IPRO 323: Modeling of Large-Scale Wind Turbines

Development of Flow Guiding Structures to Optimize Power Output of Wind Turbines

Presented By:
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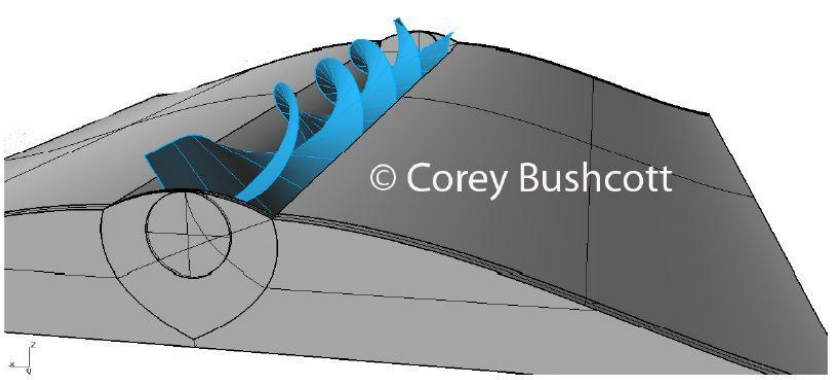
Advisers: Dr. Wark and Dr. Rempfer

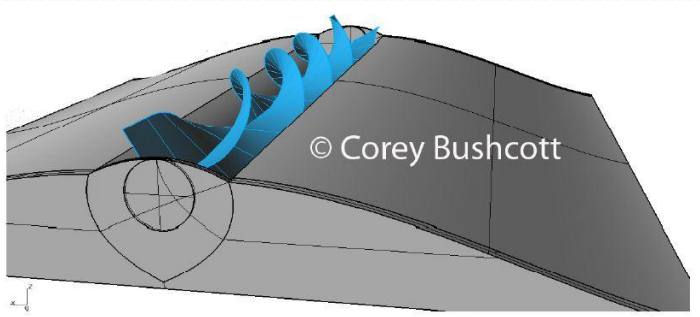
The Problem

- Integrate wind energy technology into existing and future structures.
- Optimize the power output of a wind turbine through surface design.



