From: Ohio Power Siting Board
To: Puco Docketing
Subject: public comment 16-1871-EL-BGN [ref:_00Dt0GzXt._500t0FNG2j:ref]
Date: Thursday, March 7, 2019 10:04:39 AM

Dear OPSB,

Please approve the agreement between Icebreaker and the other parties to the case and issue a Certificate as soon as possible. Wind energy is a renewable resource, adds jobs to the local economy, is environmentally responsible, fortifies the local tax base, and helps reduce the use of fossil fuels.

This is a pro-business initiative that should easily be supported by everyone.

Sincerely,

Lee Montgomery

Medina, OH 44256

ref:_00Dt0GzXt._500t0FNG2j:ref

From:	Ohio Power Siting Board
To:	Puco Docketing
Subject:	public comment 16-1871 [ref:_00Dt0GzXt._500t0FNFuz:ref]
Date:	Thursday, March 7, 2019 10:16:24 AM
Attachments:	AXIAL-FLOW-ROTOR-AAA (24).docx

--------------- Forwarded Message ---------------
From: Kari Appa [ka@wtswind.com]
Sent: 3/6/2019 5:36 PM
To: contactopsb@puc.state.oh.us
Subject: Re: Offshore Wind Turbine Project

Dear Sir/Madam,
Please include this following article along with my email message sent couple of minutes ago.
Thank you.

Dr. Kari Appa -
103 Turner
Irvine, CA. 92618, USA

949-396-4799

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On Wed, Mar 6, 2019 at 2:29 PM Kari Appa <ka@wtswind.com> wrote:

> The following article describes the design concept for the Icebreaker wind turbine project.
> This project is seen to be energy efficient and cost effective versus the conventional Radial Bladed Rotor concept.
> Please contact us for additional information.
> Thank you. Best regards.
>
> Dr. Kari Appa -
> 103 Turner
> Irvine, CA. 92618, USA
>
> ka@wtswind.com
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> ___
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> Dr. Kari Appa -
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> Irvine, CA. 92618, USA
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> 949-396-4799
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> This email transmission and any documents, files or previous email messages attached to it may contain confidential or legally privileged information and are for the intended recipient

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Axial Flow Helical Bladed Rotor

Appa Technology Initiatives / Wind Turbine Systems

Dr. Kari Appa
103 Turner, Irvine
California, US 92618

Phone: 949-396-4799, email ID: ka@wtswind.com,

Section I: Technical Merit & Lab Alignment:

1. **Company Summary:** ATI is a California based small business entity, primarily engaged in the development of high performance wind turbines. In FY 2001, ATI was funded by the California Energy Commission, to build and demonstrate a Contra Rotor Wind Turbine (CRWT) technology model. The field test study showed that the CRWT concept is able to extract in excess of 30 per cent more energy from the same wind stream.

In this study, the rotors were directly coupled to the two components of the alternator. This concept could not be demonstrated on a utility scale model, due to extreme mass inertia of the alternator.

Today, due to the advent of the Hydraulic Power Transmission (HPT) device, it is possible to integrate the CRWT and HPT to function more economically and yield better energy in the case of offshore environment.

2. Problem Statement:
The geometric size and mass inertia of the conventional radial bladed rotors increase as the cube of the blade length. When the power rating of the rotor exceeds 8 MW, it becomes more expensive to transport, install and maintain in the offshore environment.

The proposed axial flow rotor system is based on our recent **US Patent 9,537,371 B2**:. The basic rotor design as shown in **Fig. 1a**, comprises of an inner rotor **62** and an outer rotor **62**, set to spin in opposite direction to each other.

Each rotor comprise of a number of small and light weighted helically contoured blades **70**. **Fig.1b** shows a typical 3-D view of the helical bladed contra rotors. Since the rotor is axis symmetric, the following design considerations are used to generate uniform torque:

2a. Tilted Aerofoil Sections:

The composite helical blades comprise of using tilted aerofoil sections. The corresponding tilted lift component is in the direction of the blade motion. The lift vector, L (which is parallel to the airfoil section) has a tangential component leading to torque generation (**Fig. 1c**).

