Visioning 2050

BNL's Contribution to the NYS Climate Action Plan

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BROOKHAVEN NATIONAL LABORATORY
a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Outline

- Sustainable Energy Research at BNL
- Climate Change and Energy
  - Climate change: motivations for NYS action
  - Some energy facts
- New York State Climate Action Plan and BNL's Role
- Q&A

Brookhaven's Energy Research Plan

BNL Energy Vision: effective use of renewable energy through improved conversion, transmission, and storage

BNL Initiatives

CFN/Nanoscience

NSLS II

New York Blue

Core Programs

Supporting DOE Grand Challenges

Core Basic Research Efforts:

- Correlated Electron Materials: Grid
- Materials for Catalysis
- Solar Nano-materials
- Energy Storage Materials

Collaborators/Joint Appointments

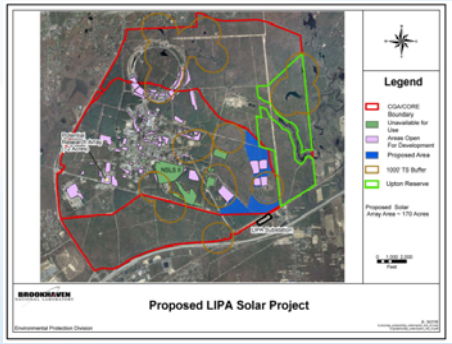
STONY BROOK STATE UNIVERSITY OF NEW YORK · GM · COLUMBIA UNIVERSITY · CORNELL UNIVERSITY FOUNDED A.D. 1865 · Rensselaer FUTURE ENERGY SYSTEMS A NYSTAR Designated Center For Advanced Technology · GE Global Research United States - India - China - Germany · IBM · COLLEGE OF NANOSCALE SCIENCE & ENGINEERING UNIVERSITY AT ALBANY State University of New York

Energy Strategy Focus: Discovery to Deployment

Sustainable Energy Technologies

- **Mission:**
  - identify and overcome scientific, technical, and policy-related barriers to the adoption and deployment of sustainable energy technologies, and
  - to conceptualize and develop new approaches/solutions and move them from discovery to deployment

- **Approach:**
  - fundamental, applied, and engineering research within four themes:
    - energy transmission, distribution
    - renewable energy technologies
    - efficient energy conversion
    - modeling and analysis of energy technologies & policies
  - broad collaborations across BNL: BES, ELS, NSLS, TCP….
  - strong partnering w/ companies, labs, universities, other agencies, NYS….



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Research Topics

- Facilitating Integration of Renewables into Grid/Smart Grid
  - Help to change the value proposition for renewables on grid
  - Explore the approaches for integrating significant numbers into utility grids
  - Investigate the use of VAR control for improved power quality & reliability
  - Modeling and simulation of T&D networks to explore value of DR
  - Measurement and Modeling of wind and solar resource variability

- Deployment of New Technologies
  - Evaluation and testing of new design concepts
  - Improved performance of components and systems
  - Studies of site selection for renewables
  - Life cycle analysis (cradle to grave impacts and costs)
  - Environmental & ecological Impacts

- Studies of Reliability and Degradation
  - Long-term reliability and degradation studies under Northeast conditions
  - Failure mode analysis, why things fail, how failures can be prevented

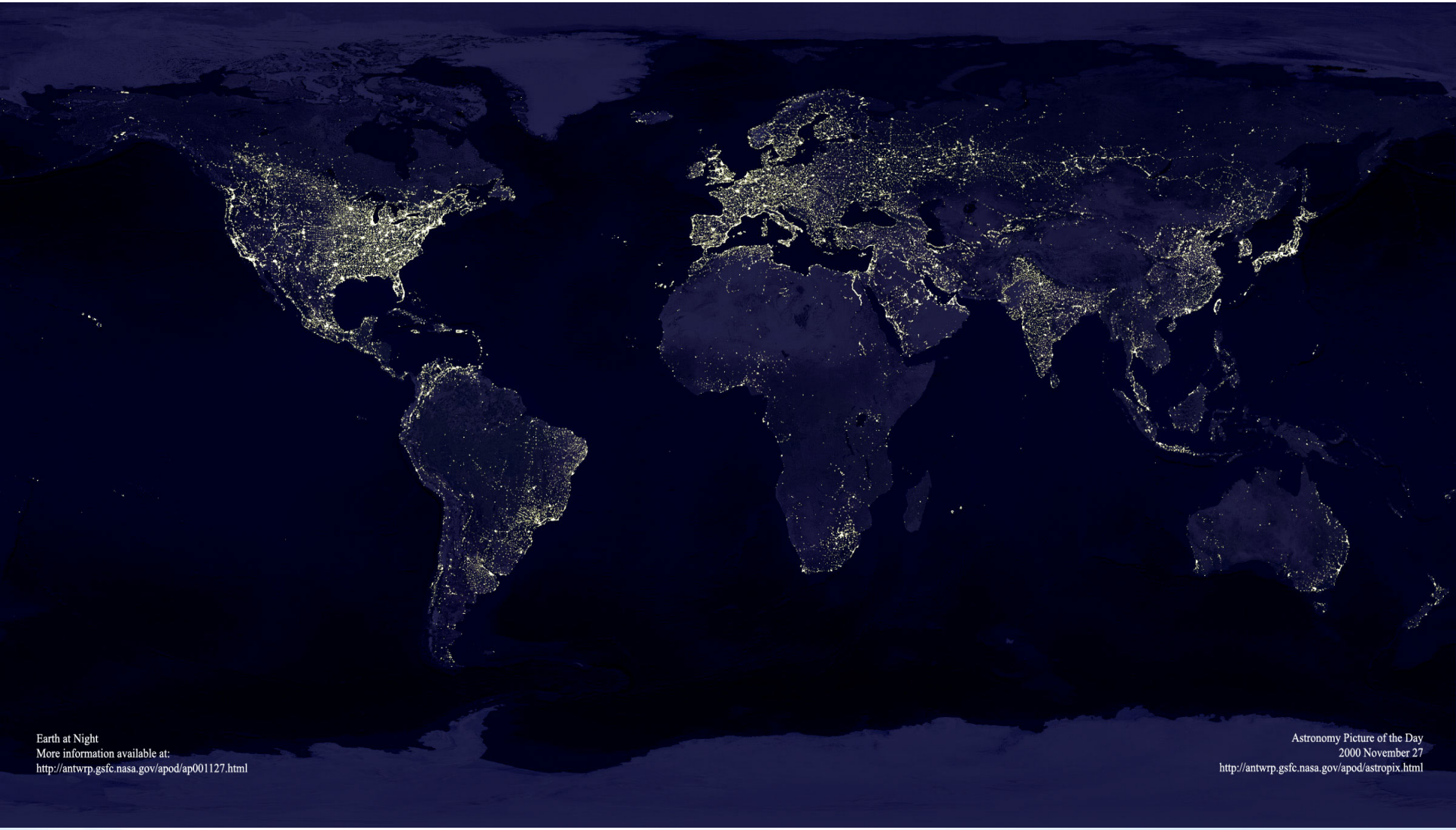
Research Areas

- Generation
  - Photovolatic Systems
    - Utility-scale system performance and monitoring
    - Testing, modeling, simulation of PV systems (component, sub-system, systems, integration)

- Energy “Intermediates”
  - Biofuels: compatability, emissions, thermochemical conversions
  - Storage
    - Studies on value of integrated grid-level storage, integration into DR
    - Evaluation of storage and control alternatives
    - Reduce intermittency, resource extension, frequency regulation capability
    - Development of new batteries: architectures, materials, synthesis
    - Hydrogen storage materials

- Transmission & Distribution: SMART GRID
  - Advanced Electric Grid Innovation and Support Center (AEGIS)
  - Advanced metering, controls, demand response, VAR dispatch

- End Use (Residential and Commercial)
    - Combustion Science, efficiency improvements of heating systems, biofuels
    - Building controls, energy management , etc.


Earth at Night
More information available at:
http://antwrp.gsfc.nasa.gov/apod/ap001127.html
Astronomy Picture of the Day
2000 November 27
http://antwrp.gsfc.nasa.gov/apod/astropix.html

The New York State 80 by 50 Plan

- In August 2009 the Governor of New York signed Executive Order 24, which tasks the State to reduce GHG emissions from all sources within the state to a level 80% below the 1990 level by 2050.

- Governor Cuomo has affirmed Executive Order 24.

- A Climate Action Council has developed a Climate Action Plan to achieve that goal, taking into account economic and other considerations.

- BNL Contributed to the overarching vision (Chapter 4 and Appendix F) and participated in the Electricity T&D Group.

- 1990 level = 277 MMT CO2e; **the goal is 55 MMT CO2e**

The New York State 80 by 50 Plan Goals

- Provide a set of long-term objectives to guide State decision making.
- Set out the policies that will enable both climate change adaptation and mitigation, helping to ensure that New York State does not make decisions in the near term that will lock in a high-carbon future or increase our vulnerability to changes in climate (such as building long-lived infrastructure that is carbon intense or climate vulnerable).
- Identify core solutions and strategically allocate available funding to effectively reduce GHG emissions and stimulate economic activity, while promoting constructive responses by other states and the nation as a whole.
- Provide a foundation for New York to gain advantage in the emerging low-carbon, clean energy economy, advancing the state's economic and strategic interests in the short and long term.

