



Solar Turbines

A Caterpillar Company

CHP Solutions to Climate Change

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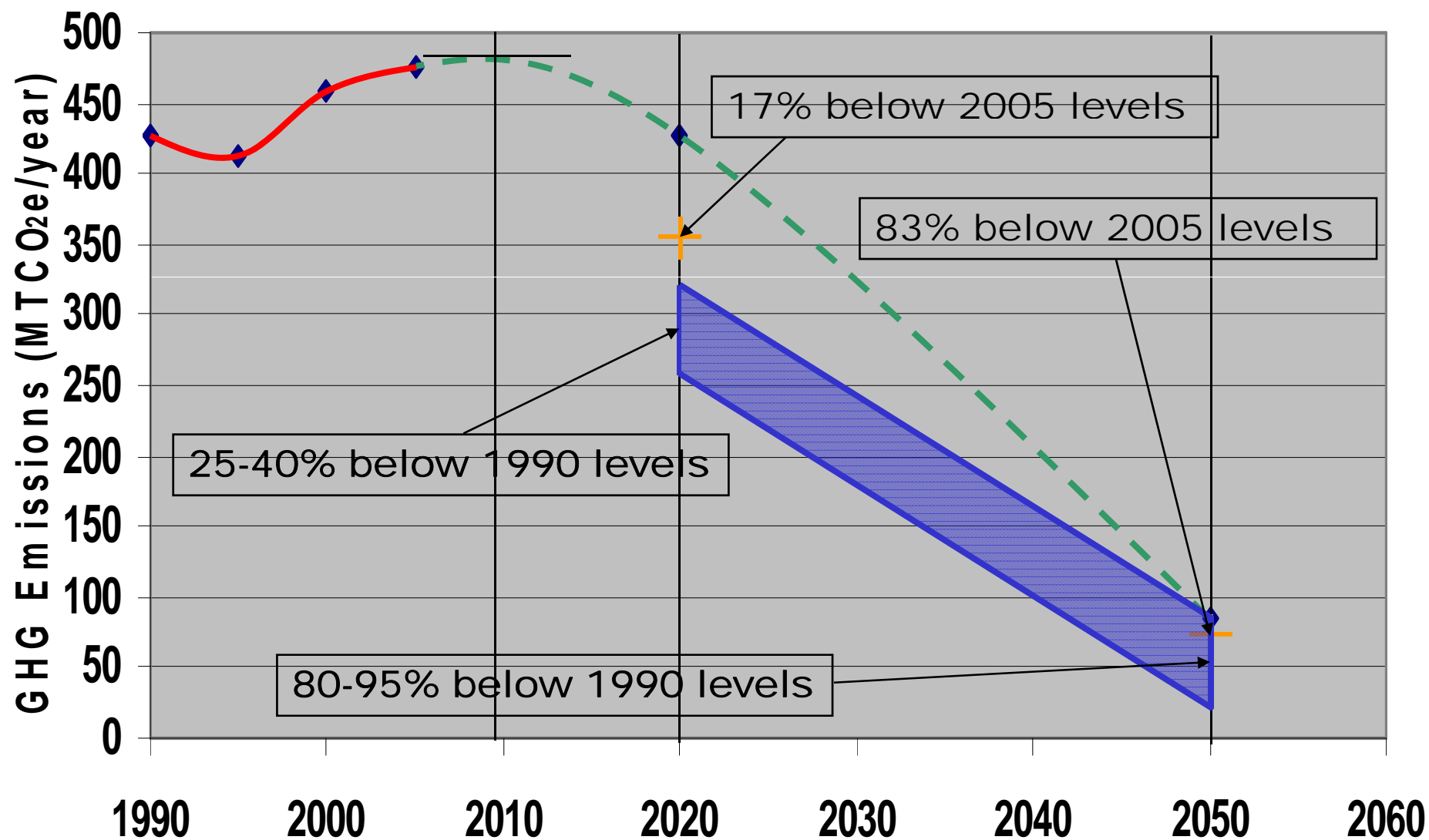
RECD. July 27 2009

David Schnaars
Manager, Environmental Strategies

California Energy Commission
CHP Workshop
July 23, 2009

- **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



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 CO₂
- Reduce Non-CO₂ Gas Emissions

