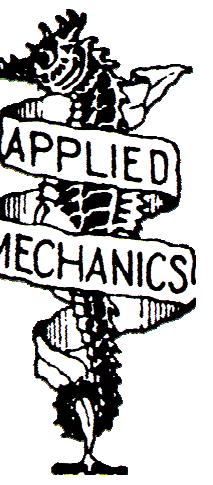


DEVELOPMENT OF SHROUDED WIND TURBINES WITH WIND-LENS TECHNOLOGY

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Abstract

This study presents an innovation related to wind power enhancement technology named “**Wind Lens**”. Wind power generation is proportional to the third power of the wind speed. If we can increase the wind speed, specifically by capturing and concentrating the wind energy locally, the output power of a wind turbine can be increased substantially. To embody the scenario, we have devised a simple shroud structure which intentionally creates vortices behind it to draw more mass flow into the wind turbine. The structure has been named “Wind Lens”.

The wind lens has a compact diffuser shroud with a broad-ring rim at the exit periphery. Our wind turbine system consists of the wind lens and a turbine inside. This system has demonstrated power augmentation for a given turbine diameter and wind speed by a factor of about 2-3 compared with a bare wind turbine.

Next generation diffusers have been developed and the details are given in this study also. The significant features of the wind-lens technology include, improved safety, reduction of acoustic noise and Doppler radar interference. We believe the wind lens can be quite suitable for installation in a variety of sites, even in well-populated areas. This study also discusses the latest development on 100kW scale wind-lens turbine system.

Objectives

Development of highly efficient small-type wind turbine

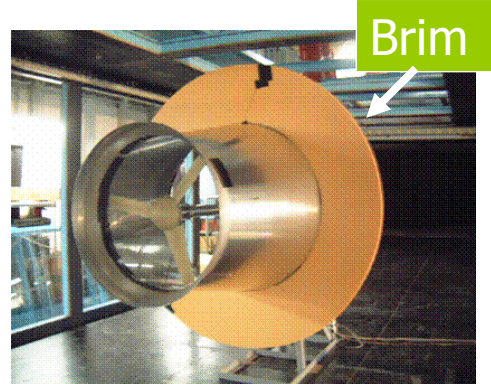
Concentration of wind energy

Wind turbine + collection and acceleration device for wind

WIND LENS

Brimmed Diffuser - Wind Lens

A “**Brim**” is attached to a diffuser shroud to improve wind collection and acceleration. The idea is to induce formation of **strong vortices**.

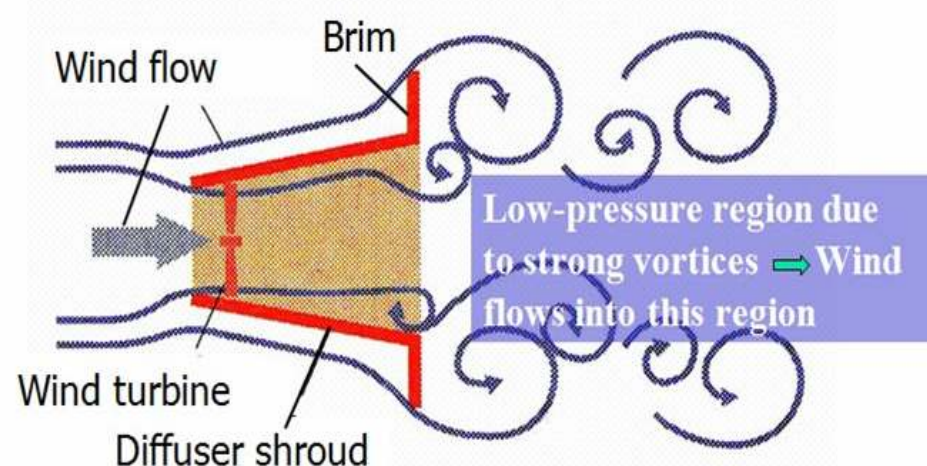


A wind turbine with the wind lens

WIND LENS
A collection-acceleration device
(Inlet shroud + Diffuser + Brim)

