Solar® Turbines
A Caterpillar Company

CHP Solutions to Climate Change

David Schnaars
Manager, Environmental Strategies

California Energy Commission
CHP Workshop
July 23, 2009

Solar® Turbines
A Caterpillar Company

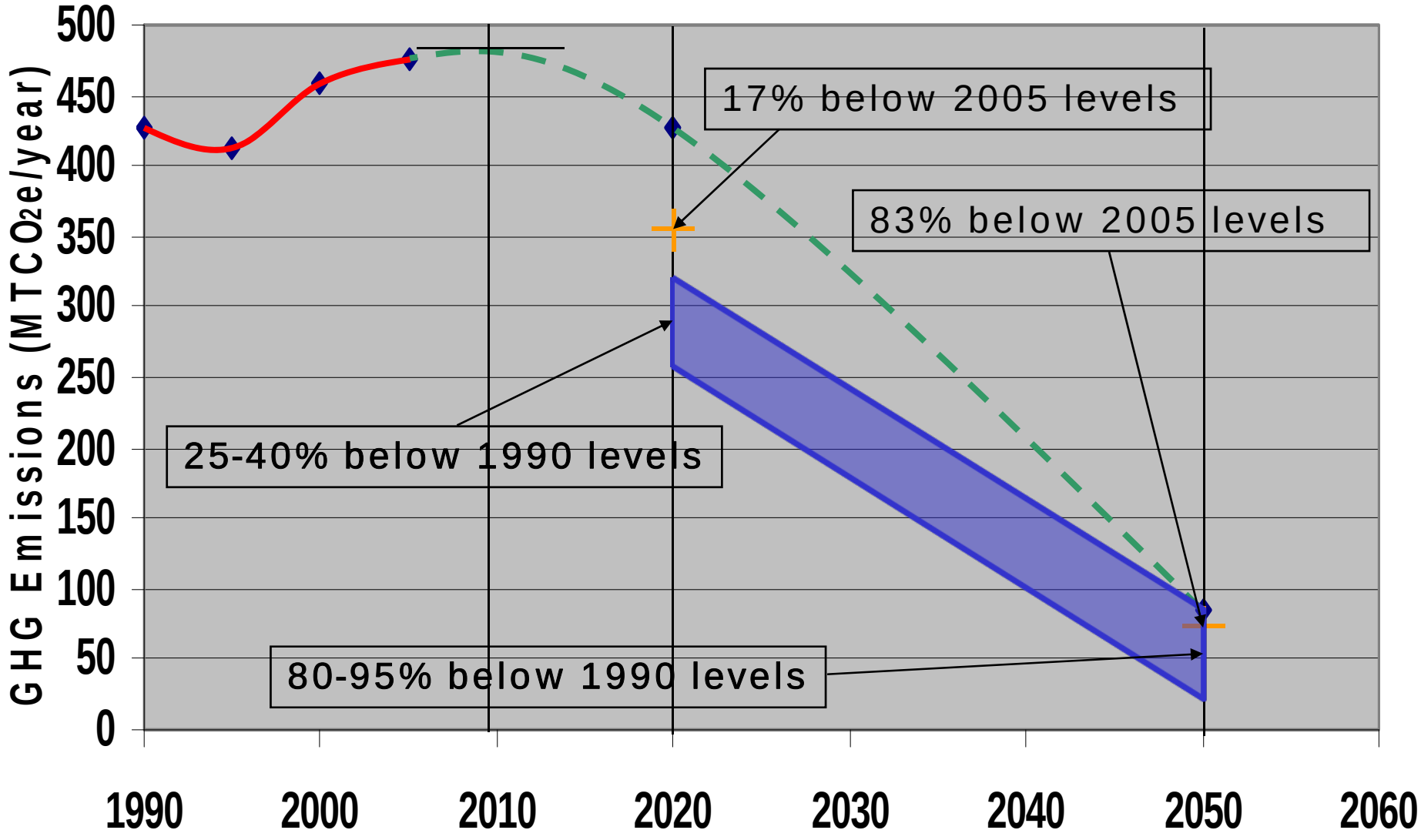
Solar Turbines Incorporated

- Based in San Diego, CA
- In Business since 1927
- More than 12,500 Gas Turbines Operating in 120 Countries
- More than 1.3 Billion Fleet Operating Hours
- World's Largest Manufacturer of Industrial Gas Turbines (1 to 15 MW Range)
- Subsidiary of Caterpillar Inc. since 1981

