PESA

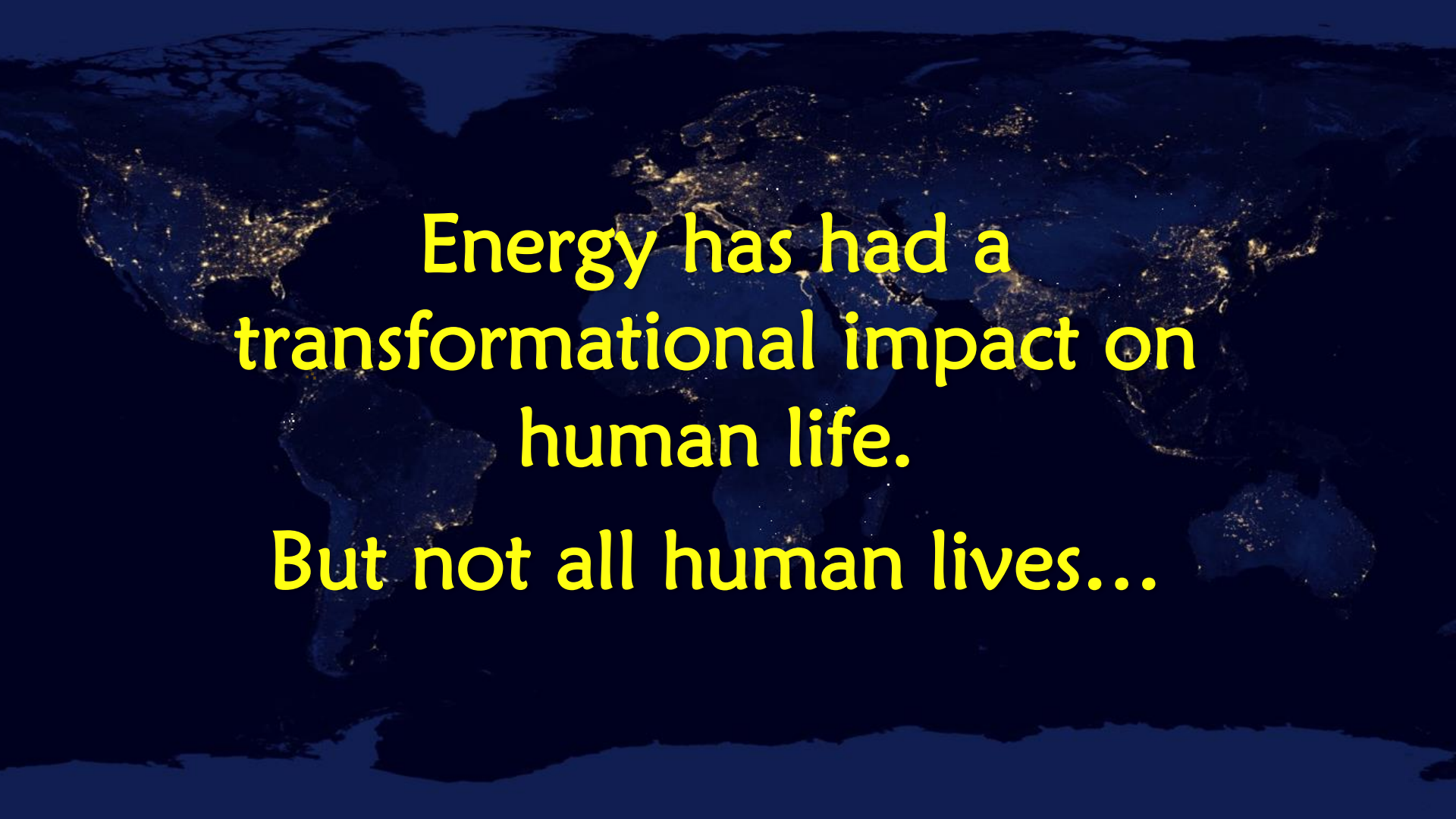
April, 2018

Energy, Poverty and Carbon

Seeking the Radical Middle

Scott W. Tinker


Population
Clean Water
Education
Healthcare
Housing
Hunger
Climate Impacts
Immigration
Status of Women
Unemployment
Crime


Energy has had a transformational impact on human life.
But not all human lives…

The Public Dialog

There is “good” energy and “bad” energy…

The Energy Narrative

Renewable energy is good.

Fossil and nuclear energy are bad.

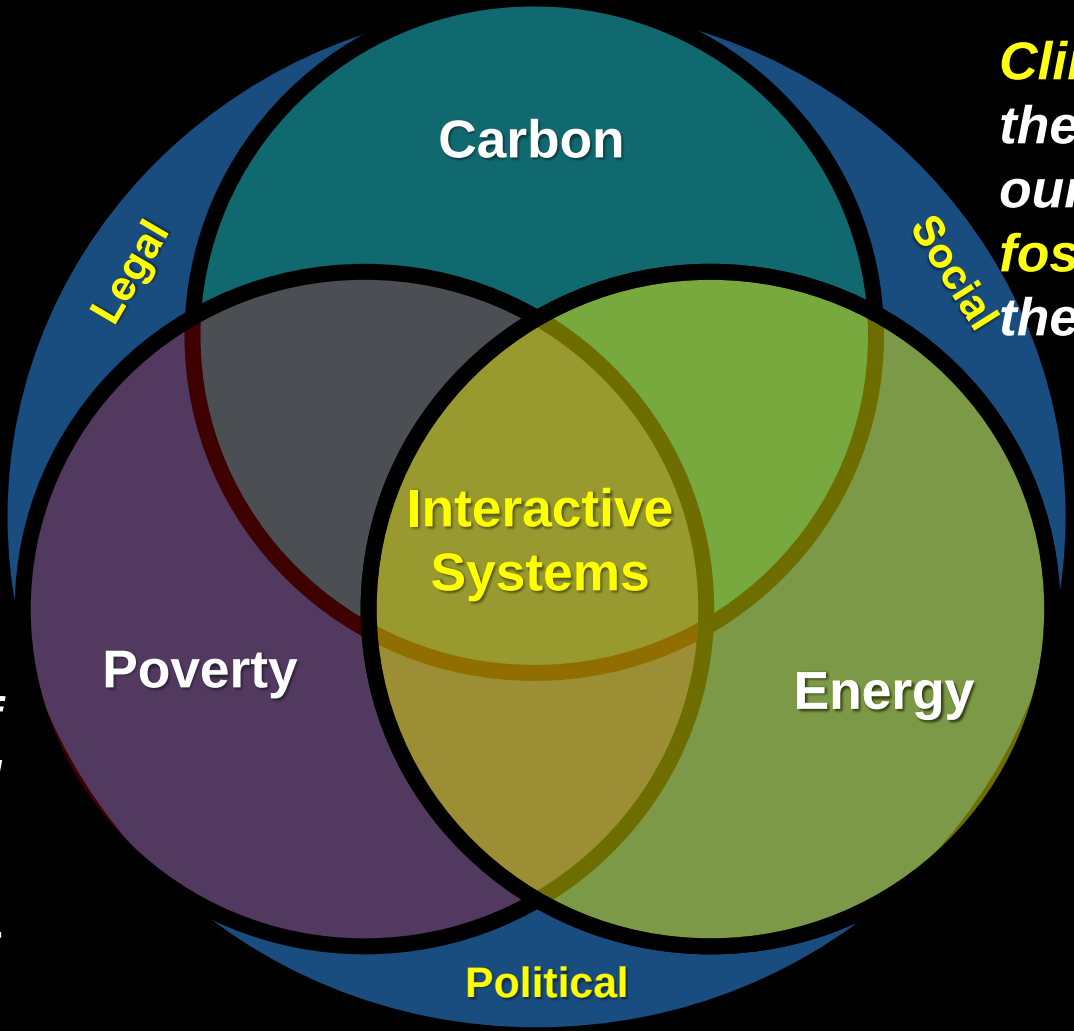
The Reality

Most people do not know how electricity is made or where gasoline comes from.

But they think they do!

