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Profitably Reducing CO₂ by Recycling Energy
Some ‘Convenient Truths’

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Climate Change Mitigation
A Governance Dilemma?

- The declining cost of energy services has driven income growth throughout U.S. history
  - Exploiting fossil fuel has produced 150 years of per capita income gains, but
  - Resultant CO$_2$ emissions are changing climate
  - 2/3’s of U.S. fossil fuel use is for heat and power
- If the power system is near optimal, then there is an apparent governance dilemma: How balance economics and a healthy biosphere?
The Conventional View: Fact or Myth?

Pollution

Cost
The U.S. Energy System is Far from Optimal

- Regulations are based on a flawed assumption – that electric power will be remotely generated and need to flow through T&D wires
- Regulatory approach assumes yesterday’s technology, blocks innovation
  - Universal ban on private wires penalizes local generation
  - Regulators typically ignore T&D costs, leading to sub optimal decisions
  - Regulations do not reward efficiency
  - Old rules preserve sub optimal approaches. These rules are ‘barriers to efficiency’
Conventional Central Approach
1960 Data (& 2003 Data)

Pollution

Fuel
100 units

Power Plant

Waste Heat

Transmission Line Losses
3 units (9.0%)

End User

67 units Waste Energy

33 units Electricity

= 100 units
Recycling Thermal Energy with Combined Heat and Power

Fuel
100 units → CHP Plant

Recycle Waste Heat

End User Site

Pollution

33 units Waste Energy
33 units Thermal Energy
33 units Electricity

= 66 units Useful Work
Comparative Deployment of Combined Heat and Power in 2004

Bar chart showing DE share as a % of total power generation for various countries and regions.
U.S. CHP Potential
(With Barriers Removed)

- U.S. could *profitably* double electric efficiency by deploying local CHP generation to recycle waste heat
  - Recycling waste heat with CHP would displace 13 Quads of fossil fuel and associated pollution
  - CHP plants, with no need for new wires, cost 60% less than new central generation
Recycling Energy, Part II
Using Industrial Waste Energy Streams

- 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
Fuel-Free Heat and Power
Recycling Industrial Energy

Saved Energy Input

End User Site

Waste Energy

Finished Goods

Energy Recycling Plant

Electricity Steam Hot Water

Electricity Process Fuel

Energy Input

Finished Goods
Recycled Industrial Energy Potential
(With Barriers Removed)

- US can *profitably* recycle industrial waste streams to ‘fuel’ 64 gigawatts:
  - Equivalent to 64 new nukes
  - No incremental fossil fuel, no incremental CO$_2$
  - Generate 14% of US power
  - Save 4 Quads per year of fossil fuel
  - Only 9.9 gigawatts installed today

- Recycled energy is environmentally equivalent to renewable energy, usually less expensive, but not encouraged by regulations
Primary Energy’s Approach
90 MW Recycled from Coke Production
Skeptics Admit Local Generation Saves Fuel, But Claim Economies of Scale Make Central Generation Optimal
# Economies of Scale?

## Central versus Decentralized Generation

<table>
<thead>
<tr>
<th></th>
<th>Generation</th>
<th>Transmission &amp; Distribution</th>
<th>Total / kW of Generation</th>
<th>KW required/ kW Load</th>
<th>Total costs/ kW New Load</th>
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</thead>
<tbody>
<tr>
<td>Central Generation</td>
<td>$890</td>
<td>$1380</td>
<td>$2,270</td>
<td>1.44</td>
<td>$3,269</td>
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<tr>
<td>Local Generation</td>
<td>$1,200</td>
<td>$138</td>
<td>$1,338</td>
<td>1.07</td>
<td>$1,432</td>
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<tr>
<td>Savings (Excess) of</td>
<td>$310</td>
<td>$1,242</td>
<td>$1,068</td>
<td>0.37</td>
<td>$1,837</td>
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<tr>
<td>Central vs. Local</td>
<td></td>
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<tr>
<td>Generation</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central generation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>capital as a % of</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>local capital</td>
<td>74%</td>
<td>1000%</td>
<td>213%</td>
<td>135%</td>
<td>228%</td>
</tr>
</tbody>
</table>
Total U.S. Recycled Energy Potential

- Could avoid 17 Quads of fossil fuel per year
- Reduce annual energy costs by $70 billion
- Reduce CO$_2$ emissions by 20%
- Preserve and grow manufacturing jobs
- Stimulate construction jobs
- Reduce electric system vulnerability
- Many associated benefits
Does the Power Industry Build Optimal Plants?
Examine the 435,000 MW New Generation Built by US Electric Utilities between 1973 and 2002

- Distributed Generation: 1%
- Central Generation: 99%

Pie chart showing the distribution of generation types.
Future Generation Options

