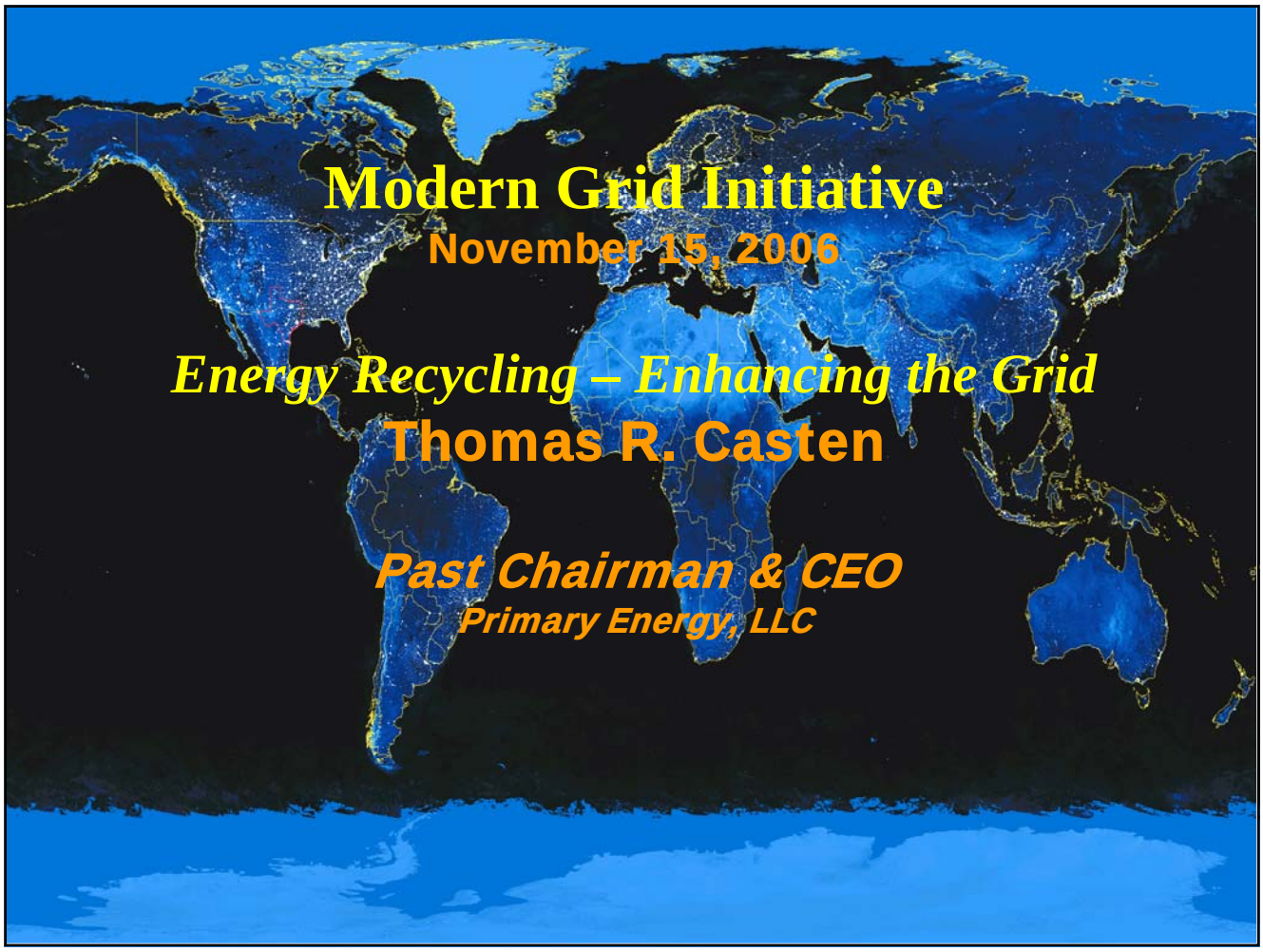

Modern Grid Initiative
November 15, 2006
Energy Recycling – Enhancing the Grid
Thomas R. Casten
Past Chairman & CEO
Primary Energy, LLC

Conference Mission

(From Conference Invitation)

- **Create a shared national agenda for modernizing the electrical system**
- **Create a framework for upgrading the U.S. electric infrastructure**
- **Actions taken will shape the direction fo the grid for years, even decades**
- **Collect best ideas from a broad group of stakeholders**

An Inconvenient Truth

- Al Gore has described global warming as an 'Inconvenient Truth' – a reality that we would rather not face
- Conventional wisdom: policy changes that mandate GHG (Greenhouse Gas) reductions will increase energy costs and penalize industry
- Electric generation produces 38% of US GHG emissions

More 'Inconvenient Truths"

- US industrial production shrinking at alarming rate, especially in Midwest
- Electricity prices under pressure from CAIR, added T&D investment and permanently higher fossil fuel prices
- Our fossil fuel addiction dictates foreign policy (and expensive wars), bloats balance of payments deficits, and exacerbates pollution control costs

Final 'Inconvenient Truth'

Adding T&D will do little to mitigate the major energy problems facing America and the world

'A Convenient Truth'
Energy Recycling Eases All Problems

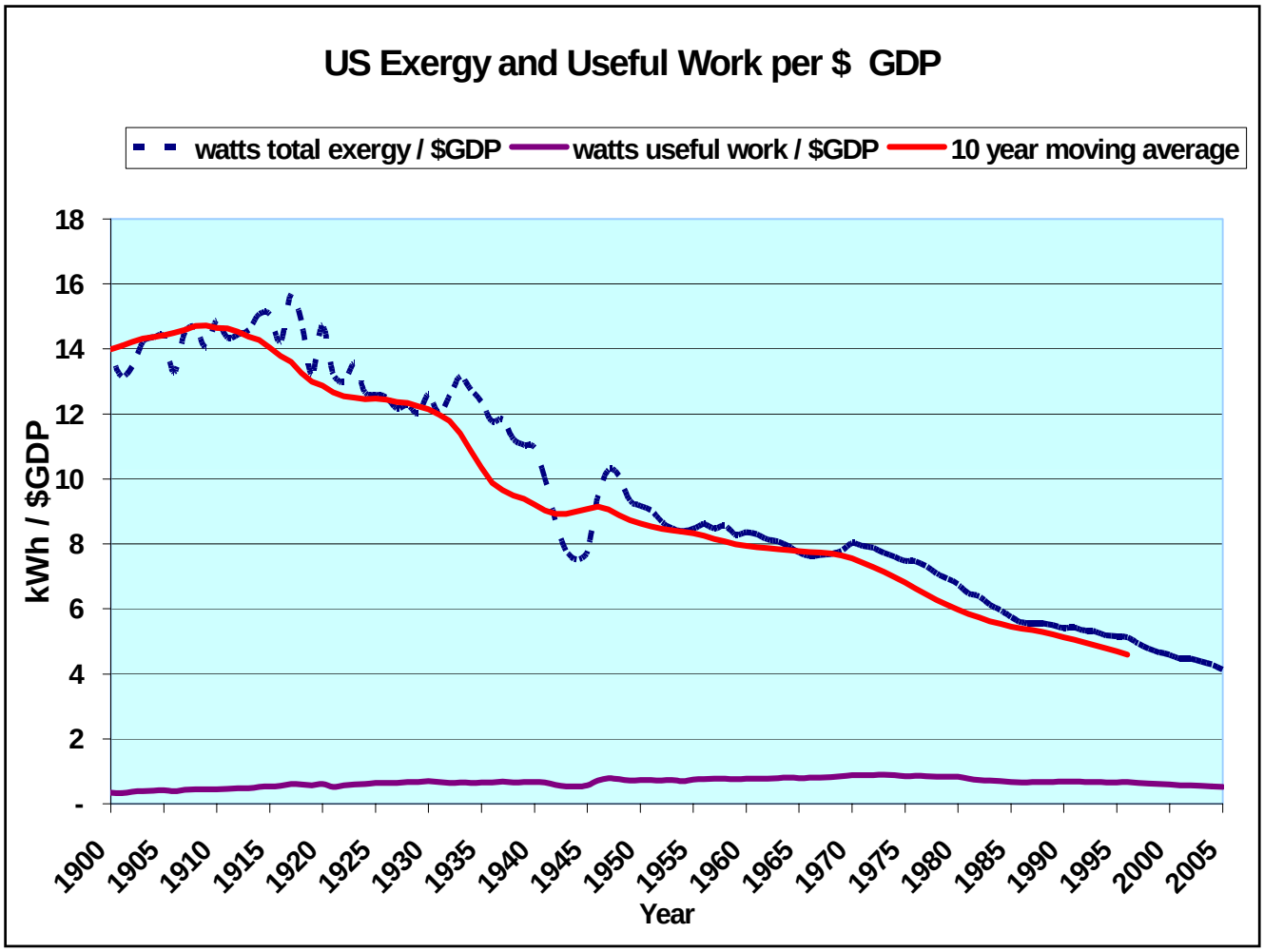
- **US industrial waste energy could produce 20% of US electricity**
  - **Recycling creates significant new revenue streams for US manufacturers and reduces emissions**
- **Power generation that recycles waste heat uses half of the fossil fuel of conventional generation**
  - **Recycling cuts power costs, reduces emissions**
- **US industries single best hope to regain competitiveness: recycle waste energy**