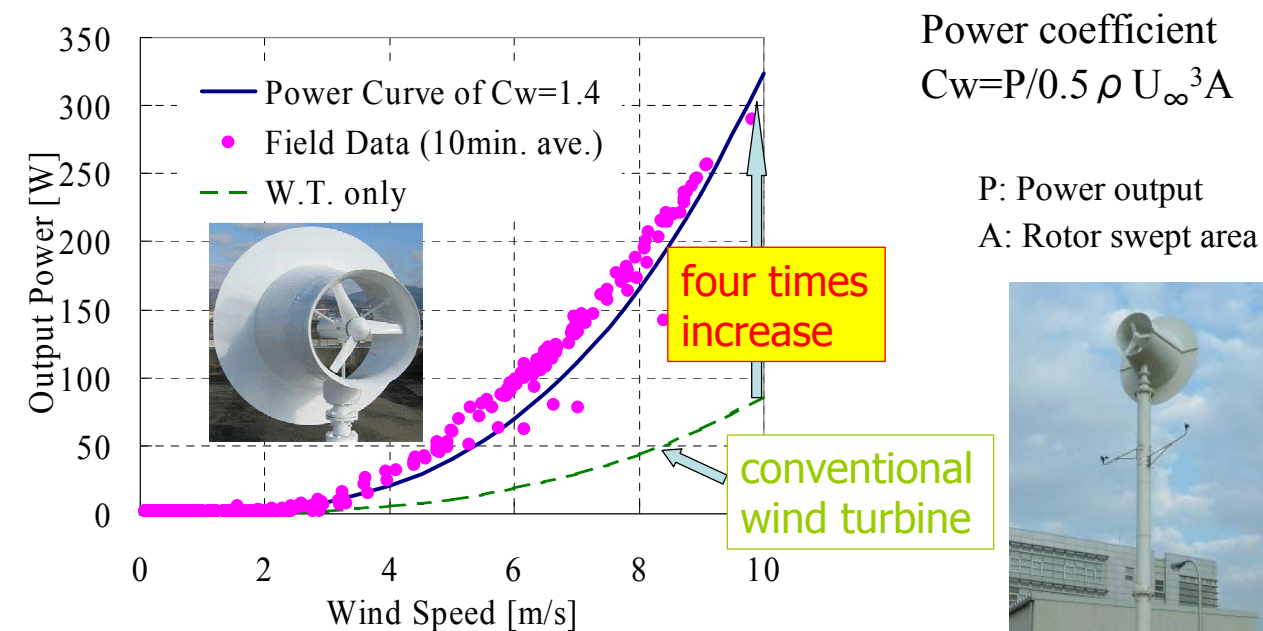
The mechanism:

The strong vortices created by the diffuser and the brim produce low pressure region behind the turbine. This increased pressure difference helps the wind to flow more into the wind lens.



Field Experiment for a 500W Wind-lens

Result of 500W wind-lens turbine field test:

