

Club of Prague

Energy Scenario Overview

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Presented by:
Dr. Arnold B. Baker
Chief Economist, Sandia National Laboratories
Phone: 505-284-4462 Fax: 505-844-3296
Email: abbaker@sandia.gov



Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.



BACKGROUND

- **Scenarios are internally consistent stories about the future**
 - “No facts about the future”
 - Stimulate strategic thinking
 - Any single scenario will be wrong; intended capture a broad range of possible outcomes
- **A team approach, supported by SNL’s Global Energy Futures Model and other data**
 - Bill Martin, Ichiro Maeda, Jessie Morey, Joe Perkowski, Isamu Seto, Ko Sugiura, Pavel Fidler, Olda Cerny, Will Kamery, Tom Drennen
- **Three Scenarios Through 2050**
 - Business As Usual
 - Tech Fix
 - New Old Thinking

World Proved Fossil Fuel Reserves are Geographically Concentrated

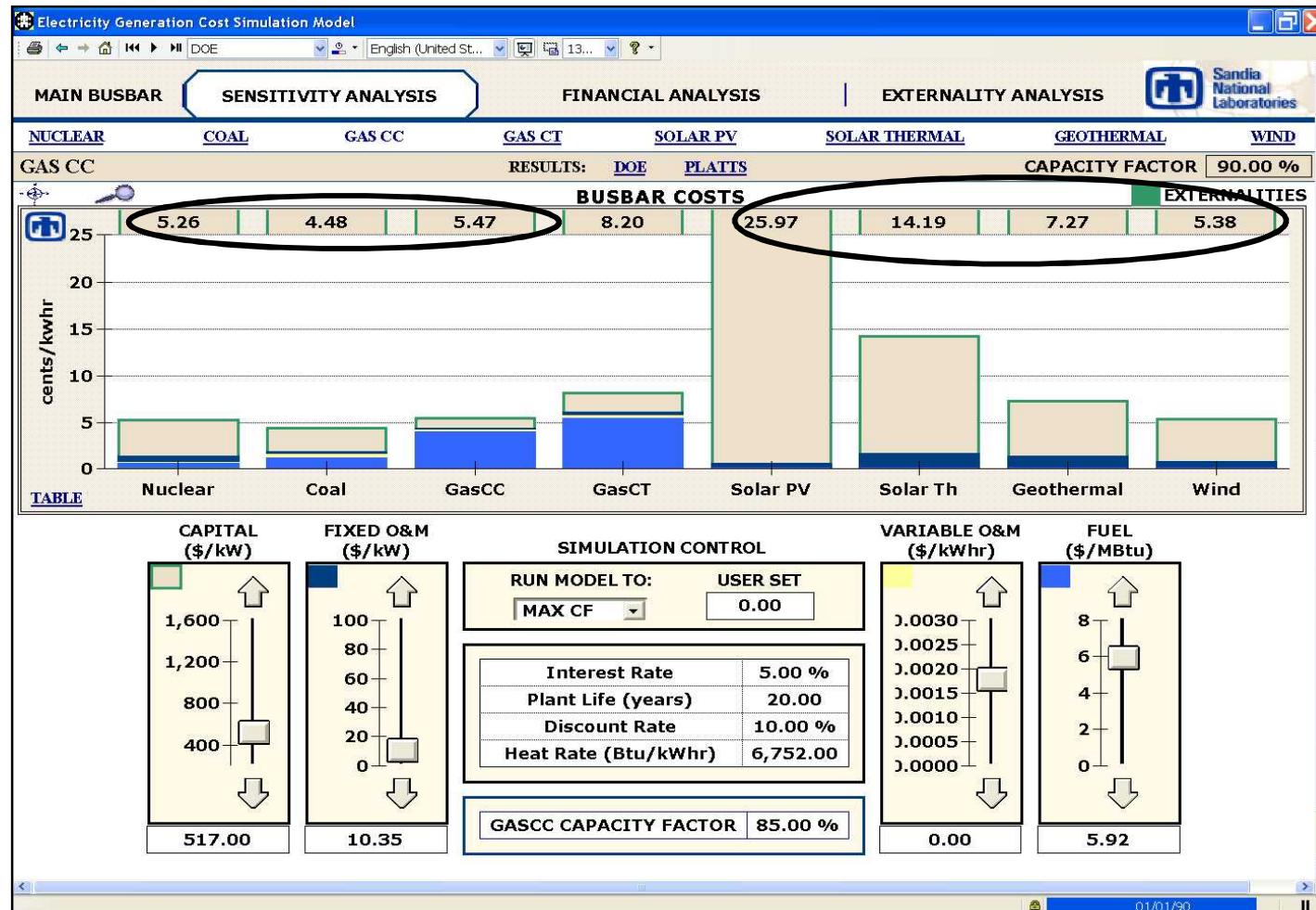
Region	Oil	Gas	Coal
Key P.G.	57	41	*
Saudi	21	4	0
Iran	10	16	*
Iraq	9	2	0
Kuwait	8	*	0
UAE	8	4	0
Qatar	1	15	0
Canada	14	*	*
Venezuela	6	2	*
Russia	5	27	17
U.S.	2	3	27
China	1	*	13
India	*	*	10
ROW	15	23	32
Total	100	100	100

Source: Oil & Gas Journal 1/1/06; EIA Int. Energy Ann. 6/13/05. * Less than 1 %

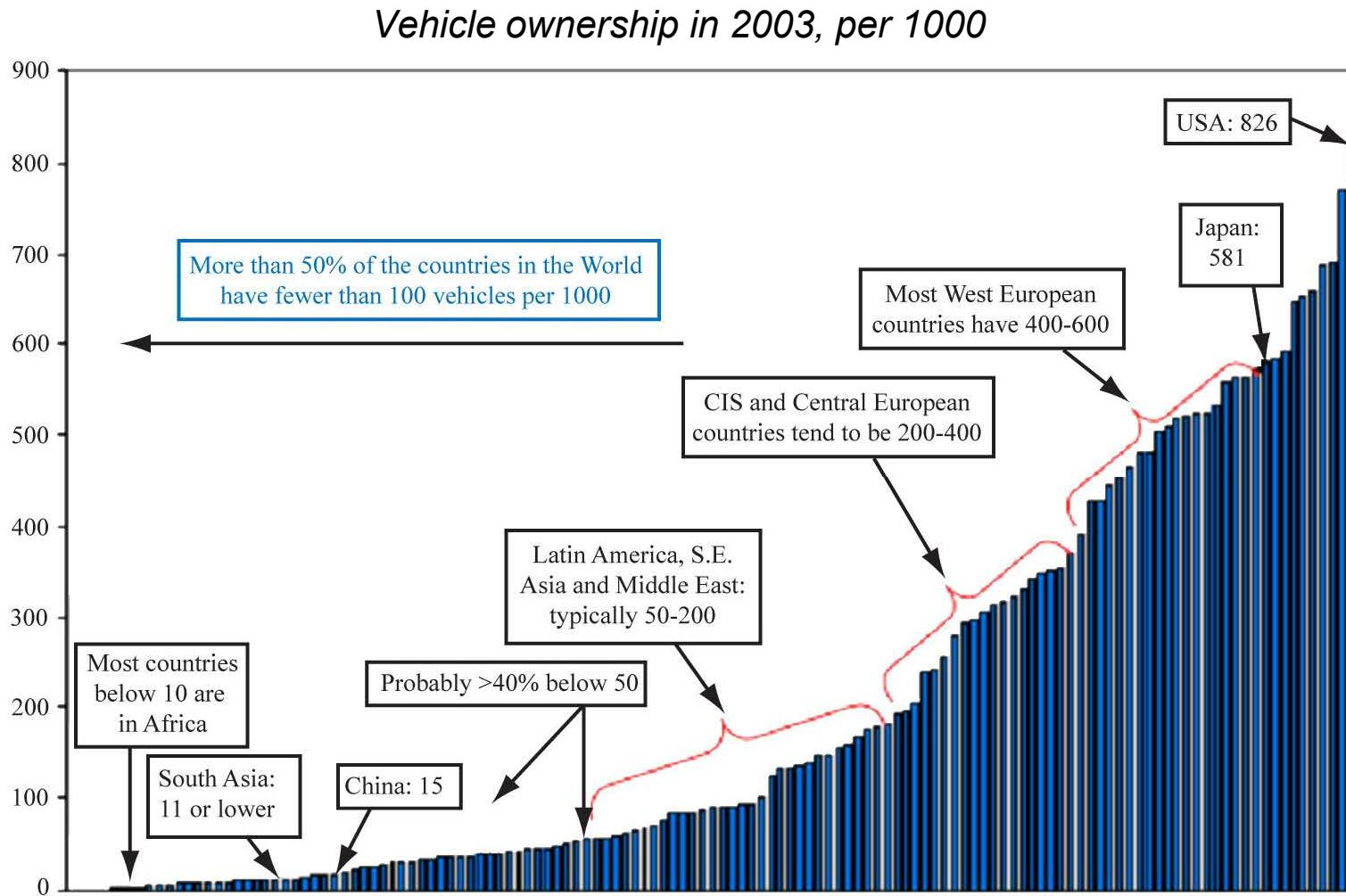
The Climate Change Policy Problem is Enormous