Outline

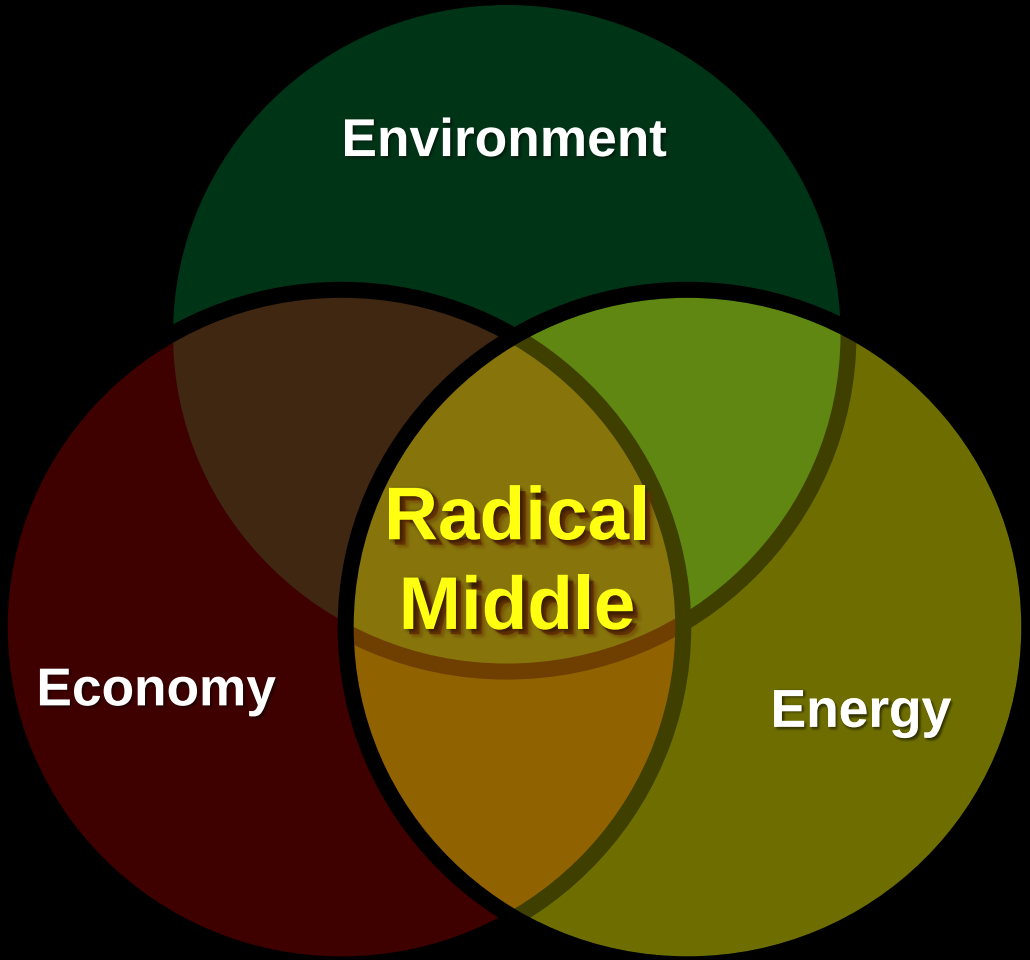
- Energy
- Carbon
- Poverty



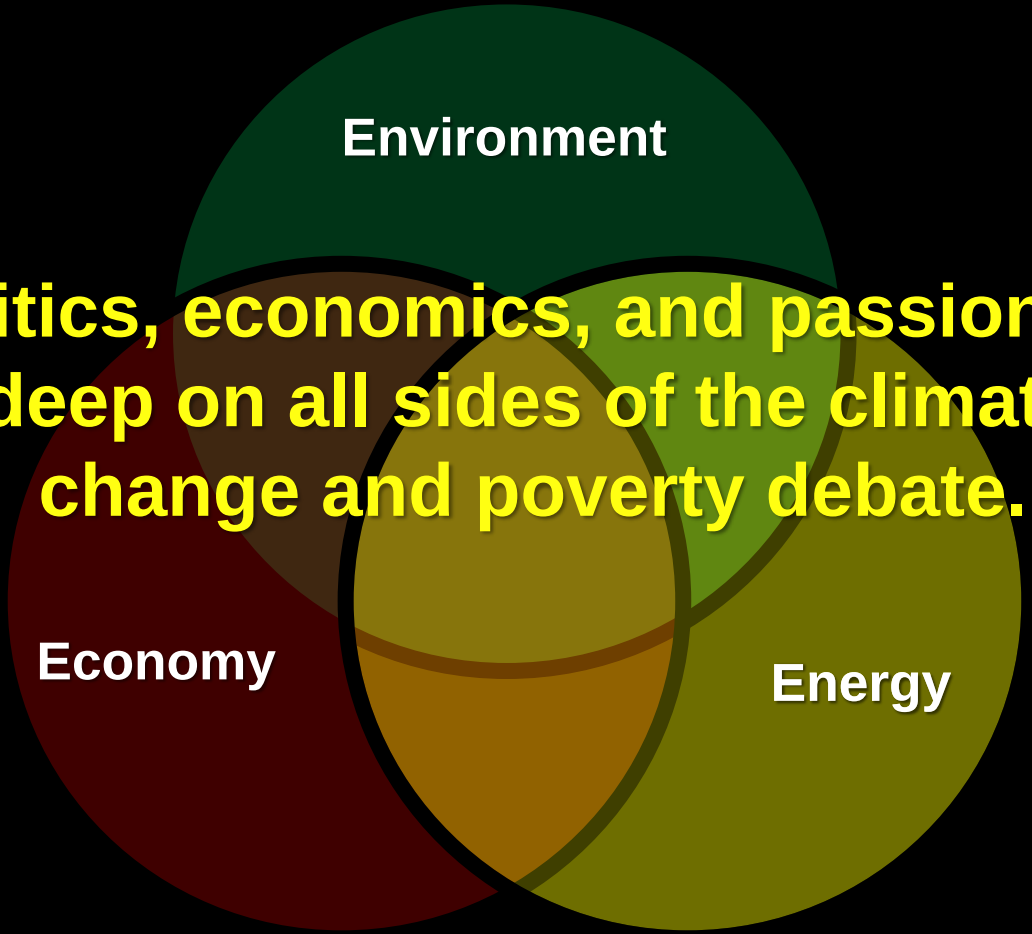
Climate Change *is the major issue of our time, and* ***fossil fuels*** *are the* ***problem***

Poverty *is the major issue of our time, and* ***fossil fuels*** *are the* ***solution***

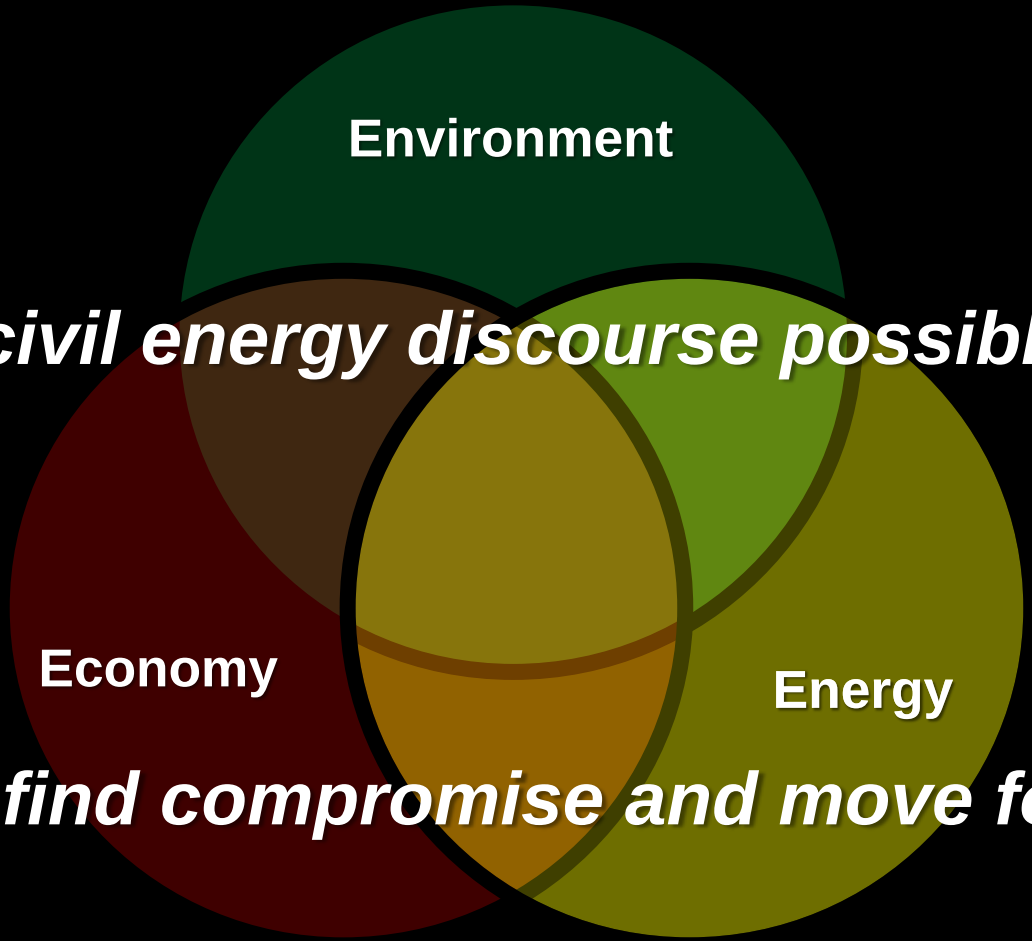
Bureau of Economic Geology



Bureau of Economic Geology



Politics, economics, and passion run deep on all sides of the climate change and poverty debate.



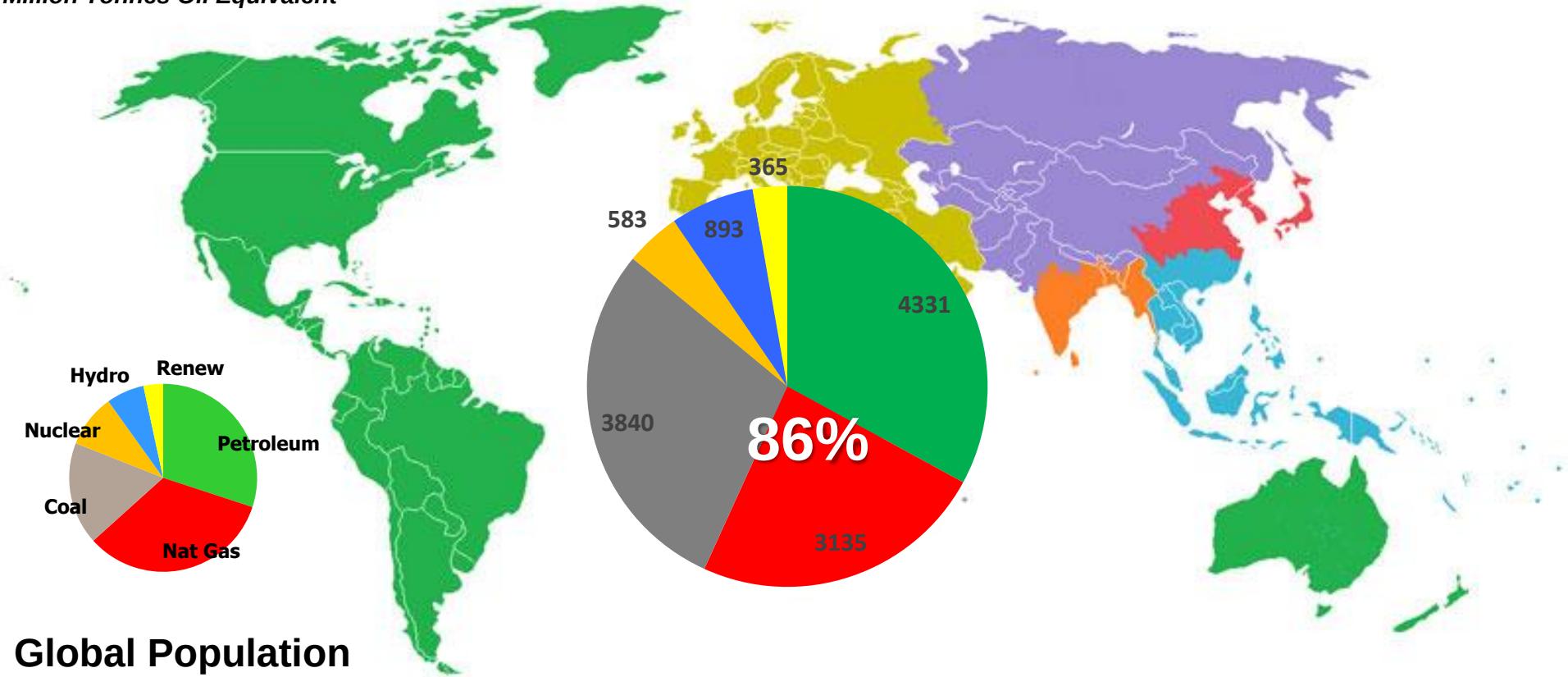
Is civil energy discourse possible?

Can we find compromise and move forward?

