LOW WIND LLC
LowWind Hi-Tech™ Turbines & Windmills
Rugged, Reliable & Virtually Maintenance-Free

Richard Sutz
Founder & CEO

Introductory Note to the Illinois Institute of Technology (IIT) Concept Paper on the Low Wind Drag-Type Wind Turbine

The following document is an Abstract of the non-confidential Concept Paper prepared for the United States Department of Energy, ARPA-E (Advanced Research Project Agency – Energy) by the IIT Renewable Energy team:

Dr. Hamid Arastoopour is the Linden Professor of Engineering and Director of Wanger Institute for Sustainable Energy Research (WISER).

He has more than 35 years of research experience in multiphase computational Fluid Dynamics (CFD). The mathematical models and numerical simulation tools that were developed by him, and his research team since 1979, are being used by several simulation codes (e.g., Fluent & MFIX) for the design of multiphase flow systems such as the one presented in this proposal.

Dr. Candace Wark is Professor of Mechanical and Aerospace Engineering. She has been performing experiments in turbulence and atmospheric boundary layer studies for over 25 years.

Dr. Bruno Monnier is Professor of Mechanical and Aerospace Engineering. He has been working on experimental work for over 10 years including the investigation of the performance of a vertical axis wind turbine in IIT's atmospheric boundary layer facility.

IIT has a long history in both experimental and computational fluid dynamics with specific experience and interest in wind energy.

Abstract - ARPA-E Concept Paper (February 2015)

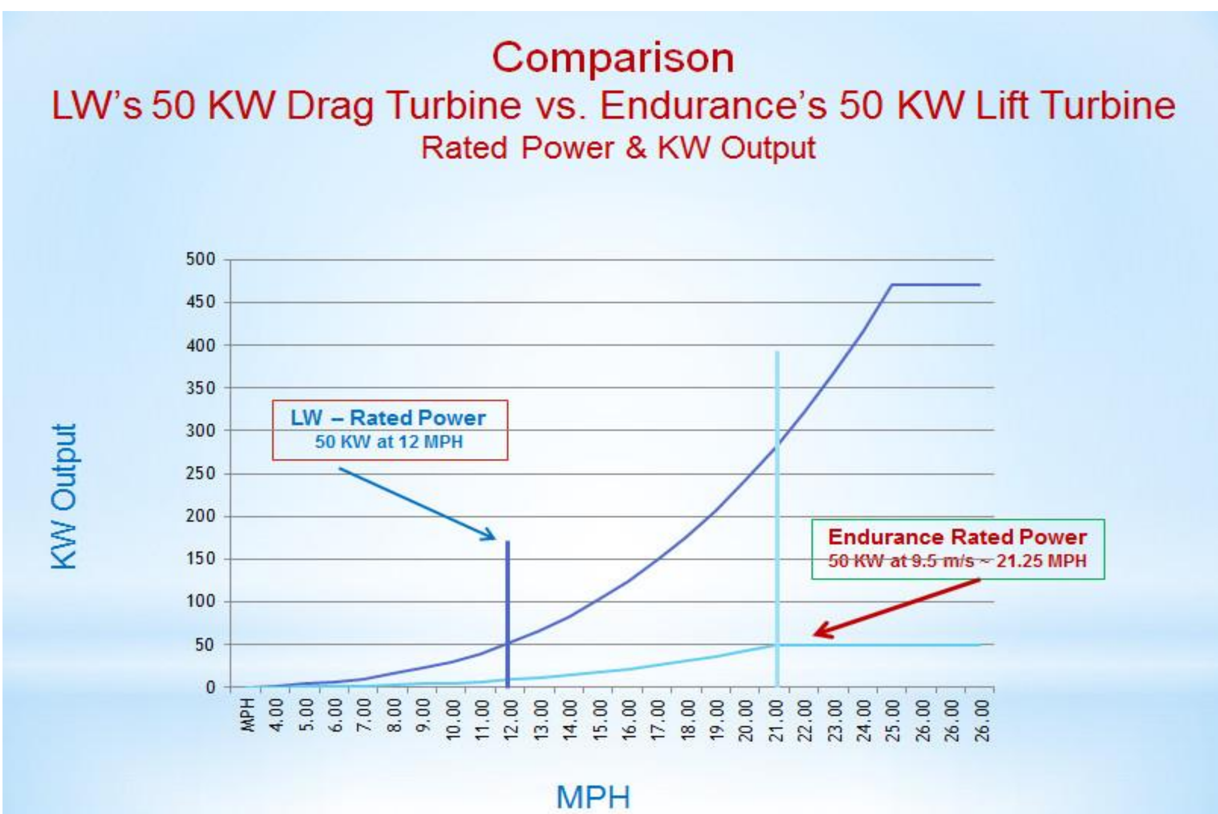
To ensure that the United States maintains a technological lead in developing advanced energy technologies we propose to develop a new class of wind turbine: a drag-type turbine with projected superior low wind operation features. A significant challenge facing wind energy is the performance of lift type turbines in low wind conditions. For example, optimal minimal performance lift turbines require prevailing winds in excess of 12-15mph which only occur over about 10% of the earth's land mass.