San Diego, California

Solar Turbines
A Caterpillar Company

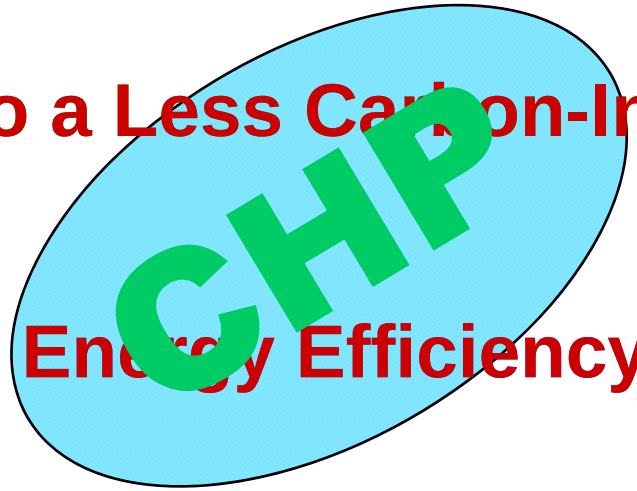
AB 32 GHG Emissions Reductions



Historical Data from ARB California GHG Emissions Inventory

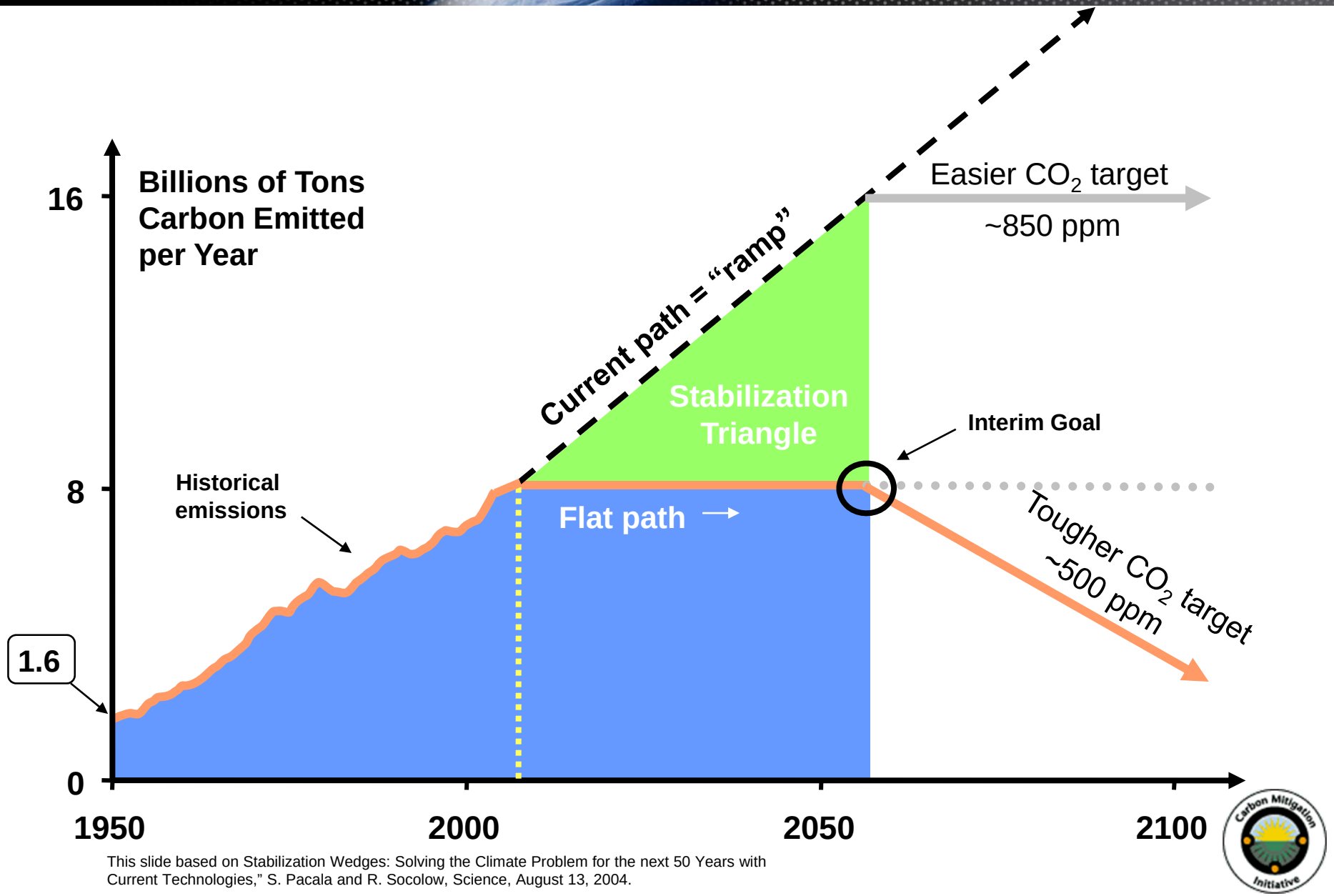
There Are Only 4 Ways to Reduce Greenhouse Gases:

- Switch to a Less Carbon-Intensive Fuel
- Increase Energy Efficiency
- Sequester Atmospheric CO_2
- Reduce Non-CO_2 Gas Emissions



Solar® Turbines
A Caterpillar Company

The Stabilization Triangle



This slide based on Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.

Solar® Turbines
A Caterpillar Company

Wind Electricity

Photo courtesy of DOE

Install 1 million 2 MW windmills to replace coal-based electricity,

OR

Use 2 million windmills to produce hydrogen fuel

A wedge worth of wind electricity will require increasing current capacity by a factor of 30

This slide based on Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.

Carbon Mitigation Initiative

Solar® Turbines
A Caterpillar Company

Solar Electricity

Install 5,000,000 acres for dedicated use by 2055

Photos courtesy of DOE Photovoltaics Program

A wedge of solar electricity would mean increasing current capacity 700 times

This slide based on Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.

Carbon Mitigation Initiative

Nuclear Electricity

Triple the world's nuclear electricity capacity by 2055

Graphic courtesy of NRC

The rate of installation required for a wedge from electricity is equal to the global rate of nuclear expansion from 1975-1990.

This slide based on Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.

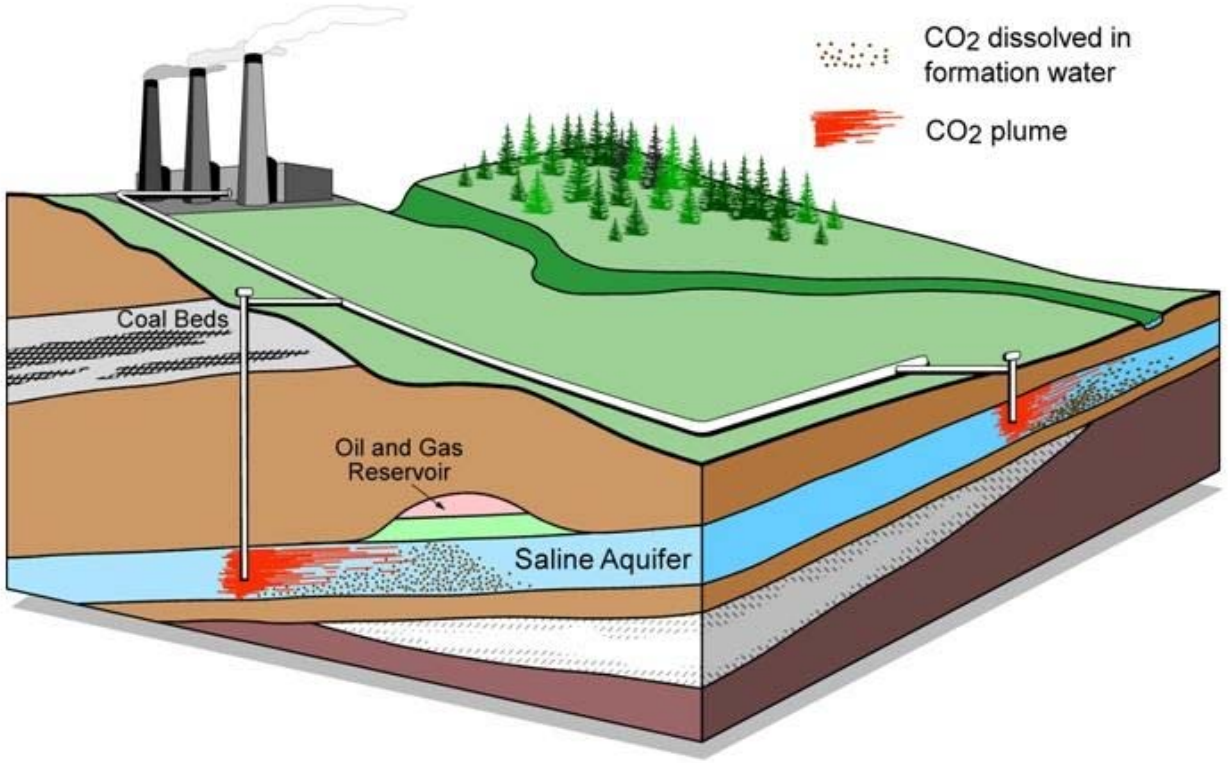
Carbon Mitigation Initiative

Solar® Turbines
A Caterpillar Company

Carbon Capture & Storage

Implement CCS at

- **800 GW coal electric plants or**
- **1600 GW natural gas electric plants or**
- **180 coal synfuels plants or**
- **10 times today's capacity of hydrogen plants**



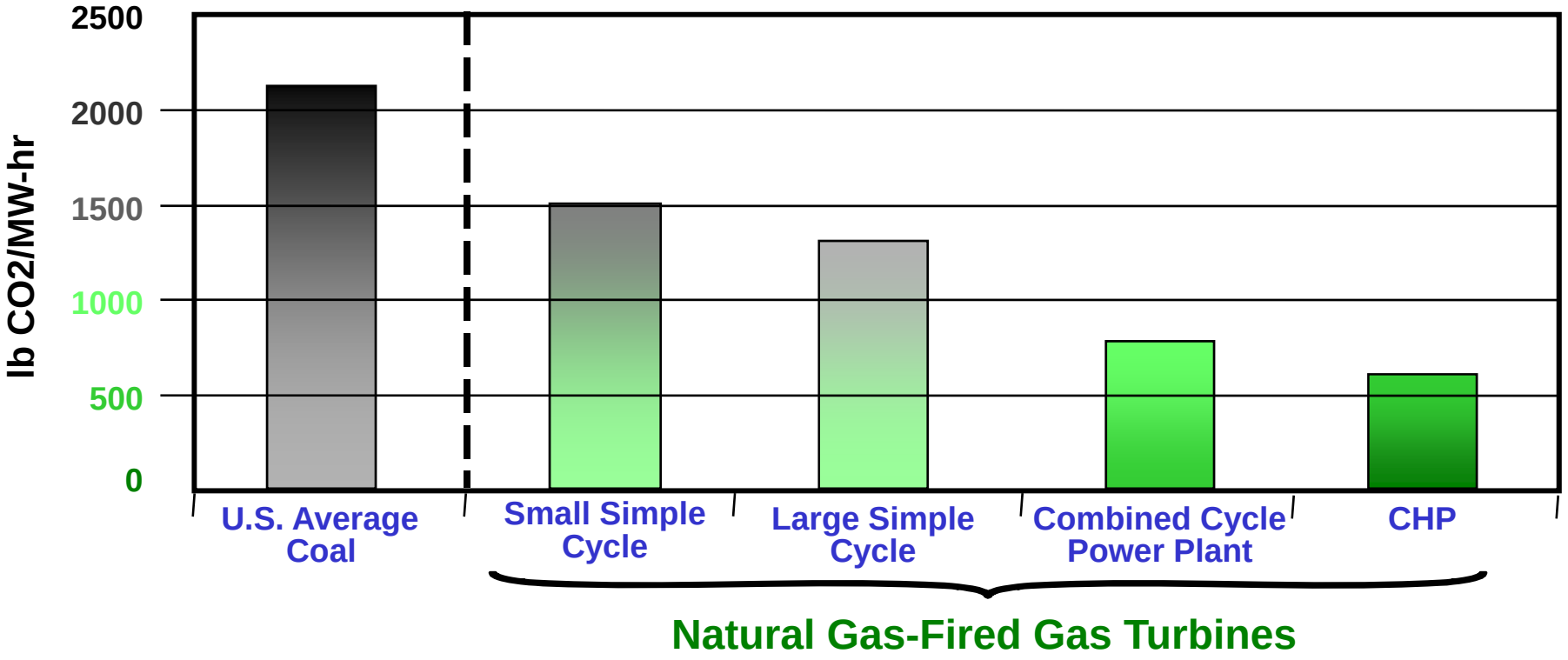
Graphic courtesy of Alberta Geological Survey