Bureau of Economic Geology

The Global Energy Mix

Million Tonnes Oil Equivalent



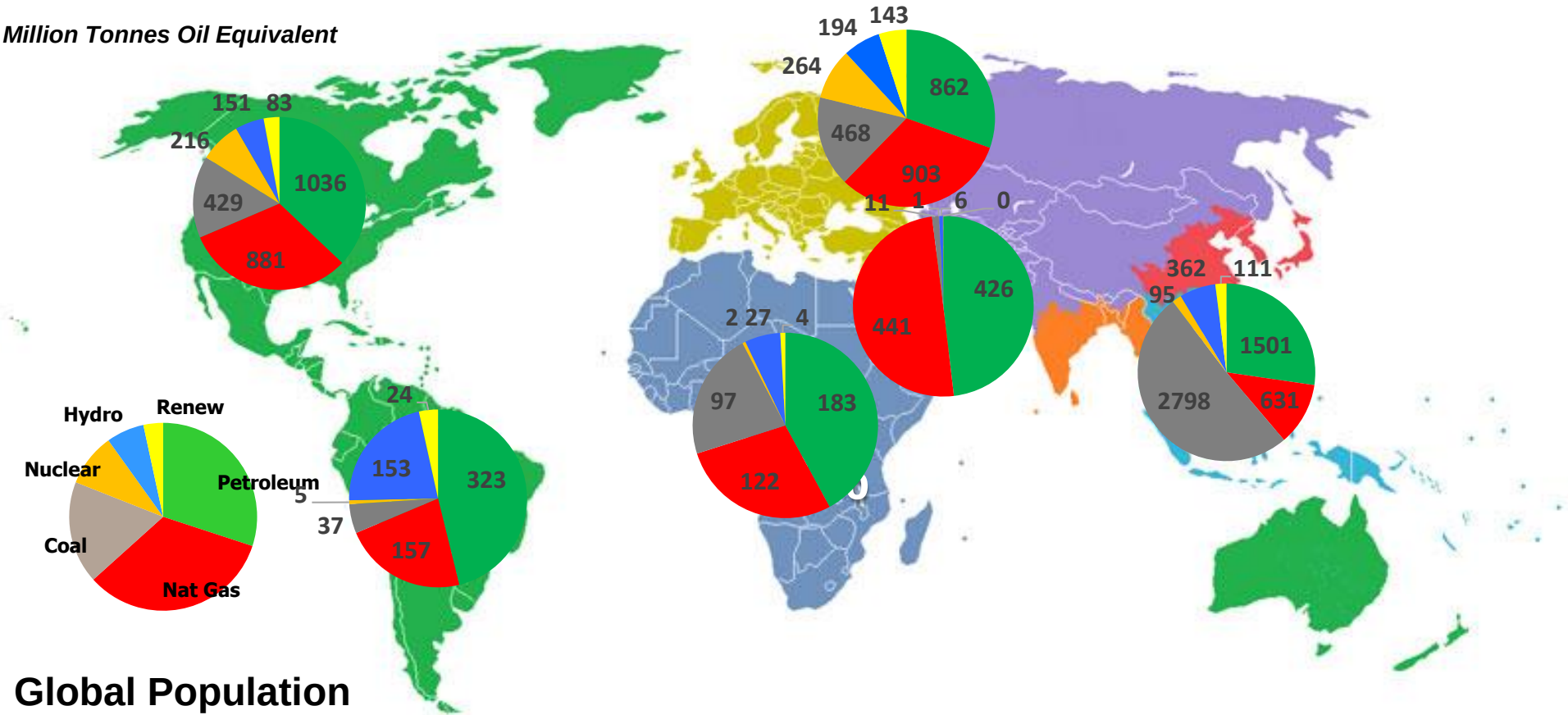
Global Population

Each color on the map represents ~ 1 billion people

Data: BP Statistical View of World Energy (2016)

The Global Energy Mix

Million Tonnes Oil Equivalent



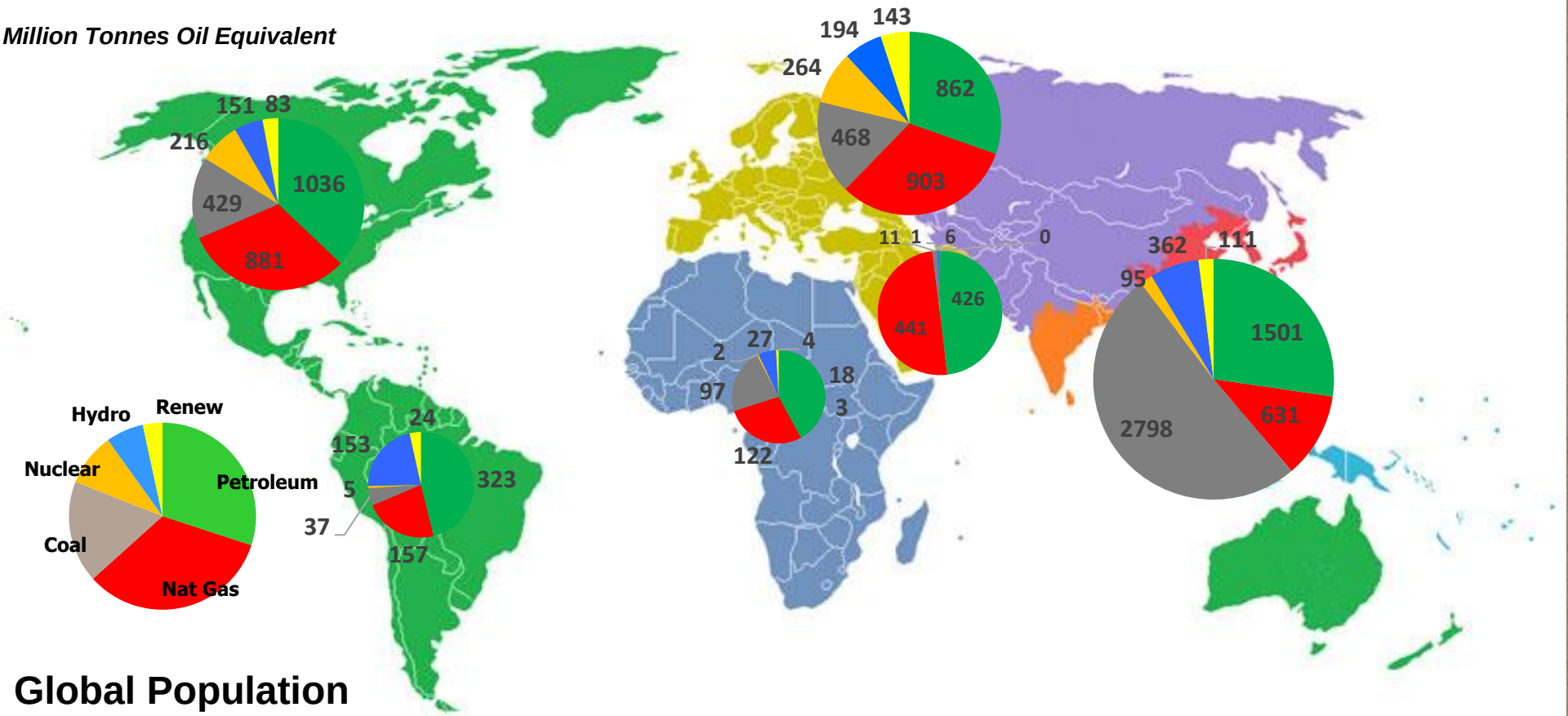
Global Population

Each color on the map represents ~ 1 billion people

Data: BP Statistical View of World Energy (2016)

Global Energy Demand

Million Tonnes Oil Equivalent



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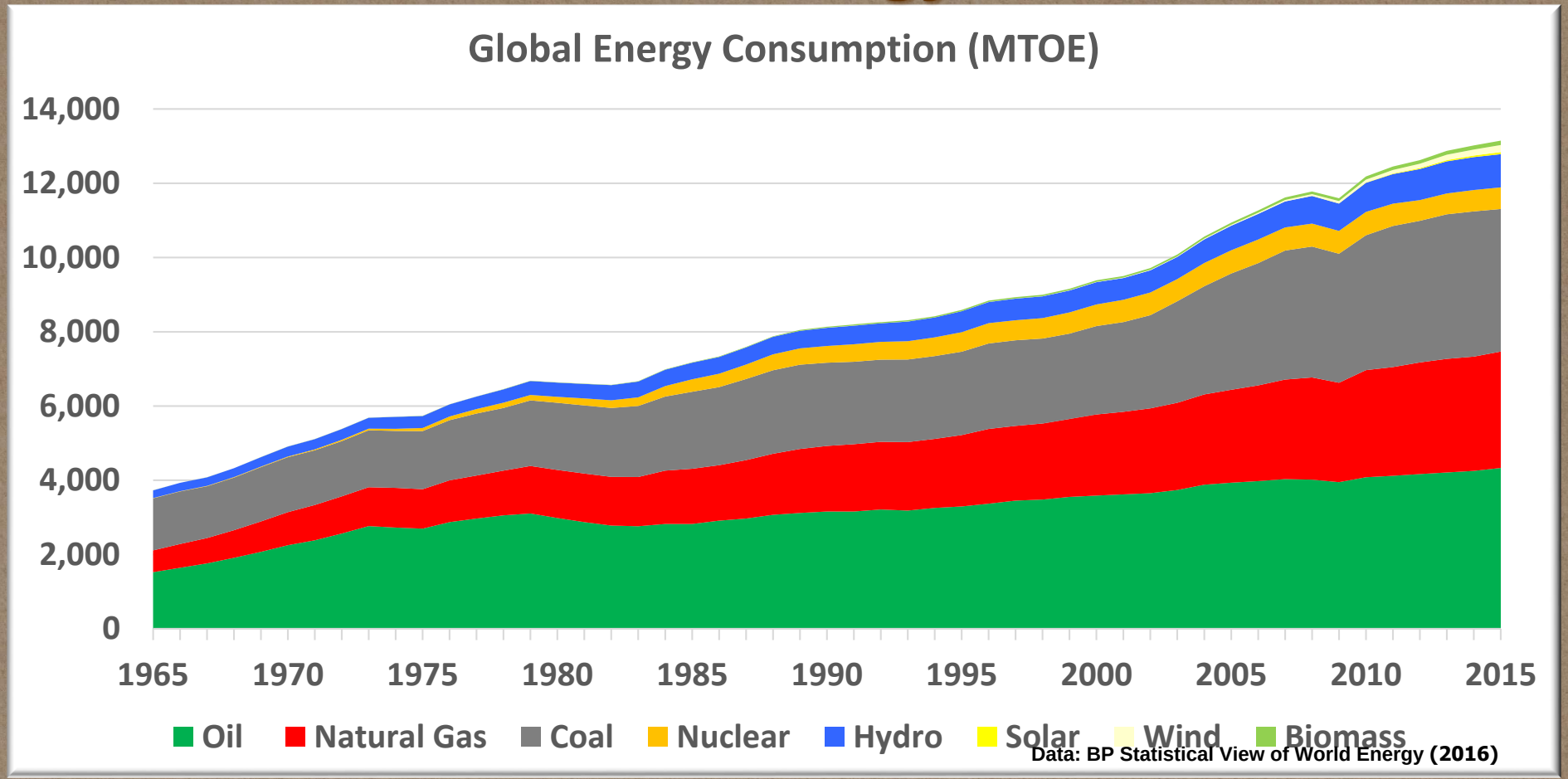
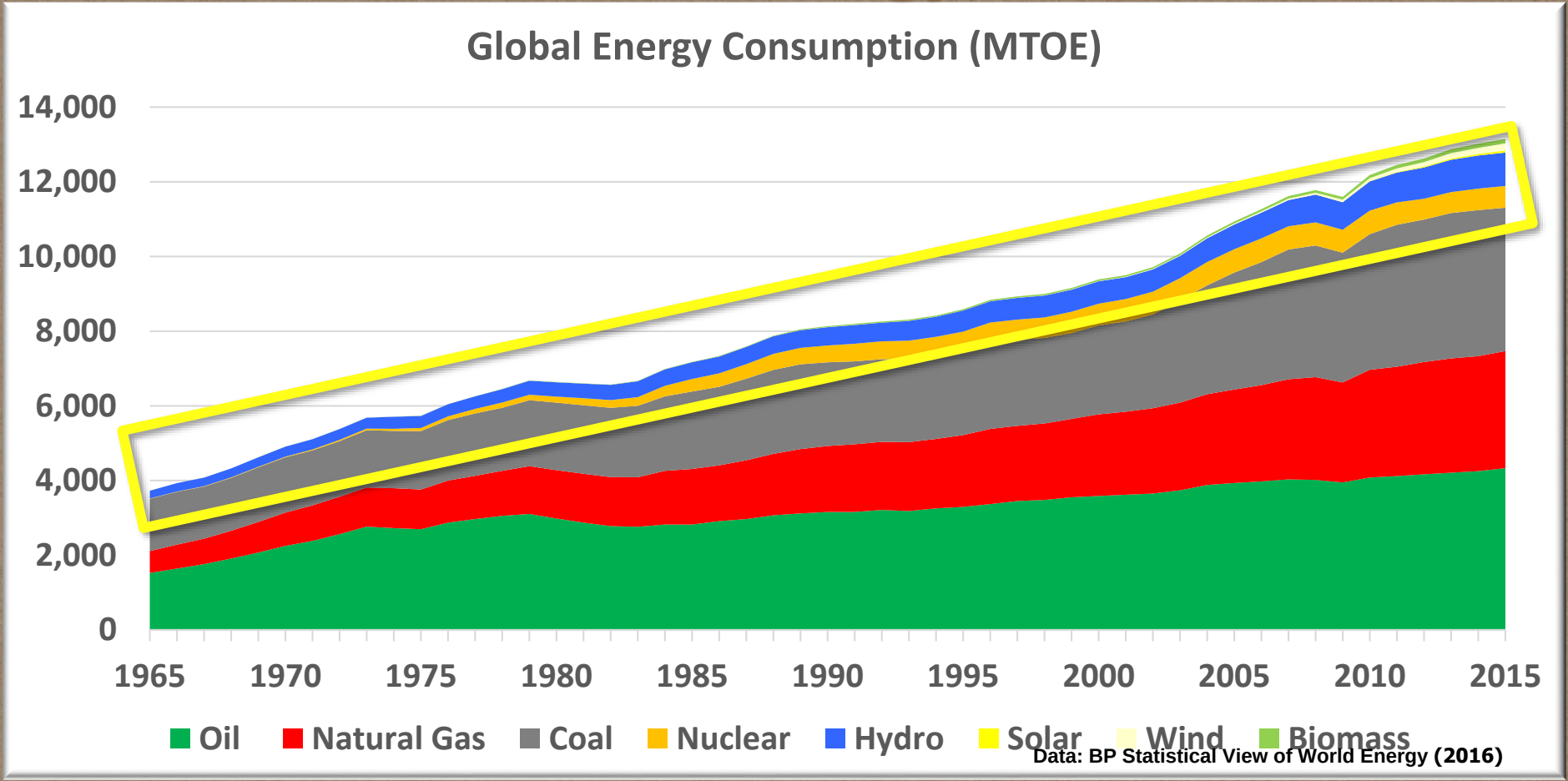