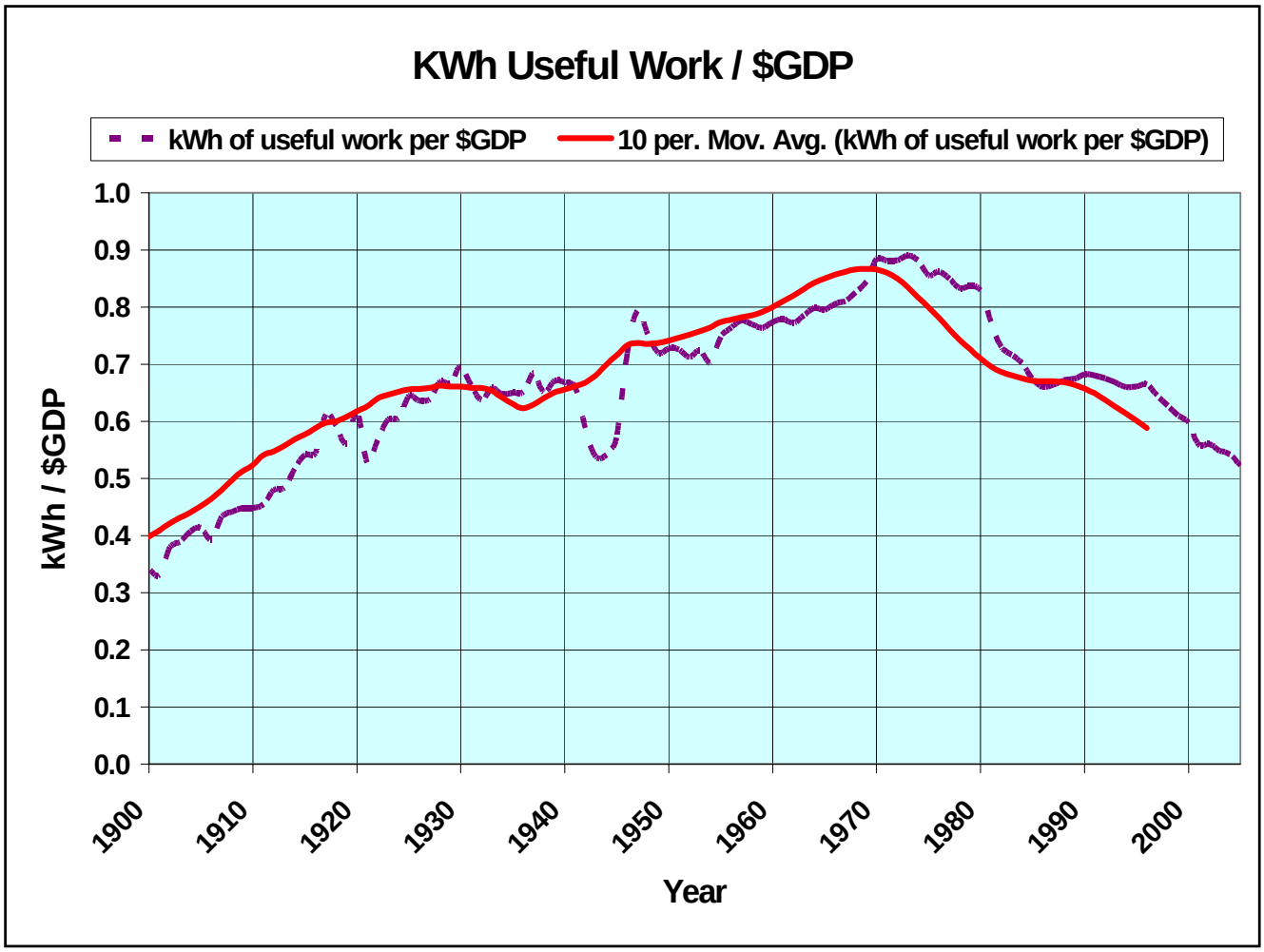
Examining Energy Trends

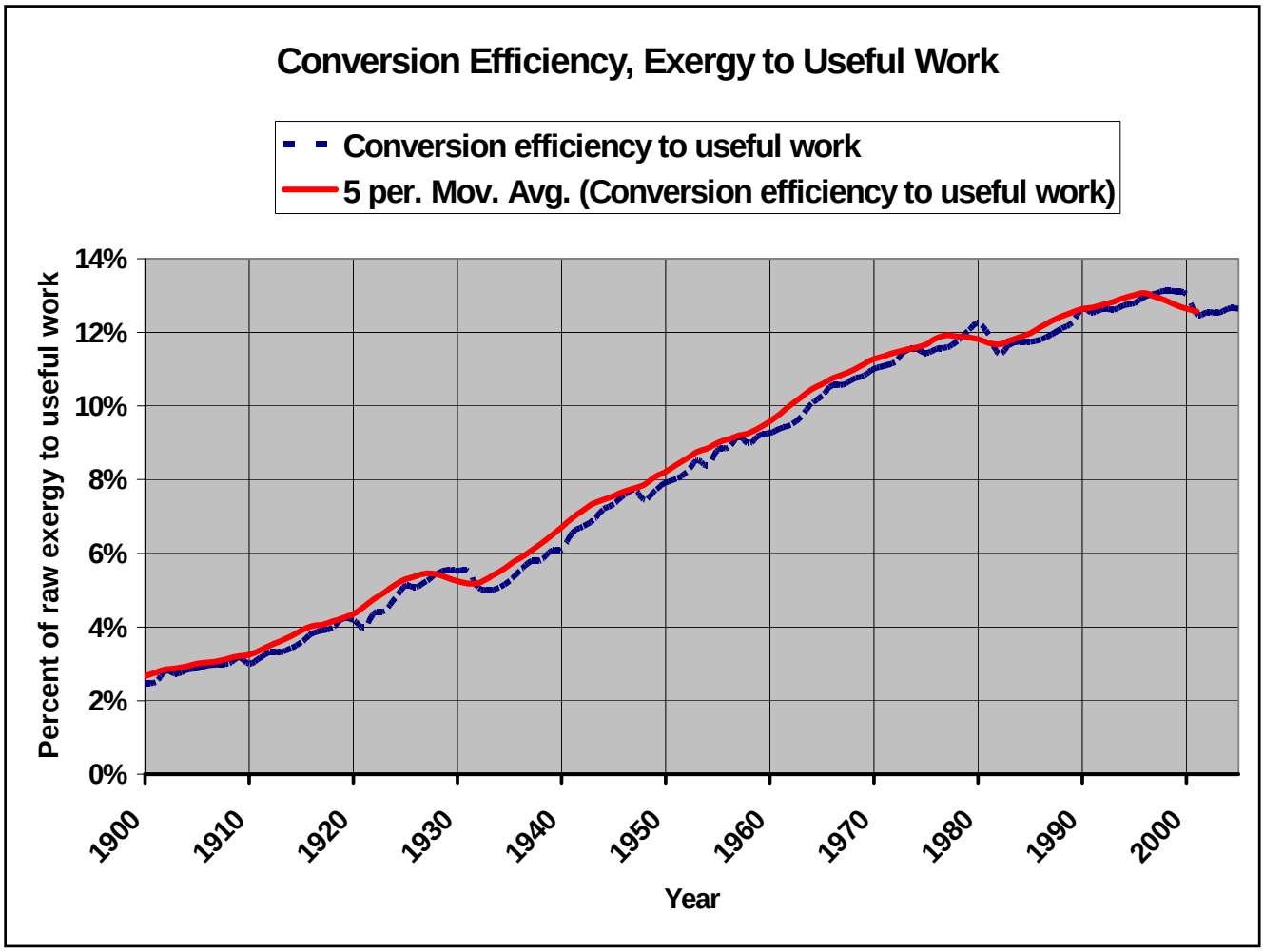
- Raw energy use and GDP do not correlate, economists treat energy as simply a 4% factor in overall economy
- Robert U. Ayres recently examined relationship between useful work and GDP (gross domestic product)
- Ayres showed that changes in useful work explained most of the past century's economic growth