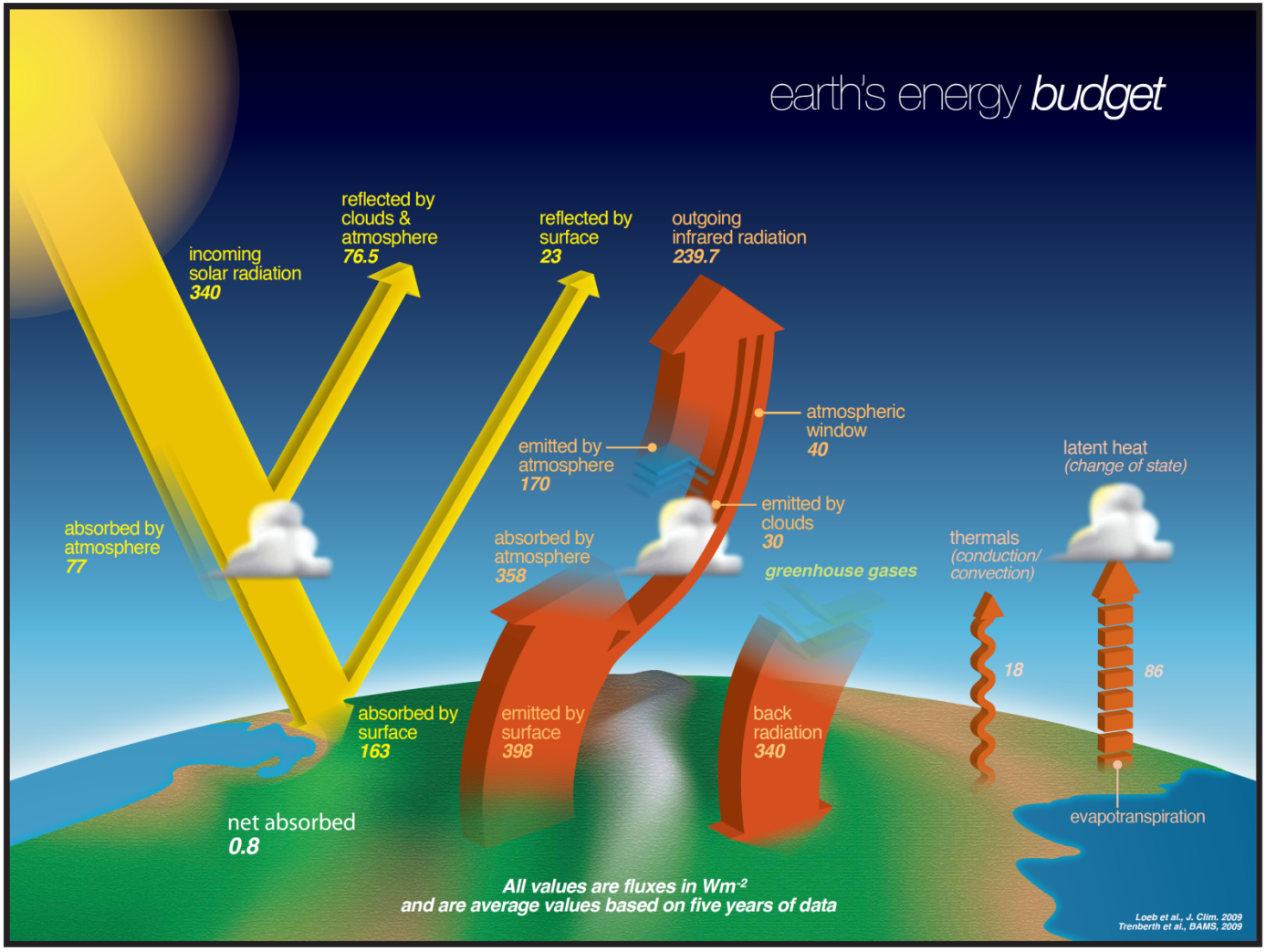
Greenhouse Gas mitigation is an active area in the states …

- 31 states have completed climate actions plans and planning is continuing in 4 others.
- Historically in the United States environmental leadership has come from the states.
- Even with a national policy, the burden of implementation will fall to the states – in particular dealing with the economic consequences – both positive and negative – will be borne at the state level.

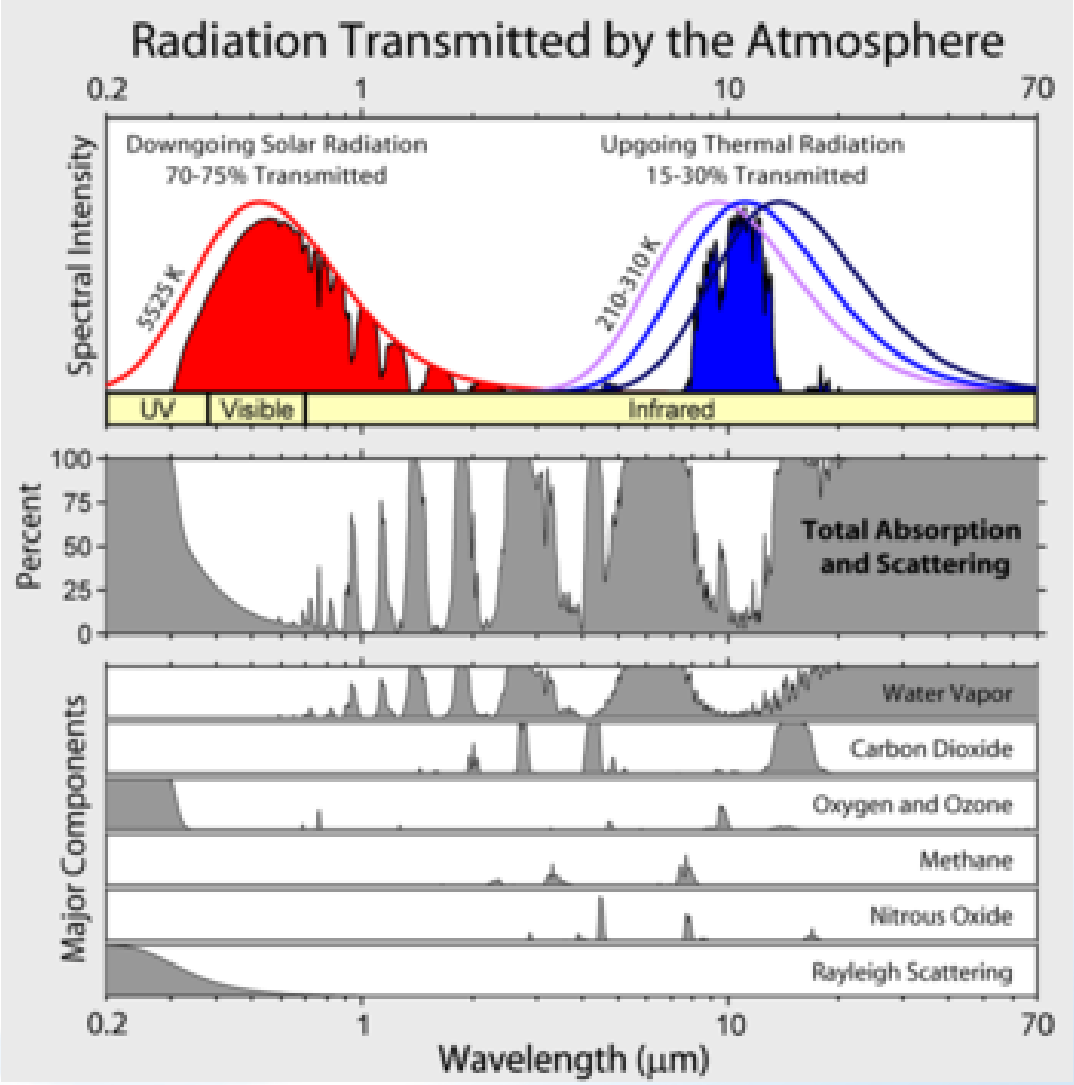
Actions have to be local and regional

- Energy demand: regional
- Economic influences – jobs, taxes … : regional
- Renewable Energy: Distinctly regional character
- CO2 storage: Local resource
- Externalities (air quality, renewable portfolio standards etc.): regional
- Off-sets like terrestrial sequestration: regional
- Limiting resources (like water) are regional
- Impacts and adaptation: distinctly regional
- Politics: always local

Earth's Energy Budget

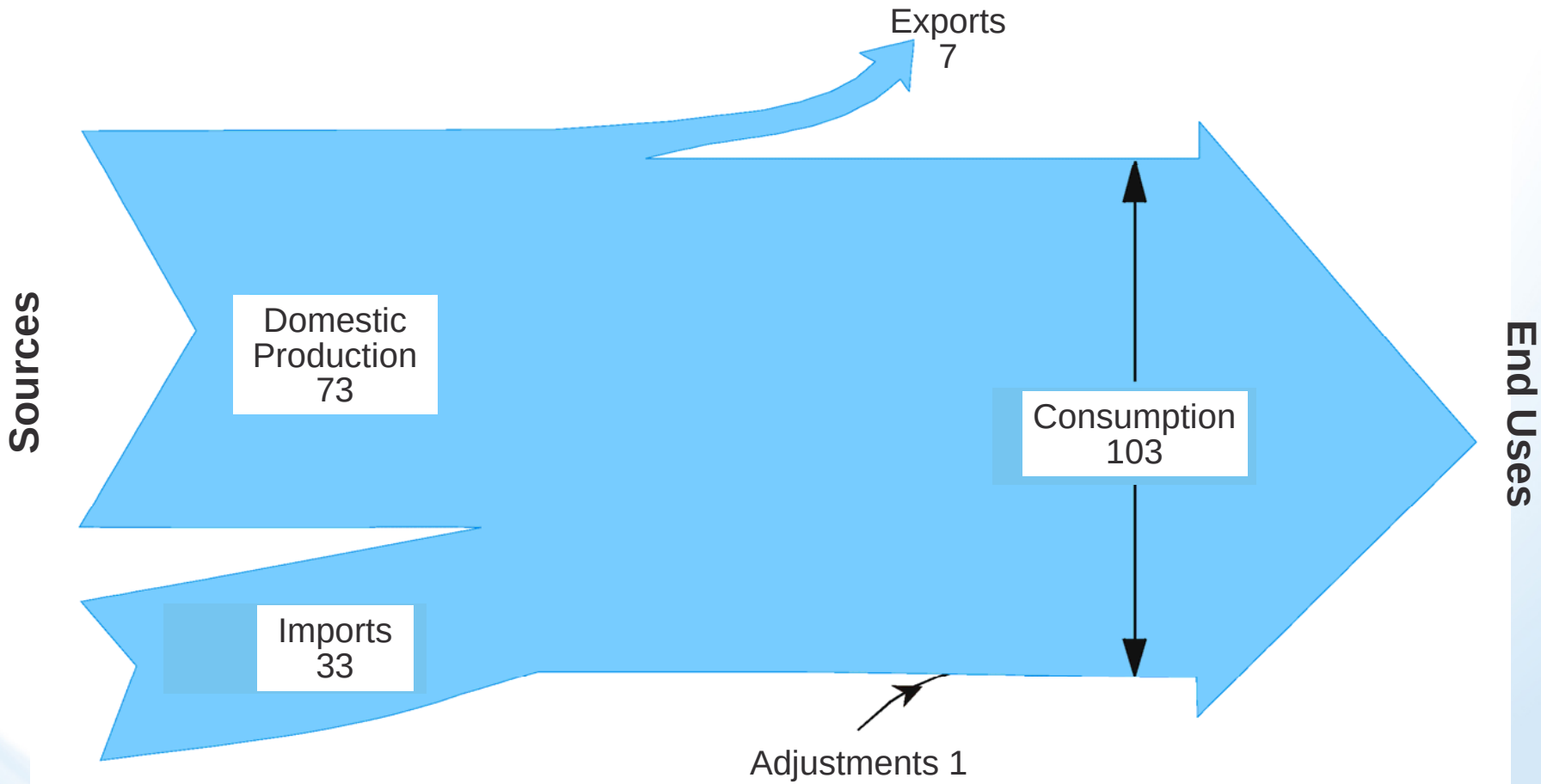


Absorption by Molecules Traps Radiation in the Atmosphere



US Energy Flows (2009)