Global Energy Mix



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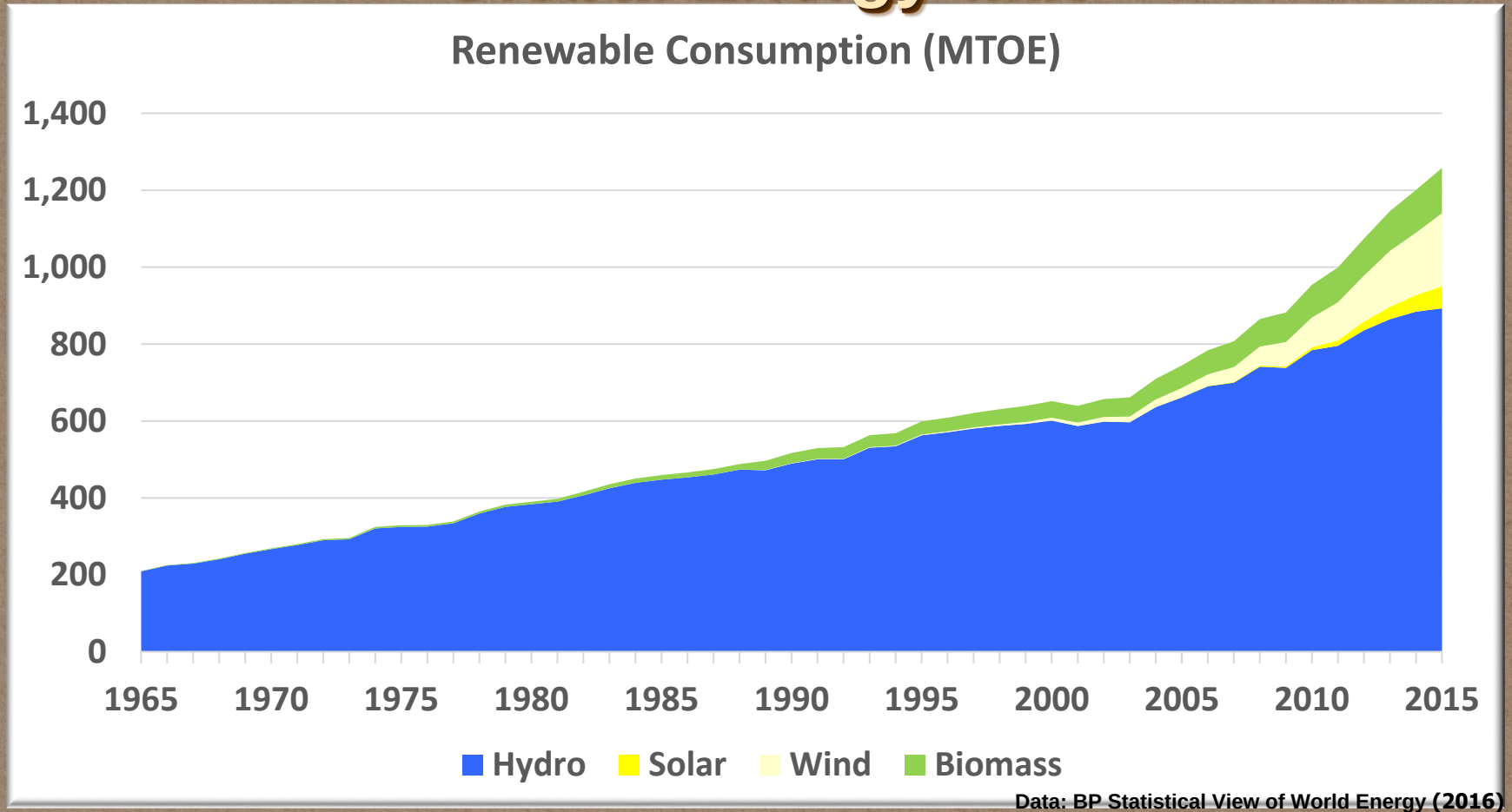

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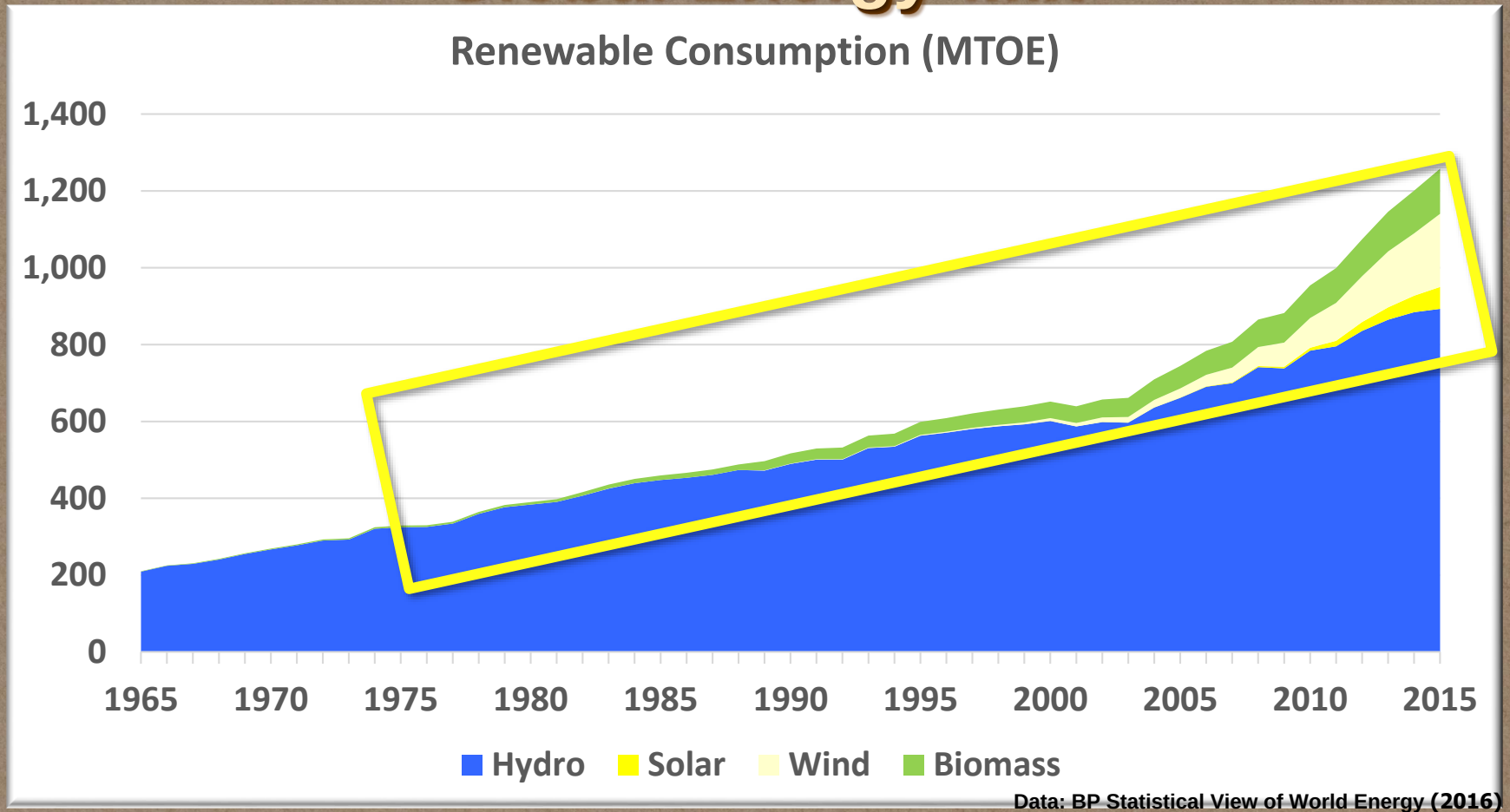
Global Energy Mix