- 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

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



Developing World Vehicle Ownership May Grow Considerably

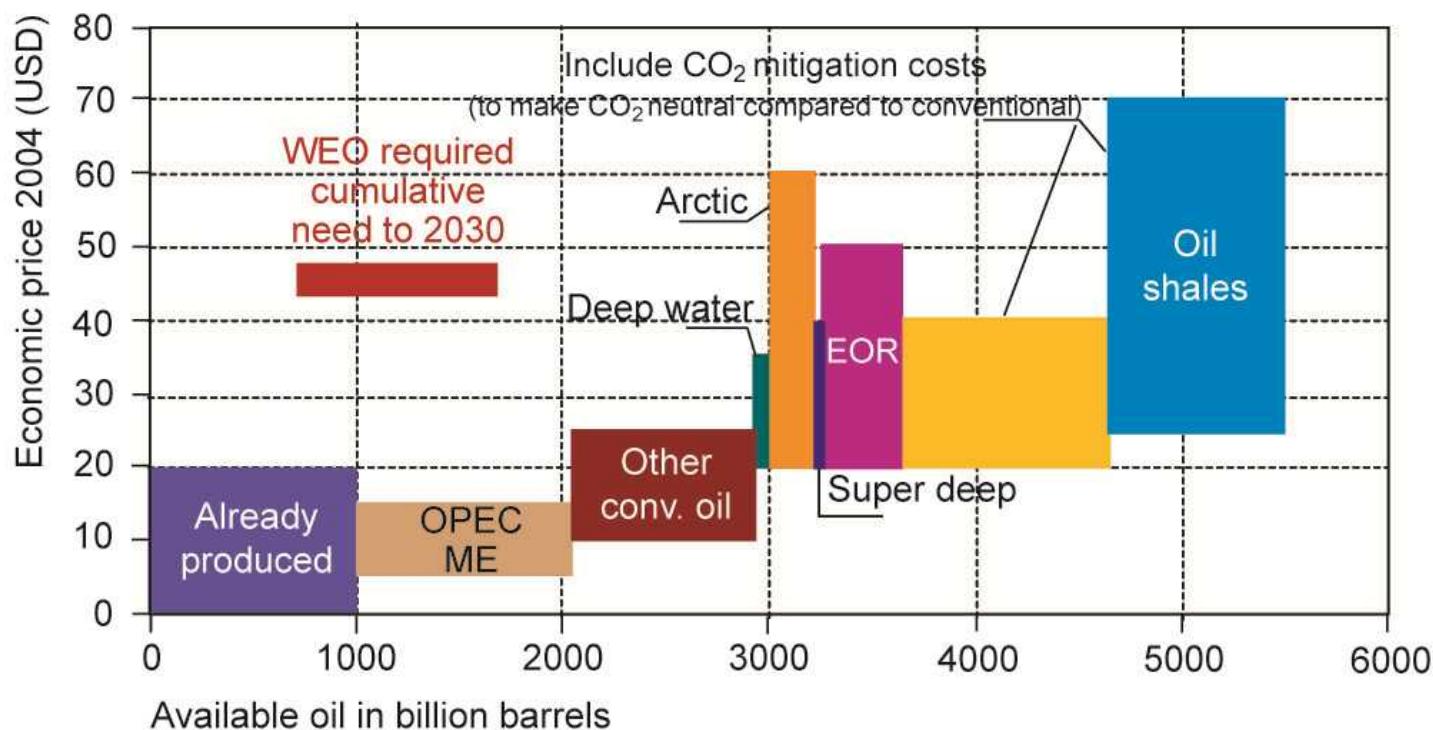


Source: "Oil Outlook to 2025," OPEC Secretariat Paper, 10th International Energy Forum, Doha, April 22-24, 2006, figure 2.4, p. 11

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

IEA's Oil Cost Curve

Figure ES.1 • Oil cost curve, including technological progress: availability of oil resources as a function of economic price



Source: Resources to Reserves, Oil and Gas Technologies for the Energy Markets of the Future, OECD/IEA 2005, P. 17

Carbon Sequestration Technologies Will Add Costs to Fossil Fuels But Are Feasible

Electricity Cost Without/With Carbon Sequestration

Power Plant Systems	Natural Gas Combined Cycle (US\$/kWh)	Pulverized Coal (US\$/kWh)	Integrated Gasification Combined Cycle (US\$/kWh)
Without Capture (Reference Plant)	.03 - .05	.04 - .05	.04 - .06
With Capture and Geological Storage	.04 - .08	.06 - .10	.05 - .09
With Capture and EOR	.04 - .07	.05 - .08	.04 - .07

Source: IPCC Special Report on Carbon Dioxide Capture and Storage, Summary for Policymakers, September 25th 2005. Table S. 3.

Business As Usual

Trends of the 1990s and Early 2000s Continue

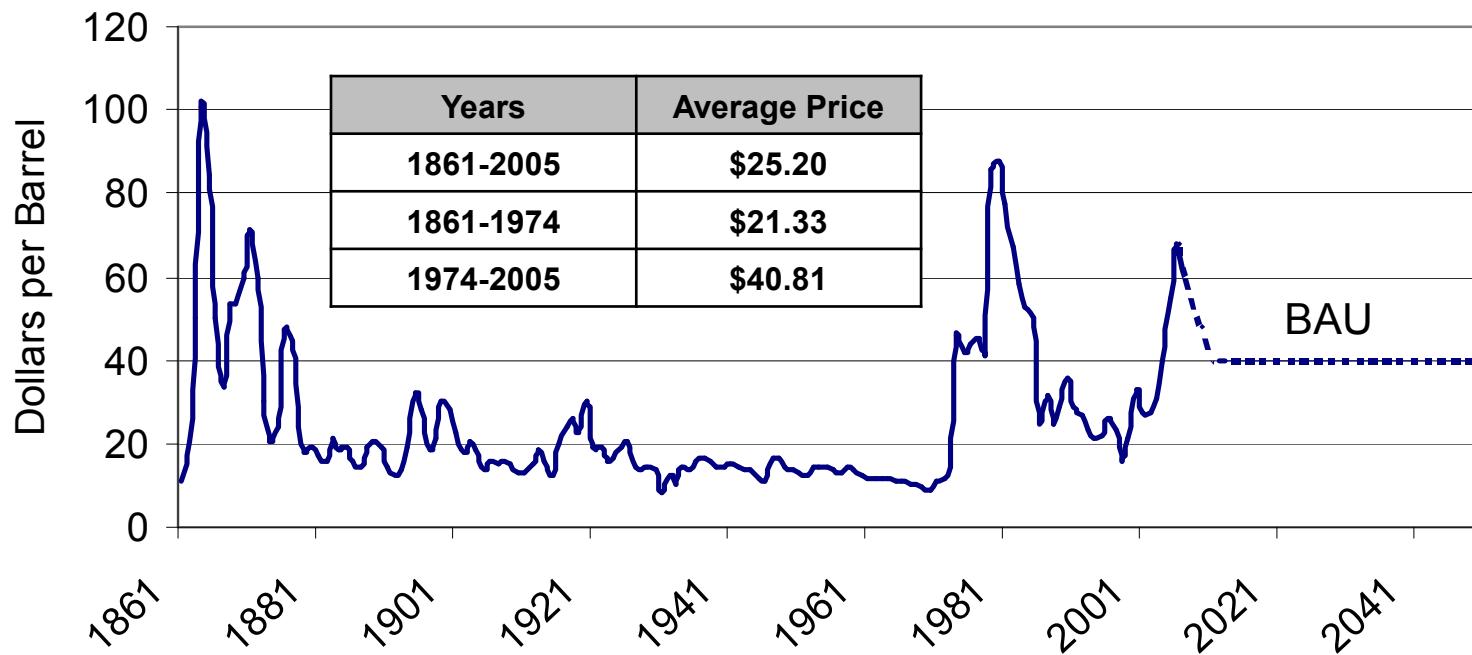
- Robust, market driven economic growth
- Increasing global integration and interdependence, despite occasional protectionist threats
- Energy security and the environment are secondary considerations
- Real oil prices fluctuate, but on average remain in the \$35-\$40/barrel range
 - NOCs and IOC cooperate and compete in the market place

Business As Usual (cont'd)

- **Energy efficiency continues to improve**
 - Driven by market competition and incremental conventional technology penetration
- **Energy demand and carbon emissions grow substantially, led by China and the developing world**
 - Nuclear power declines while renewables grow in the OECD
- **Governments have great difficulty reaching energy/environmental policy consensus and providing solutions**
 - National elections continue to be close and coalitions remain fragile
- **Intermittent international conflicts over energy supplies**
 - Exacerbated by the variability of a changing climate

