A Global Perspective on Energy Markets and Economic Integration

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Over the Near to Medium Term, Oil and Gas Markets Face Many Uncertainties

What will be the effect of

- **Iraqi Domestic instability on Iraqi oil production**
- **Negotiations surrounding Iranian nuclear technology on Iranian oil supplies**
- **Saudi commitment to expanded oil production**
- **President Putin's policies on Russian oil and natural gas supplies**
- **President Chavez's policies on Venezuelan oil supplies**
- **Higher oil prices on world economic growth**
  - Effect of economic growth on oil demand in China, India, U.S., etc.
- **Higher oil prices on non-OPEC oil supplies**
- **Katrina's impact on crude and refined products**

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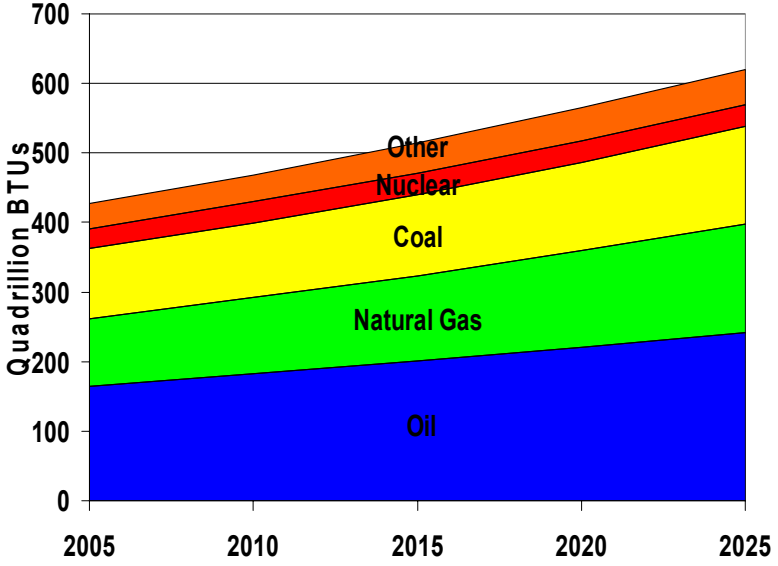
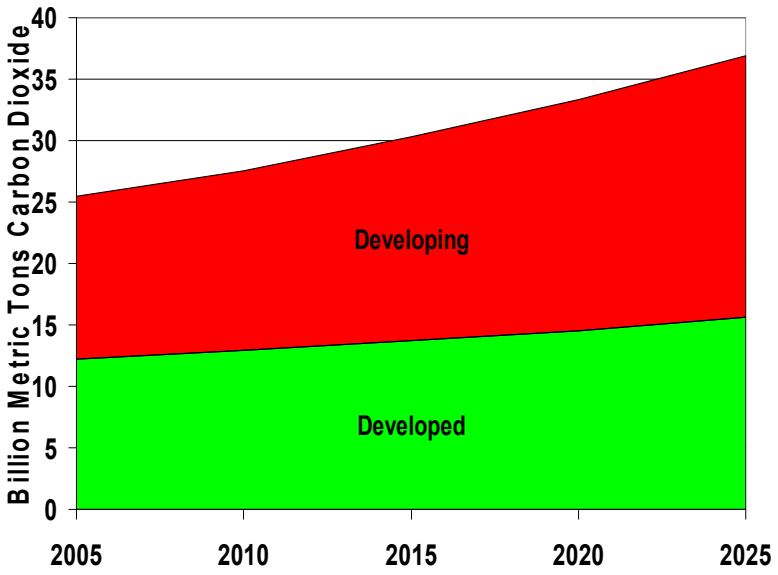
Over the Longer Term, World Energy Demand and Carbon Emissions will Grow Over 40 Percent

Energy Demand



Carbon Dioxide Emissions



and Developing Countries will Account for 70 % of the Increase

Source: USDOE EIA IEO 2004 Reference Case

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The Climate Change Policy Problem is Enormous

- **The theoretical climate change relationship is between atmospheric concentrations of GHG and climate change, not annual emissions**
- **According to the Intergovernmental Panel on Climate Change, stabilizing atmospheric concentration of GHG at current levels would require permanent emissions reductions of 60% or more below current levels**
  - Kyoto Protocols: Industrialized countries agreed to reduce emissions, on average, 5.2% from 1990 levels by 2008-2012

