K. R. Broome and Associates
485 Woodside Road, Apt. 3114
Redwood City, CA 94061
650-575-5469 Tel
broome.assocs@gmail.com

California Energy Commission
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THE BROOME TURBINE, COMMERCIAL SCALE DEMONSTRATION PROJECT OF A NEW VERY LOW-HEAD (5-15FT) HYDROELECTRIC POWER GENERATING SYSTEM

Investment Area:- Technology Demonstration and Deployment

Electricity System Values Chain:- Generation

Issues and Barriers:-

1. **Lack of reliable information on the capital and operating costs and operational efficiency of a full-scale Broome Turbine over a typical annual operating period**
2. **Requirement for Federal Energy Regulatory Commission (FERC) Conduit Exemption from the need for a license on Irrigation Canal Dams, or for units of less than 5MW at Lock/Dams on natural rivers, that is presently a lengthy (6mo} and costly($100k) process.**
3. **Need to demonstrate that installing and operating such equipment will not interfere in any way with the delivery of water to the Irrigation District's customers.**

Initiative Description and Purpose:-

The Broome Turbine Demonstration Project will be a full-width of spillway unit, located at a typical Irrigation Dam in the Central Valley, such as Drop 6 on Turlock Irrigation District's Main Canal; designed in detail by an experienced Hydroelectric Engineering firm such as MWH Inc. in Sacramento; fabricated at a typical steel fabricating plant such as N.J.McCutchen Inc. in Stockton; and installed by a contractor familiar with working conditions at Irrigation Dams, such ass W.M.Lyles in Fresno. Site work will consist of drilling two foundation piles on each bank to support thefully pre-fabricated and pre-assembled turbine/generator unit, the use of a crane to install it, and connection of the electrical system to the adjacent Distribution Line.

A report on the Operation and Maintenance of this unit for a full year will provide the reliable information needed for potential customers to determine the technical and economic feasibility of using the Broome Turbine at other similar locations.

A successful commercial scale demonstration will provide the justification for further simplification of the process for Exemption from the FERC licensing procedures.

Preparation of an Operating and Maintenance Manual based on the experience gained with the Demonstration Project will provide the assurance needed by prospective users that there will be no interference with deliveries of irrigation water to their customers.

Depending on the optimized capacity of the unit, the capital cost is likely to be in the range of $1 to $2 million based on an estimated cost per kW of $2,500.

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Stakeholders:-

Irrigation Districts, particularly those like Turlock that generate and distribute electric power as well as water, and need to satisfy the California Legislature's requirement to generate 20% of their output from renewable sources by 2020.

Electric Power Consumers in the Distribution Area near Broome Turbines, that will still be operating even if the nearby supply Grid is not functional.

Engineers, Steel Fabricators, Installation Contractors and their employees who will design, manufacture, and install the Broome Turbines.

The General Public who will benefit from reduced air pollution.

Background and State-of-the-Art:-

Ever since the beginning of the Industrial Age, very low-head dams have provided sources of mechanical energy by means of Waterwheels that were served by diverting part of the canal or river flow in by-pass channels. However , when electric power became available, and was both more economical and flexible, waterwheels were abandoned.

No other technology has so far been developed that can economically use the considerable amounts of renewable energy that are currently being wasted at the thousands of low-head dams here in California and in other States in the USA, and at Irrigation Canal Drops at hundreds of Navigation Lock-Dam spillways on major rivers in the Mid-West, and could easily be installed on small streams in Developing Countries that have no other source of electricity.

U.S.Patent No. 5,440,175 was issued on Aug.8th 1995 to cover the innovative aspects of Broome Turbine technology.

By installing a Broome Turbine immediate downstream of the full width of the spillway over a dam , accelerating the velocity of discharge by ramping up the approach to the spillway, and containing the discharge from the turbine vanes until it reaches the downstream water level, a sub-scale Model Test Program performed at the Lehigh University's Imbdt Hydraulics Laboratory showed the potential for achieving 80% hydraulic efficiency.

A full-scale Prototype Test at a sloping dam on the Intake Canal of the Semitropic Water Storage District near Lost Hills, that was funded under the California Energy Commission's PIER Program, Contract No. 500-97- 037 showed a maximum hydraulic efficiency of 71%.

Subsequent testing of an alternative concept of an Undershot Impulse-jet Turbine at full-scale under an ESIG contract was unsuccessful due to unexpected turbulence and back-pressure even though a computer analysis funded by Voith Hydro, had shown the potential for achieving 85% hydraulic efficiency.

Other approaches to recovering energy from the overflow at Very Low-Head Dams, such as the Schneider Lift-Translater, now being offered by the Natel Energy Co. and multiple bulb

turbines supplied by manufacturers such as Andritz Hydro Co. are much more expensive and difficult to maintain.

Justification:-

Sector: Renewable Energy Generation, distributed near points of use, with the potential for installation at 382 Irrigation Dams in California that could each generate an average of say 250kW and provide over 1,000,000kWhrs/yr at a plant factor of 50% from energy that would otherwise be wasted.

The number of jobs created in California, by the use of this technology, could be in the hundreds or thousands depending on the rate of application. Skills would range from design engineers to steel fabricators to construction workers and operating and maintenance staff.

No private organization is likely to take the risk of investing in the order of $1,500,000 to build a full -scale application of this new technology without having reliable performance data that can only be obtained from a full-scale commercial demonstration for at least one year, as described in this document. Public Funding is the only source that can make it happen.

Ratepayer Benefits:-

Provision of Greater Reliability of Power Supply to users in the area of a Broome Turbine, that distributes electricity even if the Grid System is not functioning- Distributed Generation.

Cost savings compared to the higher cost of other Sources of Renewable Energy such as Wind and Solar.

Environmental Benefits such as the reduction of Greenhouse Gases that would otherwise have been produced.

Waste Reduction by use of hydraulic energy that would otherwise have been lost.

Economic Development in the areas near the Steel Fabrication Plants and Electric Equipment Manufacture.

Compliance with Public Utilities Code, Sections 740.1 and 8360:-

The Project described in this Response is fully compatible with the Guidelines described in PUC Code Section 740.1, for the evaluation of Research, Development and Demonstration Programs.

The Project described in this Response will enhance the Smart Grid System by providing Distributed Generation close to points of use as required by PUC Code Section 8360.