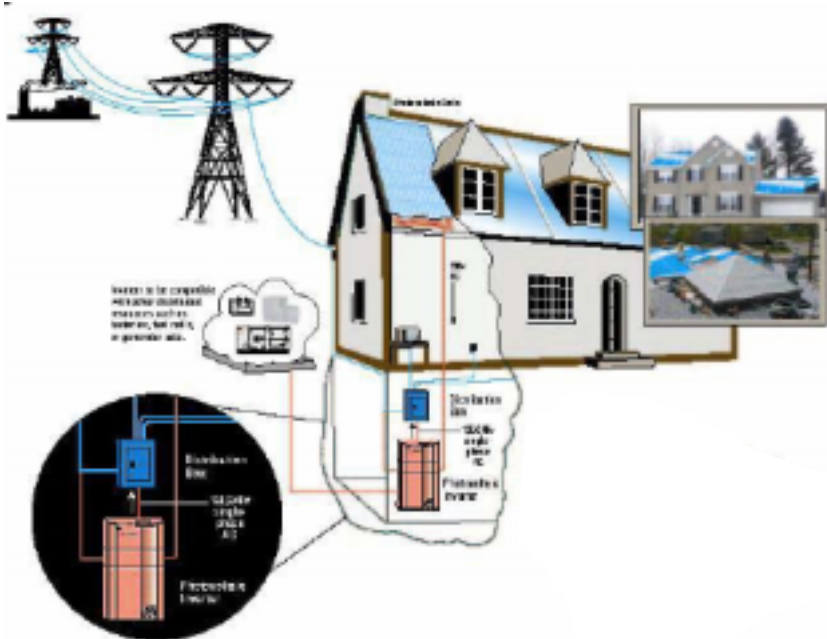


GE High Reliability PV Inverter Initiative

DOE High-Tech Inverter Workshop

Baltimore, Maryland, October 13 and 14, 2004



Joseph Smolenski (smolenski@crd.ge.com)
GE Global Research Center
Niskayuna, NY



A Company with an Innovative Heritage

112-Year-Old, High-Tech,
Growth Company

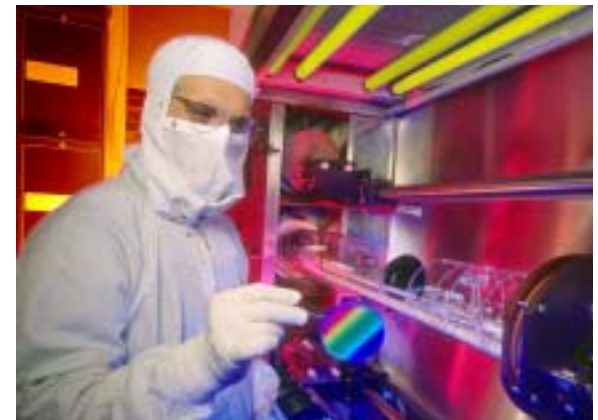
\$132 Billion in Annual Revenues

Only Company Listed in Dow
Jones Index Today That Was in
Original List in 1896

315,000+ Employees Worldwide



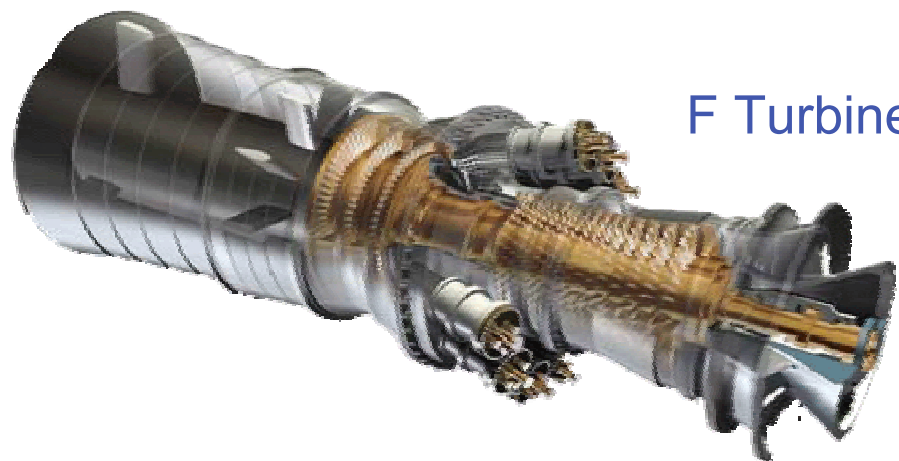
1892



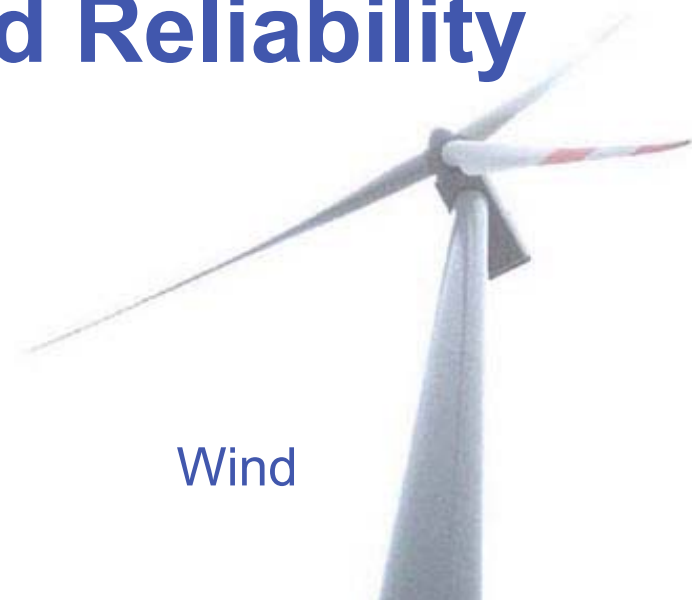
2004

Energy...

