

A world map with a dark blue background and glowing yellow city lights, serving as the background for the text.

**USAEE/IAEE 24<sup>th</sup> Annual NA Conference**

**Thinking Outside the Box  
Economic Growth and  
The Central Generation  
Paradigm**

**Thomas R. Casten**

***Chairman & CEO  
Primary Energy, LLC***

# ***A “Central Generation Paradigm” Informs Conventional Thinking***

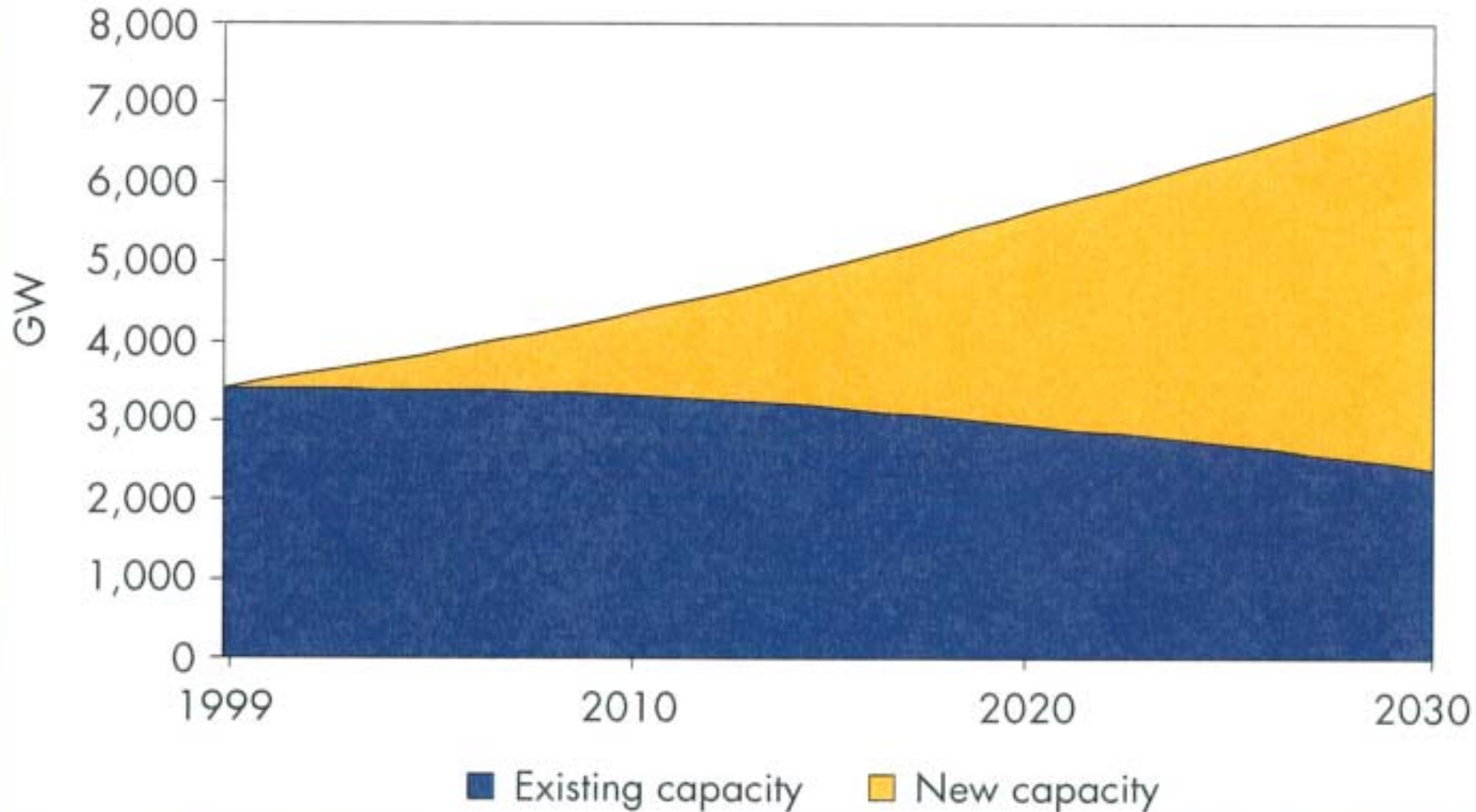
- **Universal acceptance that large generation has economies of scale**
- **Unquestioned assumption that all power will flow through wires**
- **Belief that free markets can not provide the world’s most second most important service (Beer is first)**

# ***IEA Reference Case***

## ***“In the Box” Forecasts to 2030***

- **Energy demand will grow 67%**
  - **Fossil fuel will supply 90% of the increase**
- **Electric generation will double, need 4800 GW**
- **New generation cost \$4.2 trillion**
- **Report is silent on T&D, we estimate \$6.6 trillion added capital cost**
- **CO<sub>2</sub> emissions will increase 70%**

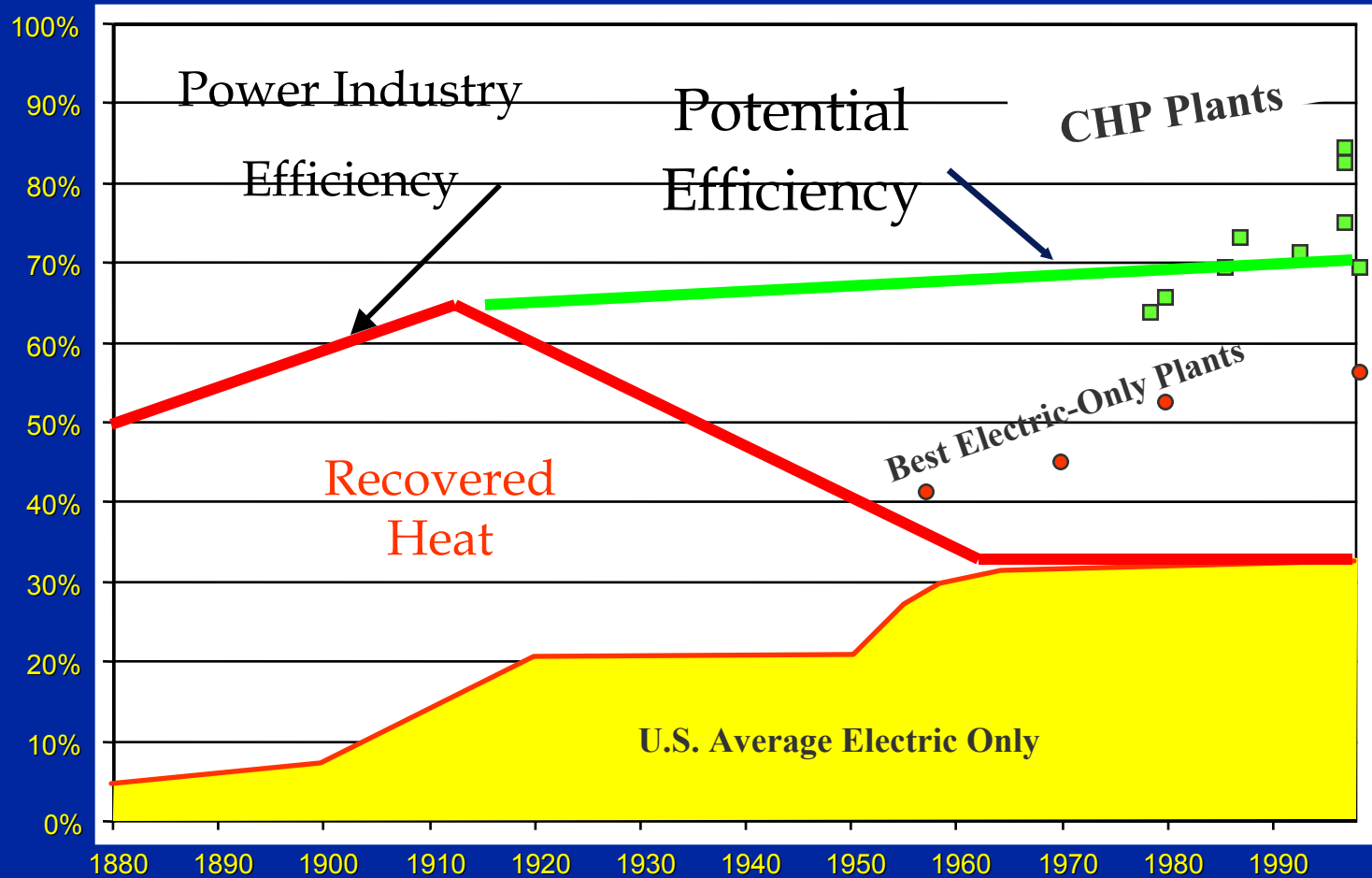
# *World Installed Electricity Generation Capacity, IEA Ref Case*