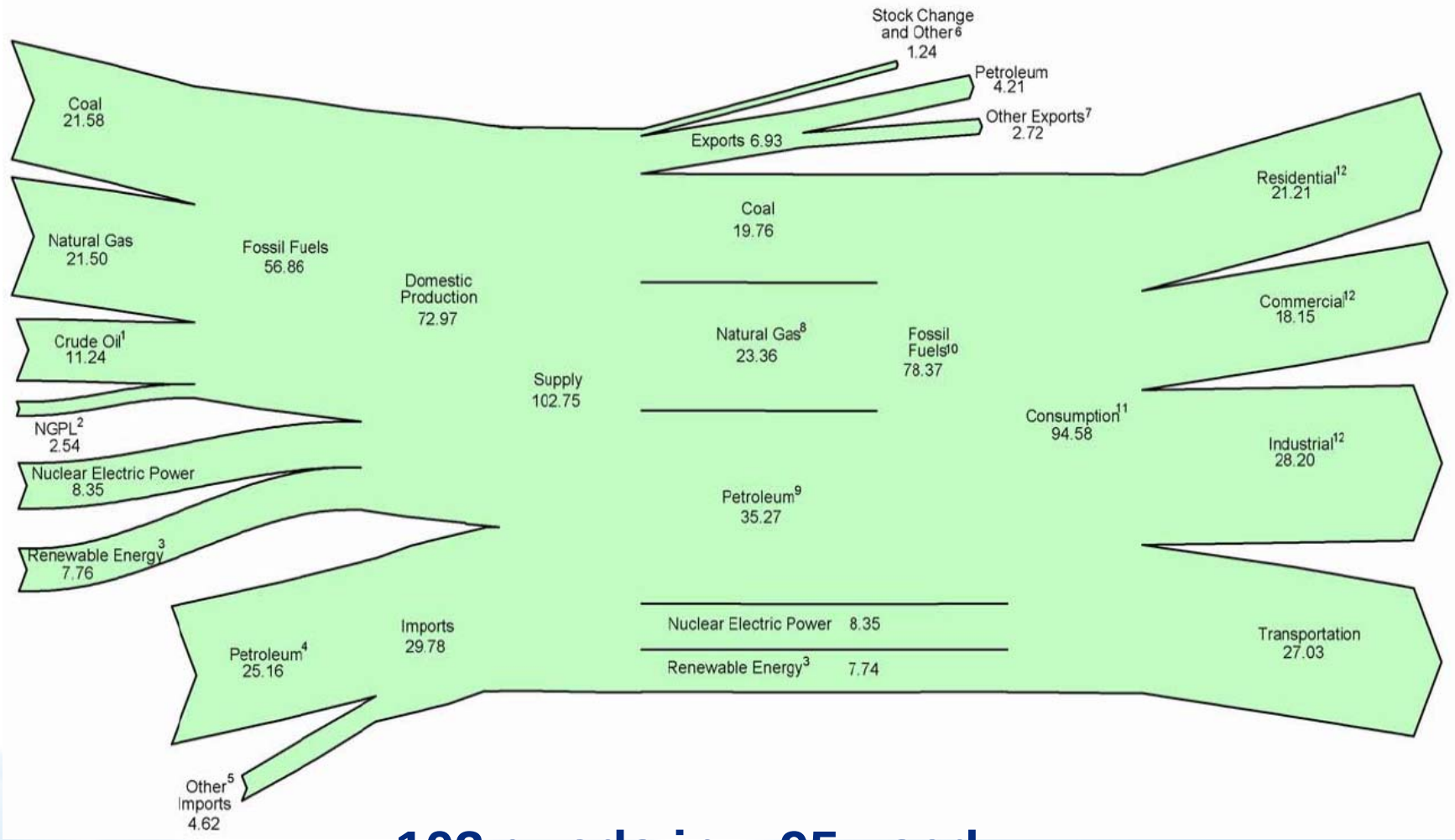
106.0 quadrillion British Thermal Units (Quads)



