Siemens Energy:
The Global Energy Business
Contents

- My career 5 min
- What is Siemens? 10 min
- Energy Biz & Quiz 15 min
- Your career 5 min
- Q & A ??
- Aerodynamics of gas turbines ??
My Background

Ph.D. from Purdue University
- CFD of unsteady aerodynamics in turbomachinery
- United Technologies Research Center (Hartford, CT)
- Developed 3D linearized unsteady CFD code for NASA
- Pratt & Whitney (West Palm Beach, FL)
- Fan and compressor aeromechanics
- Commercial: PW2000 for B757, PW4000 for B777
- Military: F119 for F-22, F135 for F-35/JSF
- Decided not to move back to Connecticut
- Siemens since 2000 in Jupiter, FL
- Flow induced vibrations: compressor, turbine, exhaust
- Aerodynamics technology for compressor & turbine
Interest in gas turbines and aerodynamics

High-school senior

1984

PhD student at Purdue

Assistant Research Engineer

1992

PhD from Purdue

Associate Research Engineer

1994

Transfer from CT to FL

Project Engineer

1997

P&W relocation from FL to CT

Senior Engineer then Principal Engineer

2000

Expert Career Path

Principal Expert Engineer

2007 →

Interest in gas turbines and aerodynamics
Energy engineering is a global business.
Be ready to be part of a global workforce.
Examples of Compressor and Turbine CFD

3D CFD models can show flow separation and identify loss mechanisms.
Compressor stall and surge

Compressors can have stability problems at off-design conditions. At off-design conditions, the flow is not completely compressed, so there is a mismatch between the amount of flow and the volume of the flow path.

Rotating stall

Surge

Axial velocity at R12 exit Unstable flow
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- **Aerodynamics of gas turbines** ??
Dare to Think BIG …
Megatrends shape our future

Urbanization

By 2030, 60% of the world’s population will live in cities.

Climate Change

Today we face the highest CO₂ concentration in the atmosphere in the past 350,000 years.

Demographic Change

Average life expectancy worldwide will increase to 72 years in 2025 from 46.6 years in 1950.

Globalization

From 1950 to 2004, the volume of global trade increased 27.5 fold.
Siemens is in more than 200 countries

- **Germany**
  - Employees: 117,000
  - Revenue (billions of €): 10.8
  - Major production facilities: 70
- **Americas**
  - Employees: 78,000
  - Revenue (billions of €): 20.9
  - Major production facilities: 77
- **Europe, C.I.S., Africa, Middle East (excl. Germany)**
  - Employees: 101,000
  - Revenue (billions of €): 29.1
  - Major production facilities: 68
- **Asia, Australia**
  - Employees: 64,000
  - Revenue (billions of €): 15.1
  - Major production facilities: 74

Employee figures as of December 31, 2013; Revenue and production sites, FY2013
All numbers refer to continuing operations
Due to rounding, numbers may not add up to precisely 100
What Siemens Does…

**Energy**
- Fossil Power Gen
- Wind Power
- Oil & Gas
- Energy Service
- Power Transmission

**Healthcare**
- Imaging & Therapy Systems
- Clinical Products
- Diagnostics
- Customer Solutions

**Industry**
- Industry Automation
- Drive Technologies
- Customer Services

**Infrastructure & Cities**
- Rail Systems
- Mobility and Logistics
- Low & Med Voltage
- Smart Grid
- Building Technologies
Our vision
To provide answers to the great challenges of our time

Siemens is the pioneer in:
- Energy efficiency
- Industrial productivity
  - Healthcare
  - Infrastructure

Siemens plans for the future:
- Electrification
- Digitization
- Automation
Electrification:
Siemens supports the entire energy conversion chain
Continuous development of gas turbine and combined cycle technology: Efficiency has seen a 10% increase in last 20 years.
The world's largest gas turbine: SGT5-8000H
Comparison of performance

1 Turbine blade = 10 Porsche
1 Gas turbine = 1100 Porsche or 13 engines of a 747
1 Combined cycle power plant = 1715 Porsche or 20 engines of a 747

Upgrading power plant to 8000H eliminates 40k tons of CO2 annually (80k cars)

Entry in the Guinness Book of World Records (2007)
The 154 m rotor for the 6.0 MW is a large piece of equipment ... larger than an Airbus A380
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Energy Quiz:
Fabulous prizes
Energy Quiz:  
The Electrification Business

How many people on Planet Earth?  7,091,000,000
How many people have NO access to electricity?  1,317,000,000

