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RECYCLYING ENERGY:
The Relationship Between Useful Work, Economic Growth & Energy Regulation

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Background Observations

- Income largely determined by availability of energy services – useful work
- Fossil fuel use has spurred huge income gains and environmental damage
- Two thirds of fuel used for heat and power
- Economists assume that the power system is near optimal, given available technology
- Apparent governance dilemma: balance economic growth and a healthy biosphere

Power System Is Not Optimal, Fails to Recycle Waste Energy

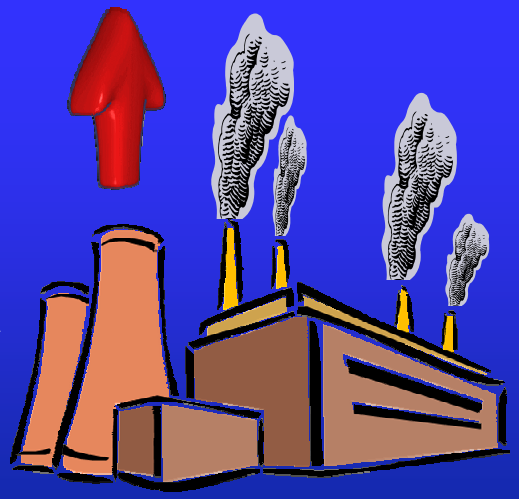
Conventional Central Approach 1960 Data (& 2003 Data)

Pollution

Waste Heat

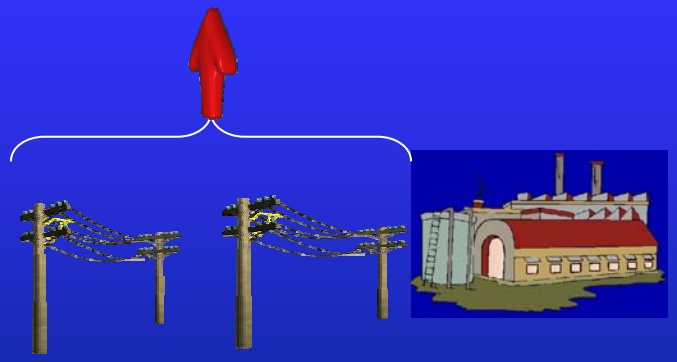
Fuel

100 units



Power Plant

Transmission Line Losses
3 units (7.5%)