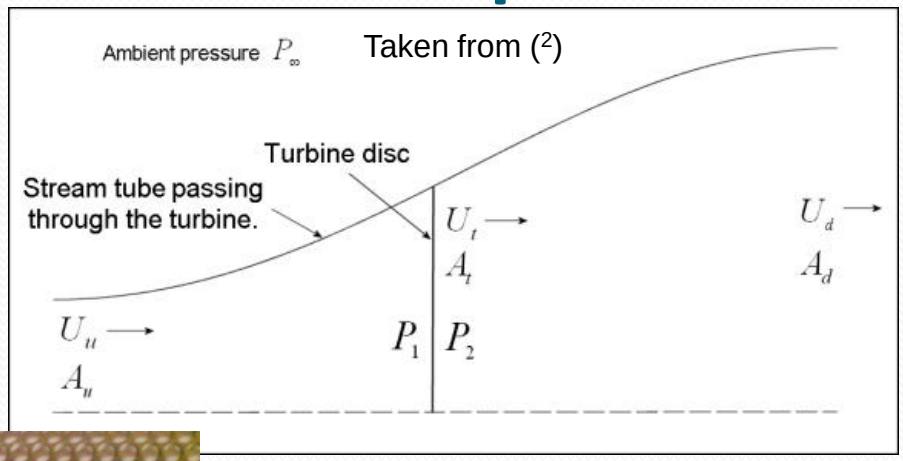
Goals

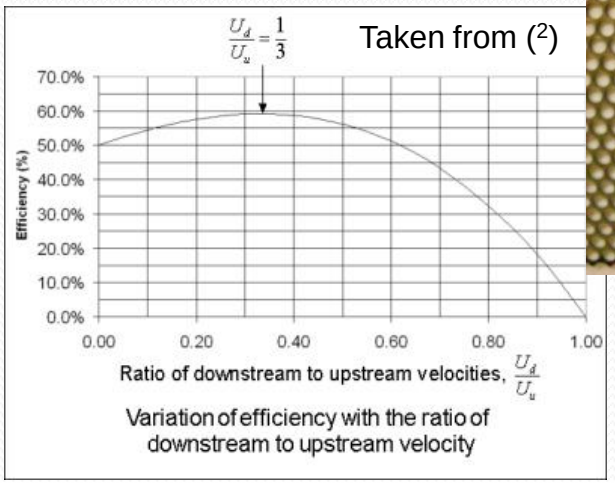
- Develop and test several module shapes.
- Compare the tested shapes to come up with the semester's optimal shape (guidance device).
- Develop a porous plate that models a wind turbine to facilitate analysis[1].
- Develop the methodology for measuring and analyzing testing parameters.

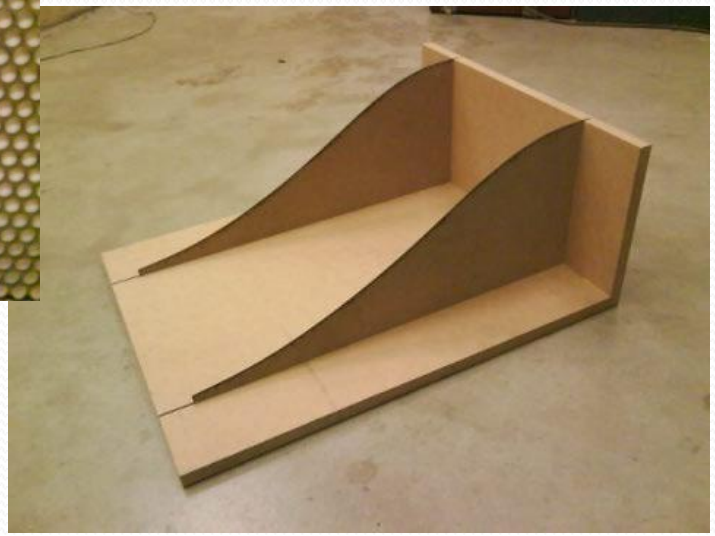


1. Aubrun, Loyer, Espana, Hayden, Hancock. "Experimental study on the wind turbine wake meandering with the help of a non-rotating simplified model and of a rotating model." *49th AIAA Aerospace Science Meeting 2011, Orlando, Florida.*

Porous Plate and Shape







2. Windpower Program. PelaFlow Consulting. 26 Feb. 2011 <http://www.wind-power-program.com/betz.htm>

Team Organization

Leader: Antonio Gonnella

Wind Tunnel Team

Jonathan Swanson

Nyla Husain

Jose Amodio Leon

Antonio Gonnella

Tom McManus

Lucas Pfiffner

Taylor Dizon

Research Team

Edward Ciciora

Corey Bushcott

Thiago Jardim

Lucas Pfiffner

Jaeyoung Kim

Kent Hoffman

Computational Fluid Dynamics Team

Taylor Dizon

Nyla Husain

Jose Amodio Leon

Antonio Gonnella

Tom McManus

Corey Bushcott

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Computational Fluid Dynamics Team Tasks

- Make a computational/theoretical analysis of the fluids model.
- Update Research Team with velocity profiles respective to their module shape.
- Update Wind Tunnel Team with results from porous plate analysis.
- Test several possible shape-porous plate combinations.
- Determine an optimum shape.