2b. Tilted Flow Dividers/Deflectors:

A number of tilted airfoil shaped flow dividers **80 (Fig. 1a)** are used to deflect the flow stream, such that it is parallel to the airfoil section and generates tilted Lift (**C_L Fig. 1c**) on the blade, which in turn leads to torque. Furthermore, the airfoil shaped flow dividers produce starting torque. Once the rotor starts spinning, a helically contoured flow field **V_R** will be developed around the rotor. The primary objective of this construction is to generate uniform torque load by means of the axial flow rotors. **Fig. 1c** outlines the method of generating torque by the axial flow rotor.

2c. Torque Generating Supporting Rings.

The blade supporting rings 30 and 32 are also designed to generate torque. Thus every component of the axial flow rotor are optimized to convert aerodynamic energy into electrical energy.

A typical comparison of wind rotors (conventional versus the new) in terms of geometric size and mass are presented in Table 1 for a 10 MW unit and in Table 2 for a 50 MW unit. The suggested rotor is much lighter, since its lifting surface is located in high velocity flow domain.

3. Suggested Wind Turbine Design Approach:

An economical axial flow rotor design concept is presented in **FIG. 2**. The new contra rotor unit will be coupled to a hydraulic power transmission device to convert the kinetic energy of the rotor(s) into the potential energy stored in a hydraulic accumulator. The hydraulic accumulator together with associated hydraulic motor and the alternator units can be placed on the ground level for easy maintenance. The wind turbine rotors and the digitally controlled hydraulic pump units need be placed on the tower top.

4. Performance Verification Using a CFD simulation Software

Many Government Laboratories and Universities have developed highly reliable CFD simulation tools. This software will be used to model the suggested axial flow rotors (power rated at 10 MW or higher) including the hydraulic power transmission device, as outlined in **Fig 2**. To achieve optimal performance, the blade configuration and deflector sizing can be performed. After successful demonstration of the axial flow rotors, we may plan for a field demonstration model.

5. National Laboratory Alignment:

This suggested new rotor model design and performance can be simulated using a state-of-the-art Computational Fluid Dynamics (CFD) software, which is available with Government and Technical Universities. The study model could represent any 5 MW to 50 MW units, so as to compare the physical dimensions of the components, mass inertia and probable cost comparison versus the conventional radial bladed rotors.

ATI will work with a selected lab to define the model configuration and the flow parameters, so as to achieve power generation and the downwind flow characteristics as the vortex strength.

6. Environmental Energy & Energy Impact: If the new design performs as expected, the benefits are:

a. Cost savings – This is the major advantage – 50 to 60% cost reduction in the rotor assembly, due to light weight of components,
b. Increased Performance: This is another important factor associated with the blade configuration selected to operate,
f. More efficient energy generation,

7. Work Scope: Using ATI generated model configuration, and ATI defined flow configuration, the National Lab will generate the CFD model and perform the flow analysis to predict loads on blades and other components, so as to evaluate the torque loads and other important side loads on the rotor assembly.

8. Expected Outcomes from the Technical Assistance: The outcome of this CFD simulation, clearly demonstrates, how the vortex flow contributes to the generation of mechanical energy generation on a contra rotor, disproving the generally understood dynamic impact on a down wind component.

Moreover, the new rotor design will impact the present environment and may be replaced with the new rotor, due to its improved performance and cost reduction.