There are currently three storage projects that each inject 1 million tons of CO_2 per year – by 2055 need 3500.

This slide based on Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies," S. Pacala and R. Socolow, Science, August 13, 2004.

Carbon Mitigation Initiative

- **NG Is the Least Carbon-Intensive Fossil Fuel:**
  - Coal = 208 lb CO_2/MMBtu (HHV)
  - Distillate Oil = 161 "
  - Natural Gas = 117 "
- **CHP Is Most Efficient Use of Natural Gas**



Solar® Turbines
A Caterpillar Company

Mercury 50 Integrated Energy System

Dell Children's Medical Center of Central Texas
Muller Energy Center of Austin Energy, Austin, Texas

Energy Center Provides Power, Heating and Cooling to Hospital

First Hospital in the World to Obtain LEED Platinum Status

Solar® Turbines
A Caterpillar Company

4.6 MW Centaur 50
California Dairies

Solar® Turbines
A Caterpillar Company

Mercury 50
Bank of America

- **Provides All Heating, Cooling, Hot Water & Steam Needs of NYC's 2nd Tallest Building**
- **Provides for 35% of the Building's Electrical Load**
- **Building Uses 50% Less Energy than Conventional Skyscraper**
- **Expected to Achieve LEED Platinum Rating**

Solar® Turbines
A Caterpillar Company

2 x 5.7 MW Taurus 60's
Talisman Energy, Alberta, Canada

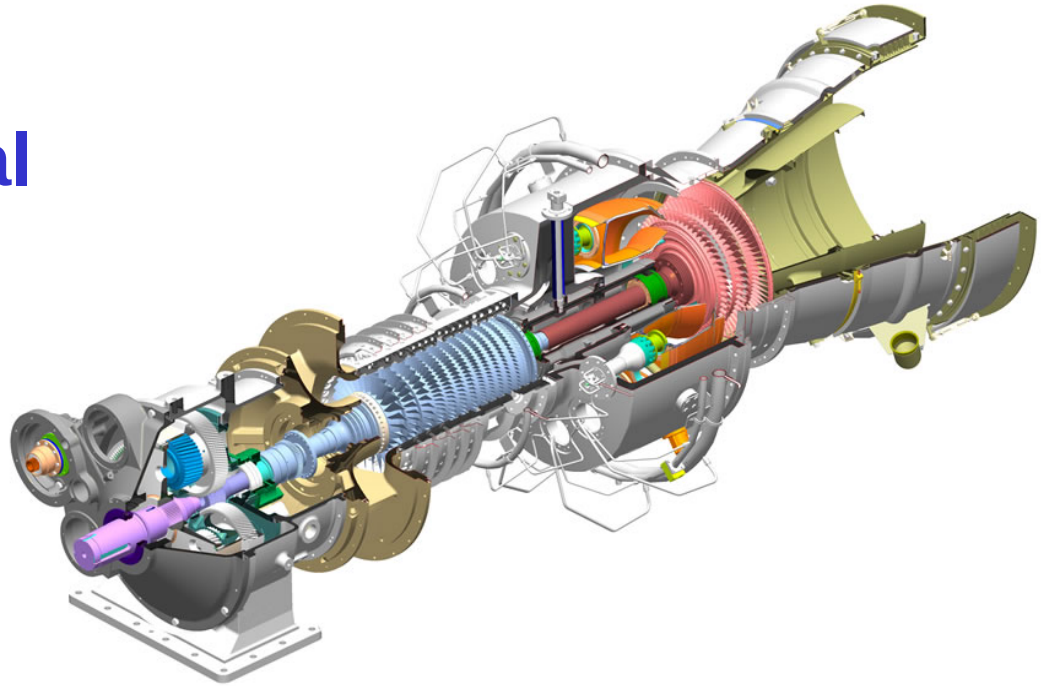
Solar® Turbines
A Caterpillar Company

6.3 MW Taurus 65, Michelin Tire
Hallstadt, Germany

Solar® Turbines
A Caterpillar Company

Taurus 65 Performance

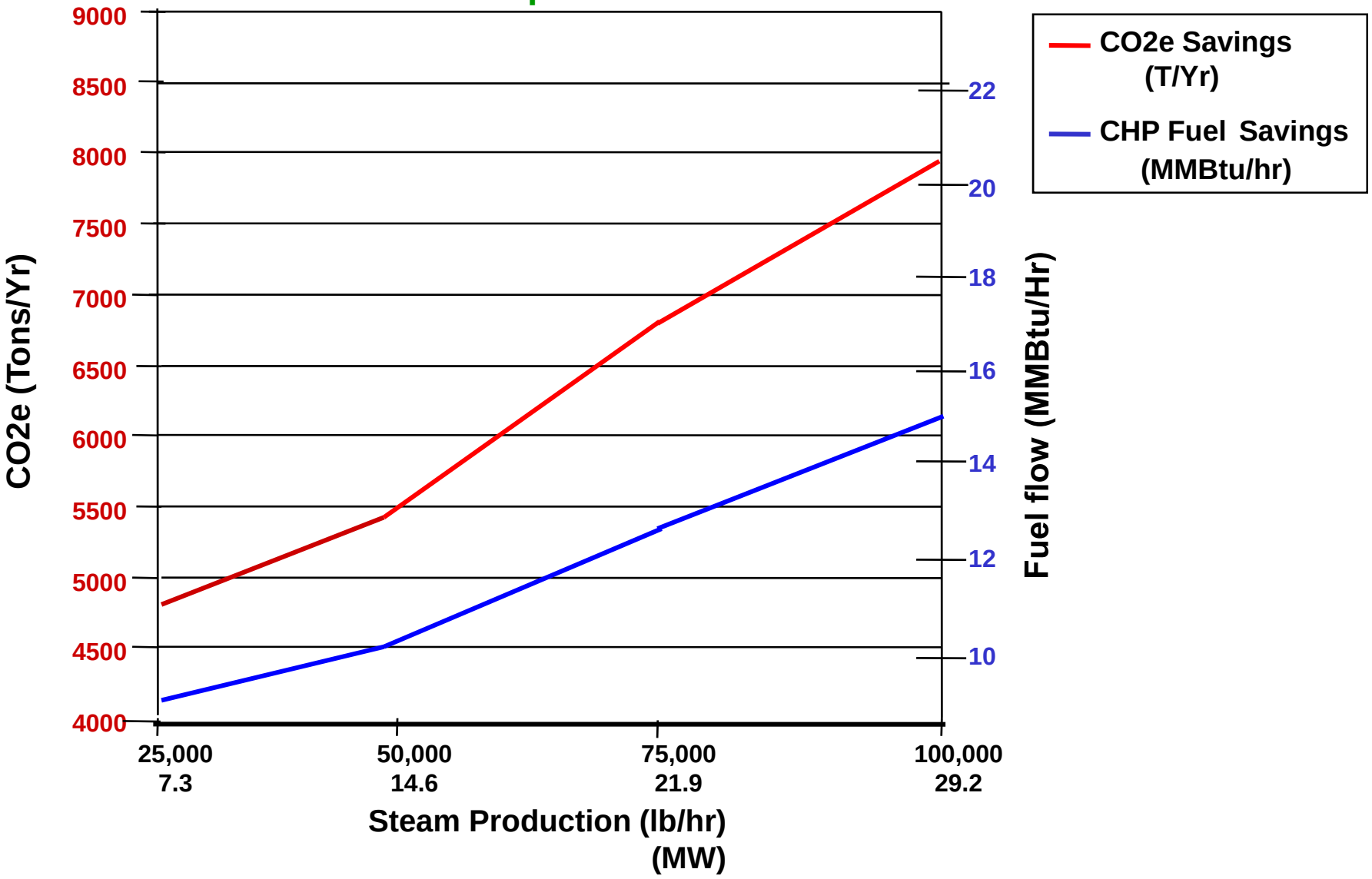
- **Power: 6.3 MW**
- **Simple Cycle Thermal Efficiency: 32.9%**
- **CHP Thermal Efficiency: 84-92%**
- **NO_x Emissions: <15 ppmv with SoLoNOx Combustion**