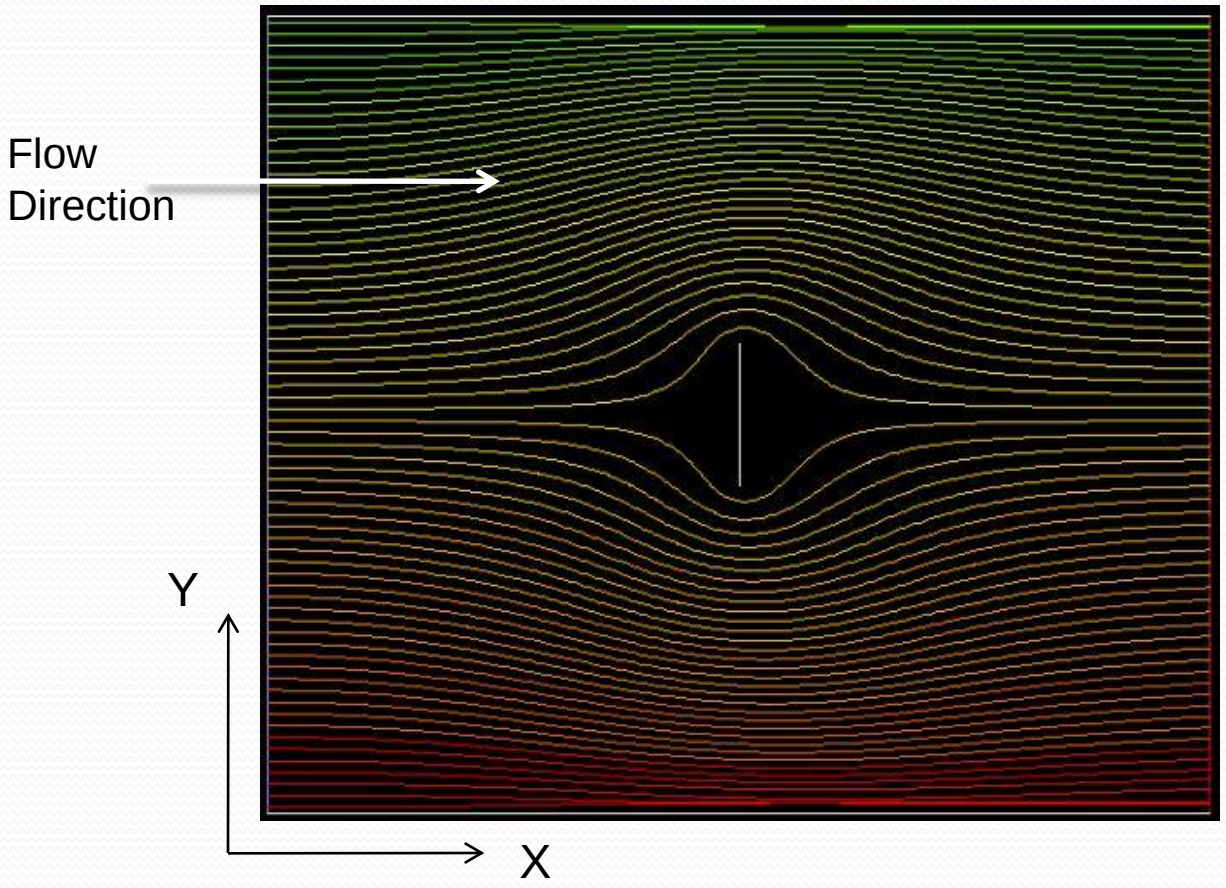
Wind Tunnel Team Tasks

- Attain proficiency with wind tunnel instrumentation and software.
- Develop a methodology to acquire and analyze data from experiments.
- Determine a plate porosity that adequately models the Betz “ideal” wind turbine.
- Test various shape-porous plate combinations.
- Determine an optimum shape.

