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## Gravitational Vortex Variable Flow Energy System (GVvFES)

### Historical and Summary Overview

The basic vortex system was originally developed in Europe and originally purposed to mix air into the water to provide higher levels of oxygen in the water supporting fish and other aquatic live down stream. The vortex system provided a solution to naturally oxygenate the water without requiring an external motor to turn an agitator blade in the basin. Later, the concept of putting a blade system in the vortex to make some electricity while oxygenating the water was pursued. This early vortex design used to generate electricity was not too successful. It was only used in remote and rural areas in small site applications (up to 10 Kw) where electricity was not available or not provided reliably. Some of the issues related to the design were extremely low power output efficiencies, limited to steadier lower flows levels that provided a somewhat more uniform power output, and could not adapt well to the varying water flows and heads throughout the year. Accordingly, the vortex type power system was not commercially developed at the time and is not currently used in North America.

Modern hydroelectric facilities in the US basically use two types of turbines to generate electricity, i.e. impulse and reaction turbines. Both create significant issues for fish passing through these types of systems, i.e. entrainment, severe injury, or mortality. Accordingly, hydro sites must use some type of screening methods to prevent fish from entering diverted water. Fish screening has a large footprint, can be damaged from high water flows and/or debris, and adds considerable costs the overall project.

The GVvFES novel design provides for safe passage for all fish species and most sizes to traverse both upstream and downstream through the fully operating power facility. This is facilitated by the formed high-energy vortex profile that uniquely concentrates the water's kinetic energy into a relatively small area around the vortex. This small portion of the vortex is the contact interface area for the vortex paddle leaving the bulk of the flowing water open for any fish passing through the unit both upstream and downstream while also increasing the natural oxygenation levels of the water.

Using the original vortex power system as a starting point, SGE has taken a proactive approach to redesigning the original vortex power system by extensively modifying it and adding several new novel features. The newly developed GVvFES design has significantly less capital costs on a per KW basis. It also operates at high efficiencies by fully adapting to fluctuating water flow rates and varying head levels throughout the year thereby producing positive cash flow. Siting the GVvFES unit is focused on low head, high flow locations. As such, it is very suitable for all "run-of-the-river" applications and use at existing low to medium head dams in which flow release rates can vary widely through out the year. No new installation of a weir or dam is required.