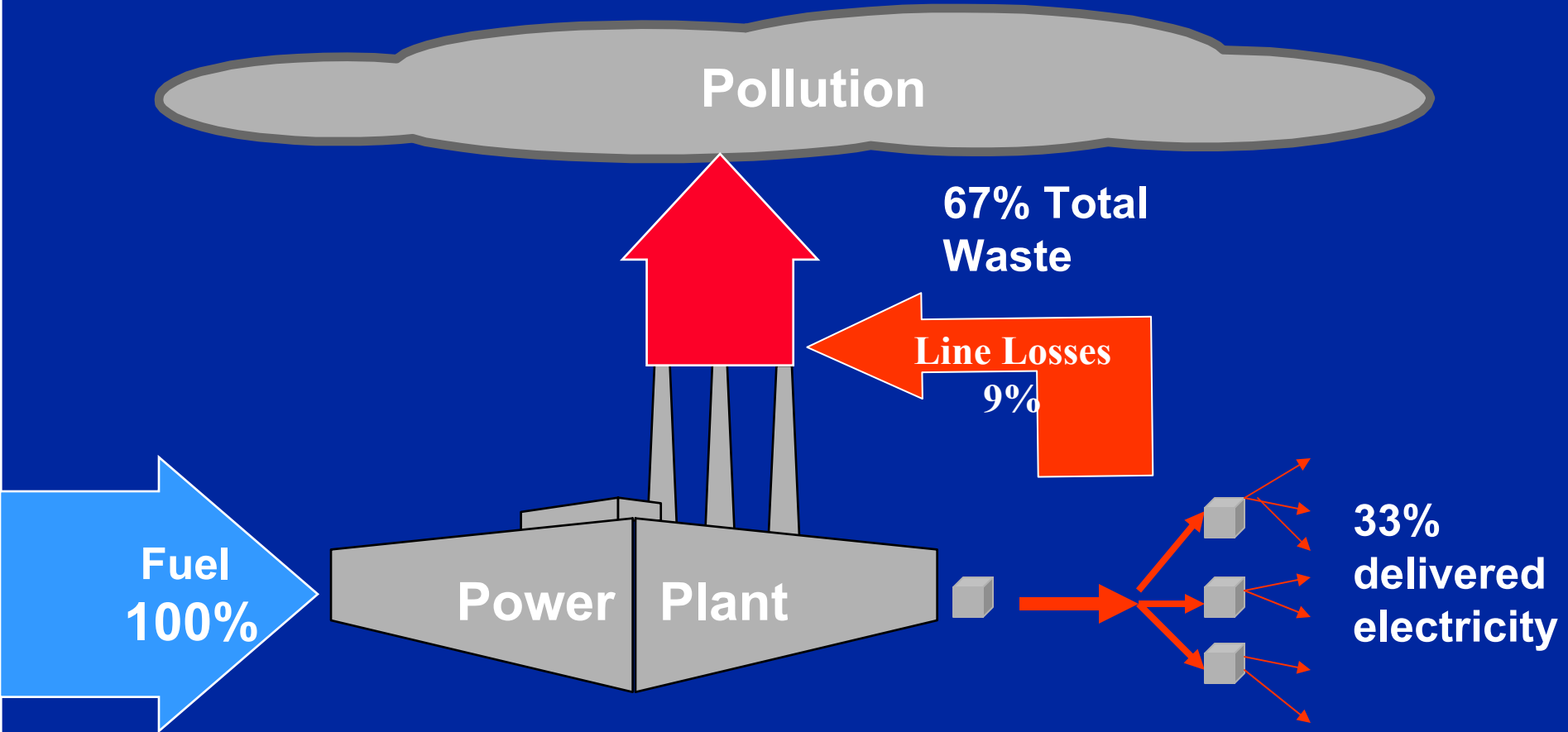
# ***Summary of Presentation***

- **The power industry chose sub-optimal technology over the past 30 years**
- **The “Central Generation Paradigm” blocks optimal energy decisions.**
- **Generating US load growth with existing technologies, sited near users, significantly improves every key outcome**
- **Extrapolating to the IEA expected global load growth, decentralized energy can:**
  - **Save \$5.0 trillion of capital,**
  - **lower incremental power costs by 35-40%**
  - **reduce CO<sub>2</sub> emissions by 50%**

# US Energy Generation Efficiency Curve



# Conventional Central Generation

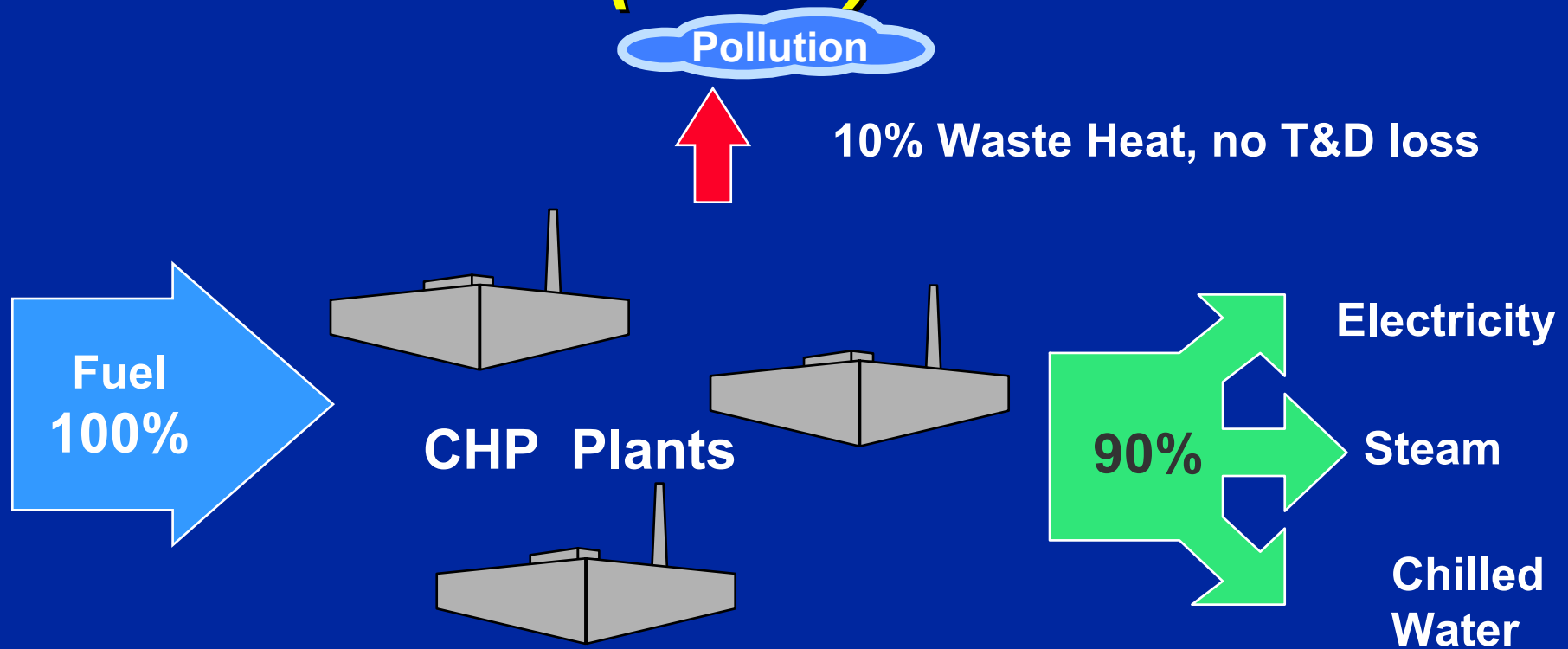


**Generation:**  
**\$890 / kW**

**Transmission:**  
**\$1,380 / kW**

**End user: .91kW:**  
**\$2,494 / kW**

# Combined Heat and Power (CHP)



(At or near thermal users)

<b>Generation:</b>	<b>Transmission</b>	<b>End users: .98 kW</b>
\$1,200/kW	\$138/kW (10% Cap)	\$1,365/kW
<b><u>DG vs. CG: (\$310)</u></b>	<b><u>\$1,242</u></b>	<b><u>\$932</u></b>