Research Team Tasks

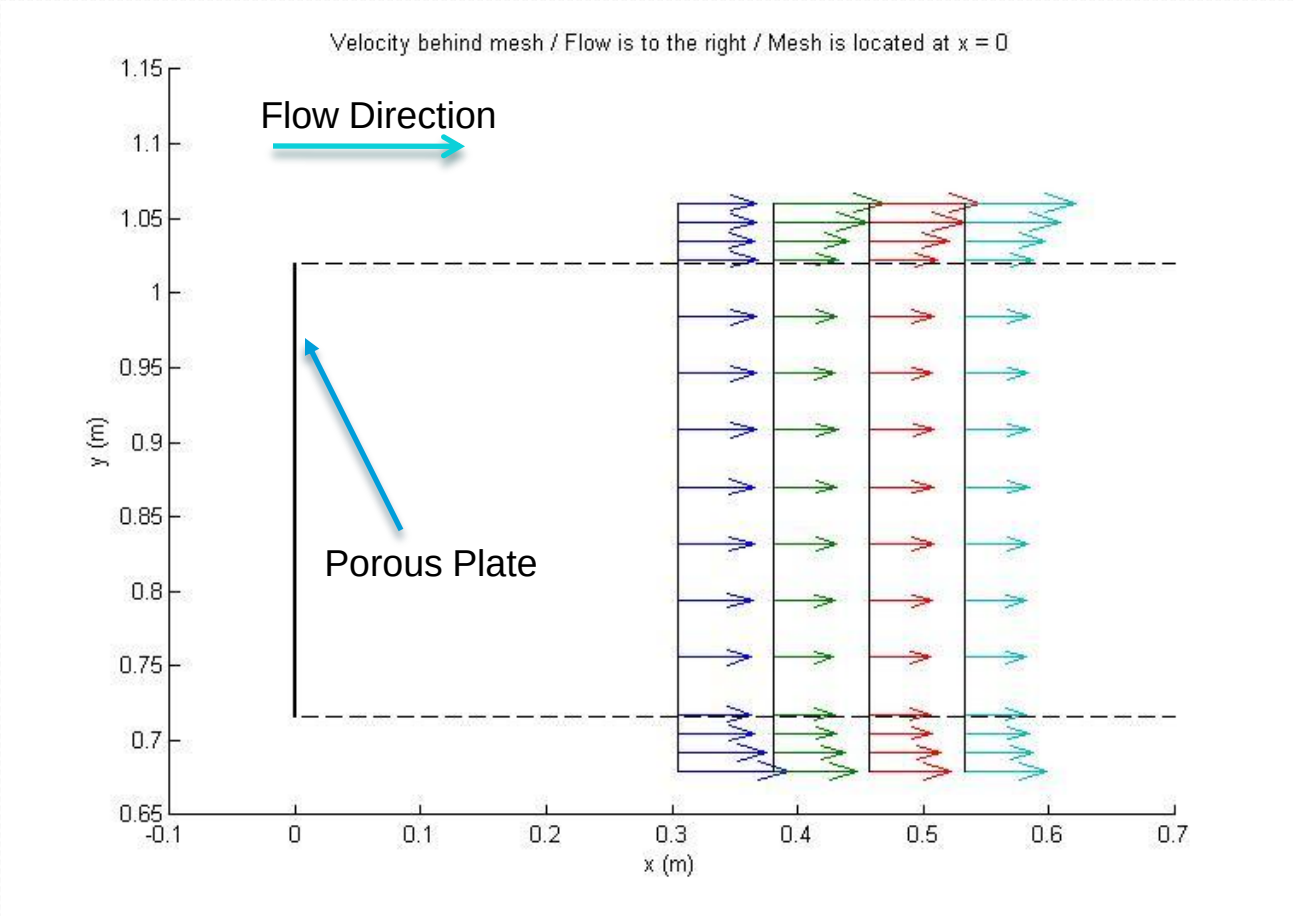
- Review past experimental data.
- Candidate surface designs.
- Manufacture module shapes for testing.
- Use collected data to refine the module shapes.
- Average building power consumption and sizing.

