pressure applications. Some conventional hydro turbines have been deployed for water delivery midstream in small (12Žand below) pipe diameters, but midstream municipal water delivery pipes demand a turbine that can operate under a wider range of excess pressures of 10 to 40psi and flows between 10 and 100 cfs in 20Ž and bigger water diameter pipes. The key benchmark is the completely new breakthrough to larger pipe diameters with a wider range of untapped excess pressures. Thus, this initiative is truly innovative.

Lucid Energy has been working on midstream in-conduit hydro since 2009. They have two pilot facilities, both which have offered tremendous learning opportunities. But at the pilot stage the system is too expensive to attract broad interest from CA water agencies. The cost needs to be decreased, which means it needs to be developed into a commercial

Part 3. Connection to Energy Commission's EPIC Framework
Energy Commission staff have developed a draft strategic framework to guide the CEC's planning and implementation of EPIC across triennial investment cycles. One of the objectives of the draft strategic framework is to communicate a consistent set of priorities for organizing current and future EPIC investments.

7. Please indicate which of the following strategic framework themes you feel the proposed initiative best fits within:
    - Advance Technology Solutions for Deep Energy Savings in Building and Facilities
    - Accelerate Widespread Customer Adoption of Distributed Energy Resources
    - Increase System Flexibility from Low-Carbon Resources
    - Increase the Cost-Competiveness of Renewable Generation
    - Create a Statewide Ecosystem for Incubating New Energy Innovations
    - Maximize Synergies in the Water-Energy-Food Nexus
    - Develop Tools and Analysis to Inform Energy Policy and Planning Decisions
    - Catalyze Clean Energy Investments in California's Underrepresented and Disadvantaged Communities

If Other, Please Specify

• Increase the Cost-Competiveness of Renewable Generation