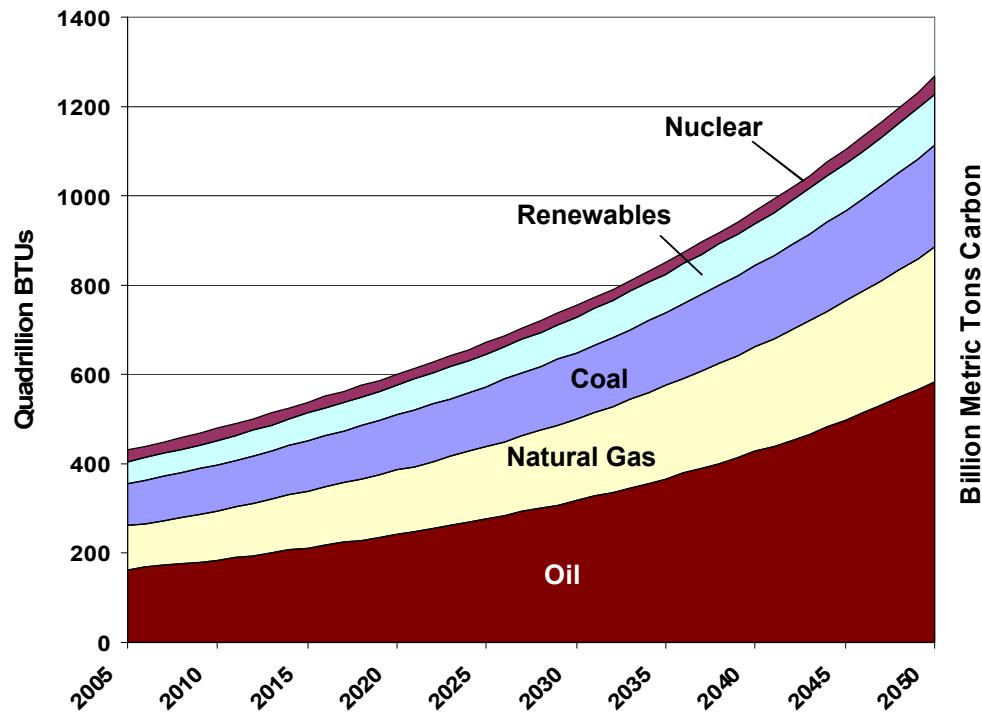
BAU Real Oil Prices

Real Oil Prices \$2005/Barrel

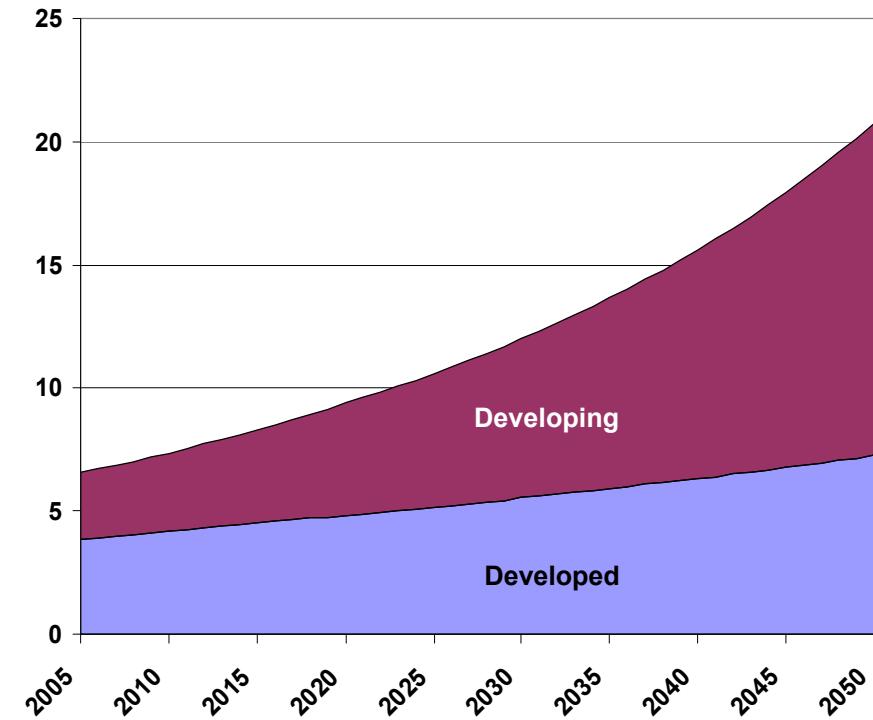


BAU World Energy Demand and Carbon Emissions Would Triple by 2050

Energy Demand



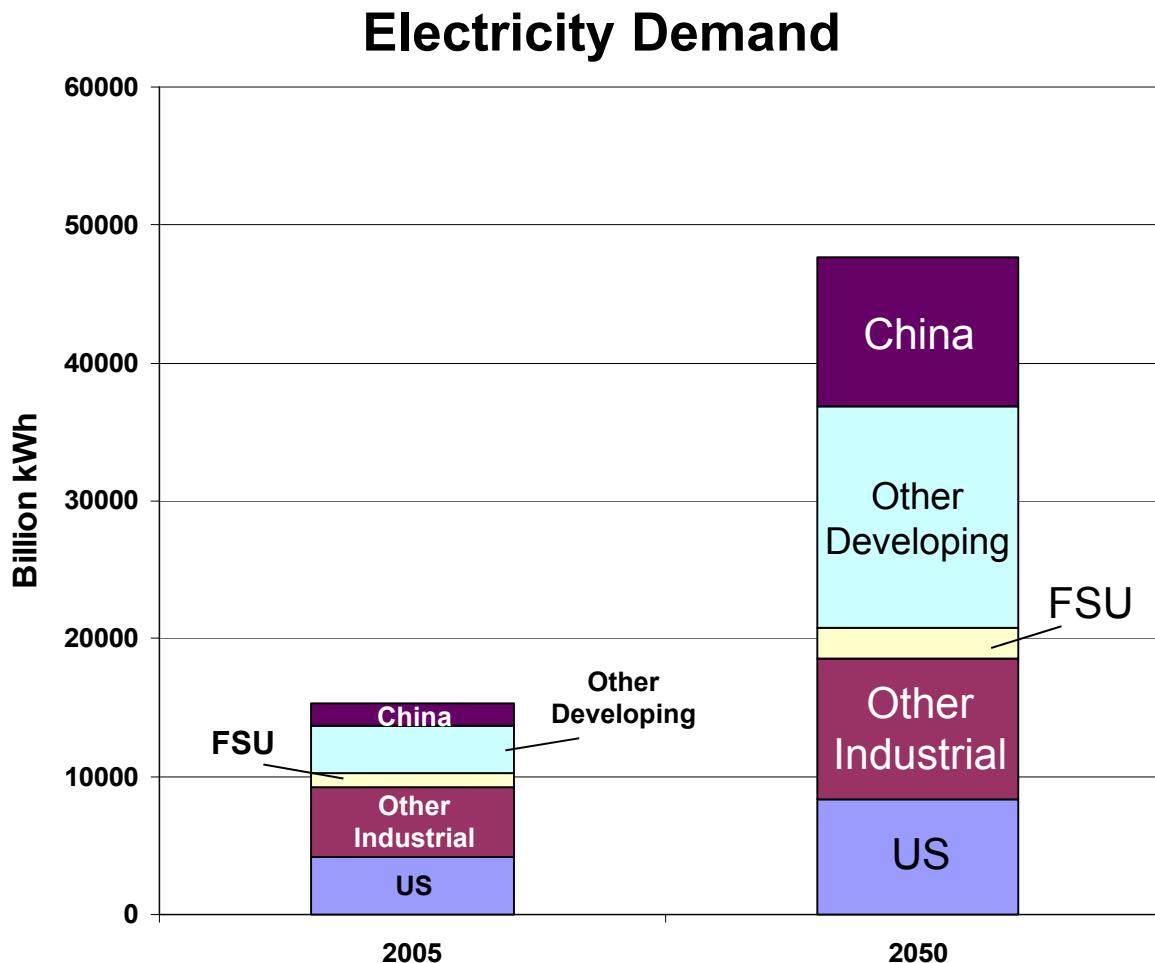
Carbon Dioxide Emissions



and Developing Countries Would Account for 3/4 of the Increase

Source: Business As Usual Scenario

BAU Electricity Demand Would Triple by 2050

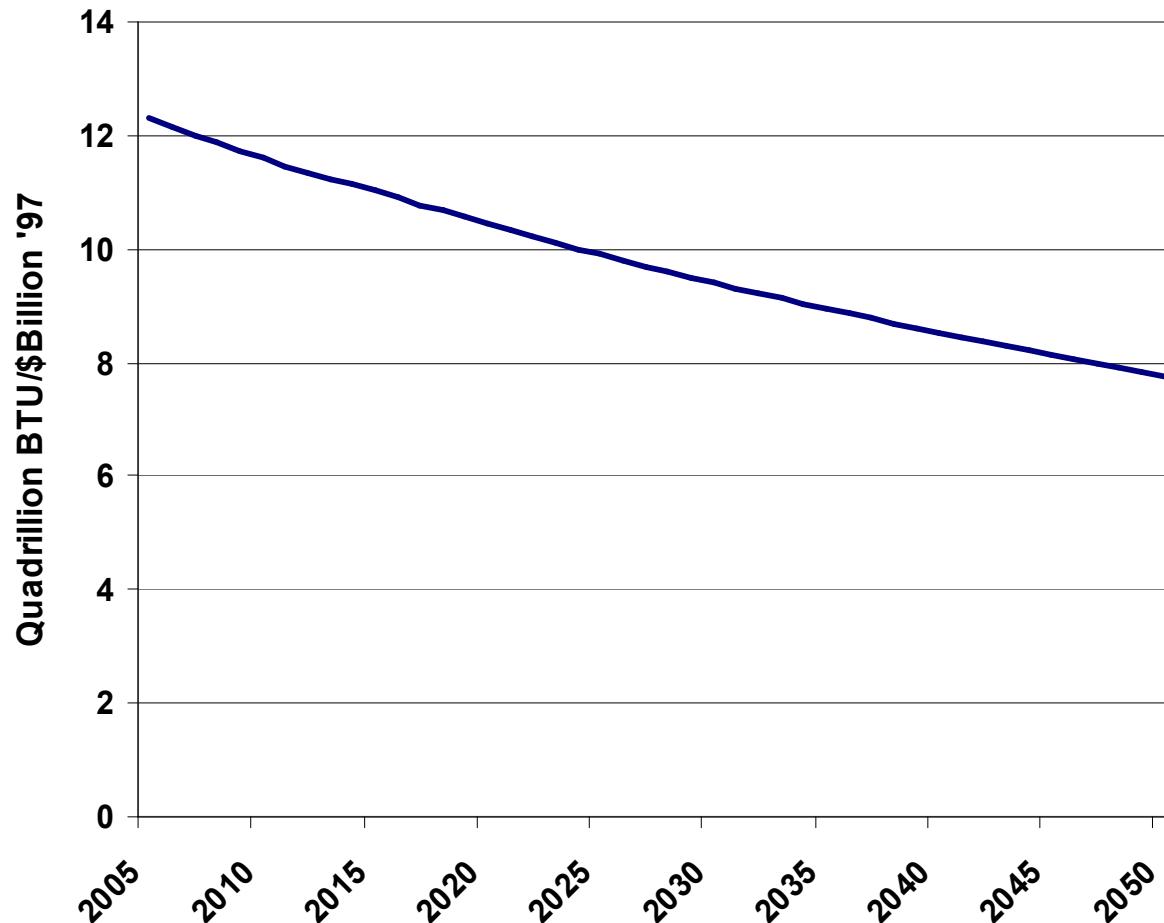


and Developing Countries Would Account for 70% of the Increase

Source: Business As Usual Scenario

Even Though the BAU World Uses 37 Percent Less Energy Per GDP By 2050

World Energy Intensity



Tech Fix

Governments Get Engaged

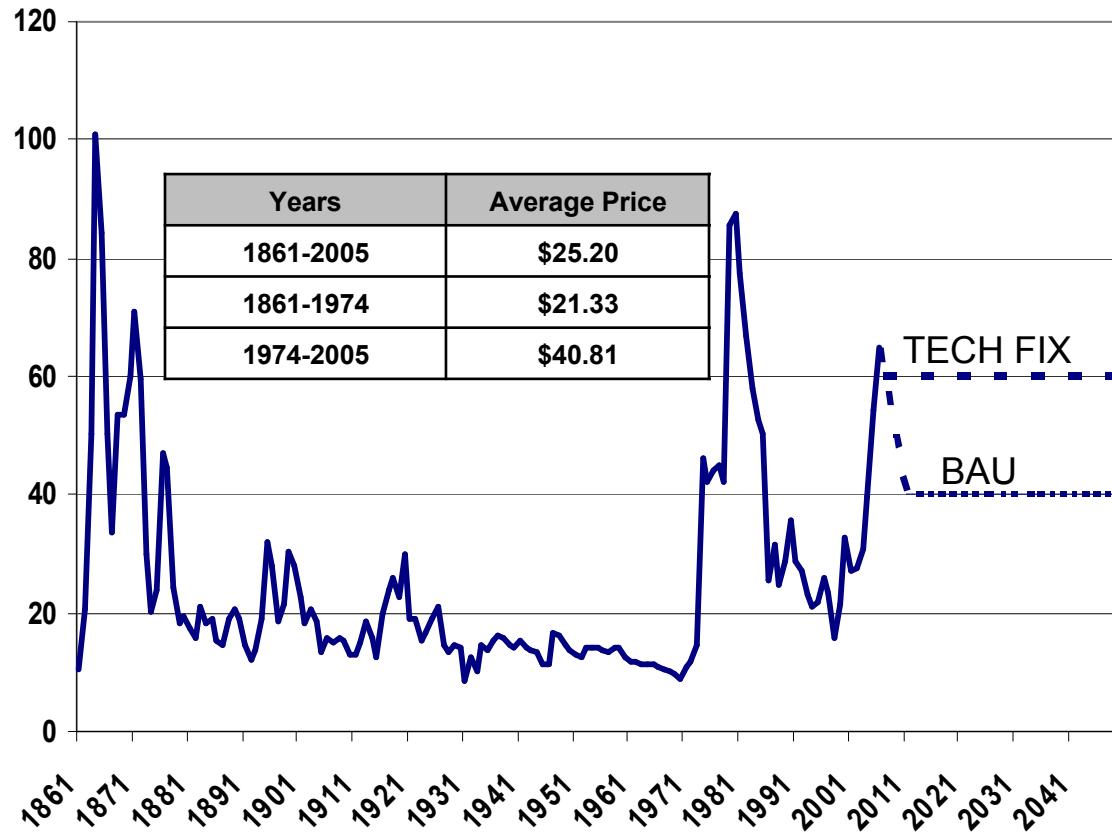
- **Strong geopolitical tensions, fears of continued energy supply interruptions, concerns over environmental disruptions, growing consumer anger**
 - National consensus and some international coalitions build
- **Energy security and the environment are on the front burner**
 - Increased energy & environmental R&D and developing country international tech transfer, aimed at energy efficiency and reduced carbon technologies
 - Supporting policies, such as renewables mandates
- **Real oil prices fluctuate, but on average remain in the \$50-\$60/barrel range**
 - NOCs flush with higher revenues, slow down E&P and IOC cooperation to manage prices
 - IOCs lands access more limited
- **Tempered, market driven economic growth**

Tech Fix (cont'd)

- **Increasing global integration and interdependence, though a bit more slowly as governments get more engaged**
- **Energy efficiency improves more rapidly**
 - Driven by market competition and advanced technology penetration, supported by government policies, government/private R&D partnerships, and higher energy prices
- **Energy demand and carbon emissions still grow, led by China and the developing world**
 - Nuclear power, renewables grow; hydrogen transportation fuels/systems enter the market
 - Carbon emissions reductions policies (e.g. emissions trading, carbon taxes, and higher energy use taxes) are adopted in some countries and help stimulate sequestration
- **Intermittent international conflicts over energy supplies remain**
 - Exacerbated by the variability of a changing climate