one hundred and six million billion BTUs

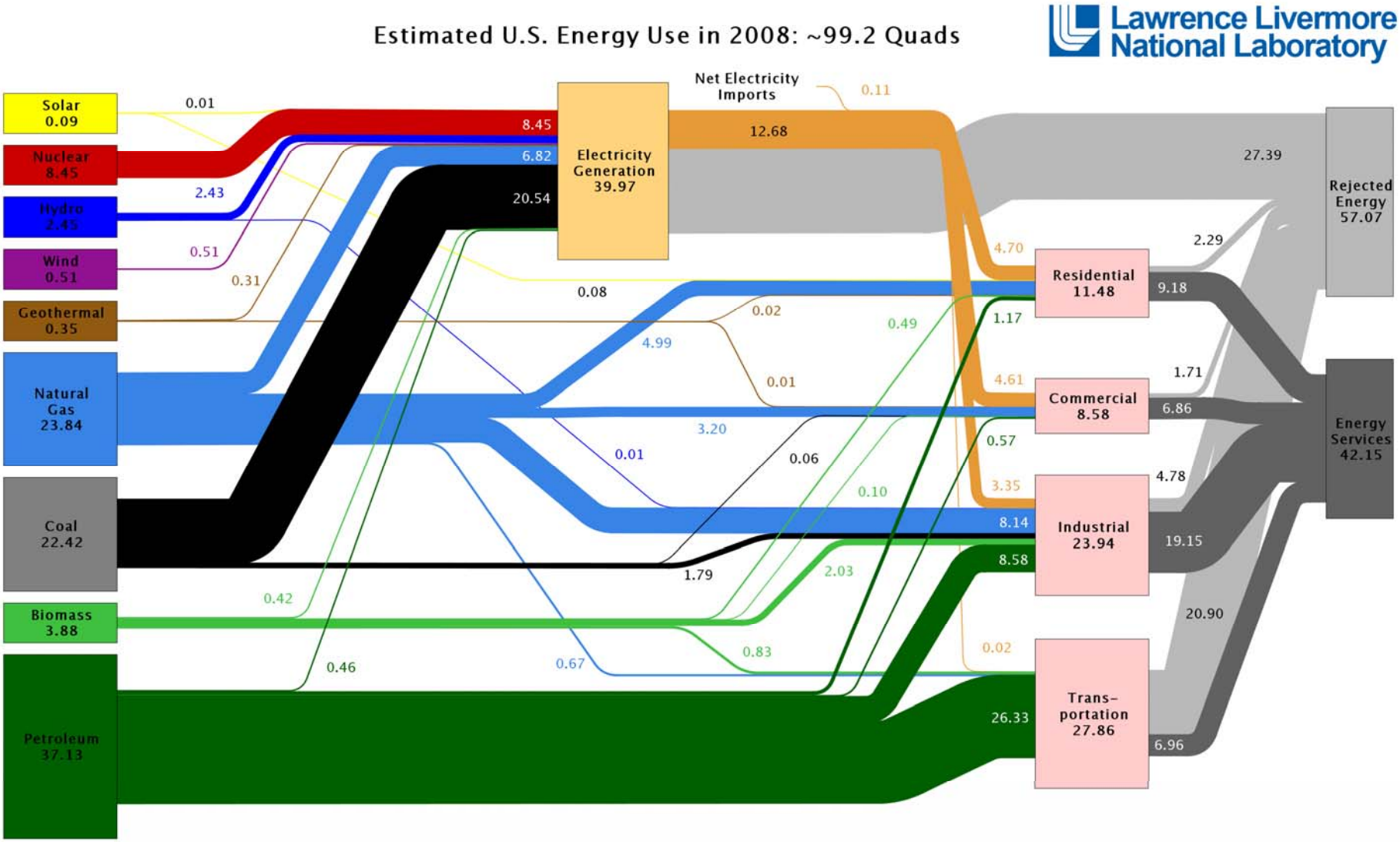
US Energy Flows – Some details

86% of primary energy is from fossil fuels, with 69% of the petroleum imported



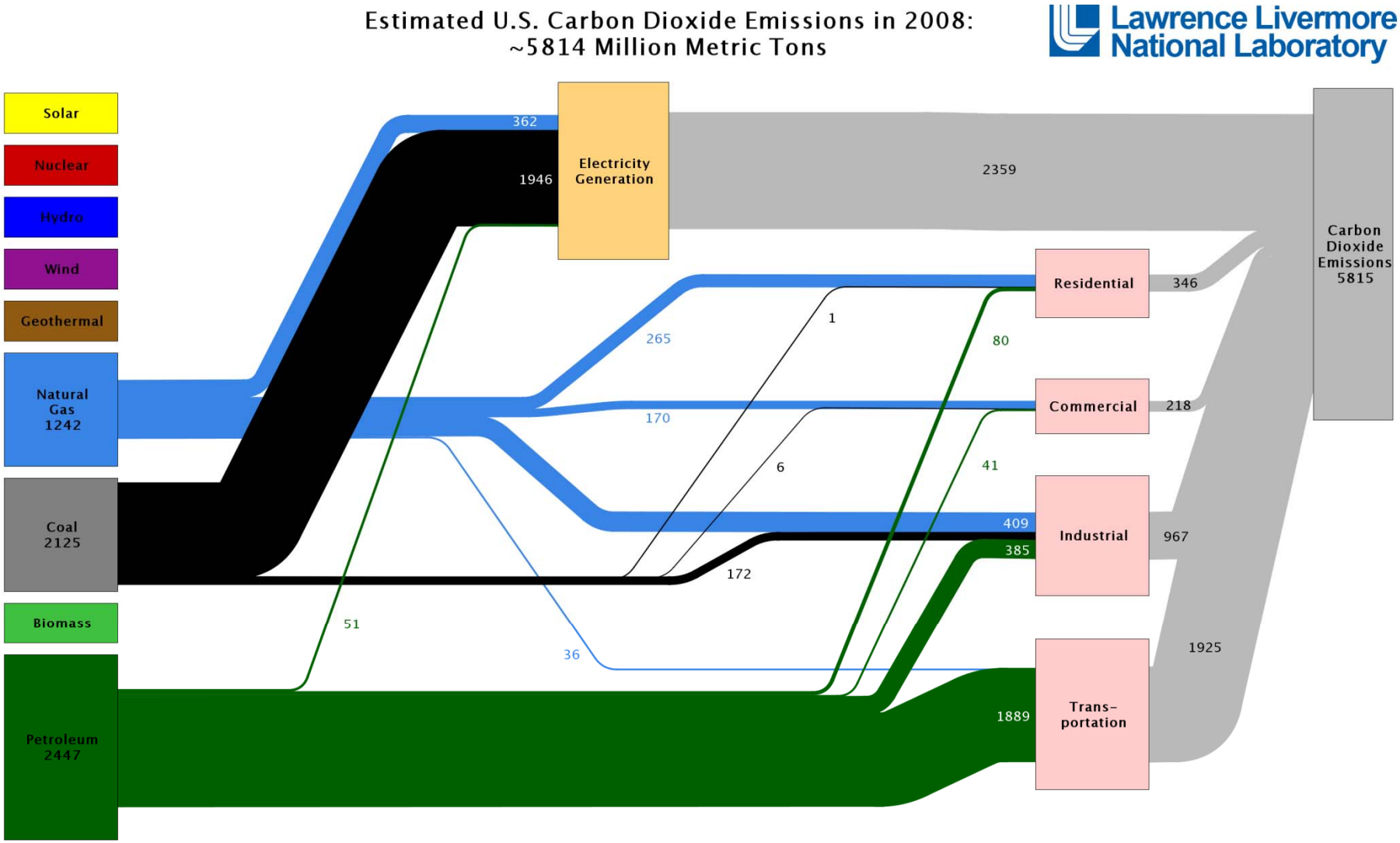
103 quads in – 95 used

US Energy Use 2008 – MORE Details



Source: LLNL 2009. Data is based on DOE/EIA-0384(2008), June 2009. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

U.S. Carbon Dioxide Emissions

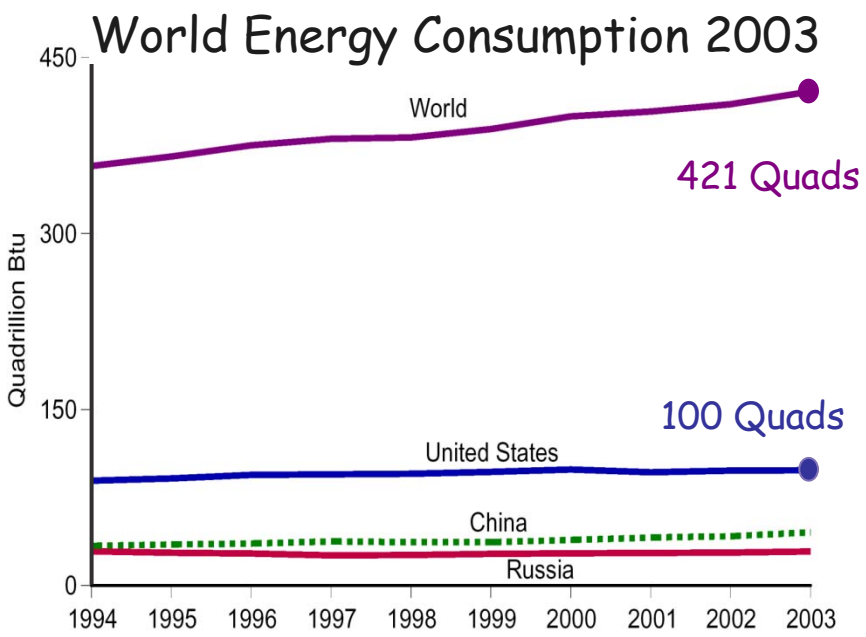


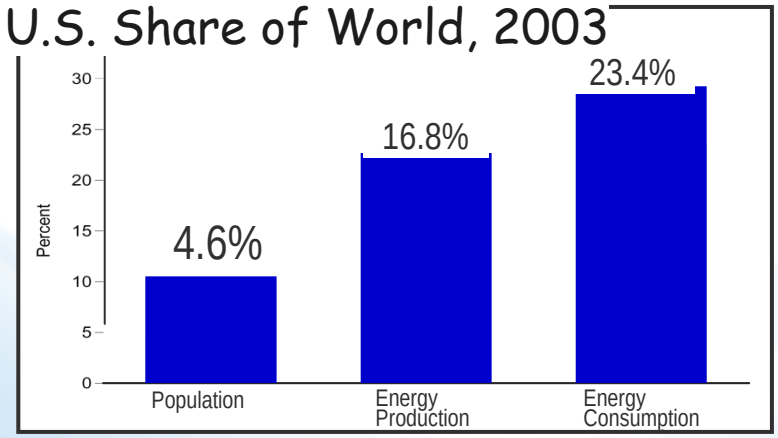
Source: LLNL 2010. Data is based on DOE/EIA-0573(2008), December 2009. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Carbon embodied in industrial and commercial products such as plastics is not shown. The flow of petroleum to electricity production includes both petroleum fuels and the plastics component of municipal solid waste. The combustion of biologically derived fuels is assumed to have zero net carbon emissions – lifecycle emissions associated with biofuels are accounted for in the Industrial and Commercial sectors. Emissions from U.S. Territories and international aviation and marine bunkers are not included. Totals may not equal sum of components due to independent rounding. LLNL-MI-411167

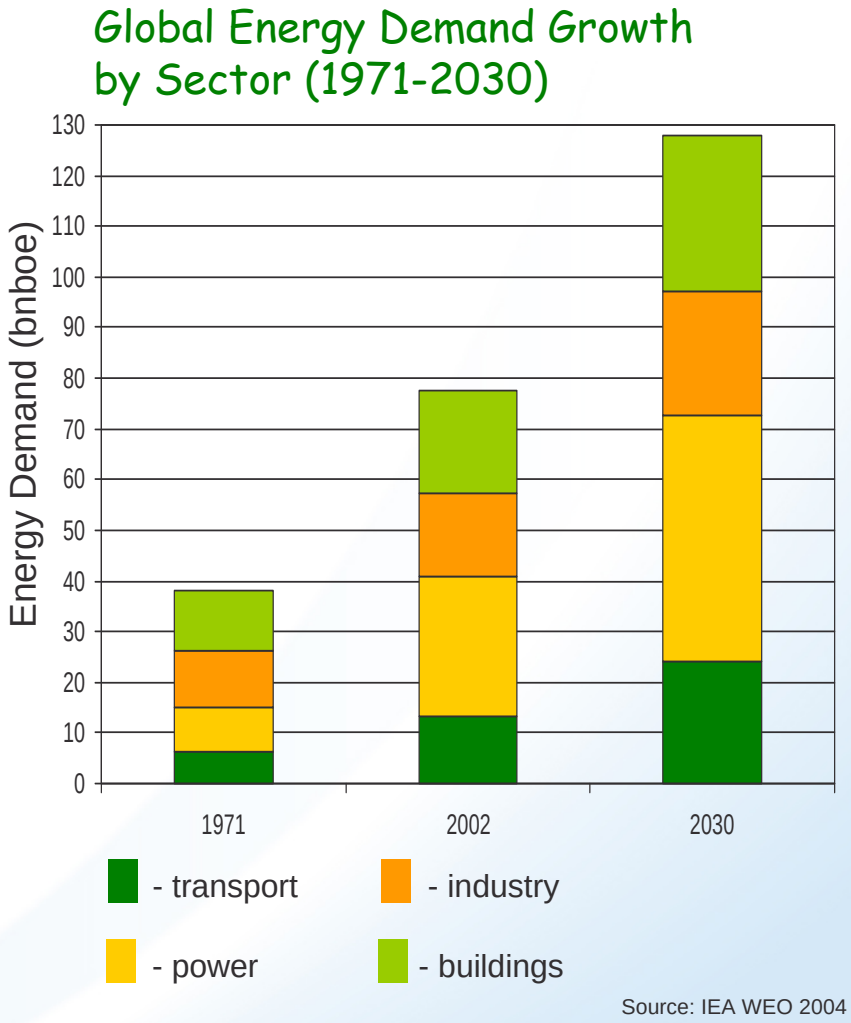
How much carbon is in a Metric Ton?

