MASS CUSTOMIZATION OF WARP™ WIND POWER PLANT DESIGN & CONSTRUCTION

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ABSTRACT

Steady development of wind power technology and the accumulation of extensive operating experience with large clusters of electric utility connected turbines have resulted in the emergence of wind power as a viable and attractive source of electricity for utilities, particularly in developing nations. A highly effective modular wind power technology, the Wind Amplified Rotor Platforms (**WARP™**) System, which utilizes many identical vertically integrated Toroidal Accelerator Rotor Platform (TARP™) Windframe™ building block modules with standard micro-turbines, forms the basis for mass customization (capacity and configuration) in power plant design and construction. WARP wind power brings the fundamentals of mass production as well as economies of scale to power plant design and construction. It can blend well with progressive engineering & construction (E&C) firm approaches which are predicated on a family of standardized designs to reduce cost, improve schedule and quality of units deployed. Since electricity has become the new world commodity with an imperative of low-cost, high-quality and environmentally responsible energy, WARP Systems designs have been proposed to meet these objectives through its inherent efficiency, mass customization and mass production features. WARP system's ability to integrally operate with photovoltaics, gas turbines or gas diesels, provides also the opportunity to generate baseload power in an environmentally responsible manner.

INTRODUCTION

The Wind Amplified Rotor Platform (WARP™) system configuration, consisting of stacked modules [Ref. 1-7], differs dramatically from the traditional single, large-diameter horizontal-axis windmill rotor mounted on a tower. Yet this patented "smart tower" wind power design draws heavily on the latest technology developments of today's conventional large diameter, high-efficiency horizontal-axis wind turbines (HAWT) without their inherent risk.

A WARP system is conceptually illustrated in Fig. 1. However, unlike conventional wind turbines, which stress ever larger diameter rotors for increased energy capture, the proposed system, using aerodynamic windframe building-block technology, focuses on wind speed amplification and multi-tasking use of its toroidal structure.

Each windframe provides highly amplified wind flow fields at each rotor level to tailored conventional, low risk, small diameter wind turbines of no more than 6 feet to 10 feet in diameter. Each module also serves as a support for the wind turbines, yaw assembly and protective housing for its core support tower and other internal sub-systems.

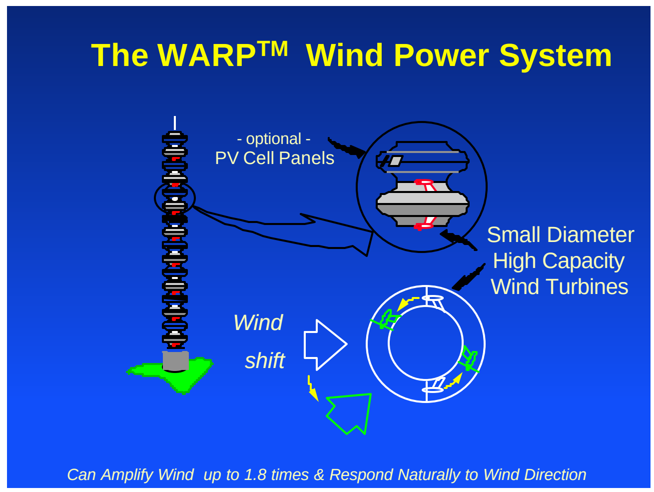

Fig. 1 The WARP Wind Power System

WARP Systems are tall module arrays about a simple core tower. These "smart", yet simple aerodynamically-faired, towers can be flexibly and incrementally deployed into multi-megawatt size wind power plants. While heavily building on proven windmill technology, WARP Systems may be shown to surpass current technology windmills in all aspects of system characteristics. WARPs have improved performance as a result of amplified gearless and shrouded turbine operation. Other benefits include user-friendly operation and maintenance, and high reliability and low risk due to small, simple and robust dynamic components. Environmental benefits include an order of magnitude less land requirement for equal conventional windmill wind farm installation power capacity, absence of bird kill potential, attractive appearance, lower far field noise and EMI/TV interference, and improved rotor safety through containment means (Ref. 7, 9). Operation under extreme icing is also afforded due to both rotor shielding and inherent self-

sustaining tower anti-icing capability. This avoids the destructive rotor imbalance and ice shedding predicaments possible with conventional windmills. System components are suited for low cost mass production, ease of transportation, erection and servicing.
Each WARP building block module windframe provides 150% to 180% disk averaged amplified wind flow fields over free wind velocity to a set of small tailored conventional, low risk, small diameter wind turbines, typically of no more than 6 to 10 feet in diameter (Ref. 7). WARP wind turbines are a commodity on the system rather than the focus of a system as are the giant rotor heads of conventional wind turbines.