Solar Turbines
A Caterpillar Company

Taurus 65 - Savings Over Grid

6.1 MW from Combined Cycle Power Plant with Steam from Conventional Boiler Compared to Taurus 65 CHP Plant



Solar® Turbines
A Caterpillar Company

CO_2 Emissions Reductions from CHP

Combined Heat & Power:

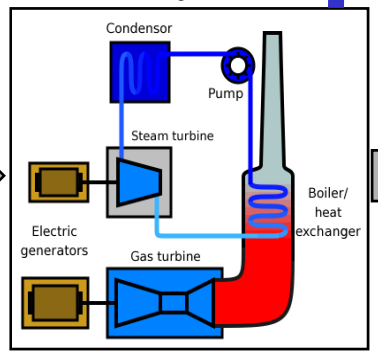
Taurus 65 Gas Turbine

Efficiency: 84%

CHP Fuel (Gas)
117
Lb/MMBtu

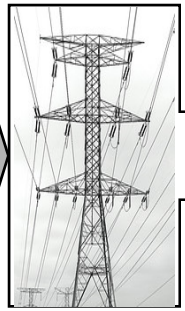
Combined Cycle Generation

Efficiency: 45%

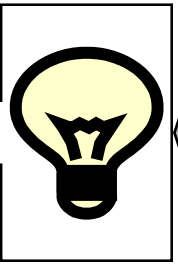


Power Station Fuel (Gas)
117
lb/MMBtu

CO_2 Emissions
19k Tonnes/yr



6.1 MWe



Efficiency: 80%

Boiler Fuel (Gas)
117
Lb/MMBtu

Boiler

Heat

9.2 MWth

Heat

CO_2 Emissions
18k Tonnes/yr

CO_2 Emissions
32k Tonnes/yr

40k Tonnes ...TOTAL ANNUAL CO_2 EMISSIONS... 32k Tonnes

8,000 Tonnes Saved/Year

Solar® Turbines
A Caterpillar Company

CHP As a Solution to Climate Change

- Today's Technology
- Flexibility to Fit a Variety of Applications
- High Efficiency Equates to Low GHG Emissions
- Also Has a Low Criteria Pollutant (NOx, CO) Signature