IPRO 323: Modeling Wind Turbine Systems

Development of surface structures to optimize power output of wind turbines

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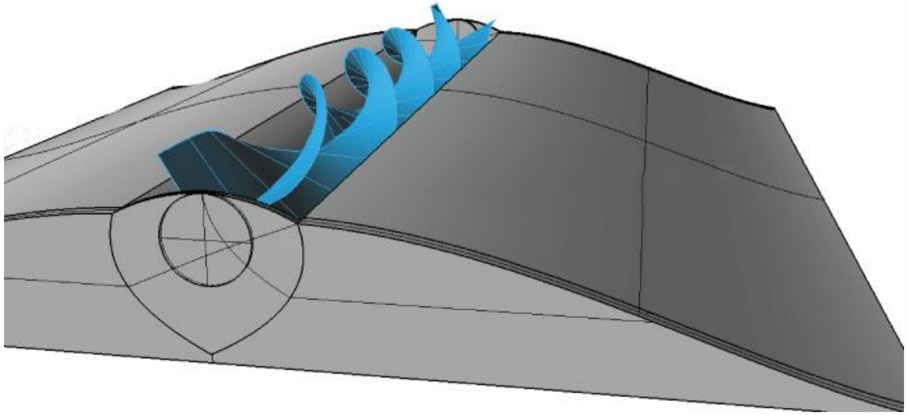
Advisers: Dr. Wark and Dr. Rempfer

Outline

- **Introduction**
  - Purpose
  - IPRO Objectives
  - Semester Objectives
- **Background**
  - Porous Plate
  - Surface Design
- **Team Organization**
- **Accomplishments**
  - Computational Fluid Dynamics
  - Wind Tunnel
  - Architecture
- **Conclusions**
- **Future Work**

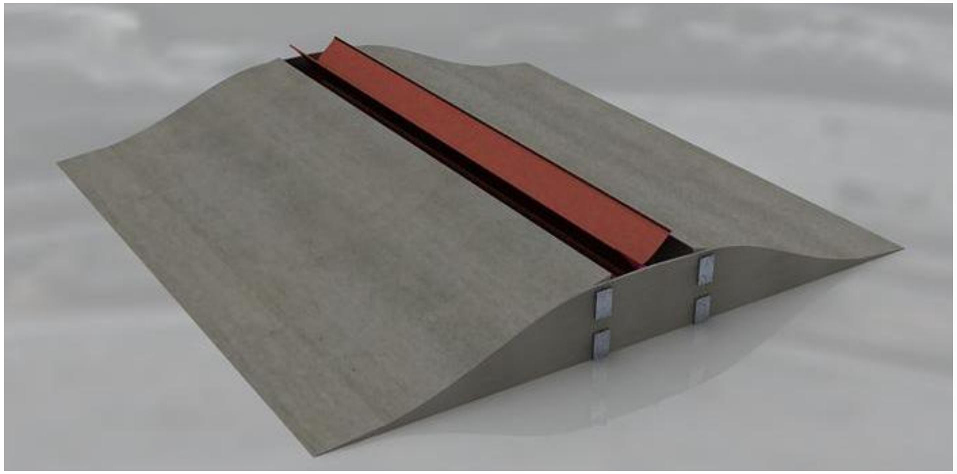
Introduction-Purpose

- Sustainabiliity
  - Wind is a renewable energy source
  - Wind turbine farms are typically grandiose



