



the Energy to Lead

GTI Perspective on Current Energy Issues

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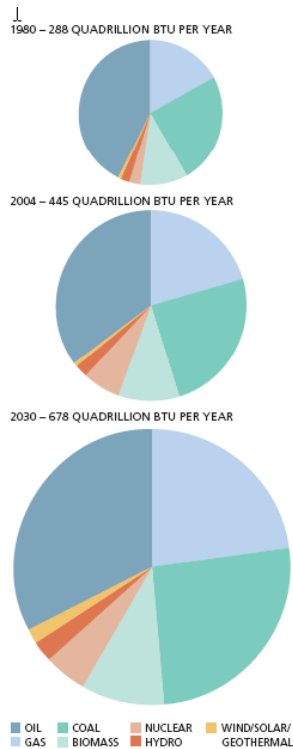
Opening Thoughts: Balancing Energy, Stewardship, and Economics

- > Emerging emphasis on Sustainability
 - Capable of being maintained economically and environmentally for a long period
- > We need the best minds, collaboration, holistic solutions, and new rules



The Sustainability Symbol
Learning to Save the World... (3 fingers at a time)

Increasing Global Energy Demand



Source: IEA, World Energy Outlook 2006.

FIGURE 4. World Energy Supply –
Historical and Projected

- > Growing population with rising expectations
- > We won't run out energy, but we need to find new sources
- > Fossil fuels remain primary; renewables fastest growth rate
- > Conservation is an important "fuel"

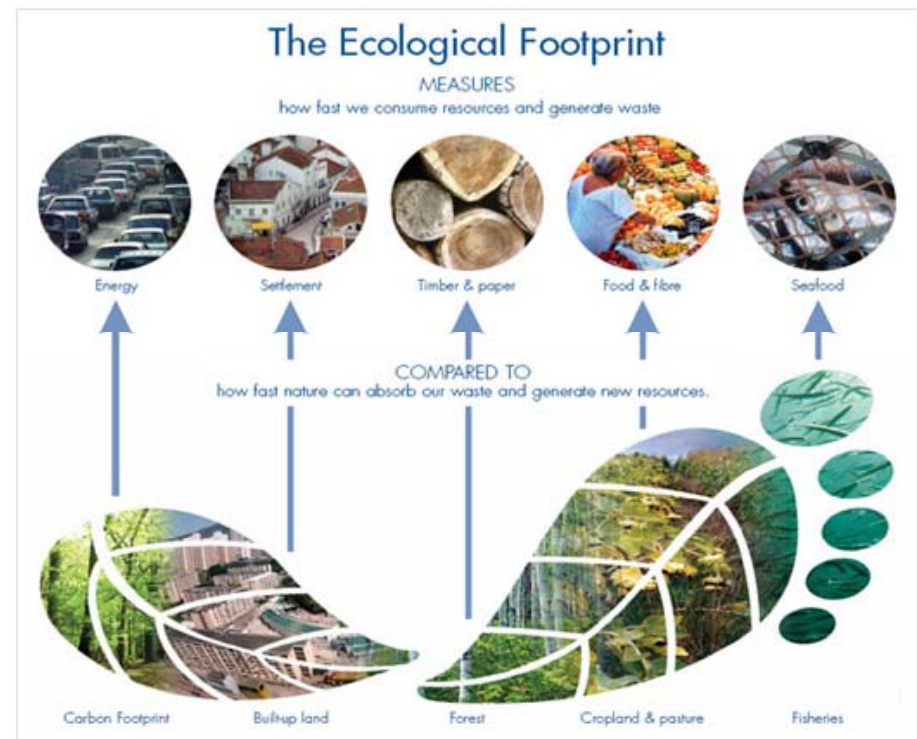
Increasing Stewardship Requirements

Environmental Footprint

- CO₂ and GHGs
- Water (next crisis)
- Land
- Noise
- Viewshed

Safety across value chain

- Operations
- Aging infrastructure



Economics

Paying More in Tight Times

- > Being Green often has higher cost
 - Initial capital cost
 - Operating
- > GHG cost is 1-2% of world GDP