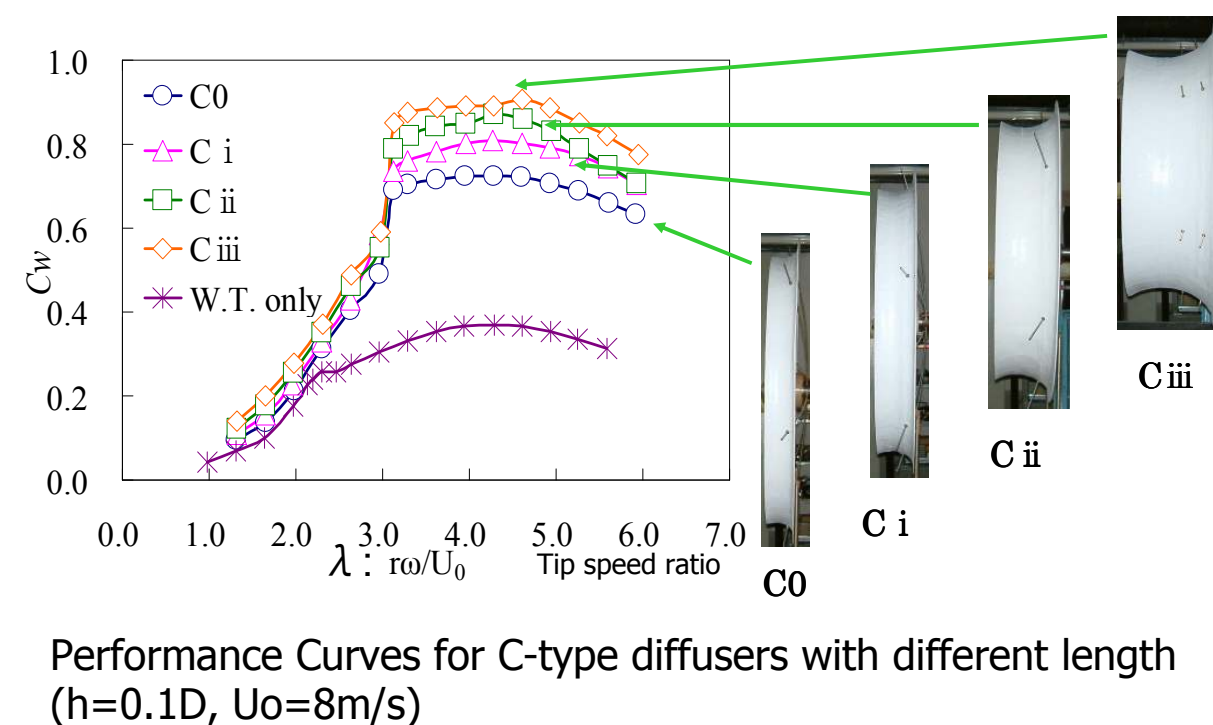


The result shows a significant increase of power output as much as 400% compared to conventional turbine. However, for larger turbines, reduction of the mass of the wind lens, and the size of the brim is important.

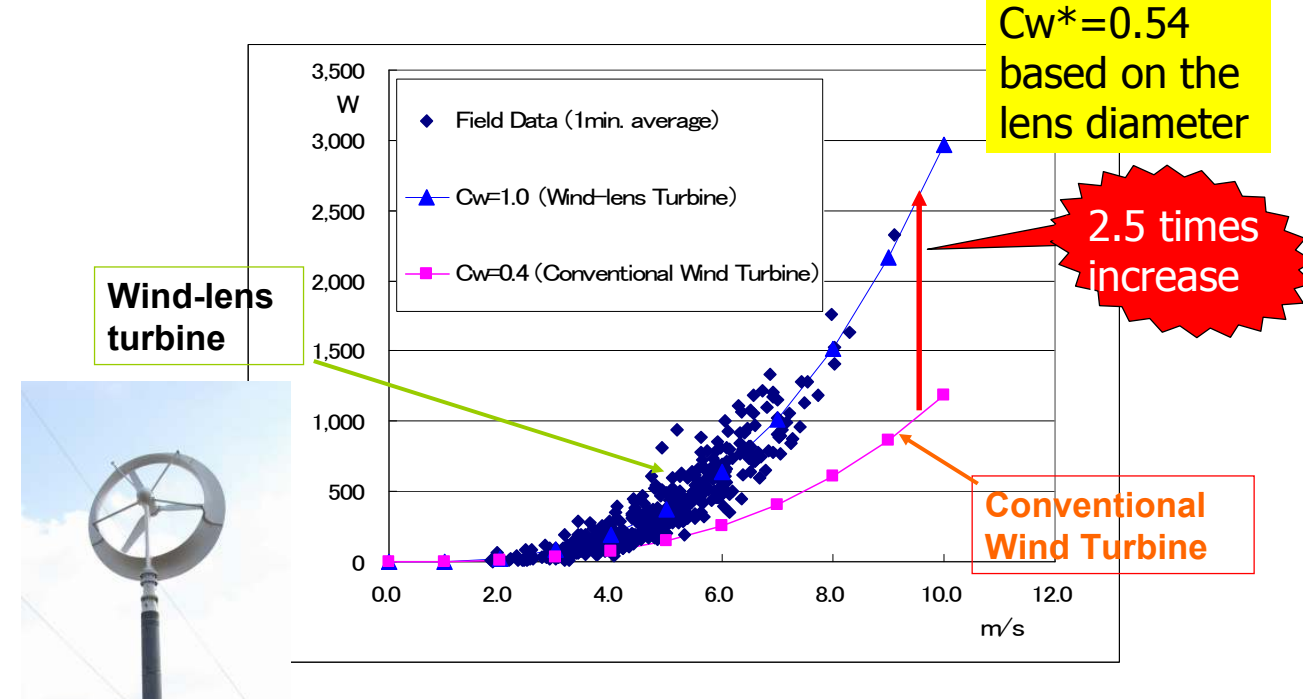
Short brimmed wind lens

Next generation wind lens have been developed. This version has shorter diffuser to reduce structural weight and narrower brim to reduce wind loads. This can be an advantage for the application to larger wind turbines.

