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Implications of Abundant Natural Gas

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Background

The natural gas revolution

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- The application of technologies for accessing “unconventional” gas shales in the United States has dramatically increased gas production, and estimates of recoverable resources even more.

- And, dramatically reduced natural gas prices.

Figure 107. Natural gas production by source, 1990-2035 (trillion cubic feet)

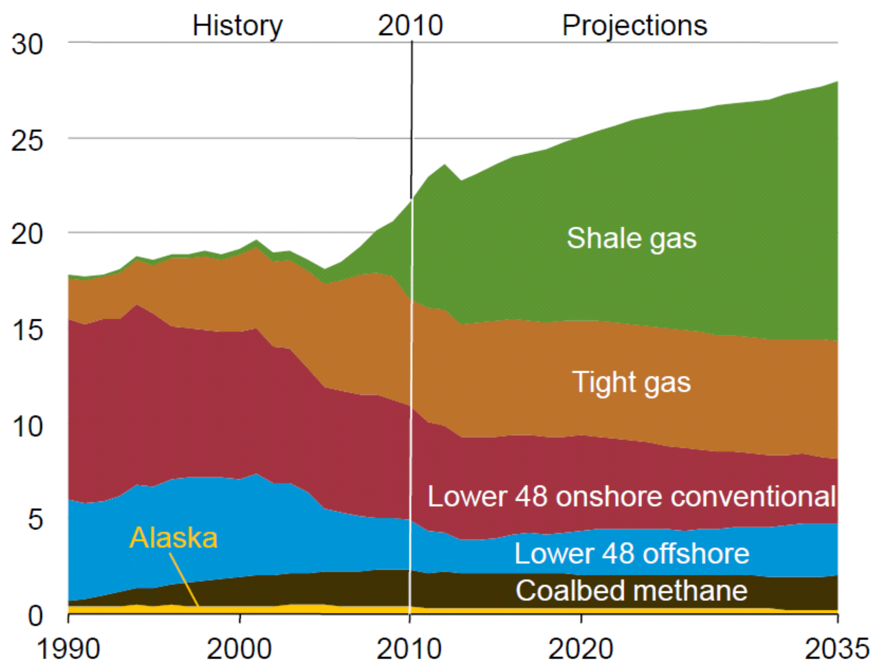
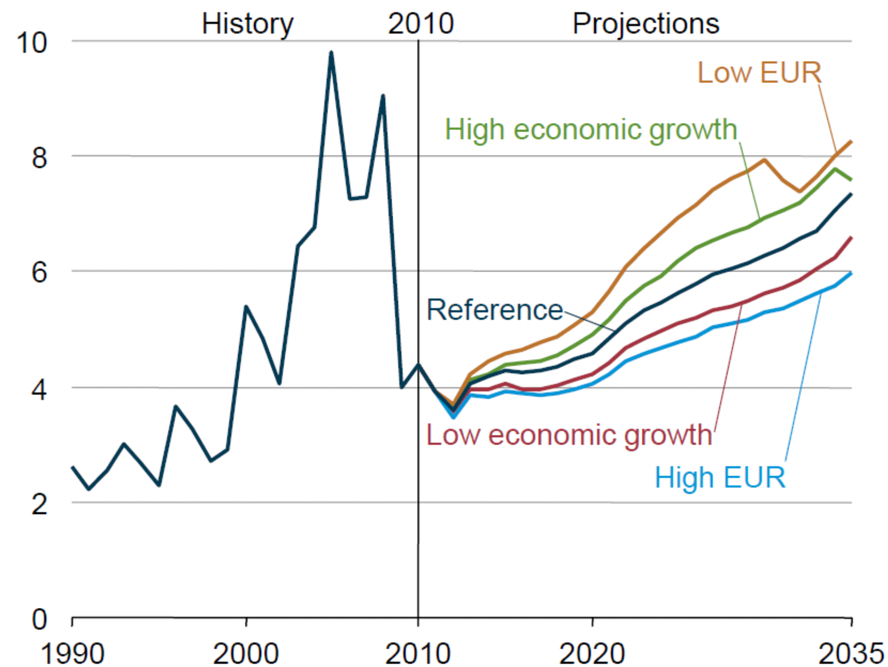


Figure 105. Annual average Henry Hub spot natural gas prices in five cases, 1990-2035 (2010 dollars per million Btu)



Source: EIA, Annual Energy Outlook 2012

Gas and the Global Energy System

- Gas is has been a growing component of the global energy system for some time.

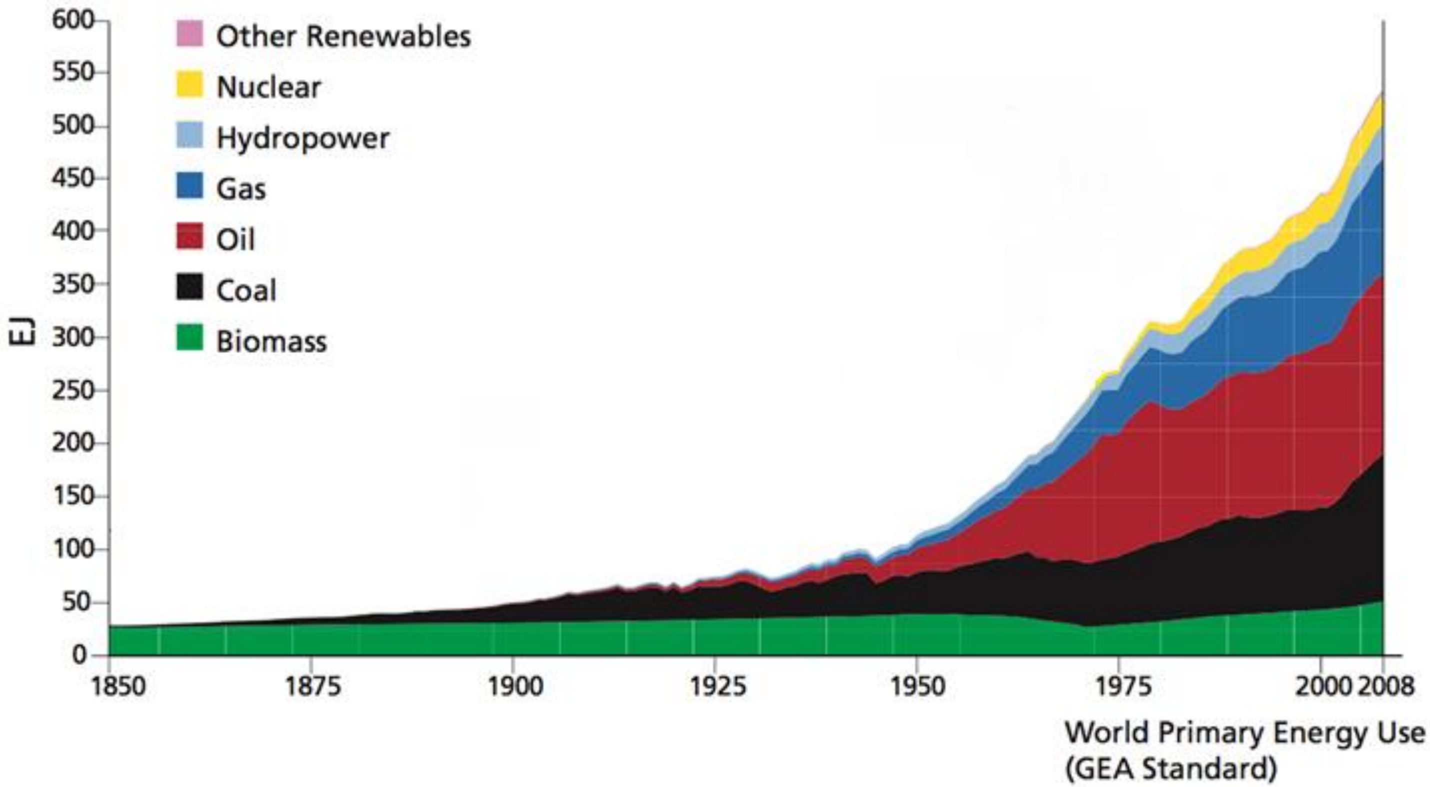


Figure SPM-1. | Evolution of primary energy shown as absolute contributions by different energy sources (EJ). Biomass refers to traditional biomass until the most recent decades, when modern biomass became more prevalent and now accounts for one-quarter of biomass energy. New renewables are discernible in the last few decades. Source: updated from Nakicenovic et al., 1998 and Grubler, 2008, see Chapter 1.[1]

Grubler et al., 2012: Chapter 1 - Energy Primer. In *Global Energy Assessment - Toward a Sustainable Future*.