Appendix A

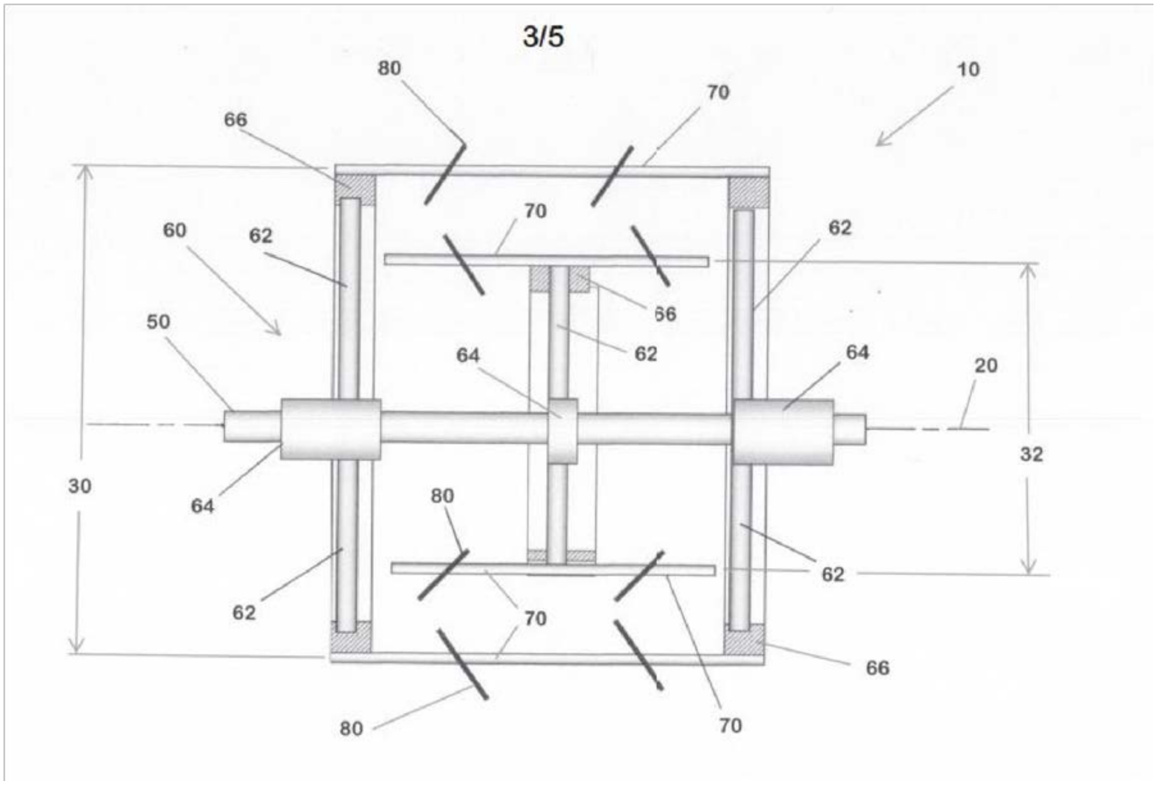

FIG. 1a Suggested Axial Flow Helical Bladed Rotor As Shown in FIG 1b

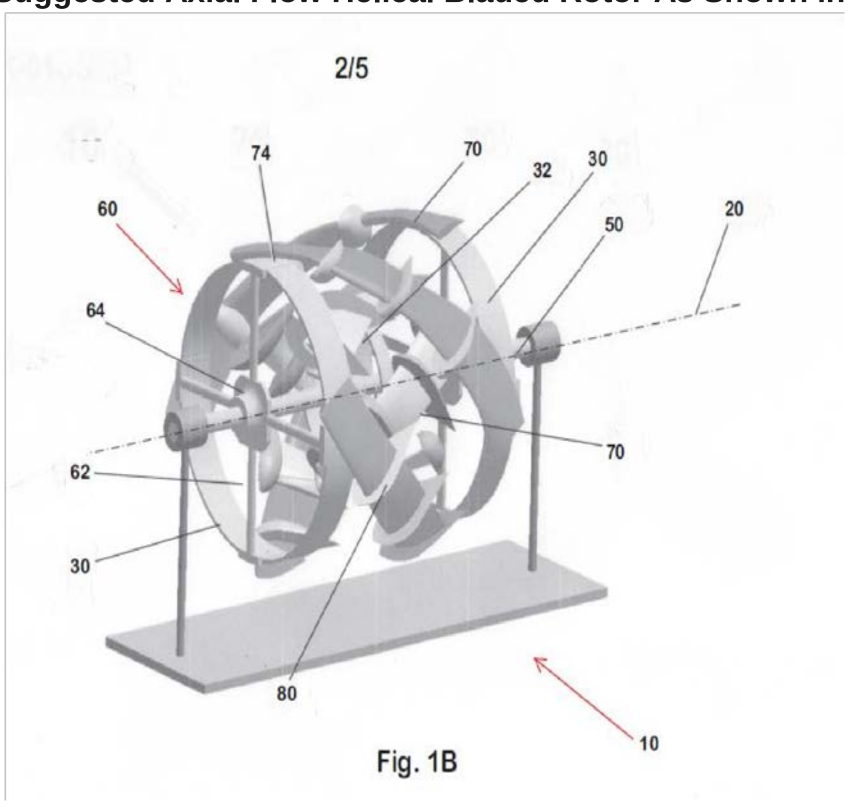

Fig. 1B

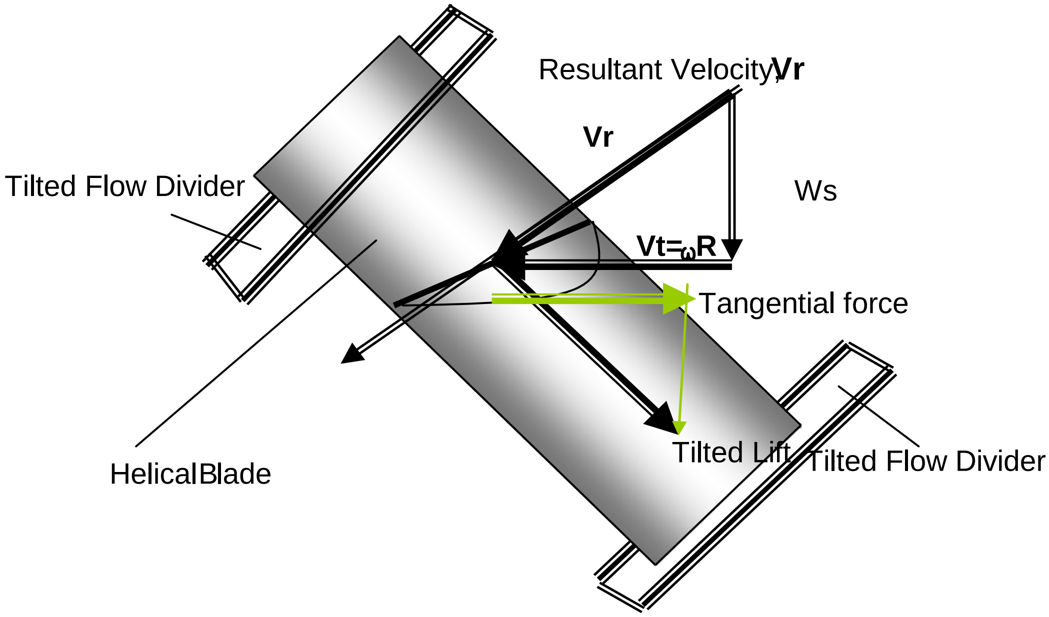

FIG. 1c Helical Blade with Tilted Airfoil and Tilted Flow Dividers

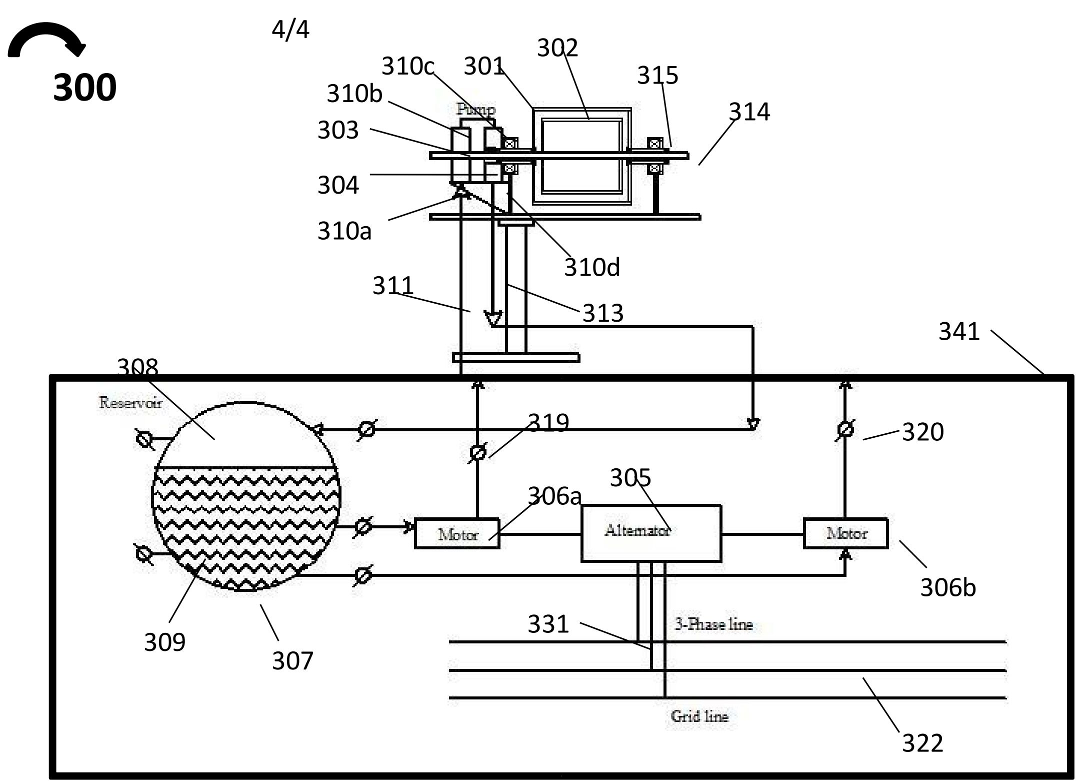

Fig 2

FIG 2. Proposed Axial Flow Helical Bladed Contra Rotor System Using Hydraulic Power Transmission

Table 1. 10 MW WIND TURBINE ROTORS

	Conventional Radial Bladed HAWT	**Suggested Rotor**
Rated Wind speed	10 m/s	10 m/s