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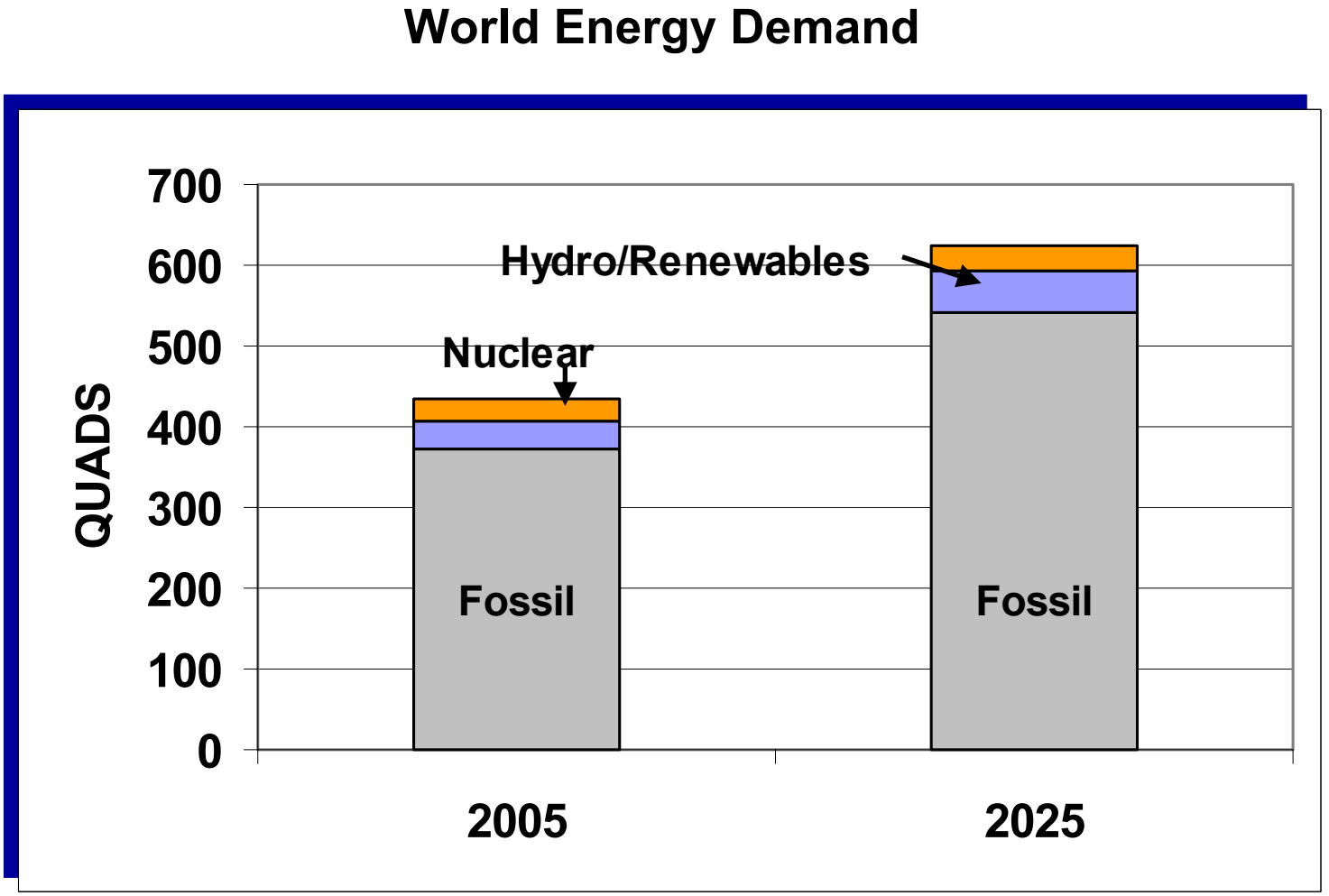
Current Fossil Alternatives are Hydro/Renewables and Nuclear, with Carbon Sequestration being Explored



Source: USDOE EIA IEO 2004 Reference Case

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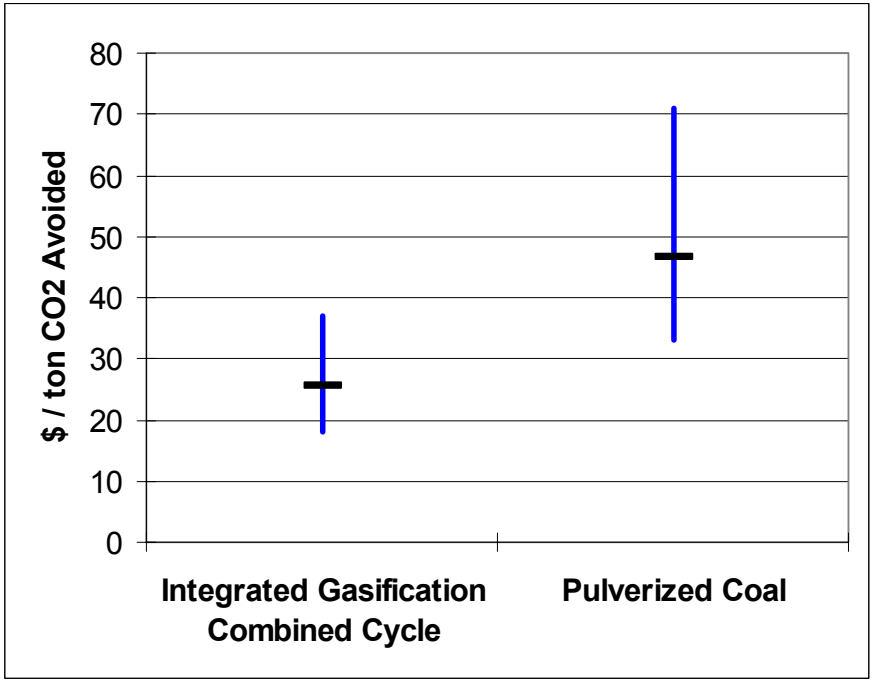
Carbon Sequestration Technologies will Add Costs to Fossil Fuels