A brief history of thinking about Natural Gas Resources

- In the 1990s total gas reserves were thought to be more abundant than oil, but gas production was expected to peak and decline before mid-21st century, because gas exploitable resources were economically limited to “conventional” resources.
  - Unconventional resources were thought to be too expensive ever to be relevant.

- In 1997, Rogner’s work on natural resources indicated that “unconventional gas” was abundant. But, modelers either were slow to incorporate unconventional gas (and oil) into their thinking or priced them as more expensive than “conventional” resources.

And then a technological revolution happened.

Key Questions

As application of new production technology spreads beyond the United States:

- How will this change our understanding of the scale and composition of the evolving global energy system?

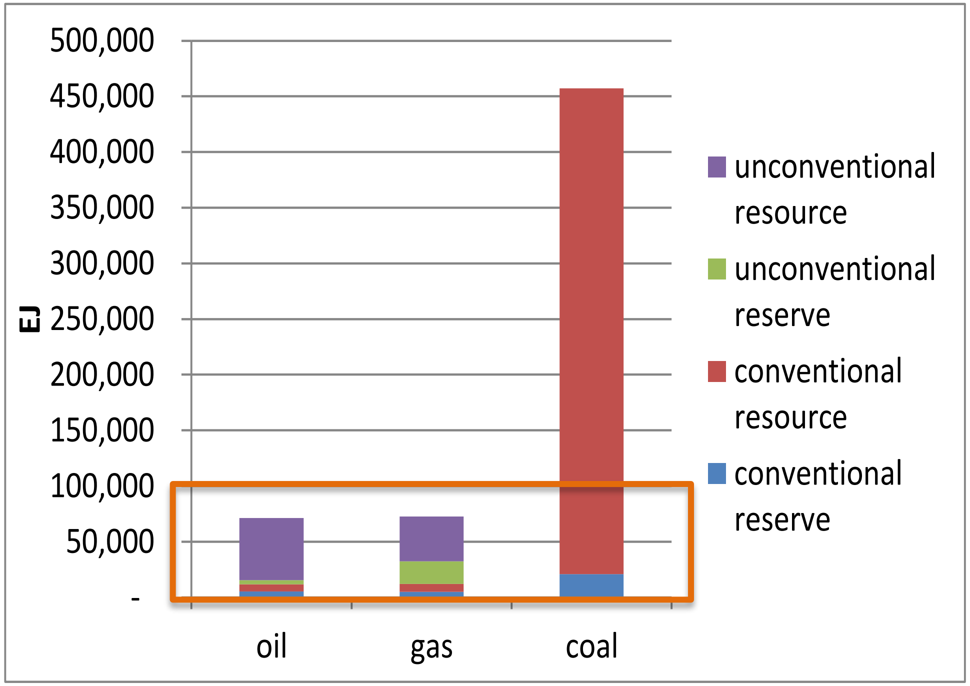
- How will this affect energy security and international trade?
- How will this affect local and regional air quality?

- What effect will this have on CO_2 and other GHG emissions and the technologies for their use in the near term and long term?
  - Globally and regionally
  - With and without emissions mitigation policies
  - Implications for regional air pollution

How Much Gas Is Out There?

Fossil Fuel Resources

- How much natural gas is there and how much does it cost?
  - How much in the larger sense means **resource availability**
- Oil, Gas and Coal
  - Conventional and unconventional for oil and gas
  - Coal is just too abundant to divide up that way.



Fossil Fuel Resources

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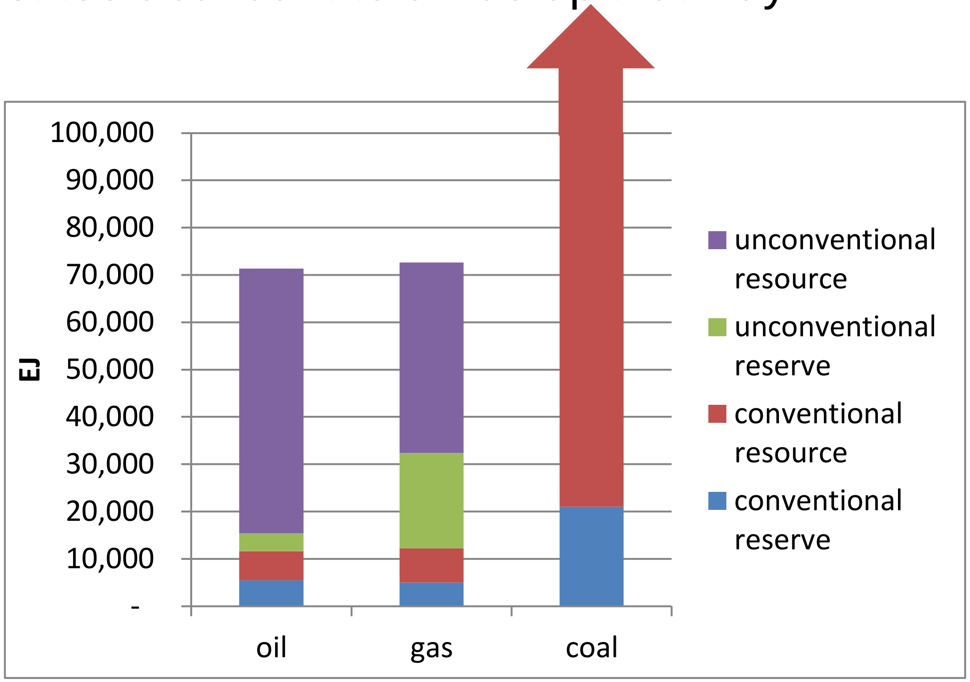

How much does it cost?

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- To help us understand the implications of abundant and inexpensive natural gas availability for the global energy system, we have developed three alternative global and regional resource supply schedules.

- **Gas Technology Circa 1990 (Gas Tech 1990 or GT1990)** this supply schedule reflects an understanding of gas resource availability circa 1990s.
- **Gas Technology Circa 2000 (Gas Tech 2000 or GT2000)** this supply schedule reflects an understanding of gas resource availability in the early 2000s.
- **Gas Technology Circa 2000 (Gas Tech 2010 or GT2010)** this supply schedule assumes that advanced technologies can be successfully deployed globally.