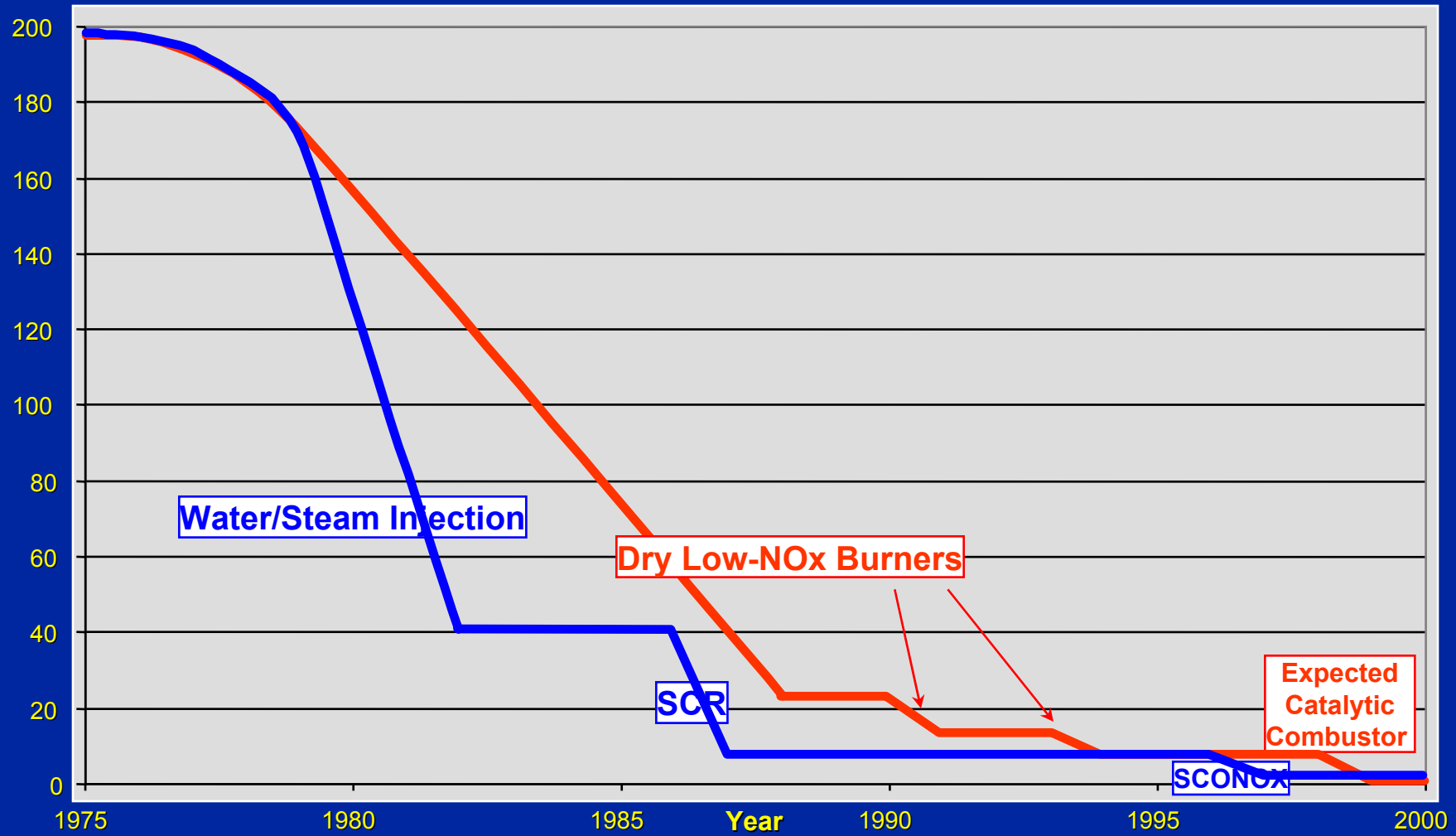


# ***Advances Enable Distributed use of Central Generation Technology***

- **Coal combustion improved, now very clean**
  - **Fluid bed and gasification technologies are only available in industrial sizes, perfect for DG**
- **Combustion turbines are most efficient way to convert natural gas today, available in all sizes**
  - **Aircraft derivative, mass-produced turbines most efficient, reverse economies of scale**
  - **2<sup>nd</sup> most efficient turbine in world is 4 MW**
- **Fuel cells will equal or exceed GT efficiency, only sized for DG use**
- **Pollutant emissions have reduced by up to 99%.**

# History of Gas Turbine NOx Controls

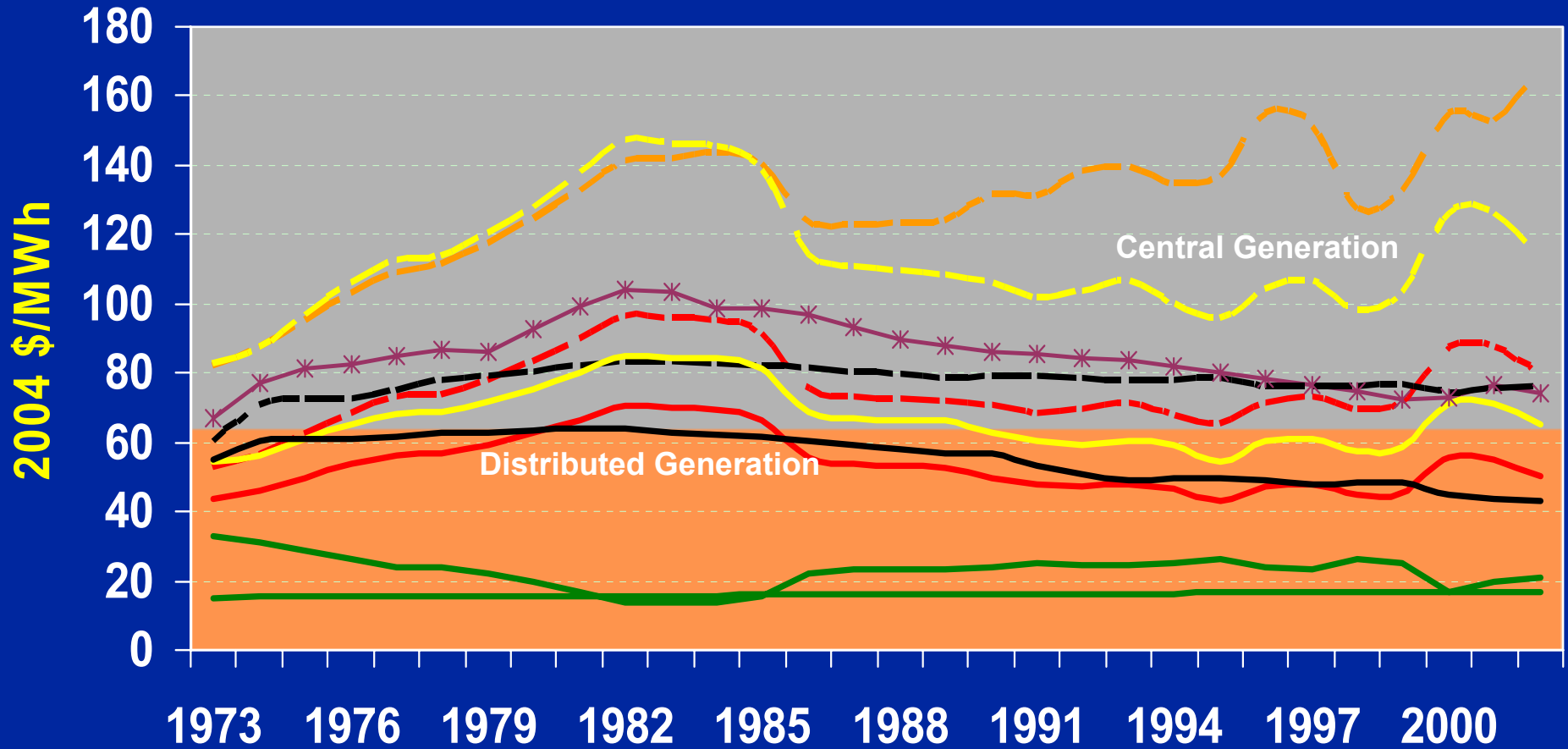
**NOx Emissions**  
(parts per million)