End User

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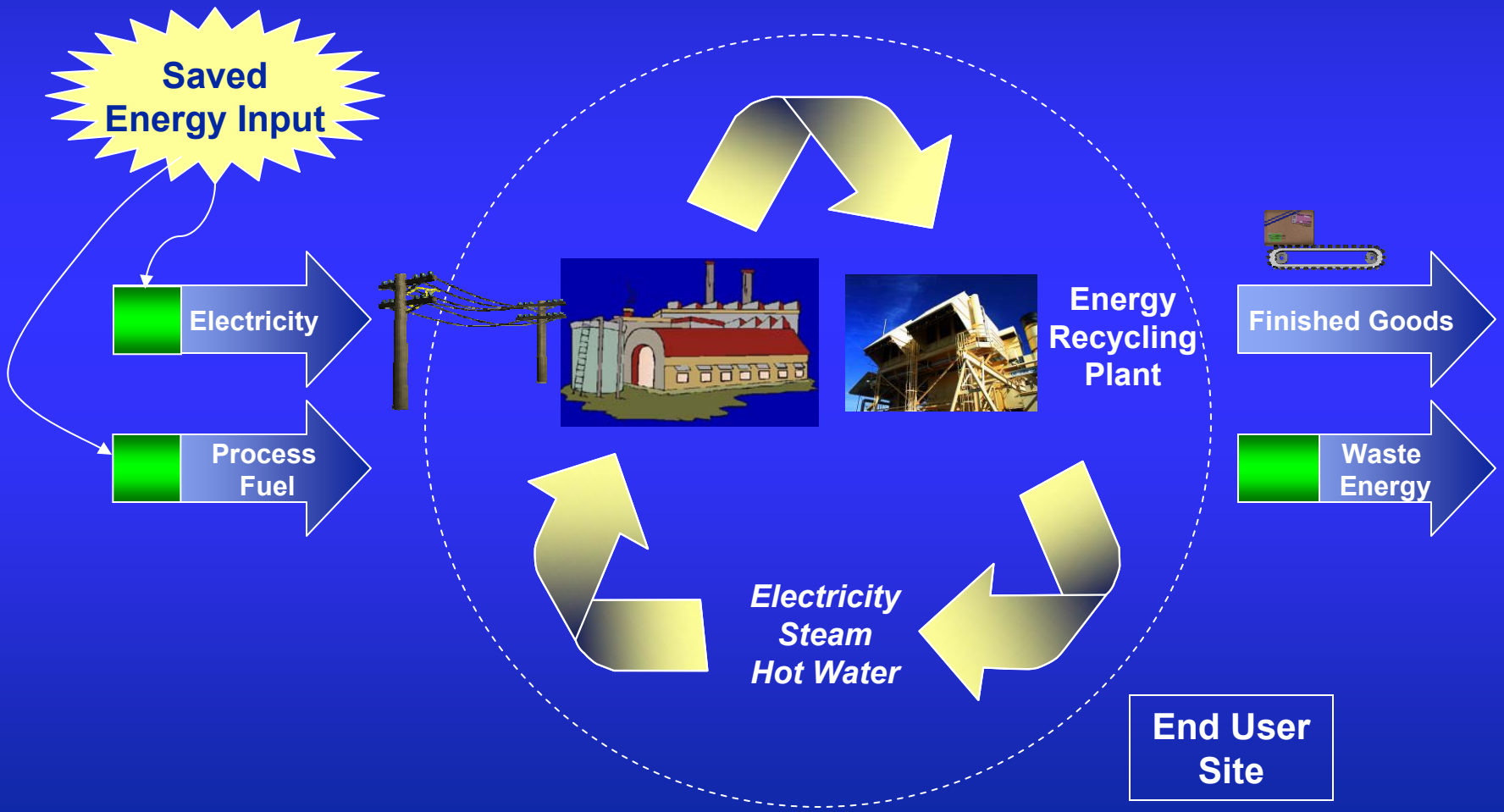
67 units Waste Energy