The three gas supply schedules (global)

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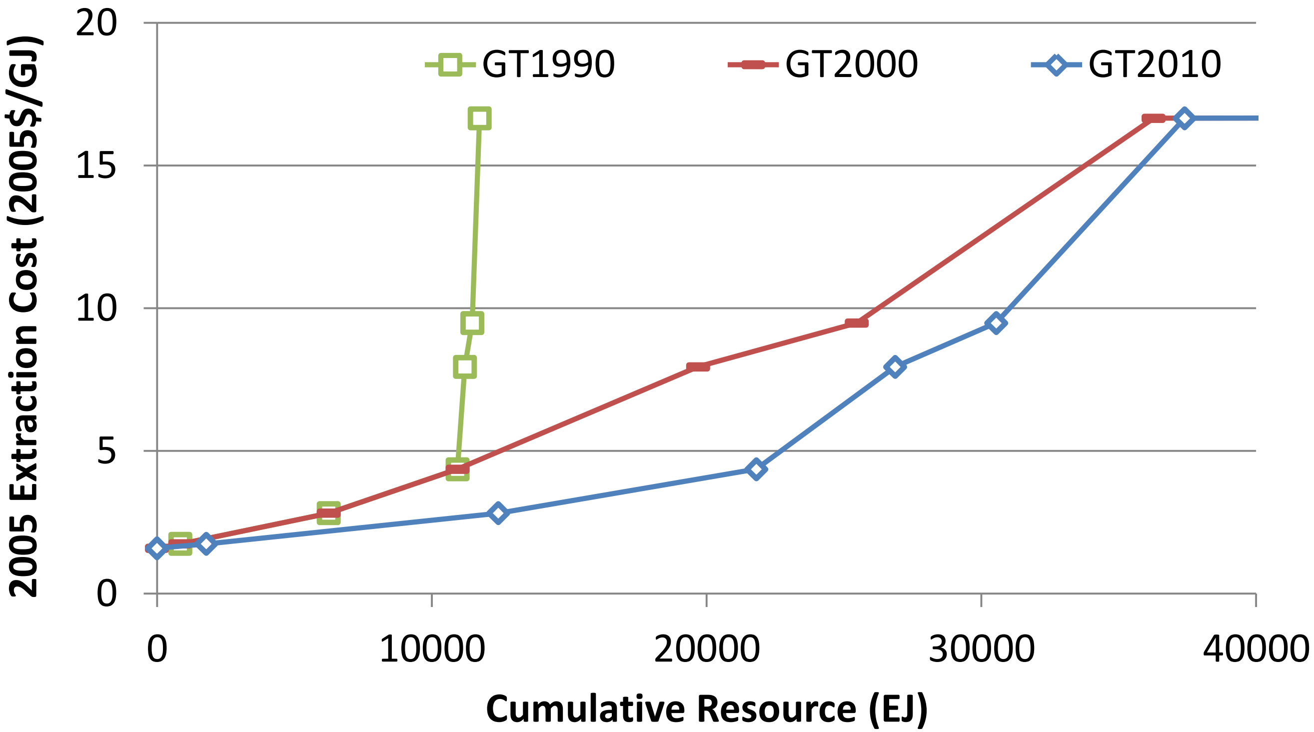
- GT1990 - Conventional Gas Resources Only, ca 1990s
- GT2000 - Expensive Unconventional Gas, ca 2000s
- GT2010 - Abundant and Inexpensive Gas Resources, 2010 and beyond



The Global Change Assessment Model

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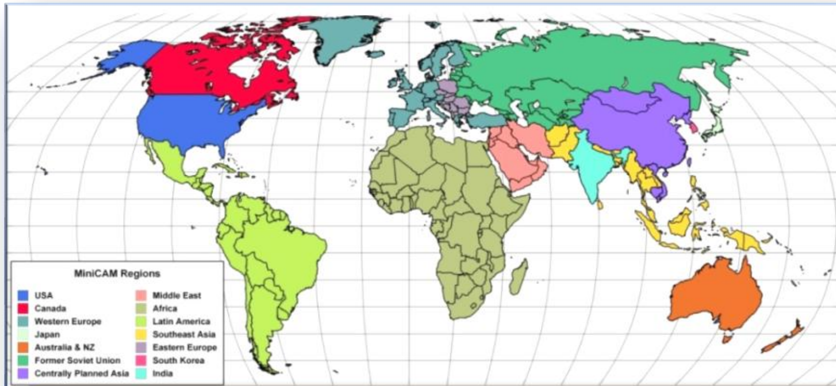
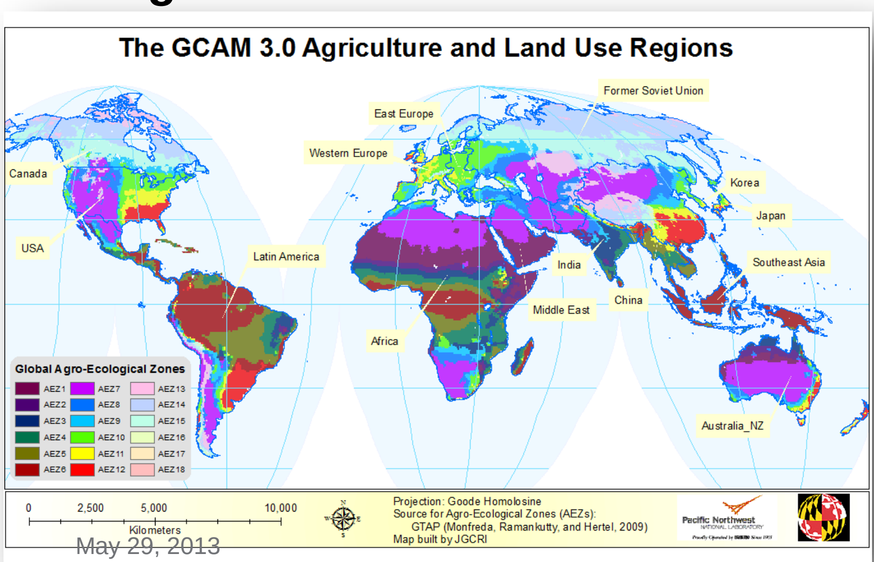
14 Region Energy/Economy Model



151 Agriculture and Land Use Model

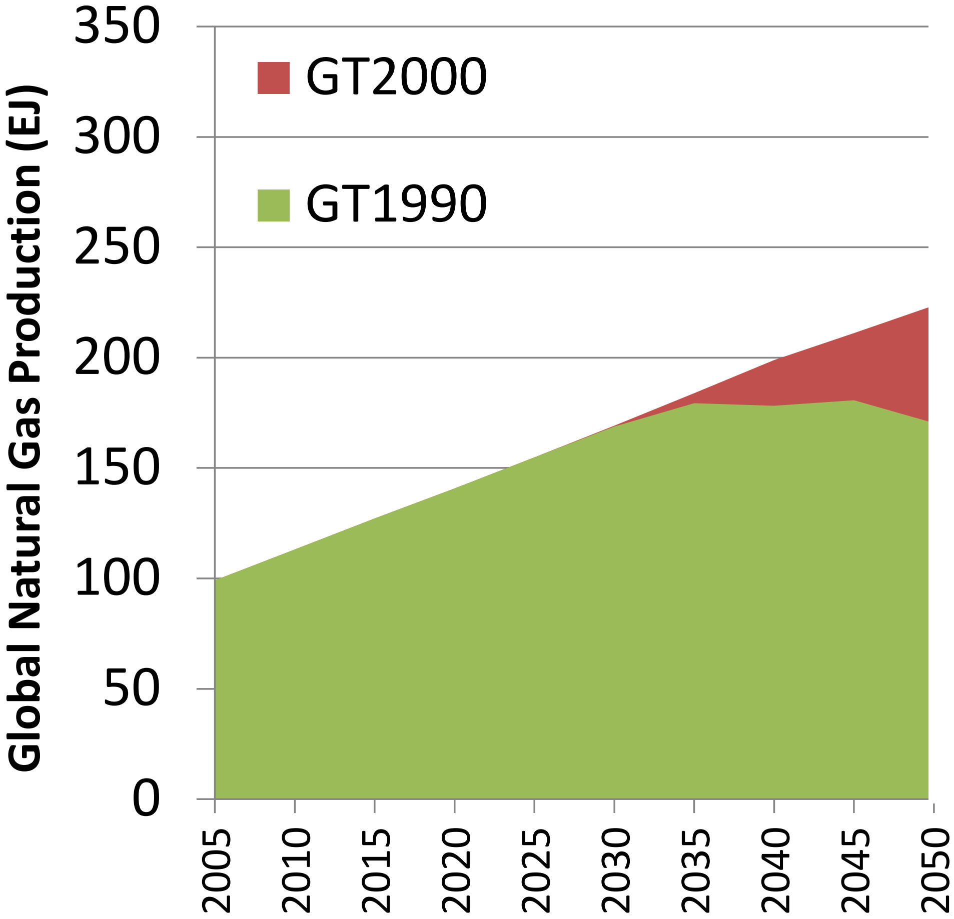


- GCAM is a **global integrated assessment model**
- GCAM links **Economic, Energy, Land-use,** and **Climate** systems
- Technology-rich model
- Emissions of 16 greenhouse gases and short-lived species: CO_2, CH_4, N_2O, halocarbons, carbonaceous aerosols, reactive gases, sulfur dioxide.
- Runs through **2095** in **5-year time-steps.**
- Dynamic Recursive
- Open Source/Model and Documentation available at: http://www.globalchange.umd.edu/models/gcam/

Gas and the Global Energy System

Adding Abundant but EXPENSIVE unconventional gas to Conventional gas

- Increased late 21st century production
  - When gas prices were driven up past present prices
- Near-term gas production and use were similar in GT1990 and GT2000.