About 61 10lbs bags of charcoal

World-Wide Energy Demand Grows



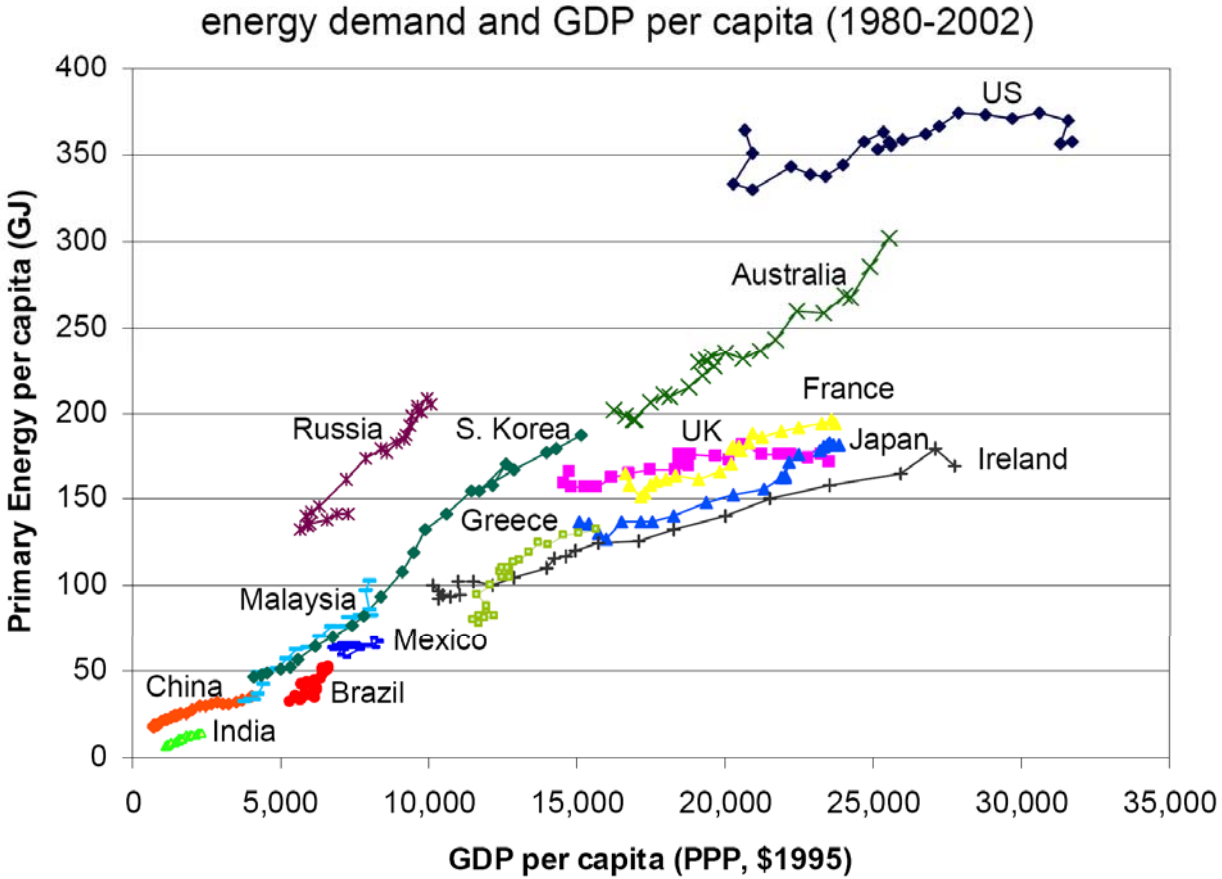




Source: IEA WEO 2004

Energy Demand Grows with Economic Development

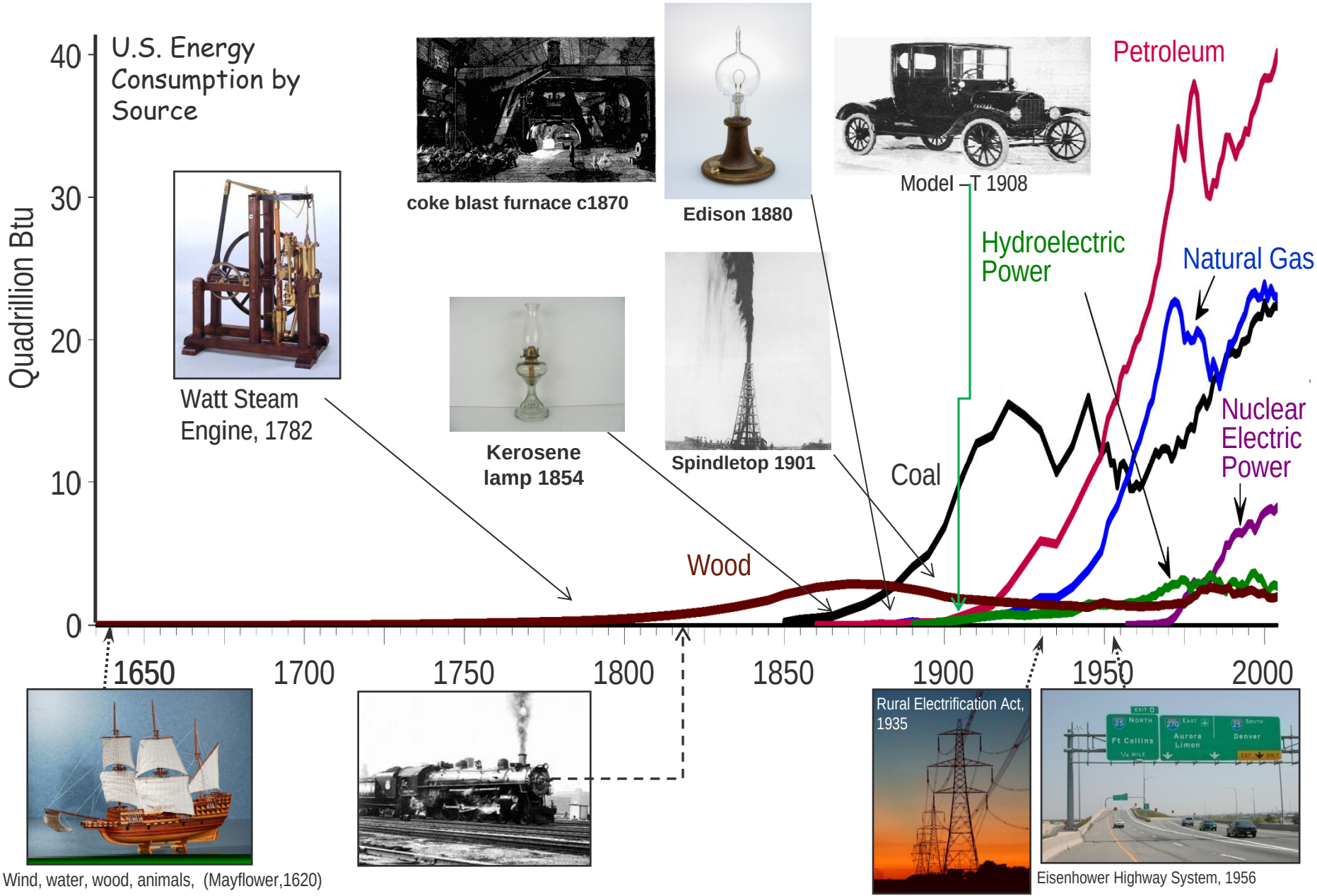
Energy demand and GDP



Source: UN and DOE EIA

Source: BP
http://www.otcnet.org/2006/presentations/alt_energy/hashmi.pdf

Technology, Energy, and Society are Inextricably Intertwined



BNL Scenario Planning: A different approach to planning for the future

- A scenario is a story that helps you think about the future – it is not a prediction or mandate

- Provides clues to the answers to the big questions:
  - Can we do this?
  - What's it take to get there?

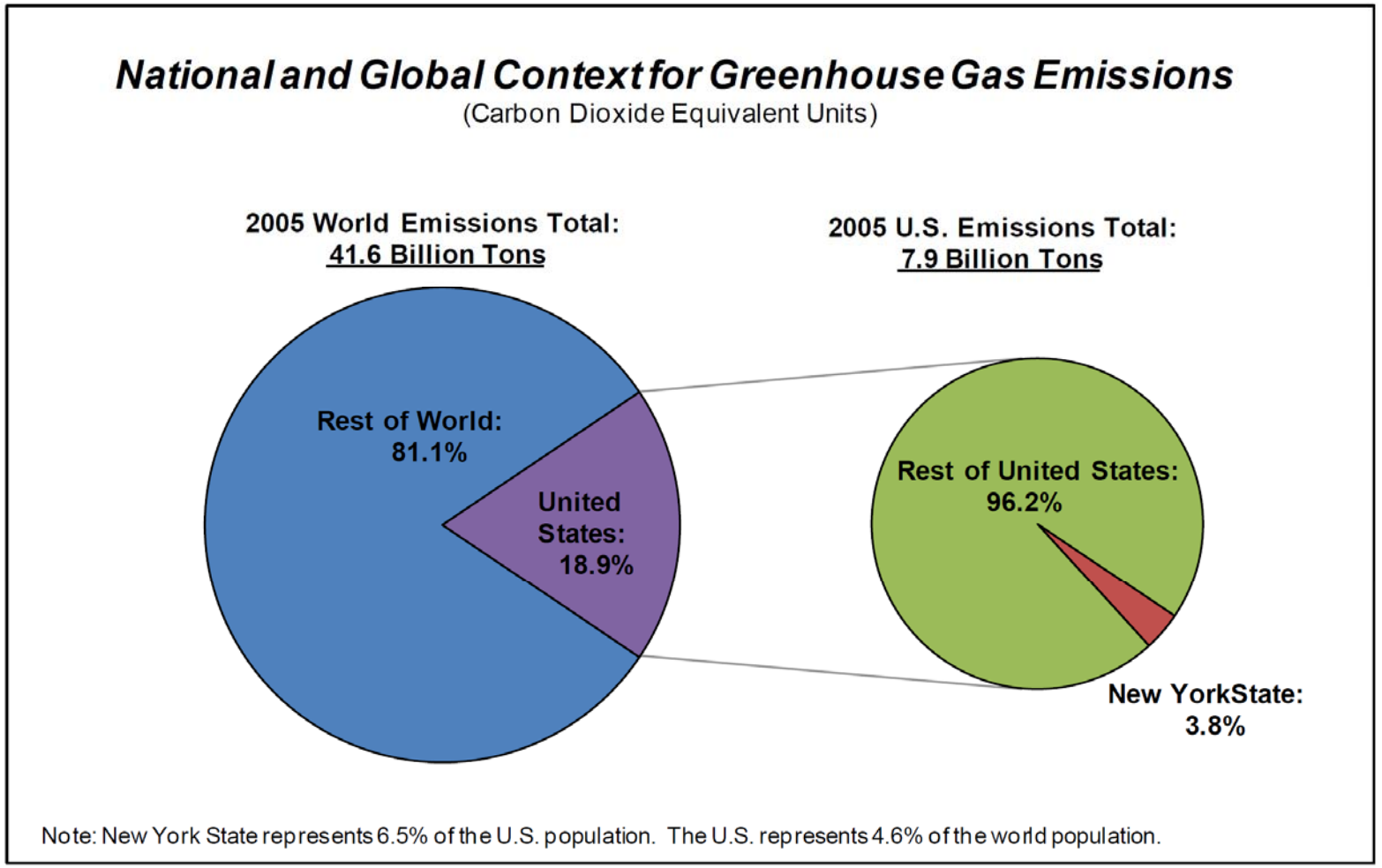
- For changes to the energy supply (and demand) system, the required changes are long term.