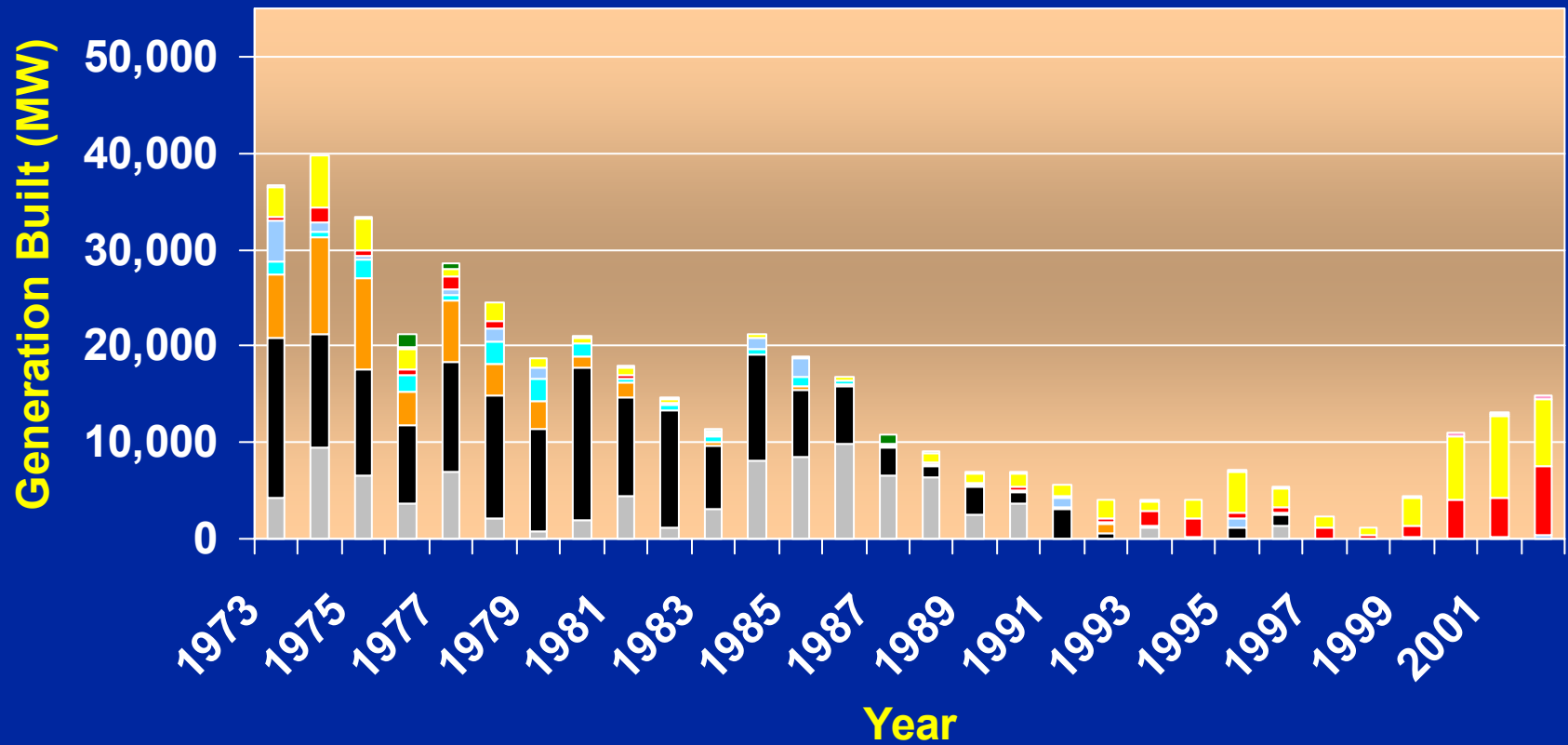
# ***Has US Power Industry Made Optimal Decisions?***

- **We analyzed major power generation technologies over 1973-2002 period**
- **Central generation needs new T&D, DG needs 10% or less new T&D wires.**
- **Assumed 8% cost of capital for CG, 12% for DG**
- **Determined retail price/kW needed in each year, given then current data.**