We will focus on the period to 2050

Abundant AND Inexpensive gas changes our understanding of the near term

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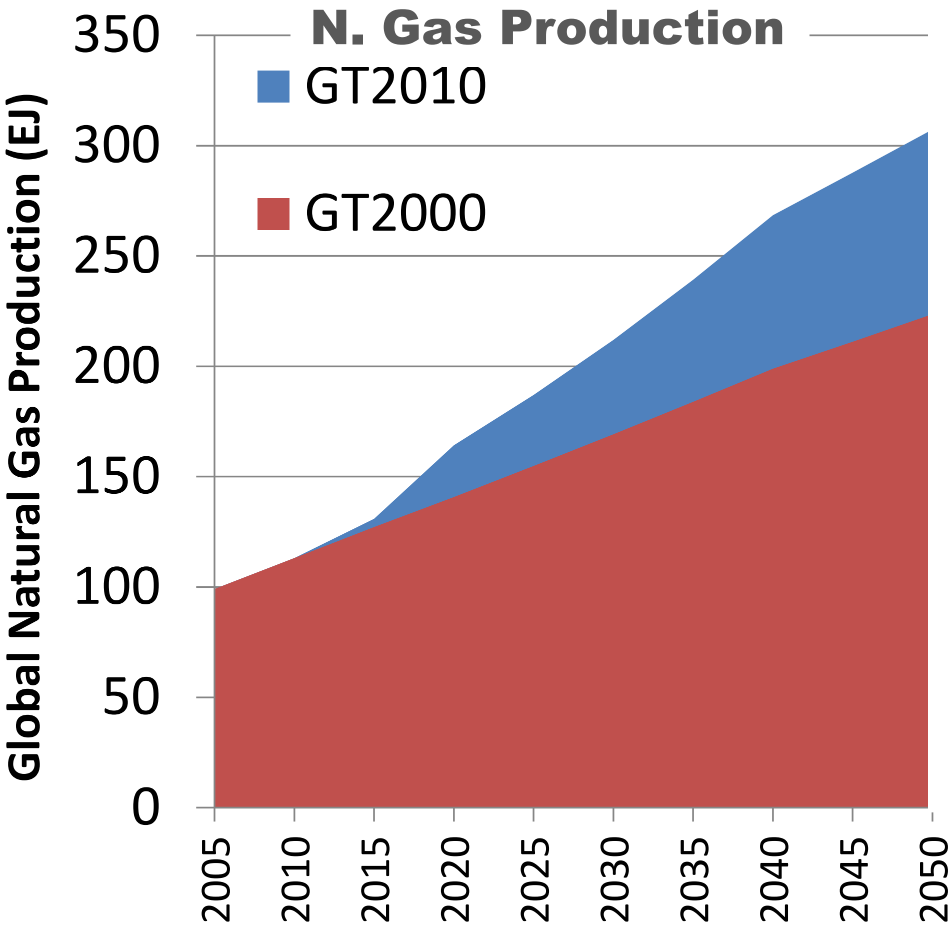
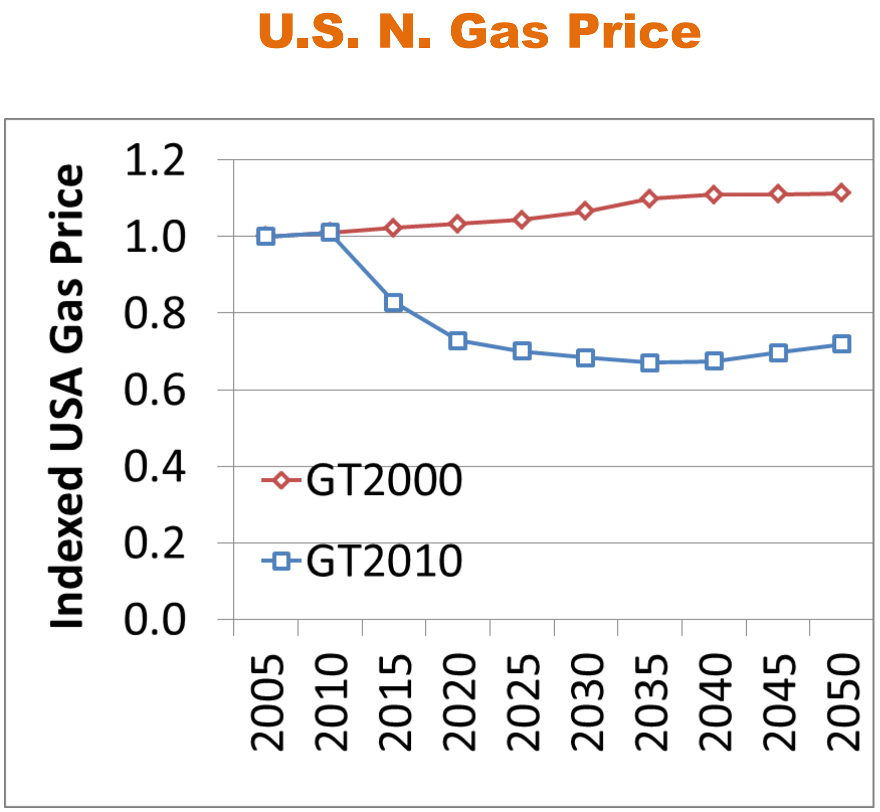
- Abundant and inexpensive gas is introduced in North America in 2015 and globally in 2020.
- The increase in natural gas production accelerates.
- And lowers the price of natural gas around the world.