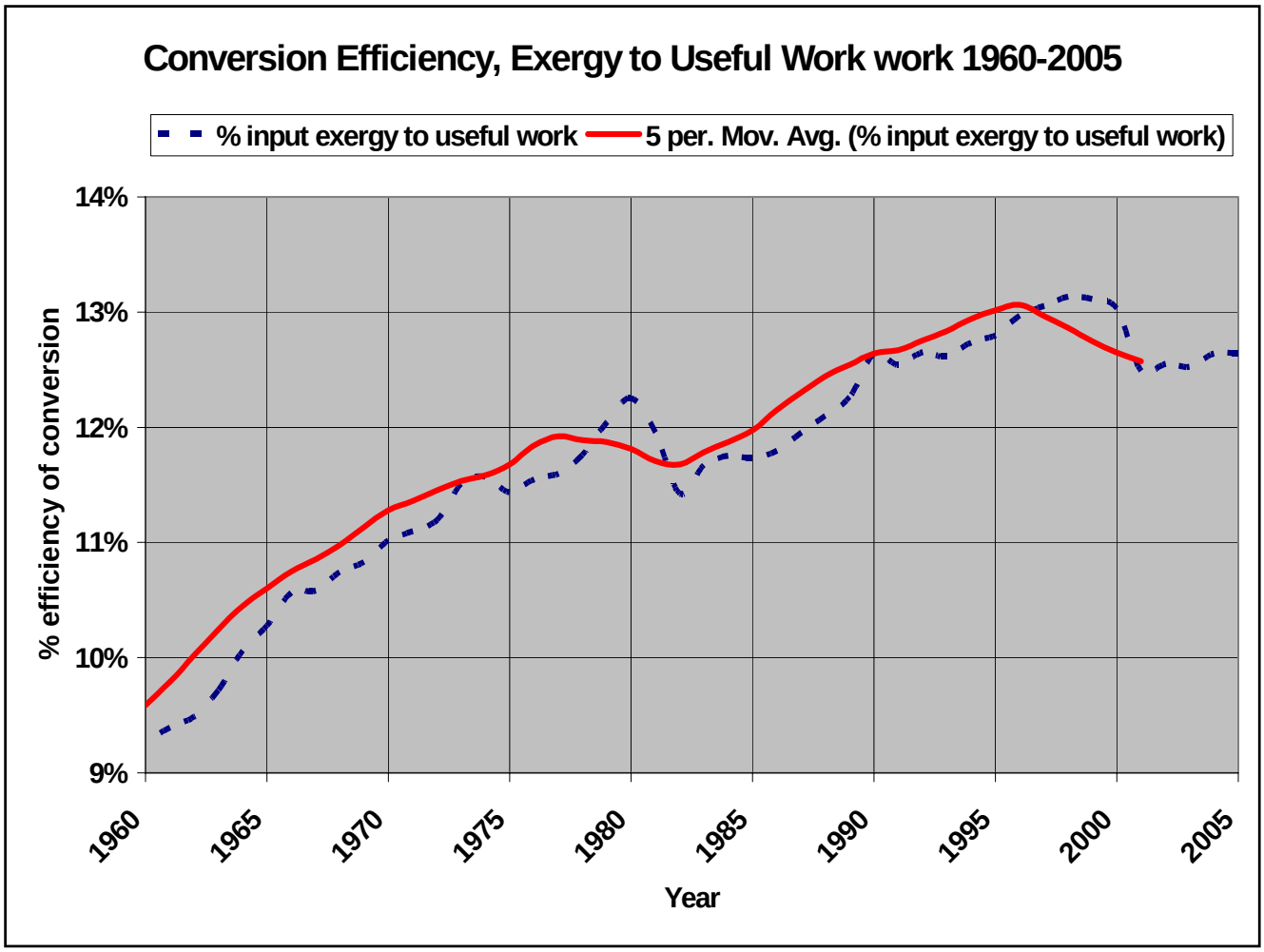
Economic Growth Threatened by Declining Energy Efficiency

- **Long trend of falling energy use per dollar of GDP, does not correlate with rising GDP**
- **Also long trend of increasing efficiency of converting potential energy to useful work**
- **Useful work per dollar of GDP has been remarkably constant**
- **However, energy efficiency growth has stopped and reversed, largely due to electric industry stagnation**


US Exergy and Useful Work per $ GDP
watts total exergy / $GDP
watts useful work / $GDP
10 year moving average
kWh / $GDP
18
16
14
12
10
8
6
4
2
-
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year

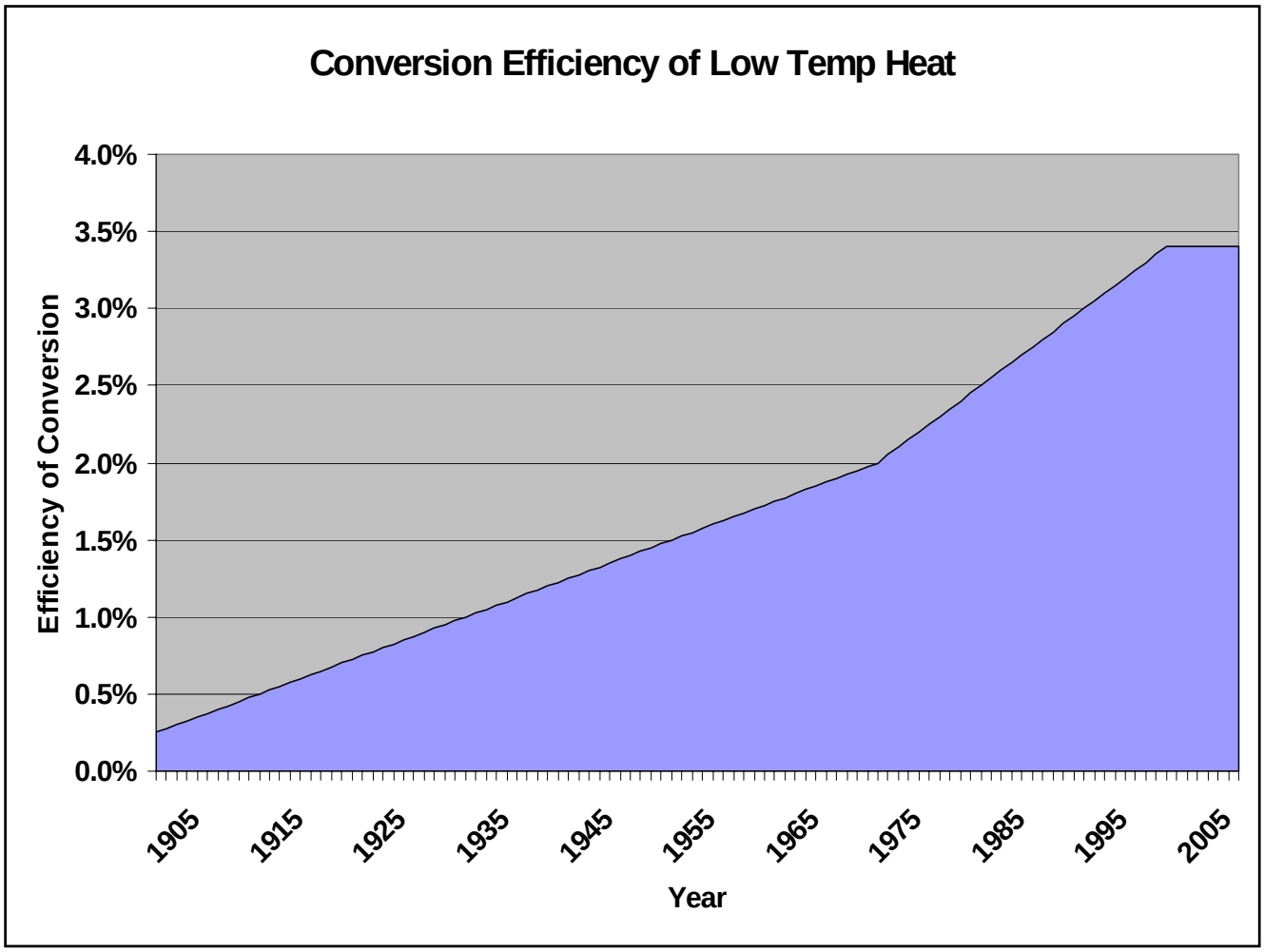

KWh Useful Work / $GDP
kWh of useful work per $GDP
10 per. Mov. Avg. (kWh of useful work per $GDP)
kWh / $GDP
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