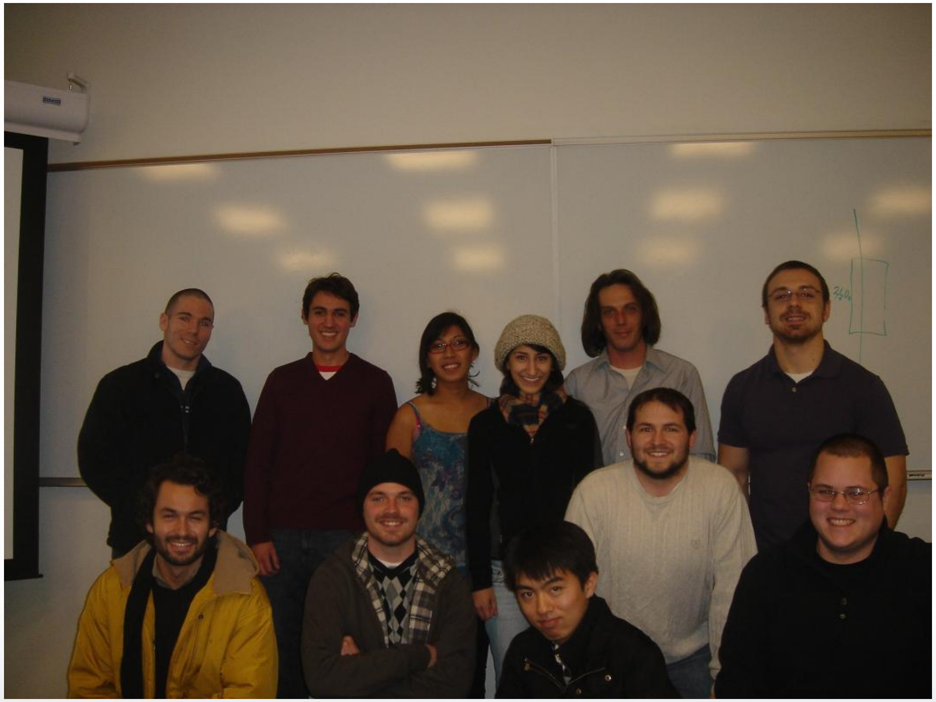
Introduction-IPRO Objectives

- Optimize the power output of a small-scale wind turbine system
- Design and develop a custom turbine system
- Integrate into buildings and cityscape



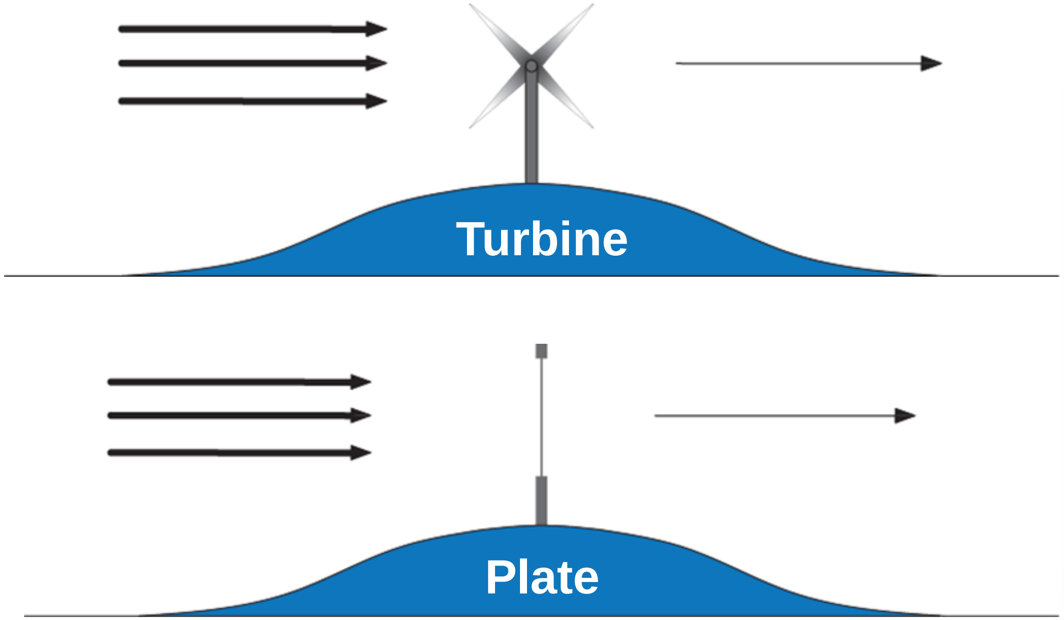
Introduction – Semester Objectives

- Measure the effects of surface shape on power output
- Digitally model a building with the surface design
- Estimate the costs versus the benefits