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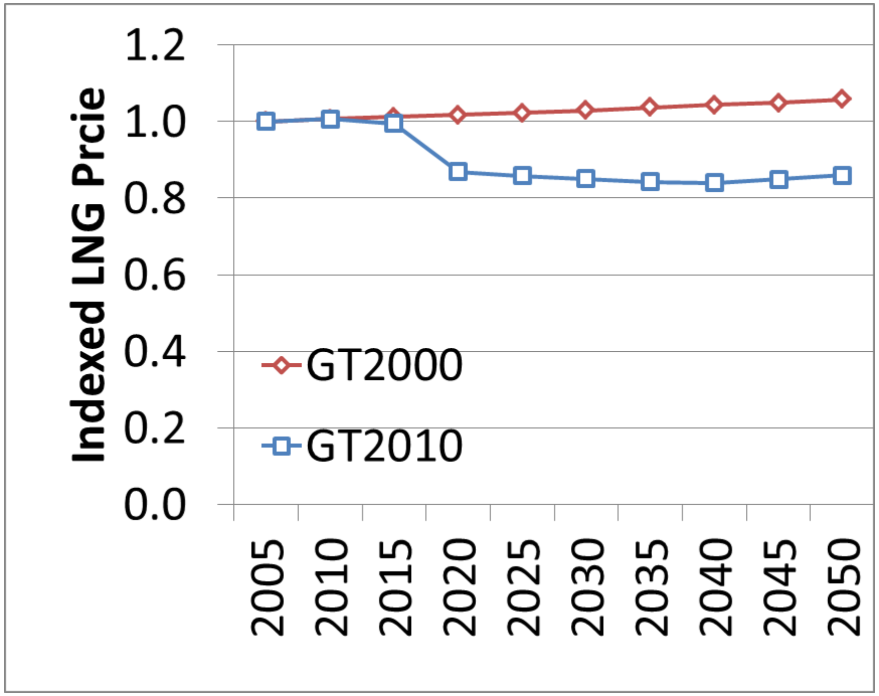
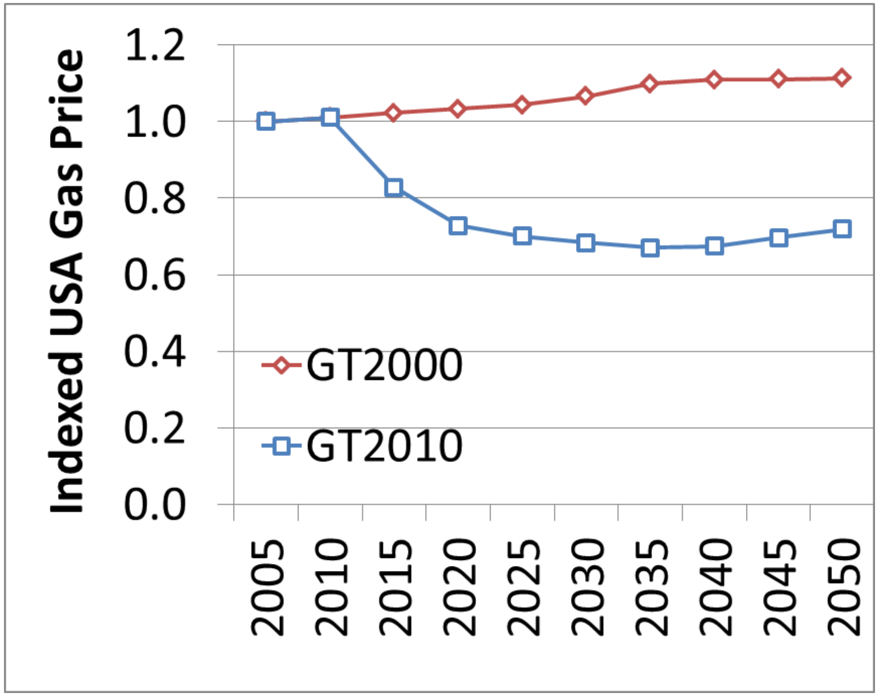
Global LNG Price



U.S. N. Gas Price



2050 Global Primary Energy Consumption

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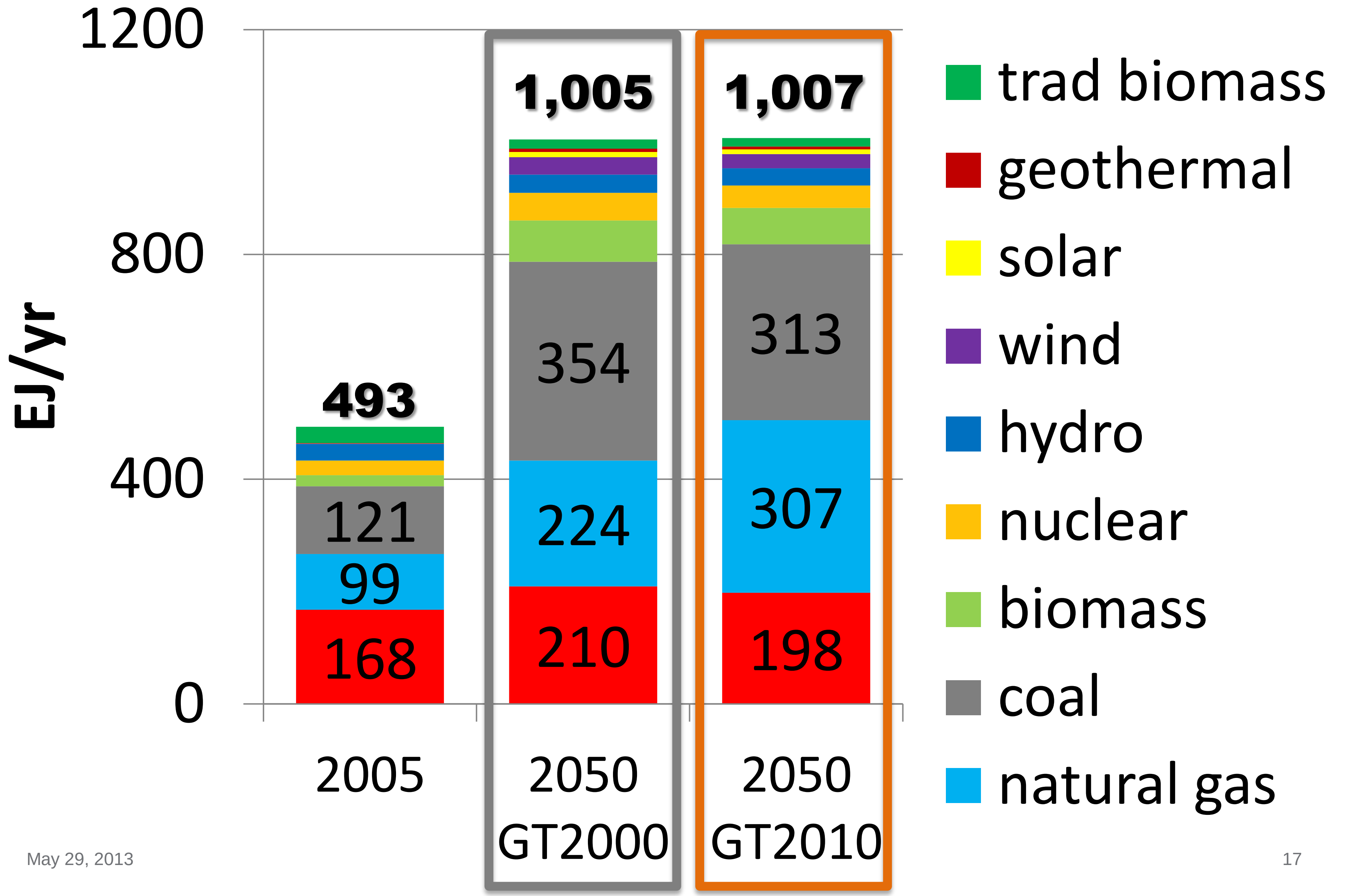
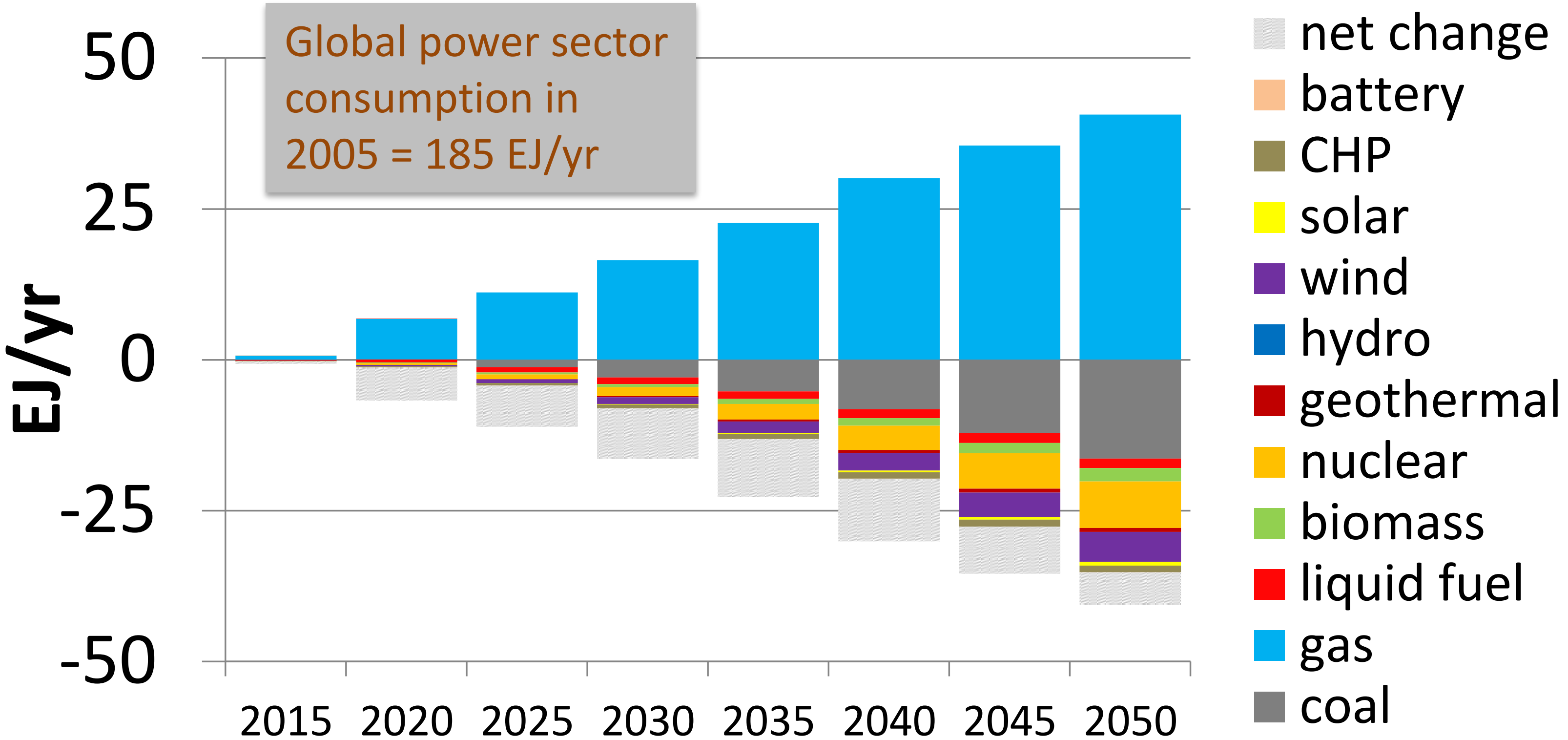