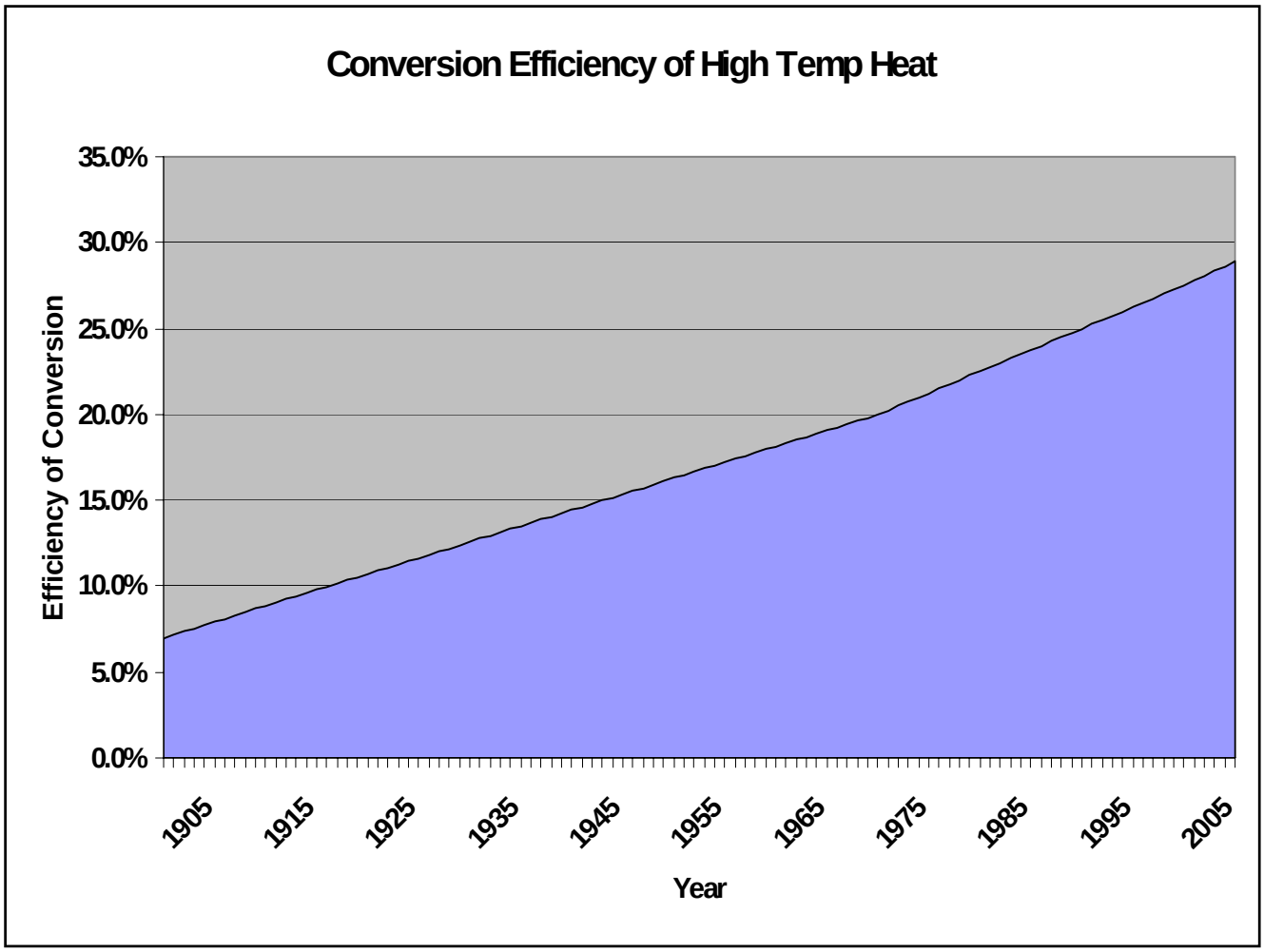

Conversion Efficiency, Exergy to Useful Work
Conversion efficiency to useful work
5 per. Mov. Avg. (Conversion efficiency to useful work)
Percent of raw exergy to useful work
14%
12%
10%
8%
6%
4%
2%
0%
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

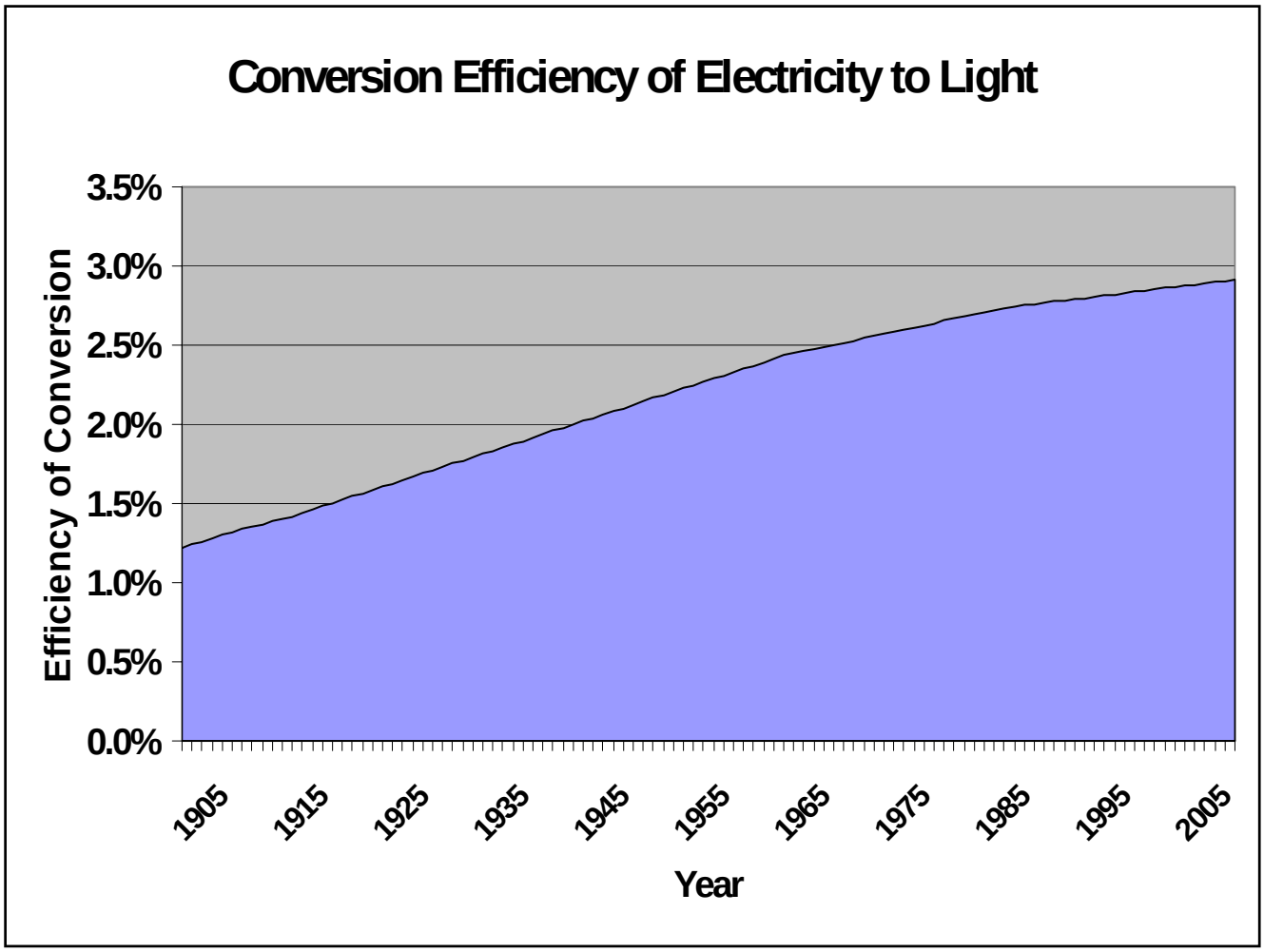

Conversion Efficiency, Exergy to Useful Work work 1960-2005
% input exergy to useful work
5 per. Mov. Avg. (% input exergy to useful work)
% efficiency of conversion
14%
13%
12%
11%
10%
9%
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year