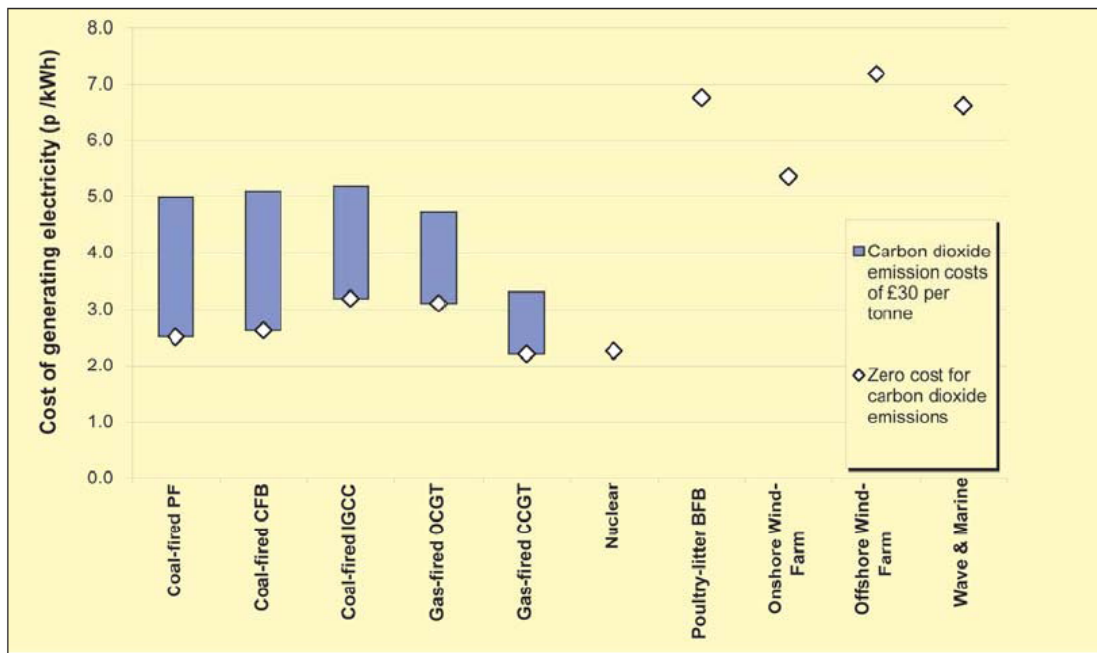
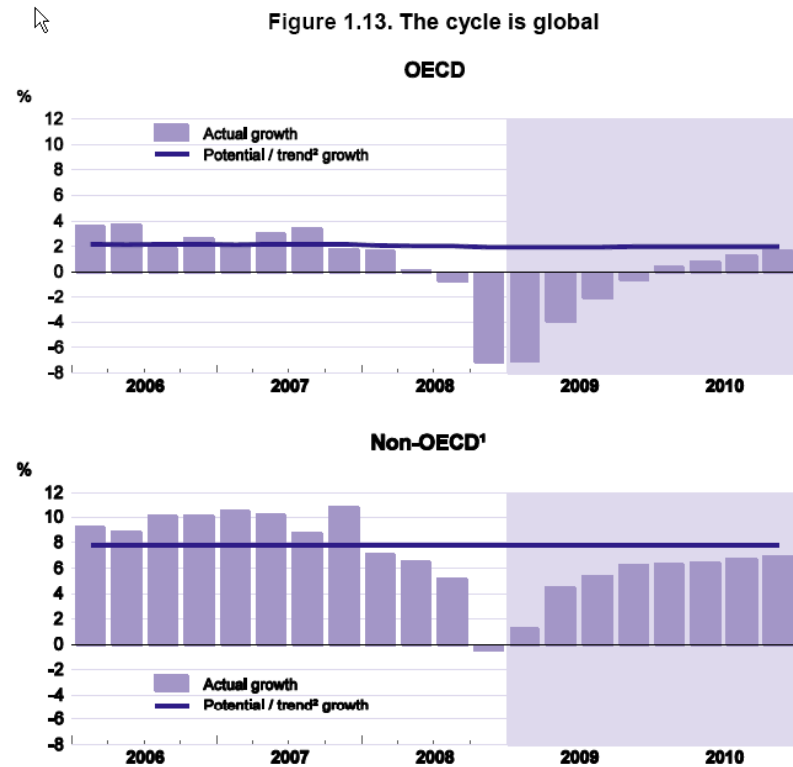