Capture Cost Ranges

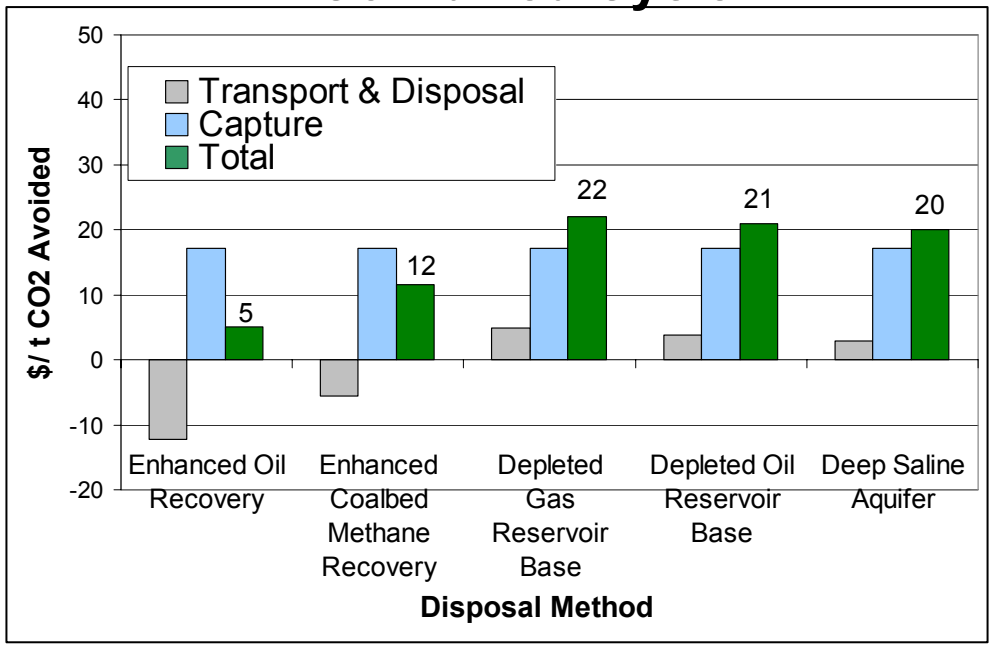


Source: David, 2000

$25/Ton CO2 = About $13/bbl Oil

CO2 Seq. < $3/Ton CO2 (2015) USDOE Program Target

Using Integrated Gasification Combined Cycle



Sources: Heddle et al., 2003.

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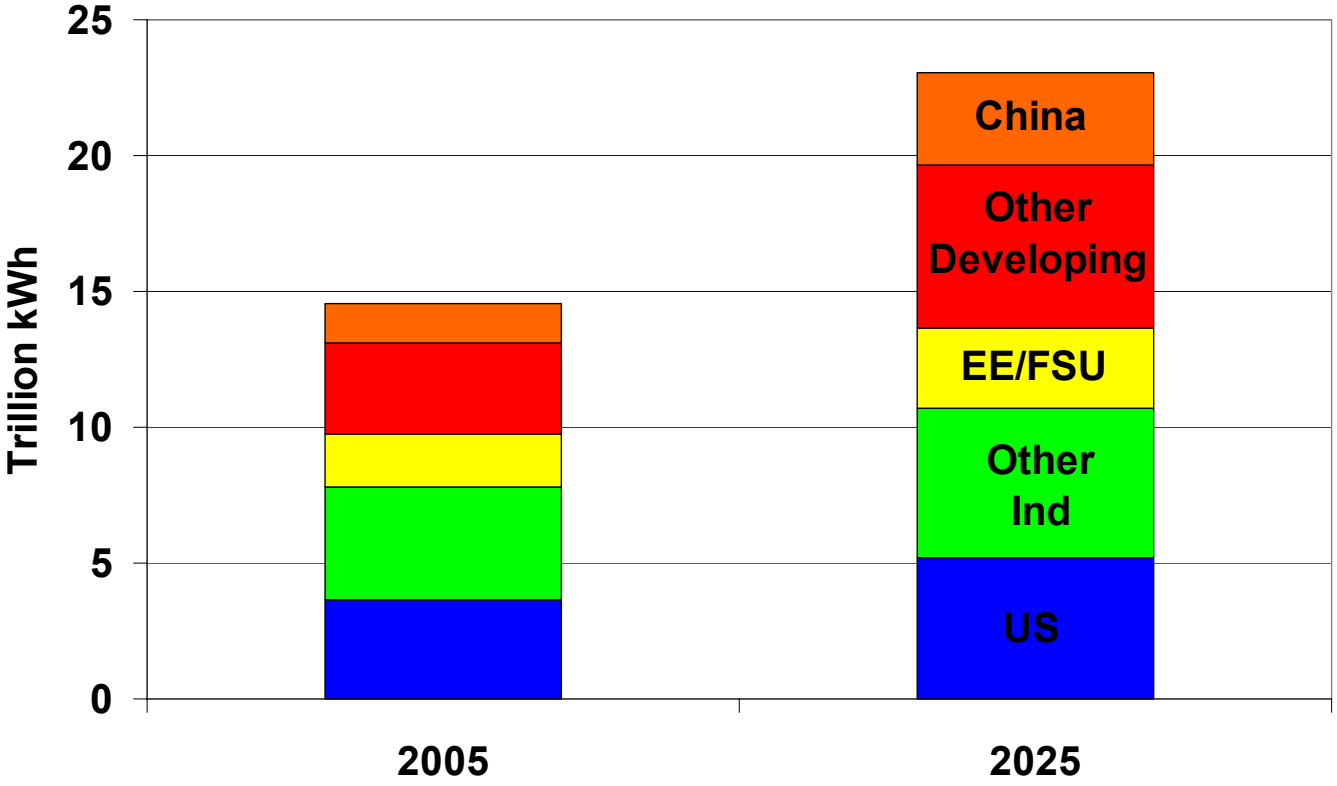
Over the Longer Term, Electricity Demand will Grow Almost 60%