Abundant and Inexpensive Gas Penetrates Power Production

- Abundant and inexpensive natural gas displaces other energy carriers in power generation
- Where it helps lower generation costs

Change in Fuel Mix for Power Generation resulting with Abundant and inexpensive natural gas rather than expensive unconventional gas



2050 Global Final Energy Consumption Change

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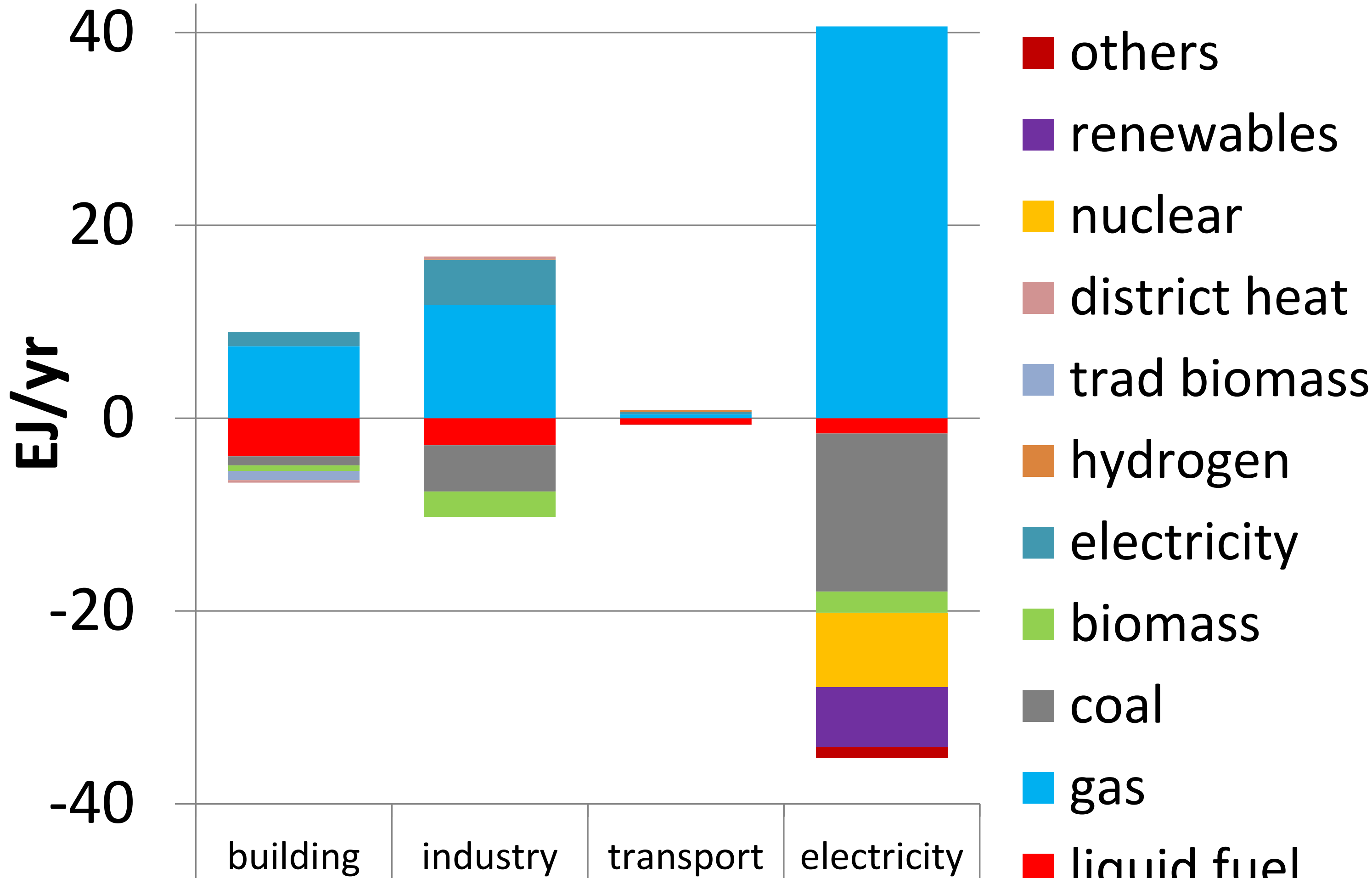


	building	industry	transport	electricity
Global consumption in 2005 (EJ)	113	152	88	185

Gas and CO_2 Emissions—Without Climate Policy

Carbon and Energy

- How does abundant gas affect expected greenhouse gas emissions?
  - CO_2, and total climate forcing.

- Carbon and energy
  - Petroleum = ~20 kgC/GJ
  - Coal = ~27 kgC/GJ
  - **Natural gas = ~14 kgC/GJ**
  - Nuclear, Solar, wind, geothermal, and other renewable energy forms = ~0 kgC/GJ