Figure 3 Cost of generating electricity with respect to carbon dioxide emission costs. (Zero to £30 per tonne)

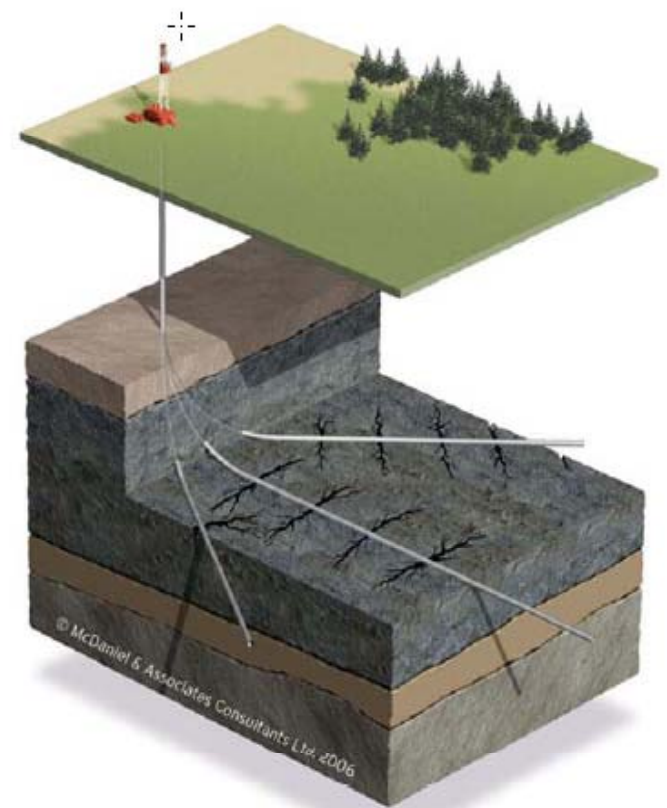
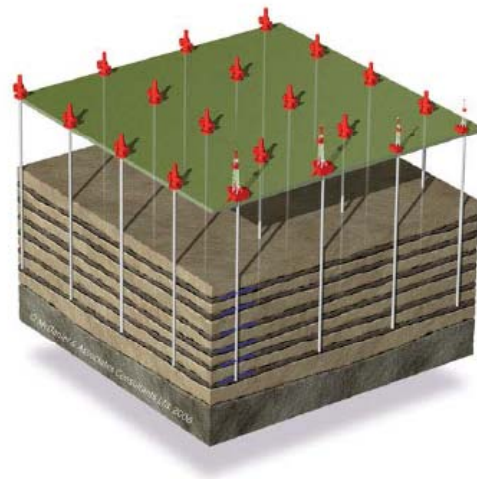
Going Green: Is it the Brake or Accelerator?

- > Need a strong economy and incentives to absorb new costs
- > “Green” is a \$1.3 T/yr business that doubles every 12 years