and Developing Countries will Account for 2/3 of the Increase

Source: USDOE EIA IEO 2004 Reference Case

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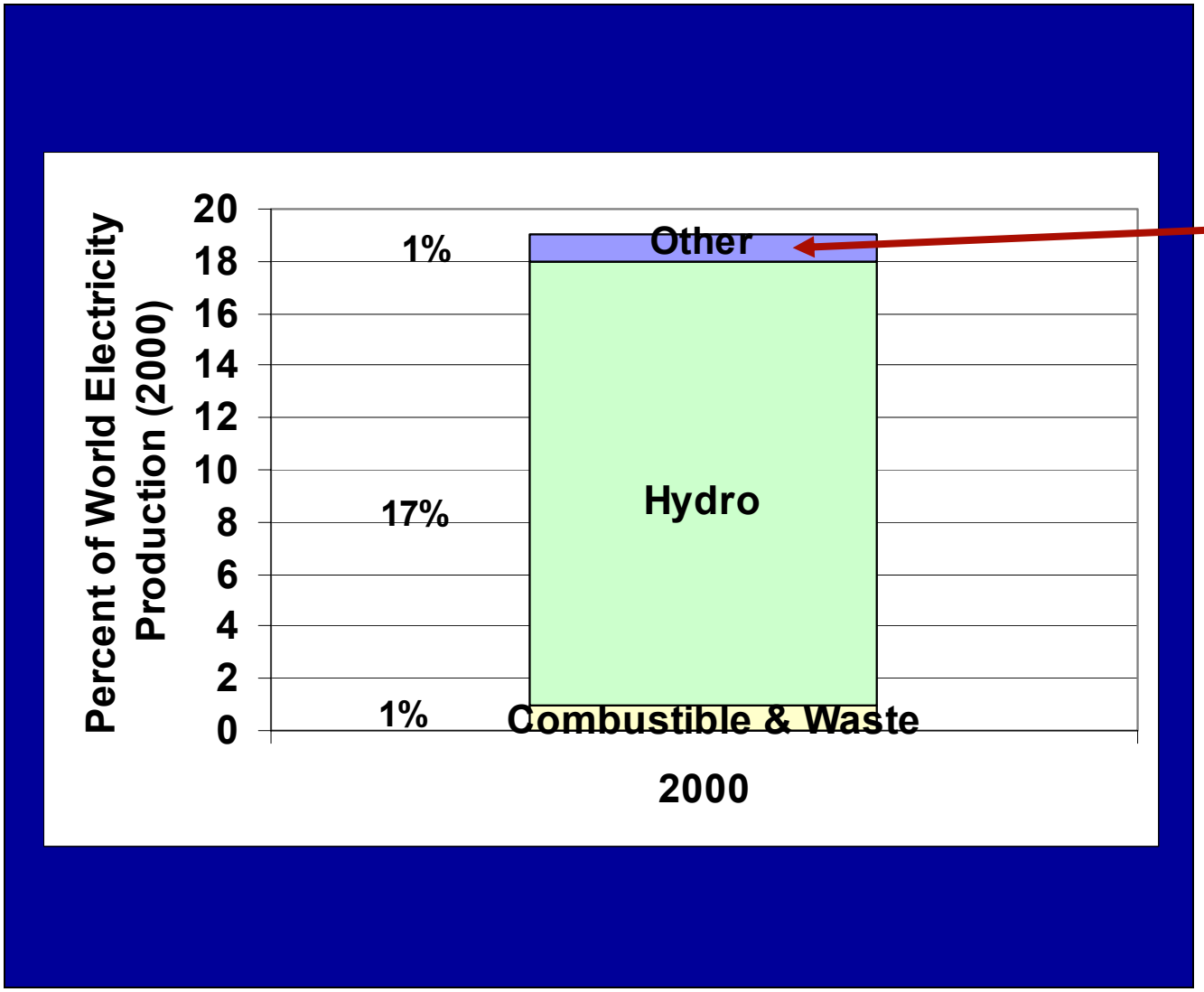
Current Renewable Electricity is Largely Hydro



