
High Efficiency Adaptive Blades for Wind Turbines



Sridhar Kota
Professor of Mechanical Engineering
Compliant Systems Design Lab
University of Michigan, Ann Arbor

Founder & President, FlexSys Inc.
Ann Arbor, MI
<http://www.flxsys.com>



Company Background

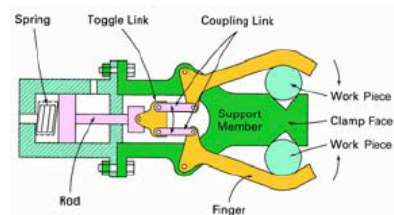
FlexSys is a technology development company focused on bringing to market innovative applications of bio-inspired compliant systems

- Founded in 2001
- 4 (+3) employees
- \$4+ million in contracts
- Existing application areas:
 - Aerospace
 - "Green technologies"
 - Automotive
 - Bio medical devices
 - Consumer goods

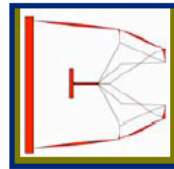
Background Technology

FlexSys adaptive airfoil technology is the outgrowth of basic research work at the University of Michigan Compliant Systems Design Laboratory

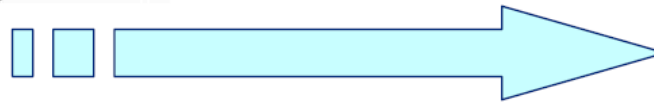
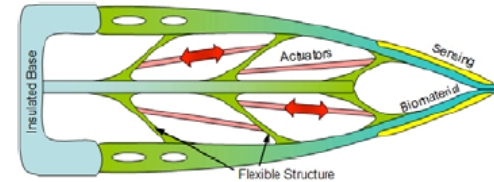
TRADITIONAL DESIGN



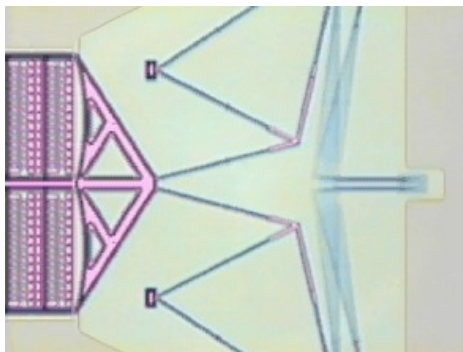
COMPLIANT DESIGN



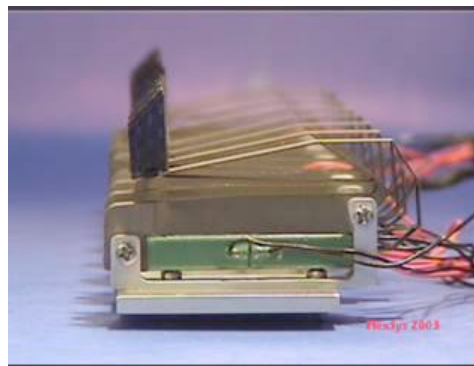
BIO-MIMETIC DESIGN



MEMS Actuators



Piezo-compliant Actuators



Active Flow Control



Fixed versus Variable Geometry

Performance of current wind turbine blades suffer from their inability to adapt to changing environmental conditions



Efficient only at a specific operational condition

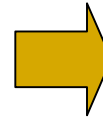
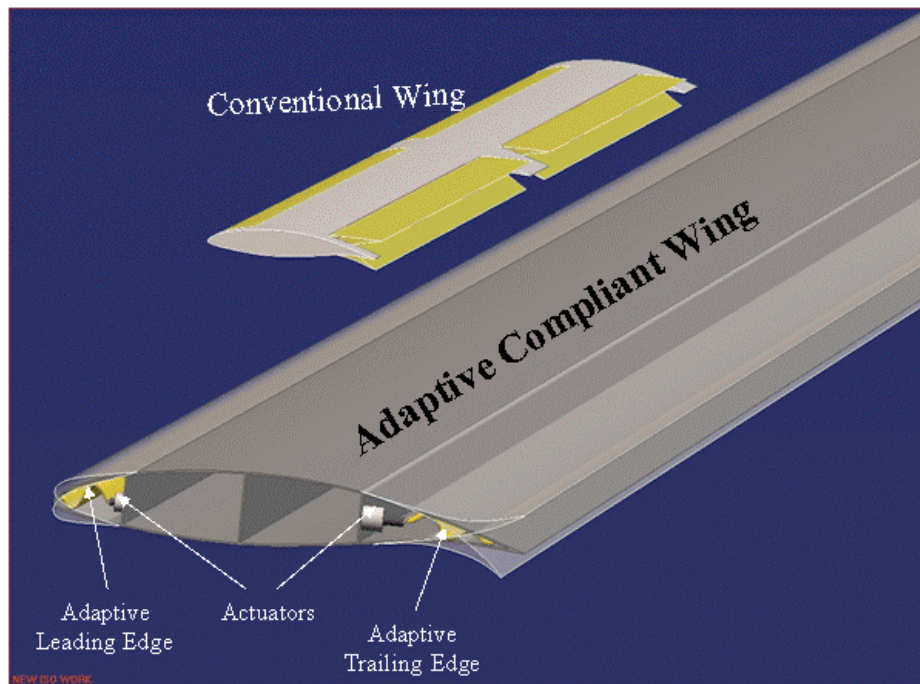
VS.