# Long Run US Marginal Costs/ MWh



# Annual US Utility Additions of Electric Generating Capacity by Technology 1973 - 2002

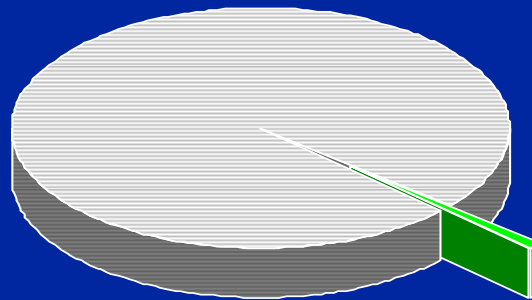




# *Spread of 435,000 MW Built by US Electric Utilities 1973 - 2002*

■ Distributed Generation ■ Central Generation

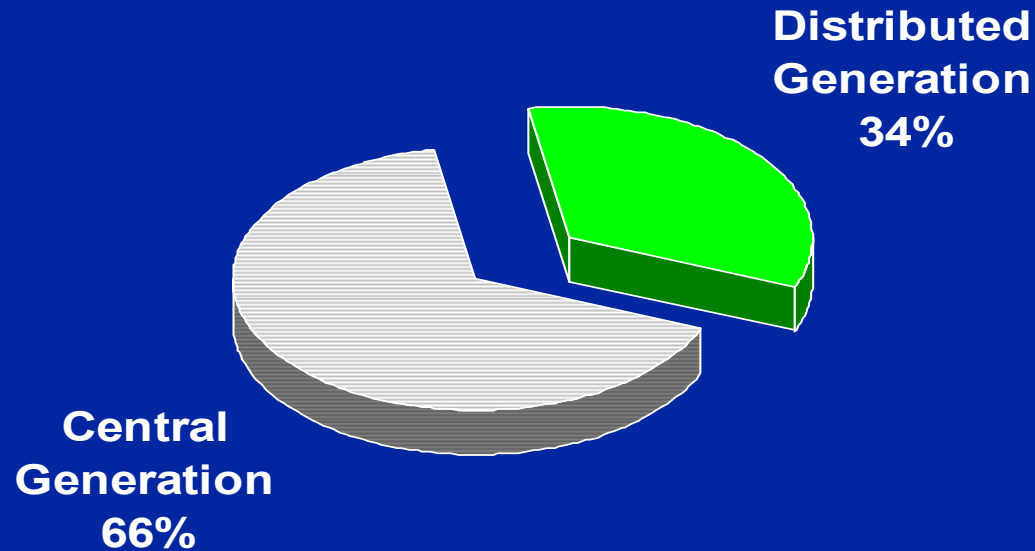
**Central  
Generation  
99%**



**Distributed  
Generation  
1%**

# *Spread of 175,000 MW Built by US IPPs 1973 - 2002*

■ Distributed Generation ■ Central Generation



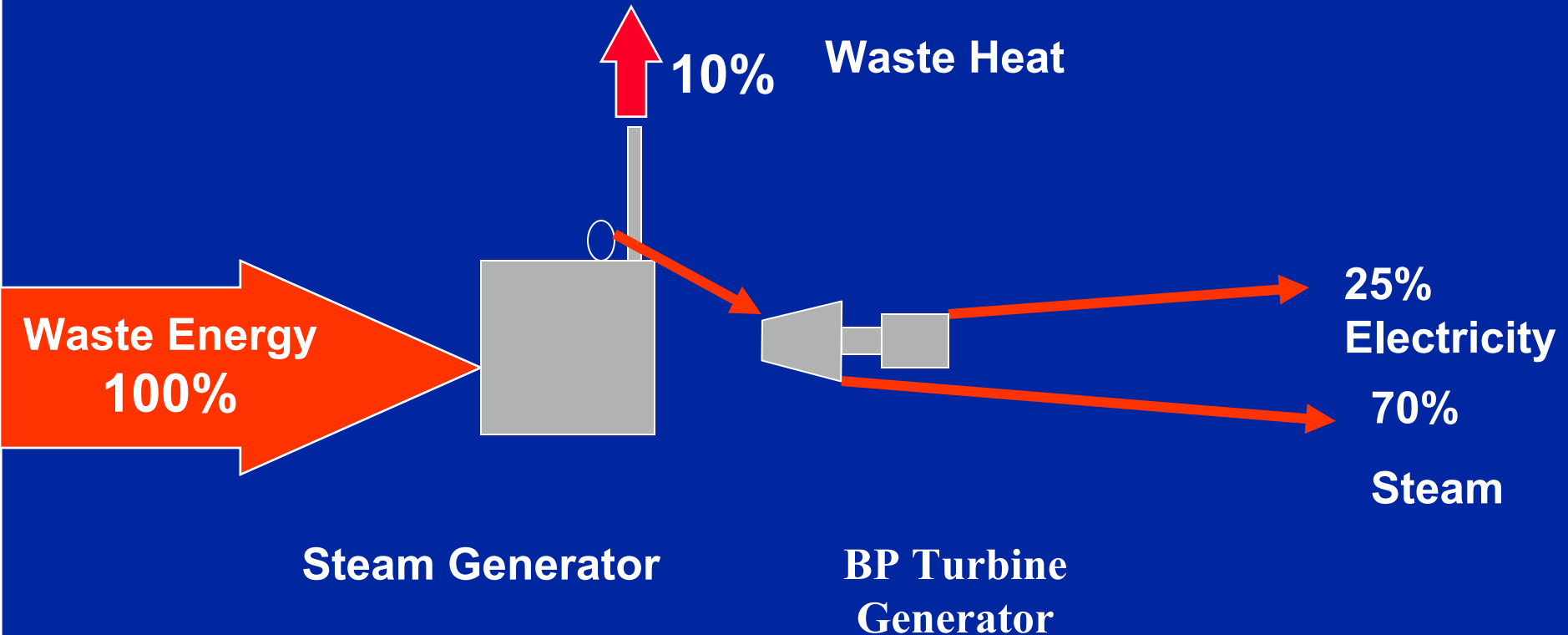


***Central Generation Paradigm  
Blinds Society to Cheapest,  
Cleanest Option:***

***Recycling Industrial Energy***

# **Recycled Energy** (At user sites)

**No Added Pollution**



**Same costs as other CHP or DG plants**

# ***Defining Recycled Energy***

- ***Recycled energy is useful energy derived from***
  - ***Exhaust heat from any industrial process;***
  - ***Industrial tail gas that would otherwise be flared, incinerated or vented; and***
  - ***Pressure drop in any gas***

# ***US Industrial Recycling Potential***

- **Recycled energy could supply 45 to 92 Gigawatts of fuel-free capacity – 13% of US peak**
- **Recycled energy is as clean as renewable energy – no incremental fuel or emissions, but:**
  - **Capital costs are \$500 to 1,500/kW, only 12% to 40% of solar and wind generation,**
  - **90% load factors versus 14-40% for solar & wind**
  - **Recycled energy is both clean and economic option for new power generation.**
- **EIA shows only 2.2 Gigawatts operating**

# ***Recycled Energy Case Study: Primary Energy***

- **NiSource invested \$300 million in six projects to recycle blast furnace gas, coke oven exhaust in four steel plants, 440 megawatts of electric capacity and 460 megawatts of steam capacity.**
- **Steel mills save over \$100 million per year and avoid significant air pollution**
  - **The CO<sub>2</sub> reduction is equivalent to the uptake of one million acres of new trees.**
- **The projects are profitable; were recently sold for \$335 million to our firm**

# ***90 MW Recycled from Coke Production Chicago in Background***



# ***Conclusion of Historical Study***

- **Electric monopolies limited choices to central plants, ignoring cheaper and cleaner distributed generation options**
- **IPP companies built DG under PURPA rules, but shifted to central generation with passage of EPACT**
- **Neither monopolies nor IPP's built projects to recycle industrial waste energy**

# ***What is Optimum Future Generation?***

- **We modeled 8 scenarios to meet EIA projected US load growth through 2020 (43%)**
- **Found each technology's capital cost, performance, emissions for each year**
- **Added 100% T&D for central generation, 10% for DG**
- **Met load growth with 8 scenarios: all central, all DG and blended scenarios**



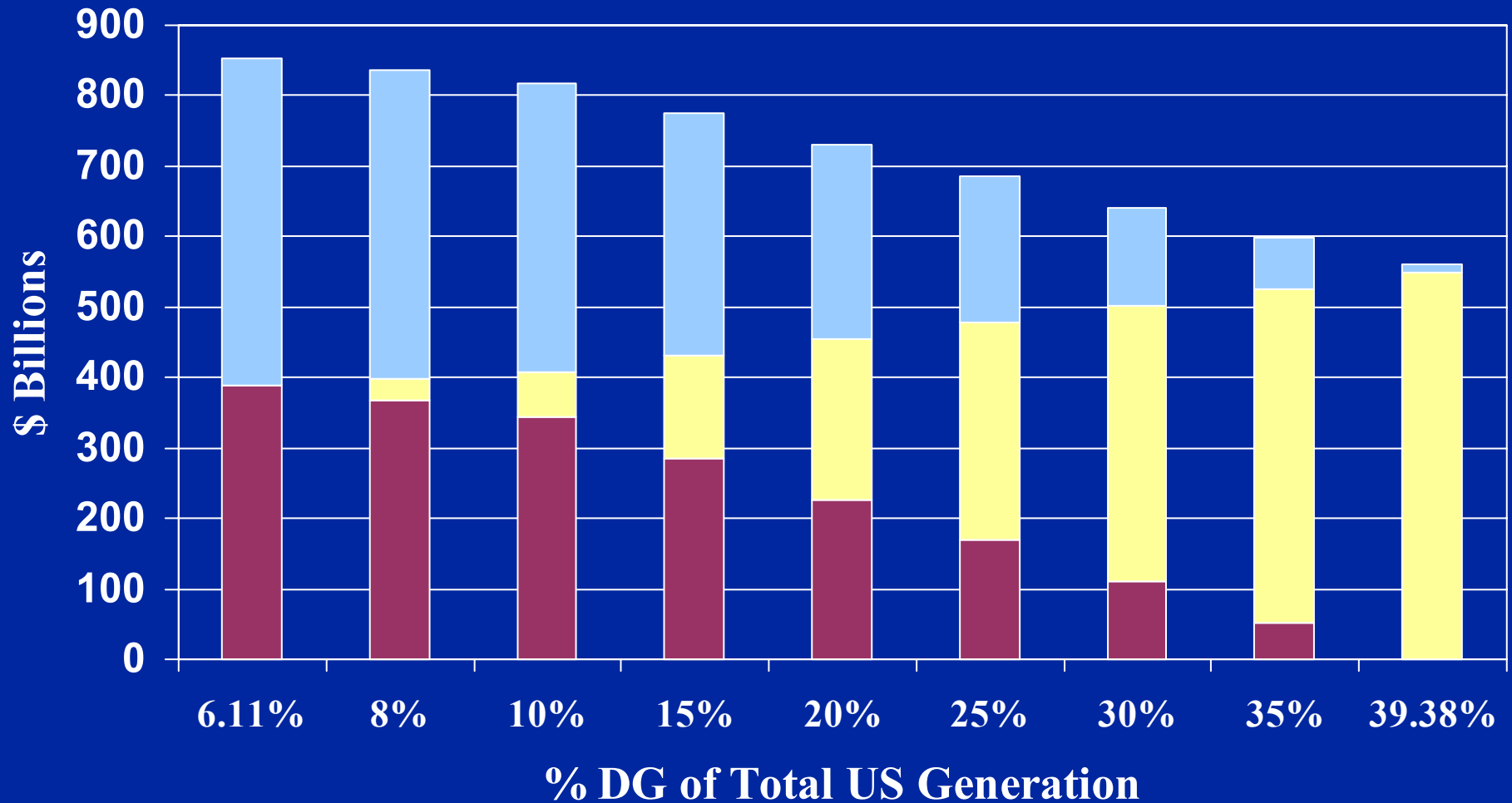
# ***Results, CG versus DG Dollars***

***(Dollars in Billions)***

<b>Item</b>	<b>All CG</b>	<b>All DG</b>	<b>Savings</b>	<b>% Saved</b>
<b>Capacity + T&amp;D</b>	<b>\$831</b>	<b>\$504</b>	<b>\$326</b>	<b>39%</b>
<b>Power Cost</b>	<b>\$145</b>	<b>\$92</b>	<b>\$53</b>	<b>36%</b>
<b>Tons NOx</b>	<b>288</b>	<b>122</b>	<b>166</b>	<b>58%</b>
<b>Tons SO<sub>2</sub></b>	<b>333</b>	<b>19</b>	<b>314</b>	<b>94%</b>
<b>MM Tonnes CO<sub>2</sub></b>	<b>776</b>	<b>394</b>	<b>381</b>	<b>49%</b>

