

The Next 100 Years of Global Energy: Part I Energy Security and Energy Poverty*

Scott W. Tinker¹

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¹Director, Bureau of Economic Geology, The University of Texas at Austin (scott.tinker@beg.utexas.edu)

Preface

Forum Topics

- | | |
|---|-----------------|
| • Energy Security and Energy Poverty | Scott W. Tinker |
| • Global Population, Energy Demand and Future Technology | E. Koonin |
| • Global Petroleum Resources and Transportation Fuel Options | Cindy Yeilding |
| • Global Power Fuel Mix and Carbon Transition | Mark Snell |
| • Energy Density, Fake and True News about Energy and Environment | Jesse Ausubel |
| • The Grand Energy Challenge: Energy Diversity and Economic Realities | Kenneth Medlock |

Outline

Energy Security

Energy Poverty

Energy Reality

Summary

1. Oil, natural gas, and coal are secure sources of energy and will remain vital well into the 21st Century.
2. Secure energy is required to lift humanity from poverty.
3. Secure energy—affordable, available, reliable, sustainable—underpins economies and is required for investment in the environment.

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AAPG ACE

The Next 100 Years of Global Energy

April, 2017

Energy Security and Energy Poverty

Scott W. Tinker

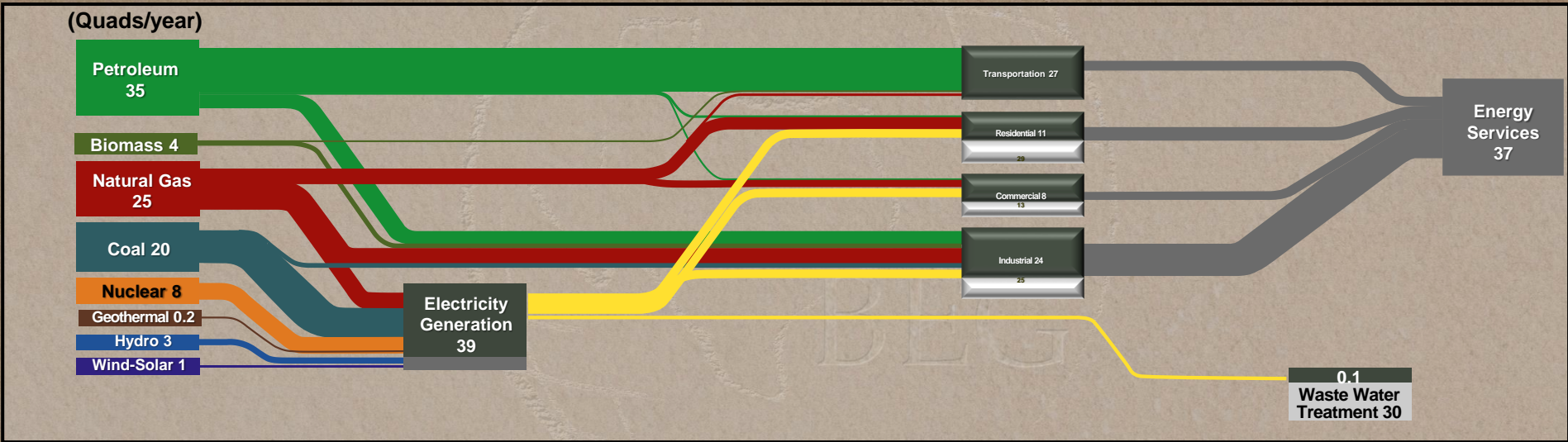
Bureau of Economic Geology



Outline

- ❖ **Energy Security**
- ❖ **Energy Poverty**
- ❖ **Energy Reality**

U.S. Primary Energy Demand



The Next 100 Years of Energy

Population, Energy Demand and Future Technology

Steven E. Koonin

Petroleum Resources and Transportation Fuel Options

Cindy Yeilding

Power Fuel Mix and Carbon Transition

Mark Snell

Energy Density, Fake & True News about Energy and Environment

Jesse Ausubel

Energy Challenge: Diversity and Economic Realities

Kenneth Medlock

The Next 100 Years of Energy

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Energy Challenge: Diversity and Economic Realities

Energy Security

Affordable

Cost: per unit of energy

Price Volatility: stable or fluctuating

Infrastructure: cost to build the plant

Available

Access: substantial resources

Reliable

Intermittent: source consistent or variable

Safe: natural/human causes

Sustainable

Clean: air and atmospheric emissions

Dense: energy per area, weight and volume

Dry: fresh water use/risk

Energy Security Challenges

Transportation

I. Oil

- Available, affordable, reliable
- Land use, water, emissions

II. Natural Gas (CNG, LPG, LNG, GTL)

- Available, affordable, reliable
- Dirtier than certain electric fuels

III. Electricity

- Benefits depend on fuel source
- Mining, expensive, chemicals, range

IV. Biofuels

- Scale, land use, water, cost

V. Hydrogen



Energy Security Challenges

Electricity Generation

I. Coal

- **Available, affordable, reliable**
- Mining, water, air emissions, CO₂

II. Natural Gas

- **Available, affordable, reliable**
- Water, methane and CO₂

III. Nuclear

- **Available, affordable, reliable, sustainable**
- Radioactive waste, safety



Energy Security Challenges

Electricity Generation

IV. Hydro

- **Affordable**
- Water and topography

V. Geothermal

- **Reliable, sustainable**
- Energy density

VI. Wind

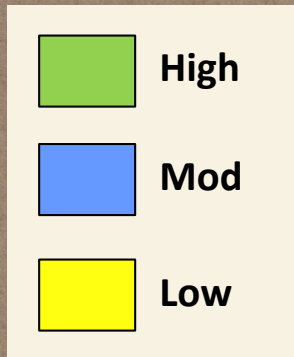
- **Affordable, sustainable**
- Intermittent, land and visual, transmission

VII. Solar

- **Available, sustainable**
- Expensive, intermittent, inefficient



Energy Security



	Available	Affordable	Reliable	Sustainable
Solar	High	Low	Mod	High
Hydro	Mod	High	Mod	Mod
Wind	Mod	High	Mod	High
Geothermal	Mod	Mod	High	High
Nuclear				
Natural Gas	Baseload Electricity			
Coal				
Biofuels	Mod	Mod	Mod	Low

Energy Security



	Available	Affordable	Reliable	Sustainable
Solar	High	Low	Mod	High
Hydro	Mod	High	Mod	Mod
Wind	Mod	High	Mod	High
Geothermal	Mod	High	High	High
Nuclear	High	Mod	High	High
Natural Gas	High	High	High	Mod
Coal	High	High	High	Low
Biofuels	Mod	Mod	Mod	Low

No Form of Energy is Perfectly Secure

Outline

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- ❖ Energy Reality

Electricity and Poverty

Poverty and electricity access in selected developing countries, circles sized by total population