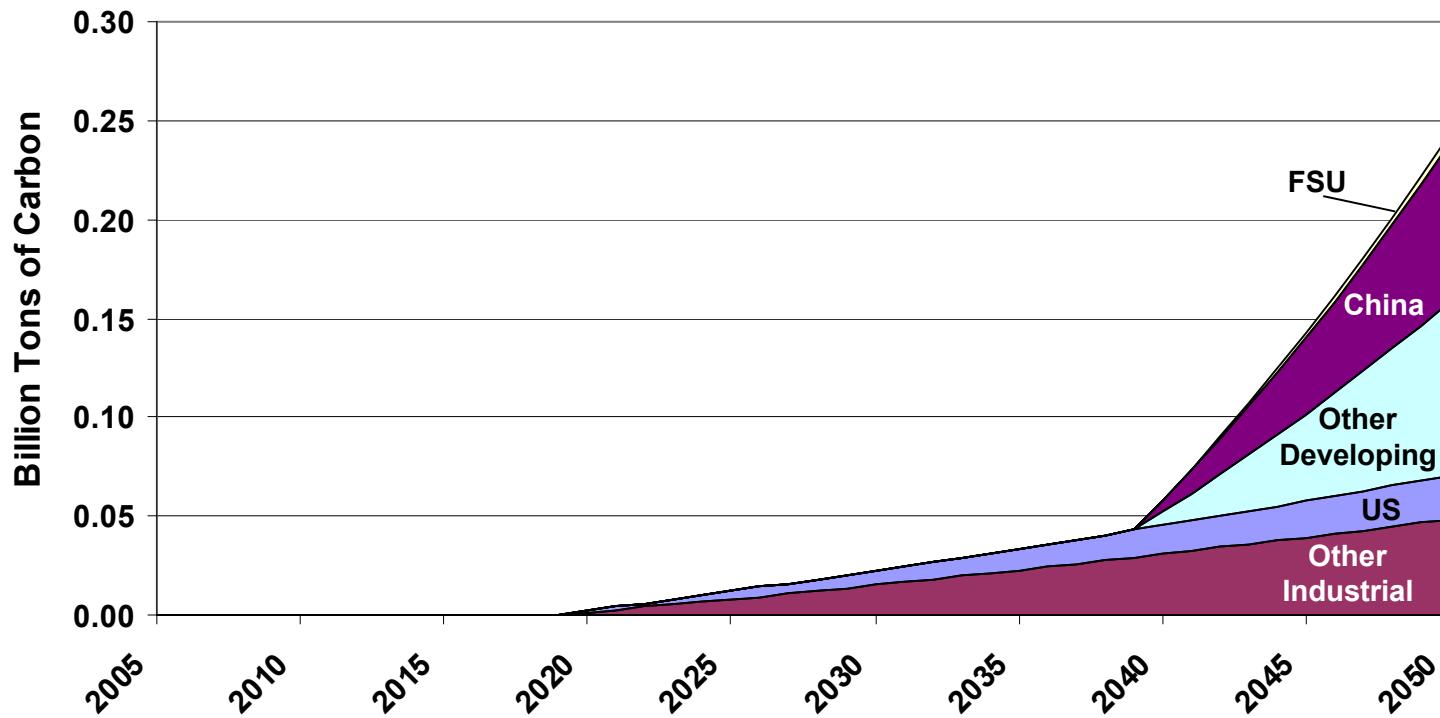
Tech Fix Real Oil Prices

Real Oil Prices \$2005/Barrel



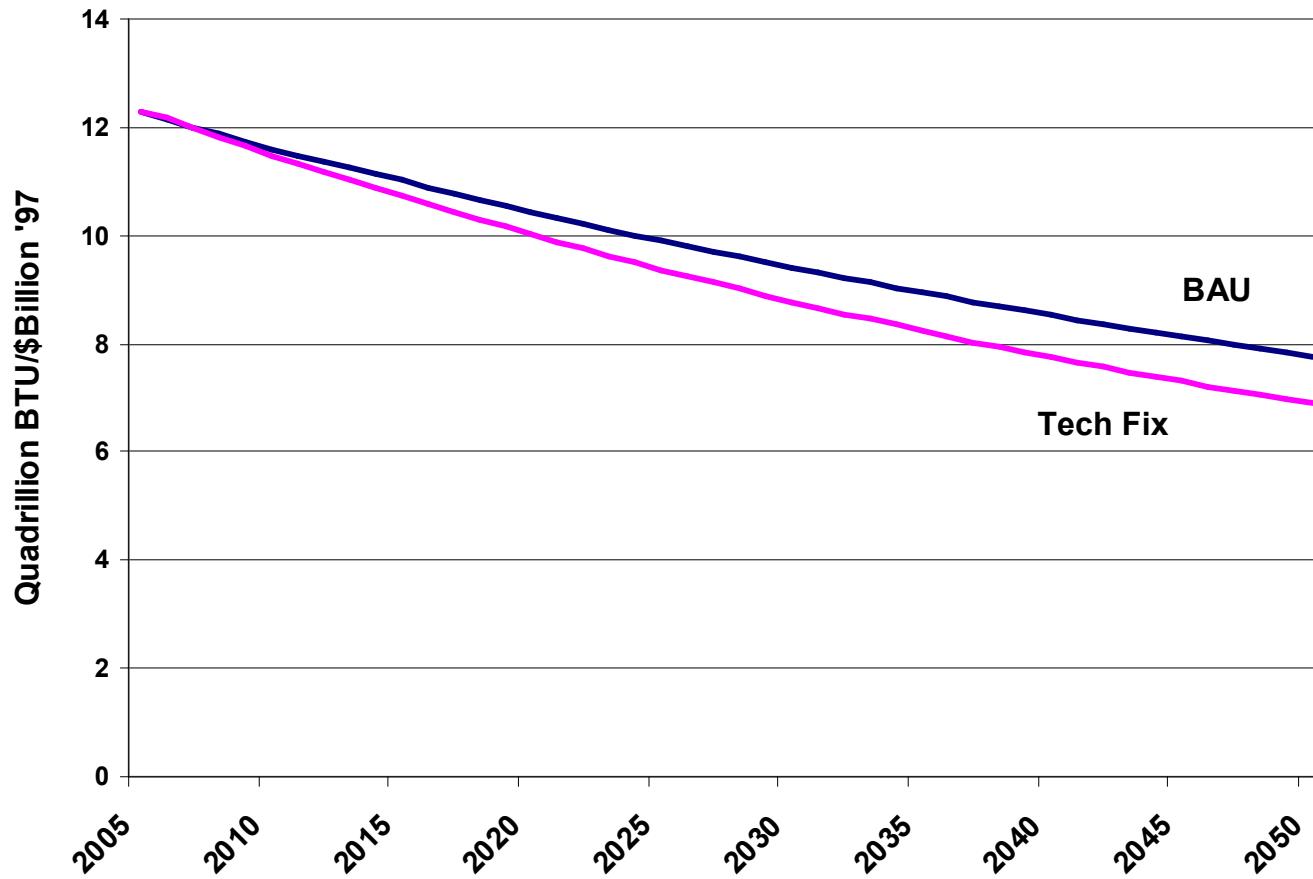
2050 Tech Fix VS BAU: Carbon Sequestration Small But Growing

Carbon Sequestration



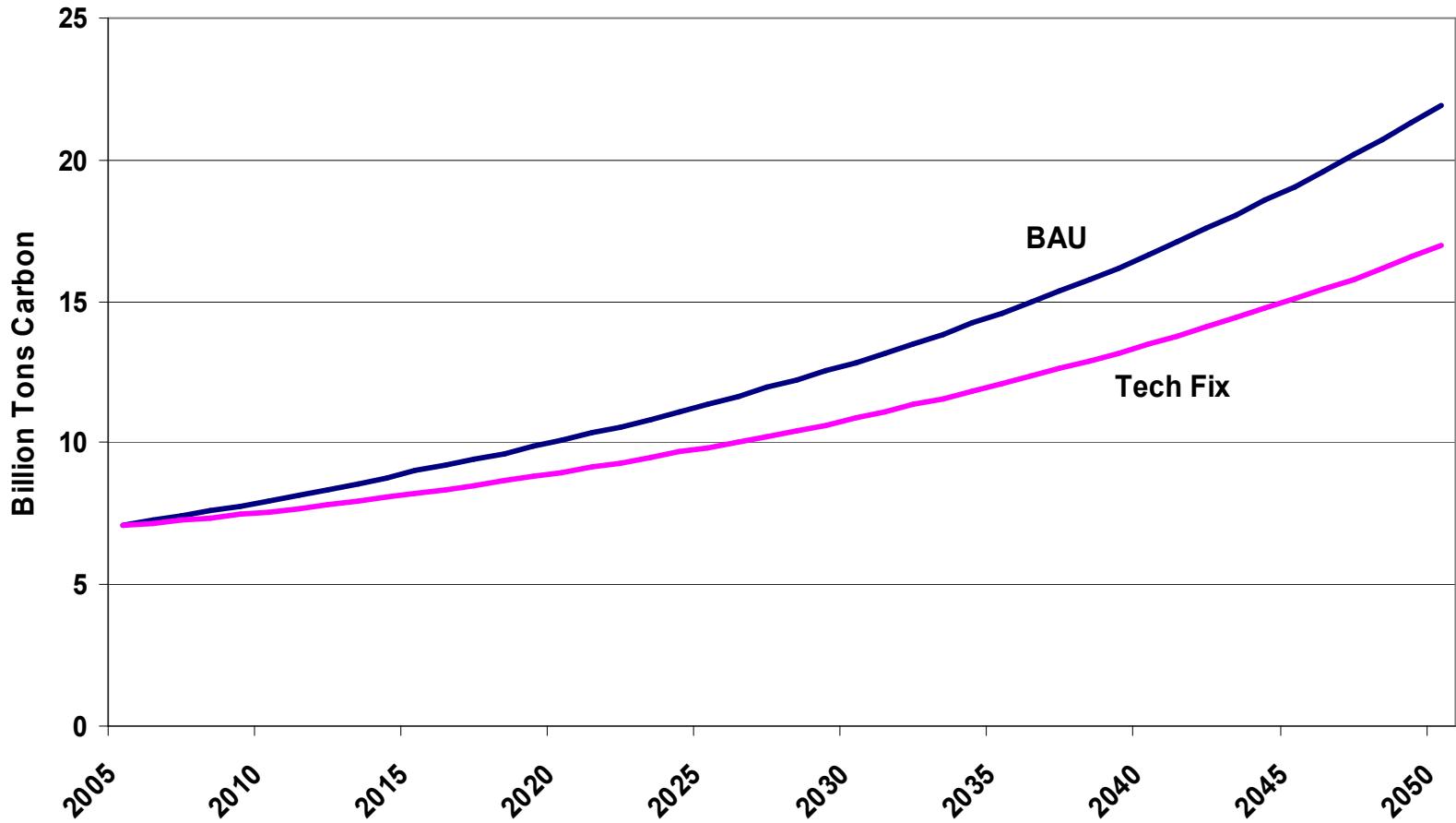
2050 Tech Fix VS BAU: Uses 11 Percent Less Energy Per GDP In 2050