- Goals are set for times well beyond any credible predictions.

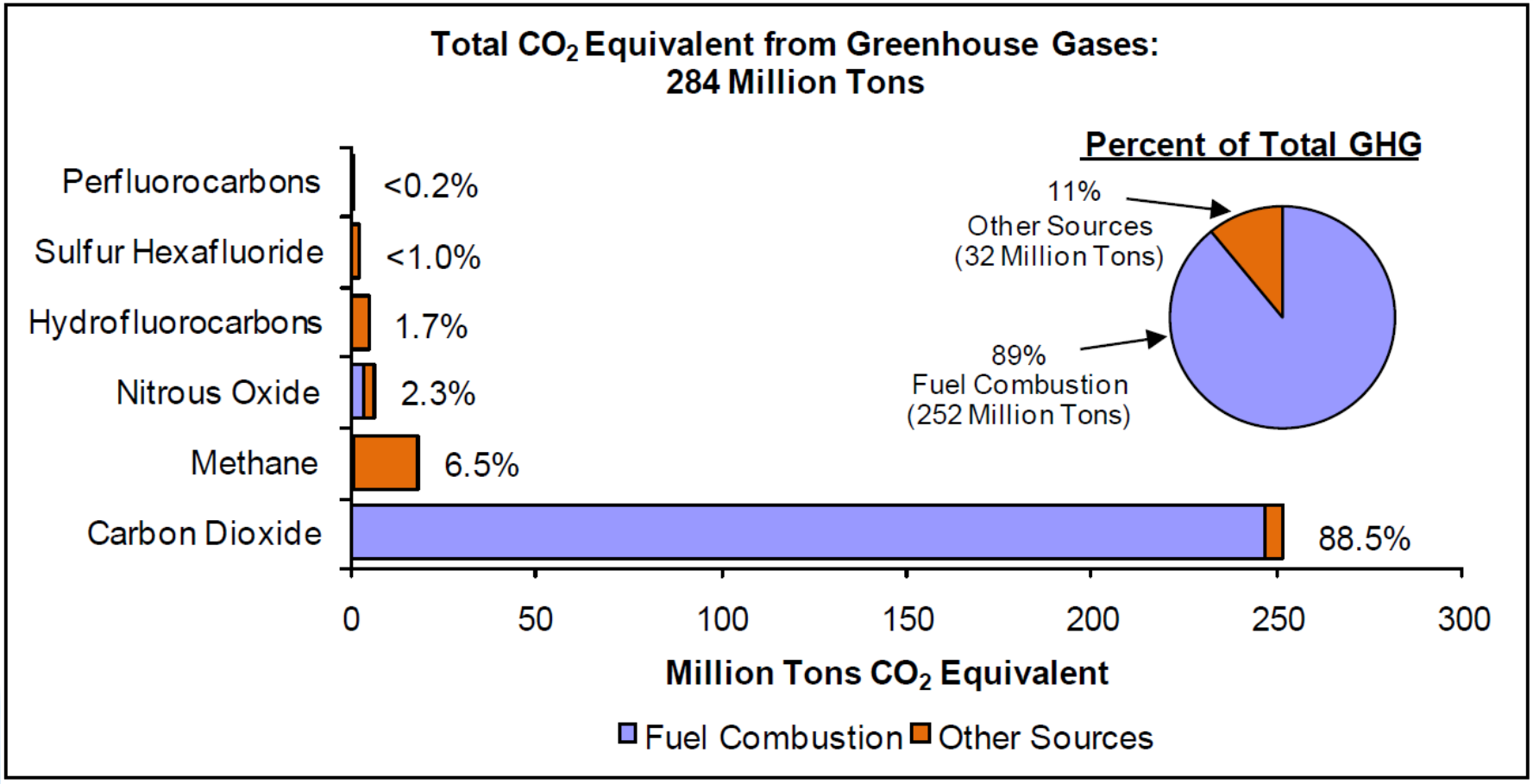
The “visioning” approach

- We project the energy and mobility needs of the State in 2050
- We recognize that economic development relies on production and transportation of goods, delivery of services, and want NYS to evolve to a “green tech’ economy
- We postulate future distributions of CO2 among the key economic sectors
- We identify technology strategies that can meet the proposed emissions allocation (scenarios)
- This is a back-casting scenario which supports a “future-by-choice” approach as guide to policy.

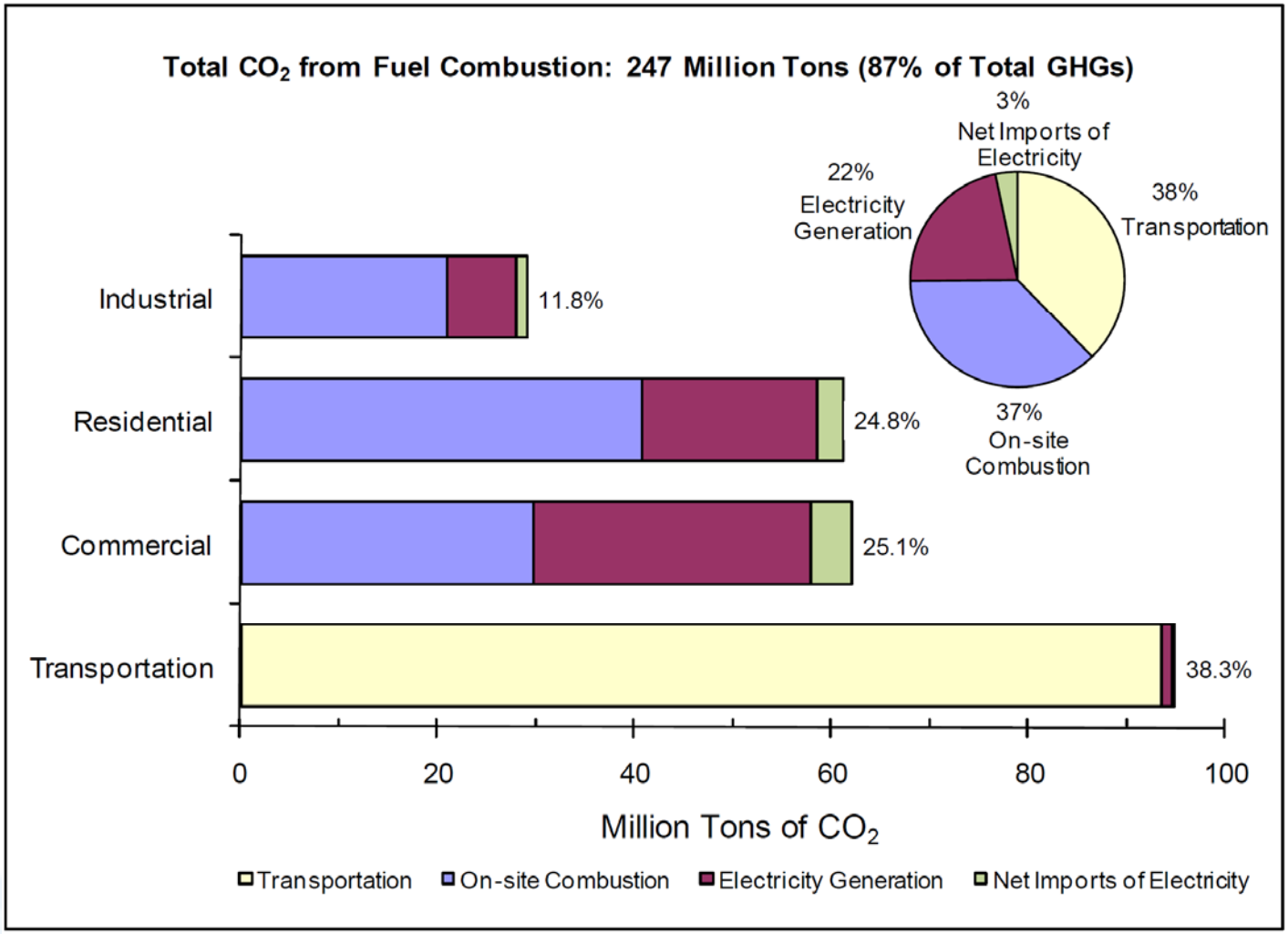
NYS's Carbon Footprint



Most of NYS GHG Emissions is from CO2



GHG Emissions Largely Come from Combustion



What is the NYS starting point?

Sector	CO_2 Emissions (MMT CO_2)		Notes
	Current (2007)	BAU (2050)	
Residential	37.6	45.0	**567×10^6 MBTU Gas** **154×10^6 MBTU Liquid**
Commercial	27.2	39.1	**431×10^6 MBTU Gas** **156×10^6 MBTU Liquid**
Industrial	19.0	24.1	**79×10^6 MBTU Gas** **21×10^6 MBTU Liquid** **80×10^6 MBTU Coal/Coke**
Transportation	88.3	126	14.8×10^9 VMT HDV 209.2×10^9 VMT LDV
Electricity	49.2	83.3	**271,000 GWh** **R-88.2; C-140;** **I-36.3; T-6.2**
Other	28.8	43.0	**SF6; NG leaks;** **MSW; HFC**
Total	250.2	360.5	