Each module also serves as a support for the wind turbines, yaw assembly and protective housing for a core tower and other internal sub-systems. Thereby, these "smart" WARP towers can be flexibly and incrementally deployed into multi-megawatt size wind power plants.

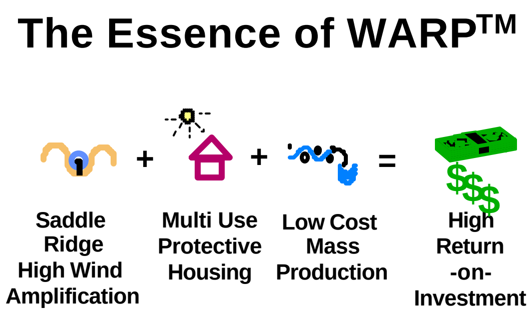

Fig. 2 The Essence of WARP Wind Power

WARP MASS PRODUCTION DESIGN

As is being noted repeatedly today, the increasing power demands of the new global economies in Asia Pacific and eastern Europe, is resulting in electricity becoming the new world commodity, presenting enormous opportunities for many companies.

Consequently, a common business imperative has emerged for the need of environmentally responsible low-cost, high-quality energy that provides operators and developers with the greatest potential for a return on equity.

One solution to this challenge, as pointed out by Bechtel Corporation’s K. C. Choi, (Ref. 8), is predicated chiefly on the design and construction of reliable, low-cost generating plants; in other words, the concept of “mass customization.”

Along this line of reasoning, WARP Wind Power Systems emerge as a uniquely qualified power plant design for mass customization whereby one can achieve the economies of mass production and also provide the flexibility needed by individual plants and owners. As Choi notes, “this process reaps the benefits of standardization and, at the same time, permits a degree of customization so the design will meet the differing needs of independents, utilities and other power producers.”

Capturing the efficiencies of mass customized WARP wind power plant design is an approach developed by ENECO which stems from years and over $1 million of R&D in conjunction with Rensselaer Polytechnic Institute and the New York State Energy Research & Development Authority (NYSERDA). It extends well beyond that of the traditional wind turbine approach as well as the engineer-constructor approach to power plant design and construction which has to date been essentially an individual tailoring of each plant.

Mass production has long been recognized as an effective means of reducing a product’s unit cost. It has enabled manufacturing companies around the world to produce high-quality products that leverage the economies of scale based on division of labor and automated, standardized components and processes. The principle drivers are the learning curve and the bulk purchasing power afforded by large quantity of identical components. Cost and cycle time can be reduced even further by extending the approach to suppliers and also incorporating the buying power of bulk material procurements.

The Ref. 8 article by Bechtel points out further that while theories of mass production have guided the manufacturing industry for decades, engineering and construction (E&C) in the power industry has remained in large measure a custom business. Most E&C firms continue to approach plants as one-of-a-kind efforts, designed by project teams that are assembled and disbanded as jobs open and close.

The modular WARP systems design., to the contrary, is ideally suited to provide not only standardized sub-components and modular repetitive sub-assemblies for mass production and procurement benefits, but also brings a significant measure of value in terms of environmentally clean power to both customer and locale in which it is being operated in..

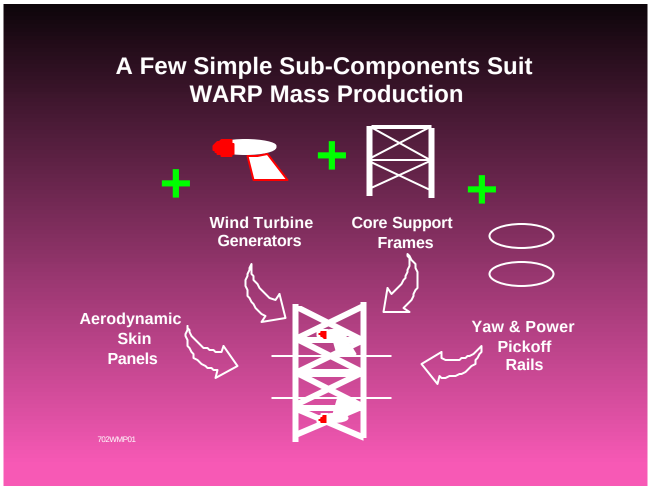

Fig. 3 Mass Producibility of WARP Systems

This system design meets one of the prized key principals of mass customization criteria cited by Bechtel's Choi; namely, modular design. Its mass production will find economies in production of large number of deliverables that are essentially identical - i.e.; the WARP windframe modules.

Production definition can be deconstructed into smaller, standard modules that can be aggregated rapidly to define the overall power plant given the site specific energy needs and wind and solar resource characteristics.