Performances of wind lenses with different length:

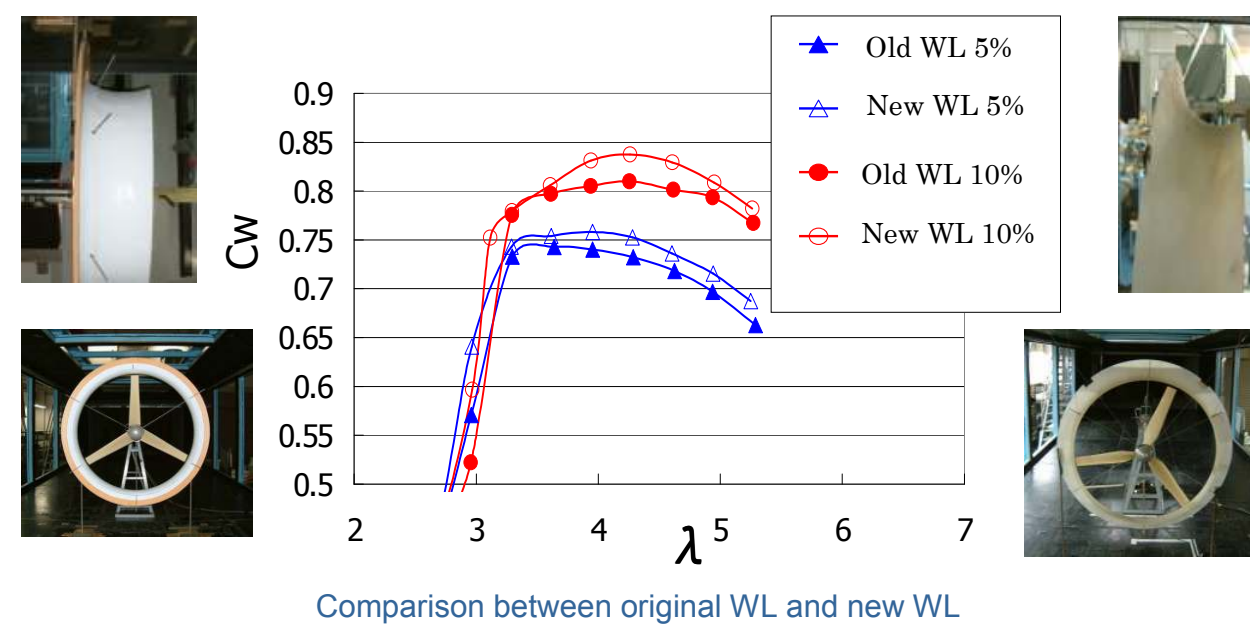


Field test result of 5kW Cii-type Wind-Lens turbine:



Further optimization of the wind-lens shape (Ci):