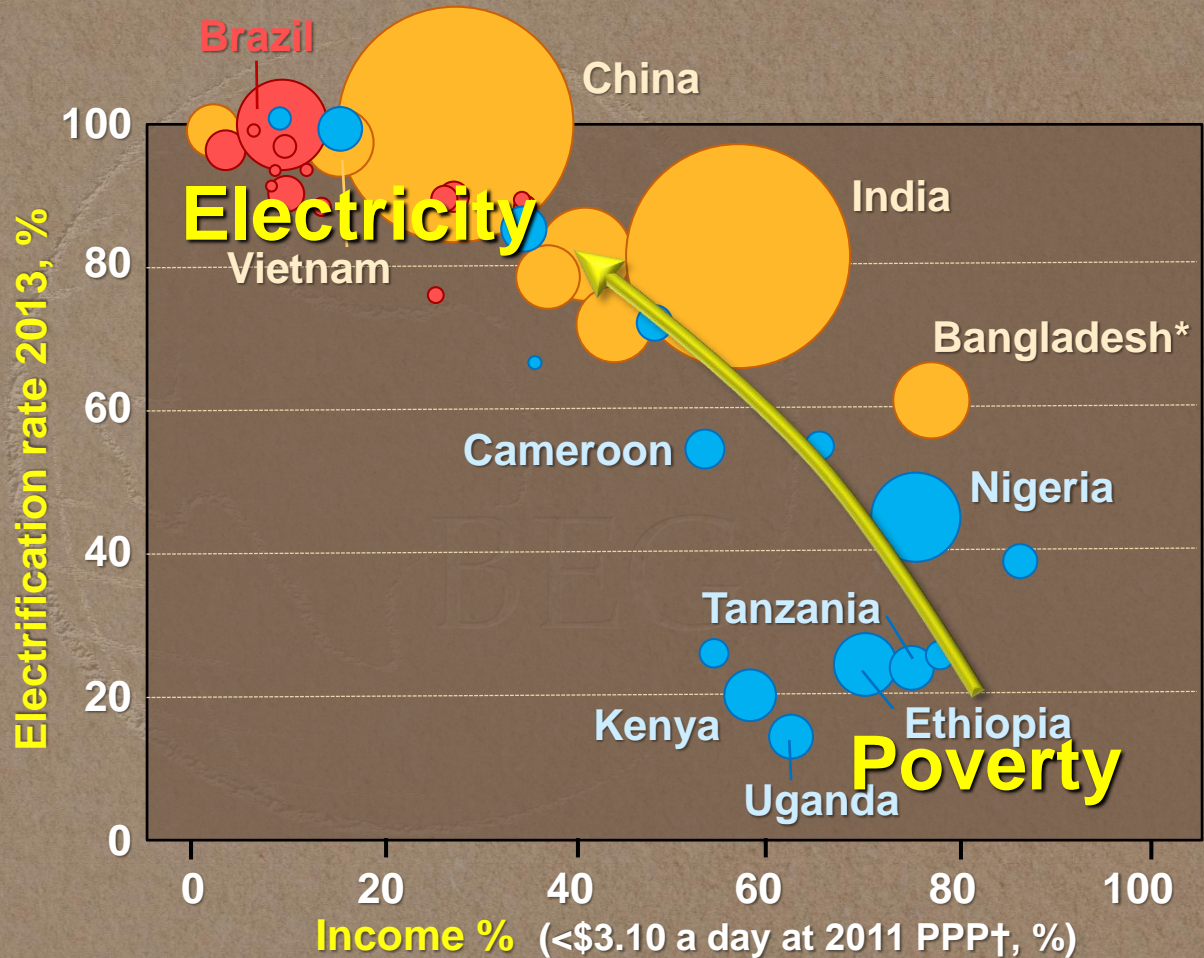
● Africa

● Asia

● Latin America

* Bangladesh uses 2005 PPP and \$2 a day poverty line

† Purchasing power parity







Photos Lynch, Ecuador, 2017

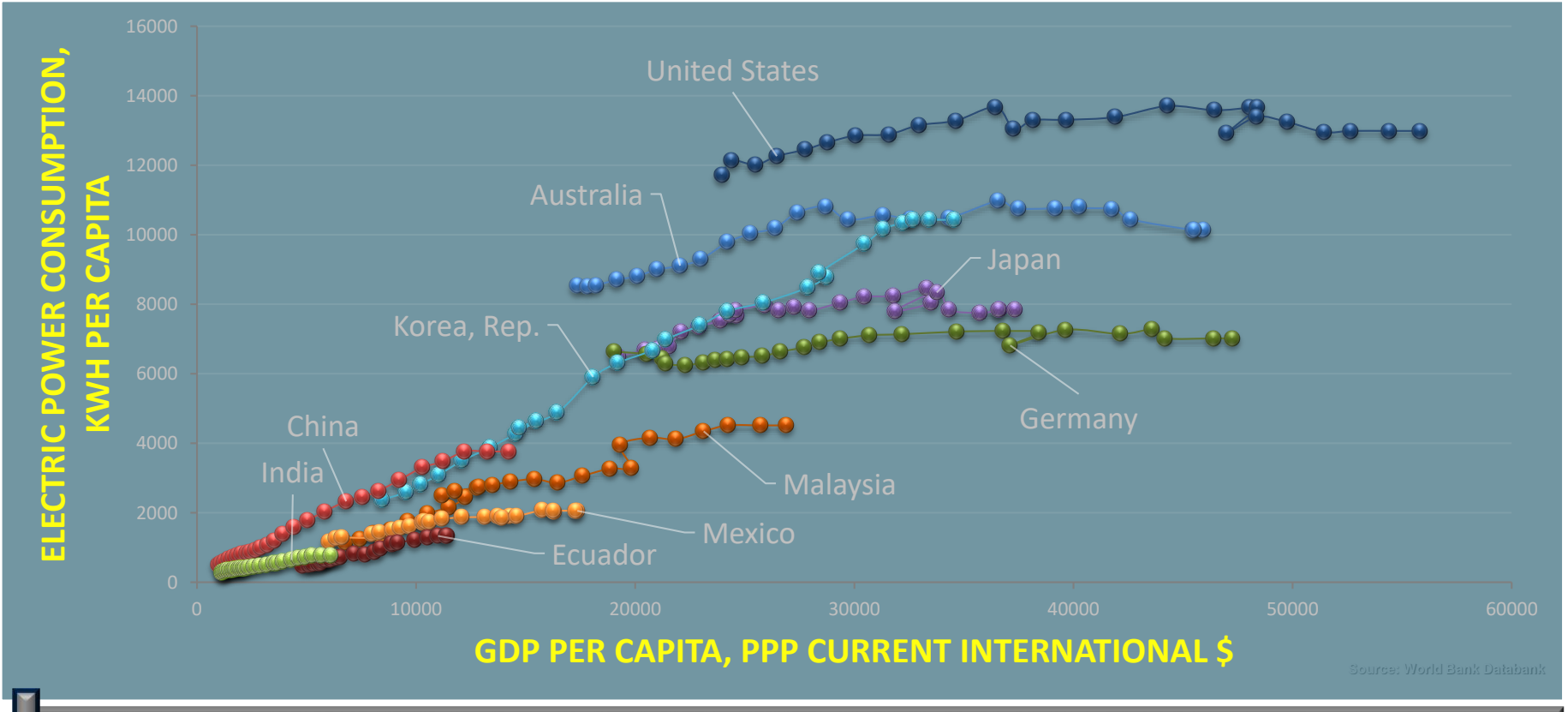


Electricity does not end poverty.

Poverty cannot be ended without electricity.

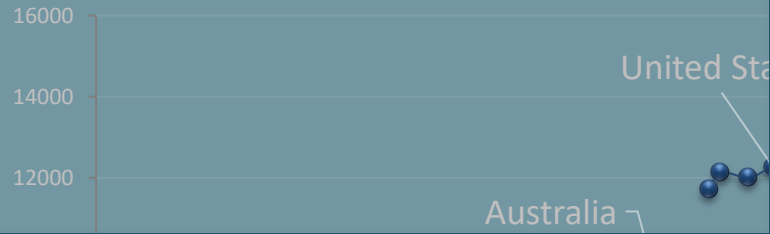


Limited Access to Electricity Restricts Standard of Living



Source: World Bank Databank

ELECTRIC POWER CONSUMPTION, KWH PER CAPITA



Developing Nations

- Increasing electrification:
 - ✓ Improving grid access
 - ✓ Utilizing available energy options
 - ✓ New technology
- Higher electrification accompanied by increasing GDP per capita

Developed Nations

- Energy consumption per capita plateaued
- Increasing GDP per capita:
 - ✓ Complete and pervasive grid access
 - ✓ Energy efficiency
 - ✓ New technology
 - ✓ Access to broad range of resources