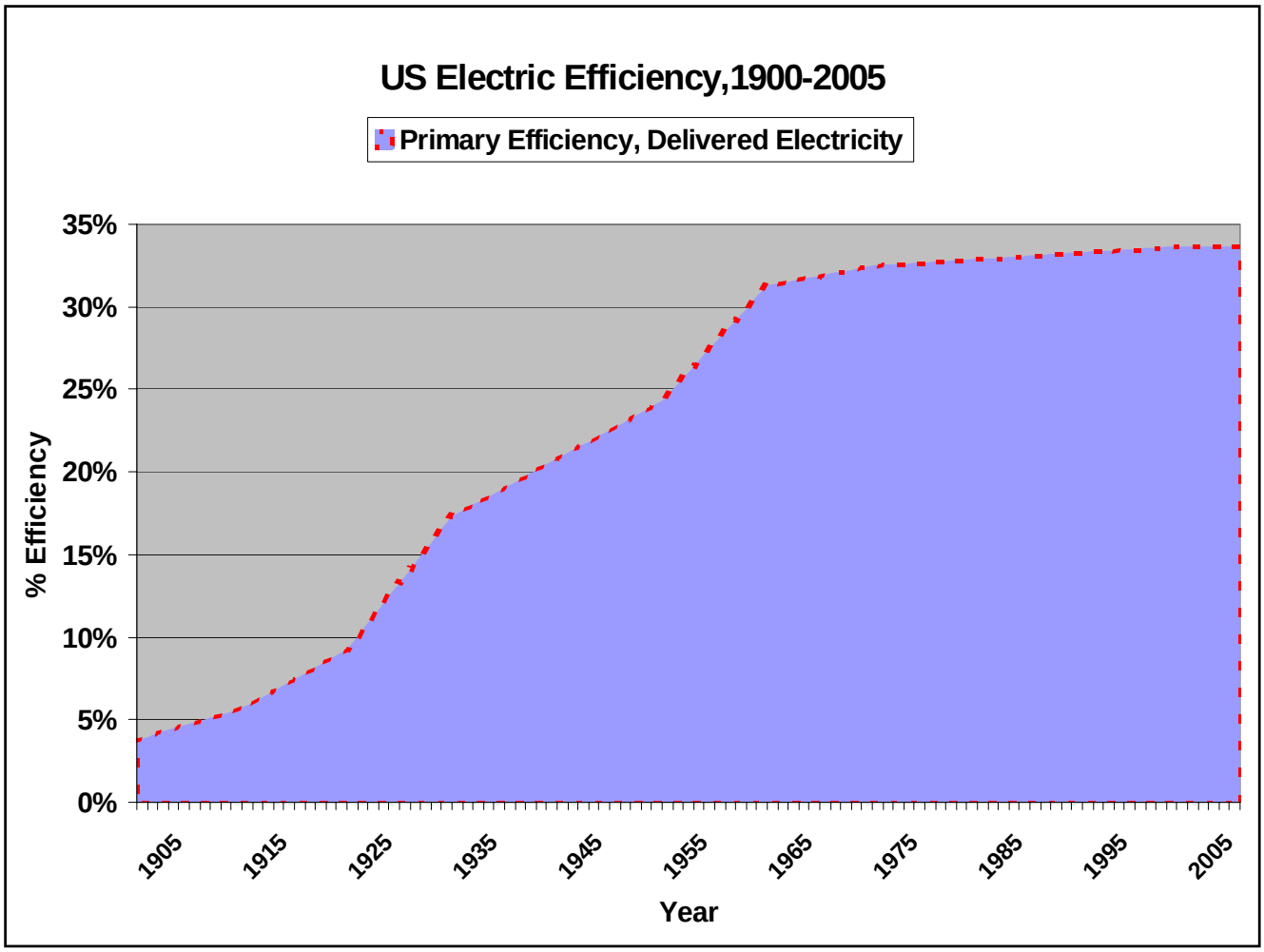
Exergy Conversion to Useful work by Sector

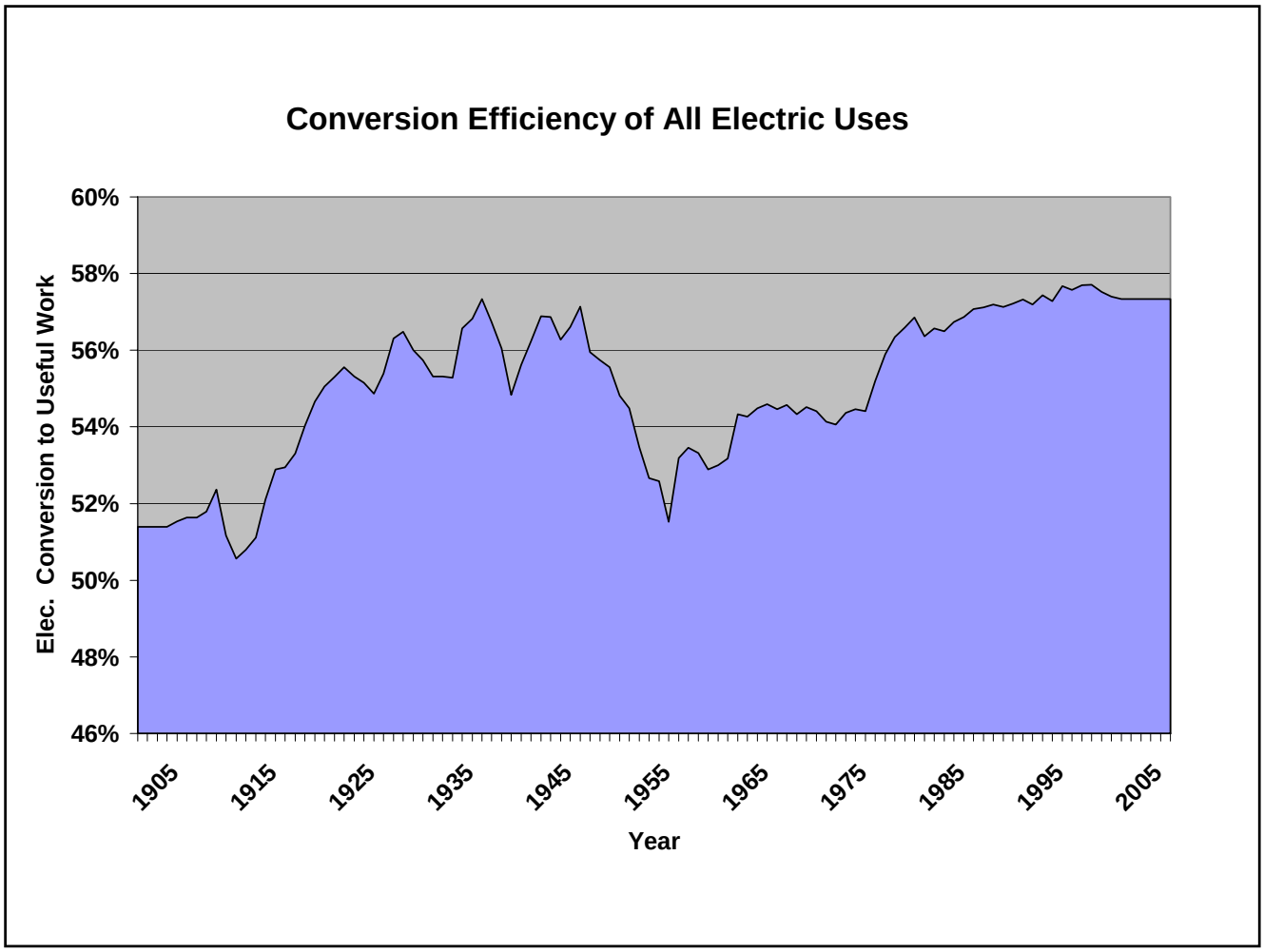
- Look at the % of exergy converted to useful work in low temperature heat, high temperature heat, lighting, and electricity
- Electricity is by far the most efficient way to use energy, but
- Efficiency has stagnated in electricity production
  - Stagnant power industry efficiency is key to many US problems, including industrial competitiveness, pollution, jobs, balance of payments, and global warming