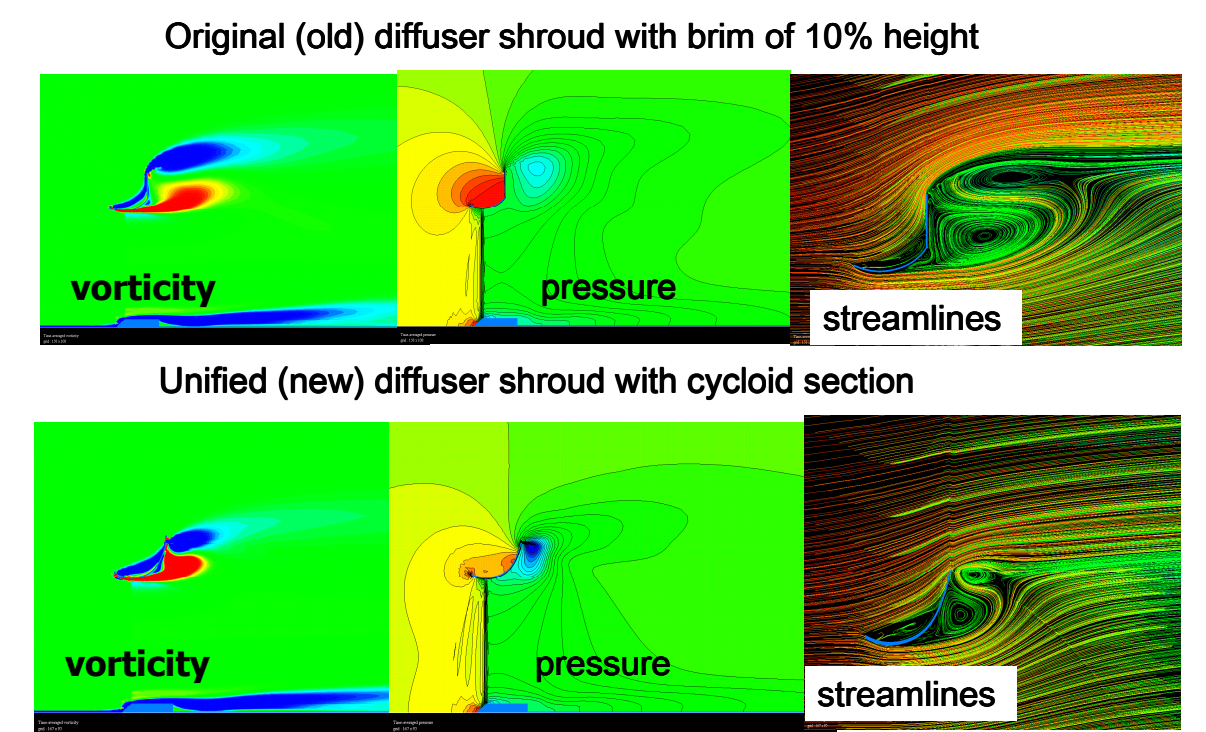
Also an optimization study of the shape of wind lens has been done. The newest type has cycloid cross section.



Original wind lens has curved diffuser and straight brim. Two parts are assembled together.

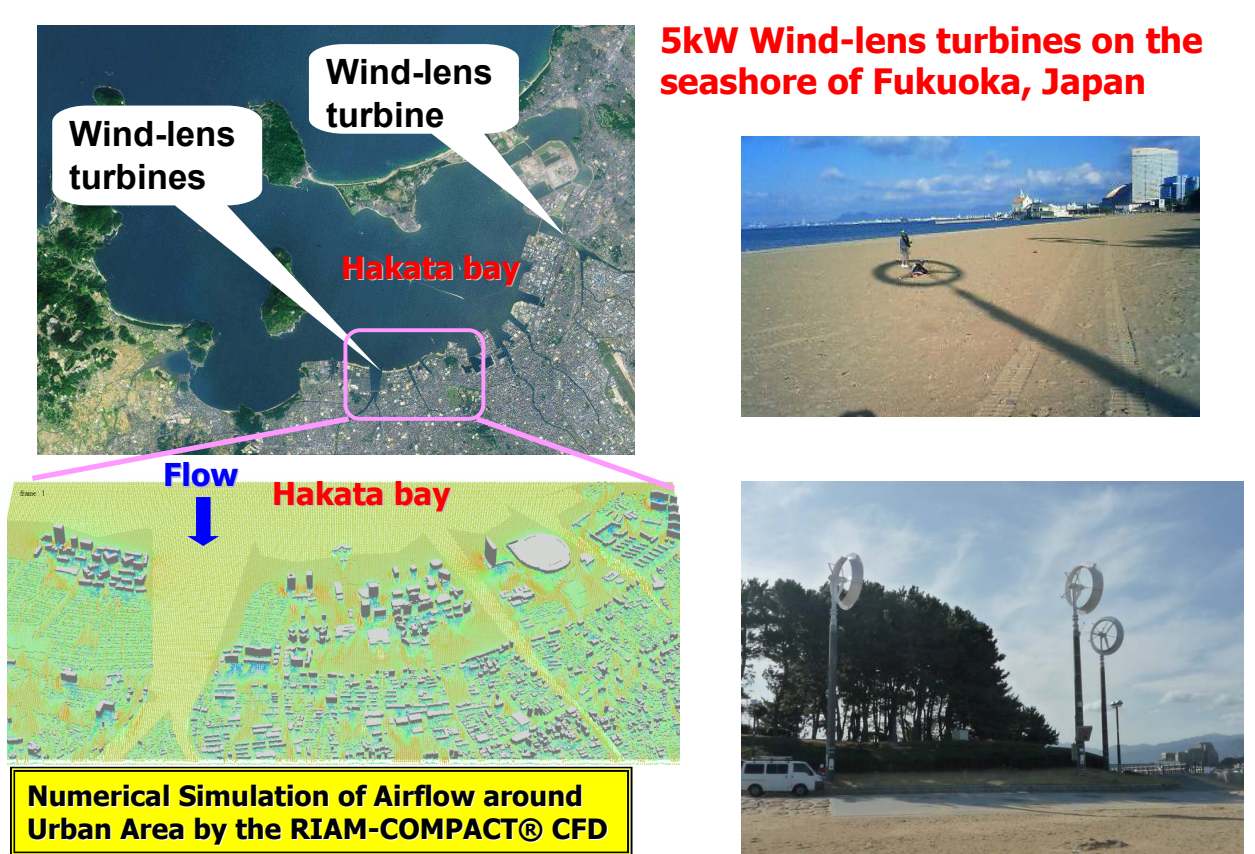
The new version of the WL has continuous structure and has Cycloid shape cross section.