Efficiency, Emissions and Reliability



F Turbine

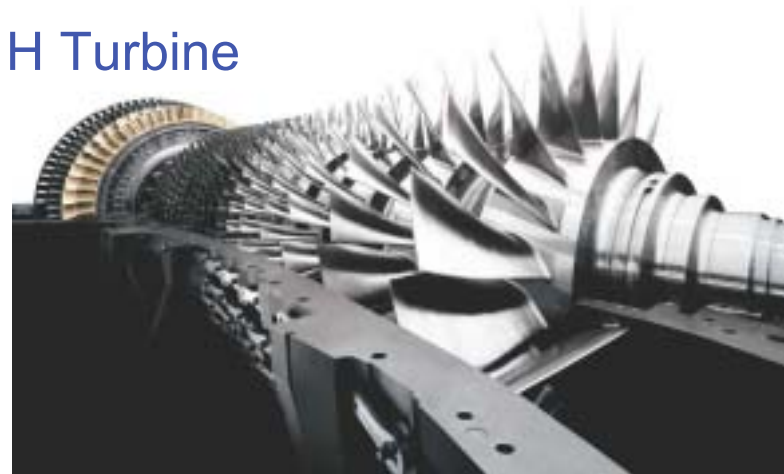


Wind

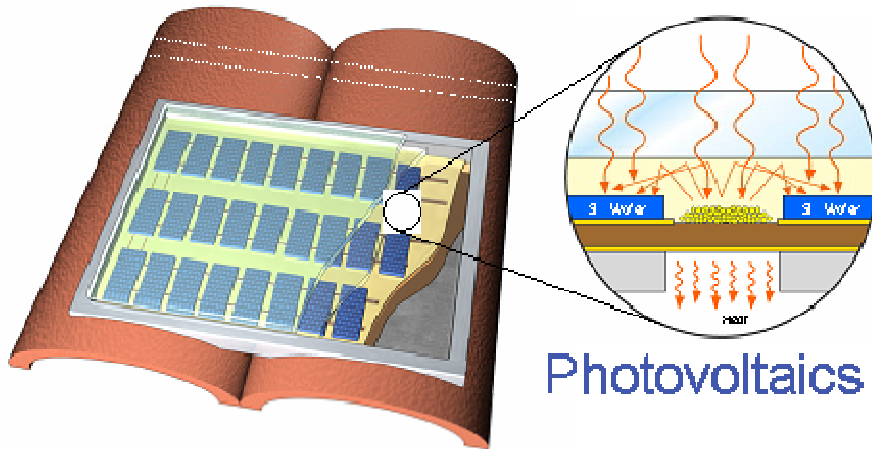


Steam Turbine

H Turbine

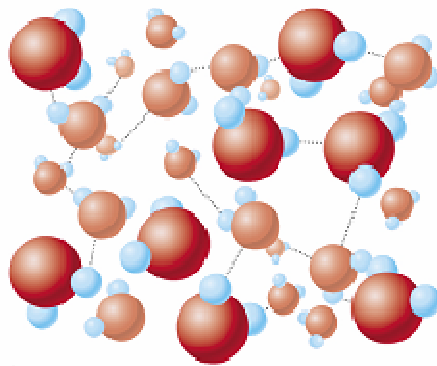


Energy... Environmental Impact



Photovoltaics

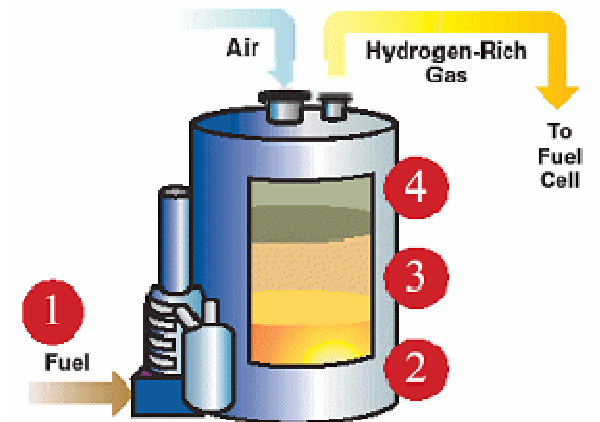
Fuel Cells



(8)
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Hydrogen



PV System Issues Today

- **Overall System Cost**
- **Architectural Appearance**
- **Lack of Completely Integrated Systems**
- **Poor Compatibility with Building Construction**
- **Large Scale Manufacturing**
- **Inverter Reliability**
- **Inverter Performance**

GE and Sandia National Laboratories High Reliability Inverter Program



- Customer Inputs
- Requirements
- Concept Design
- Tradeoff and Selection

- Marketing Update
- Detailed Design
- Reliability Analysis
- Prototype Fabrication
- Validation
- HALT Testing
- Manufacturing Planning

- Transition to Manufacturing
- Agency Certification
- Reliability Growth Testing

Key Project Goals

- Mean Time to First Failure >10 Years
- Cost < \$0.90 per watt @ 10,000 Units per year
- 1-10 kW
- Peak Efficiency >94%
- UL1741 Listing
- Meet Codes and Standards

Design For Reliability

➤ GE Design For Six Sigma Process

- Design process enables requirements to be met under worst case conditions, accounts for component and process variability.

➤ Requirements

- Specified I/O disturbances and “real world” disturbance data.
- Operating and fault modes.
- Failure Modes and Effects Analysis (FMEA).

➤ Component Selection and Derating