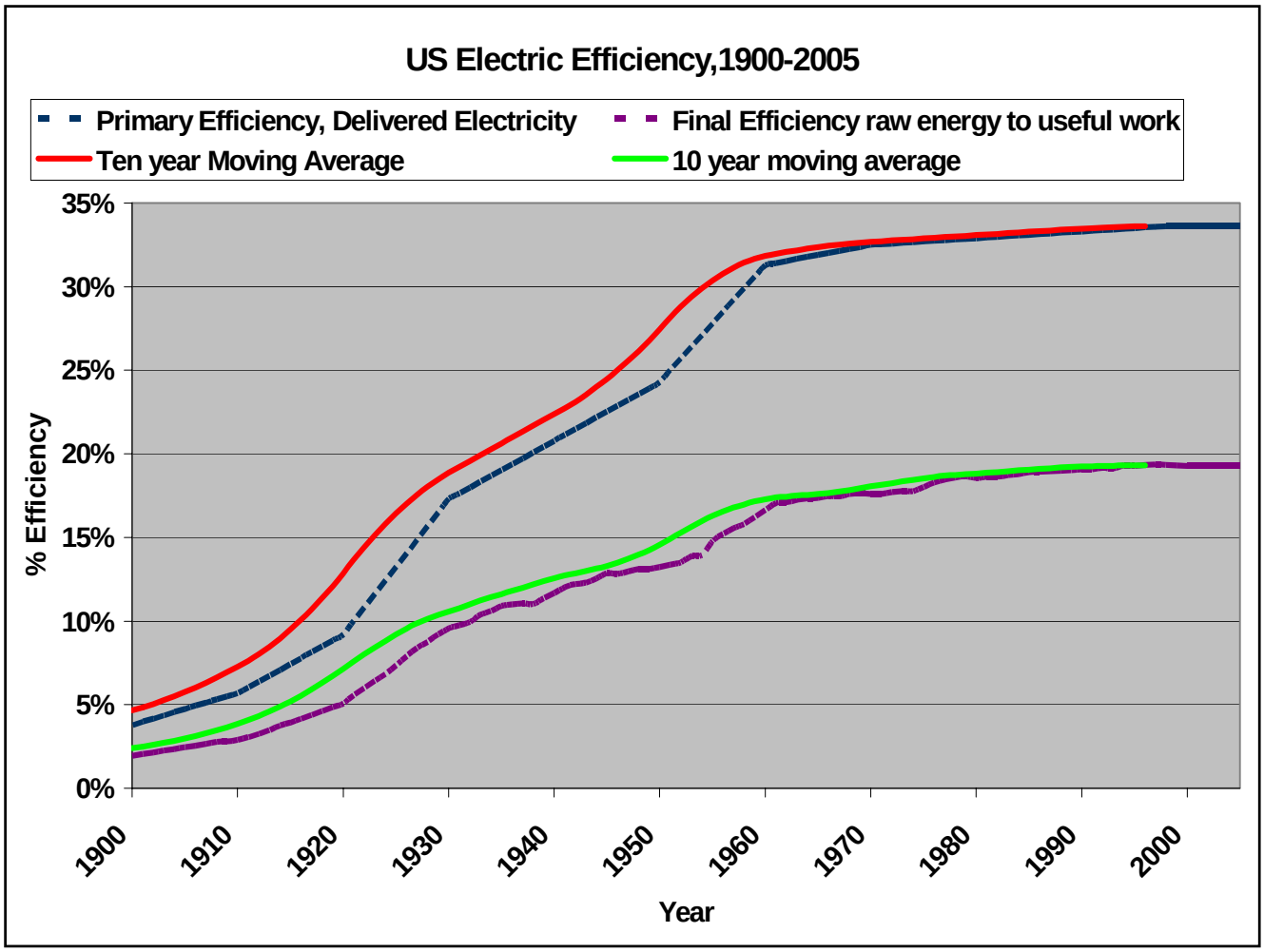

Conversion Efficiency of Low Temp Heat
Efficiency of Conversion
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year


Conversion Efficiency of High Temp Heat
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Efficiency of Conversion
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year


Conversion Efficiency of Electricity to Light
Efficiency of Conversion
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year


US Electric Efficiency,1900-2005
Primary Efficiency, Delivered Electricity
35%
30%
25%
20%
15%
10%
5%
0%
% Efficiency
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year


Conversion Efficiency of All Electric Uses
60%
58%
56%
54%
52%
50%
48%
46%
Elec. Conversion to Useful Work
1905
1915
1925
1935
1945
1955
1965
1975
1985
1995
2005
Year


US Electric Efficiency,1900-2005
Primary Efficiency, Delivered Electricity
Final Efficiency raw energy to useful work
Ten year Moving Average
10 year moving average
35%
30%
25%
20%
15%
10%
5%
0%
% Efficiency
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year

We Need Better Generation Options

Recycle energy to reduce cost and reduce pollution

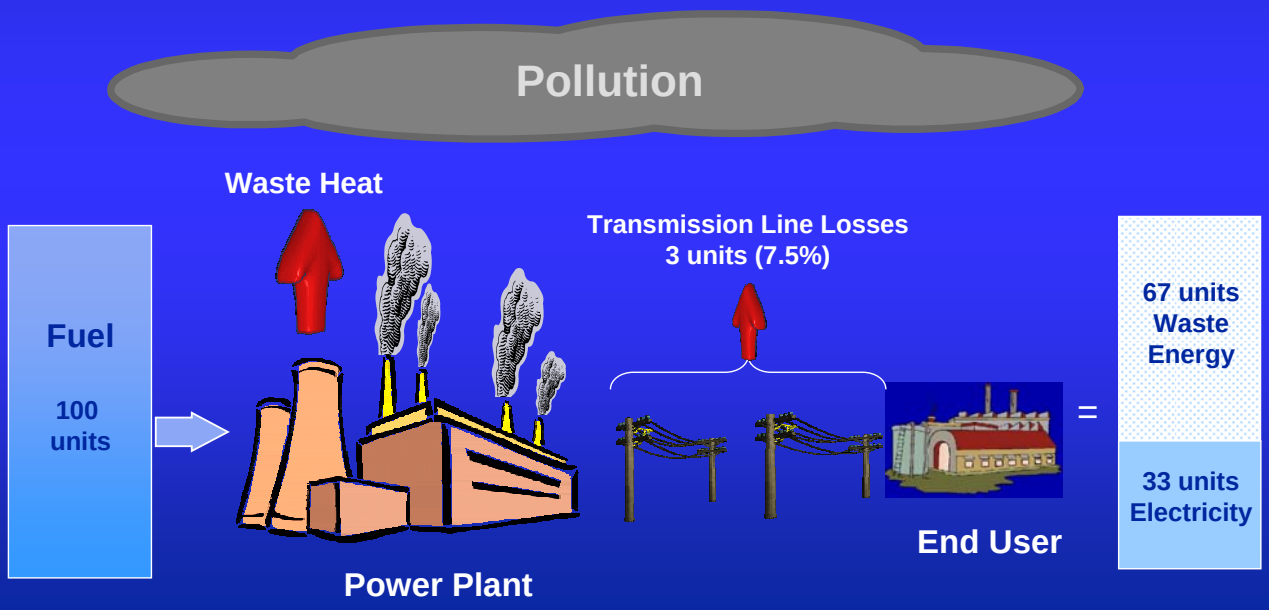
Defining Recycled Energy

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

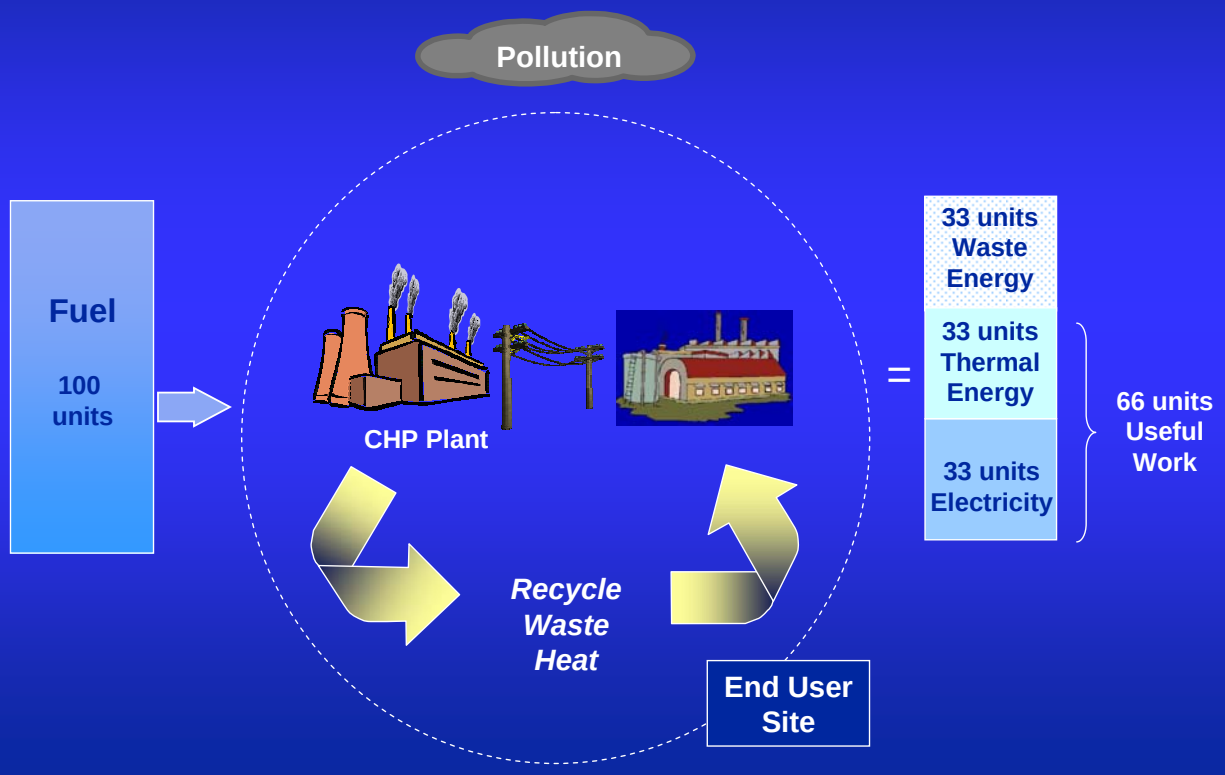
Energy Recycling Impact on the Grid

- **Only local generation can recycle waste energy – impossible to recycle waste energy from remote generation plants**
- **Local generation reduces grid loading, line losses and need for new T&D**
- **Local generation stabilizes voltages, can provide active capacitance and inductance and reduce vulnerability to extreme weather and terrorists**