Numerical simulation by DNS for original and new wind lens (Ci):



Ongoing and future wind farm projects

Wind Energy Utilization Project in Fukuoka city:

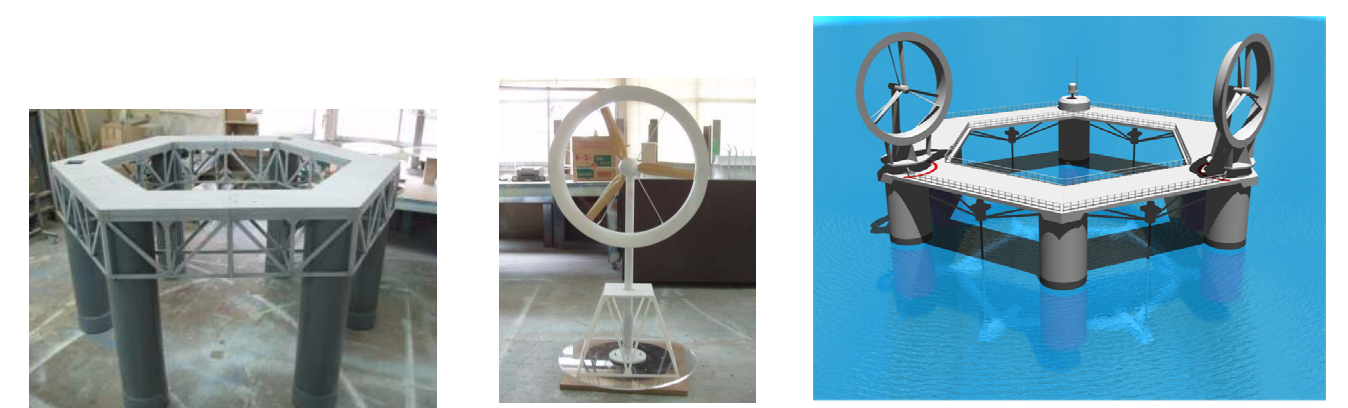


Hundred kW Wind Lens turbine at Kyushu-U:



Ocean Energy Farm project:

Development of combined energy farm on the ocean surface is currently ongoing at Kyushu University. The project begins with building an experimental wind farm on a floating structure on the ocean surface.



Remarkable merits of the Wind Lens

- 1) **Two-five time increase in output power** compared to conventional wind turbines
- 2) Brim-based yaw control
- 3) **Significant reduction in wind turbine noise due to suppression of tip vortices**
- 4) Improved safety
- 5) Possible reduction in Doppler radar interference