Perforated Plate

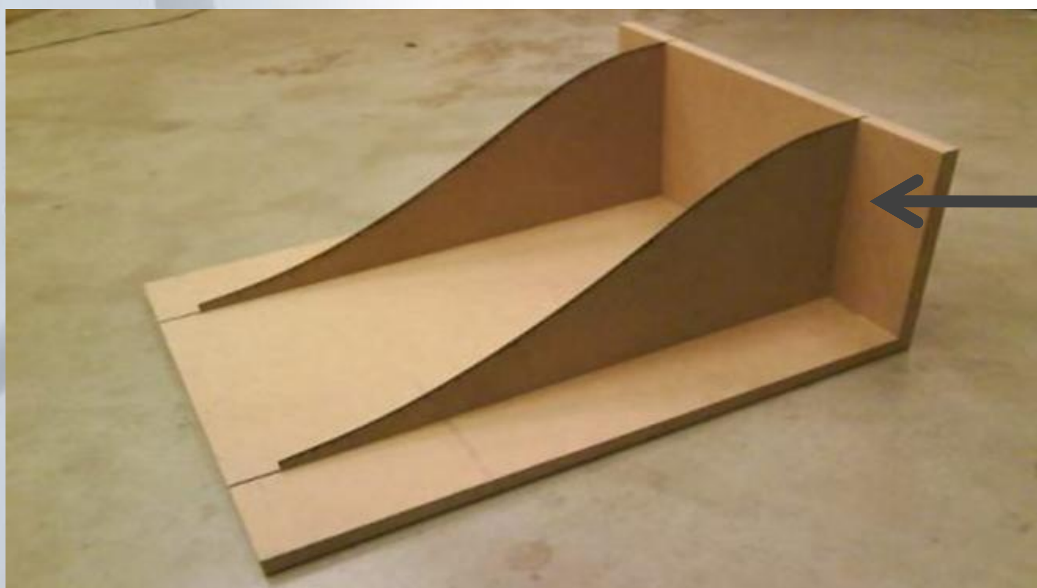
- Time and cost effective
- Perforated plate simulates the downstream effects of a wind turbine



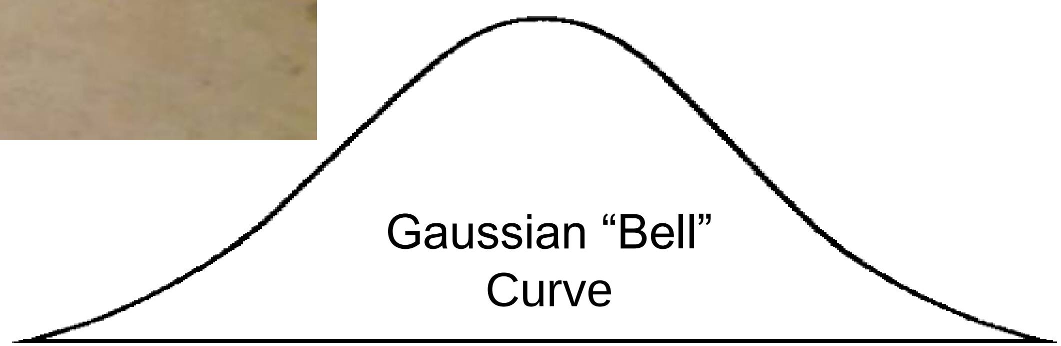
1) Aubrun, Loyer, Espana, Hayden, Hancock. "Experimental study on the wind turbine wake meandering with the help of a non-rotating simplified model and of a rotating model." *49th AIAA Aerospace Science Meeting 2011, Orlando, Florida.*

Surface Design

- Surface design accelerates wind speed
- Bell curve selected as a starting point



shape jig



Team Structure

- Wind Tunnel Testing Team
- Research Team
- Computational Fluid Dynamics Team (CFD)
- Architectural Research and Development Team