CHP

The Stabilization Triangle

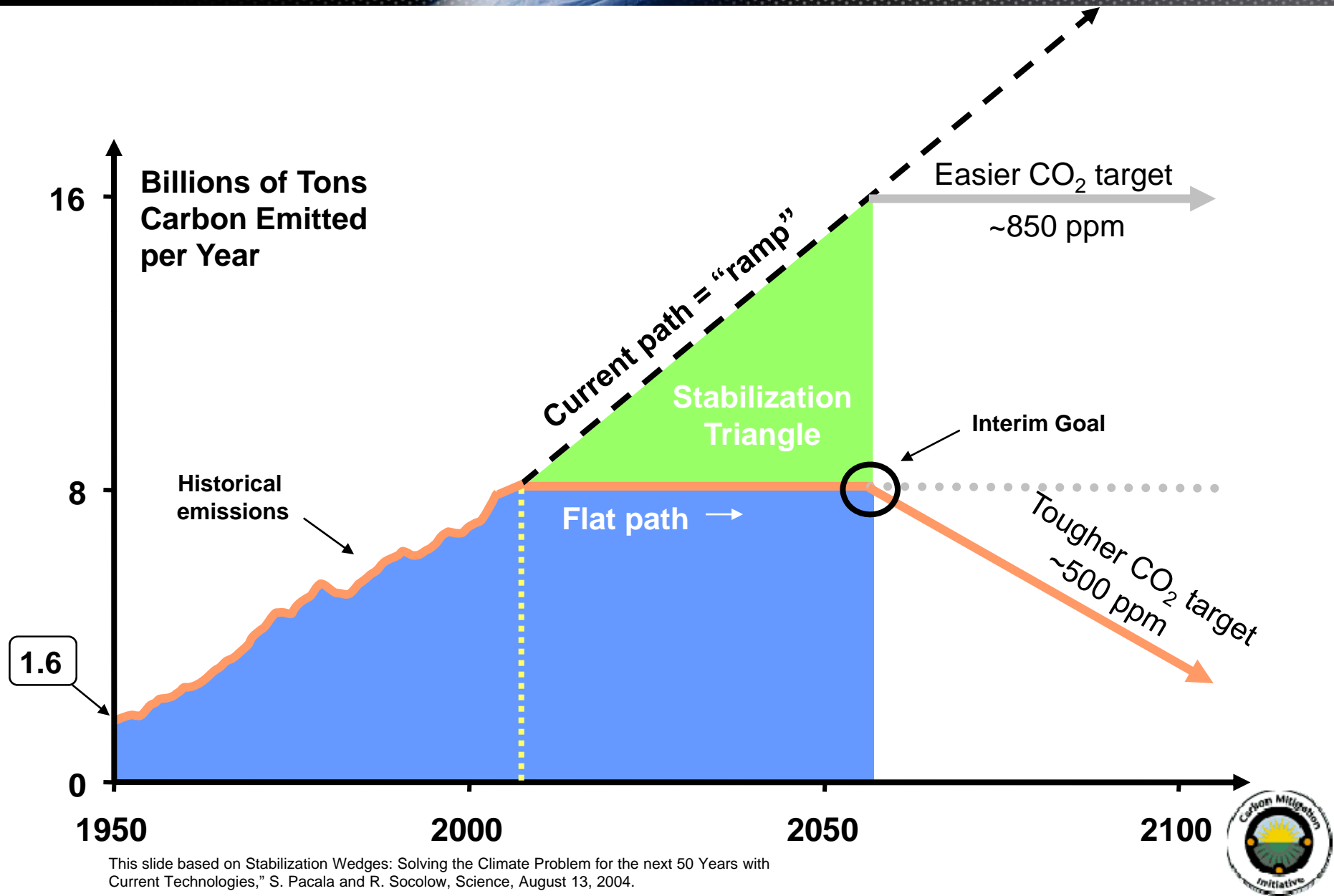




Photo courtesy of DOE

**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**

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Solar Electricity



