

North American Wind Energy Academy Meeting – an Industry Perspective

August 8, 2012

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GE Energy

&

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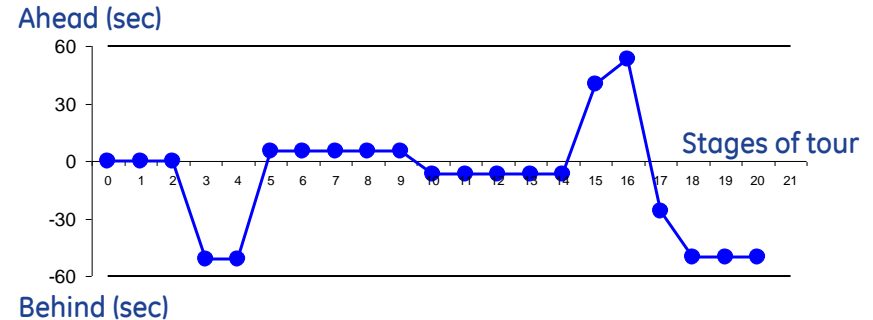


A Story of Technology - 1989

1989 Tour de France (23 days, 2,025 mi)

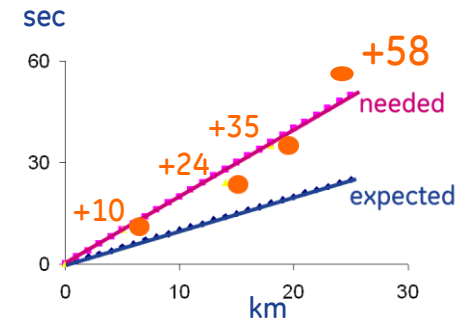
Greg Lemond

- Underdog
- 50sec behind entering last day



Last Day Time Trial – 15.2mi

- Consensus – best could pick up was 25 sec
- Finished in 26min 50 sec – Avg 34 mph!!!
- Gained 58 sec, won tour by 8 sec

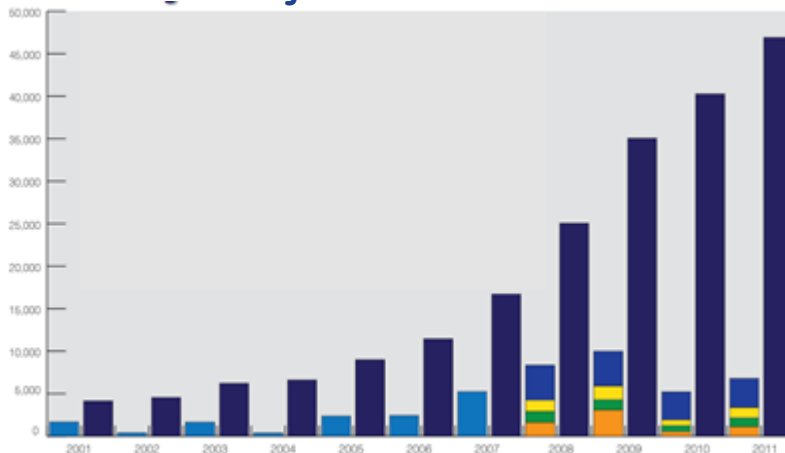


The Rest of the Story - Technology

- Aero bars – up to 60 sec
- Aero helmet – up to 15 sec

What a Difference a Decade Makes!!!

U.S. Wind Projects Installations



Source: AWEA U.S. Wind Industry Annual Market Report Year End 2011

46,916 MW
Total Wind Installations

35%
5-yr avg annual growth

Growth Enabled by . . .

. . . Technology

. . . Research and development

. . . Innovation

. . . Engineers

GE Renewables ...

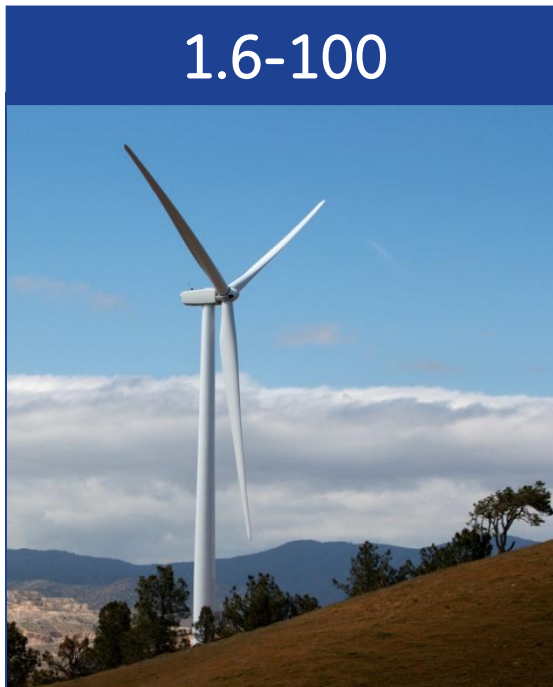
World's most efficient & reliable wind turbine fleet