To improve performance of lift type turbines at low wind conditions, technology efforts have been focused on the improvement of the aerodynamics of the rotor and the reduction of the drag. Our proposal is a drag-type Low Wind LLC turbine (LW) with multiblade rotors which will be cost effective in low wind conditions, beginning at 5 mph, and which potentially could have a major impact on the cost effectiveness of wind turbines, worldwide, for renewable energy in locations with prevailing wind speeds =< 12 mph (5.4 m/s).

The proposed work represents a disruptive technology in that these turbines would have a significant impact in wind farm applications with prevailing winds less than 12-15mph thereby allowing greatly expanded use.

The LW turbine design is an innovative extrapolation of the rugged, reliable and virtually maintenance free multiblade water pumping wind machines that have been in use worldwide for several decades. The LW turbine does not require new state-of-the-art materials, e.g., like the composite materials for lift turbine blades. 90% of the material in the LW turbines (in the = <100KW range), is low carbon galvanized steel. The remaining 10% require only standard available materials, and for manufacture, only machine-shop level skills and off-the-shelf components customized for this application.

The chart below compares calculated Power Curves for LW's 50kW Drag-Type turbine vs. a published Power Curve for the Endurance 50 kW Lift-Type turbine. The LW Turbine generates 50kW at 12mph. The 50kW lift turbine generates 50kW only when wind speed reaches ≈21mph.



The next step is to perform experimental and computational studies of an LW turbine to validate this analysis of its SolidWorks design. We therefore propose to study a reduced scale model experimentally in an atmospheric boundary layer facility at IIT and to concurrently perform computational fluid dynamics (CFD) studies.

This dual, synergistic approach is best for this problem since the Reynolds number scaling issues cannot be addressed experimentally alone or computationally alone. An alternate approach would be to test larger scale models approaching full scale; however, to be cost effective a reduced scale model should be studied first, both experimentally and computationally, at the conditions proposed to evaluate and test design modifications before running more expensive full-scale tests.

The experimental results will be used to validate and fine tune the computational model after which a simulation at prototype conditions will be run for use in optimizing LW's product line of full scale 5 to 100 kW turbines.

The Low Wind turbines are ideal for distributed energy applications. MW farms would be composed of multiple Low Wind turbines. In MW farms, the projected cost/MW for multiple Low Wind turbines is approximately equal to one lift turbine. For example, the cost for ten 100 KW Low Wind turbines would be approximately equal to the cost of a single one MW Lift turbine.

However, the Low Wind farm would produce more kWh since a lift type turbine, in the same wind environment as a Low Wind turbine, would be operating below its optimal generating capability. The warranties and projected life of similar size lift turbines is a standard 5-year warranty with a projected 20-year life. For the LW turbine, the warrantied life would be 50 years with a projected life of 75 years. The projected LW Turbines O&M costs are also much lower: and will produce power at an unsubsidized cost of ≈$0.01/kwh.

The LW innovative development represents a possible <u>new class of wind machine</u>, and a disruptive technology that could have a significant impact in reducing our nation's dependence on energy from foreign sources, thereby enhancing our economic and energy security.