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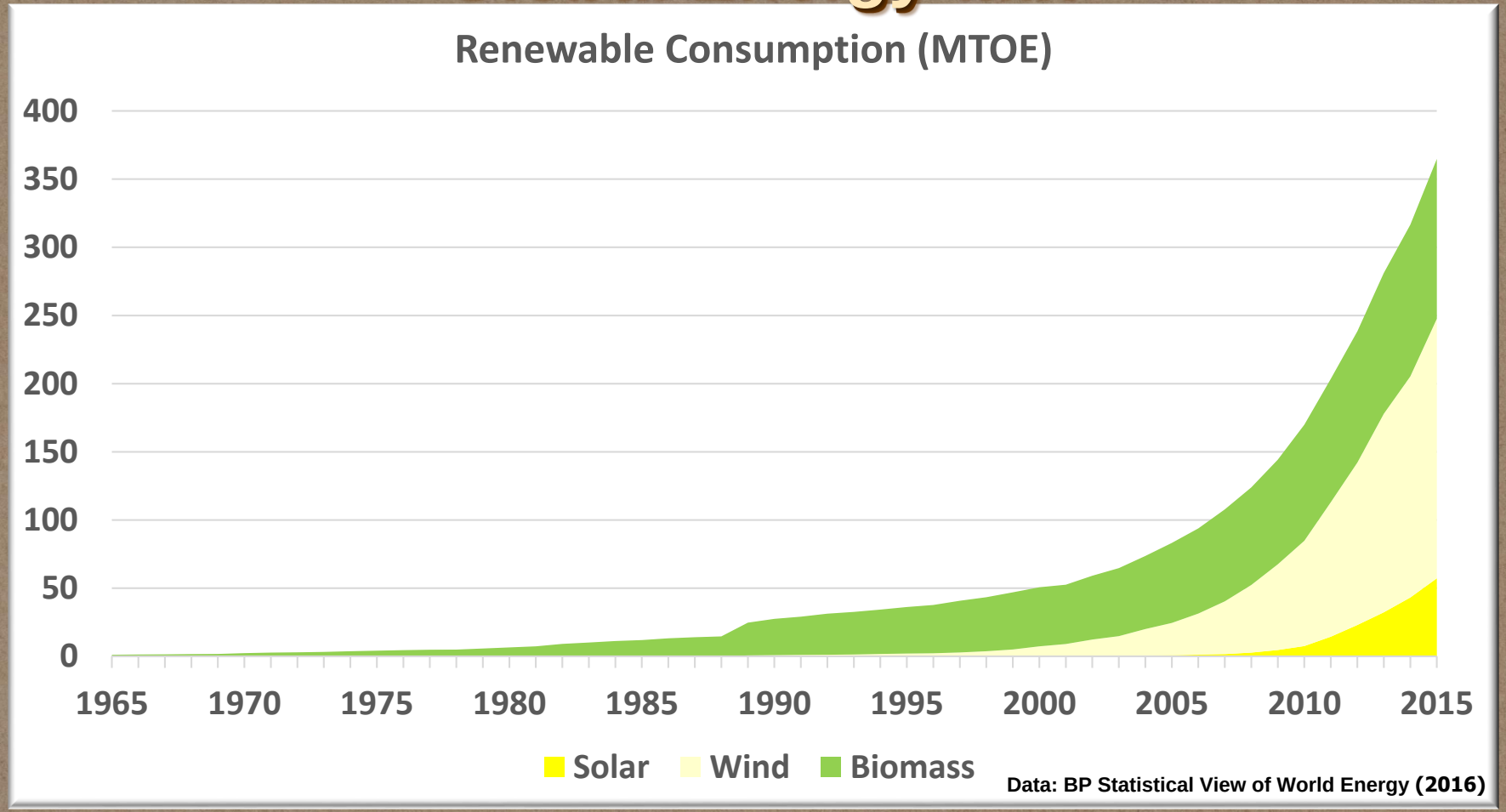
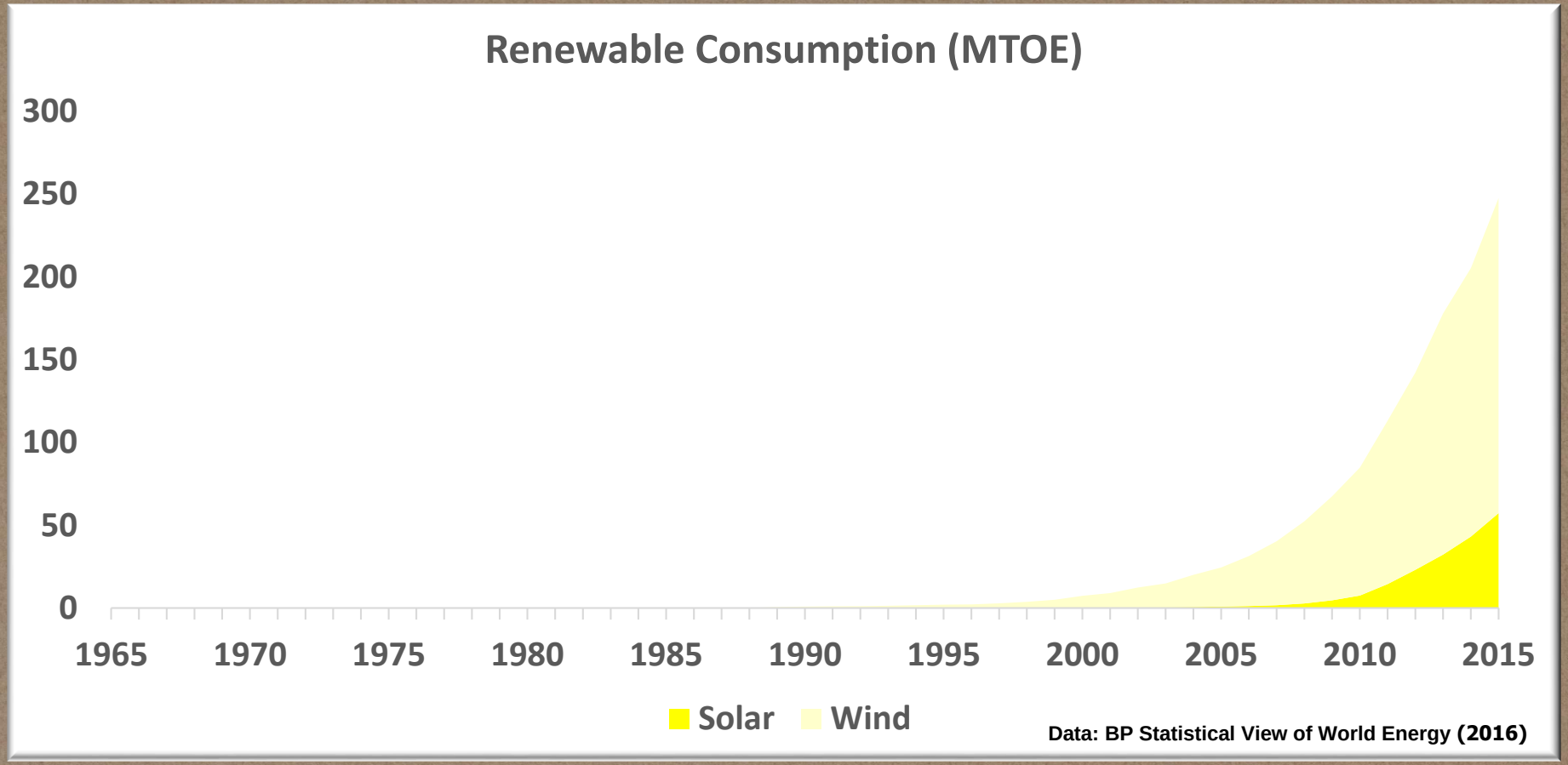


