# GE's Installed Wind Fleet

**USA**
(12,081 units/18,124 MW)

**Canada**
(936 units/1,411 MW)

**Europe +Turkey** –
16 Countries
(3,055 units/5,094 MW)

**China**
(747 units/1,121 MW)

**Japan**
(290 units/478 MW)

**17,000+ WTGs, 27GW+ installed … 22 countries**



As of 3Q, 2011

# GE global research footprint

## 5 global research centers

Niskayuna, New York

Munich, Germany

Shanghai, China

Bangalore, India

Rio de Janeiro, Brazil

### Highlights

- 2,600 research employees (nearly 1,000 PhDs)
- 27,000 GE technologists worldwide
- $5.7B technology spend
- 700+ renewable energy patents filed since 2002

**Global research driving advanced technology solutions**

imagination at work

# Component Test Lab – Greenville, SC

- Test equipment utilizes real wind turbine field data
- Validates robust design
- Expertise from Thermal heritage

**Gold standard lab test facility**

imagination at work

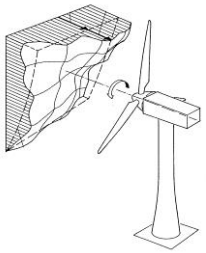
## Basic Physics of Wind Resource

Power = f (Air density * Velocity ^ 3 * Radius^2 )

# Advanced Loads Control (ALC)

## ALC is a load mitigation strategy

1) Optimizes turbine performance and energy capture by pitching each blade individually .,.. Measures and calculates the effects of the wind throughout the blade rotation.



