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LUCIDPIPE™ POWER SYSTEM

Purdue ECT Team

Construction Engineering & Management, Purdue University, ectinfo@purdue.edu

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LUCIDPIPE™ POWER SYSTEM

THE NEED

In most gravity fed water transmission pipelines, it is desired to reduce excess pressure head to prevent undue strain on a pipeline and lower the incidence of leaks. Normally this is done with pressure reducing valves that essentially burn off this excess pressure as heat. The LucidPipe™ system instead converts it to low cost electricity thereby removing unwanted pressure and generating energy at the same time - energy that can be put used behind the grid or put back on the grid. The LucidPipe™ system extracts a small percentage of pressure head providing nearly invisible operation allowing water operators to fulfill their primary mission of delivering water to consumers.

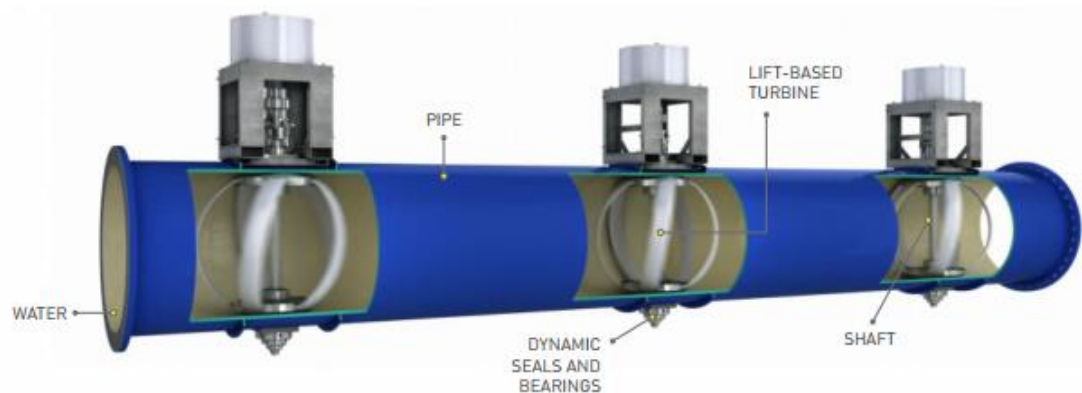


FIGURE 1 LUCIDPIPE™ POWER SYSTEM: HARVESTING RENEWABLE, LOW-COST ELECTRICITY FROM GRAVITY-FED WATER PIPES

THE TECHNOLOGY

LucidPipe™ utilizes a unique, lift-based, vertical axis spherical turbine that fits inside of large diameter (24"-60") water pipes. Water flows through the hydrodynamic turbine, generating power as the turbine spins. The hydrodynamic turbine has been carefully designed and lab-tested to maximize efficiency and power generation without interrupting the flow of water. As velocities increase, power production increases. Due to the lift-based design of LucidPipe™, the system generates power across a very wide range of flow conditions, volumes and velocities. LucidPipe™ extracts very little head pressure per turbine, just 1-6 PSI (1-4 meters). This allows the modular LucidPipe™ system to be placed in series, while allowing for uninterrupted water flow. LucidPipe™





does not need to be placed in a pressure transient zone or where extreme differential pressures are needed. The modular nature of the LucidPipe™ Power System and the operational flexibility it affords make it truly unique. Figure 2 shows a typical 4 turbine system installed inline to a water transmission pipeline. The control system, power electronics and braking systems are all located on or near the pipeline thereby minimizing footprint and installation costs.