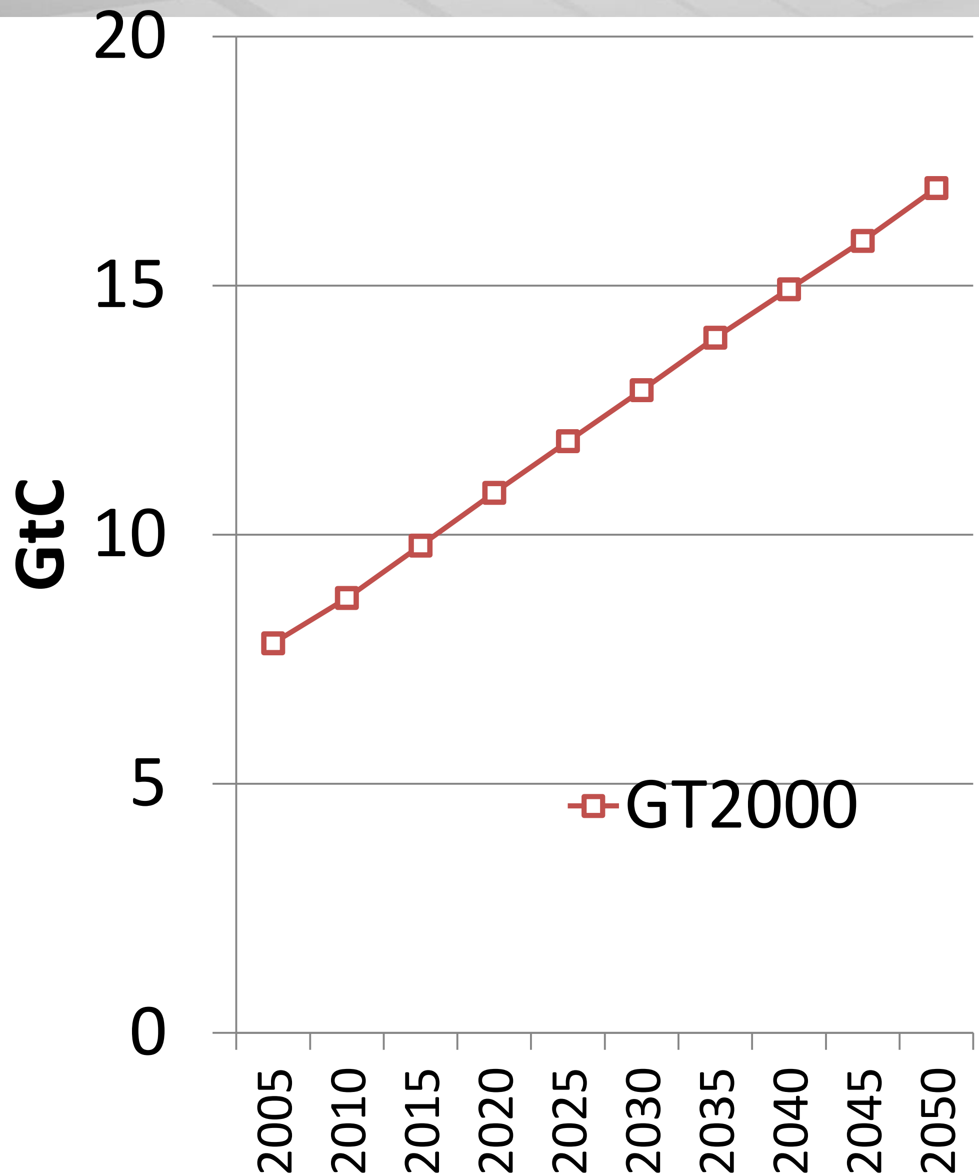
  Bioenergy is 0 net emissions for the energy sector, but indirect land use change emissions are accounted.

Carbon-energy ratios in the larger economy

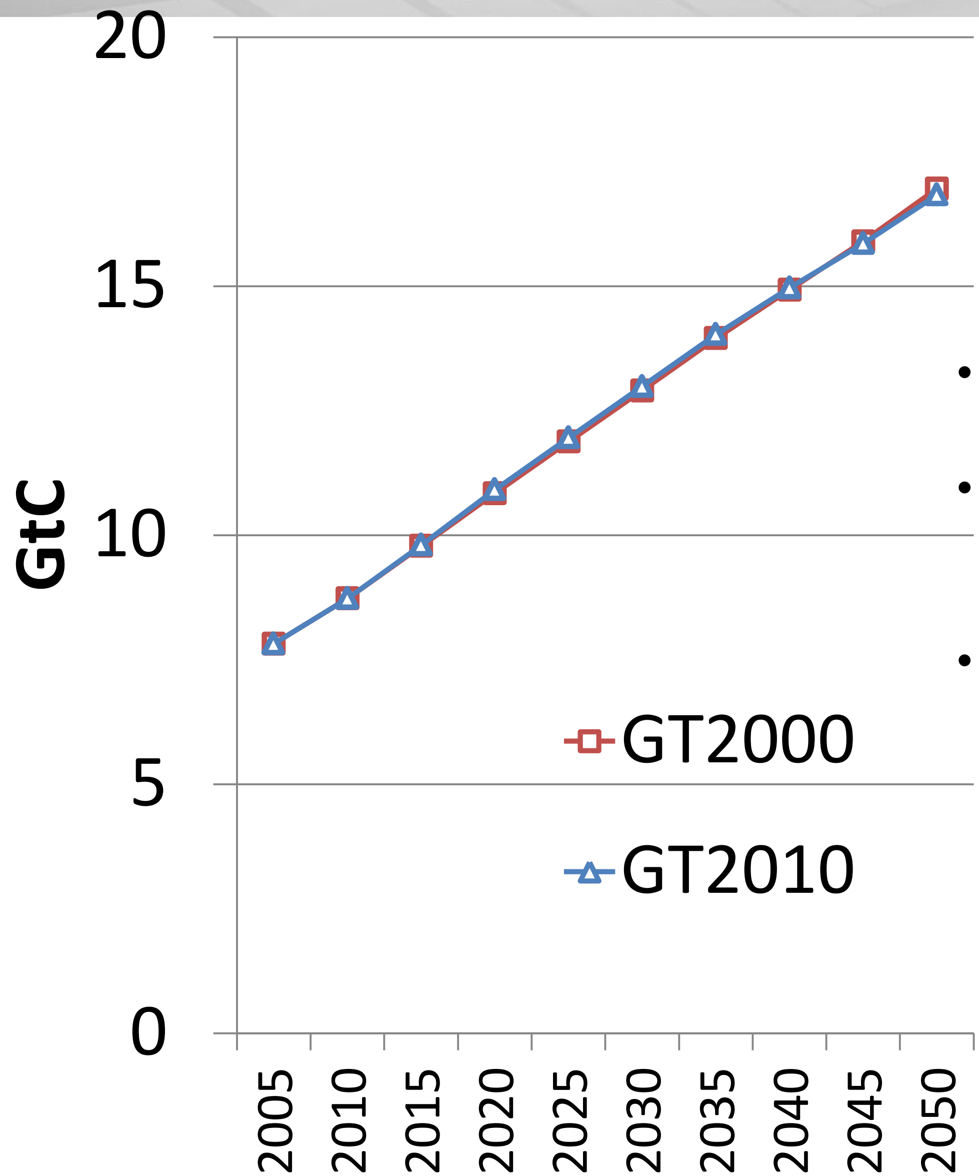
- Average carbon intensities (kgC/GJ):
  - **Natural gas ~14**
  - Petroleum ~20
  - Coal ~27
  - Average global 2030 **~17**

- Regional average carbon-energy ratios in 2010 (kgC/GJ):
  - Average US **~16**
  - Average China **~22 (modern ~24)**
  - Average India **~16 (modern ~20)**
  - Average W. Europe ~15
  - Average Africa **~11 (modern ~15)**

CO_2 Emissions: Abundant and Inexpensive versus Expensive Unconventional Gas



CO_2 Emissions: Abundant and Inexpensive versus Expensive Unconventional Gas



- Virtually no change in Fossil Fuel CO_2 emissions.
- Slightly higher in the early years due to increased energy consumption.
- Slightly lower in the later years due to crowding out coal.

Why did CO_2 emissions not decline?

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- On average natural gas' Carbon-Energy ratio is only slightly lower than the average for the world.
  - Increasing gas backs out both coal and other competitors, so on average the decline in the Carbon-Energy ratio is small.
- There is a small increase in aggregate energy use, so there is a small take-back effect from the increase in system scale.

Gas and Greenhouse Emissions—Without Climate Policy

Gas and Non-CO_2 GHG Emissions

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- How does abundant gas affect expected greenhouse gas emissions?
  - CO_2, and total climate forcing.
- Carbon and energy
  - Petroleum = ~20 kgC/GJ
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  - **Natural gas = ~14 kgC/GJ**
  - Nuclear, Solar, wind, geothermal, and other renewable energy forms = ~0 kgC/GJ. Bioenergy is 0 net emissions for the energy sector, but indirect land use change emissions are accounted.
- Methane emissions have a (100 year) Global Warming Potential of
  - ~25 gCO_2/gCH_4
  - 12% of methane emissions was from natural gas in 2005.
  - Sources include: emissions from FF, e.g. coal mining, gas transmissions & distribution, gas venting, etc., (also land use, agriculture, animal husbandry, waste …)

Will Abundant Gas INCREASE total GHG emissions?