Global Energy Mix



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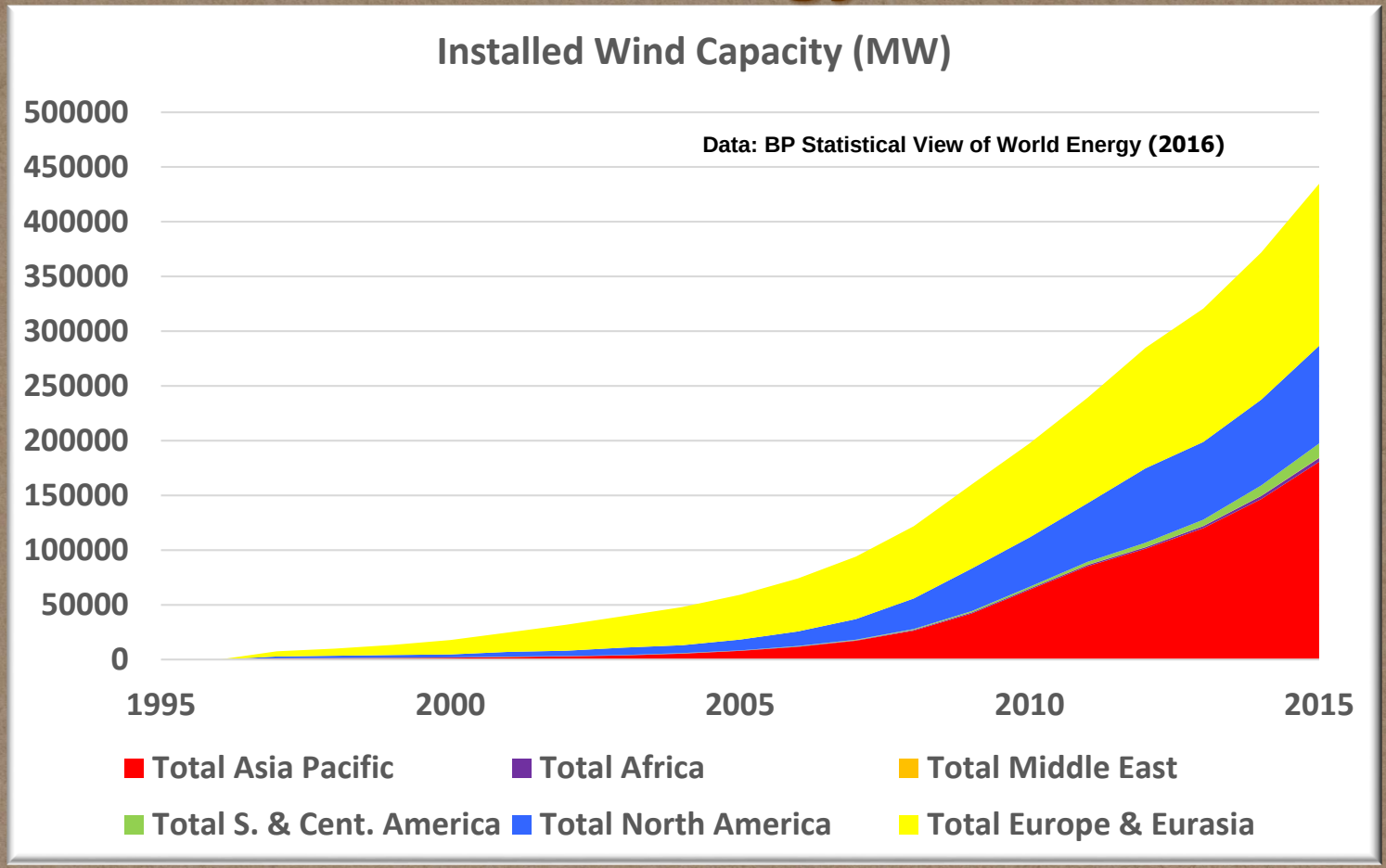
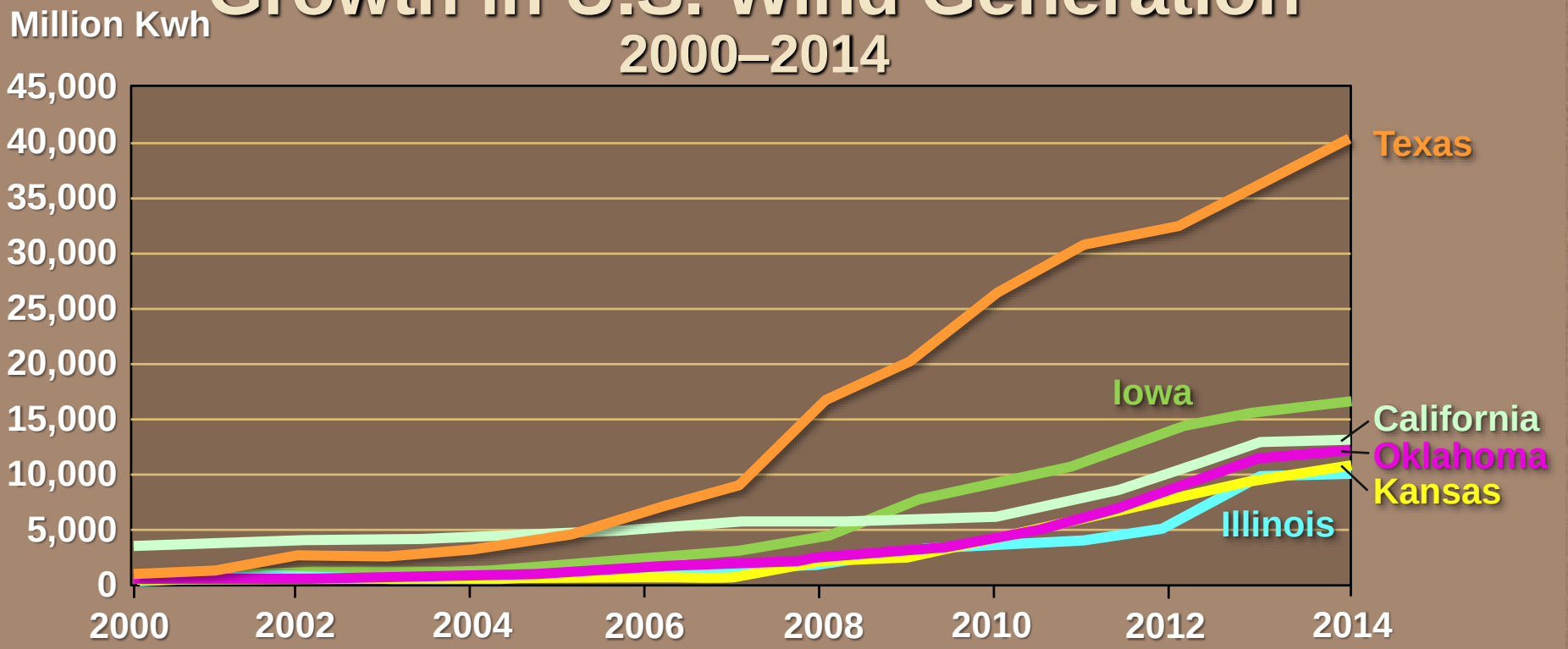
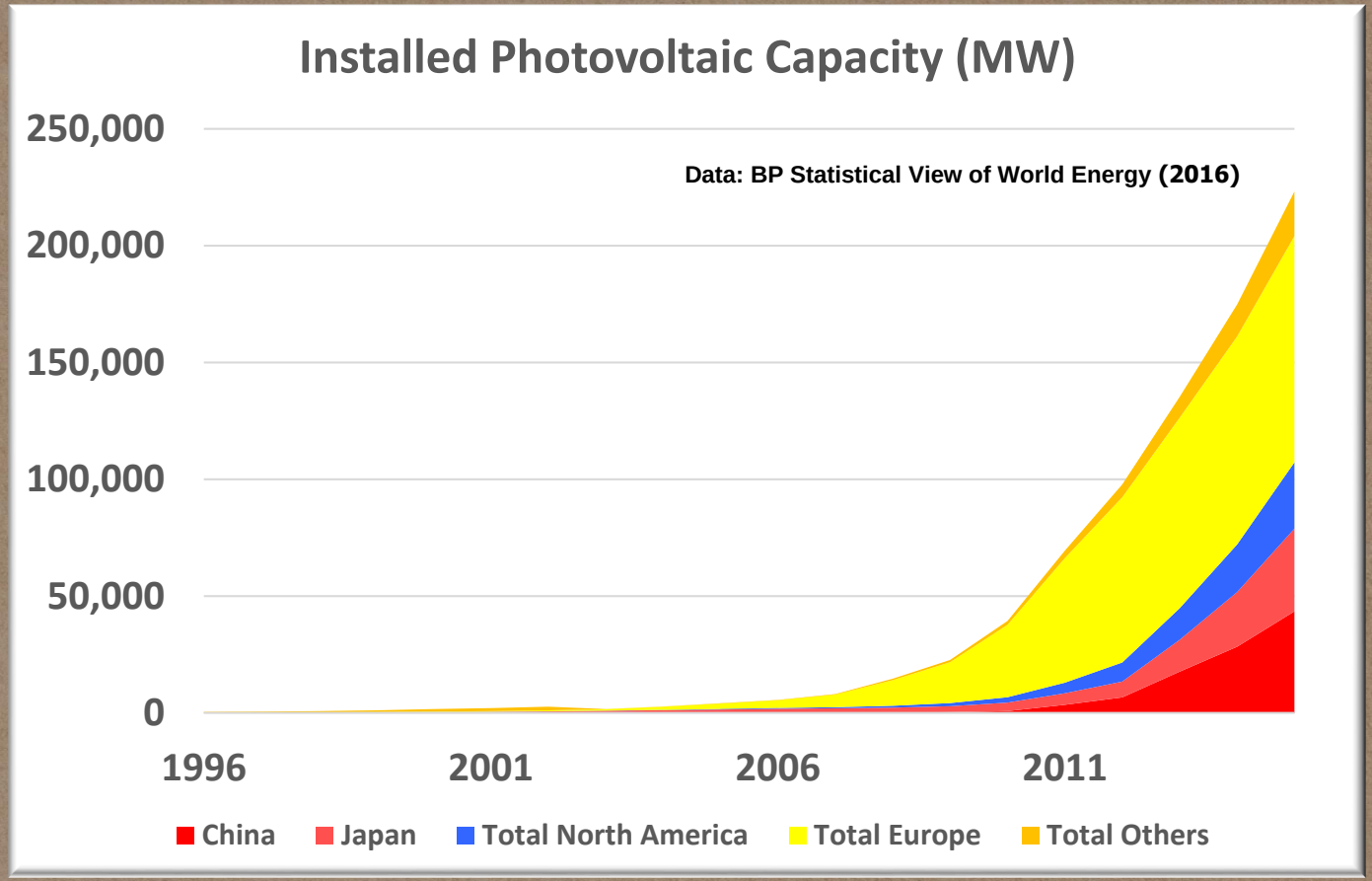