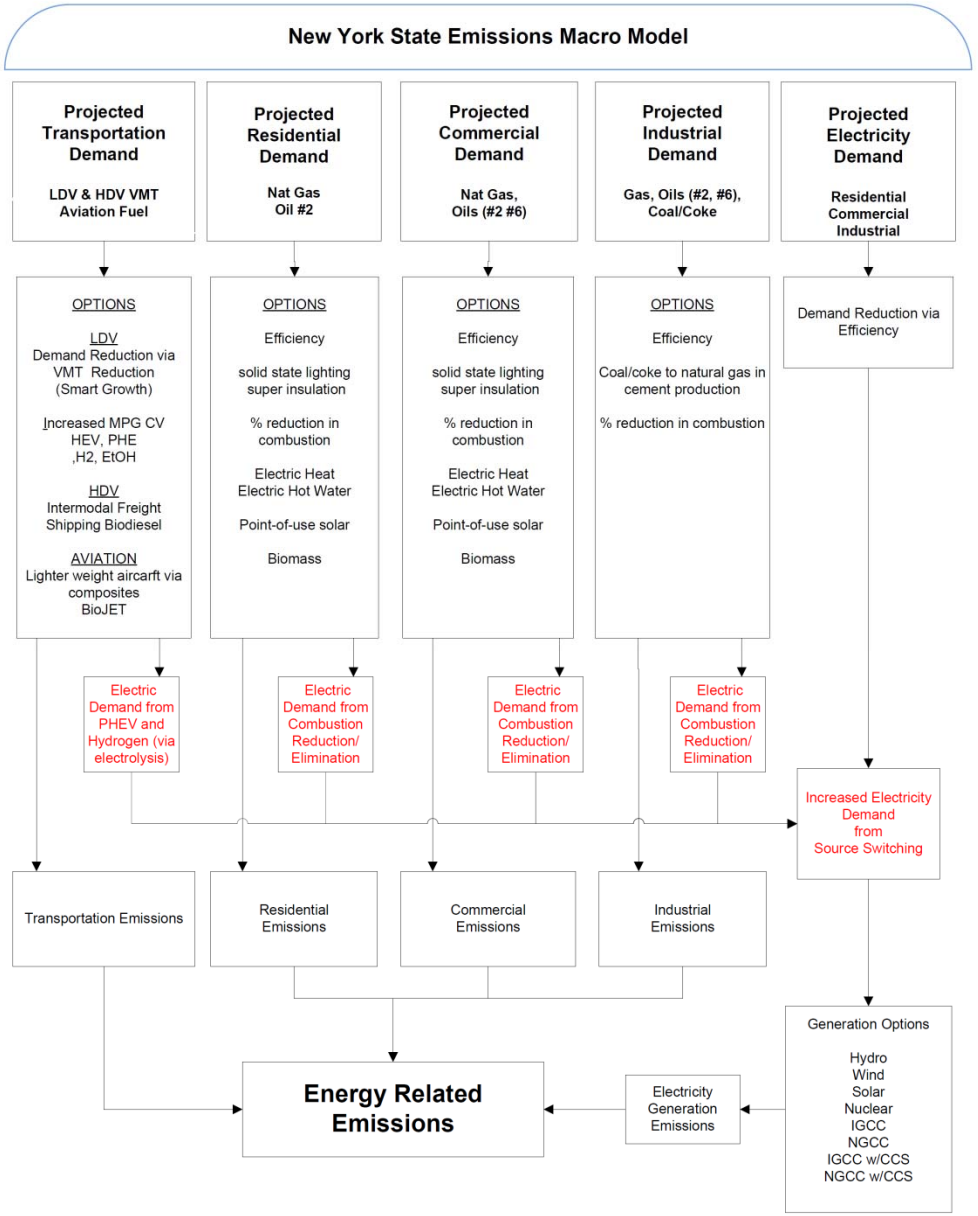
Note: 1990 emissions = 277 MMT CO_2e
The 80 goal 55.4 MMT CO_2e

Three scenarios were developed to illustrate possible 2050 outcomes

- Yellow: This scenario could be called a “conventional wisdom” scenario – efficiency and non-biomass renewables are exploited “completely”. It gets us most of the way to the 2050 goal. It highlights the importance of the transport sector in meeting the goal.

- Deep Blue: This scenario approached transport using hydrogen as an energy carrier, drives the building sectors to complete electrification, and increases the electrification of the industrial sector.

- Ultraviolet: Essentially the same scenario as Deep Blue except that the energy carrier of choice is electricity rather than hydrogen.



Current Energy Sources

Transportation
HDV – Freight, Farm Equipment Diesel/Gas
LDV – Cars, Pick-up Trucks Gas/Diesel
Aviation – Kerosene

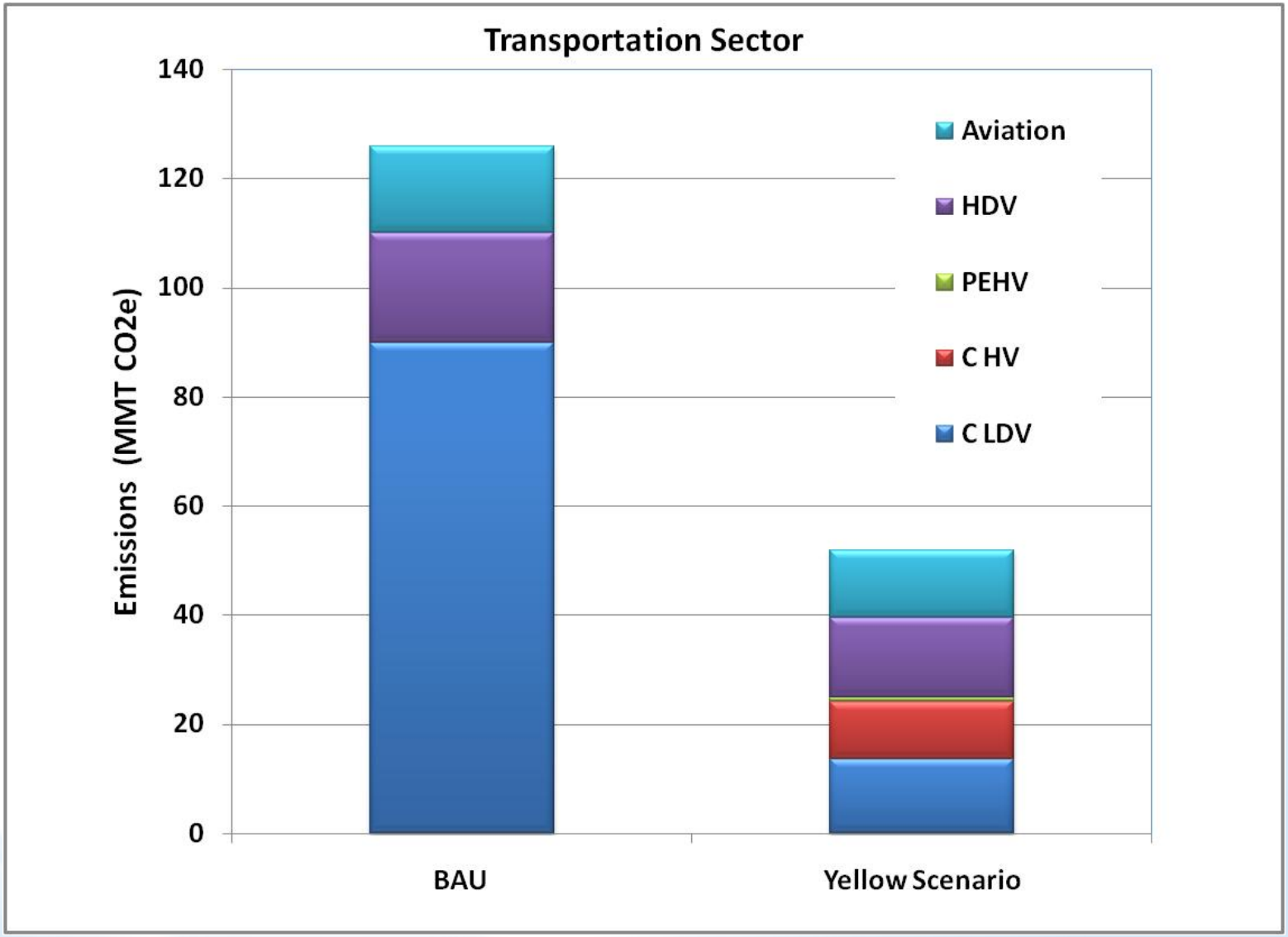
Residential
Electricity, NG, Oil

Commercial
Electricity, NG, Oil

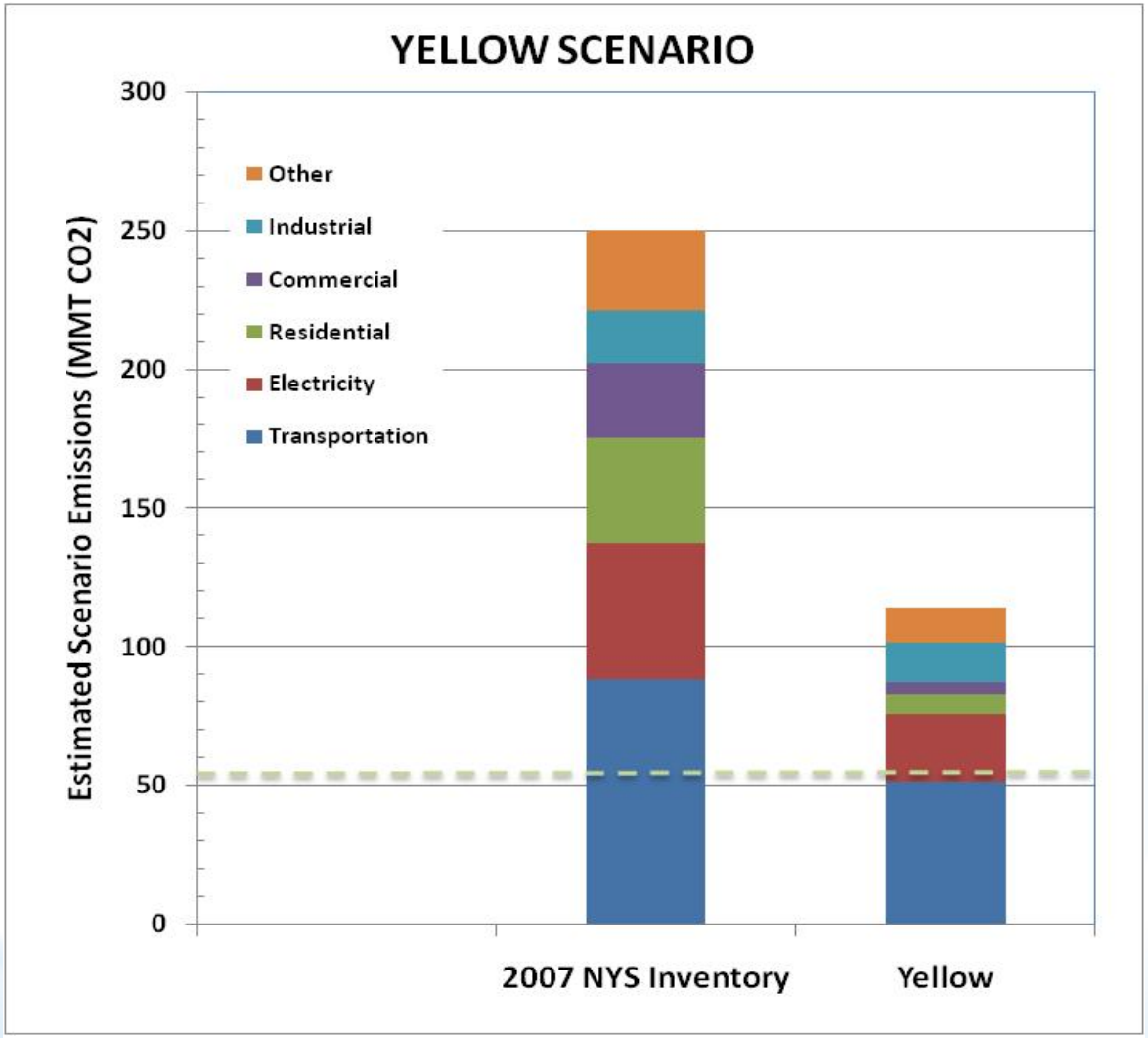
Industrial
Electricity, NG, Residual Oils, Coal, Coke