Team Organization

Leader: Antonio Gonnella

CFD

<u>Taylor Dizon</u>

Nyla Husain

Jose Amodio Leon

Antonio Gonnella

Tom McManus

Wind Tunnel

<u>Jonathan Swanson</u>

Nyla Husain

Jose Amodio Leon

Antonio Gonnella

Tom McManus

Lucas Pfiffner

Taylor Dizon

Architectural R&D

<u>Corey Bushcott</u>

Edward Ciciora

Thiago Jardim

Jaeyoung Kim

Kent Hoffman

Research

<u>Edward Ciciora</u>

Corey Bushcott

Thiago Jardim

Lucas Pfiffner

Jaeyoung Kim

Kent Hoffman

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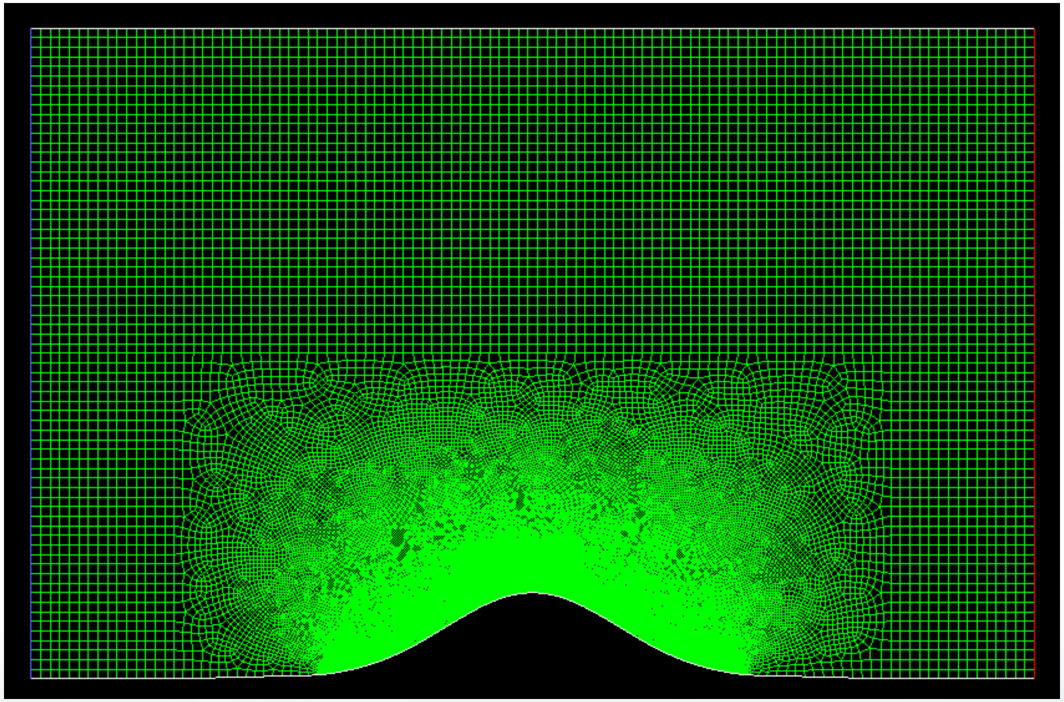
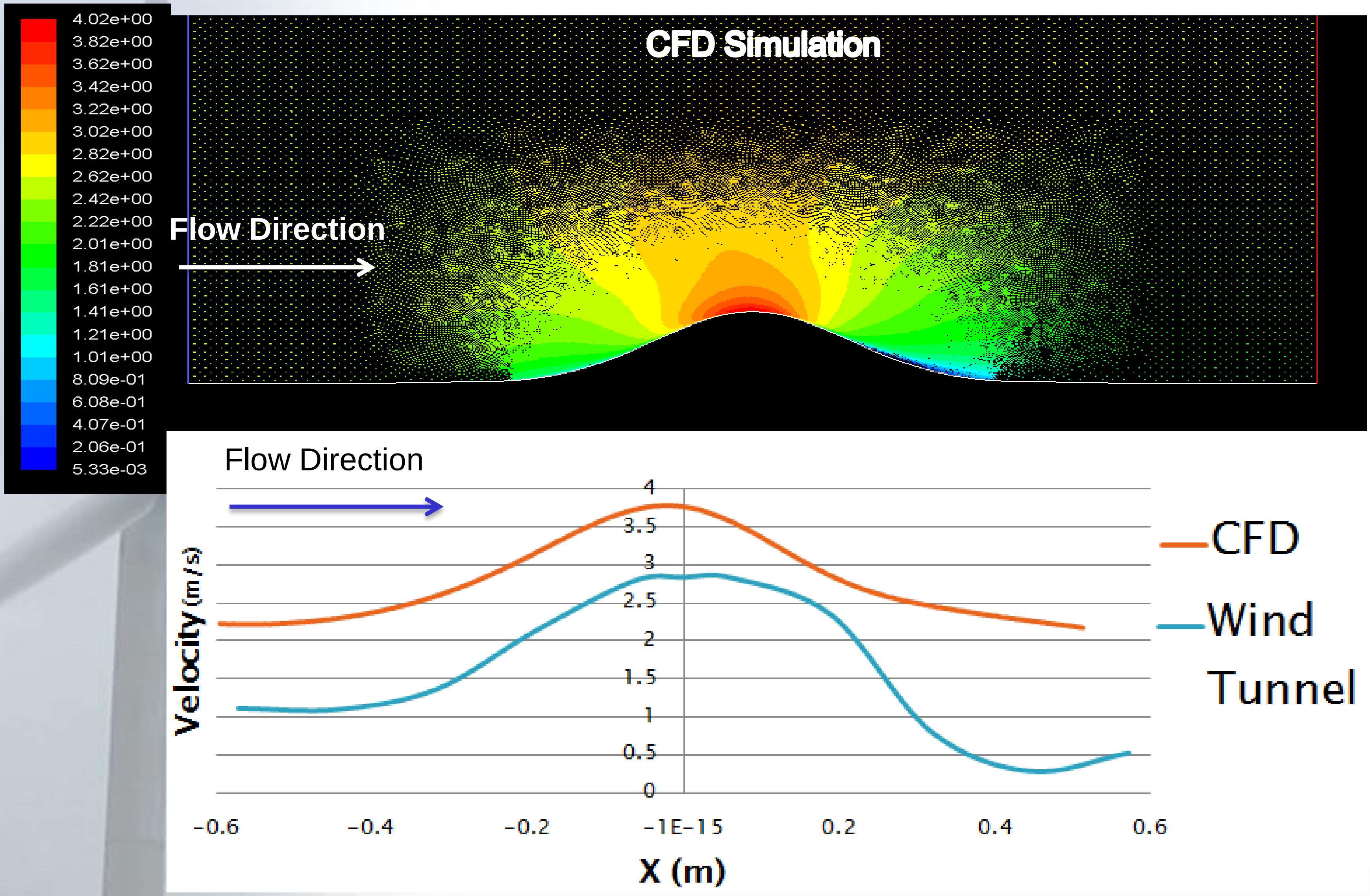
Computational Fluid Dynamics (CFD) Team Accomplishments