Source: Renewable Information 2002, IEA

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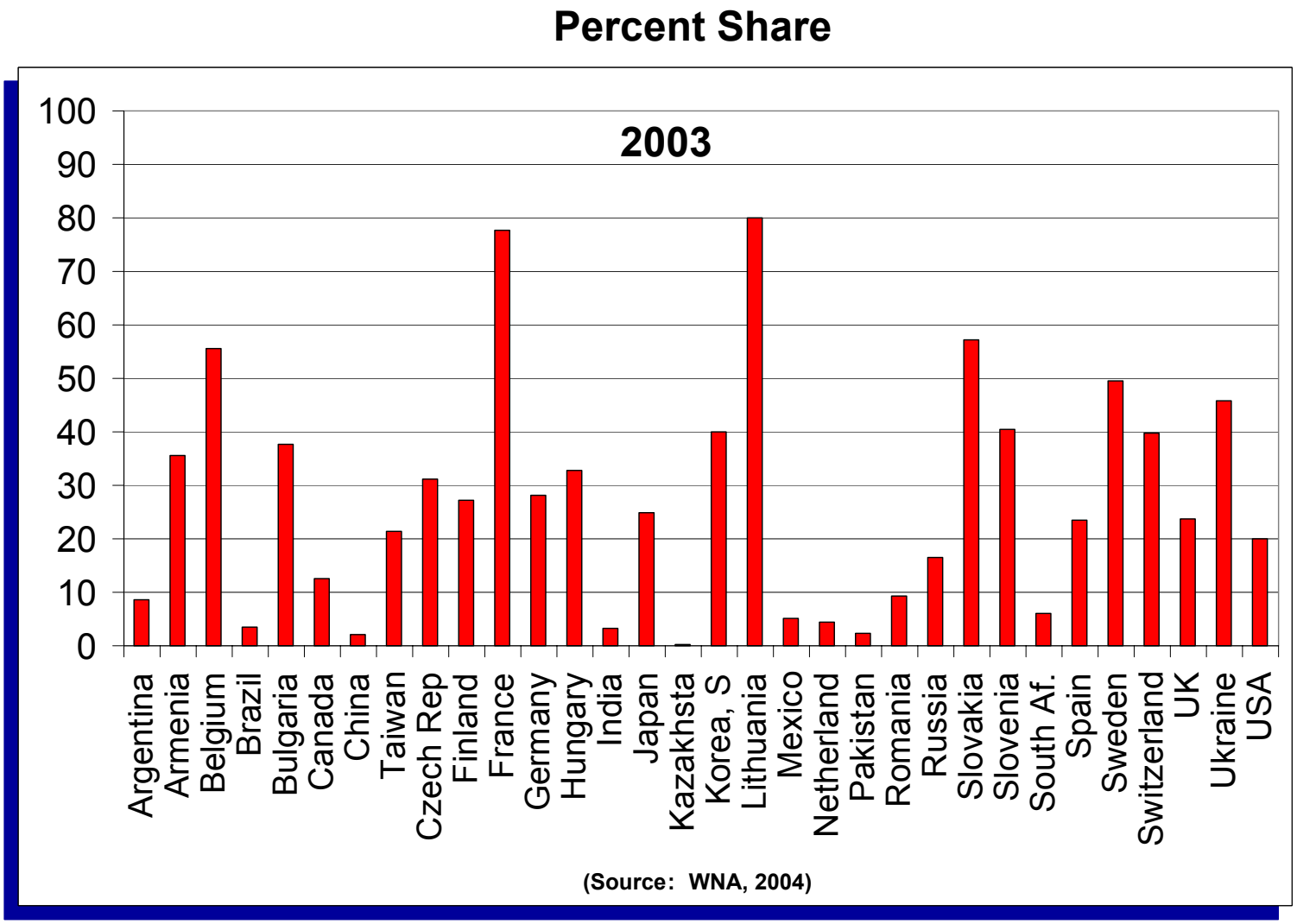
Nuclear Contributes to Electric Power in Many Countries



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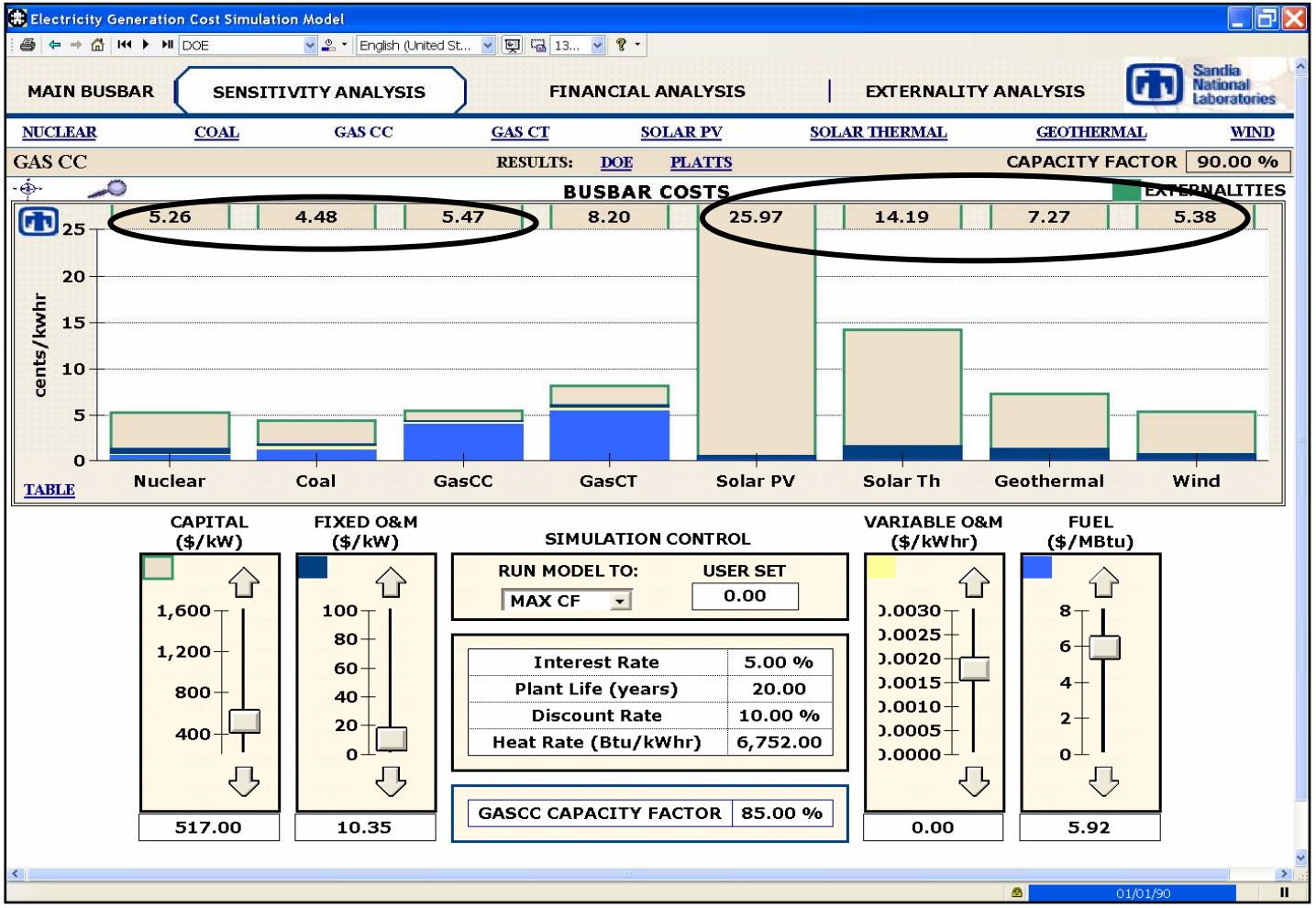
New Nuclear Electricity Plants are Cost Competitive in US, Depending on Capital Cost and Perceived Risk