2) Controls the tower movement through generator torque and blade pitch

## Where Used

- 2.75-100 & 103
- 2.5-100 & 103
- 1.6-82.5
- 1.5-77

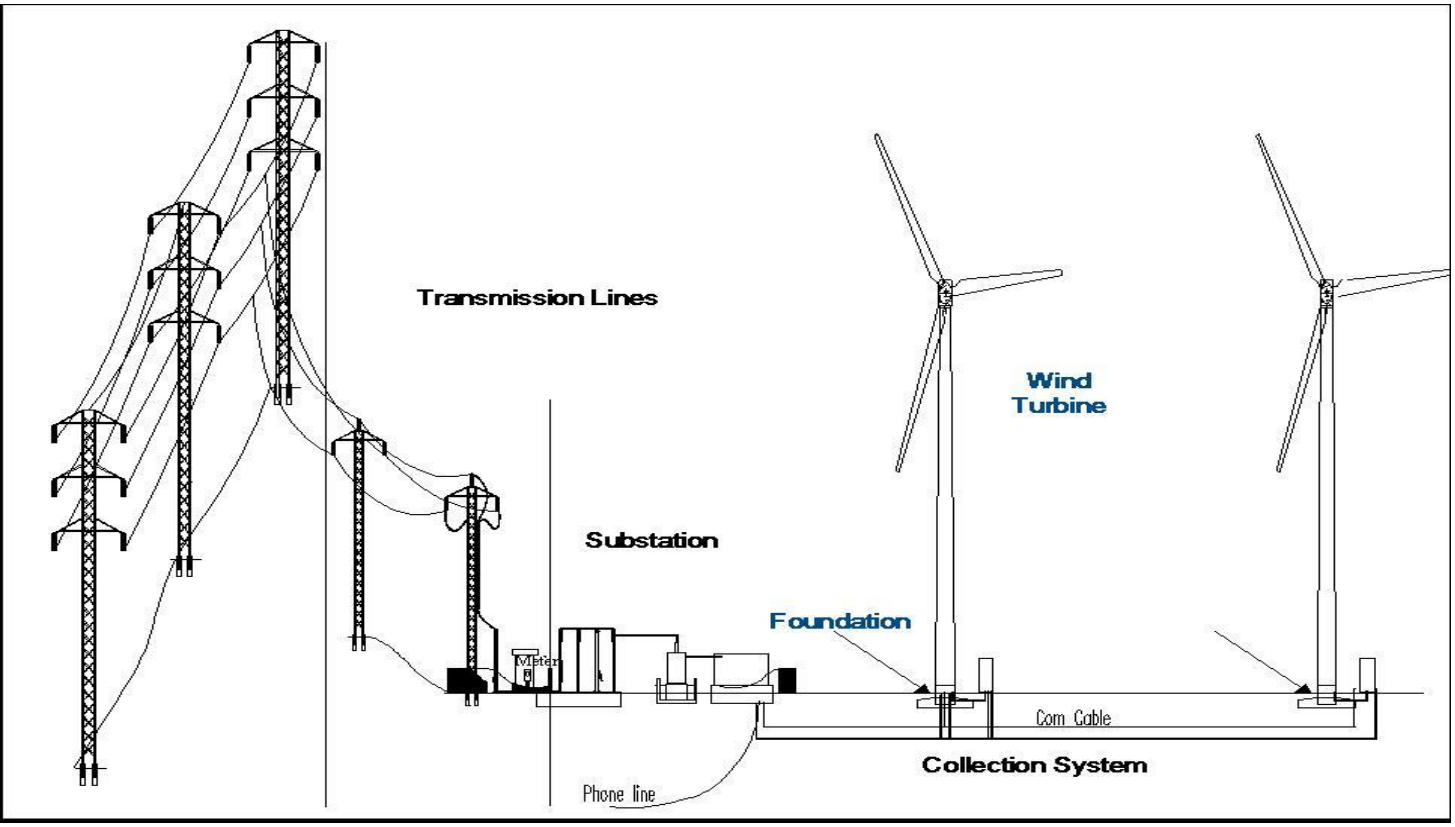
## Customer Benefit

- Increases energy capture to provide more revenue generation.
  - Higher capacity factor and AEP
  - Optimizes land utilization for turbine siting
  - Increases performance envelope by extending cutout speed from 20m/s to 25 m/s

## How it works

- Sensors enable improved machine control.
- Sensors allow the control system to adjust generator torque and speed more accurately for fatigue reduction.
- ALC allows individual blade pitching by sensing main shaft deflection

imagination at work




## Wind Farm Basic Layout

- Wind turbine generators
- Pad mounted transformers
- Power cables, control circuits, protection, and SCADA
- Substation transformer
- Point of interconnection

# “Grid Friendly” wind power plant

## Address reliability concerns

Industry leading ride-through technology WindRIDE-THRU™ since 2005

## Improve grid operability & security

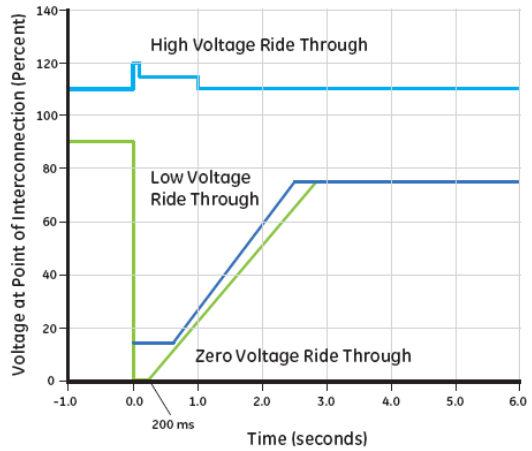
200+ WindCONTROL™ installs, 8,500 turbines

Voltage and Megawatt control

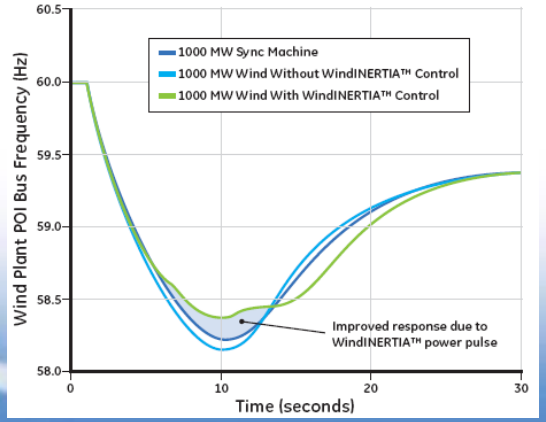
## Enable high levels of wind penetration

WindINERTIA™ – new grid feature by GE

GE's Standard WindRIDE-THRU® Offerings




Simulated System Response Following a Trip of a Large Generator




**Controls technology driving grid leadership**

# Benefits of GE grid integration technology

- Enabling wind farms to behave like conventional power plants
- GE Energy Consulting … recognized leader in grid integration studies and solutions
- Building on power electronics and controls technology utilized across thermal, nuclear, steam, IGCC, aero-derivatives, and renewable energy
- Integrated into turbine design and operation…not “bolt on” to meet grid requirements
- Continued investment to solve grid needs ... at turbine, at plant, across windplants

**Building on a 100+ year history of power plant integration**

imagination at work