- Develop a computational fluids model
  - Geometry
  - Flow characteristic functions
- Complement experimental data



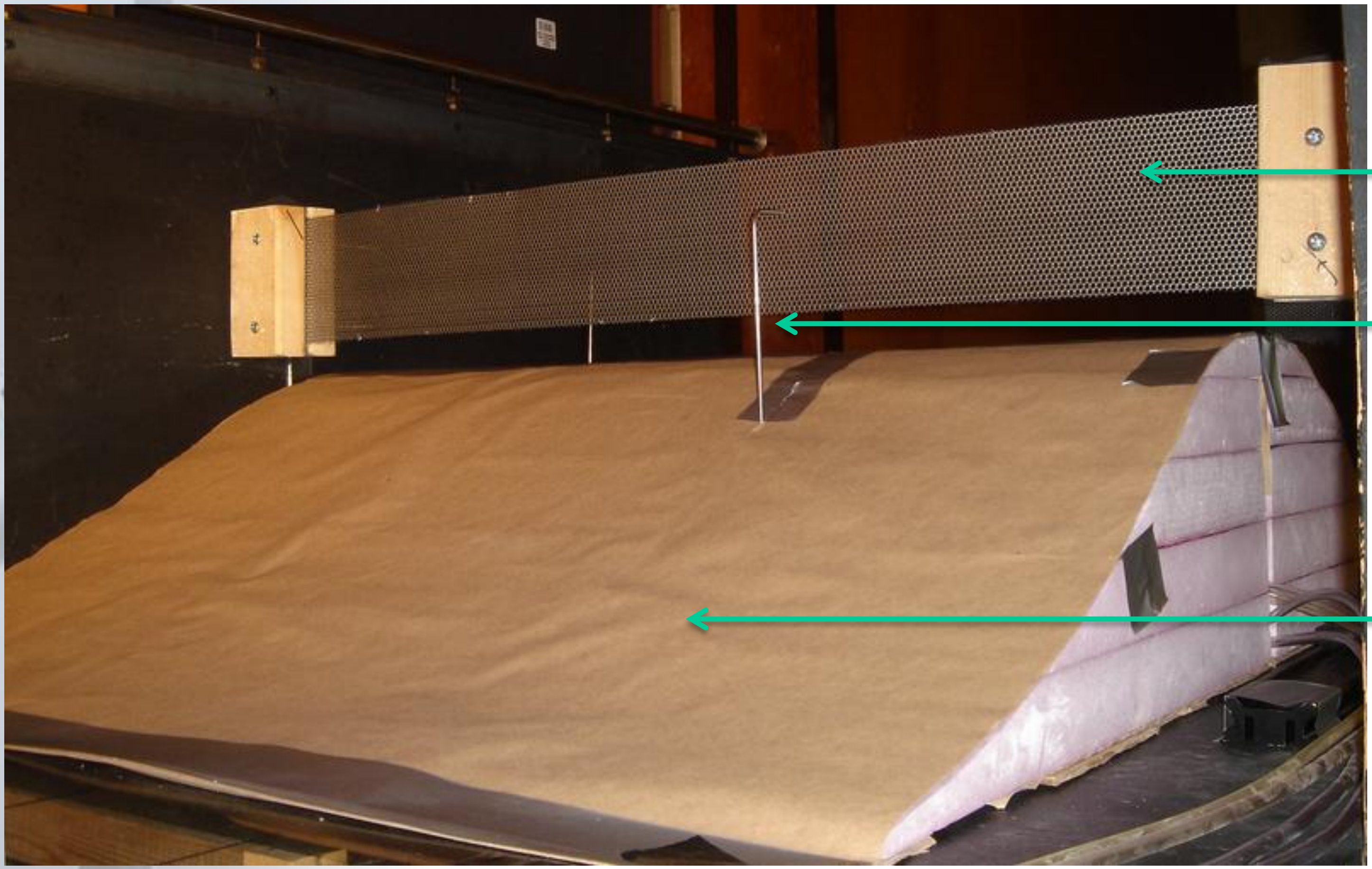
Computational Fluid Dynamics (CFD)