33 units Electricity

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

Industrial Energy Options

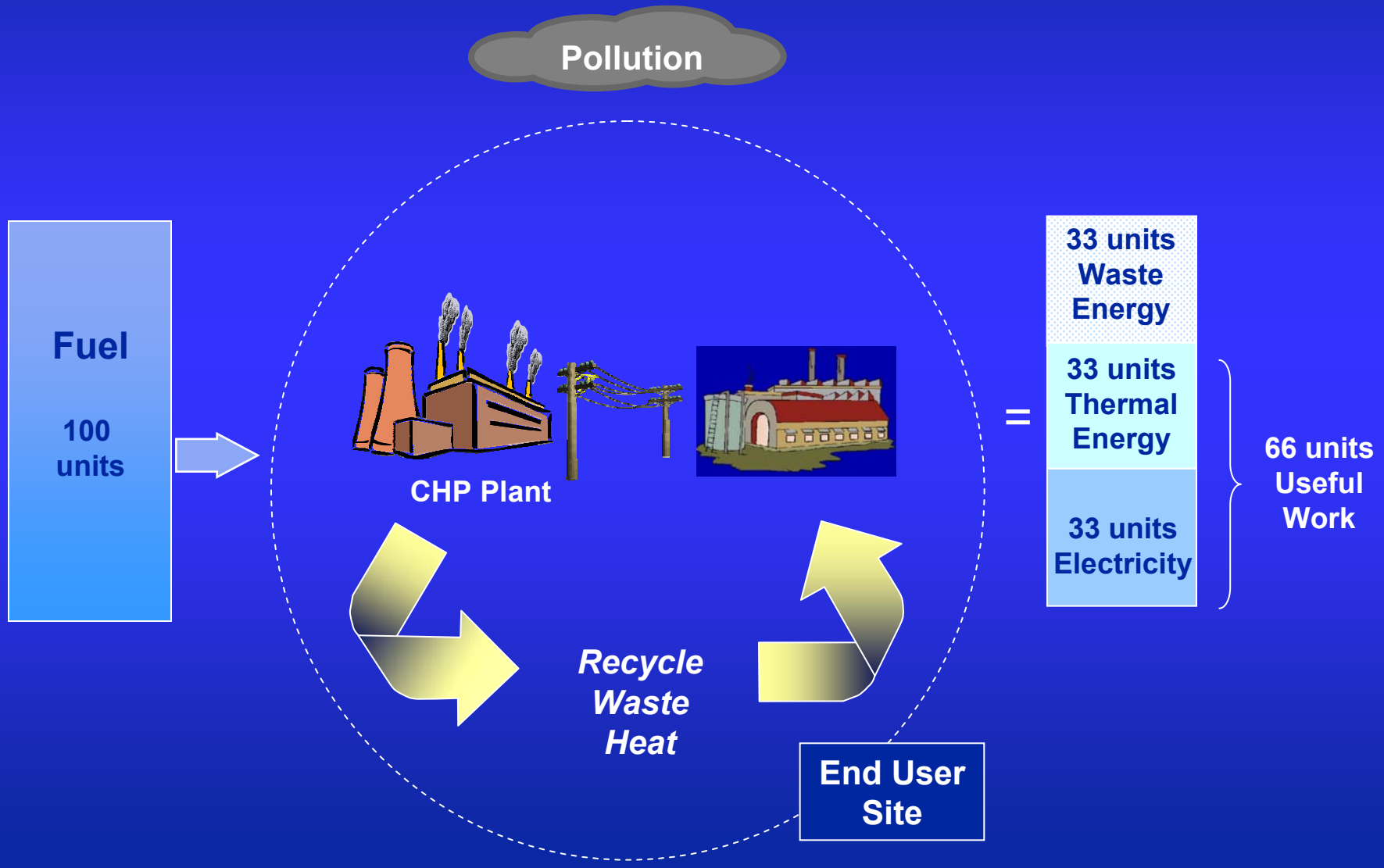


Primary Energy's Approach
90 MW Recycled from Coke Production

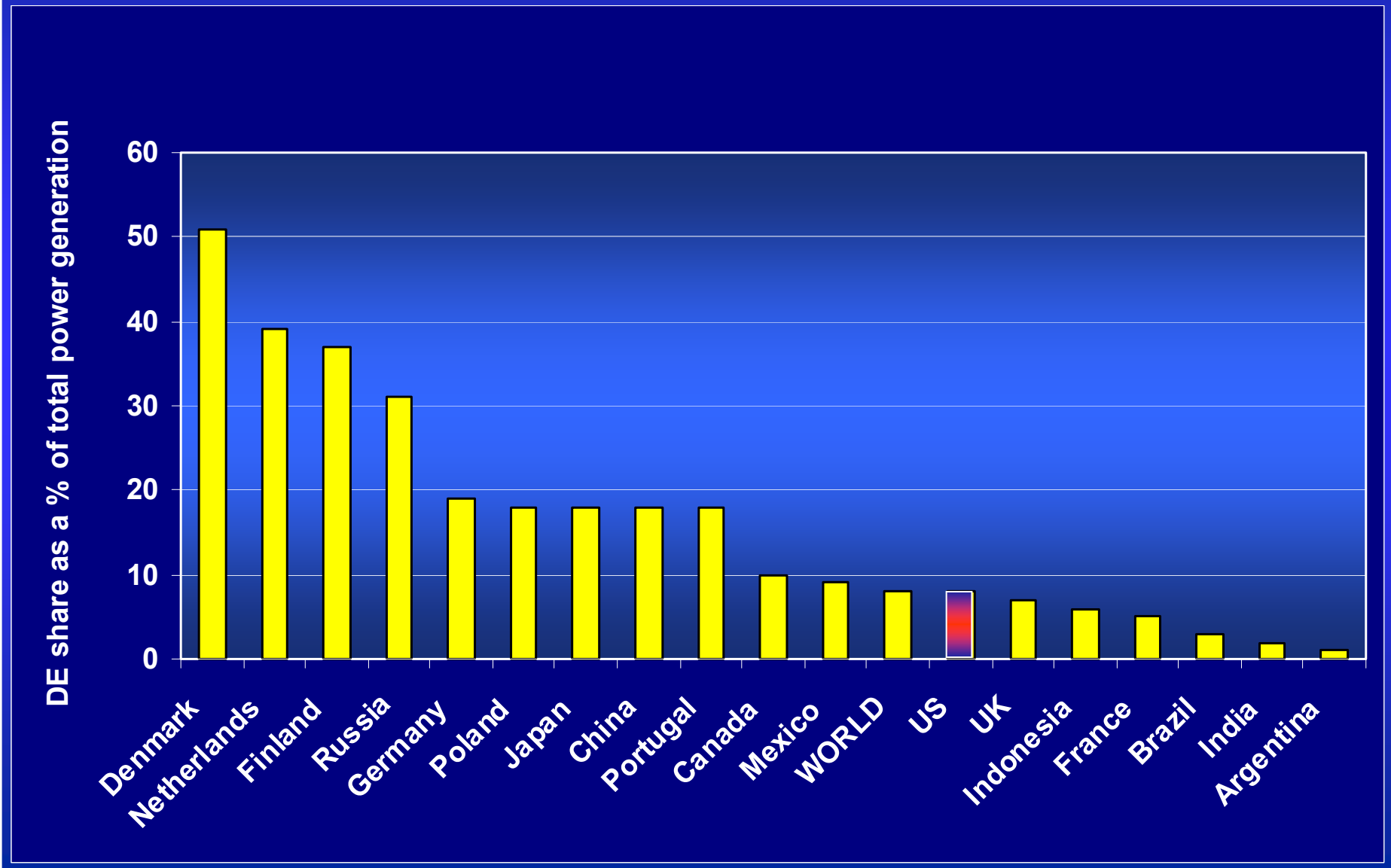
Recycled Industrial Energy Potential

- **Recycled industrial energy could supply 45 to 92 gigawatts (Per US EPA study)**
  - **30% to 60% of US nuclear fleet**
  - **Could supply 19% of US power**
  - **Comparable numbers likely in other industrialized nations**
- **Recycled energy is as clean as renewable energy – no incremental fuel or emissions**
- **Only 9.9 gigawatts operating**

Decentralized Generation Option
Combined Heat and Power



Potential for up to 50% of Electricity from CHP, based on Selected Countries in 2004



Skeptics Admit Local Generation Saves Fuel, But Claim Economies of Scale Make Central Generation Optimal

Economies of Scale?
Central versus Decentralized Generation

	Generation	Transmission & Distribution	Total / kW of Generation	KW required/ kW Load	Total costs/ kW New Load
Conventional Central Generation	$890	$1380	$2,270	1.52	$3,450
Decentralized Generation	$1,200	$138	$1,338	1.07	$1,432
Savings (Loss) of Local vs Central Generation	($310)	$1,242	$1,068	0.47	$2,018
Central Generation Capital as a % of DG Capital	(74%)	1000%	213%	142%	241%

Local generation that recycles energy is more efficient, less capital intensive, less polluting, and less vulnerable to extreme weather and terrorism than central generation

Why Do Most Countries Keep Building Central Generation?

- Power industry is enormous with many players, so we assume market forces must drive industry towards optimality
- This suggests something must be wrong with analysis, but
- The flaw is in the assumption, power industry governance ignores lessons of economics

Market Enabling Conditions Are Not Met in Any Country

- Free entry into the business
- Clear price signals
- Absence of price subsidies that distort decisions
- Charges for externalities
- Restriction of predatory practices by established firms against insurgent firms

Anti-trust rules are inverted in the electric power sector, helping incumbent monopolies block insurgent company innovation

What is Economic Impact of Energy Inefficiency?

- Economists have not been overly concerned: Raw energy use does not correlate with income growth, seems to be only one of many inputs
- But useful work does matter
  - Ayres estimated useful work done every year of 20th century, factoring in all efficiencies in energy chain
  - Replaced 'TPF' with changes in useful work in three factor model and predicted observed growth