# Capital Cost to Supply 2020

## Electric Load Growth

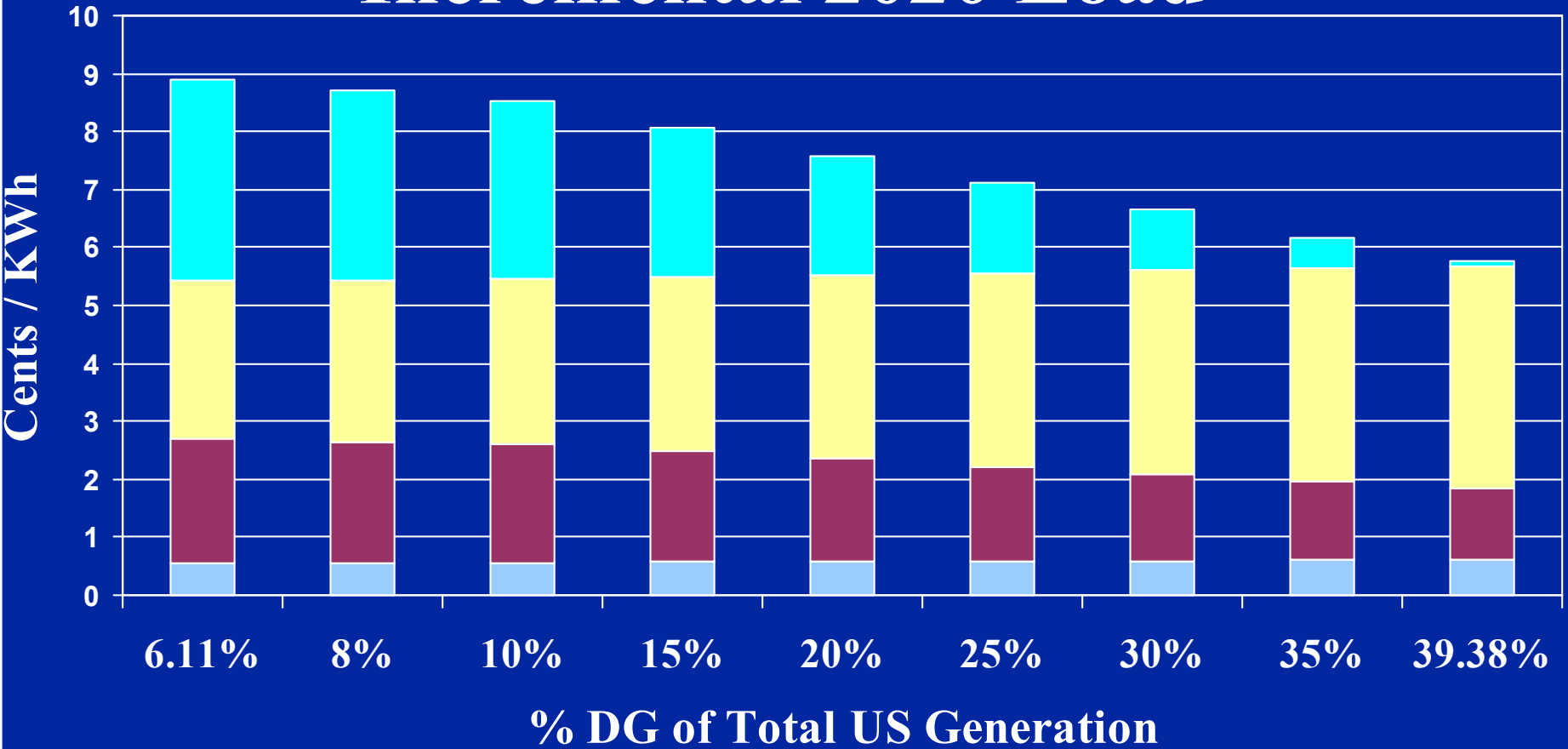


■ Inv. In New Cent. Gen.

■ Inv. In new Dist. Gen.