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



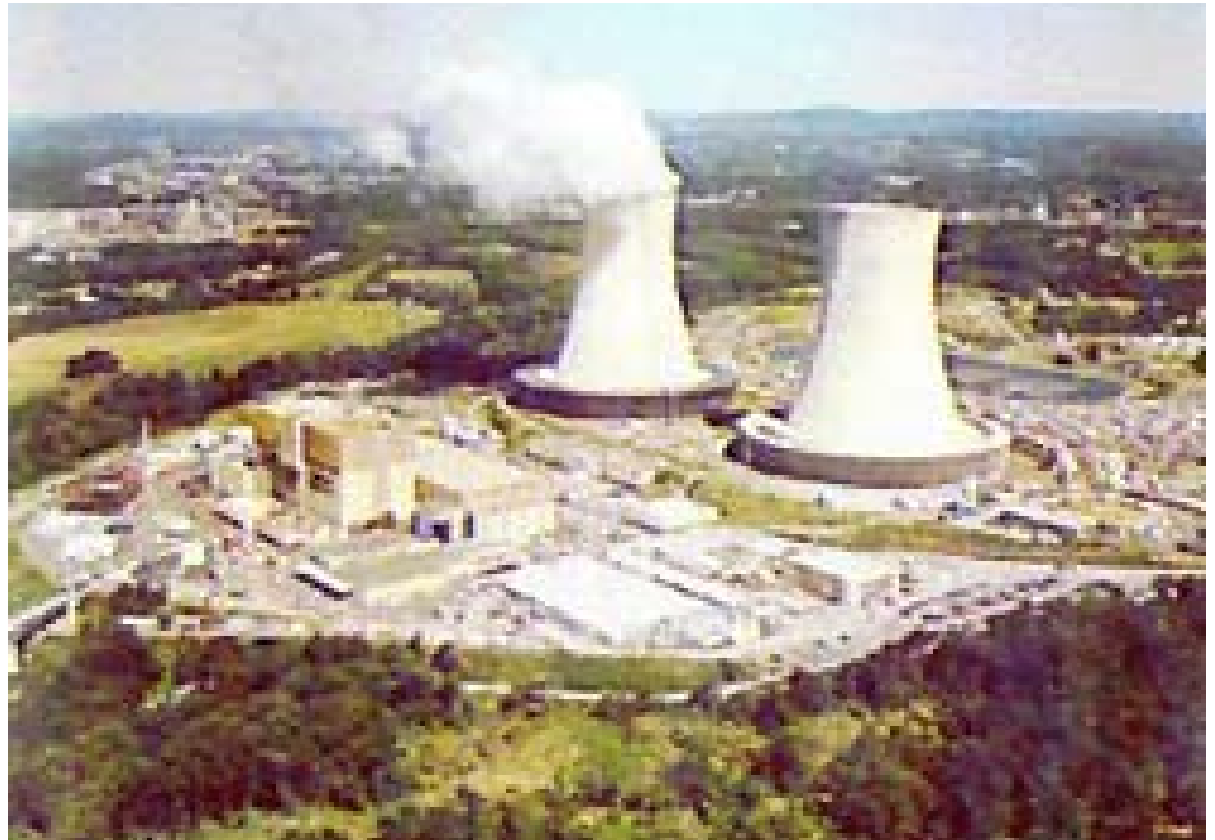
Photos courtesy of DOE Photovoltaics Program

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.