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World Conventional Proved Fossil Fuel Reserves are Geographically Concentrated

(Percent Share)

Region	Oil	Gas	Coal
Key P.G.	64	40	*
Saudi	25	4	0
Iraq	11	2	0
Iran	10	15	*
Kuwait	10	1	0
UAE	6	3	0
Qatar	2	15	0
Russia	6	28	16
Venezuela	5	2	*
China	2	1	12
U.S.	2	3	25
India	*	*	9
ROW	21	26	38
Total	100	100	100

Source: EIA 2003. Excludes Oil Sands. * Less than 0.4 %

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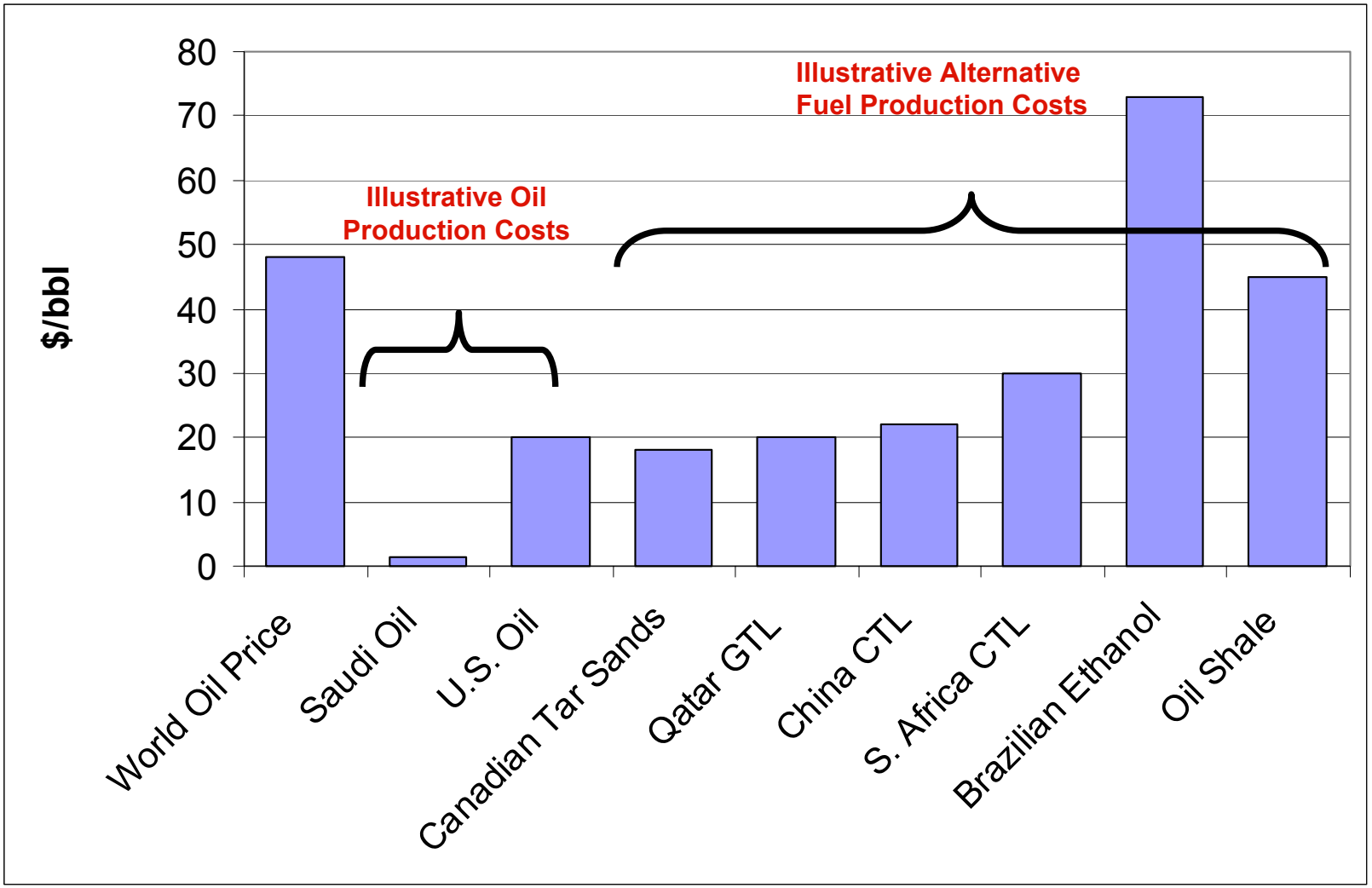
A Wide Range of Prospects for Alternative Liquid Fuels, But Will Take Time to Develop