- Voltage, Current, Junction Temp, Power. (e.g. BJT derate 60% V_{max})
 - e.g. MIL-STD-975M, MIL-STD-1547B, JPL D-8545B, NAVMAT P-4855-1A.
- Extra Cost vs. Derating and Reliability – Dilemma.

➤ Product Design

- Thermal – component temperatures.
- Design for Reliability – voltage spacing, shock, vibration, connections, insulation, hot spot temps, etc.
- Design for manufacturing.

Manufacturing Quality

➤ GE Six Sigma Process

- Evaluate and define controls on manufacturing processes.

➤ GE Supplier Quality Management System

- Develop a manufacturing quality plan
- Qualification of the manufacturing process.
- Continuous feedback on critical to quality items.

➤ ISO 9000/QS9000 Certification.

➤ Design for Manufacturing.

- Work with manufacturers during the design process.
- Compatible tolerances, standard processes.
- IPC2221 design standards for PWB boards.

➤ Field Failure Analysis and Corrective Actions System

- Use Field Failure Data to correct quality problems.

Inverter Technology Ideas

- **Advanced Switching Components**
 - **SiC Devices**
 - **High Temp**
 - **Lower Losses**
 - **No Reverse Recovery**
 - **Higher Switching Frequency**
- **Improved Capacitors**
 - **Aluminum Electrolytic Wear-Out Mechanism**
- **Reduce Interconnections**
 - **More Integration of functions – “Inverter on a chip”**
- **Improved Thermal Management Techniques**
 - **Lower Max Junction Temperatures**
- **Improved Transient Protection Devices**
 - **Long Term Performance, Cost, Energy Ratings.**



imagination at work



imagination at work