It is worthwhile to invest considerably in configuring the base design to achieve the lowest cost both with respect to life-cycle as well as capital cost. This is achieved by investing in those components that directly contribute to the efficiency or availability of the plant, such as the aerodynamic WARP windframe and the turbines, while minimizing the plants physical size for accommodating all the necessary equipment. For example, one can conceivably have the same WARP power capacity resident in a relatively short, stocky and material intensive tower assembly versus a higher slenderness ratio taller WARP tower which is considerably less material intensive. The favorable trade for the latter comes in large part from the added wind energy resource available at higher elevations.

It is also important to recognize that base designs in themselves are continuously updated as improvements are fed back from lessons learned from operational projects or as unique requirements are imposed as they might for extraordinary environments such as those having arctic , sand storm or high salt air conditions

A WARP wind power system also provides an ability to operate autonomously in conjunction with conventional fossil generators *within its base* for base-load operation with large fuel and operation/maintenance savings along with sizable emission reductions. And from the standpoint of site-specific business characteristics, it lends itself to construction and maintenance by relatively unsophisticated labor. This can therefore benefit the local economy for added community support.

SUMMARY

Based on WARP systems' propensity for mass customization, it provides economic benefits in power plant design and construction not readily found in traditional power plants. WARPs also have the ability to provide an environmentally attractive power plant that manages to resolve the many critical issues facing electric power plants today, including those of large scale conventional windmills. Key features of WARPs, including on a comparison with today's conventional wind turbines, are:

- Mass production/customization for low cost;
- Better performance;
- Reduced risk and liability;
- More user-friendly servicing;
- Greater environmental benefits such as:
  - No pollutants;
  - Greatly reduced land needs;
  - Essential absence of EMI/TV interference;
  - Virtually no bird kill potential;
  - Lower noise;
  - Attractive appearance;
  - Material resource conserving;
  - Improved safety.
  - Ability to integrate PV solar at reduced cost.

The synergistic impact of these WARP system benefits bring attractively low cost of energy and/or savings for excellent return on investment.

ACKNOWLEDGMENTS

The assistance, cooperation and guidance offered by Dr. Robert E. Duffy, former Chairman of Aeronautical Engineering, Rensselaer Polytechnic Institute, Dr. Joseph Callerame, Assistant Director, R&D Div. of the Raytheon Co., and Prof. Dr. Karl Pucher, Technical University Graz, Austria, are gratefully acknowledged in the technical and economic assessment of WARP™ wind power technology.

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Mr. Alfred Weisbrich is the founder and principal of ENECO and the originator of the advanced WARP™ wind power technology with modular TARP™ design and patents. His professional career has included aerospace industry rotary wing R&D for advanced helicopters, prop-fan aircraft propulsion and wind power systems, as well as space propulsion rocket engine development. He has broad based experience in engineering systems, project management and new product/business development along with TQM/QFD expertise. Specific conventional wind power development experience includes the 4 megawatt 250 foot diameter Hamilton Standard wind turbine built for NASA and U.S. Department of the Interior, the Kaman Aerospace 50 kW Vertical Axis Wind Turbine (VAWT) built for Sandia Laboratories and a 150 foot wind turbine blade for the U.S. DOE.

As originator of the WARP™ wind power concept, was also responsible for its R&D including design, analyses and testing with Rensselaer Polytechnic Institute. He initiated the TARP™ Wind-energized Independent Lighting (TWILIGHT) prototype development program with the New York State Energy Research & Development Authority. He supported Raytheon's evaluation and selection of WARP™ for electric utility scale system proposal bid under the U.S. DOE Advanced Wind Turbine Program. WARP™ technology is being made available for licensing in various fields-of-use in the Americas, Europe, Far East, India, Australia & New Zealand.

Mr. Weisbrich has served as a Presidential Intern in Washington D.C. under former Apollo 11 Astronaut Michael Collins; he received his professional engineering (PE) status in Connecticut and has authored and co-authored AIAA, AHS, ASME, IEEE and other forum technical papers on advanced helicopter rotors, turboprops and wind power as well as on engineering and business process TQM/QFD. He is a member or former member of various technical, honorary and industry societies and associations such as Tau Beta Pi, Sigma Gamma Tau, Sigma Xi, the AIAA and the American Wind Energy Association. Mr. Weisbrich earned a Bachelor and a Masters Degrees in Aeronautical Engineering and a Masters Degree in Management from Rensselaer Polytechnic Institute.
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He has served as President and CEO of Alfa Laval AB subsidiary Chemap, Inc., Vice President and General Manager of GNA Industrial Furnaces, Inc. and of Wellman Thermal Systems Corporation, and Manager of Business Planning and Project Engineering Manager, Combustion Engineering, Inc.

He served in the U.S. military as one of the youngest officers and battery commanders of Hawk surface to air missiles.

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