Implications

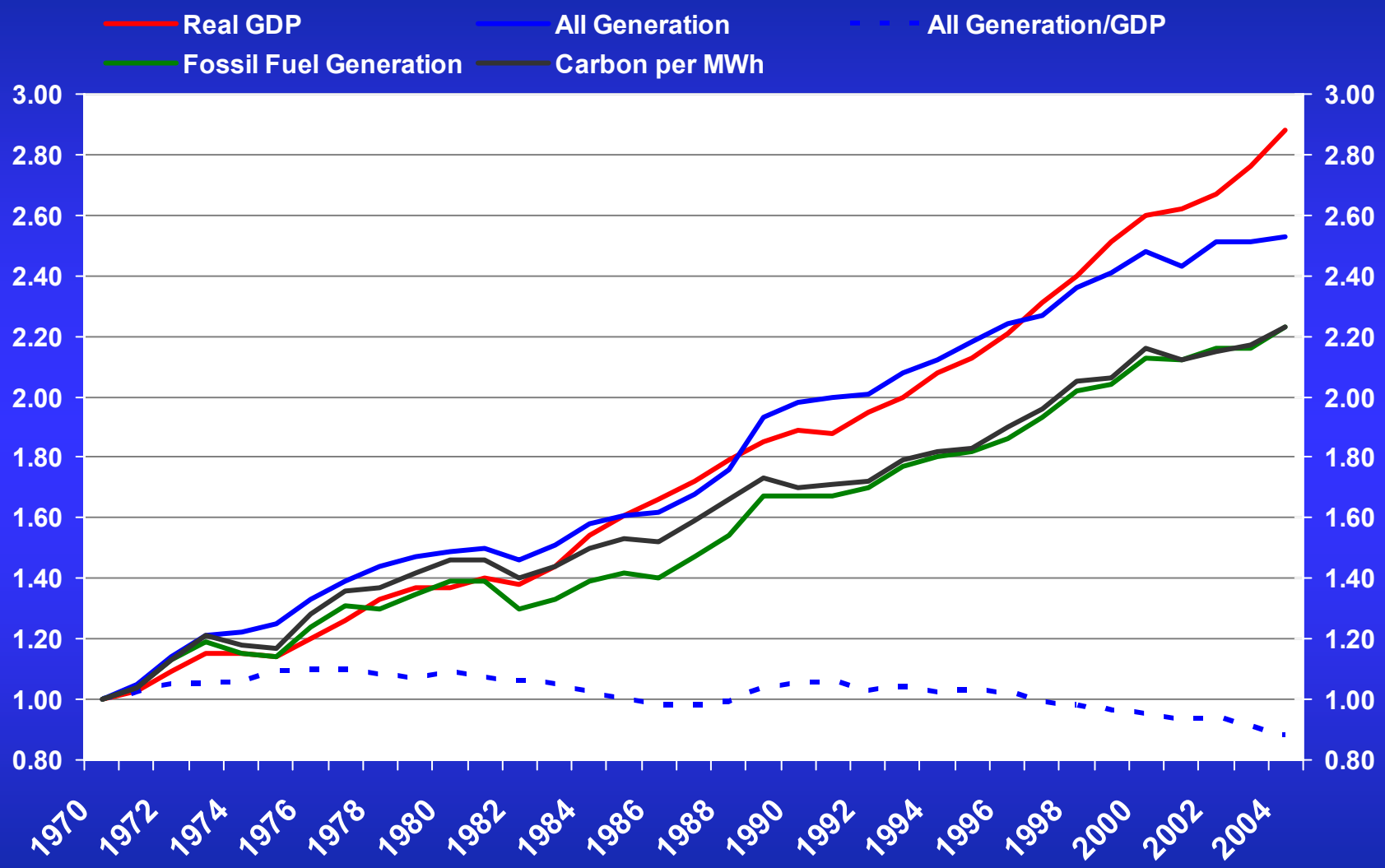
- Changes in useful work appear to explin 7/8ths of observed income growth, but:
  - Power system efficiency stagnated after 1960
  - Century long fossil fuel price decline has reversed
  - Mandates to deploy renewable energy are raising costs of energy services
- Income growth is not a given – increasing costs of energy services could slow or even reverse income growth
- It is thus vital to optimize production of heat and power, which requires local generation that recycles waste energy

Conclusion:

Global economic and environmental health depends upon the speed at which governments unleash competition in the world's largest industry: electric power generation


Thank you

Electricity Generation CO2 Performance versus GDP



Growth of US Real GDP & Fossil Carbon Emissions, All Sectors of the Economy