**Triple the world's
nuclear electricity
capacity by 2055**



Graphic courtesy of NRC

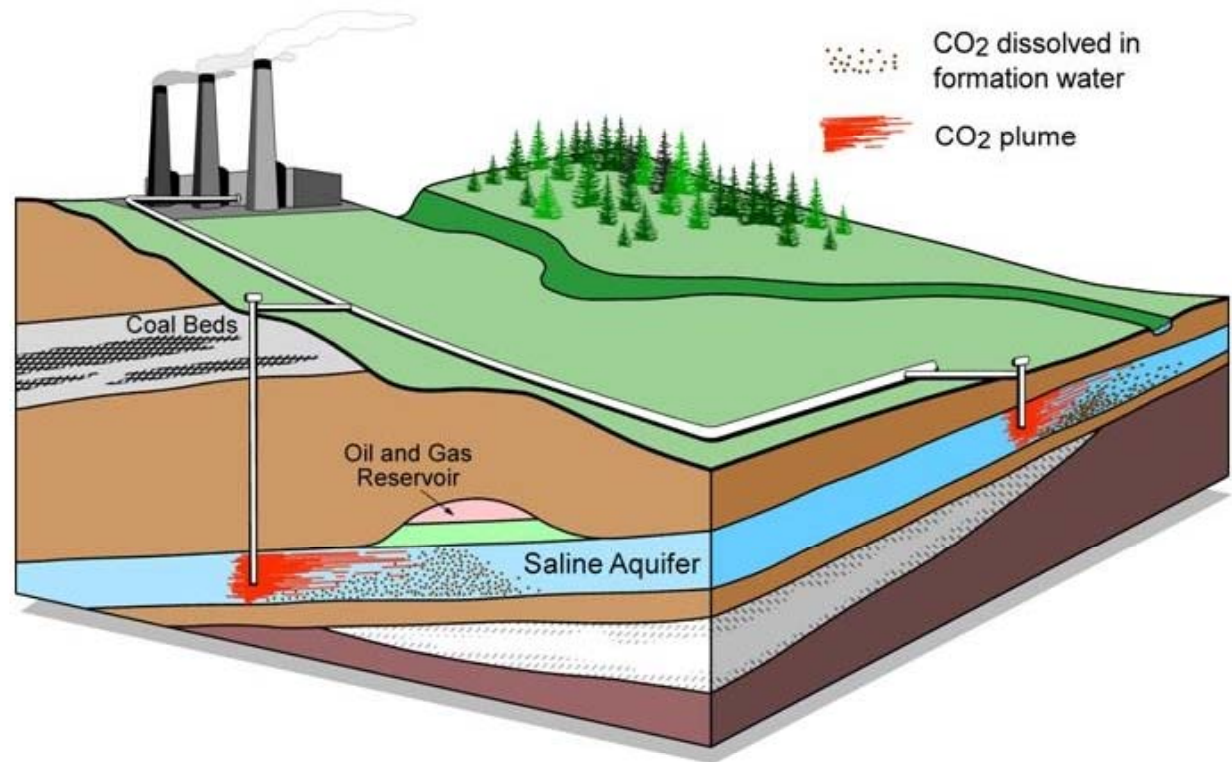
The rate of installation required for a wedge from electricity is equal to the global rate of nuclear expansion from 1975-1990.