Electricity
NG. Coal, Petroleum (oil/diesel)
Hydro, Wind
Nuclear

Yellow Scenario: Transportation Sector



Yellow Scenario: "Conventional Wisdom"
60% Reductions Below 1990 Level: Not Enough



408, 000 GWh INCREASE in Electricity Demand
~30 NEW Power Plants, All Low or No Carbon

Residential
20% Efficiency
80% NG to electricity
70% Liquids to electricity
10% of electricity demand increase met through local solar

Commercial
30% Efficiency
20% Liquid & NG efficiency
80% of balance to electricity
10% of electricity demand increase met through local solar

Industrial
NG – 49% efficiency
50% to electricity
Liquids - 20% efficiency
Balance of energy needs to the grid
Burning Solids – all to NG

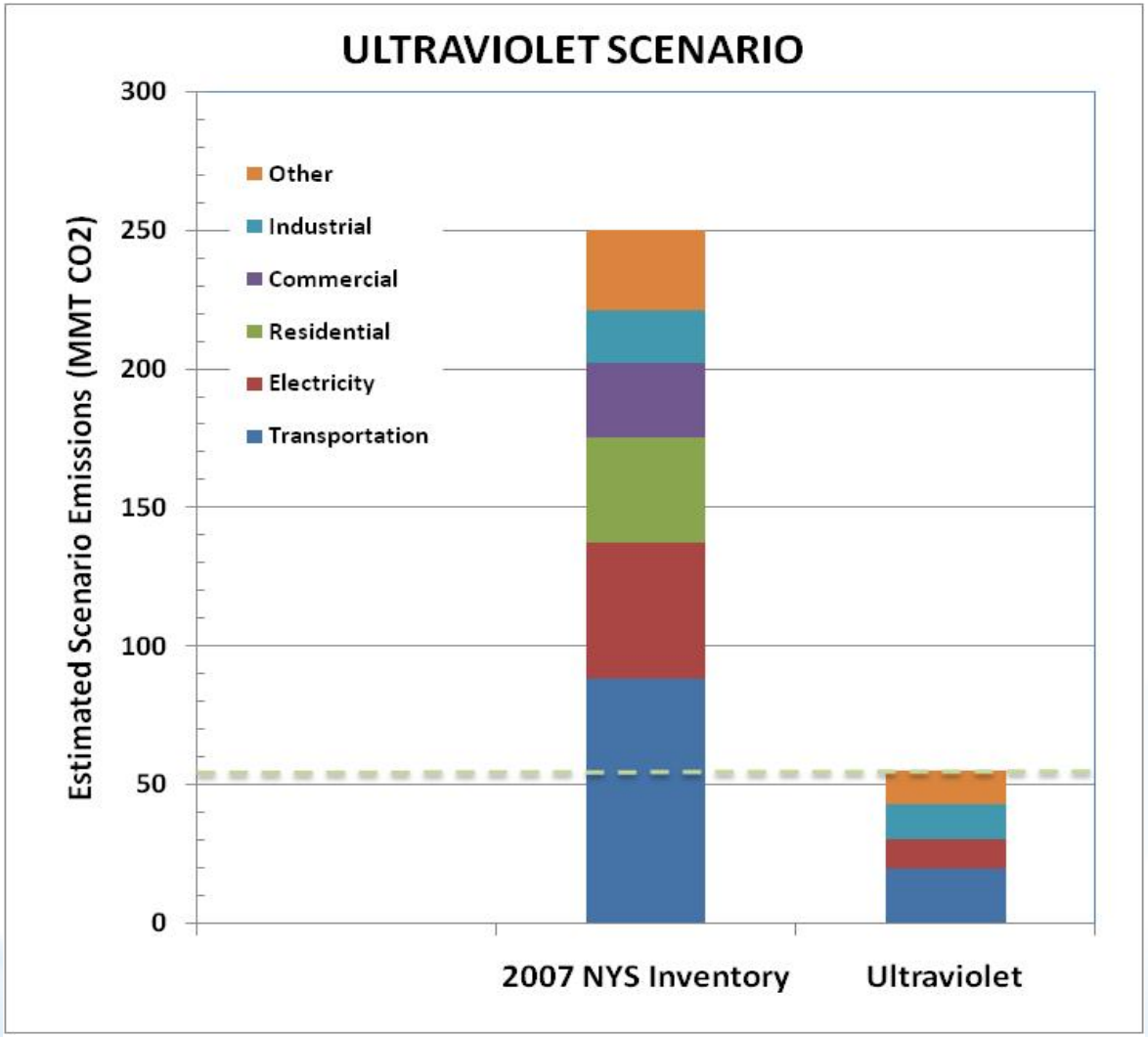
Electricity
MAX Solar, Wind, Hydro resources
No new nuclear – no loss, either
IGCC/NGCC with Carbon Capture @ 95%

Transportation
HDV – 50% to intermodal; 6.9 mpg for balance
LDV – 10% conservation
30% CV – 37mpg
30% HEV – 50 mpg
40% PHEV – 95% electric
Aviation – 30% efficiency in 90% of fleet

Yellow Scenario – bottom line

- Does not meet goal
- Eliminates all current fossil combustion for electricity
  - All power plants switch to combined cycle (NG or Coal) w/CCS
- Does not use biofuels/biomass or increase nuclear
- Calls for massive deployment of wind and solar
- Requires significant new electricity generation
- Doubles the demand on the grid (reliability? T&D?)

Ultraviolet Scenario: Meeting the Challenge



408, 000 GWh INCREASE in Electricity Demand
~30 NEW Power Plants, All Carbon Free

Residential
40% efficiency gains;
Eliminate NG and #2 Oil
40% w/local solar; balance to grid
How much bio-derived fuel could be delivered?

Commercial
30% NG efficiency & 20% Liquid efficiency
80% of balance to electricity
30% of electricity demand increase met through local solar

Industrial
Eliminate Coke/Coal Burning – Switch to NG
Eliminate Oil (#2, #6), current NG: Switch to Electricity

Electricity
MAX Solar, Wind, Hydro
Nuclear existing + 15 NEW
Balance NGCC with Carbon Capture @ 99%

Transportation
HDV – 50% to intermodal; 6.9 mpg for balance
LDV – 10% conservation of VMT
100% PHEV – 95% electric; biofuels for balance
Aviation – 30% efficiency; 50% to biofuels;

Reflecting on the results

Sector	Ultraviolet	Deep Blue	Yellow	Baseline	Notes
Residential	0	0	7.5	37.6/45.0	
Commercial	0	0	4.5	27.2/39.1	
Industrial	12.7	12.7	14.1	19.0/24.1	
Transport	20.1	20.1	51	88.3/126	
Electricity	10	13	24	49.2/83.3	
Other	12.3	12.3	12.3	28.8/43.0	
Total	55.1	58.1	113.4	250.2/360.5	Goal – 55.4

- Transport and Industrial emissions get the largest share
- Non-energy emissions (the “Other”) becomes imporant
- CCS and nuclear are key to reductions in the electric sector
- While presented as zero existing structures will be a major challenge
- We have assumed biofuels are carbon neutral

So, what's it take?

- **Energy efficiency is an essential, but not sufficient, strategy that can be aggressively pursued today.**

- **A broad shift from reliance on burning fossil fuels to electricity generated from low- or no-carbon sources, or widespread use of carbon capture and sequestration, will be needed.**

- **Transportation and buildings (residential and commercial) will have to move away from reliance on combustion of fossil fuels to alternate sources with significantly lower carbon or no carbon emissions.**

- **Development and redevelopment based on smart growth principles, as well as the building design practices, building technologies, and construction methods can significantly reduce the energy demand for buildings, as well as transportation.**

- **Incremental, short-term planning cannot achieve the goal. Near-term decisions – both those taken and not taken – can preclude longer-term options, such as infrastructure projects requiring long lead times. Key climate strategies *must* reflect this reality.**

Looking ahead …

- The baseline scenario is for a very robust economy with a growing industrial base – not the contraction seen since 1990 - and the move to electrification, is consistent with a 21st Century economy (green-, info-, bio- and nano- tech).

- There are clearly big decisions and unknowns in achieving this goal – many probably need to made sooner rather than later – infrastructure, fuel sources.
  - The role of nuclear and CCS
  - The reliability and capacity of the grid
  - The role for biomass
  - ……..

- All renewable energy is from within the state resources, adding a significant sector to the state economy.
  - How the state cooperates with its neighbors will be important (generation, grid) is important.
  - Achievement of renewable goals is a critical success factor for the strategy.

- NYS is not alone; all States will need large amounts of renewable energy: Energy Innovation, GREEN TECH will undoubtedly lead to job creation – will we trade our dependence on foreign oil to a dependence on foreign renewable energy?

Acknowledgements:
NYSERDA, NY DEC
Numerous others across NYS

Thank you!

http://nyclimatechange.us/