World Energy Intensity

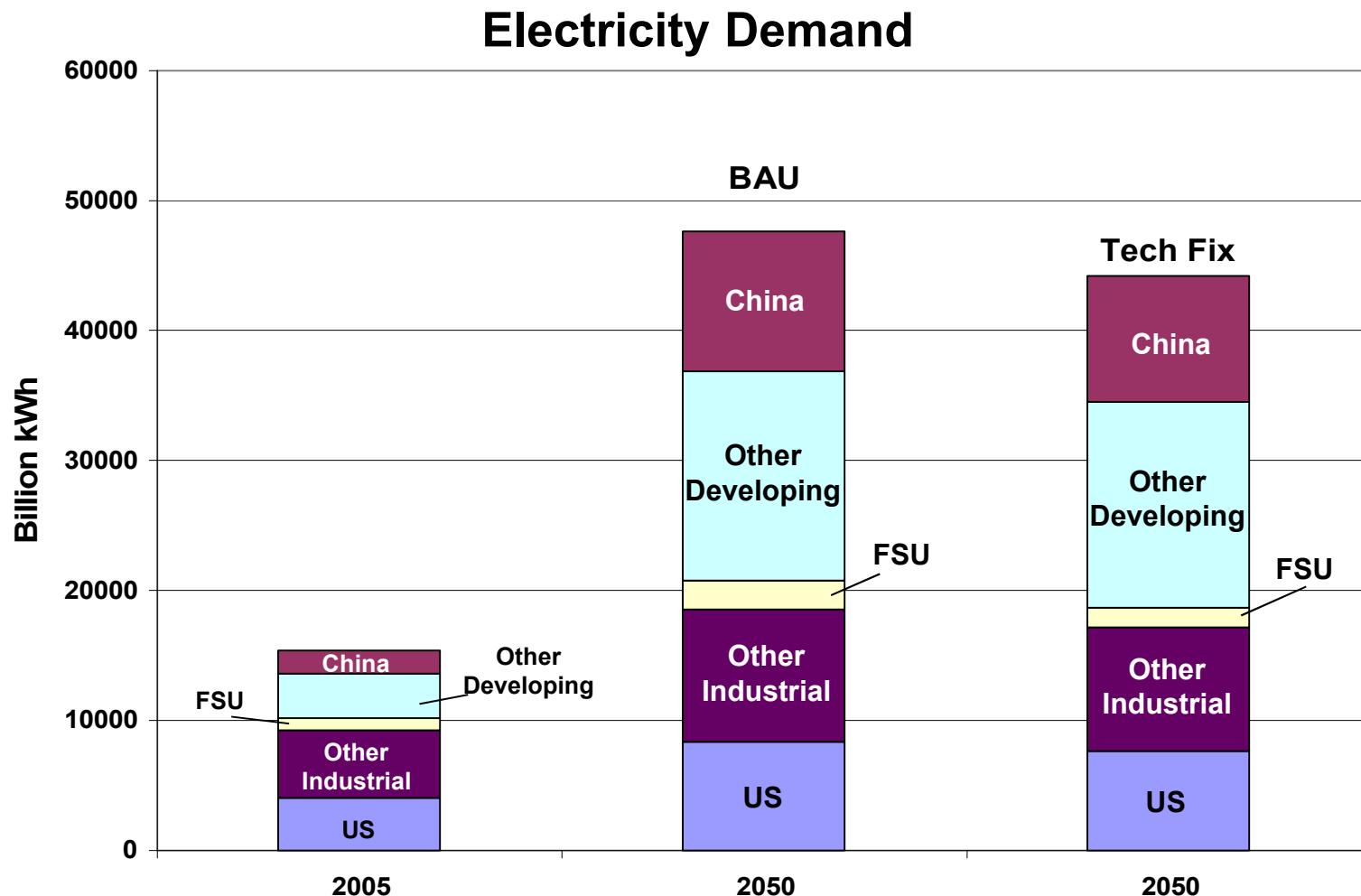


2050 Tech Fix VS BAU: Carbon Emissions Are 23% Lower

World Carbon Emissions

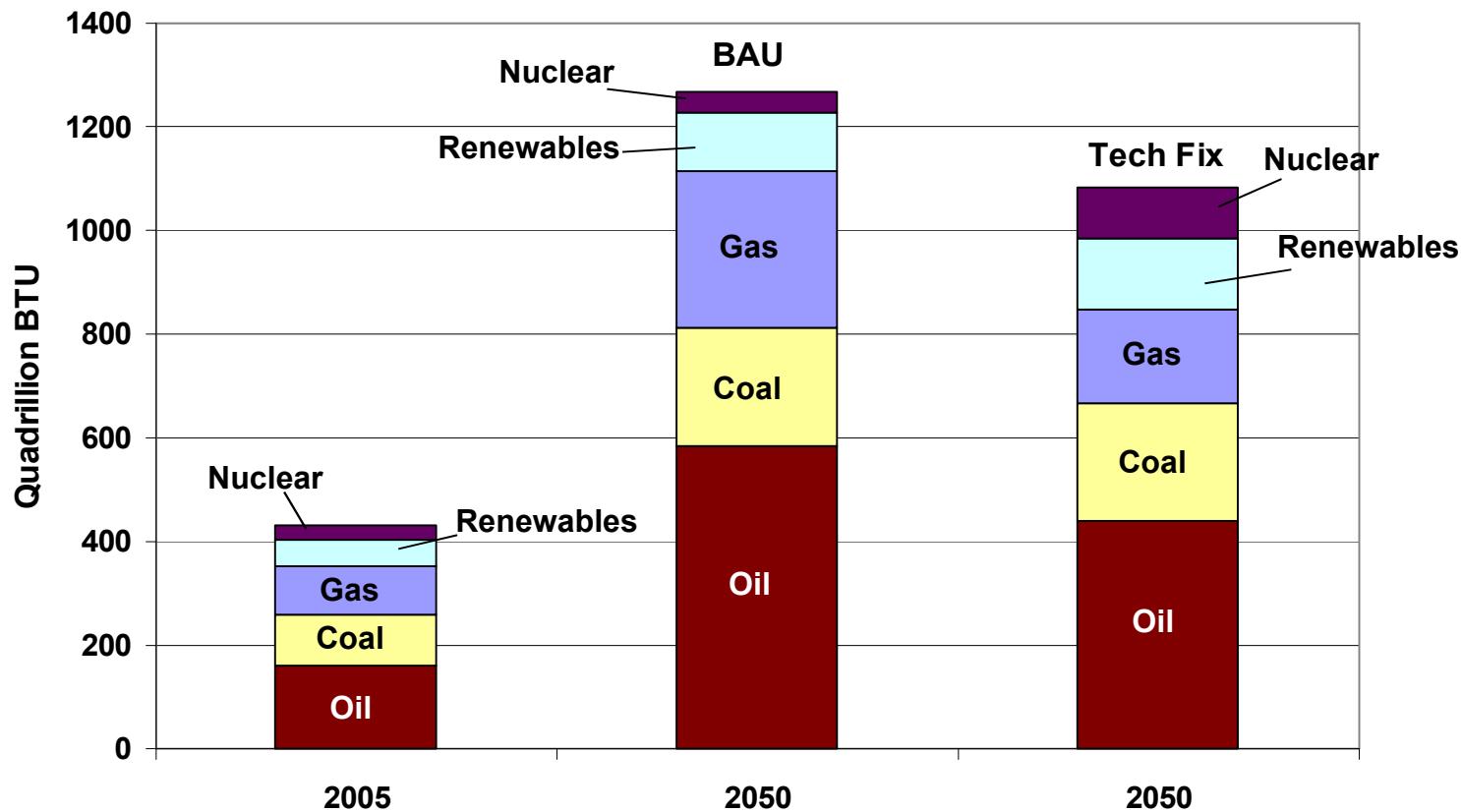


2050 Tech Fix VS BAU: Electricity Demand is 7% Lower



2050 Tech Fix VS BAU: Energy Demand Is 15% Lower

Energy Demand

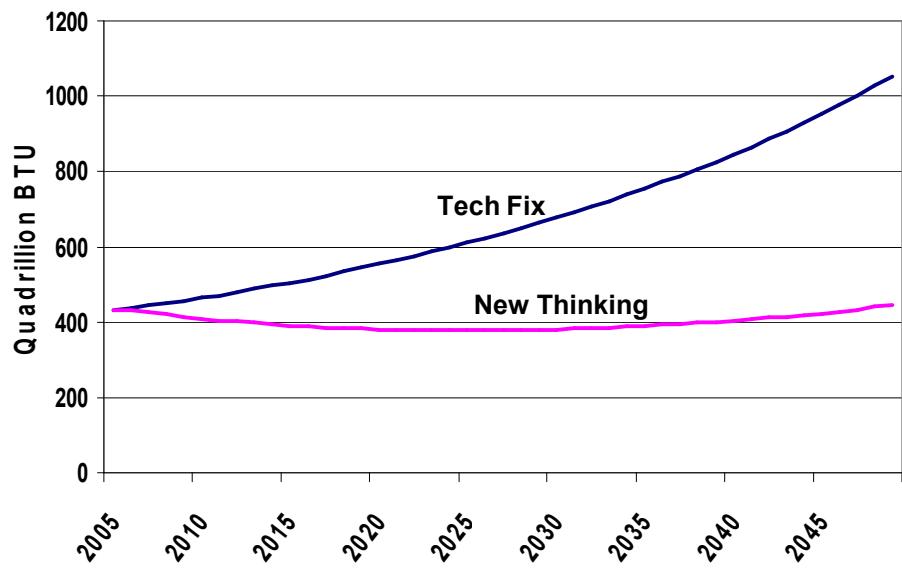


New Thinking

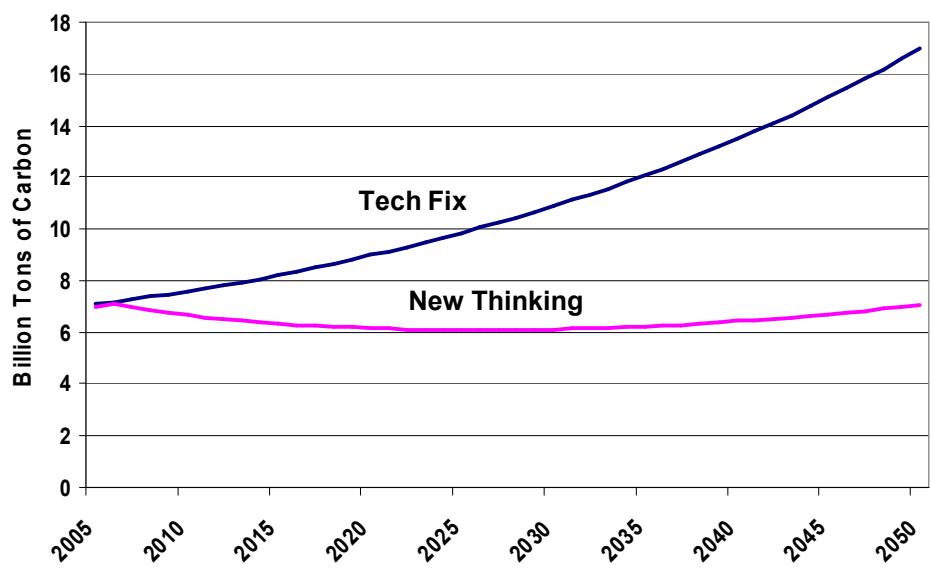
- **To help frame the problem, consider four sensitivities to the Tech Fix scenario**