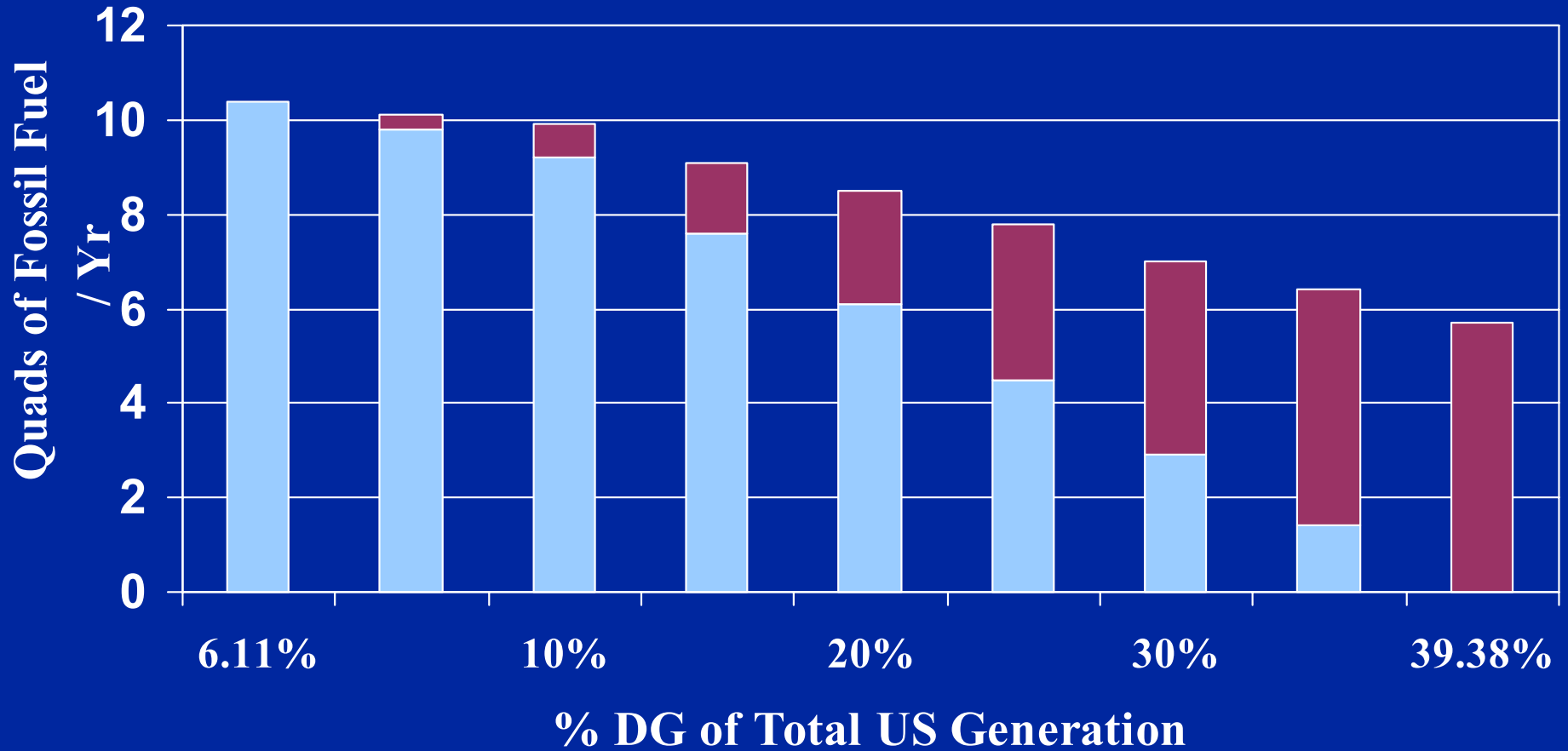
■ Inv. In T&D

# Retail Costs per KWh for Incremental 2020 Load



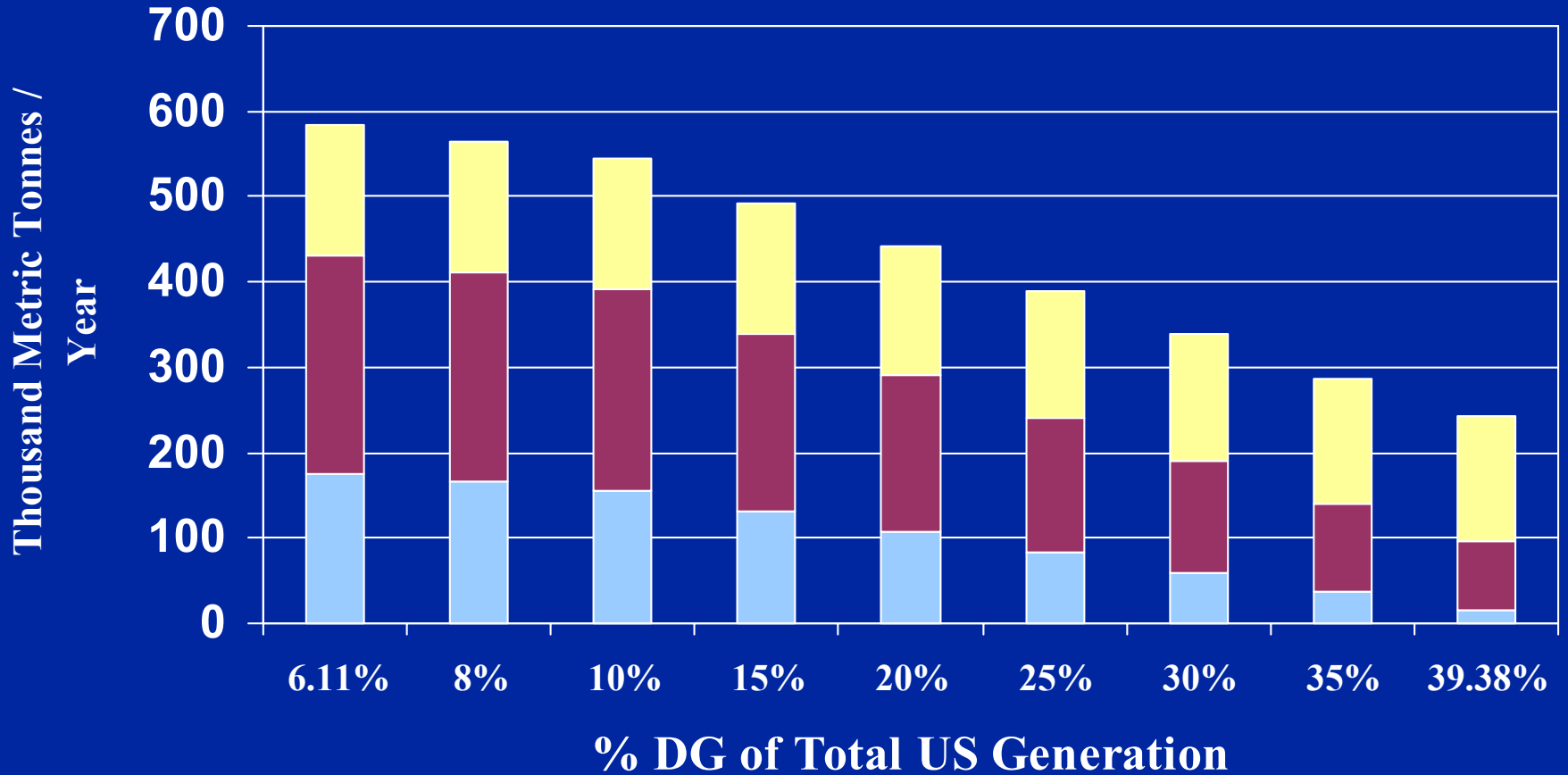
- T&D Amorization on New T&D
- Capital Amorization + Profit On New Capacity
- Fuel
- O&M of New Capacity

# Added Annual Fossil Fuel Use for Incremental 2020 Load



■ Total "New" Distributed Generation Fuel Use  
■ Total "New" Central Generation Fuel Use