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.



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 CO₂ per year – by 2055 need 3500.

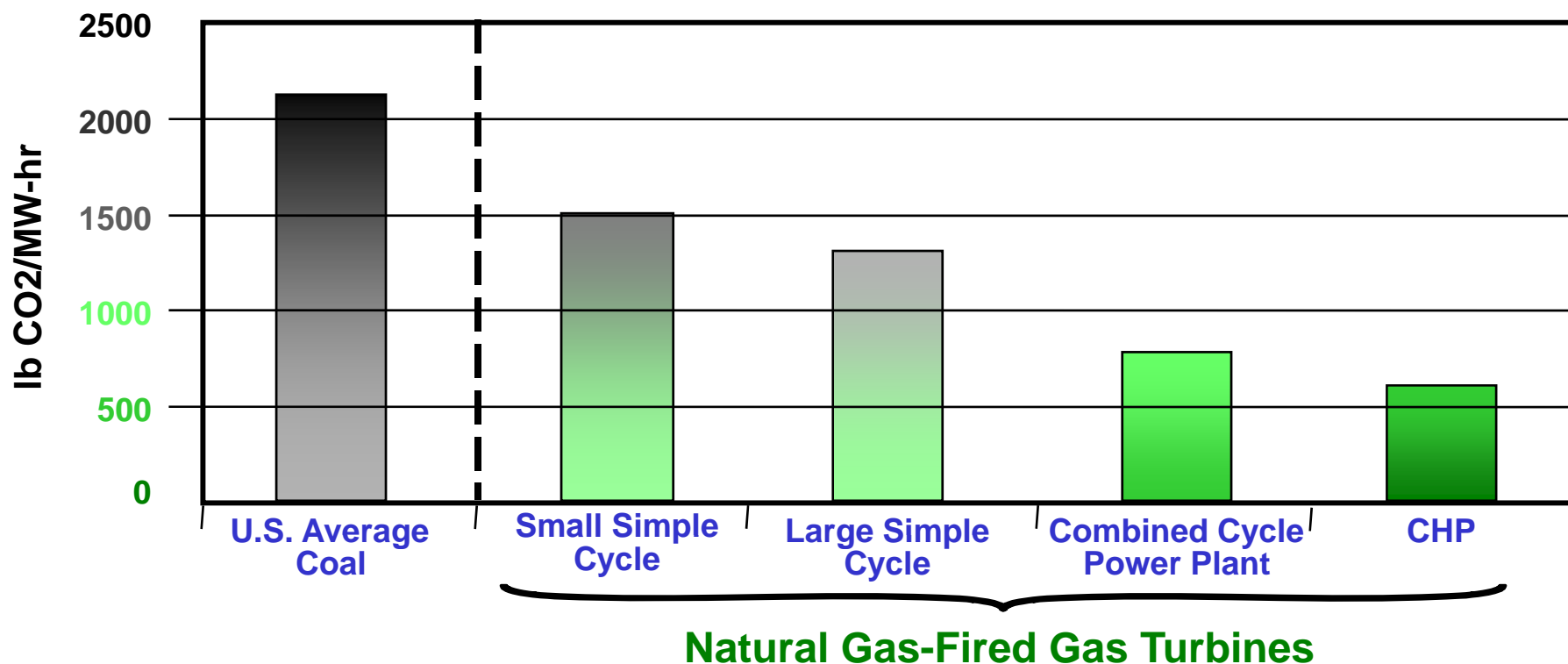
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- **NG Is the Least Carbon-Intensive Fossil Fuel:**