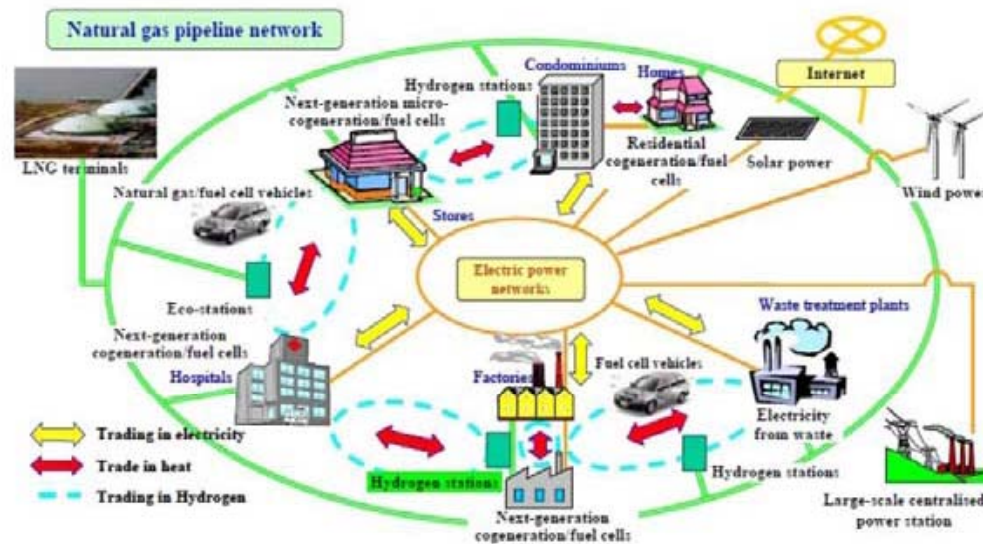
Finding the Balance Point

- > Increasing the supply while reducing the cost and environmental footprint for natural gas



Changing the Game: Holistic Smart Energy Grid

Japanese View of Integrated Energy Grid



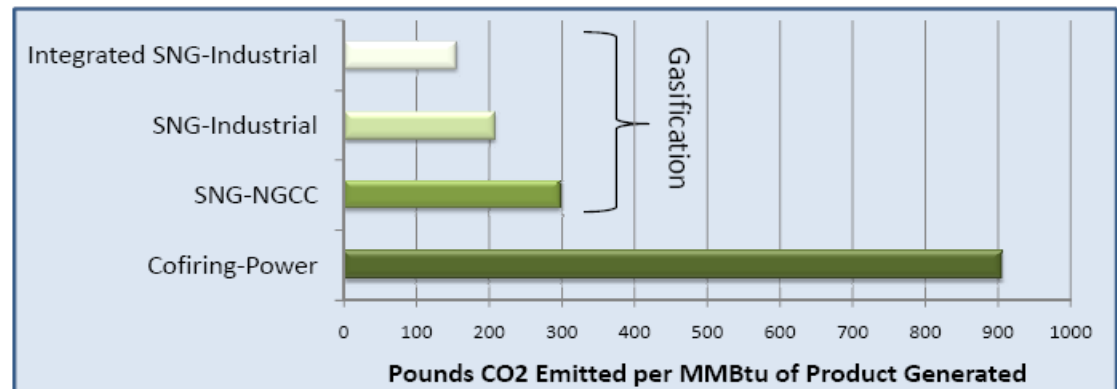
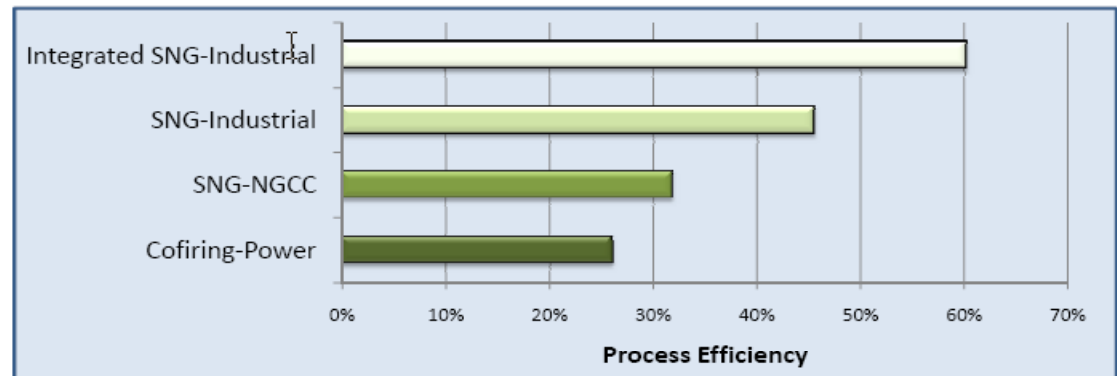
- > Benefits from integrating power, gas, renewables into a Smart Energy Grid
 - O&M information to drive down utilities' delivery cost
 - Defer or eliminate new construction through efficiency-driven conservation
 - Increased reliability for primary and back-up power
 - Provide expanded energy and carbon management options

Rethinking the Problem

US has ~1.3B ton/yr recoverable biomass, a valuable resource for low-carbon energy