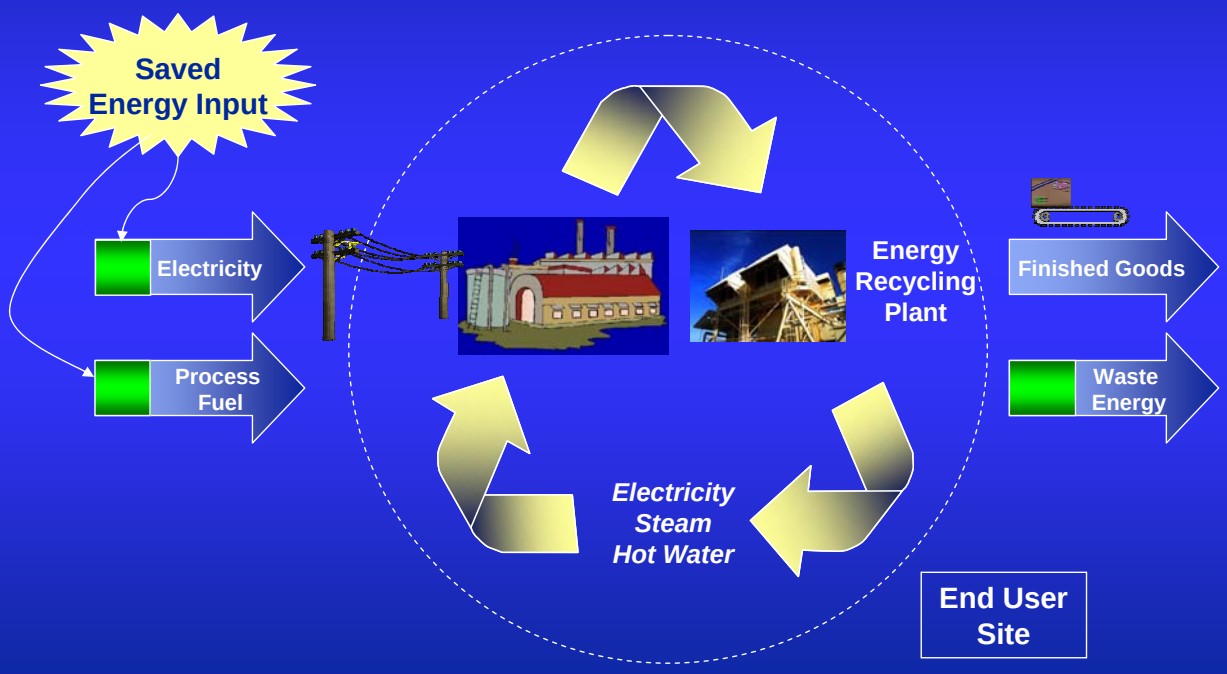
Conventional Central Approach 1960 Data (& 2003 Data)



Decentralized Generation Option Combined Heat and Power



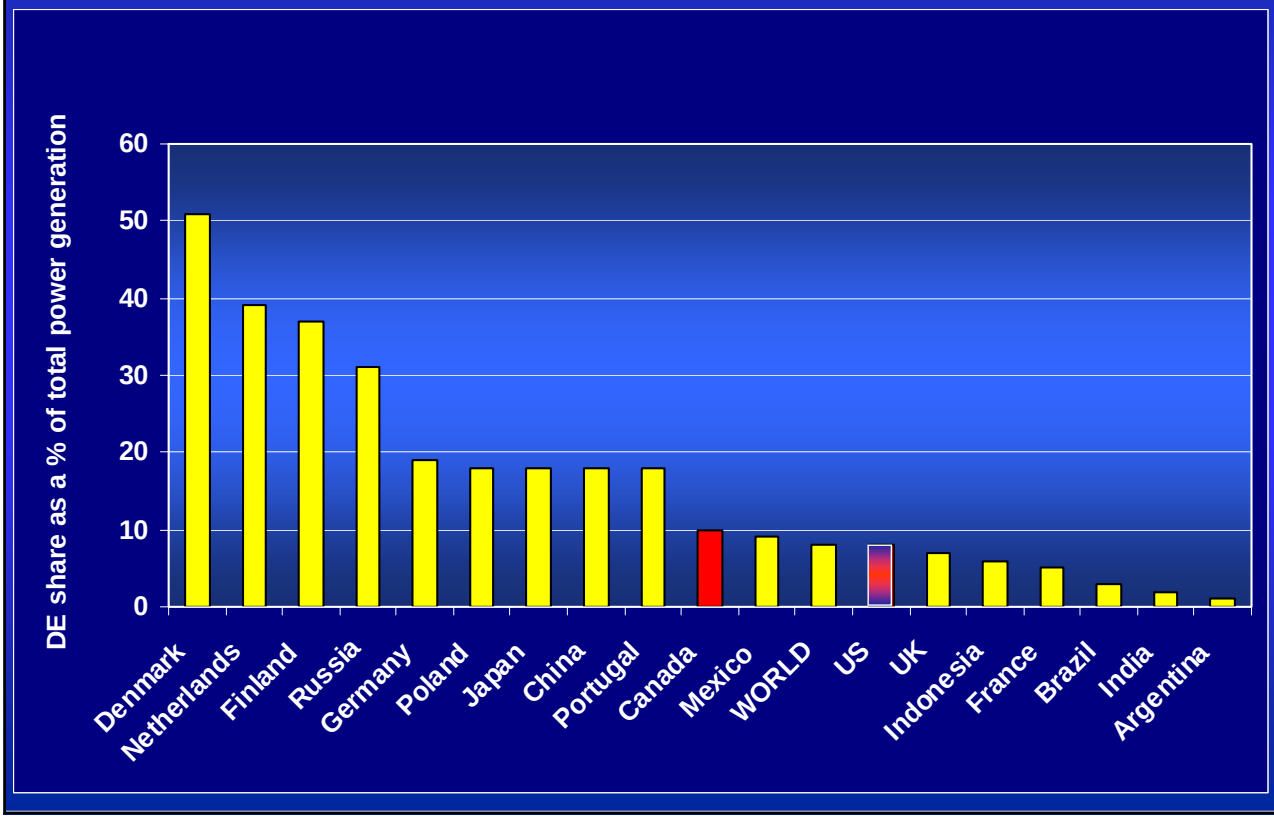
Industrial Energy Options



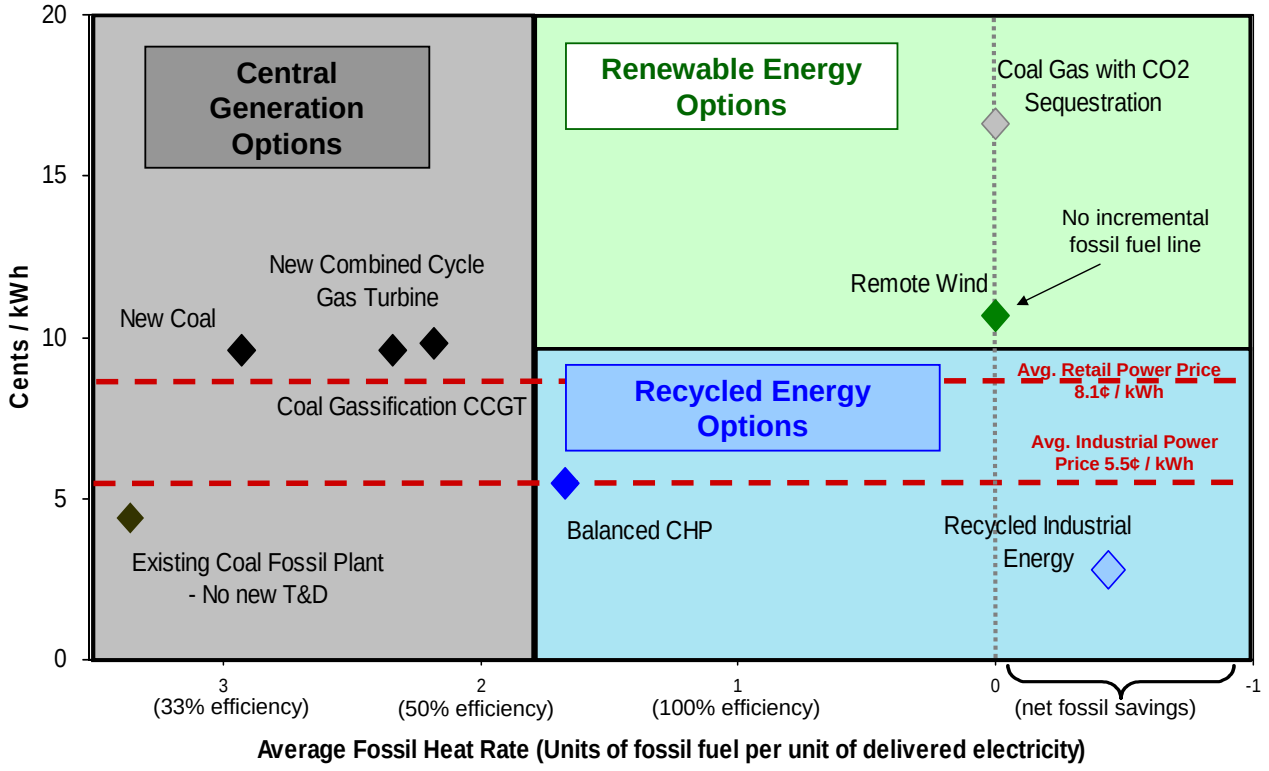
Economies of Scale?
Central versus Decentralized Generation