Tip Speed Ratio	6	6.0
Rotor Speed	5.7 rpm	5.8 rpm
Rated Power	10 MW	10 MW
Blade Length	**98 m**	**15 m**
Number of Blades	3	252
Blade Tip Chord	**4.8 m**	**0.134m**
Each Blade Weight	**55 tons**	**0.05 ton**
Rotor Diameter	196 m	200 m
Hub Height	130 m	120 m
Blade Helix Angle		80 deg
Total Rotor Weight	**165 tons**	**12 tons**

Table 2. 50 MW WIND TURBINE ROTOR

	Conventional Radial Bladed HAWT	**Suggested Rotor**
Rated Wind speed	10 m/s	10 m/s
Tip Speed Ratio	6	6.0
Rotor Speed	2.6 rpm	2.6 rpm
Rated Power	50 MW	50 MW
Blade Length	**220 m**	**33 m**
Number of Blades	3	252
Blade Tip Chord	**10.5 m**	**0.29 m**
Each Blade Weight	**421 tons**	**0.25 ton**
Rotor Diameter	441 m	440 m
Hub Height	300 m	300 m
Blade Helix Angle		80 deg
Total Rotor Weight	**1263 tons**	**61.0 tons**

Appendix B

KEY PERSONNEL RESUME

Dr. Kari Appa:

Responsibility: Principal Investigator

He takes the responsibility to conduct, direct and manage technical activities of the project. He will also manage the financial aspects of the project. He will coordinate with the National Laboratory Program Administrator.