Table 1: Electricity access in 2009 - Regional aggregates

<table>
<thead>
<tr>
<th>Region</th>
<th>Population without electricity (millions)</th>
<th>Electrification rate (%)</th>
<th>Urban electrification rate (%)</th>
<th>Rural electrification rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>587</td>
<td>41.8</td>
<td>68.8</td>
<td>25.0</td>
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<tr>
<td>North Africa</td>
<td>2</td>
<td>99.0</td>
<td>99.6</td>
<td>98.4</td>
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<tr>
<td>Sub-Saharan Africa</td>
<td>585</td>
<td>30.5</td>
<td>59.9</td>
<td>14.2</td>
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<tr>
<td>Developing Asia</td>
<td>675</td>
<td>81.0</td>
<td>94.0</td>
<td>73.2</td>
</tr>
<tr>
<td>China &amp; East Asia</td>
<td>182</td>
<td>90.8</td>
<td>96.4</td>
<td>86.4</td>
</tr>
<tr>
<td>South Asia</td>
<td>493</td>
<td>68.5</td>
<td>89.5</td>
<td>59.9</td>
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<tr>
<td>Latin America</td>
<td>31</td>
<td>93.2</td>
<td>98.8</td>
<td>73.6</td>
</tr>
<tr>
<td>Middle East</td>
<td>21</td>
<td>89.0</td>
<td>98.5</td>
<td>71.8</td>
</tr>
<tr>
<td>Developing countries</td>
<td>1,314</td>
<td>74.7</td>
<td>90.6</td>
<td>63.2</td>
</tr>
<tr>
<td>World*</td>
<td>1,317</td>
<td>80.5</td>
<td>93.7</td>
<td>68.0</td>
</tr>
</tbody>
</table>

*World includes OECD and Eastern Europe / Eurasia
GDP and power consumption are climbing together

Source: Global Insight, Siemens
The markets are shifting –
Growth primarily in emerging countries

China and India together are adding more power generation capability than the rest of the world combined.

Source: Siemens ¹) SWE, NWE, GER, CEE
Energy Quiz: How big is the global electricity business?

By 2030 global demand will increase 67% - Why?

Power generation mix worldwide, in TWh

<table>
<thead>
<tr>
<th>Source: Siemens</th>
</tr>
</thead>
</table>

- **2011**
  - Coal: 41%
  - Gas: 22%
  - Oil: 4%
  - Nuclear: 13%
  - Water: 16%
  - Renewables: 4%

- **2030**
  - Coal: 34%
  - Gas: 24%
  - Oil: 3%
  - Nuclear: 11%
  - Water: 15%
  - Renewables: 13%

- **37,100 TWh**
  - +2.8% p.a.
  - Total 2030 forecast: 22,100 TWh to 37,100 TWh (67% increase)

- **Why?**
  - Population growth
  - Urbanization
  - Economic development
  - Growing middle class

Source: Siemens
Energy Quiz:
How many power plants & renewables will be built?

Electricity production doubles in 20 years

Capacity must grow by 100%, even though we just said demand will increase by 67%.
Why does it have to be greater?

- renewables have low availability
- renewables are not demand responsive
- maintenance outages
- meet peak demands


Source: Siemens
How big is the Energy business?

How much will be invested annually in Energy worldwide over next 20 years?

Cost to de-carbonize ~ $45 Trillion
At this rate it takes ~ 300 years

Primary energy: $650–910 B
Power generation: $390 B
Power grids: $260 B

$1.3 Trillion per year

Source: IEA 2010; Siemens
How is electricity produced and consumed in the US

Numbers are Quadrillion BTUs

We can reduce energy consumption by reducing conversion losses.

Source: US DOE Energy Information Administration
Data for 2011
Energy Quiz:
Why move wind power offshore?

Why offshore?

Advantages
- Out of site
- No noise complaints
- Stronger winds
  - 2X wind → 8X power

Disadvantages
- Difficult installation
- Corrosion
- More expensive maintenance
- Power transmission difficulty

Offshore wind power has both advantages and disadvantages.
Power Transmission Innovations

We also need innovations in power transmission, not just generation.
What about innovation for greenhouse gases?

The EPRI wedge – CO2 emissions, how to reduce it, and by how much?

We need multiple innovations if we are to reduce CO2 in the atmosphere.
Energy quiz
Why not put the CO₂ in the ground?

Why not just capture all of the CO₂ from power plants and be done with it? Answers include: a) engineering challenges, b) costs, c) policy

CO₂ options

Enhance Oil Recovery
market driven CO₂ option

Currently >250,000 bbls/day in the US
Summary of the energy business

Mid- and long-term increase in demand for power world wide

Fossil fuels will continue as the backbone of our energy infrastructure for generations to come

Renewable energy will grow as part of the world-wide energy mix

We will move towards an electrical society, with growing but not universal access to electricity

No silver bullet, we need “all of the above” to meet the growing demand for electricity and reduce our carbon footprint
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Where does innovation come from?

Advances that will transform life, business and the global economy

- Mobile Internet
- Automation of knowledge work
- Internet of Things
- Cloud technology
- Advanced robotics
- Autonomous and near-autonomous vehicles
- Next-generation genomics
- Energy storage
- 3D printing
- Advanced materials
- Advanced oil and gas exploration and recovery
- Renewable energy

Source: May 2013 report by McKinsey Global Institute
Where you could fit in...

Career Opportunities in Energy at Siemens:

- Electrical Engineering
- Mechanical Engineering
- Material Engineering
- Civil Engineering
- Chemical Engineering
- Industrial Engineering

Education is the Key to a Successful Career in the Energy Business
What you need to know…

Such Math
Much Physics
Many Engineering
Very Computers
and how to explain it

Education is the Key to a Successful Career in the Energy Business
Summary of Siemens Energy

The Future of Energy

- Global
- Growing
- Diverse
- Greener & Cleaner

Siemens Energy

- Global
- Growing
- Diverse
- Greener & Cleaner
Siemens Energy -
Clean electricity for the world

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Questions?