GDP PER CAPITA, GDP CURRENT INTERNATIONAL \$

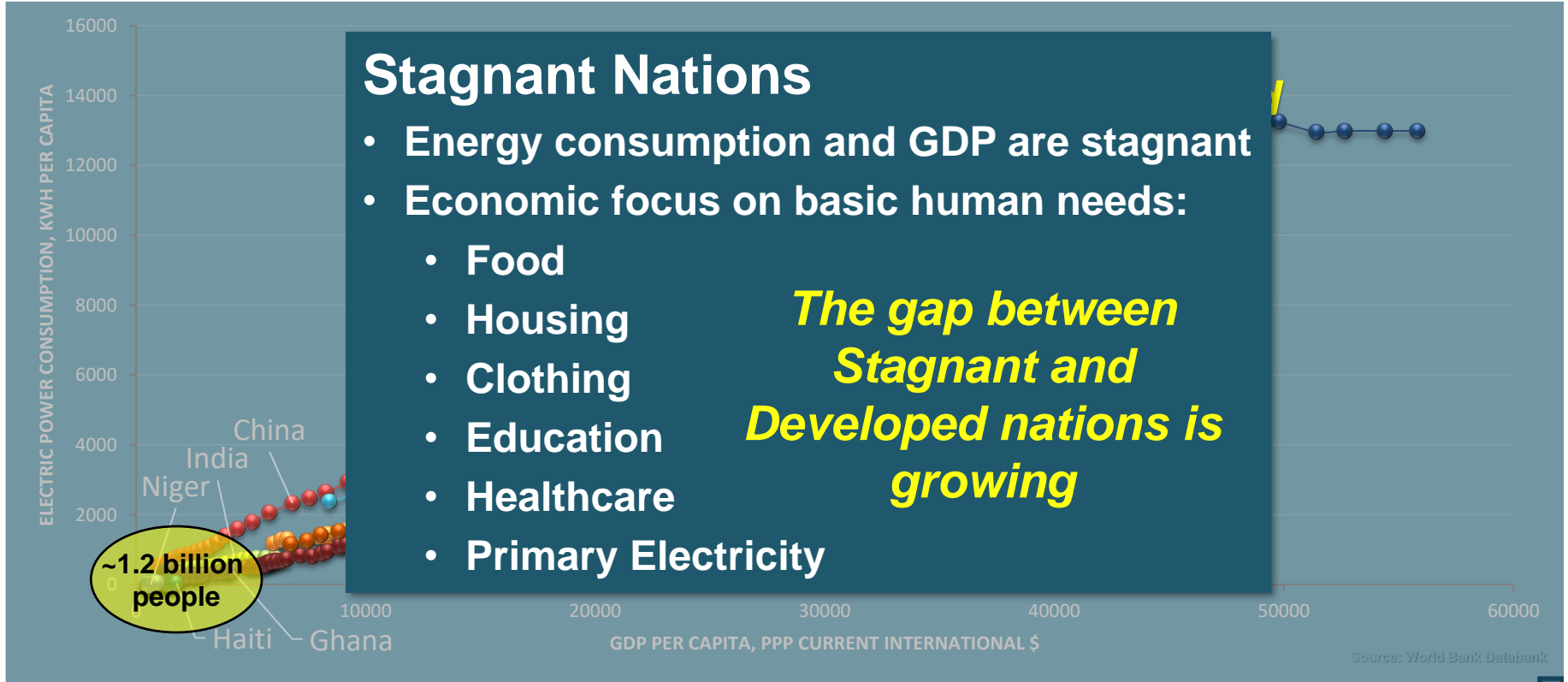
Source: World Bank Databank

Limited Access to Electricity Propagates Inequality

1.2 billion people are being left behind

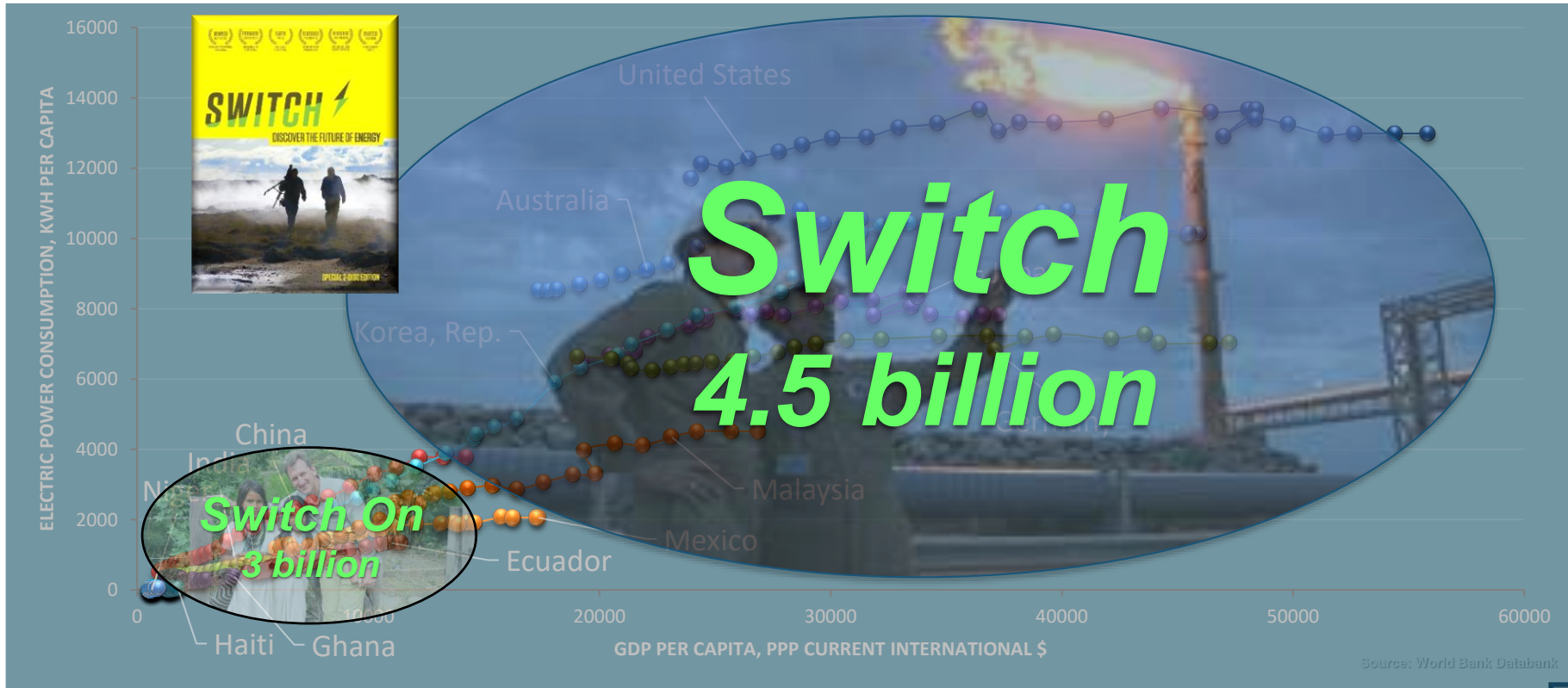


Source: World Bank Databank





Source: World Bank Databank



It's Time to Power the People

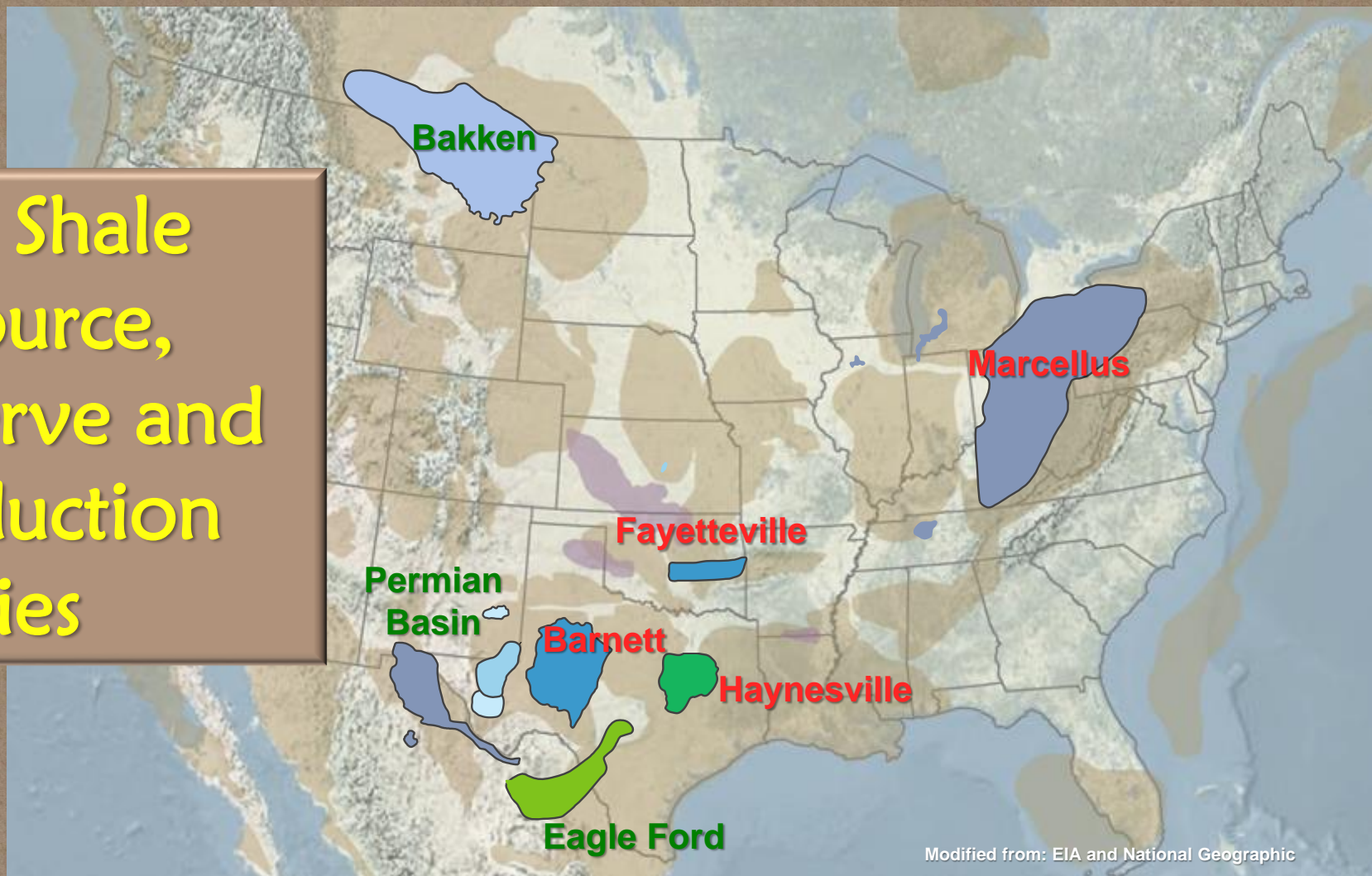


A world map at night, showing city lights in yellow and orange against a dark blue background. The map is centered on the Atlantic Ocean, with North and South America on the left and Europe and Africa on the right.

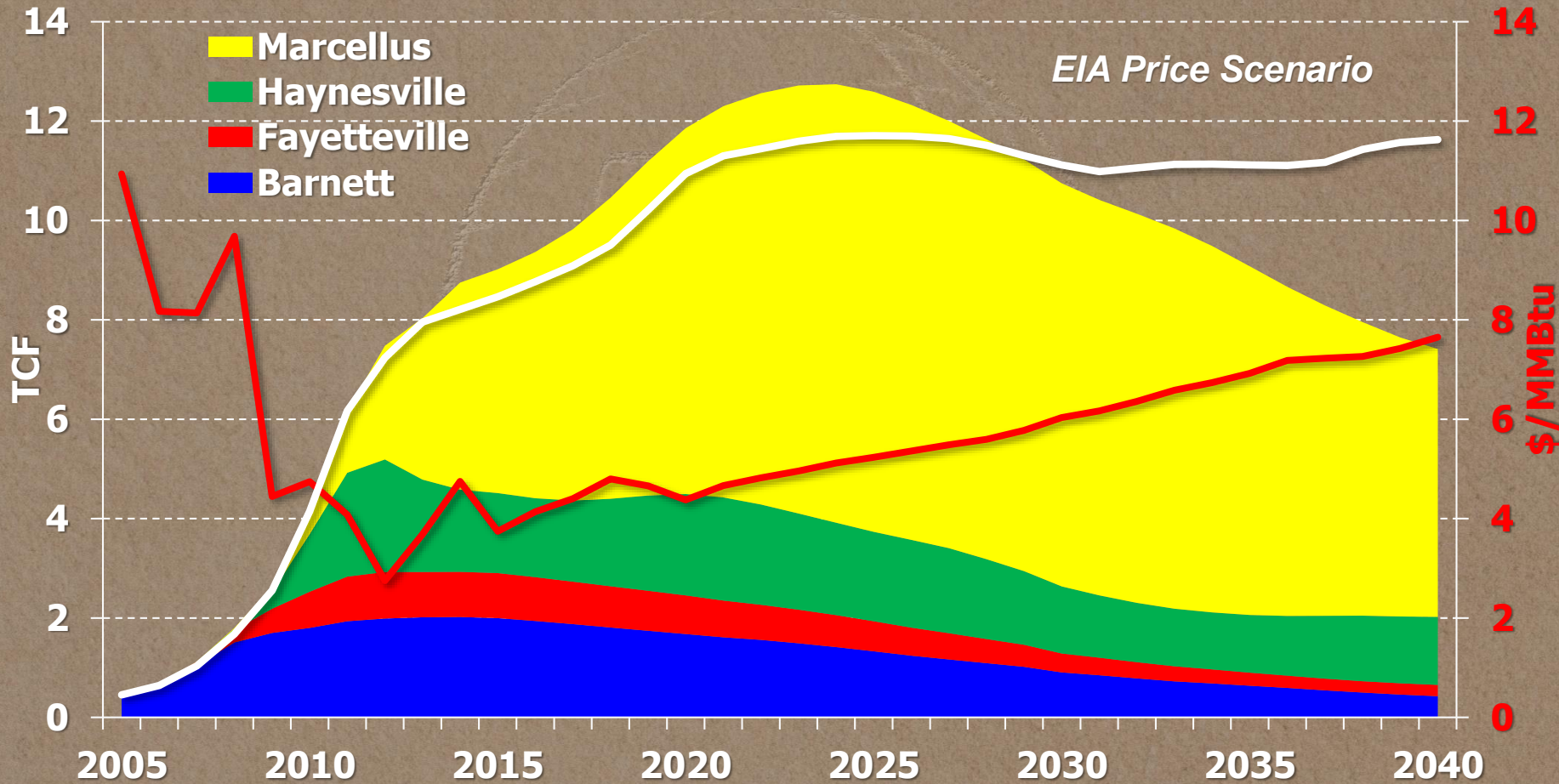
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BEG Shale Resource, Reserve and Production Studies