Computational Fluid Dynamics 2-D Streamlines

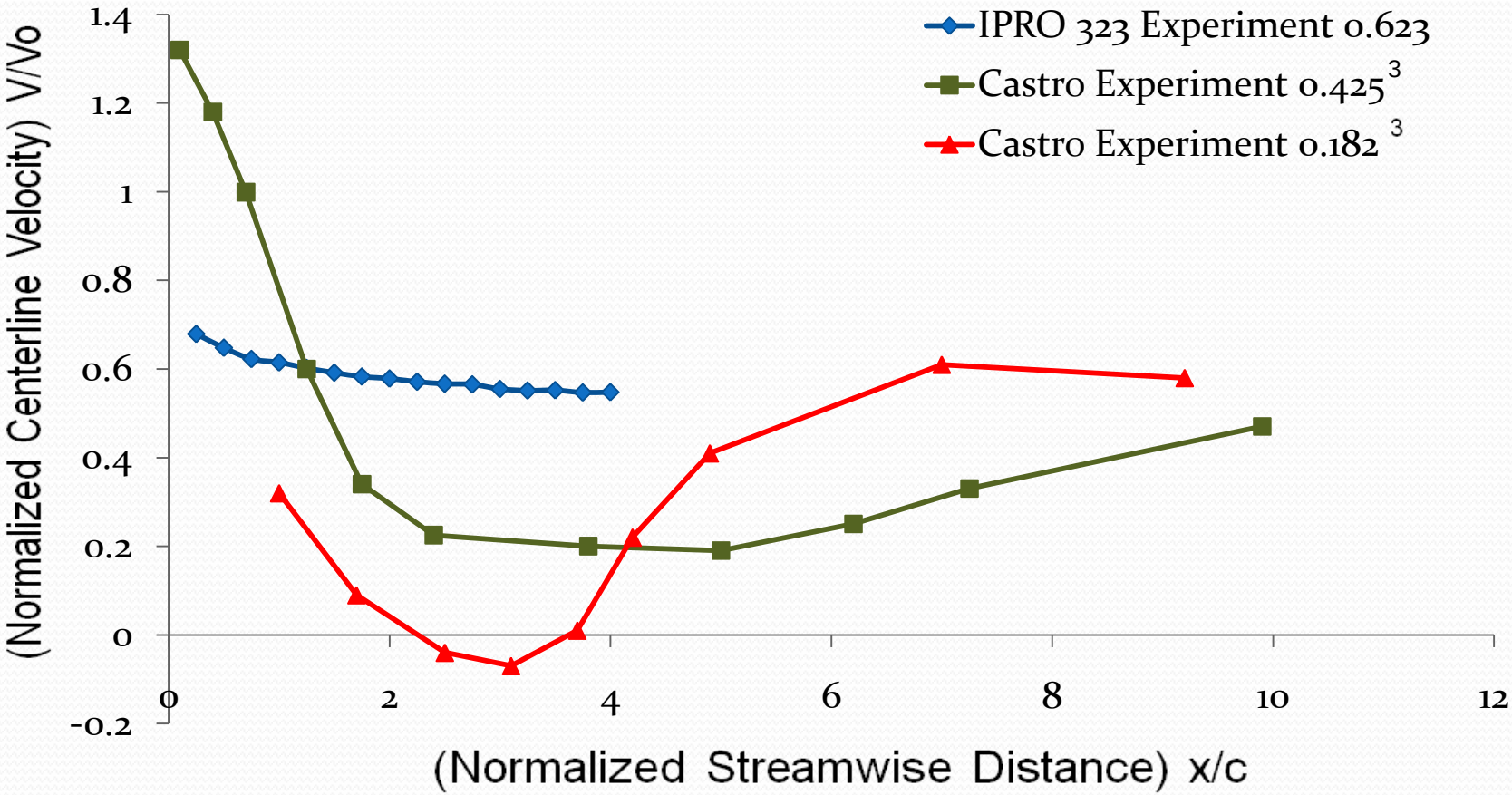


Velocity Distributions at Downstream Locations

Velocity as a function of distance from porous plate.



Velocity vs. Downstream Position



3. I. P. Castro. “Wake characteristics of two-dimensional perforated plates normal to an air-stream”. Journal Fluid Mechanics. (1971), vol. 46, part 3, pp. 599-609. Printed in Great Britain.

Encountered Obstacles

- Getting started: Understanding and setting viable semester goals.
- Learning new software.
- Learning wind tunnel measurement equipment and data acquisition system.

Future Obstacles

- Adjusted experimental methodology for porous-plate and shape combination.
- Analysis of the experimental and computational data.

Questions?