Variable geometry results in energy efficiency under *all* operating conditions.

Taking Nature's Lead

At FlexSys we started by reinventing the Wright brothers wing and the helicopter blade for the U.S. Air Force...



Taking Nature's Lead (cont.)

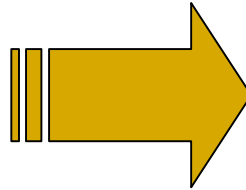
The results were dramatic

- 3% fuel savings on retrofitted wings (= **\$1.2 Billion** annual fuel cost savings)
- Fuel savings of 15% on reengineered wings



Transferable Technology

Our work on helicopter blades is transferable to wind turbine blades



The Specific Challenge

Currently wind energy is not price competitive with conventional energy sources

Coal 3.14 cents/kwh

Wind 3.45 cents/kwh (with PTC - Production Tax Credit)

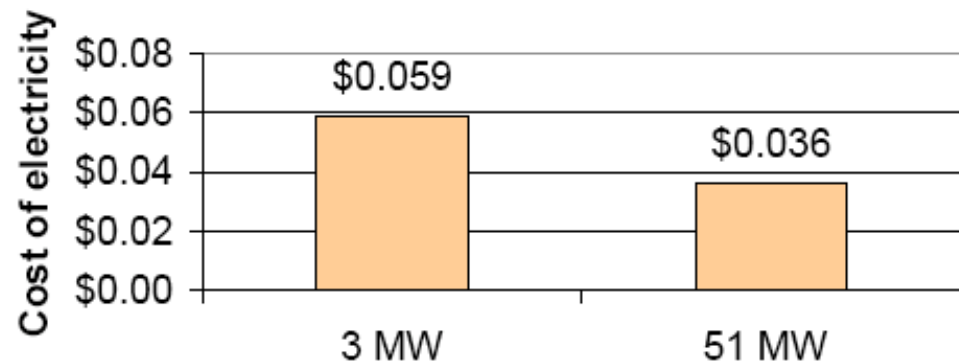
A more efficient wind turbine could tip the energy market in the favor of wind energy

Cost of Wind Energy

Turbine Size vs. Capital Cost vs. Reliability

- 5X rotor diameter ---> 25X annual electricity output
- Wind power is proportional to cube of the wind velocity

**Cost of Energy -- Large
Windfarm v. Small**



The Solution

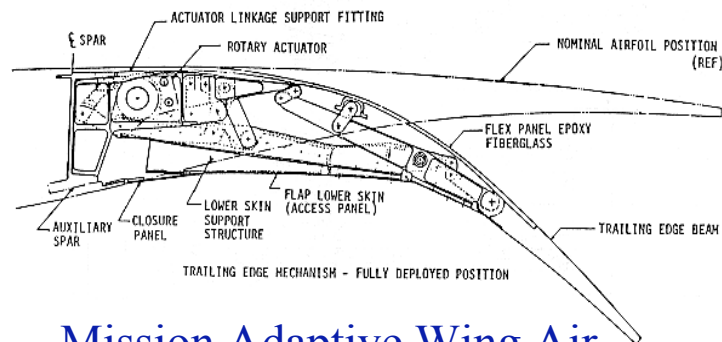
Highly efficient adaptive blades for wind turbines

- Adaptive wind turbine blades which morph on demand offer significant benefits:
 - 80% reduction in structural loads (blade fatigue)
 - 35% increase in turbine performance*
 - 20% reduction in wind energy cost*
- A wind turbine manufacturer with a significantly more efficient blade can significantly increase their market share

*Sources: DoE/Sandia Report, Dale Berg, Sandia

How it Works

***Simplicity by design...Lightweight, low power,
no moving parts***



Mission Adaptive Wing Air
Force Research Labs, 1987

Too Complex and Too heavy



FlexSys Adaptive Compliant
Wing, 2006

Video clip

The Market

The market for wind turbine blades is significant and growing

- 22% average growth over last 5 years (2001-2006)
- 11,700 MW installed in the US by 2006
- 3000 MW will be installed in 2007 alone in the US
- 2008 worldwide market projection -- \$50Billion

Targeted Market

FlexSys has targeted 1.5MW Turbines

- Market size \$3.6Billion (in 2006)
- 17% of turbines installed in 2006 are greater than 2MW