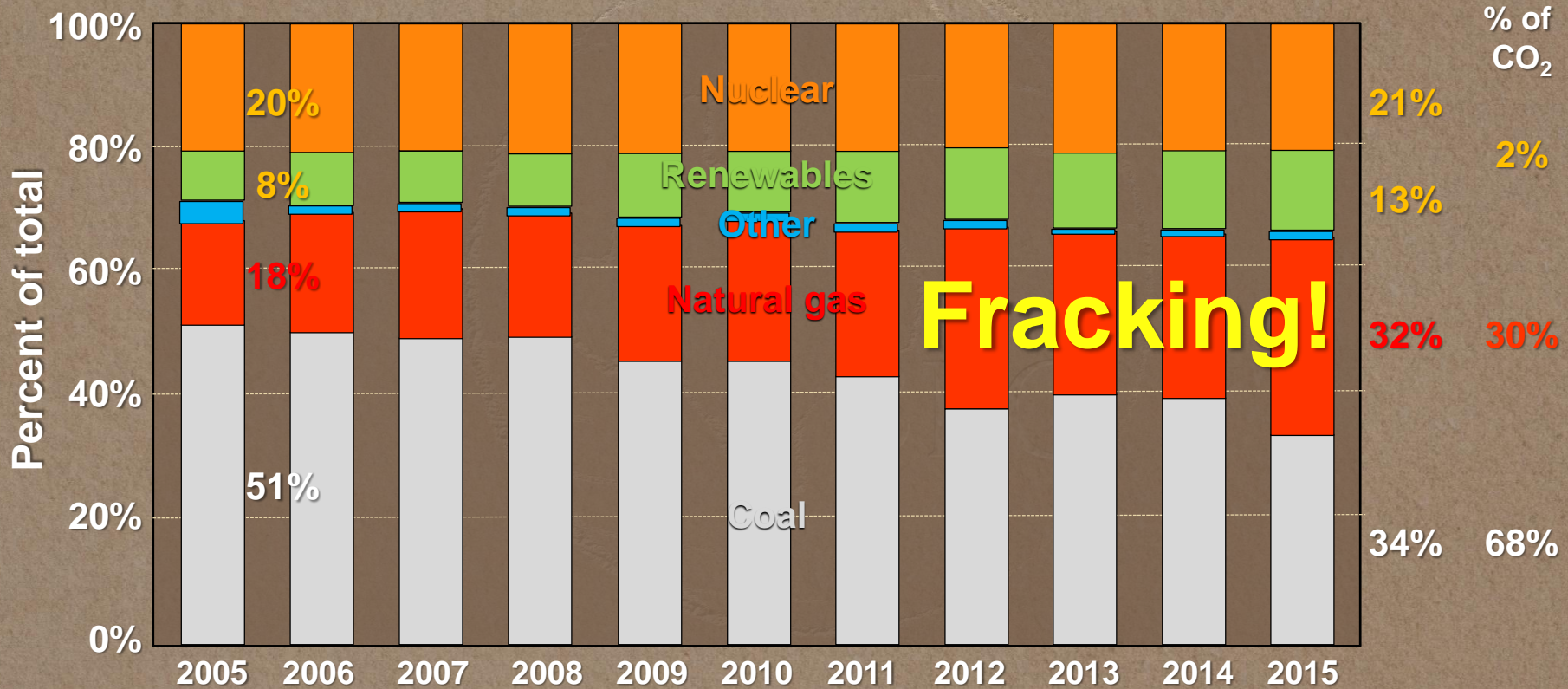
U.S. Shale Gas



U.S. Shale Gas

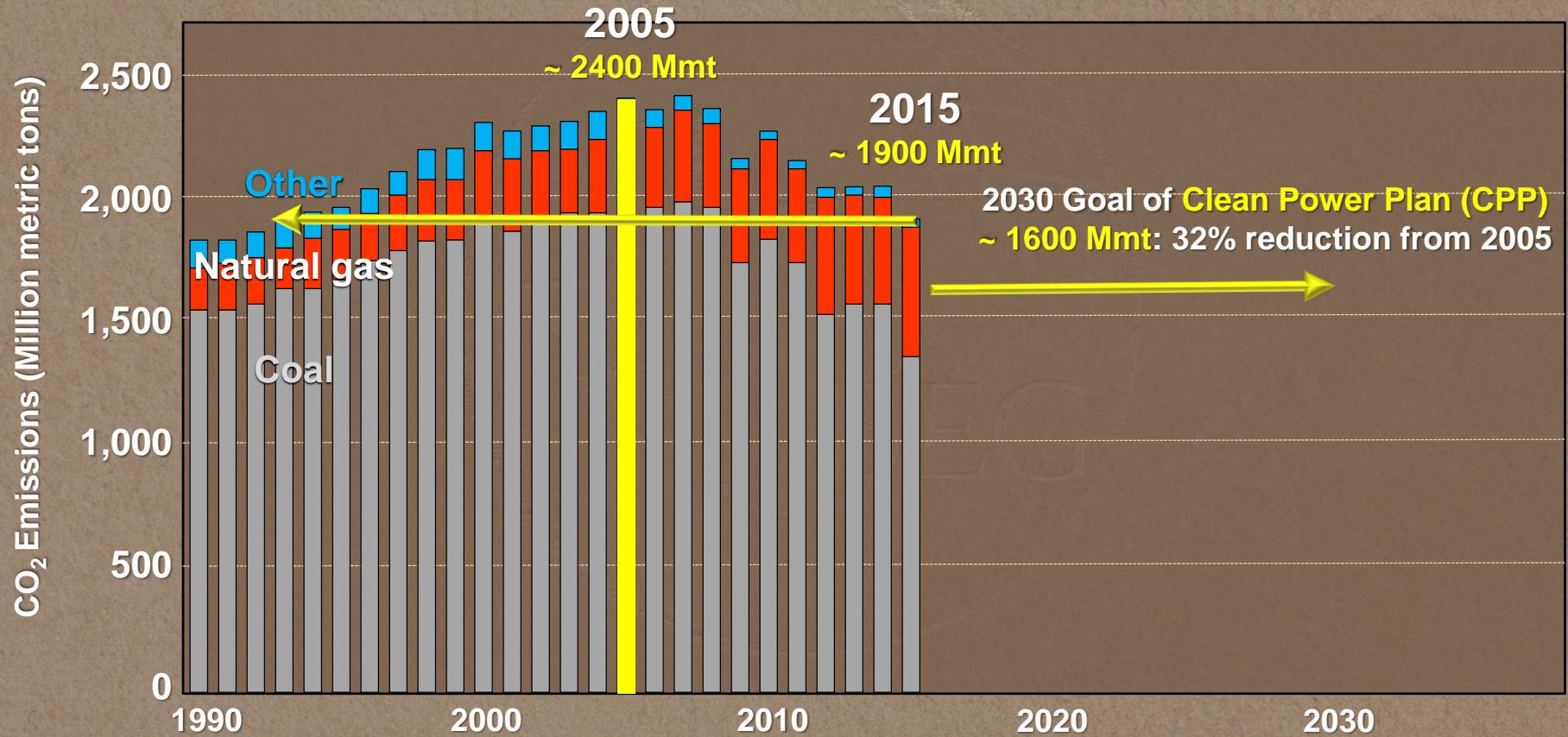
Formation	OGIP _{free}	Prod. through 2045			RF (P50)
		P10	P50	P90	
Barnett	444	37	47	57	11%
Fayetteville	80	12	18	23	23%
Haynesville	489	33	52	72	11%
Marcellus	2071	-	183	-	9%
	3084		300		10%

U.S. Electric Generation Shares (2005-15)



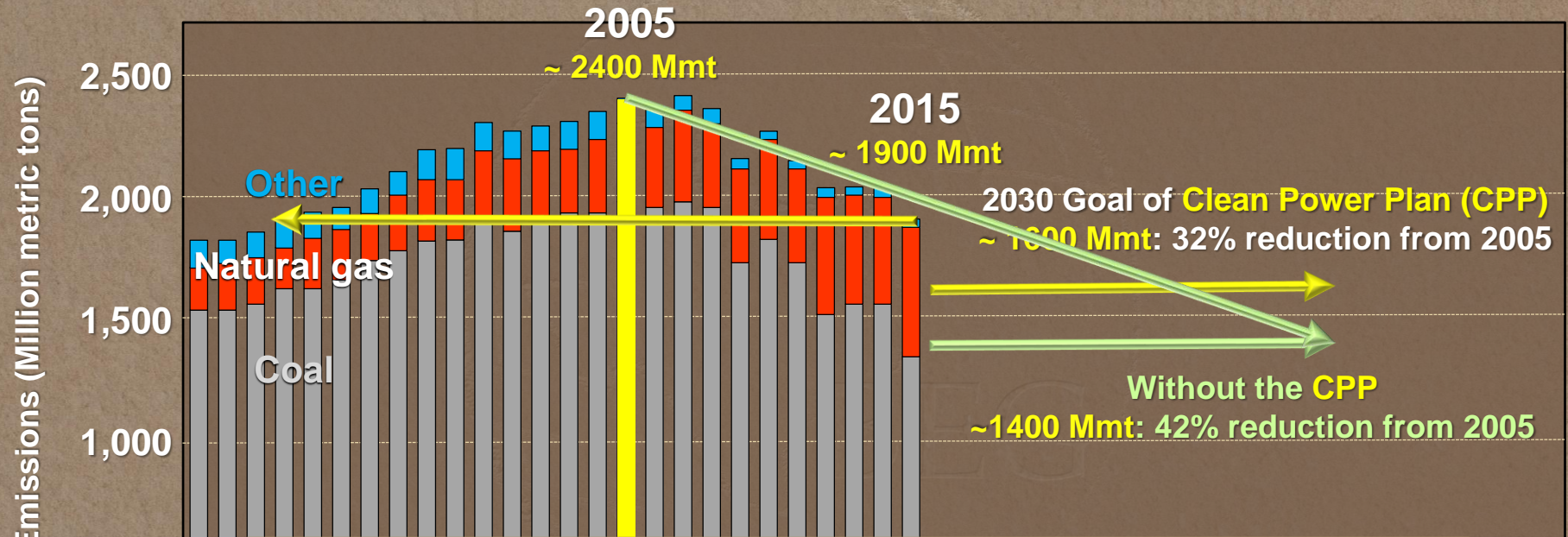
Electric Power Sector U.S. Carbon Dioxide Emissions

Clean Power Plan



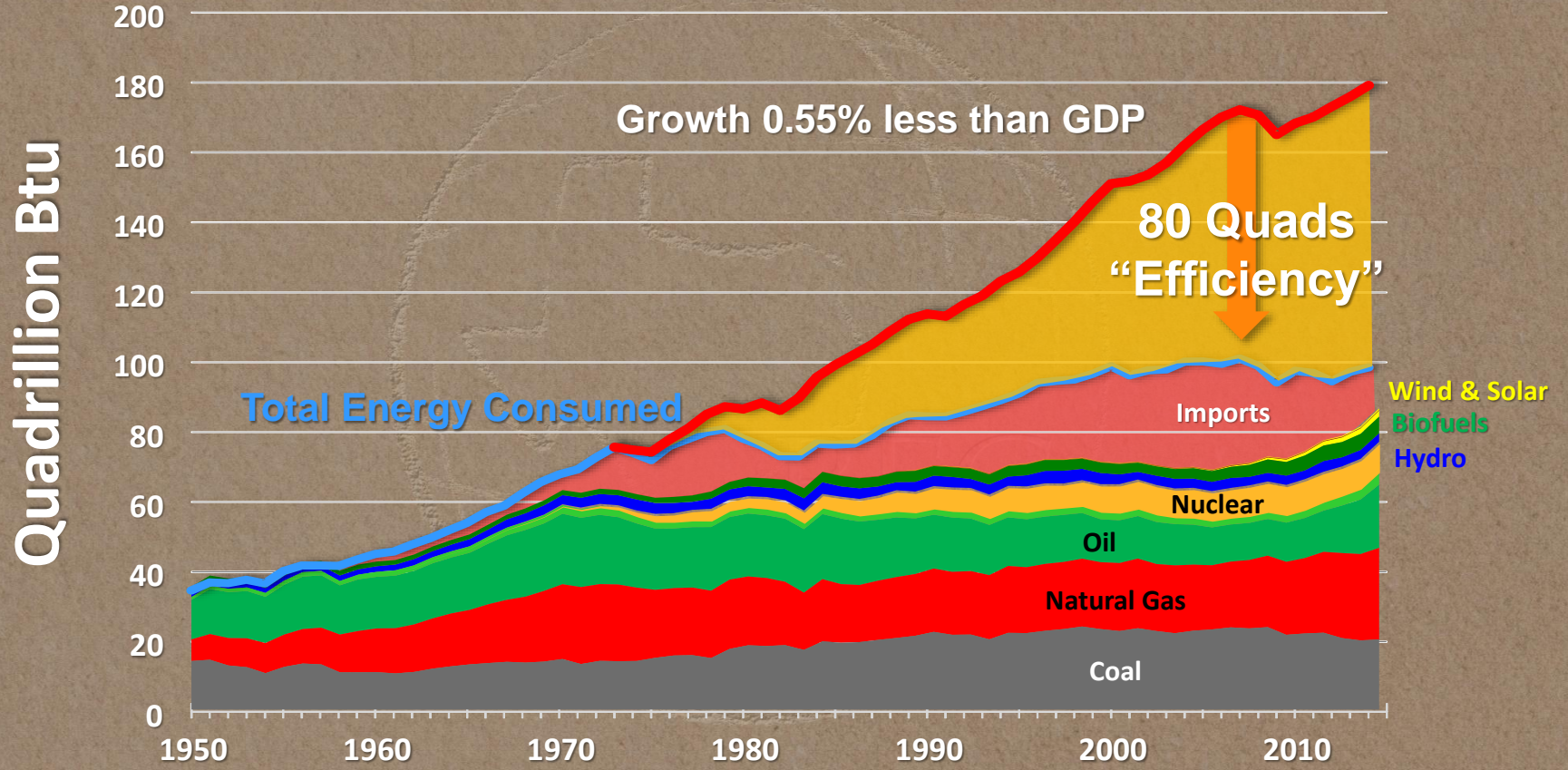
Electric Power Sector U.S. Carbon Dioxide Emissions

Clean Power Plan



- **CPP is less ambitious than current trends**
- **~2/3 of the way there already**
- ✓ **Shale gas, renewables, coal policy**