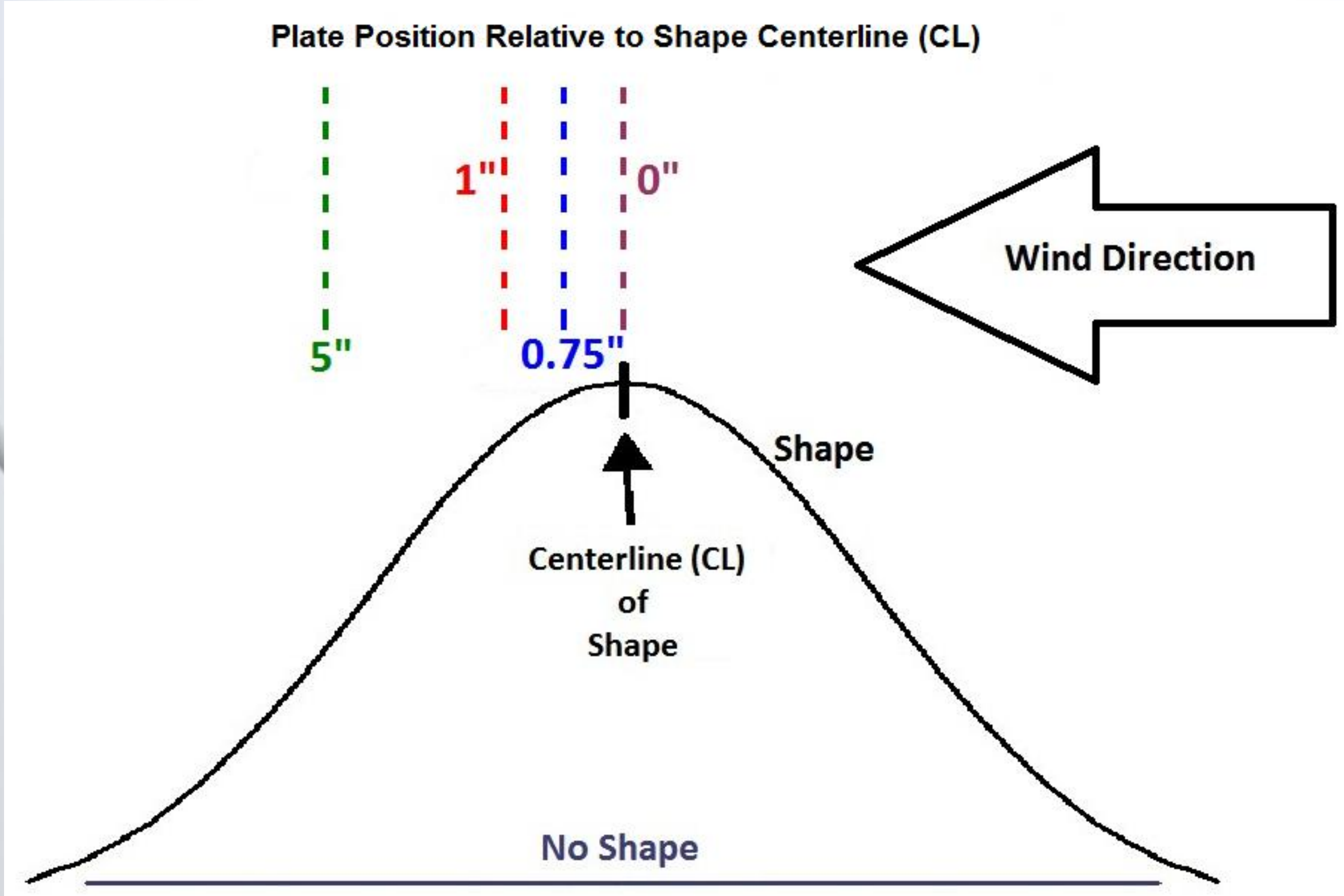
Wind Tunnel Team Accomplishments

- Wind tunnel instrumentation and software
- Methods for measuring velocity and pressure distributions