- Coal = 208 lb CO₂/MMBtu (HHV)
- Distillate Oil = 161 “
- Natural Gas = 117 “

- **CHP Is Most Efficient Use of Natural Gas**



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

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4.6 MW Centaur 50 California Dairies



- **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**



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



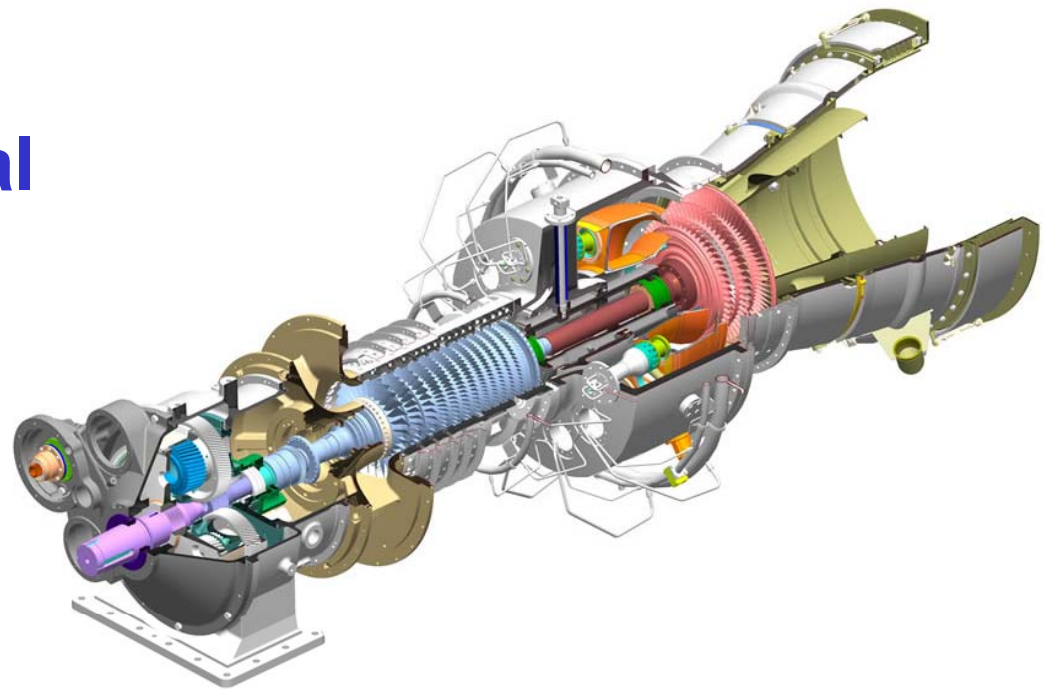
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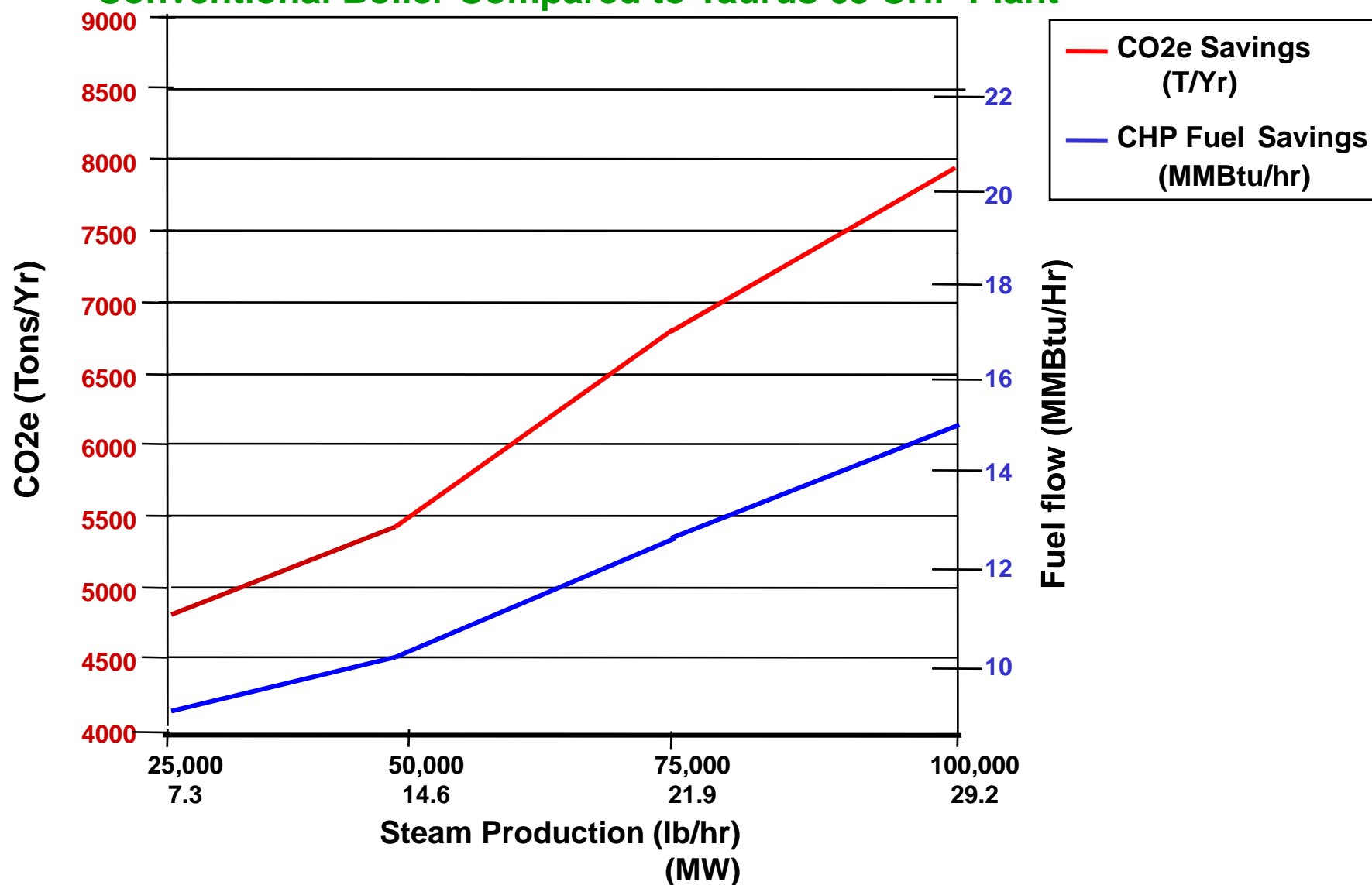
6.3 MW Taurus 65, Michelin Tire Hallstadt, Germany