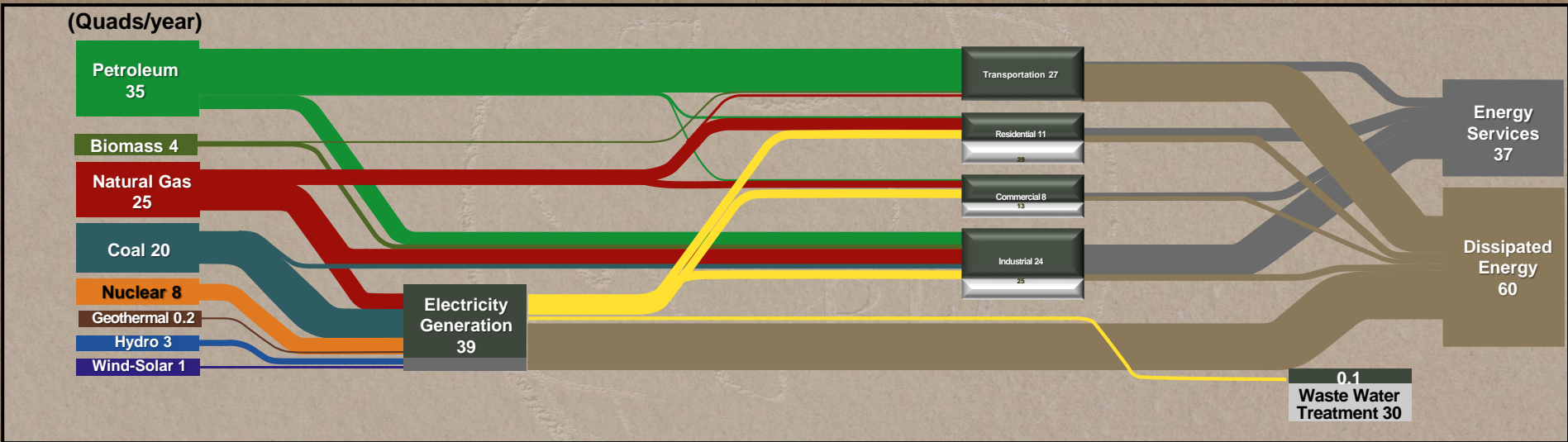
US Energy Mix



After Jim Sweeney, 2015. Data: EIA, Monthly Energy Review

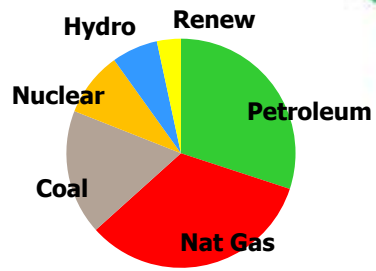
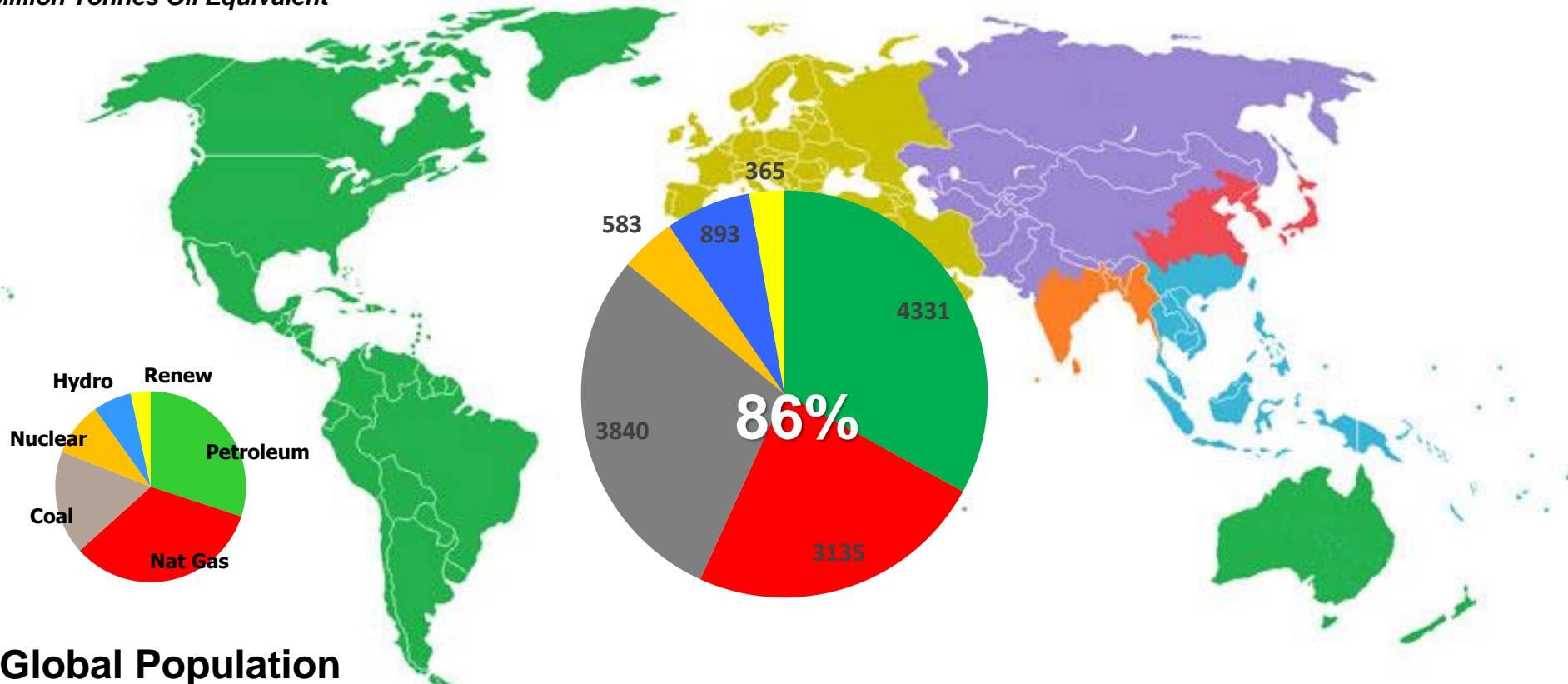
Energy