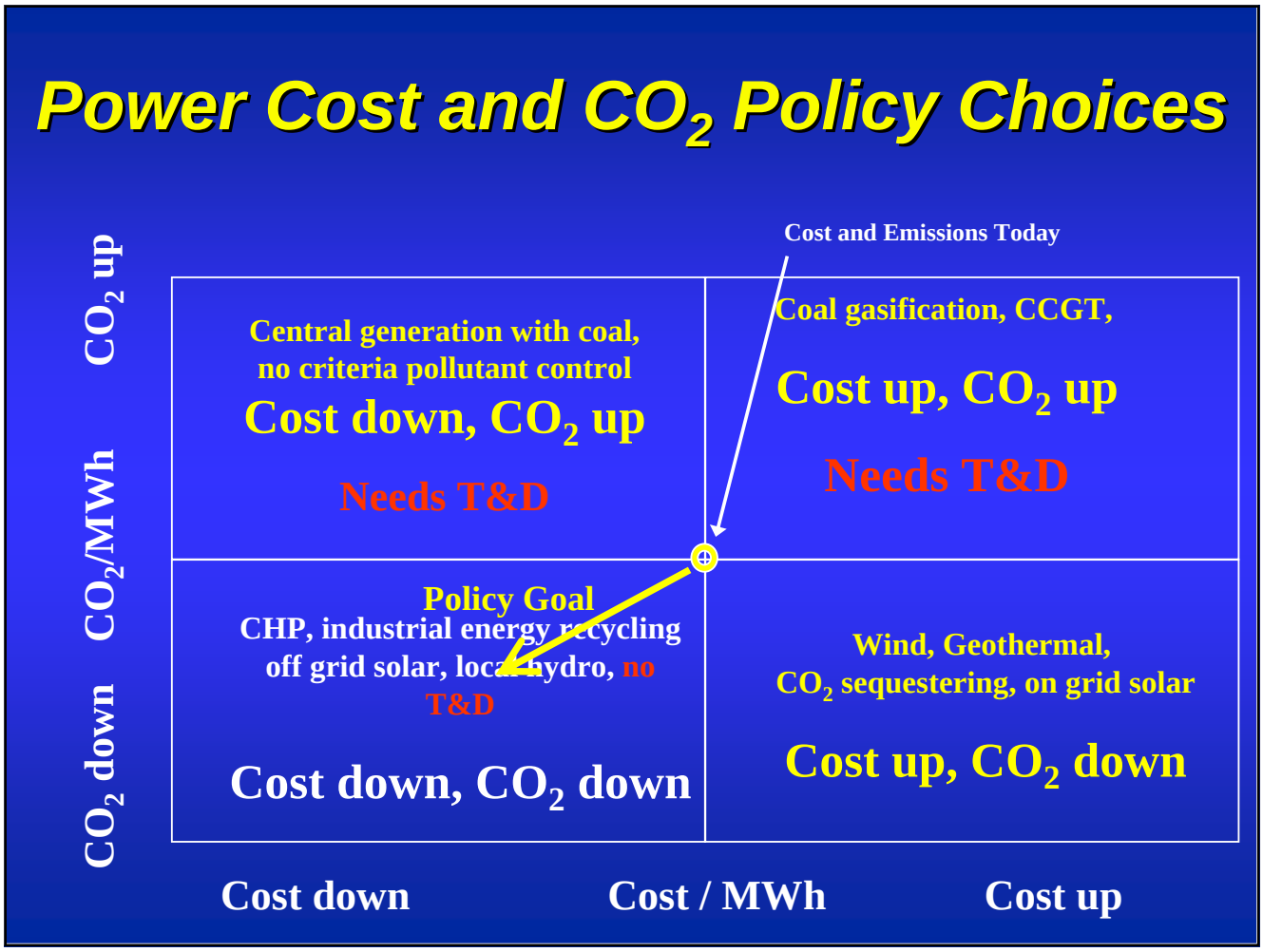
	Generation	Transmission & Distribution	Total / kW of Generation	KW required/ kW Load	Total costs/ kW New Load
Central Generation	$890	$1380	$2,270	1.44	$3,269
Local Generation	$1,200	$138	$1,338	1.07	$1,432
Savings (Excess) of Central vs. Local Generation	$310	$1,242	$1,068	0.37	$1,837
Central generation capital as a % of local capital	74%	1000%	213%	135%	228%

Comparative Deployment of Combined Heat and Power in 2004



Future Generation Options




Power Cost and CO2 Policy Choices
Cost and Emissions Today
Central generation with coal, no criteria pollutant control
Cost down, CO2 up
Needs T&D
Coal gasification, CCGT,
Cost up, CO2 up
Needs T&D
Policy Goal
CHP, industrial energy recycling off grid solar, local hydro, no T&D
Cost down, CO2 down
Wind, Geothermal, CO2 sequestering, on grid solar
Cost up, CO2 down
CO2 up
CO2/MWh
CO2 down
Cost down
Cost / MWh
Cost up

How Can Policy Spur Recycled Energy?

- **Replace old rules that are now barriers to modern technology**
- **Enable *recycled energy* projects to capture more of value they create**
  - **Reward local generation for avoiding T&D capital and line losses**
  - **Pay part of health and environmental savings to *energy recycling* facilities**

More Specific Suggestions

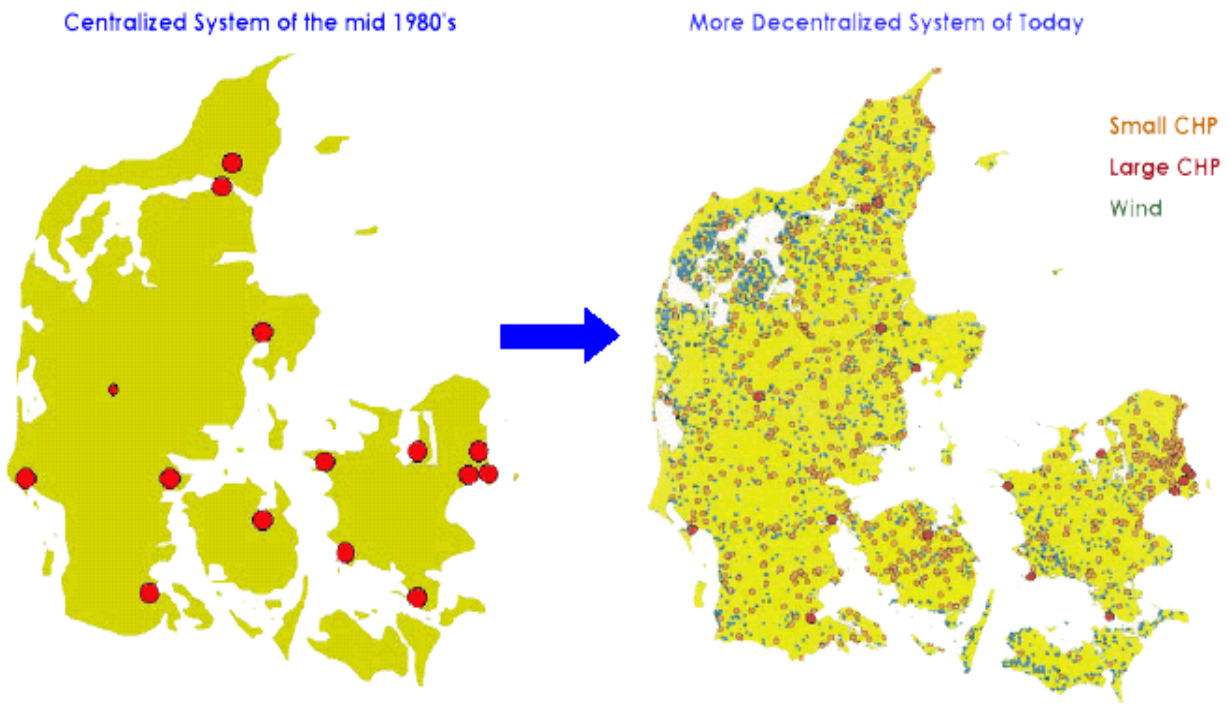
- Provide standard offer for power from energy recycling facilities
- Provide limited loan guarantees for industrial energy recycling plants, valid only if waste energy supply ceases
- Identify specific barriers to efficiency and enact new rules that serve the social purpose but do not block efficiency.

Convenient Truth:

Energy Recycling Solves Multiple Problems

- **US can 'mine' industrial waste energy, create added revenue streams for industry**
  - **Recycle presently wasted energy streams to provide affordable, clean energy**
- **Requires unconventional, innovative governance**
  - **Remove barriers to efficiency**
  - **Pay part of health savings to recycled energy facilities that create those savings**
  - **Pay T&D savings to energy recycling facilities**
  - **Permit energy recycling as pollution control device**

Denmark Changed in Two Decades



Conclusions:

- A modern electric infrastructure must address more than transmission failures
  - Consider impact on local pollution, global warming and industrial competitiveness
- Energy recycling reduces power costs and emissions, and largely eliminates the need for more T&D investments
- Our collective future depends on how fast governments remove barriers to efficiency and encourage clean energy

Thank you for listening