 - Double annual improvement in energy efficiency
 - Replace all transportation fuel with non-fossil sources
 - Replace 100 percent of electricity with nuclear power (or non-carbon renewables)
 - Reduce economic growth rates by half

New Thinking: Double Annual Energy Efficiency Improvement

Energy Demand

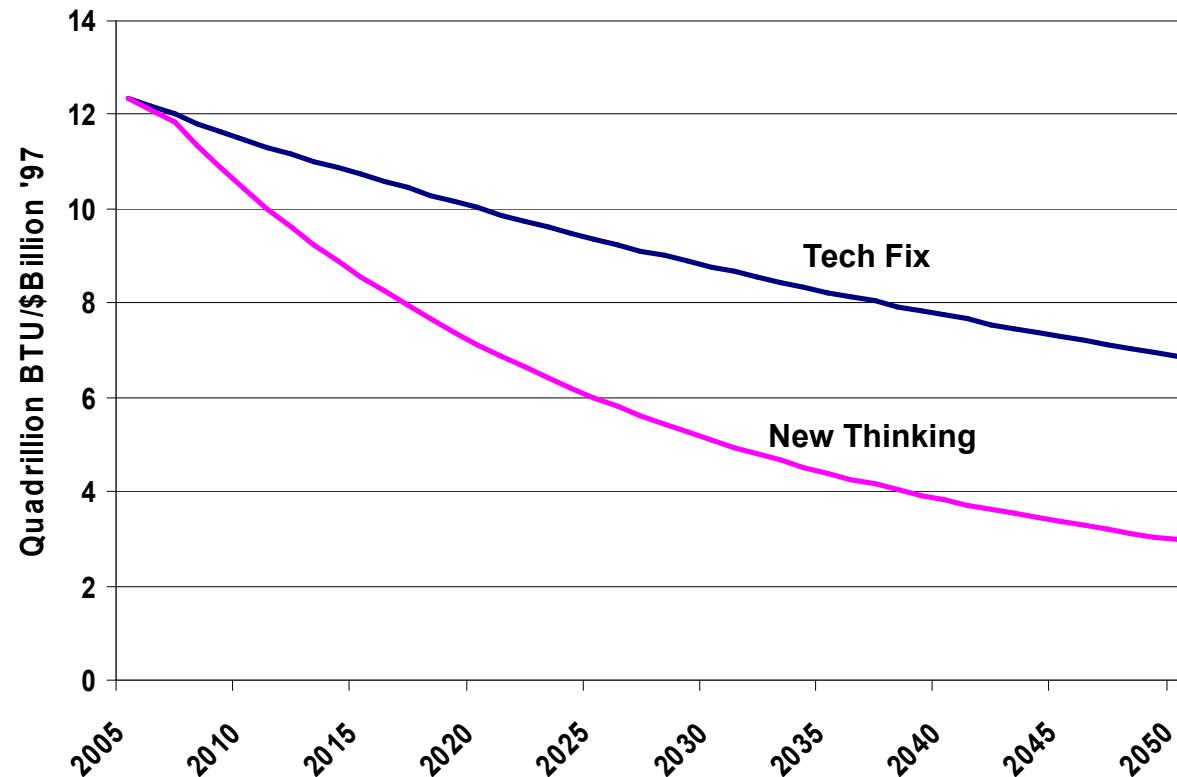


Carbon Emissions



New Thinking: Double Annual Energy Efficiency Improvement (cont'd)