Education: M.S., Aerospace Eng. 1959, Indian Institute of Science, Bangalore, India;

Ph. D, Aerospace Eng., 1966, University of Stuttgart, Germany

1968-1977: Bell Aerospace, Niagara Falls, NY, Senior Design Engineer 1977-

1979 Pratt & Whitney, West Palm beach, FL.

1979-1998: Northrop Grumman Corporation, California. As principal engineer, was responsible for research and methods development in structural dynamics, flight loads, aeroservoelasticity, multidisciplinary optimization, and smart structures innovations, steady and unsteady aerodynamics.

1998-Present: Started a small business entity, focusing on aircraft and wind energy R&D activities. Built and demonstrated several contra rotating wind turbine model. One 6 kW system was built and demonstrated under California Energy Commission funding (EISG Grant No. 51809A/00-09, FY2001-2002). Test result showed that nearly 30 percent of additional power could be extracted from leeward rotors of a Contra Rotor System. Further, it was learnt that slower the rotor speed, more efficient a contra rotor system could be. Dr. Appa is currently developing more efficient wind turbine rotors, specially meant for offshore wind farms. He is the author of seven US patents:

- Continuously deformable smart trailing edge and leading edge aerodynamic effectors. US Patent No. 5,887,828, March 30, 1999.
- Extendible leading edges to alleviate roll reversal speeds and to enhance flight maneuver capabilities of tactical aircraft. Us patent no. 5, 921, 506, July 13, 1999.
- Monolithic composite wing design and fabrication methodology, US patent no. 6,190,484 b1, February 20, 2001.
- Active control surface modal system for aircraft buffet and gust load alleviation and flutter suppression, US patent. No. 6,375,127, April 23, 2002.

US Patents on Wind Turbine Issued to Dr. Kari Appa:

1. Jet assisted counter rotating wind turbine- US Patent 6,127,739- October 3, 2000,
2. Contra-Rotating Wind Turbine System, US Patent No. 6,278,197 B1, August 21, 2001
3. US PTO , 6,375,127, April 23, 2002,
4. Jet Assisted Hybrid Wind Turbine System US Patent No. 6492743 , 12/10/2002
5. Contra Rotating Generator US Patent No. 7679249, 03/16/2010
6. US PTO, 7,789,624, September 7, 2010.: Methods and devices for improving efficiency of wind turbines in low speed sites

He is the author of well over 40 publications, a few are:

1. Appa, K., "Recent Advances in Maneuver Loads Analysis," Computer Methods in Applied Mechanics and Engineering, Vol.90, No.1- 3, 1991. North-Holland.
2. Appa, K. „ Maneuver Loads Analysis for Military Aircraft." Section 6, Chapter 5, in Flight-Vehicle Materials, Structures, and Dynamics-Assessment and Future Directions Vol. 1, Editors; A. K. Noor and S. L. Venneri, Published by The American Society of Mechanical Engineers New York, N.Y. 10017, 1994.
3. Appa, K., Khot, N. S., and Ausman, J. Feasibility Assessment and Optimization Study of Smart Actuation Systems for Enhanced Aircraft Maneuver Performance, Air Force Report, WL-TR-97-3083, July 1997, Flight Dynamics Directorate, Wright Laboratory, Air Force Materiel Command, Wright-Paterson Air Force Base, OH 45433-7562.
4. Appa, K., Ausman, J., and Khot, N. S., "Smart Actuation Systems For Enhanced Aircraft Maneuver Performance," Flight Dynamics Directorate, AFRL-VA-WP-TR-1999-3047, October 1998.
5. Appa, K., Ausman, J., Khot, N. S., and Brenner, M. J., "Aircraft Dynamic Load Alleviation Using A Smart Actuation System," Air Vehicles Directorate, AFRL-VA-WP-TR-2000-3033, March 2000.
6. Appa, K., Counter Rotating Wind Turbine System, Appendix A to FAR 51809A/00-09, Energy Innovations Small Grant, (EISG) Program, EISG Final Report, April, 2002