- ✓ 27GW+ installed ... ~18k WTGs in 22 countries
- ✓ 98%+ availability
- ✓ Energy capture ↑50%



HOFF

GE products ... customer value through technology



- Swept Area: +47% (vs 1.6-82.5)
- AEP: +19% (@ 7.5 m/s)
- GCF: 53% (@ 7.5 m/s)



- Swept Area: +6% (vs 2.5-100)
- AEP: +9% (@ 8.5 m/s)
- Low Noise Trailing Edge

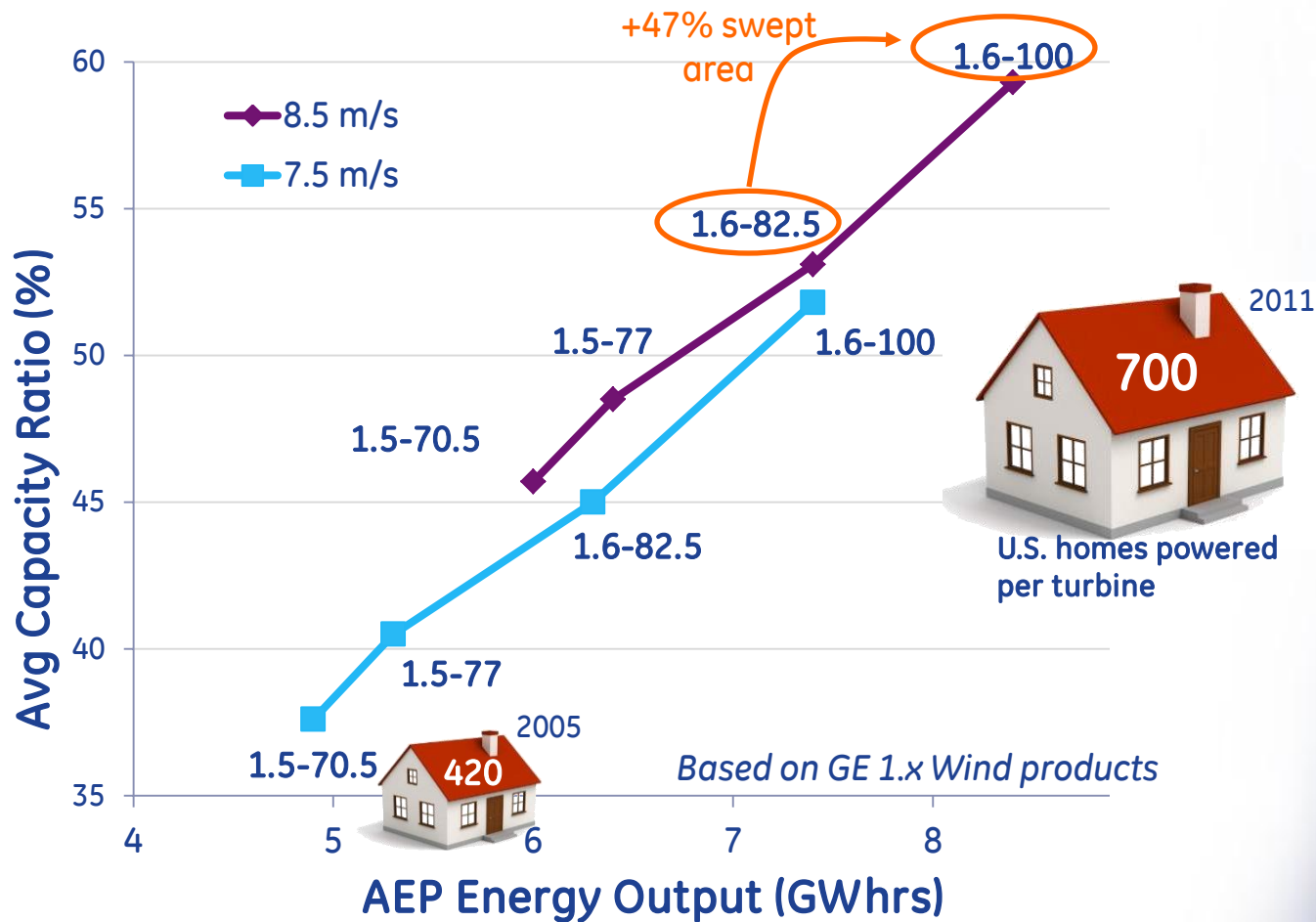
Technology Drives Wind Performance



	'02	'11
AEP (GWh/yr)*	6.0	11.6 +94%
Availability (%)	85	98 +15%

(* @8.5m/s AMWS)

Technology Brings Value to Customer



Sources of Technology, R&D, Innovation

Universities



Industry



National Labs



Department of Energy



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Validation by Test and Learn – a Must for any Engineer