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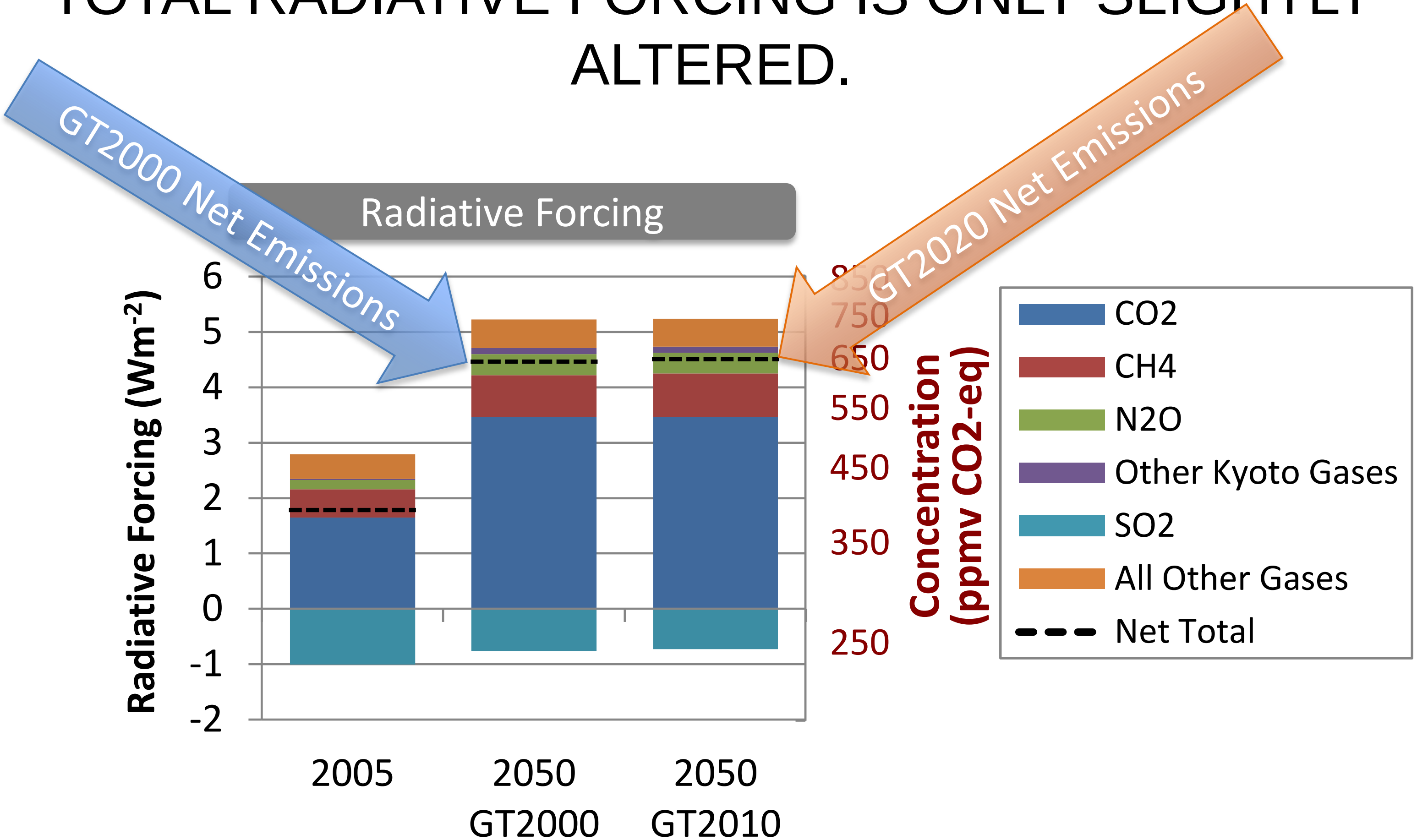
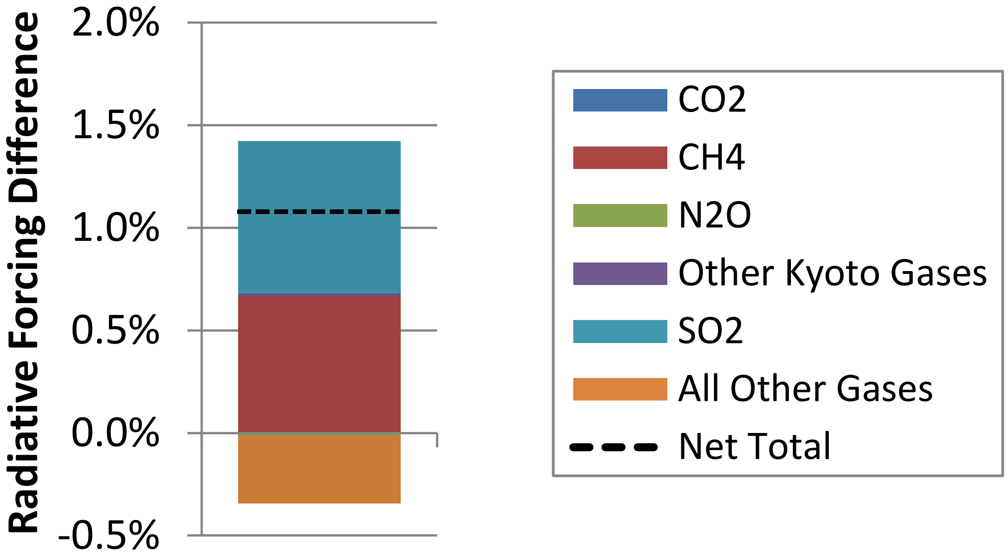
TOTAL RADIATIVE FORCING IS ONLY SLIGHTLY ALTERED.



Offsetting changes

- Increased fugitive methane emissions from natural gas extraction.
- Reductions in coal use
  - Reduce cooling from SO_2 from coal burning
  - Reduce fugitive methane emissions from coal mining.
  - Reduce Black Carbon emissions from coal burning.
- Slightly reduced CO_2 emissions from reduced biomass land use change emissions.



Radiative Forcing Difference

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Other Considerations

Local and Regional Environmental Quality

- The penetration of gas into the market reduces local and regional air pollutants, e.g. black and organic carbon and sulfur emissions
- These reductions confer non-greenhouse environmental benefits.
- Ground water has been an issue and needs continued attention.

DISCUSSION

- We have focused on scenarios with no specific climate or energy policies.
- **Other researchers have obtained similar results**—e.g. Brian Fisher, IEA.

- **Interactions with other policies** need analysis, e.g. renewable portfolio standards that protect renewable energy forms from the market penetration of gas.

- While we have not had time to discuss here, **Gas Trade Patterns** change significantly, e.g. the USA becomes a small net exporter

- While we do not discuss the results here, we found little impact from abundant gas on the cost of stabilizing climate forcing under IDEALIZED POLICIES.
- Non-idealized policies also need analysis.

SUMMING UP

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- Natural gas has been increasing its market share for decades
- Technologies that make commercially available gas more abundant and less expensive accelerate this trend
- This has major implications for competition among all primary energy sources; for energy production, transformation, distribution and end use; energy security; local and regional air pollution; investments in facilities and infrastructure; supply and value chain interactions within and among sectors and regions and trade
- Gas displaces other fuels but does not significantly alter the overall scale of the global energy system through 2050
- Availability of abundant, less expensive gas through 2050 does not significantly change
  - Global fossil fuel CO_2 emissions or total radiative forcing, or
  - The carbon price required in an idealized mitigation scenario

END