U. S. Energy Demand



The Global Energy Mix

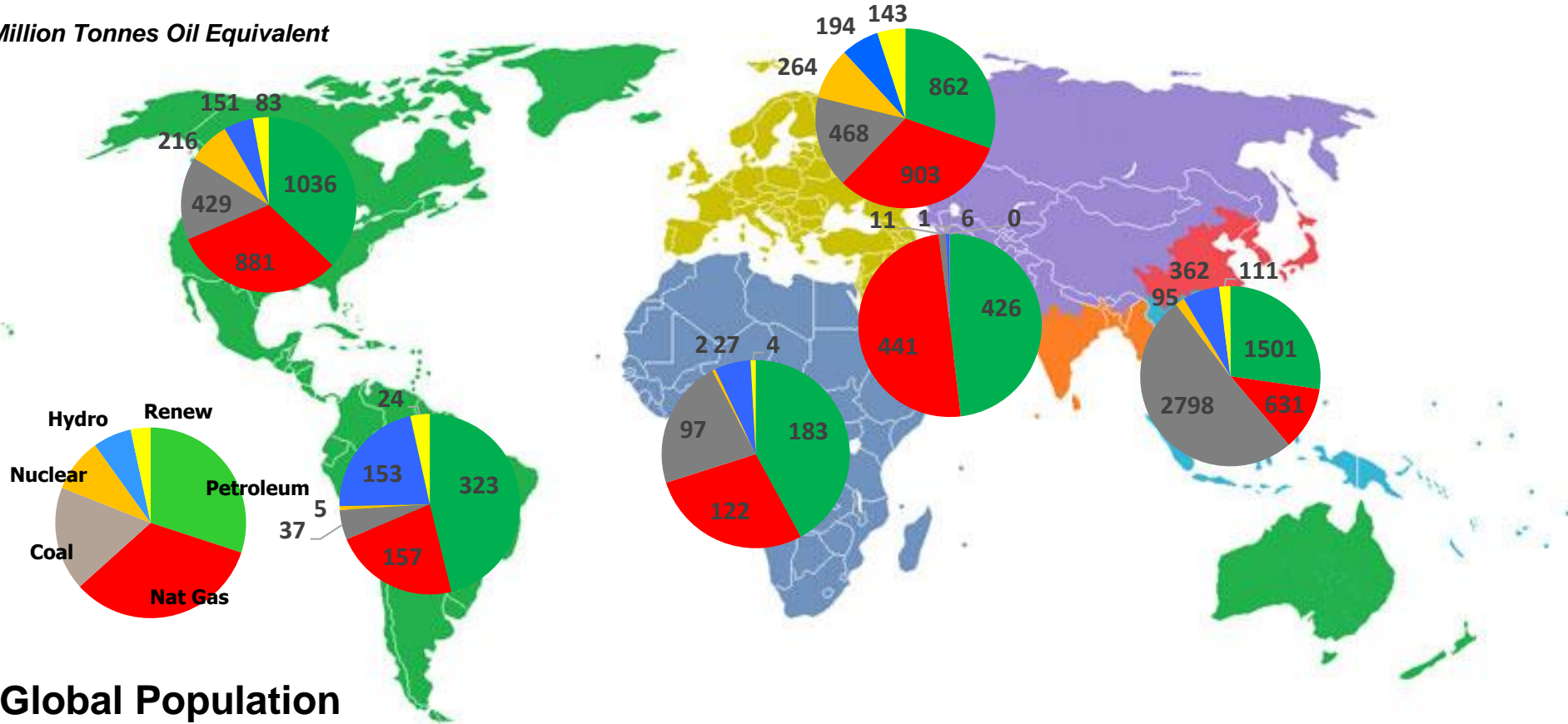
Million Tonnes Oil Equivalent



Global Population
Each color on the map represents ~ 1 billion people

The Global Energy Mix

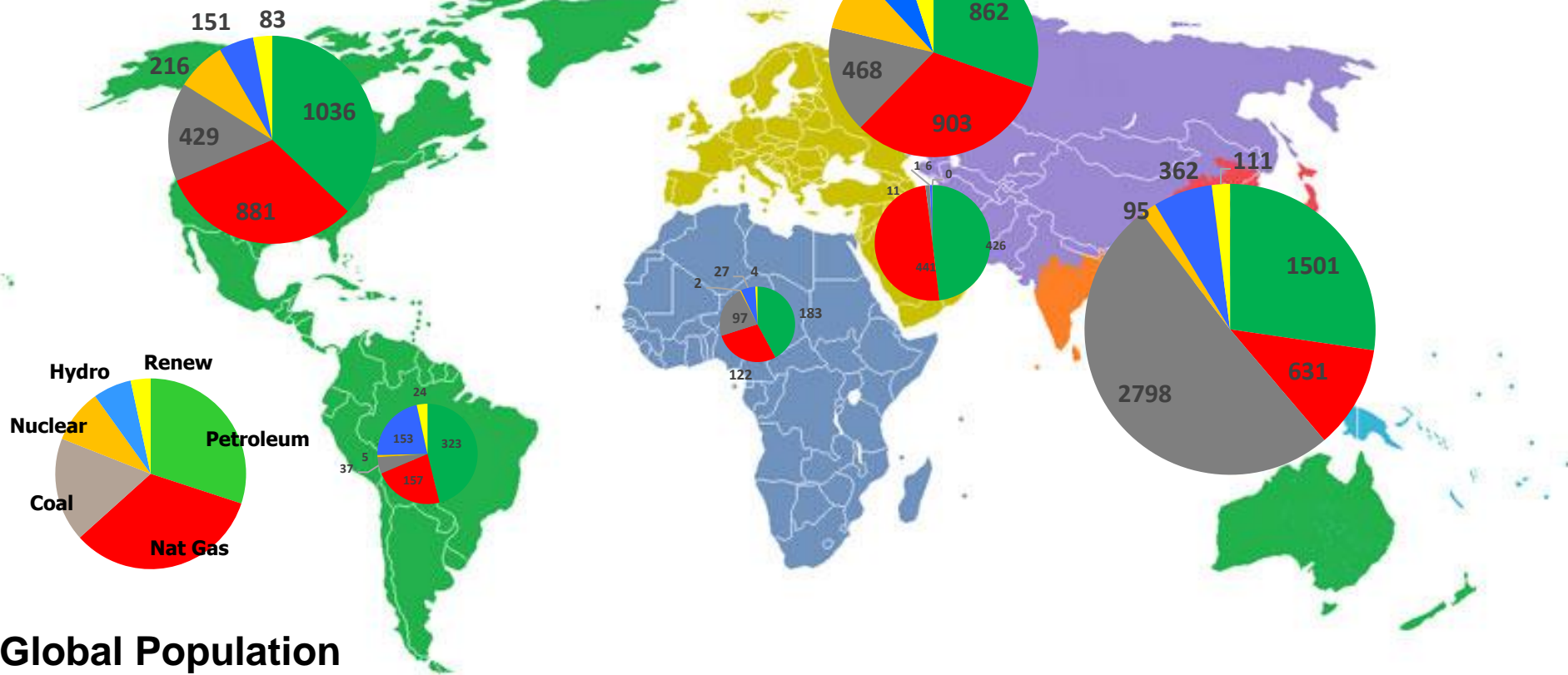
Million Tonnes Oil Equivalent



Global Population
 Each color on the map represents ~ 1 billion people

The Global Energy Mix Scaled to Consumption

Million Tonnes Oil Equivalent

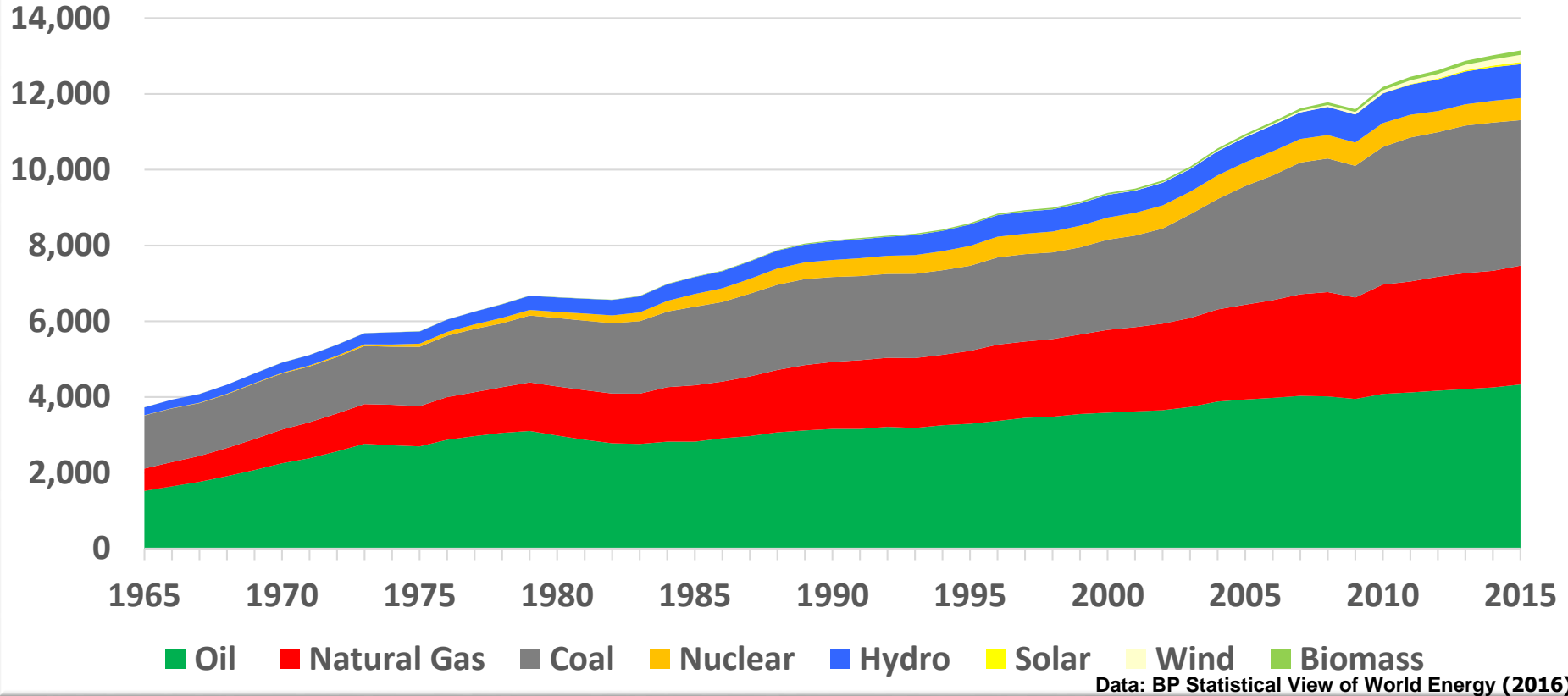


Global Population
Each color on the map represents ~ 1 billion people

Global Energy Mix

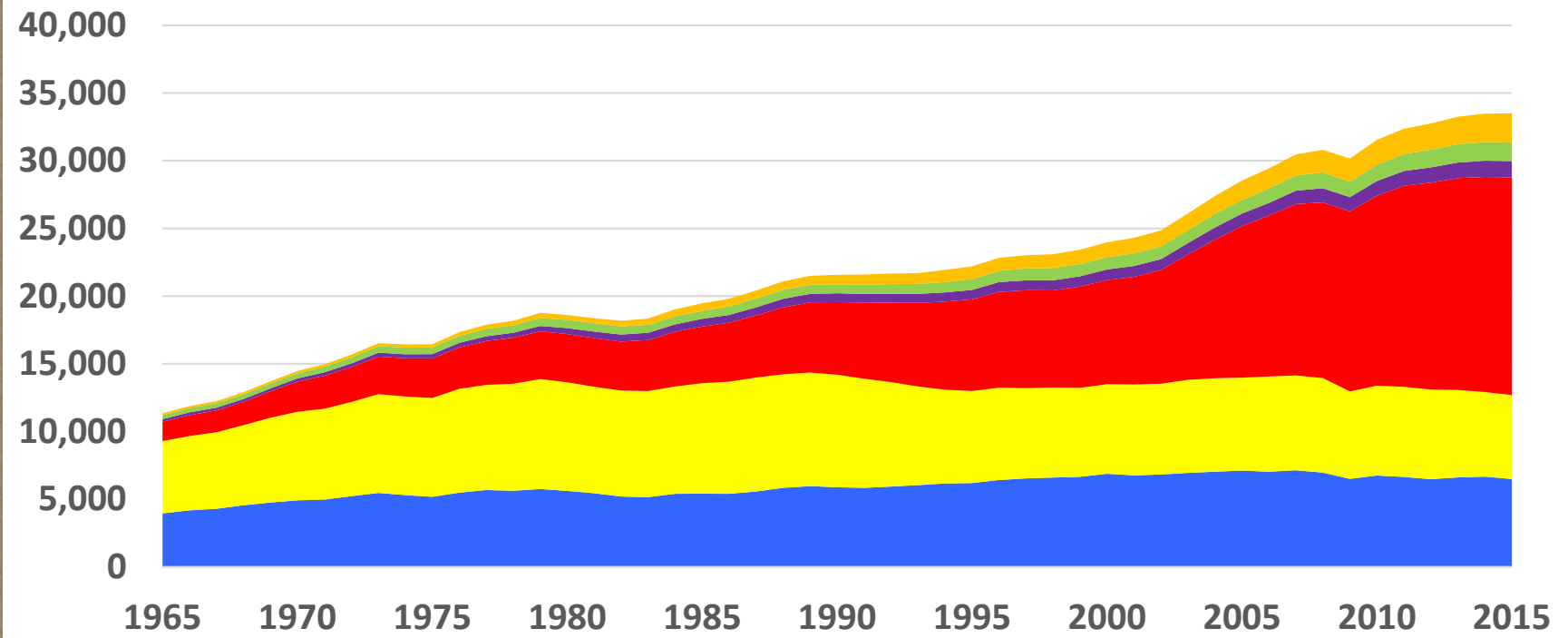
Million Tonnes Oil Equivalent

Global Energy Consumption (MTOE)



CO₂ Emissions

CO₂ Emissions (Million Tonnes)



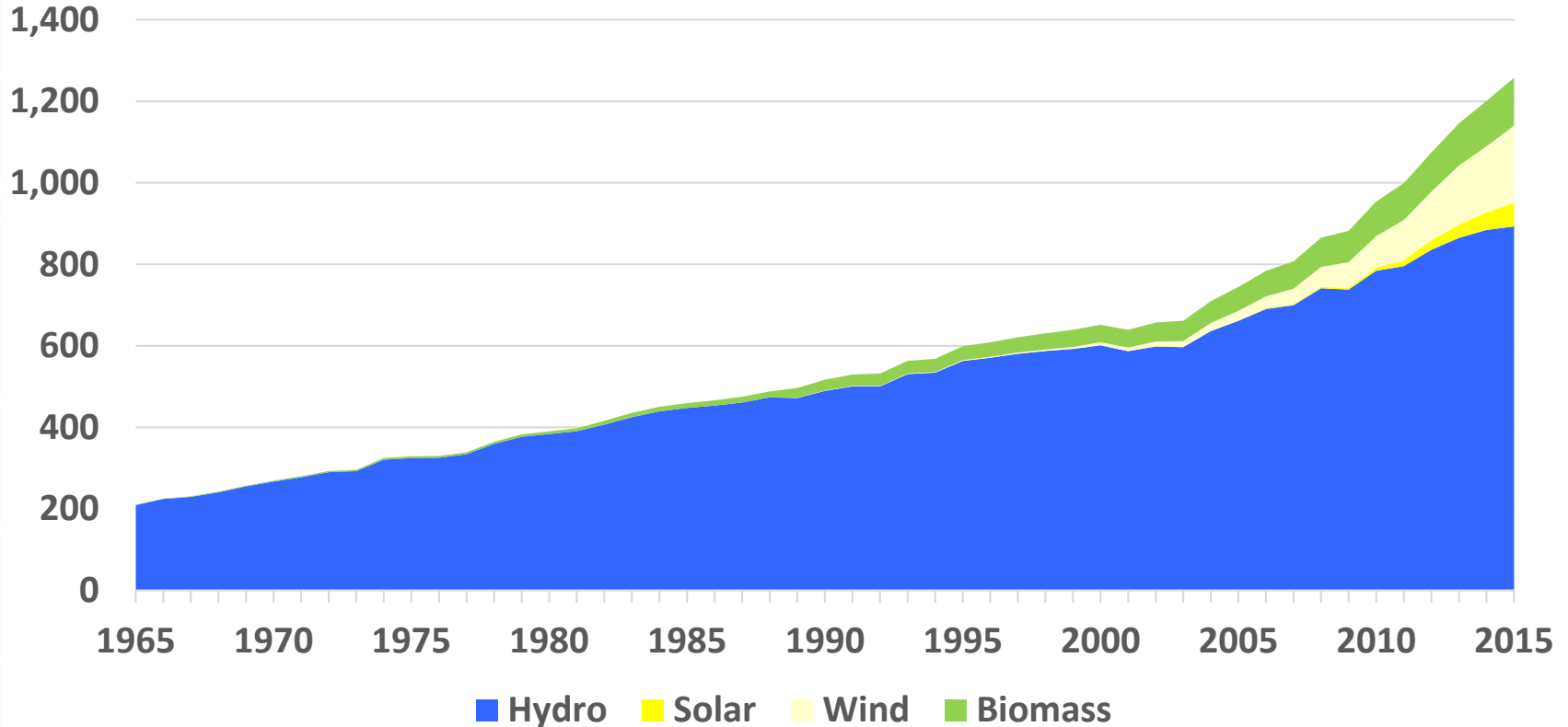
- Total North America
- Total Europe & Eurasia
- Total Asia Pacific
- Total Africa
- Total S. & Cent. America
- Total Middle East

Data: BP Statistical View of World Energy (2016)