Shaft



Pitch Bearing



864-242-0164

Bedplate



Gearbox



Key US Validation Facilities

NREL (CO) – drive train & blade test



MA Clean Energy Center – Blade Testing

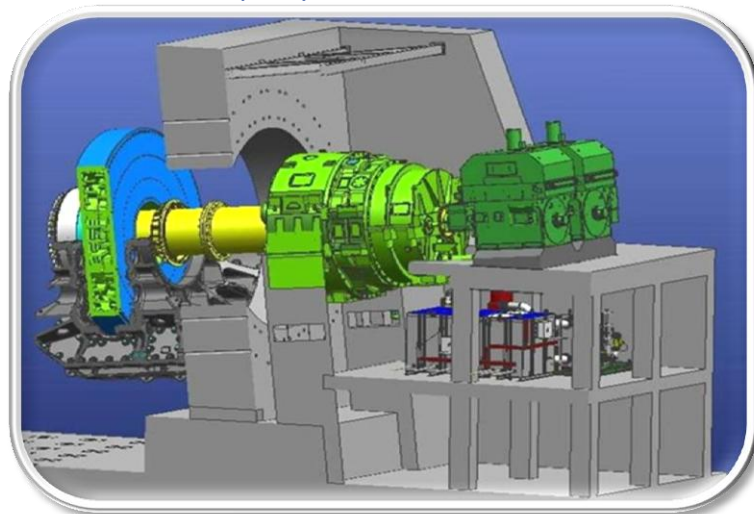


Courtesy Clean Energy Center

Clemson (SC) – Drive train test



Courtesy National Renewable Energy Laboratory



Courtesy Clemson University

AWEA R&D Committee - Technology Needed . . . 3 yrs . . . 5 yrs

Component Technology

- Adv drivetrains
- Adv blades – aero & mechanical
- Adv manufacturing
- Adv towers

Grid Integration

- Flexibility, intermittency
- Weather forecasting
- Wind farm operation

Transmission Capacity

Technical Workforce for Tomorrow

- Engineers
- Technicians

Siting Issues – understanding & solutions

- Wildlife interactions
- Radar interactions

Small Wind Technology

- Materials, components, manufacturing
- Certification

Offshore Wind

- Unique technical challenges –
- Siting & permitting with government agencies
- Early demonstrations

**Reduce Cost of Electricity & Address Siting
Constraints or Barriers**

Technologies Needed ... 3 yrs ... 5 yrs

Wake interactions ... extending Wind performance

Turbine centric view

Design



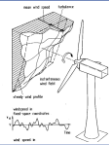
Design as
standalone unit

Micrositing



Optimize layout for
max AEP/min COE

Due
Diligence



Turbine Suitability
Analysis, Mechanical
Loads analysis

Operation



Operate as
independent units
in wind farm

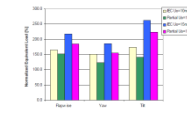
Farm level approach



Design for *op. in*
wind farm



Very large farms
Terrain interaction
Farm interactions



Remove excess
margins



Cooperative
operation, park
level control

Adv. prediction
capabilities

Learning from
data

New technology
developments

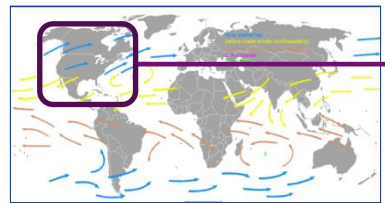
Technologies Needed ... 3 yrs ... 5 yrs

Tools ... innovate by understanding the physics

Retaining physics through boundary interfaces

Global
(1Mm)

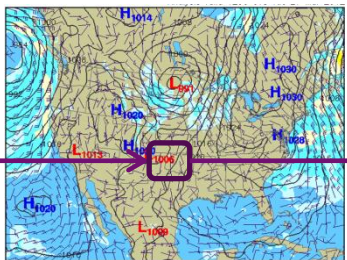
TODAY:
Mesoscale



Source: Wikipedia

Regional
(100km)

Mesoscale

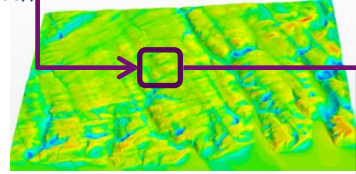


Source: NOAA Aviation Weather Center
(<http://aviationweather.gov/adds/winds/>)

Park
(10km)

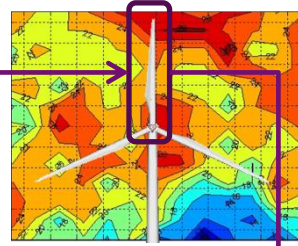
Linear modeling
CFD (RANS)
DES/LES
Multi-physics

- Actuator disk
- Vortex models



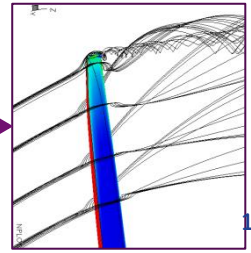
Turbine
(100m)

BEM
Modal
Vortex models
Multi-body
FSI



Blade
(1m)

BEM
Vortex models
CFD (RANS)
DES/LES
FSI





Technology

... R&D

... Innovation

... Engineers

- Key to getting here
- Key to going forward

Thank You