# Emissions from Generating Incremental 2020 Electric Load

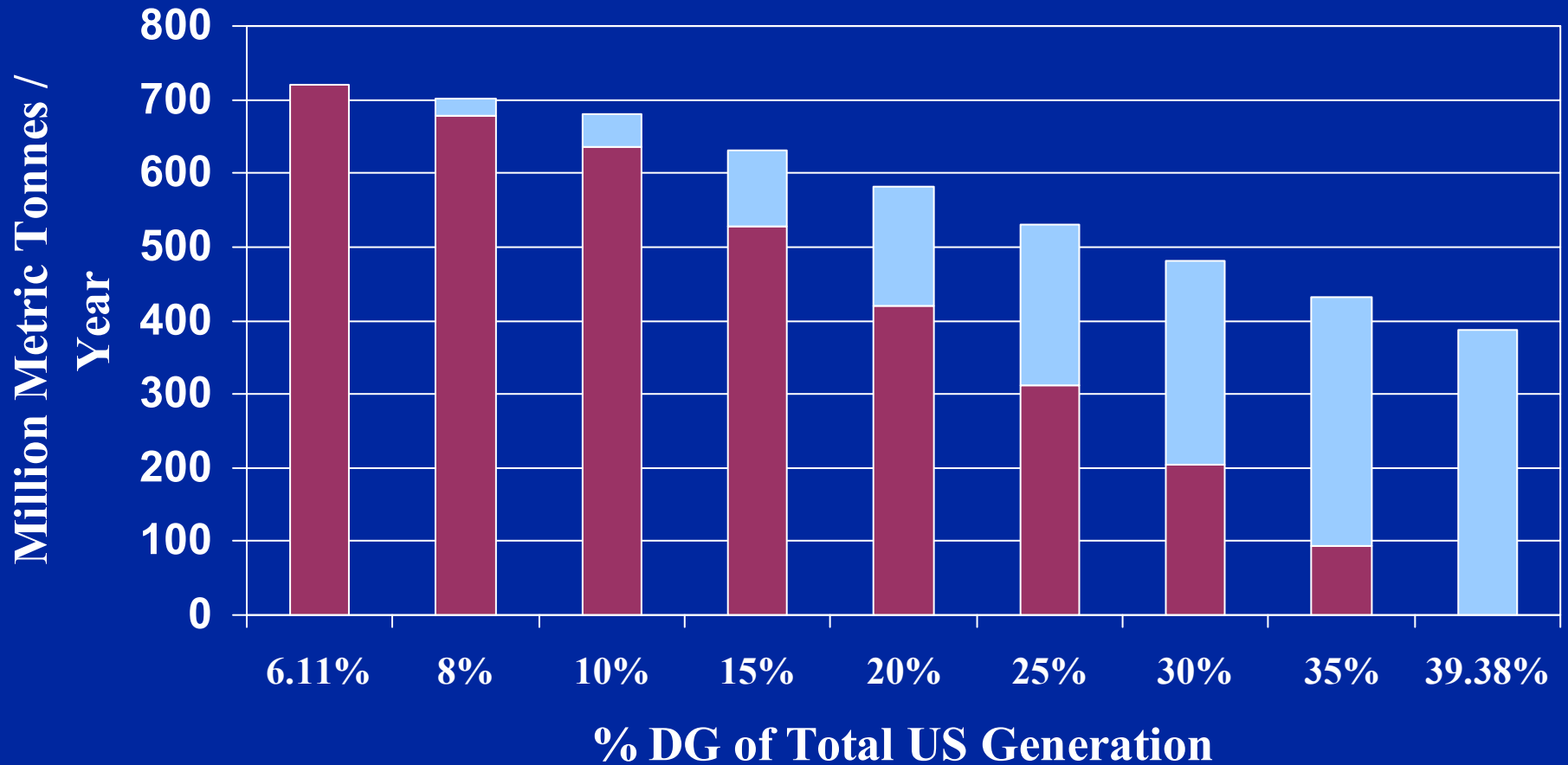


SO2 Emissions

NOx Emissions

PM10 Emissions

# Added Annual CO2 Emissions for Incremental 2020 Load

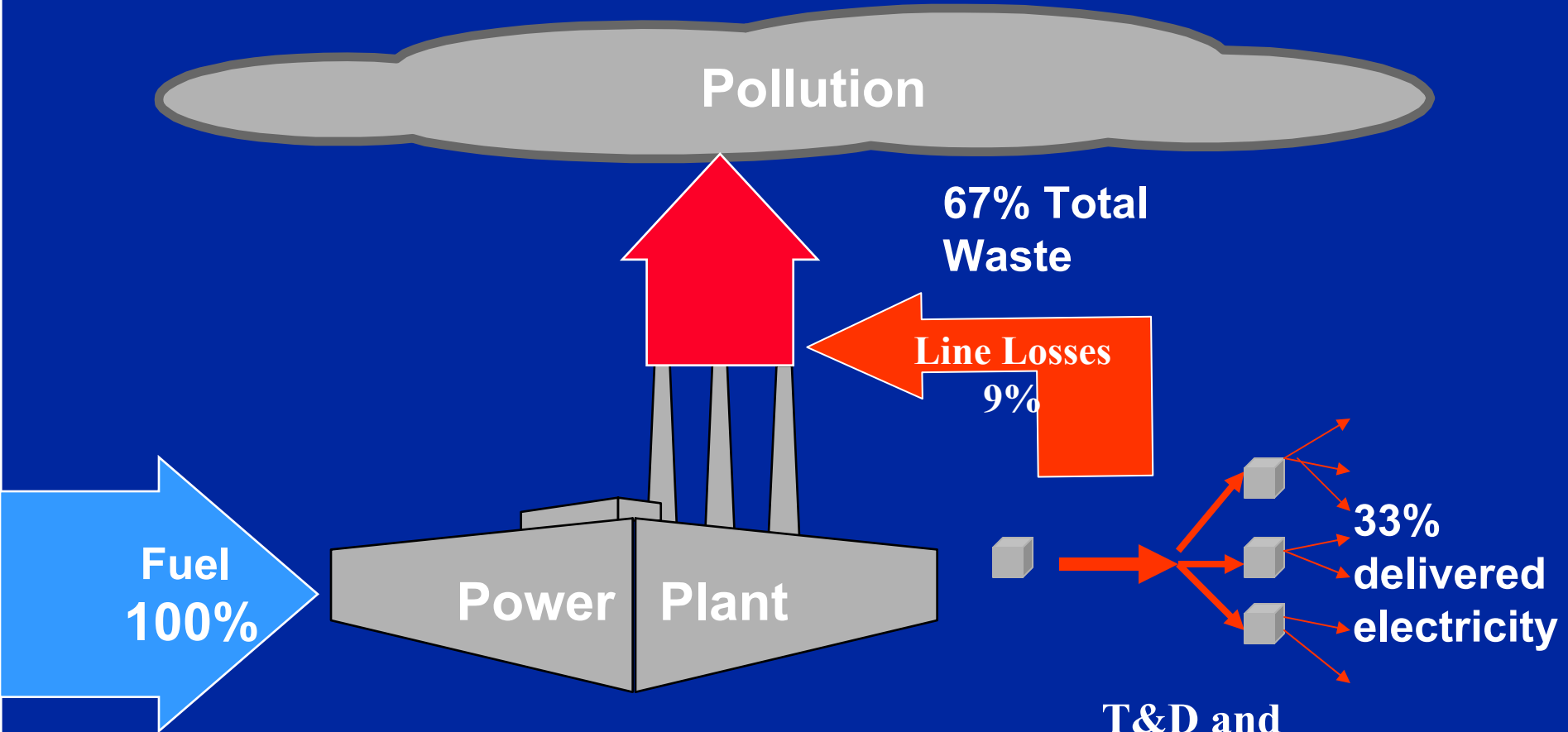


■ CO2 emitted for added Cent. Gen. ■ CO2 emitted for added Dist. Gen.

# ***Extrapolating US Analysis to IEA World Case***

- **Insufficient data to run model for world**
- **We believe numbers are directionally correct for CG versus DG comparisons**
- **Look at cost of “in the box” approach of IEA Reference Case versus optimal solutions.**

# Conventional Central Generation



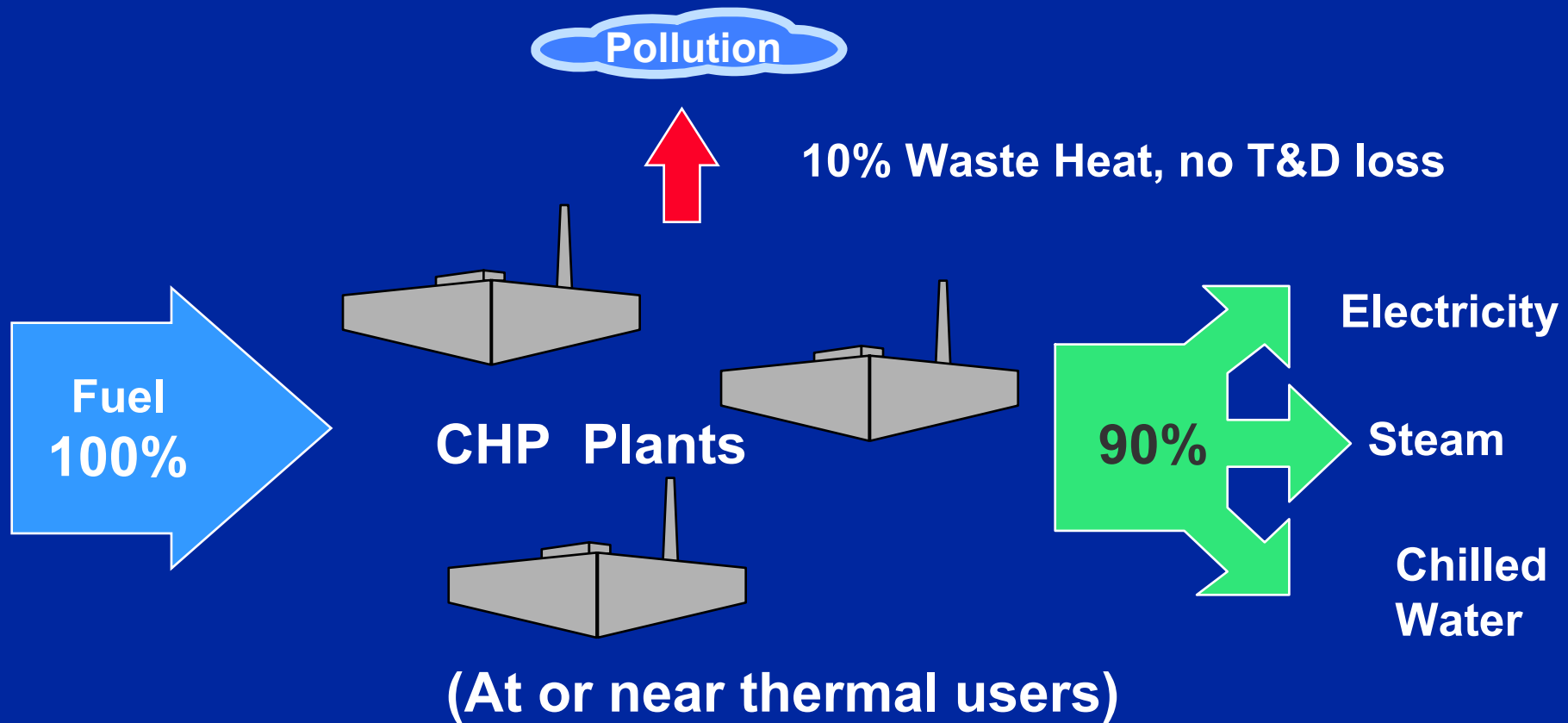
**Generation:**  
\$890 / kW  
4,800 GW worldwide  
\$4.2 trillion

**Transmission:**  
\$1,380 / kW  
4,800 GW  
\$6.6trillion

**T&D and  
Transformers  
To end users:**  
\$2,495 / kW  
4,368 GW  
\$10.8 trillion



# Combined Heat and Power (CHP)



## Generation:

\$1,200/kW

4,368 GW

World Cost: \$5.2 trillion

DG vs. CG: (\$1.0 trillion)

## Transmission

\$138/kW (10% Cap.)

0.44 GW DG

\$600 billion

\$6.0 trillion

## To End Users

\$1,338/kW

4,368 GW

\$5.8 trillion

\$5.0 trillion

## ***What is Lost if World Opts for DG?***

- **World will consume 122 billion fewer barrels of oil equivalent ( $\frac{1}{2}$  Saudi oil reserves)**
- **Fossil fuel sales down \$2.8 trillion**
- **Medical revenues from air pollution related illnesses may drop precipitously**
- **Governments might spend much of the savings, opting to supply electric services to entire population**
- **Global warming might slow down**

# ***IAEE Suggested Member Actions***

- You are key advisors to energy policy makers, who will not remove barriers to efficiency without economist support.
- Please challenge, help us fix or explain flaws
- Suggest policy changes to send correct signals to power industry
- Demand hard proof of statements and studies that assume central generation is optimal
- Lets work together to change the way the world makes heat and power

A world map at night, showing city lights in yellow and orange. The state of Texas is highlighted in red. The text "Thank you for listening!" is overlaid in the center in a bold, orange font.

**Thank you for listening!**