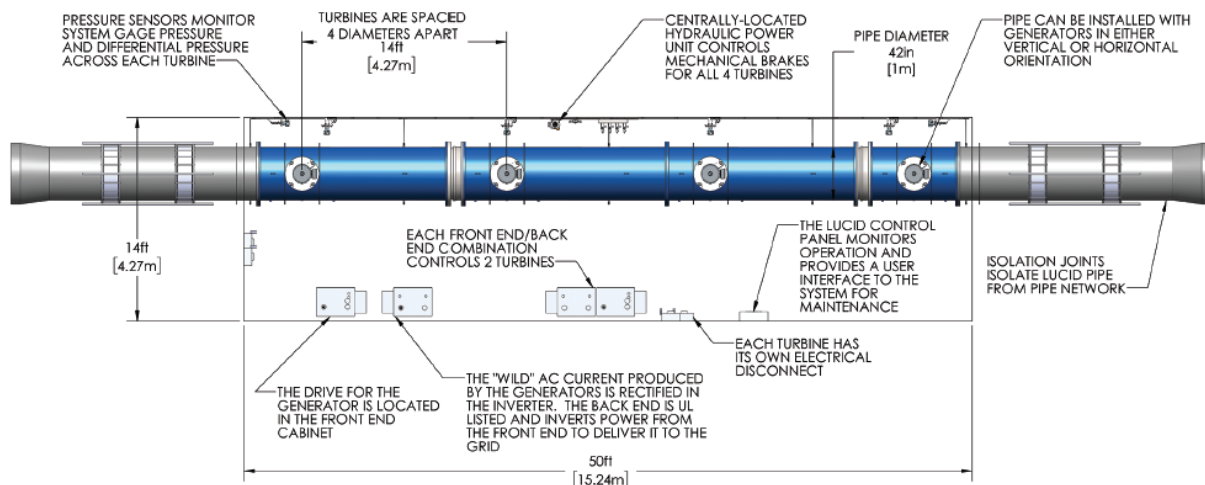


FIGURE 2 TYPICAL LAYOUT FOR A 4-TURBINE, 200kW LUCIDPIPE™ POWER SYSTEM IN A 42IN DIAMETER PIPE

Performance and Technical Specifications

The unique flexibility of the LucidPipe™ Power System design accommodates multiple configurations and flow systems. This enables LucidPipe™ to be used in a broad range of applications for municipal, industrial, irrigation, oil & gas and desalination facilities among others. The capacity factor for water and wastewater applications of LucidPipe™ is 2-3X that of solar and wind power.

- The LucidPipe™ Power System is designed for use in large-diameter (24"-96") water pipes for maximum efficiency and energy output. The renewable energy produced can be used off grid, fed back into the grid or used to directly power devices and equipment such as pumps, meters, controls, smart water devices, mixers, lights at the outfall, hypochlorite machines, etc.
- Water velocity helps determine the optimal size of the LucidPipe™ system that can be operated in a pipeline. Also factored in are the pipeline diameter, head pressure that is available for extraction and the capacity factor (frequency and duration of water flow). Best performance and reliability of the LucidPipe™ turbine is achieved at velocities greater than 4 ft/s.
- Water velocity is the most important indicator for determining the energy generating capacity of a pipeline. The power generated by the LucidPipe™ is proportional to the water velocity. Typical water velocities in pipelines are 4-7 ft/s (1.7-2.1 m/s). In most cases, it is necessary to reduce the



diameter of the pipeline where a LucidPipe™ system is installed. This increases water velocity through the turbine for increased energy output.

- The LucidPipe™ automatic and remote control system can stop or slow down the turbine as needed. LucidPipe™ is designed to be a component of a large water operation. The system allows for monitoring, managing and controlling water velocity to maintain output to the optimal operational efficiency.

TABLE 1 LUCIDPIPE™ POWER DATA OVERVIEW

LucidPipe™ Diameter (in)	Rated Power (kW)	Rated Flow (MGD)	Gauge Pressure Required for Rated output (psi)	Head Extraction at Rated (psi)	Head Extraction at Rated While Stopped (psi)	Operational Head Loss Coefficient (Running /Stopped)
24	14	24	48	5.2	1.2	6.7-8.4/2.0
42	50	64	43	5.9	1.1	7.7-10/2.3
60	100	128	43	5.0	1.2	7.7-10.1/2.3

THE BENEFITS

Because the LucidPipe™ system extracts only a small percentage of pressure head when operating, and about 1 psi of pressure head when stopped, it is virtually invisible in a pipe network and can be placed directly in-line without the need of a bypass for the turbine. Traditional hydropower turbines effectively halt the flow of water when stopped, and can cause dangerous water hammer when grid power is disconnected so they must be placed in a bypass to not interrupt the safe delivery of water. Also, traditional hydropower turbines operate in a narrow band of pressures and flows whereas the LucidPipe™ system has a wide operating range typically found in municipal water transmission system. The LucidPipe™ system adjusts to meet the demands of water delivery rather than a water operator having to adjust the water to meet the demands of the turbine.

STATUS

The first Lucid system was installed in Riverside, California in 2010 and went through several turbine generations. This pilot fed more than 20 megawatt hours of renewable electricity to the grid. As a result of the successful pilot, Riverside Public Utilities decided to install a permanent system. The LucidPipe™ Power System installation at Riverside was awarded a 2011 Outstanding Energy Management Award by the California-Nevada section of the American Water Works Association. In December 2014 a production 4-turbine system went online in Portland Oregon and has been running ever since. The two systems won numerous awards, had well over 600 articles and press releases written about the technology including a segment aired on the NPR News Hour. Requests for information have been coming in from around the



world including a visit in 2015 by Mayor Parks of Johannesburg to visit Lucid Energy. Upon his return to South Africa he proclaimed Joburg would be installing the LucidPipe™ system to help alleviate his towns energy crisis.

BARRIERS

One of the biggest barriers is selling a new technology that generates electricity to a risk adverse water industry whose primary mission is to deliver water, not make energy. The other barrier is it takes a rather large amount of moving water to create enough energy to make an installation economically viable. 14 million gallons per day for the smallest system - a 24" turbine, up to over a hundred million gallons for larger systems. This amount of water is usually only found in large pipe transmission systems feeding large municipalities, not in smaller pipe distribution systems. The problem is there are far fewer large transmission lines with enough flow, and this is especially true in international markets dominated by small pipes.



POINTS OF CONTACT

Ron Peters, Director of Engineering

Tel: (971) 806-8991, Email: info@lucidenergy.com

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REVIEWERS

Peer reviewed as an emerging construction technology

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