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



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



Solar® Turbines

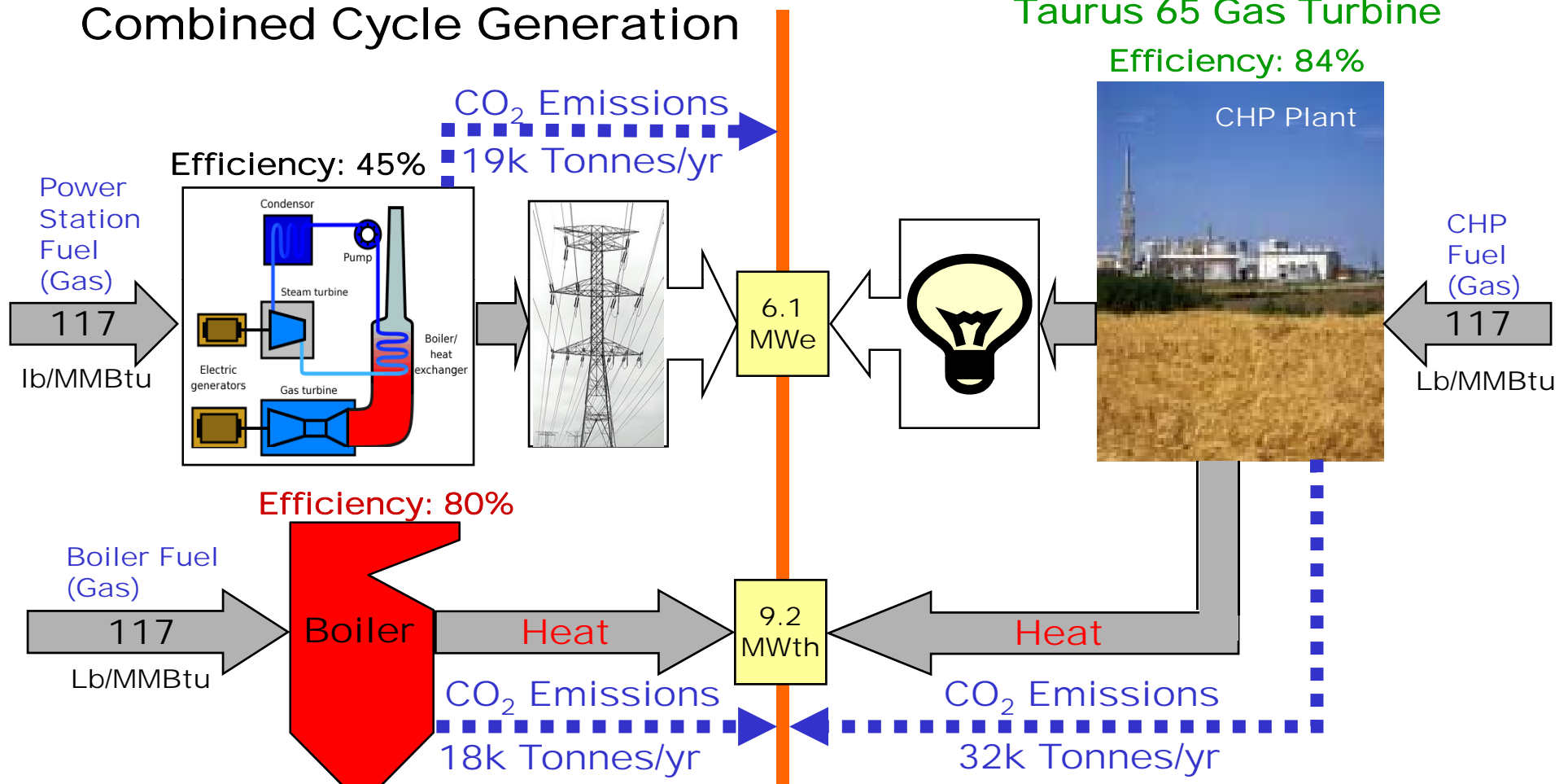
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CO₂ Emissions Reductions from CHP

Combined Heat & Power:

Taurus 65 Gas Turbine

Efficiency: 84%



40k Tonnes ...TOTAL ANNUAL CO₂ EMISSIONS... 32k Tonnes

8,000 Tonnes Saved/Year

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