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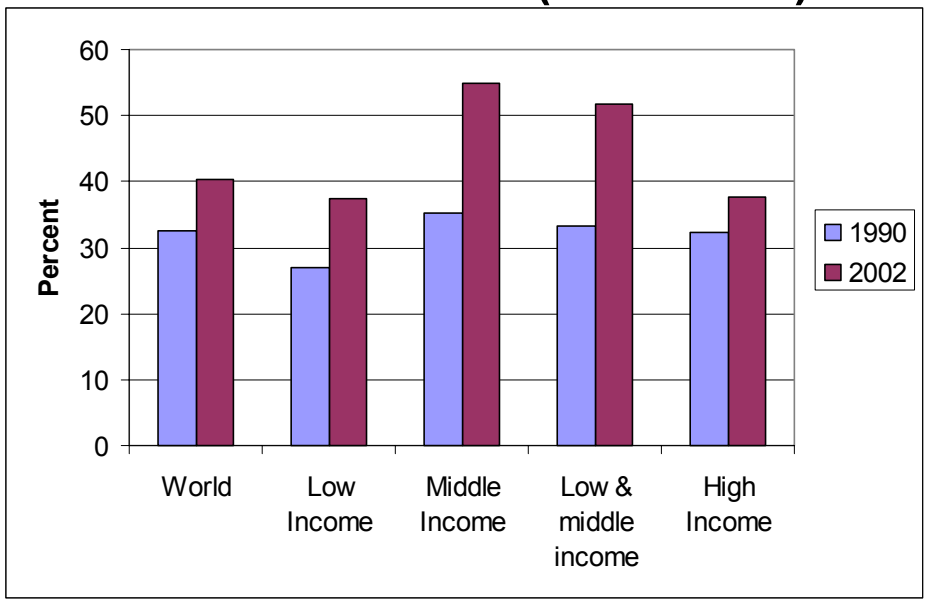
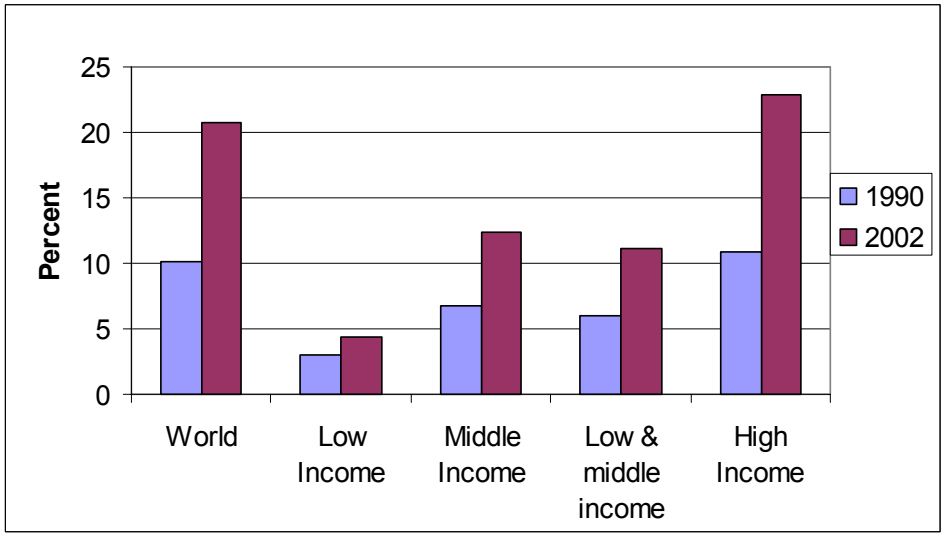
National Economies are Becoming Increasingly Intertwined

Trade in Goods (% of GDP)



Gross Private Capital Flows (% of GDP)



Source: The World Bank, 2004.

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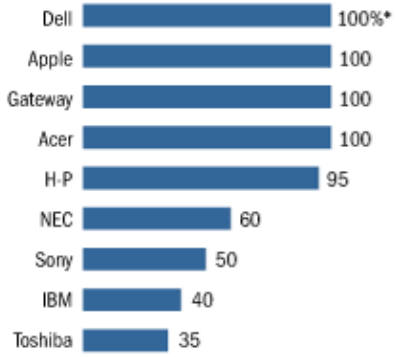
So Are Manufacturing Processes

All Over the Map

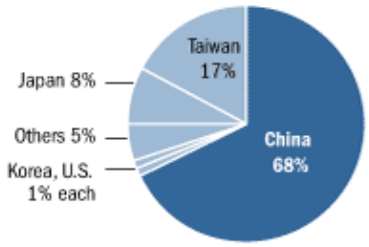
When a U.S. customer orders an H-P Pavilion laptop, the request travels all the way to China in just days. A look at the process, and China's increasing role not just as manufacturer, but supplier of more sophisticated laptop parts

Outsourcing ratio for world's top laptop PC brands, 2004:



*Dell takes care of final assembly in its factories.
Source: Merrill Lynch

World-wide laptop PC production by country, 2005:



Source: IDC

Filling the order

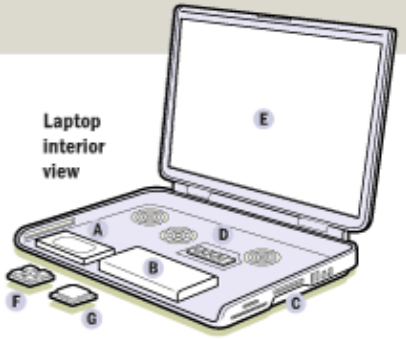
1. **Order** placed online in the U.S.
2. **Validated** order transmitted to Taiwanese-owned Quanta plant in Shanghai
3. **Laptop assembled** from parts from China and all over the world
4. **Computer shipments** consolidated at Shanghai airport and flown freight to the U.S.
5. **Individual laptops** sent to customers