Central Generation Options

- New Coal
- Gas Turbine
- New Combined Cycle
- Coal Gasification CCGT
- Existing US Coal Fossil Plant - No new T&D

Renewable Energy Options

- Remote Wind
- Coal Gas with CO2 Sequestration

Recycled Energy Options

- Balanced CHP
- Recycled Industrial Energy

Average Fossil Heat Rate (Units of fossil fuel per unit of delivered electricity)

Cents / kWh

Average Retail Power Price: 8.1¢ / kWh
Average Industrial Power Price: 5.5¢ / kWh

(33% efficiency) (50% efficiency) (100% efficiency) (net fossil savings)
Power Cost and CO$_2$ Policy Choices

<table>
<thead>
<tr>
<th>Power Source</th>
<th>CO$_2$ Impact</th>
<th>Cost Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central generation with coal, no criteria pollutant control</td>
<td>CO$_2$ up</td>
<td>Cost down, CO$_2$ up</td>
</tr>
<tr>
<td>Coal gasification, CCGT,</td>
<td>CO$_2$ up</td>
<td>Cost up, CO$_2$ up</td>
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<tr>
<td>Policy Goal</td>
<td>CO$_2$ down</td>
<td>Cost down, CO$_2$ down</td>
</tr>
<tr>
<td>Wind, Geothermal, CO2 sequestering, on grid solar</td>
<td>Cost up</td>
<td>Cost up, CO$_2$ down</td>
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Cost and Emissions Today
So Why Do We Keep Building Central Generation?

- Governance ignores economic lessons
  - Universal bans on private wires protect power industry from market forces
  - Without competitive spurs, power industry avoids complexity of recycling energy
  - Under cost of service regulation, utilities that increase customer efficiency reduce their profits
Markets Will Optimize when Essential Conditions Are Present

- Free entry into the business
- Clear price signals
- No subsidies that distort decisions
- Prices include externality costs, and
- Restriction of predatory practices by incumbent firms against insurgent firms
Entry Not Free for Local Generation

- Deregulation allowed wholesale central generation, had measurable effects:
  - Increased load factors at nuclear and coal plants avoided 100,000 MW new capacity, or $150 billion new capital investment
  - Employment per 100 MW of capacity dropped from 75 persons in 1990 to 39 persons in 2004 (-52%)
- But private wire bans were not eased, and this limits competition from local power generation that would recycle energy
Private Wire Bans Stem from Flawed Natural Monopoly Logic

- Logic assumes society benefits by paying for only one set of wires, but:
  - Local generation avoids most T&D investment
  - Thus, local wire bans increase societal investment in transmission wires and block energy recycling
  - The cure is worse than the disease

- When governments have allowed private wires, energy recycling has flourished
  - Private wires allowed in UK, Denmark, other high CHP countries
Price Signals Are Not Accurate

- Regulated prices are average for season
- Actual cost per KWh on peak can be 10 times the costs of off peak generation
- When California struggles to satisfy 50 gigawatt peak loads, citizens use 1 gigawatt to wash clothes
- Accurate, real time price signals would change behavior to limit peak demand
Energy Subsidies are Ubiquitous

- Governments respond to voter pressure and subsidize energy
  - Depletions allowances, gasoline subsidies
  - State power agencies fund all capital investments with taxpayer backed debt
  - Municipal power companies allowed to issue tax exempt debt, pay no taxes
  - Other taxes then pay for energy subsidies
- All U.S. energy is sold below cost; result is under investment in efficiency and over consumption of energy services
Fossil Fuel Prices Do Not Cover Externality Costs

- Health impacts from burning fossil fuel are paid by government and individual health insurance.
- Acid rain and global warming mitigation costs are not covered by taxes on the cause – burning fossil fuel.
- Large defense costs are associated with preserving access to fossil fuel supplies, but paid with income taxes.
Anti-trust rules are inverted in the electric power sector, helping incumbent monopolies block insurgent company innovation.
Convenient Truth:

Energy Recycling with Local Generation is a Win/Win

- Recycling energy will lower costs, reduce fossil fuel use, and cut all emissions
- To achieve, expose power industry to competitive forces, from all approaches
  - End central generation paradigm
  - Modernize obsolete rules that are barriers
  - Fix environmental rules to reward efficiency
  - Reward utilities for efficiency improvements
  - Allow private wires
Changing Regulations at work in Denmark

Centralized System of the mid 1980's

More Decentralized System of Today

Small CHP
Large CHP
Wind
Conclusions:

- Global warming a very serious problem
- We need to deploy all clean energy solutions to reduce CO₂ buildup
- Our economic health depends on access to affordable energy services
- Energy recycling can lower CO₂ and the cost of energy services, and buy time for deployment of renewable energy services
- Our collective future depends on how fast governments remove barriers to efficiency and encourage clean energy
Thank you