Global Energy Mix

Growth in U.S. Wind Generation



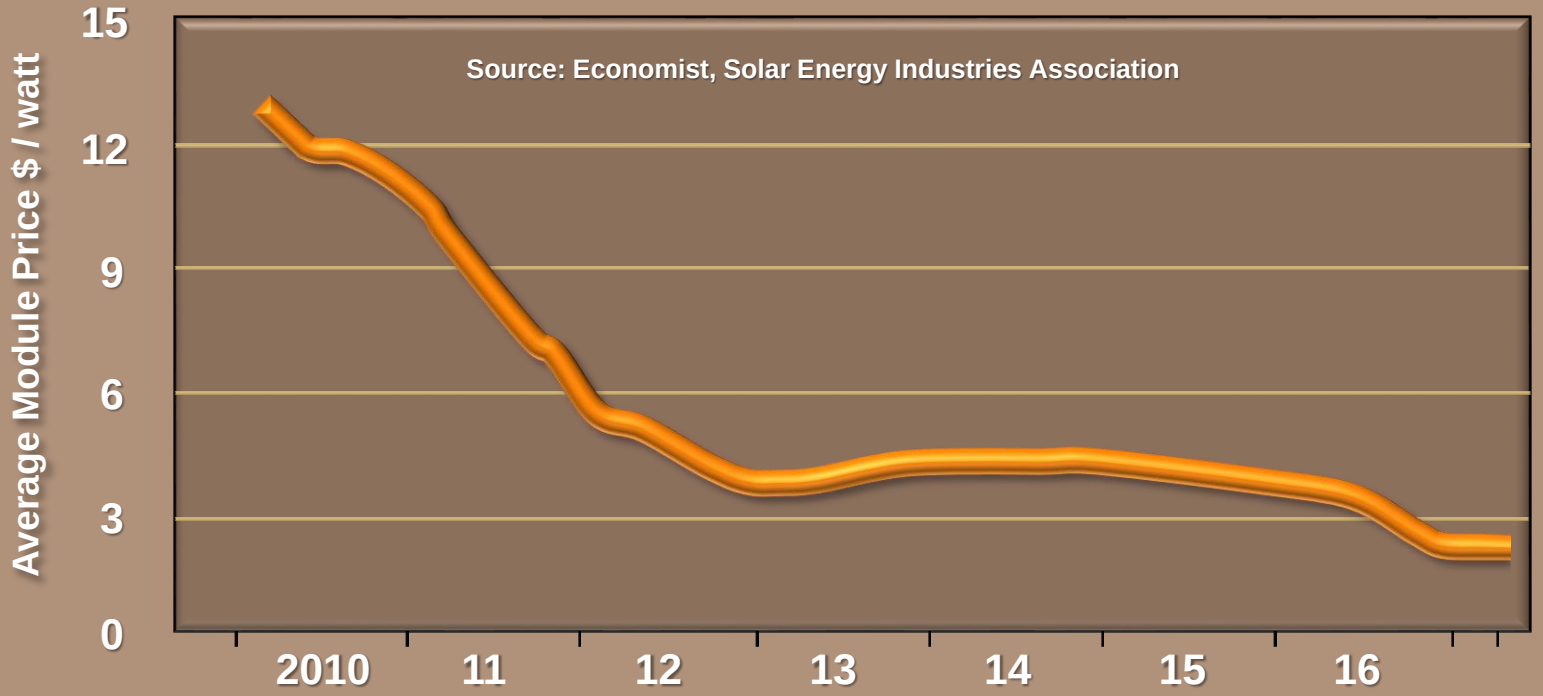
Global Energy Mix



Global Energy Mix

United States

Solar photovoltaics



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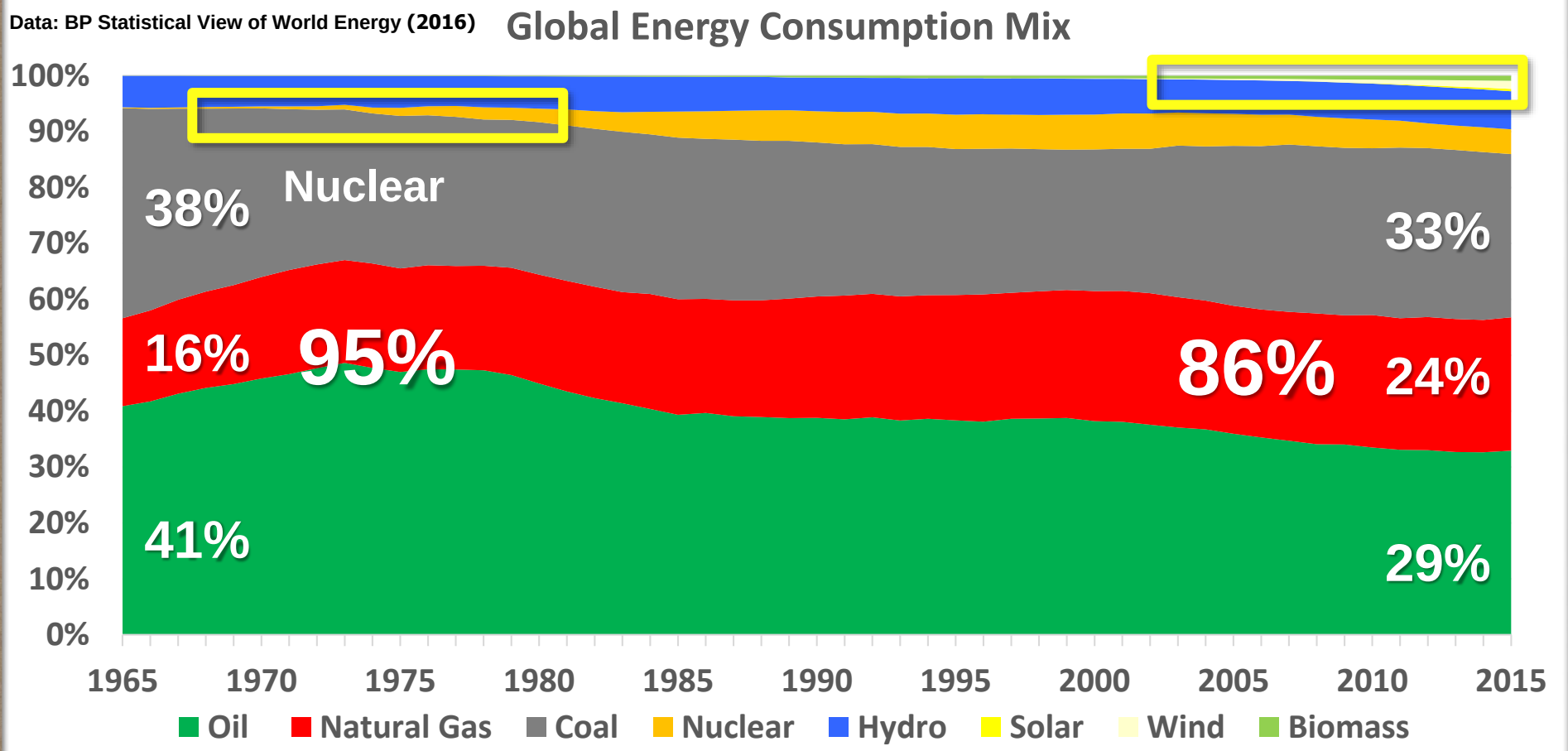
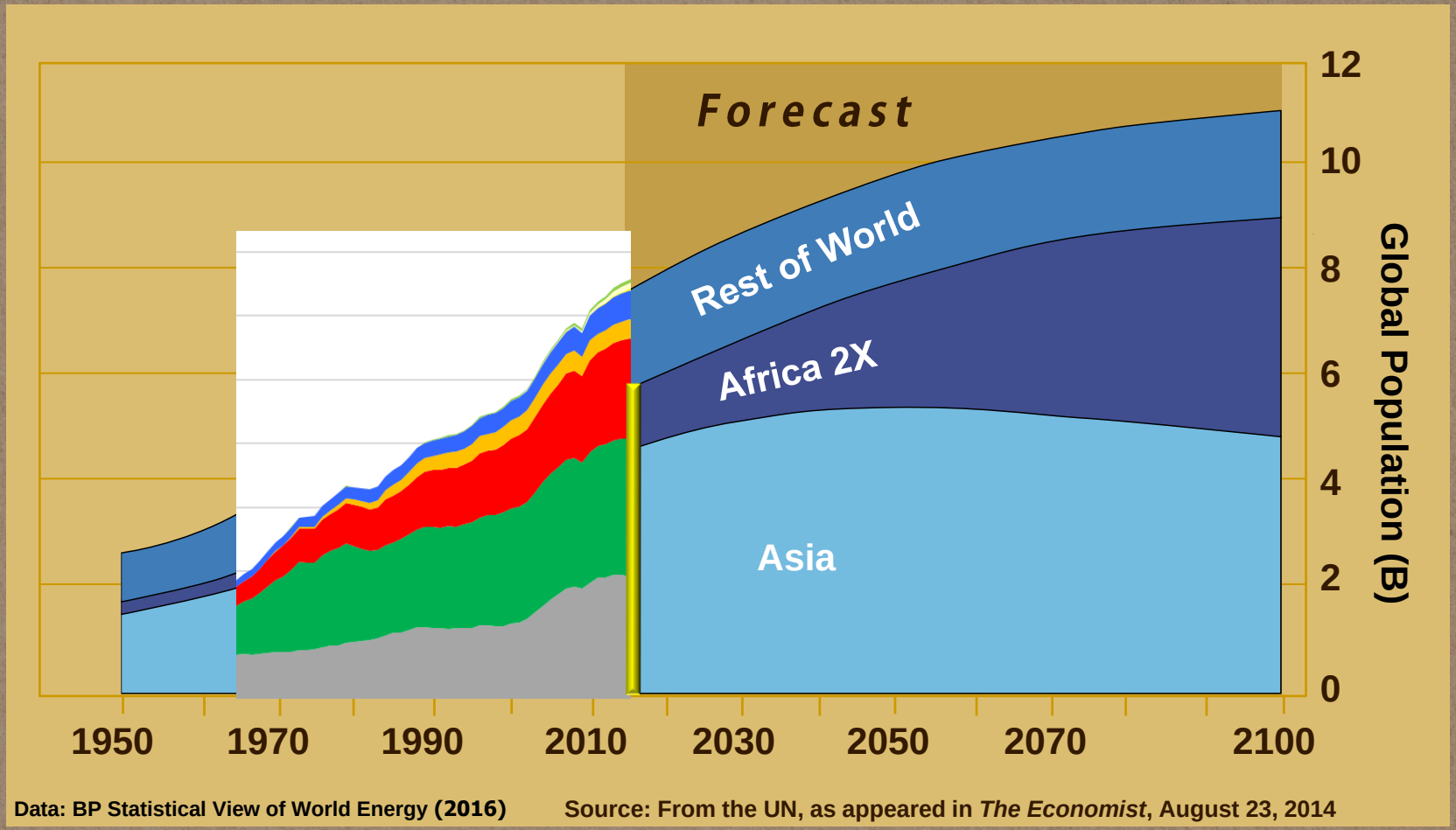
Global Energy Mix



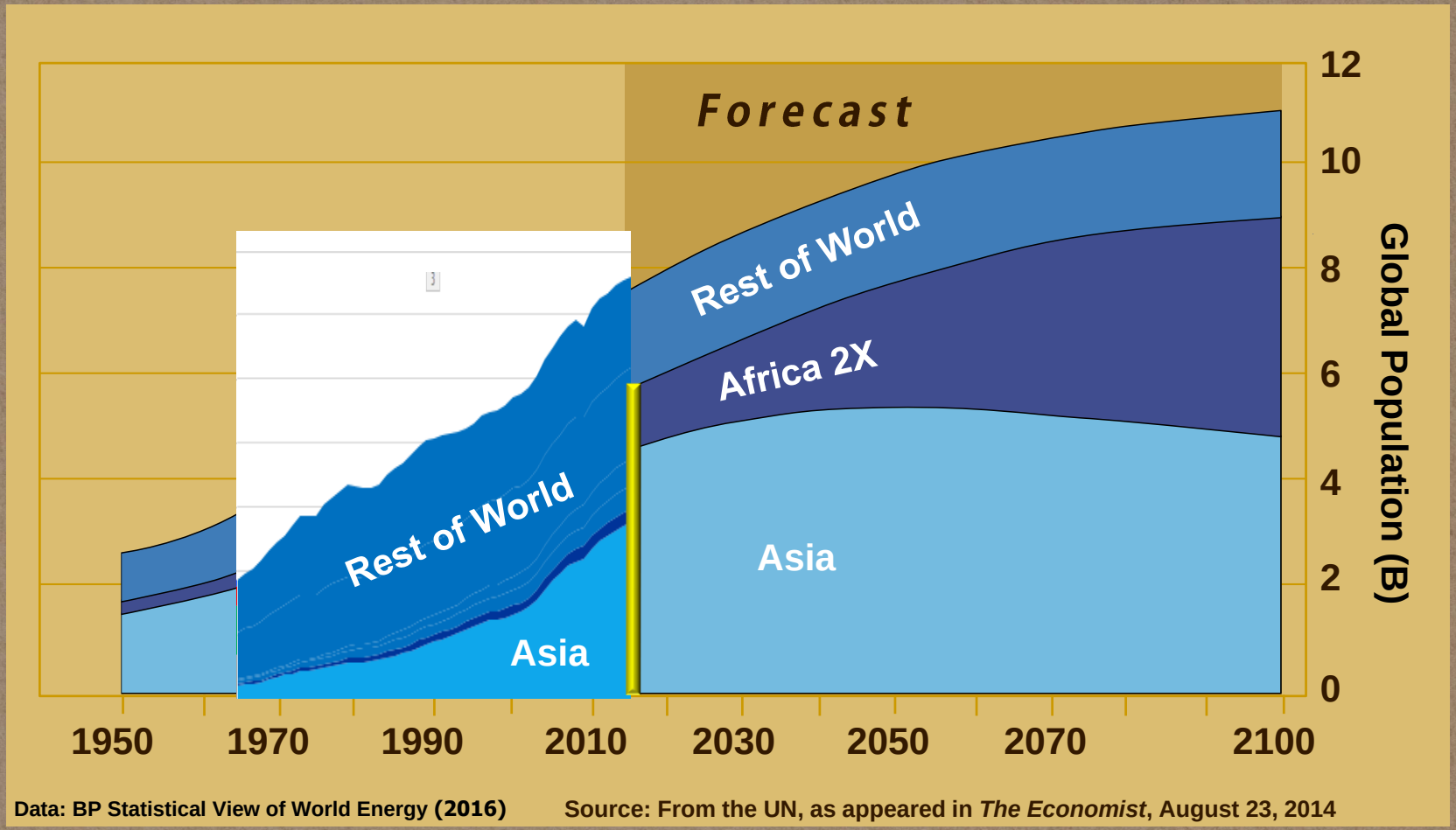
Population and Energy



Data: BP Statistical View of World Energy (2016)