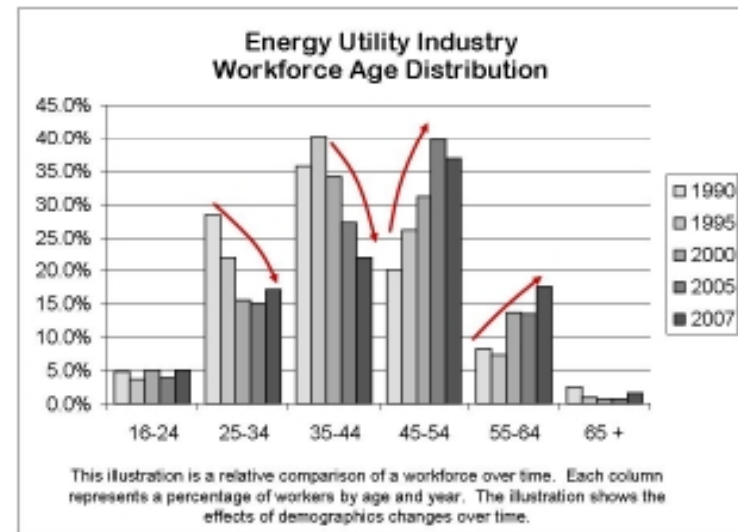
What is best use?

- Ethanol at 30-40% conversion efficiency
- Cofiring at 25% efficiency
- Renewable synthetic gas at 45-60% efficiency



Tough Trends: Workforce Demographics

- No one is getting younger
 - Scientists
 - Engineers
 - Operators
 - Maintenance
- Education is critical
 - GTI programs and training across gas industry
 - Consortia like C²ST to move into schools



Tough Trends: Energy R&D Investment

- 1940-80's model of energy investment as "public benefit" leads to many new technologies
- 1980's-2008 model of "cost sharing" with industry leads to declining energy R&D
- Projected 2-10X current

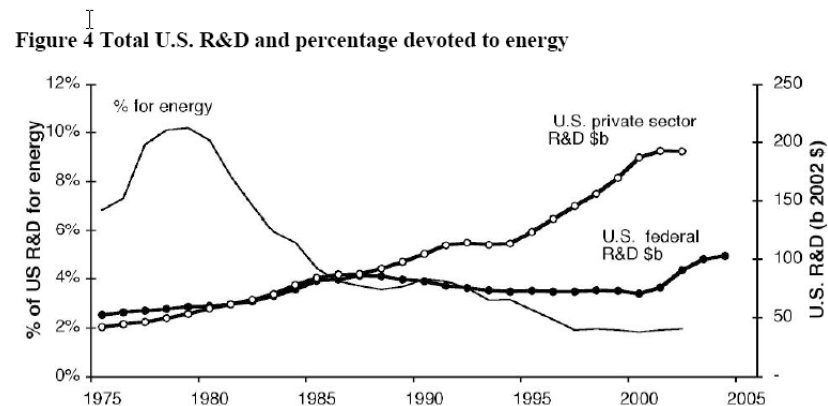
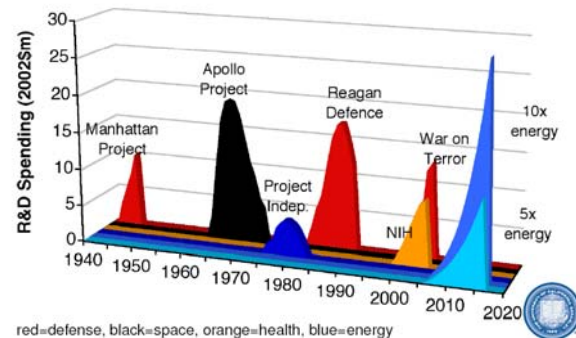


Figure: Major U.S. Public R&D programs



Final Thoughts

- > Energy is essential to economic well-being, but cost is not the only criteria
 - Stewardship important
 - Sustainability is key
- > We need to evolve with the challenge
 - Partnerships to bring the best ideas forward
 - Innovative business and technical approaches to change how we use energy
 - Policies incentivizing goals, not route
 - Ecosystem that attracts human and economic investment in energy, including RD&D