



### PROJECT DATA REQUIREMENTS

For any proposed LucidPipe Power System (LPS) to be evaluated, designed, and commissioned, a detailed understanding of the operating conditions of a prospective site is required. The LPS design is based on operational data from the target pipeline. This ensures proper specification of system components, effective operation and maximum energy generation. Site plans and a hydraulic profile are required prior to final specification and design.

Data must be compiled to determine the excess pressure head, volume and velocity available for energy generation:

- Pipeline diameter
- Gauge pressure in pipeline
- Pressure required downstream of turbine(s)
- Average volumetric flow (and capacity factor – frequency of flow)

### PROJECT SPECIFICATION AND DESIGN

After initial design, Lucid Energy works with the customer, the engineering firm, and the ESCO to finalize the specification, design and installation plan based upon site data, project requirements and engineering analysis. Baseline energy usage will be established for calculating and verifying energy savings from the LucidPipe.

A complete LucidPipe Power System includes these major components:

- Pipe Section
- Turbine and Drivetrain
- Generator
- Power Electronics
- Control System

These components are designed by Lucid Energy and specified in collaboration with the water asset owner and engineering team.

### PROCUREMENT

Lucid Energy will supply the LucidPipe Power System to the ESCO on a subcontract vendor basis, in the same way that the ESCO purchases other energy conservation measures (ECM's) for performance contracts such as a wind turbine or solar panels.

### INSTALLATION

Installation of a LucidPipe Power System requires site preparation. If the pipeline is located below ground, a vault will be required to house the new section of LucidPipe. A site plan will be developed in collaboration with the ESCO/AEC firm, the customer and Lucid. In addition, Lucid Energy will provide technical staff to assist in installation, testing and commissioning of the system.

A detailed installation plan will be established prior to procurement activities.

## LUCIDPIPE - OPERATING PARAMETERS

As energy is produced from excess head pressure, there will be a small reduction in the downstream water pressure (not noticeable to the customer). Lucid Energy will provide a site-specific control system program to operate the LucidPipe Power System.

The control system will monitor and log the following data:\*

- Upstream and downstream pressure
- Volumetric flow
- Velocity
- Shaft torque and RPM
- Vibration
- Electrical and mechanical power production

The integrated control system allows for precise operation within pre-established ranges of both the LucidPipe Power System and the pipeline that houses it.

\* useful for pipeline operations & analysis; optimizing energy generation; preventative maintenance & diagnostics

## PROJECT MONITORING & VERIFICATION (M&V)

### Operating Flexibility & Control

Operating parameters will be monitored in real time, allowing for automated response to changes in flow and pressure. The output of the LucidPipe Power System is monitored by the control system. Out-of-range readings may suggest a planned slowing or stopping of the LPS turbine. In addition to automated control, manual controls are available for mechanical or electro-magnetic braking.

### Energy Generation

The LPS electricity (energy) output is measured via an electrical meter at the point of connection to an electrical load. This meter is supplied by the electric utility or to their standard by the owner. Like a solar panel or wind turbine, the electrical output is measured by the utility meter. In addition, both mechanical and electric power is measured. These outputs can be compared to electric utility measurements.

### Energy Verification

The LPS control system monitors and compiles this data and the actual performance can be compared to expected figures. Power output can be correlated to water flow rates. This data allows for the verification of expected power vs. actual power at any given flow rate, as well as expected head loss vs. actual head loss at any given flow rate.

This systematic protocol allows for rigorous characterization and verification of the LucidPipe Power System as deployed within any given pipeline. This is useful for project assessment (pre- and post-installation), engineering analysis & optimization, financial tracking and analysis, and documenting customer energy savings/generation for the purpose of fulfilling energy performance contracts.