Year	2004	2005	2006
Total MW supplied	8,508	11,338	16,007
Product (Size range)	% of total MW		
"Small WTGs" <750 kW	5.4%	3.6%	2.4%
"One-MW " 750-1500 kW	50.9%	48.2%	43.3%
"Mainstream" 1501-2500 kW	42.8%	45.8%	49.9%
"Multi-MW Class" >2500 kW	0.9%	2.4%	4.3%
Total	100.0%	100.0%	100.0%

Source: BTM Consult ApS - March 2007

Competitors

Currently there are a limited number of competitive technologies

- Turbines have become too large for passive control
- Several recent attempts at *active control* did not result in practical solutions
- Significant blade load alleviation by applying span-wise distributed load control devices
- Design challenges: Reliability, Cost

Competition – Technological comparison
The FlexSys solution is superior on all significant customer metrics

Customer Needs	Competing Technologies	FlexSys Technology
Cost of Energy	Passive Blade Control	Active Blade Control
Reliability	Conventional flaps	Compliant Flap
Scalability	Not Scalable	Scalable
Weight and Complexity	High	Low

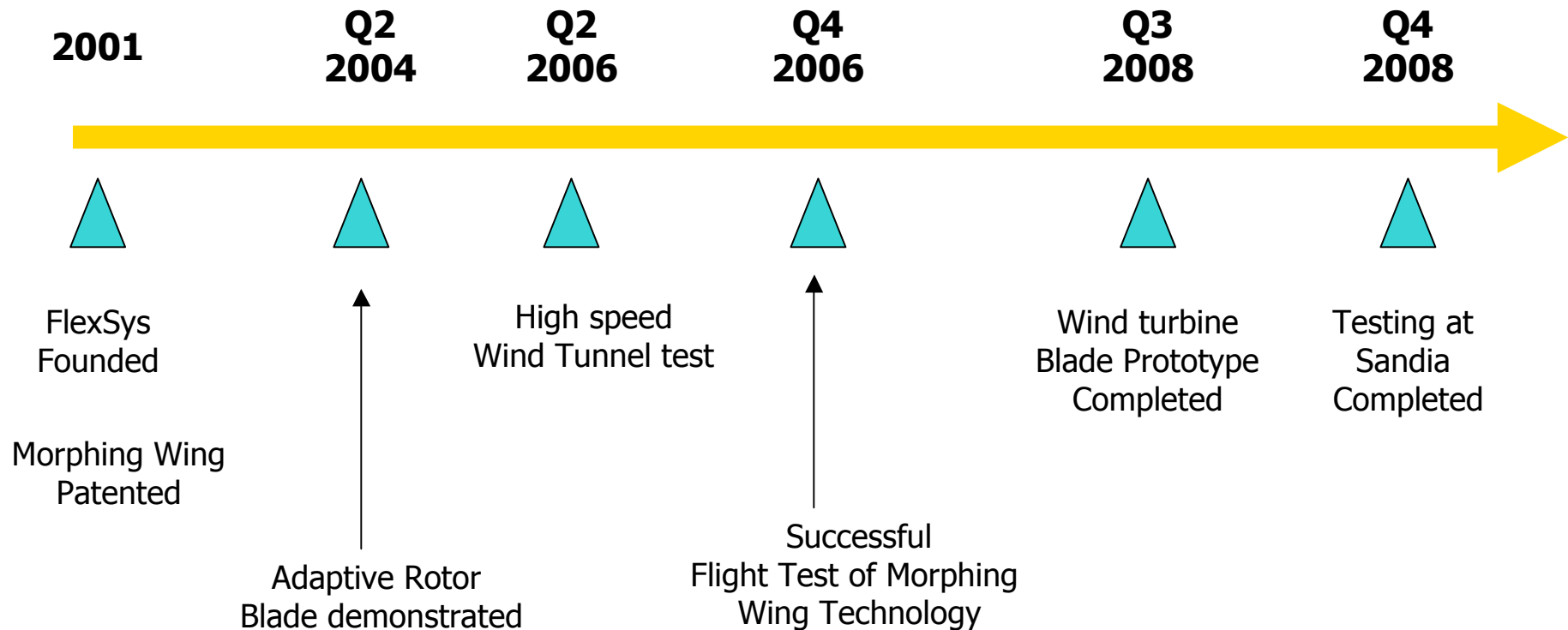
Competitive Advantage

The applicable technologies are well protected under intellectual property laws

- Technology of morphing airfoils is patented worldwide and is available for licensing through FlexSys Inc.
- Background Technology for Active Flow Control (a complementary technology for improving efficiency) is licensed to FlexSys through University of Michigan

Key Technology milestones

We anticipate having a product ready for market by Q4 2008



QUESTIONS

Sridhar Kota
FlexSys Inc.
Ann Arbor, MI
<http://www.flxsys.com>