H-P Pavilion zd8000 laptop computer

Putting it together

A	**Hard-disk drives**	Japan, China, Singapore, U.S.
B	**Power supplies**	China
C	**Magnesium casings**	China
D	**Memory chips**	S. Korea, Taiwan, U.S., Germany
E	**Liquid-crystal display**	S. Korea, Taiwan, Japan, China
F	**Microprocessors**	United States
G	**Graphics processors**	Designed in U.S., Canada; made in Taiwan

Note: List does not include every country that manufactures a given part
Sources: Hewlett-Packard; WSJ research



Source: Wall Street Journal, June 9, 2005, p. B1

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And Even Universities

Study Abroad - Singapore has courted top-tier schools:

- **1998: French business school INSEAD**
  - Offers MBA, executive education
- **2000: University of Chicago**
  - Graduate School of Business opens a Singapore campus
- **2003: Johns Hopkins Singapore**
  - Operates as a full division of the university
- **2003: Duke**
  - Medical school agrees to open a school at the National University of Singapore
- **2005: MIT**
  - Grants engineering master's degrees in a joint venture with two Singaporean universities

Source: Wall Street Journal, July 12, 2005, p. B1

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And this Trend Toward Interdependency will Accelerate

- **The Internet and silicon revolution will continue to break down communication and economic barriers**
  - Greater numbers of countries will participate in the world economy and financial markets
  - Integrated supply chain logistics of service & manufacturing industries will seamlessly cross national borders
    - As will distance education and technology transfer
- **Both global economic competition and global economic cooperation will intensify**

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And this Trend Toward Interdependency will Accelerate (continued)

- **Scope for national public policies with major economic impact will become more limited**
  - Can't afford to have costs out of line with competitor countries
  - Growing need to send domestic energy consumers and producers consistent market signals, and to integrate domestic energy security, environmental and economic objectives and polices
  - Driven toward greater policy and regulatory harmonization (lowest common denominator?)

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And this Trend Toward Interdependency will Accelerate (continued)

- **Supply and demand shocks will be transmitted more rapidly**

  Country ⟶ Global Market ⟶ Country

- **Science and technology developments will accelerate and transcend high tech national borders**
  - But they are unlikely to "solve" energy and environmental problems any time soon

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Some Governments and Car Companies are Aiming for a Hydrogen Economy

- **Hydrogen may solve many problems:**
  - Lowered, or even zero, carbon emissions
  - Energy security
  - Limited fossil fuels and uneven distribution

Source: Fuelcell.org

- **Many hurdles to overcome:**
  - Lifetime of fuel cell
  - Economic hydrogen production
  - Lack of hydrogen infrastructure
  - Sequestration of carbon if hydrogen derived from fossil fuels
  - Unlikely to be cost competitive until at least mid 2020s

Source: GM

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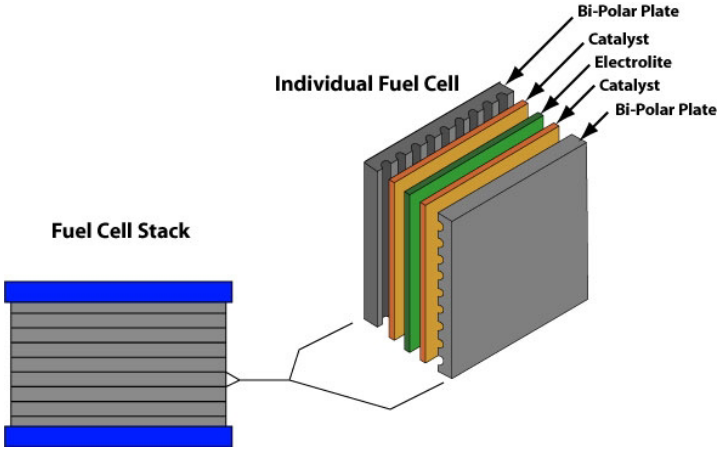
Over Several Decades, Advanced Energy Technologies Could "Disrupt" The Current System

- **Nanotechnology has the potential to fundamentally change energy supply and demand**
- **Examples:**
  - Solid State Lighting Using "Quantum Dots" could cut power for lighting use by 50%
  - Ultra-high strength lightweight nanophase materials could improve car, airplane efficiency
  - Nanoparticles and Nanoarchitectures for Energy Conversion and Storage may offer solutions to low cost fuel cells and batteries.

Lauren Rowher, SNL



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Conclusions

- **Over the nearer term**
  - Many uncertainties in oil and natural gas markets remain
- **Over the longer term**
  - The world economy and its energy markets will become increasingly integrated and interdependent
  - Energy use and carbon emissions will grow substantially, driven by the developing world, and mostly fueled by fossil energy
  - The potential for oil and natural gas supply shocks will grow, as will the economic transmission of those shocks
  - Oil and natural gas price instability will increase
  - Major new energy technology platforms that transform economies and energy could emerge

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Conclusions (continued)

- **At the same time**
  - Both economic competition and cooperation will intensify
  - Scope for national public policies with major economic impact will become increasingly limited
  - Need for clear domestic consumer-producer energy price signals and consistent energy security, environmental and economic objectives and policies will grow
  - Pressure for policy and regulatory harmonization will increase, as will requirements for decision-making speed, and the cost of mistakes will grow

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Conclusions (continued)

- **International flexibility, cooperation and partnering on many fronts, including public policy and science & technology investment, will be critical to**
  - Avoid bumps in the road
  - Support national political economic security
  - Improve the health and well being of the developing world
  - Provide a foundation for global and regional prosperity and environmental sustainability

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