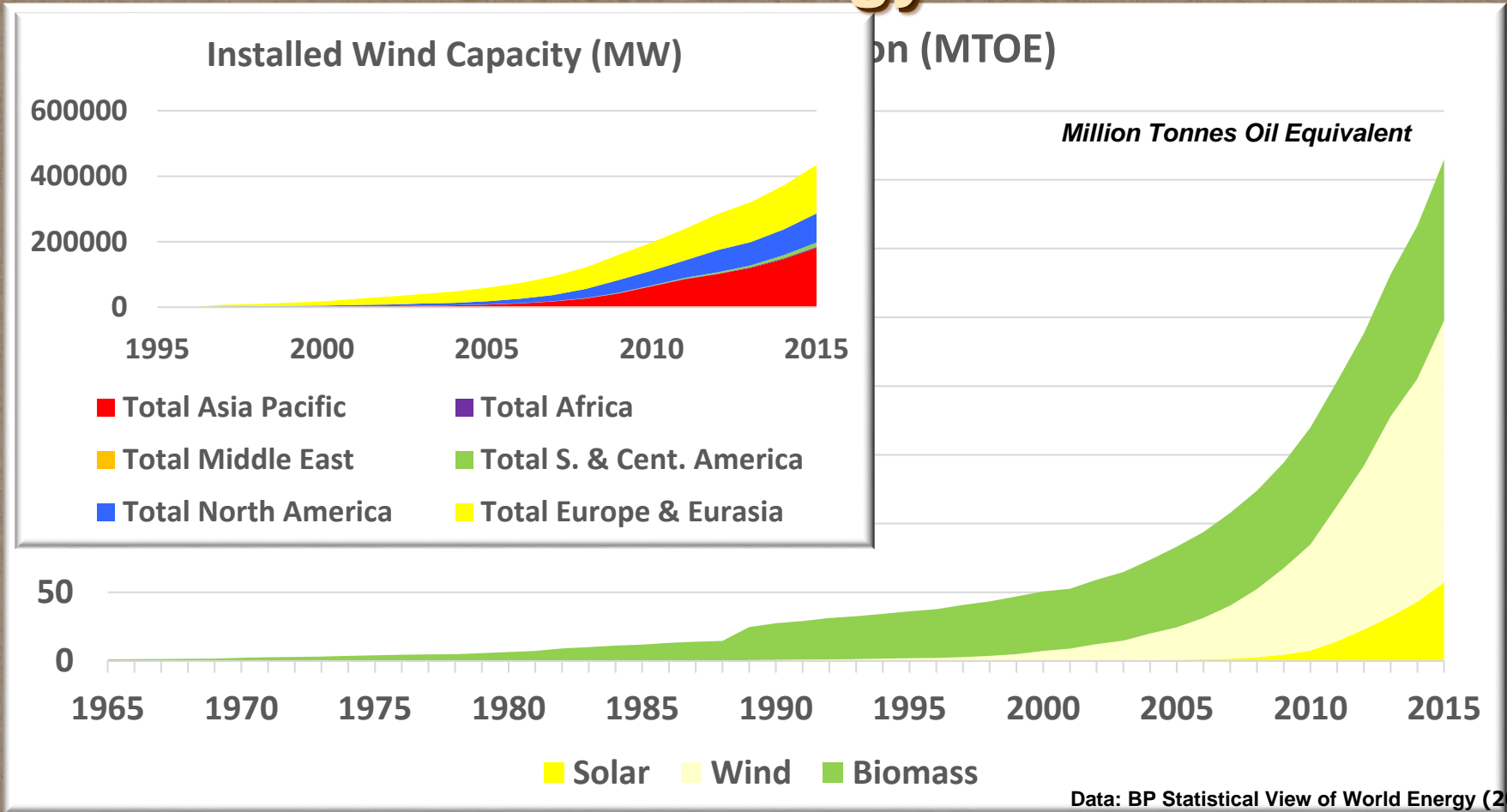
Global Energy Mix

Million Tonnes Oil Equivalent

Renewable Consumption (MTOE)

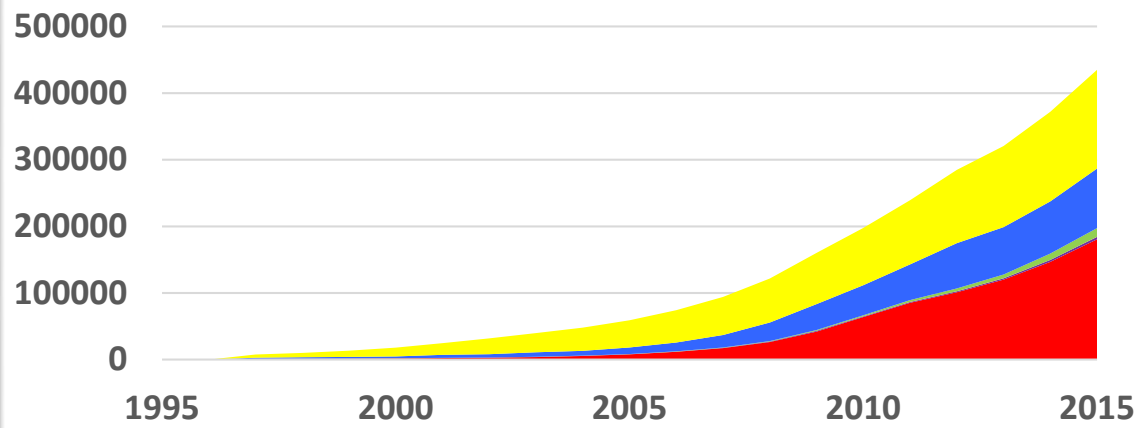


Global Energy Mix



Global Energy Mix

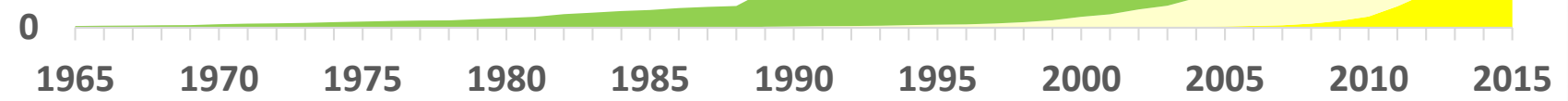
Installed Wind Capacity (MW)



- Total Asia Pacific
- Total Africa
- Total Middle East
- Total S. & Cent. America
- Total North America
- Total Europe & Eurasia

(MTOE)

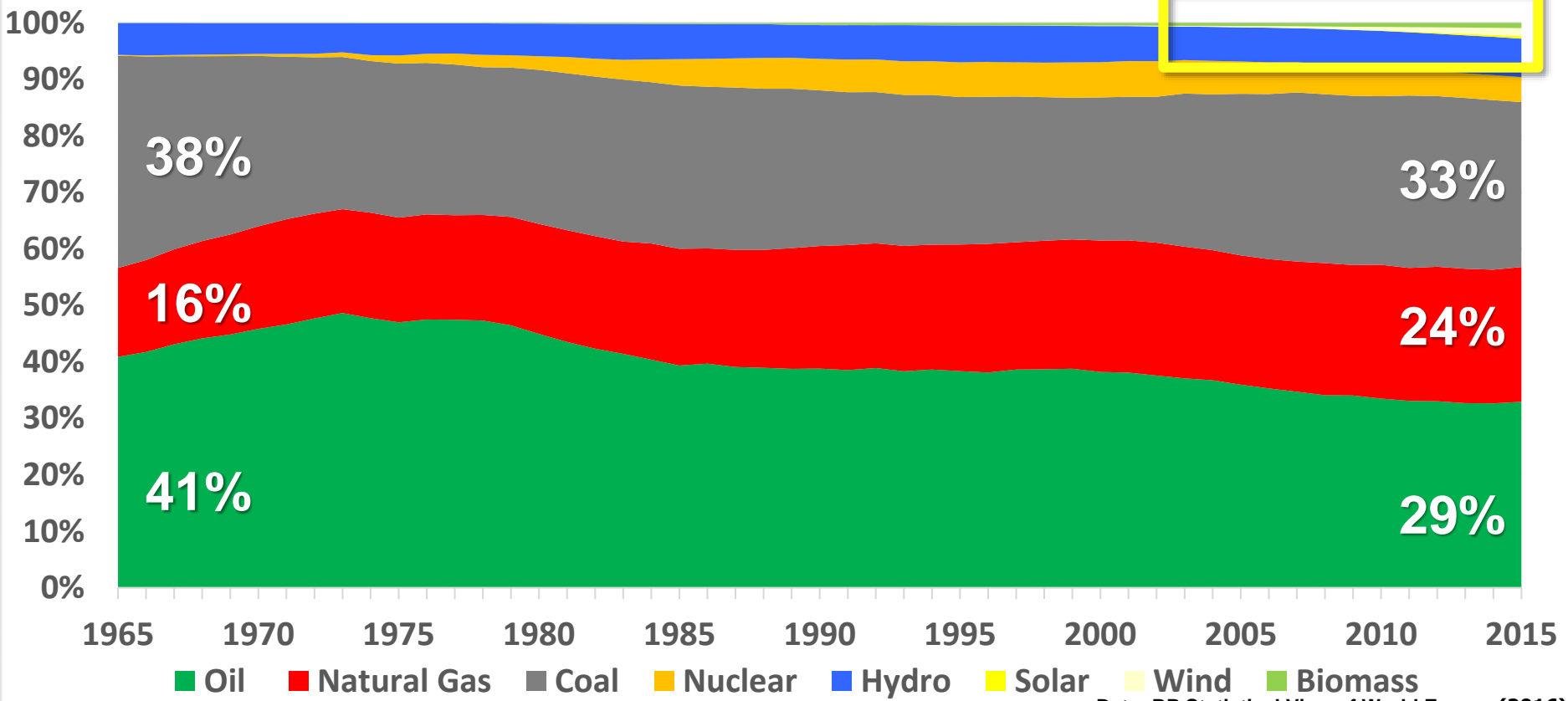
Million Tonnes Oil Equivalent



- Solar
- Wind
- Biomass

Global Energy Mix

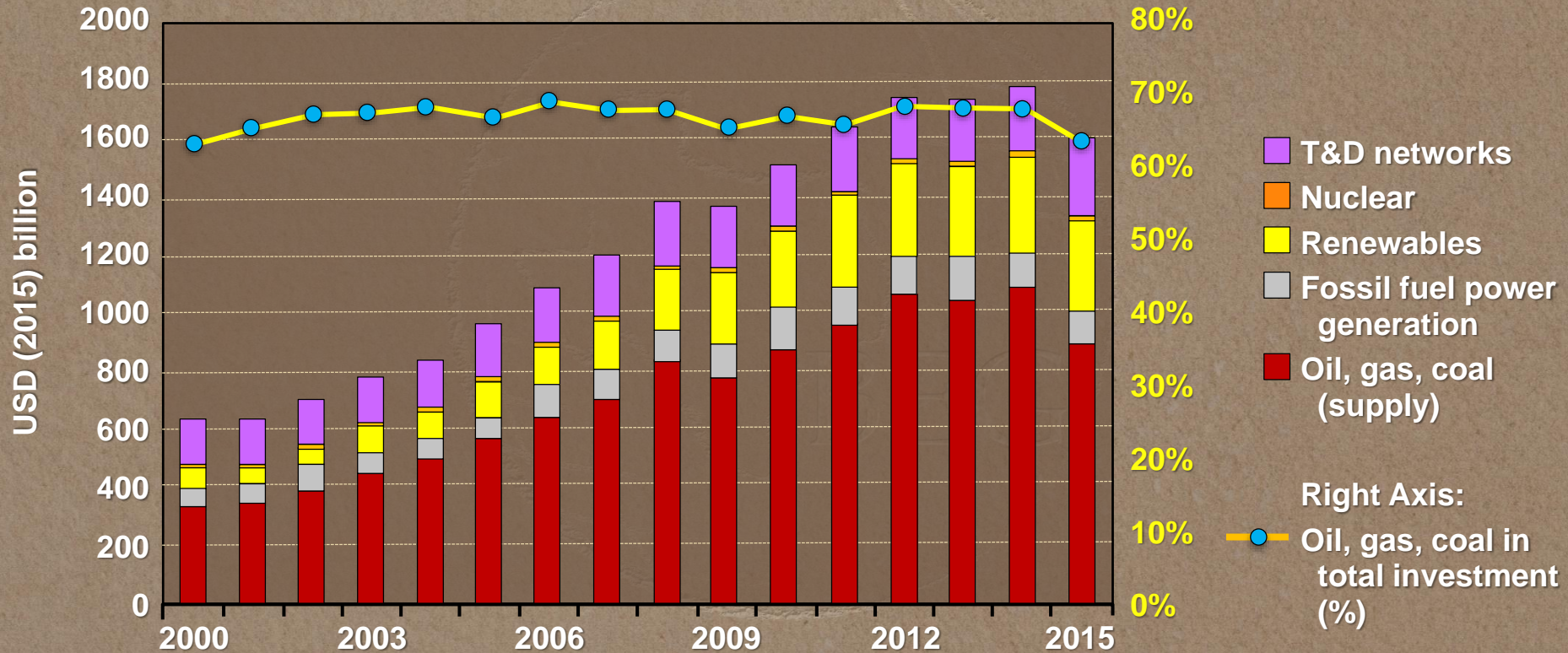
Global Energy Consumption Mix



Data: BP Statistical View of World Energy (2016)