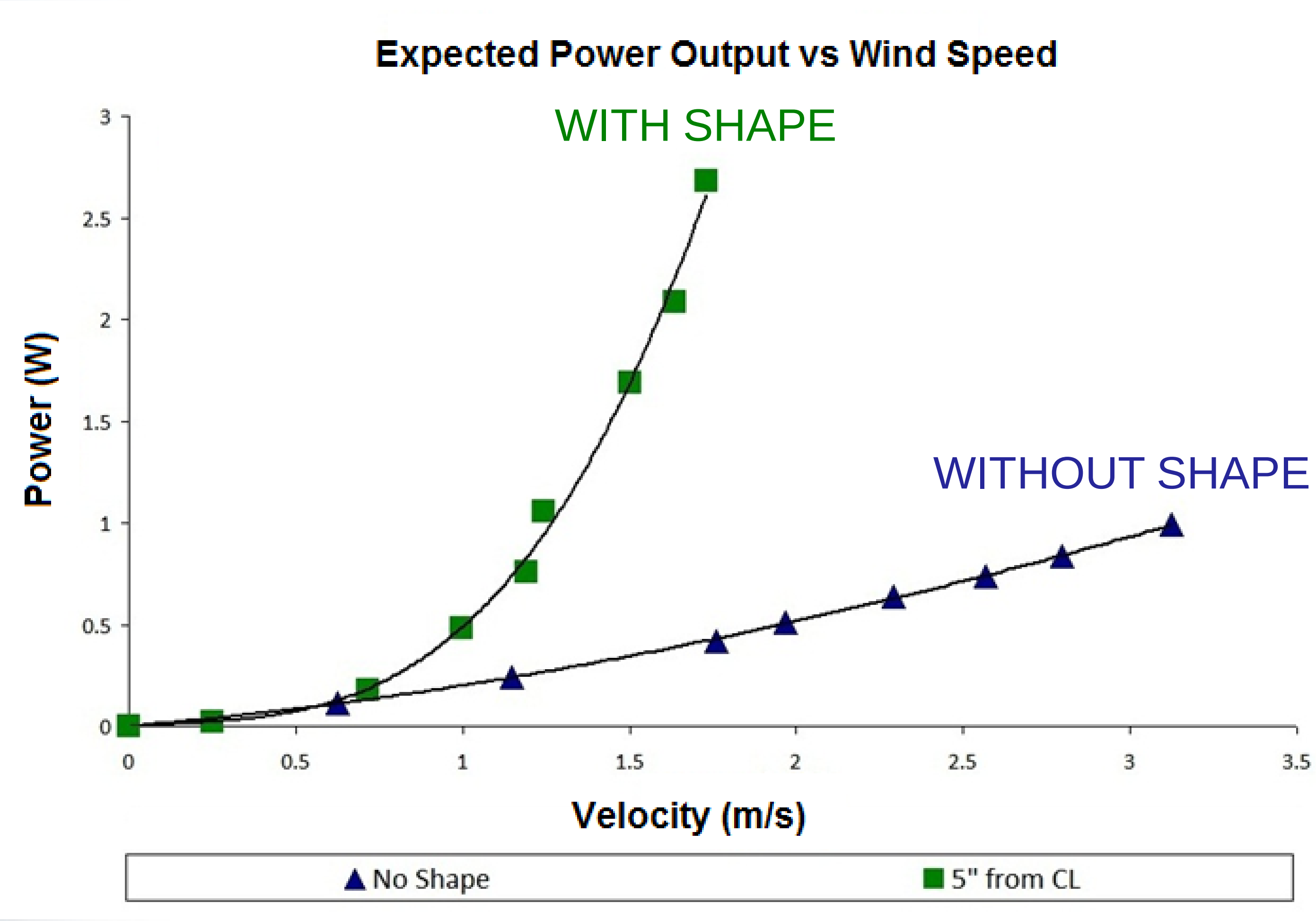
Wind Tunnel Set-Up



Perforated Plate Position

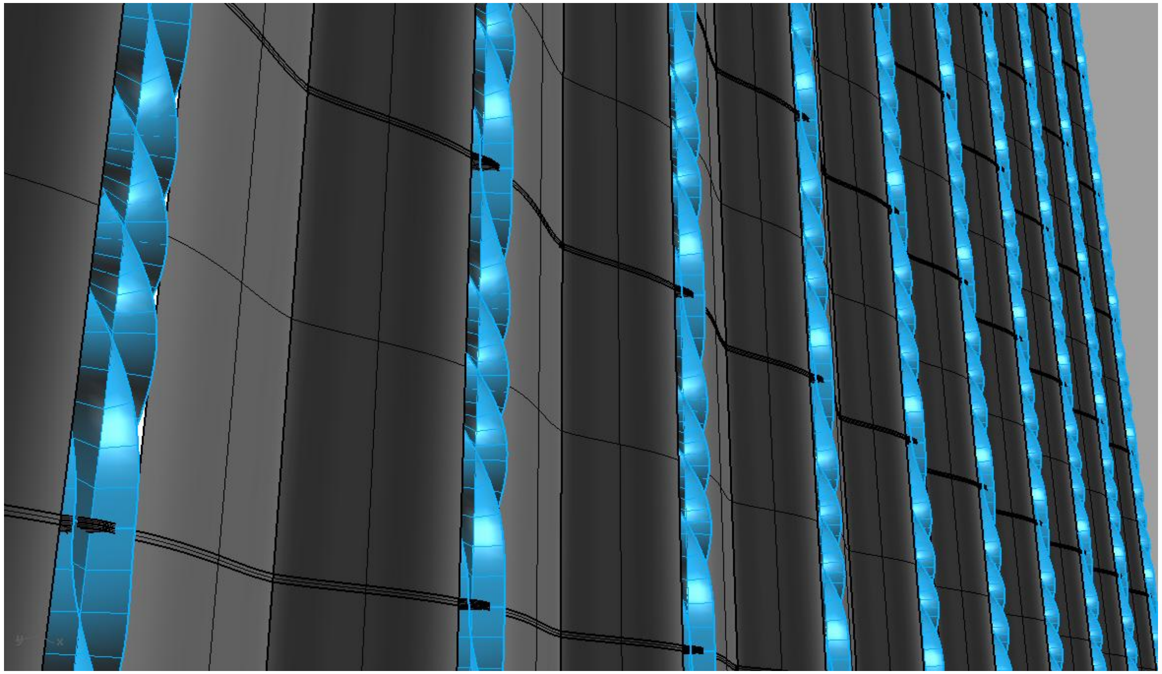


Results


Expected Power Output vs Wind Speed
WITH SHAPE
WITHOUT SHAPE
Power (W)
3
2.5
2
1.5
1
0.5
0
0
0.5
1
1.5
2
2.5
3
3.5
Velocity (m/s)
No Shape
5" from CL

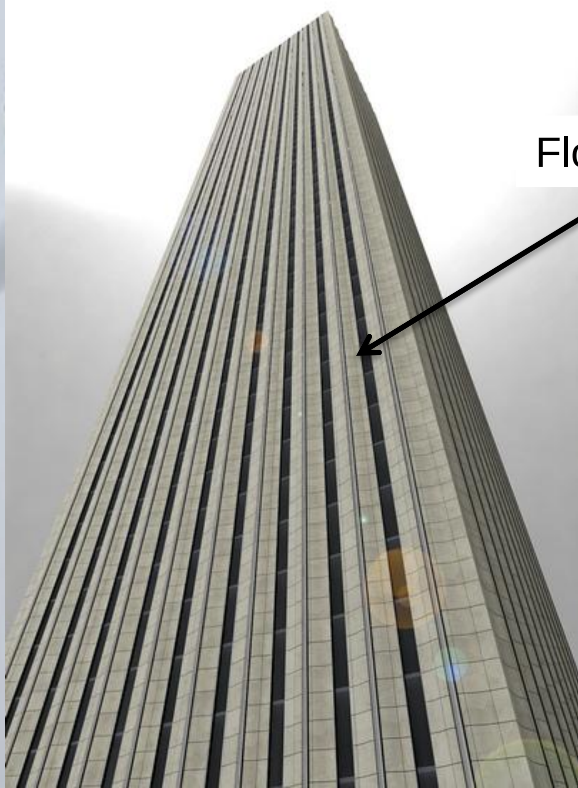
Architectural R&D Team Accomplishments

- Modeled buildings
- Estimated cost
- Estimated power



Building Power Consumption Estimation

- Mid-sized office building uses 167 kWh/m^2 annually
- Initial tests estimate:
  - 67.5 kWh/m^2 annually for 5 m/s
  - 536.6 kWh/m^2 annually for 10 m/s



Flow guiding surface

Model of buildings with candidate flow guiding surface

Cost Estimation

- Tubular aluminum frame
  - Approx. 45’ of ¾” sq. tubing — $50
  - Welded — $50
- Molded plastic upper — $5
- Foam insulation — $20
- Turbine body
  - Solid paddle — $10
  - Solid savonius — $20
  - Membrane paddle/savonius — $30
- Magnetic generator — $100
- Transformer — $65

- Total — $315

Conclusions

- Power output can be improved
- Estimates suggest commercial viability

Future Work

- Optimize power output
- Test multiple surface designs
- Turbine considerations
- Integrate system

Questions?