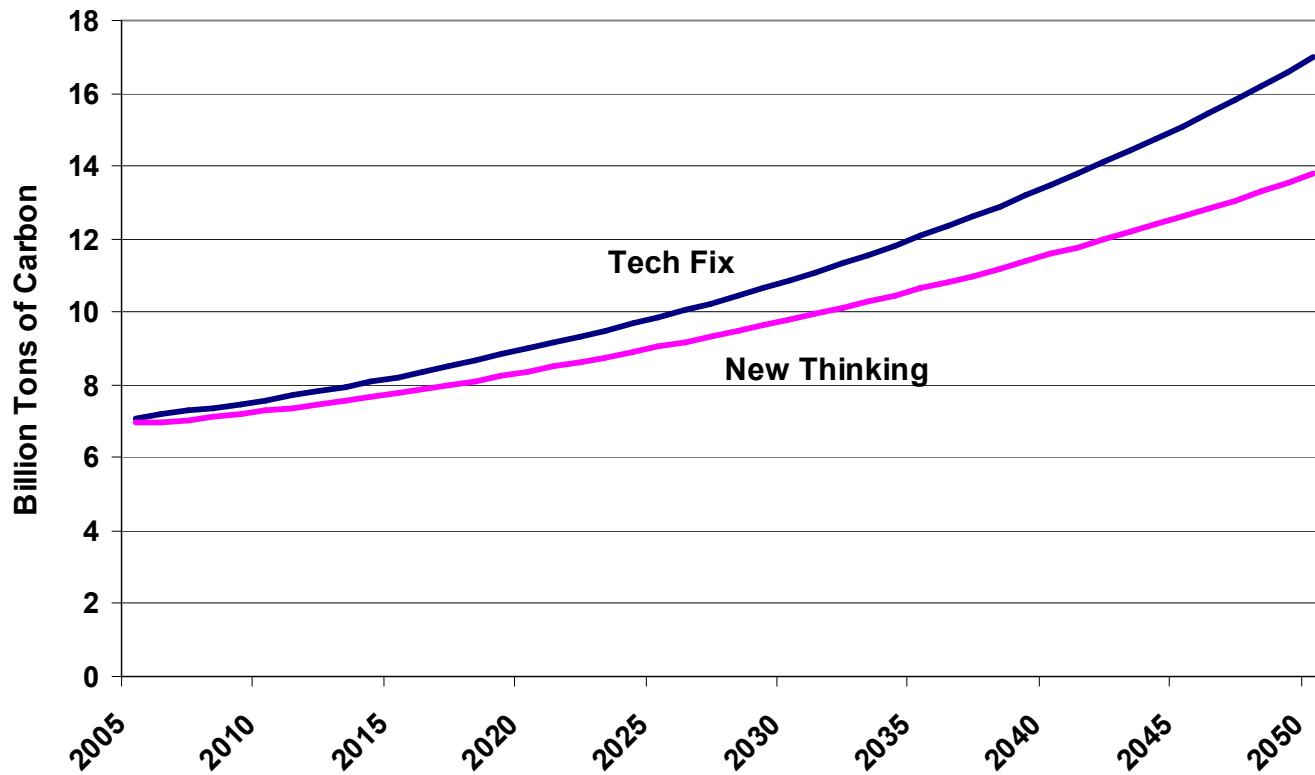
Energy Intensity



Would reduce 2050 energy per unit of GDP by 60% below Tech Fix

New Thinking: 100% Non Carbon Transportation Fuel

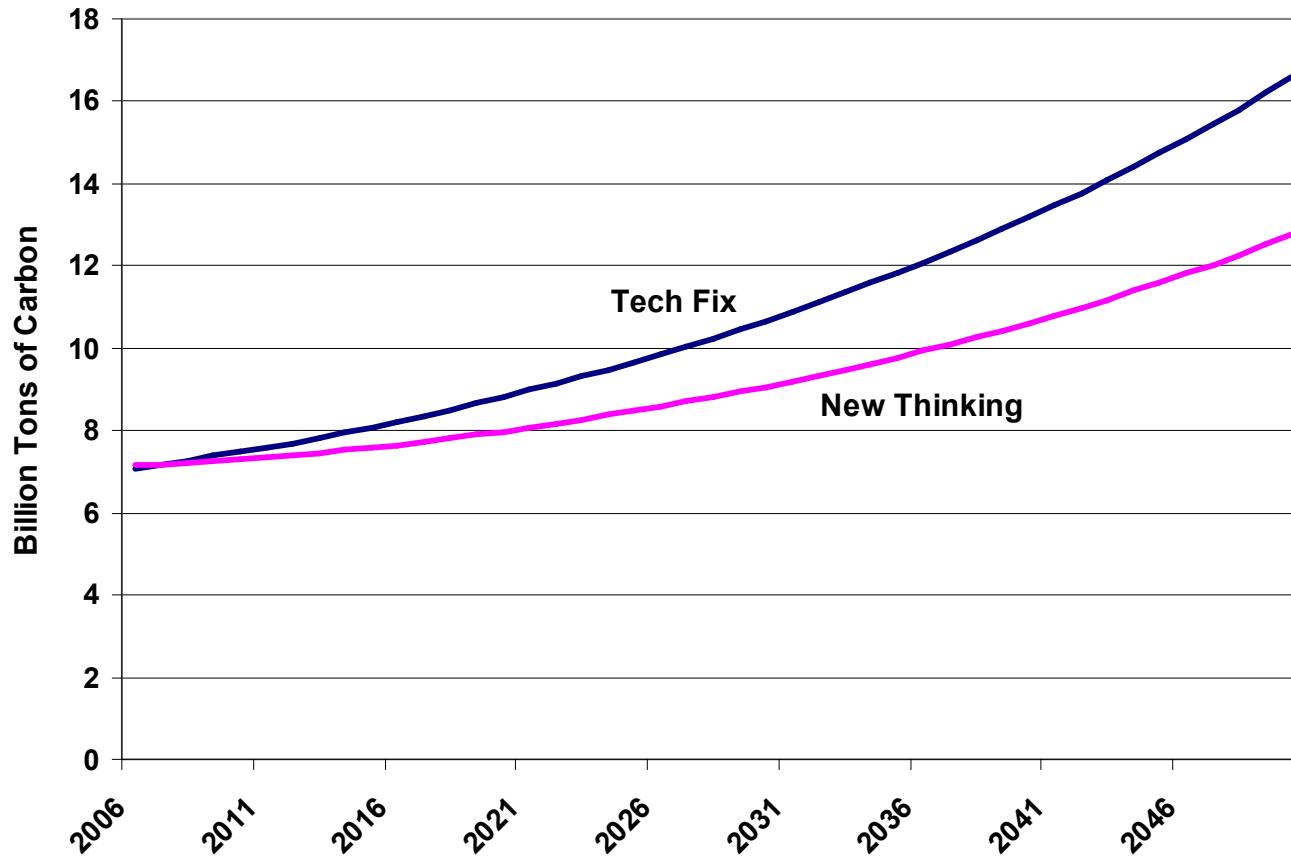
Carbon Emissions



Would reduce 2050 carbon emissions by 19%

New Thinking: 100% Nuclear (Or Non Carbon Renewable) Electricity

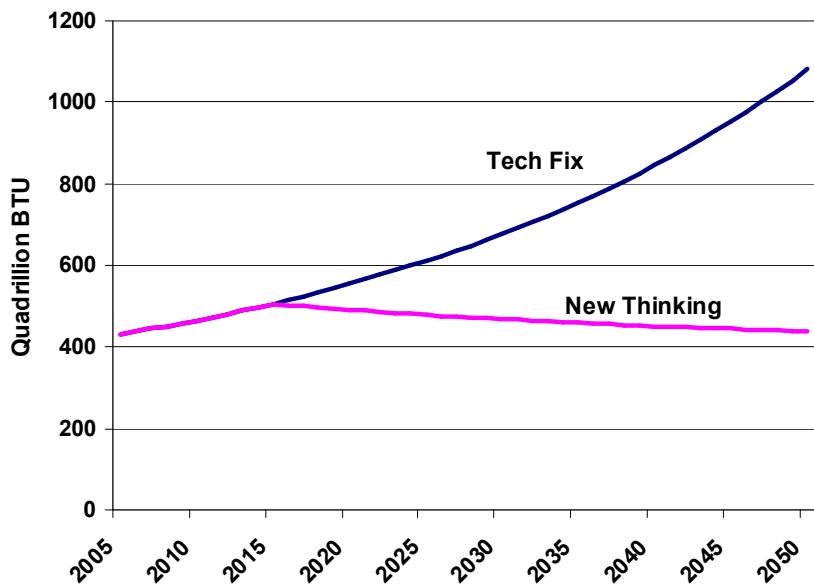
Carbon Emissions



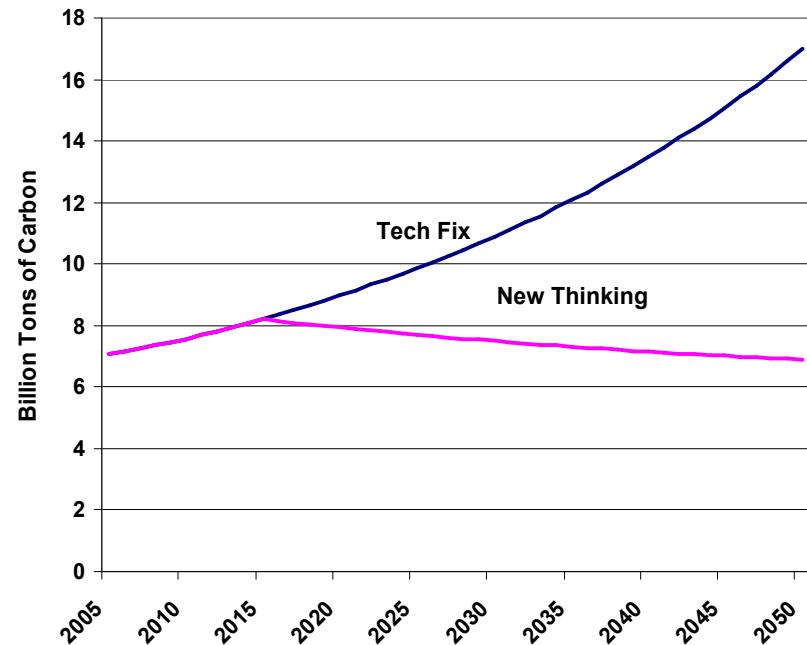
Would reduce 2050 carbon emissions by 23%

New Thinking: Reduce Annual Economic Growth Rates by About Half

Energy Demand



Carbon Emissions



Annual Real GDP Growth Rates

		Other			Other	
	US	Industrial	FSU	China	Developing	World
Tech Fix	2.8	2.5	4.1	6.6	4.4	3.4
New Thinking	1.4	1.2	2.1	3.2	2.1	1.6

Would return energy demand and carbon emissions to current levels by 2050

Summary

- **It will be very difficult to substantially reduce future world energy demand and carbon emissions without radically**
 - New technology that marketplaces want to adopt
 - New ways of societal thinking about and meeting energy, economic, and environmental needs