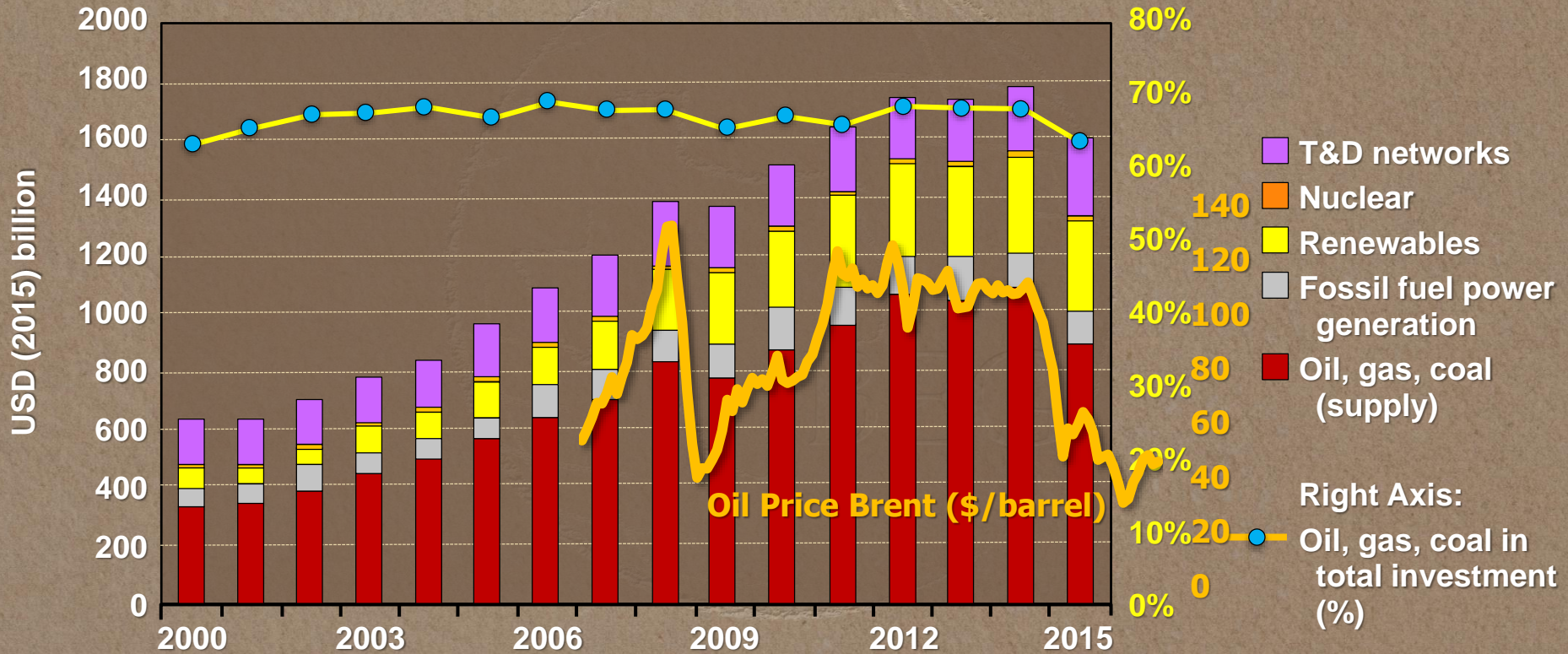
Total Energy Supply

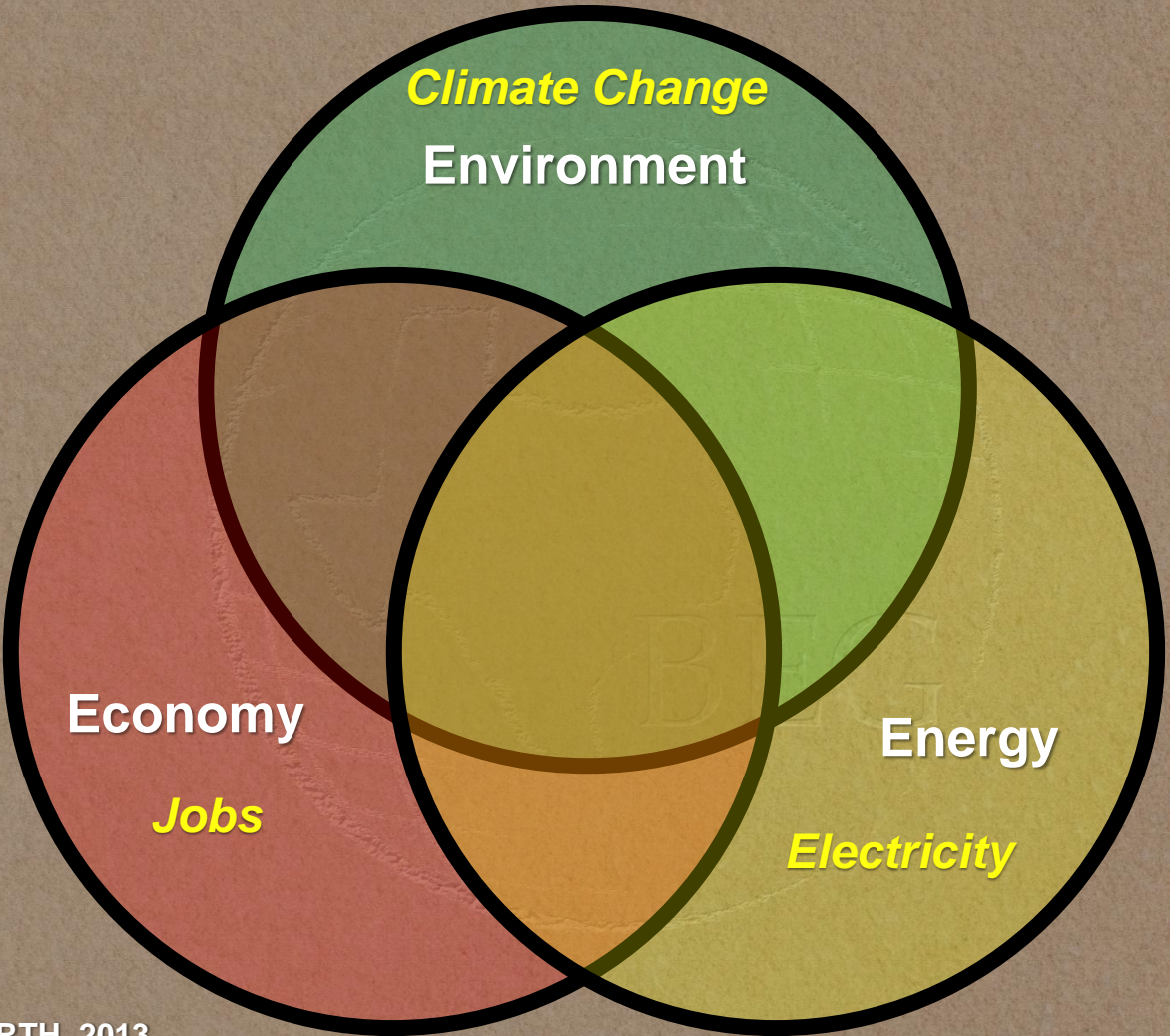
Global Investment 2015 USD \$ Billion

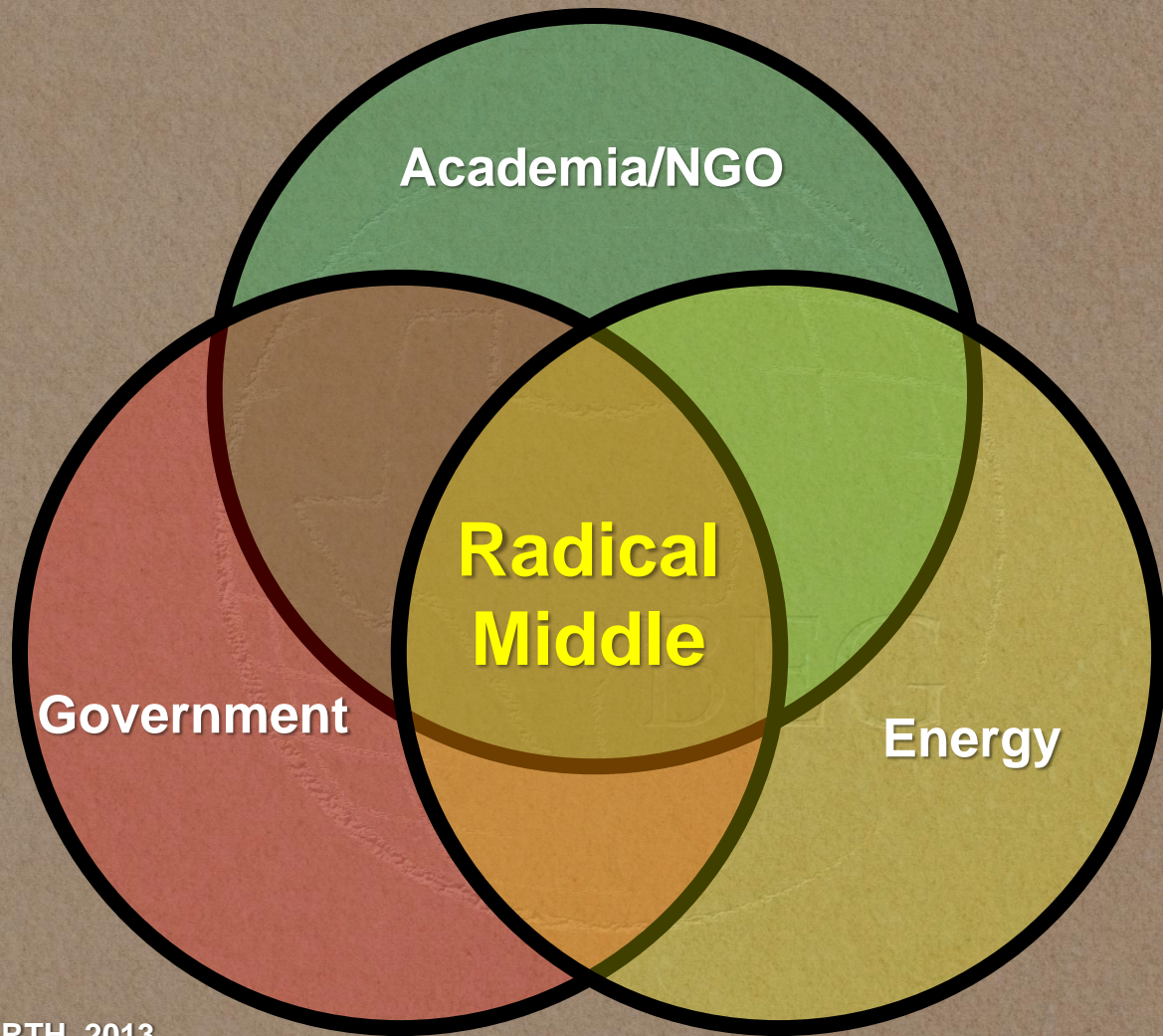


Total Energy Supply

Global Investment 2015 USD \$ Billion







Tinker's Top Take Away's

- 1. Oil, natural gas and coal are secure sources of energy, and will remain vital well into the 21st Century.**
- 2. Secure energy is required to lift humanity from poverty.**
- 3. Secure energy—affordable, available, reliable, sustainable—underpins economies and is required for investment in the environment.**



Thanks!