Source: From the UN, as appeared in *The Economist*, August 23, 2014

Population and Energy



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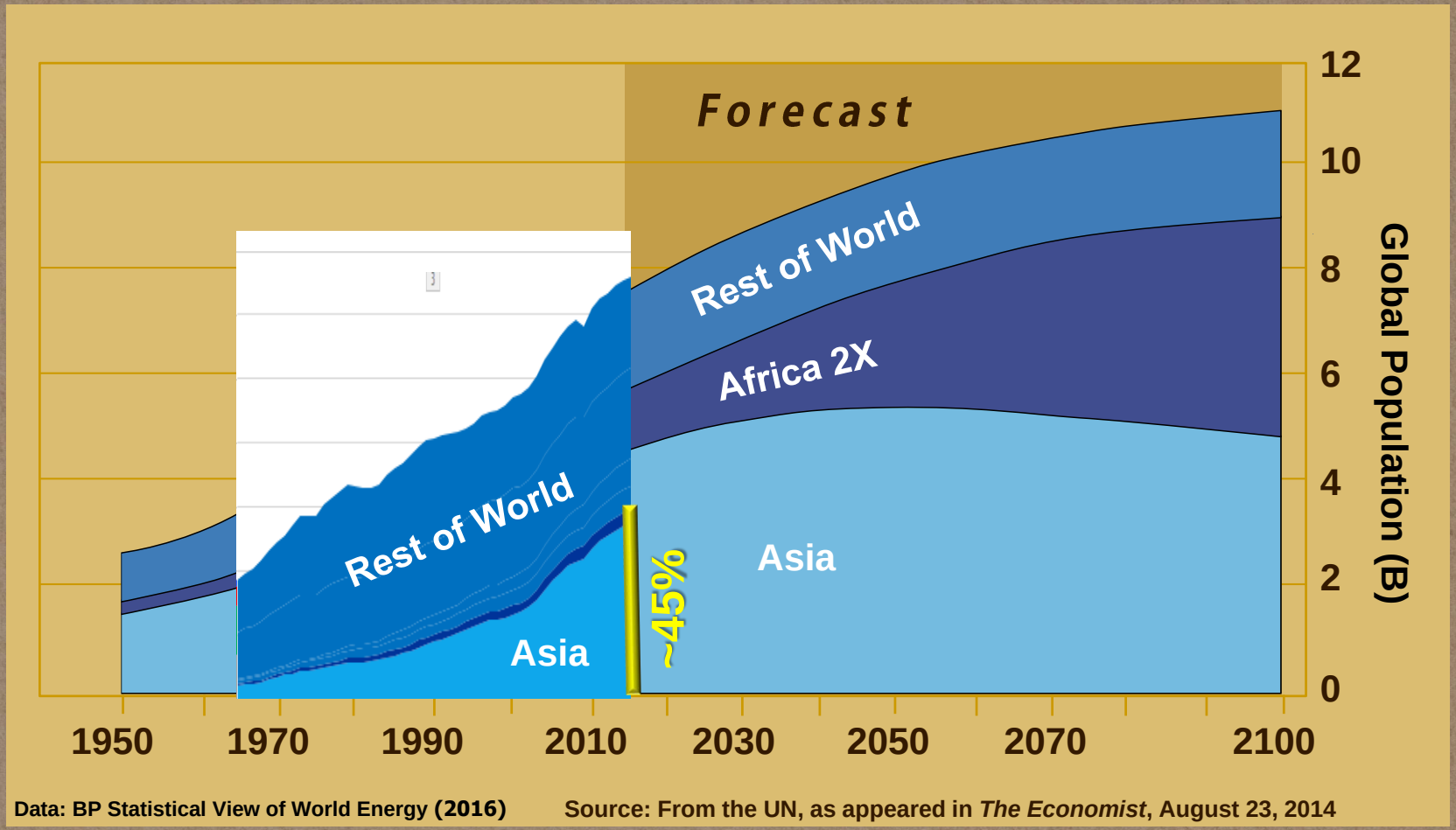

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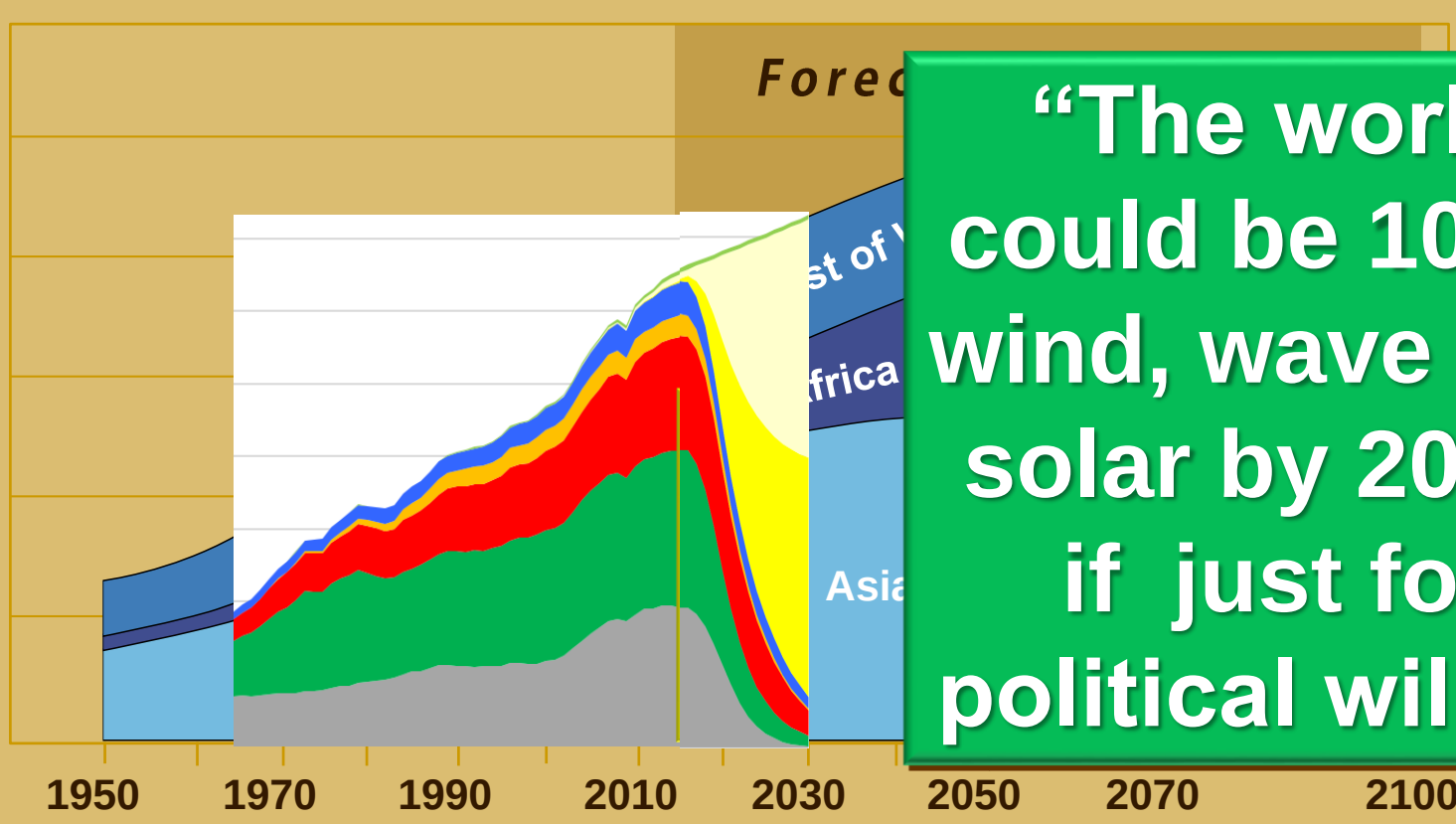

"The world could be 100% wind, wave and solar by 2030, if just for political will…"

Data: BP Statistical View of World Energy (2016)

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Population and Energy

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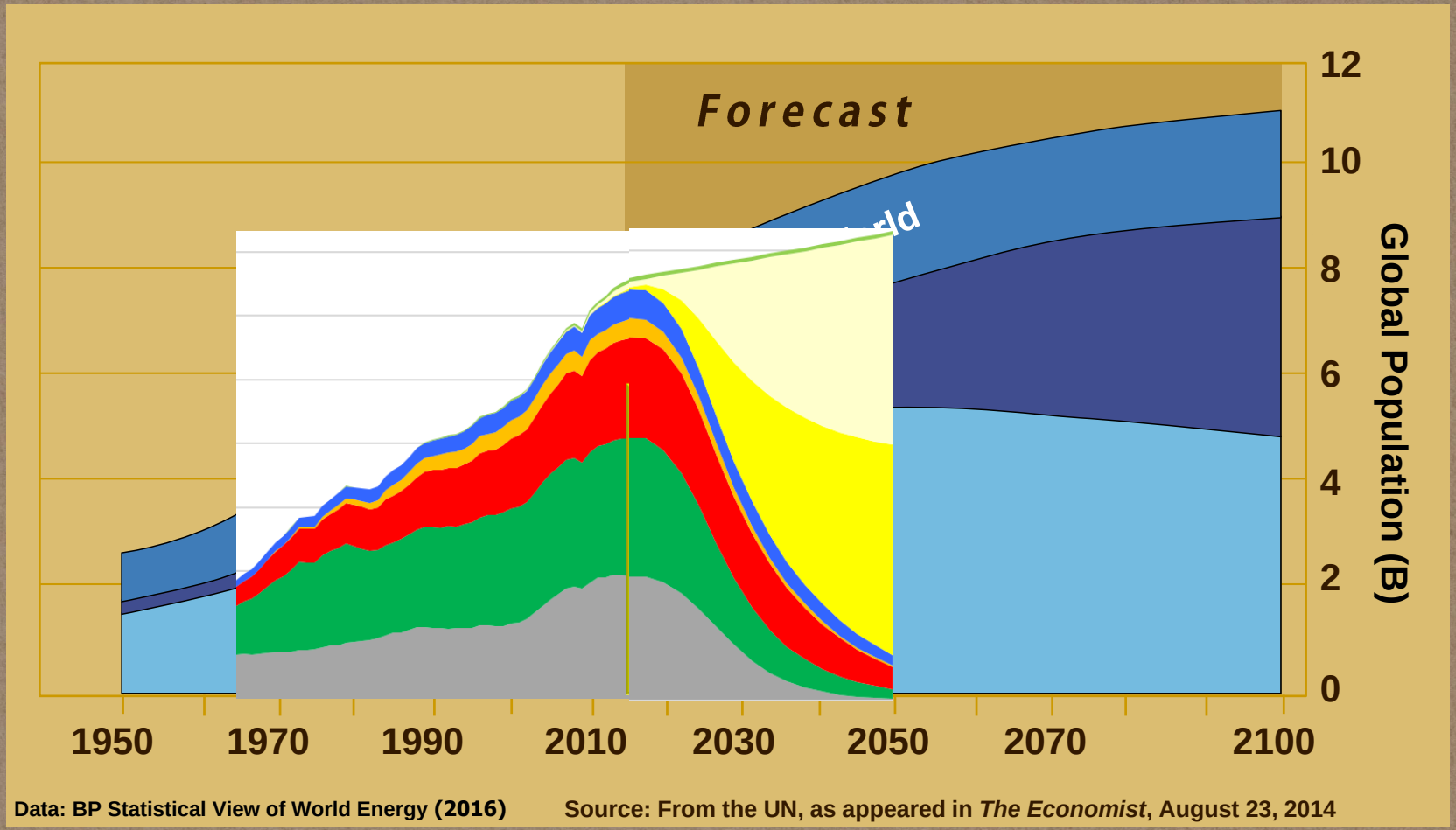

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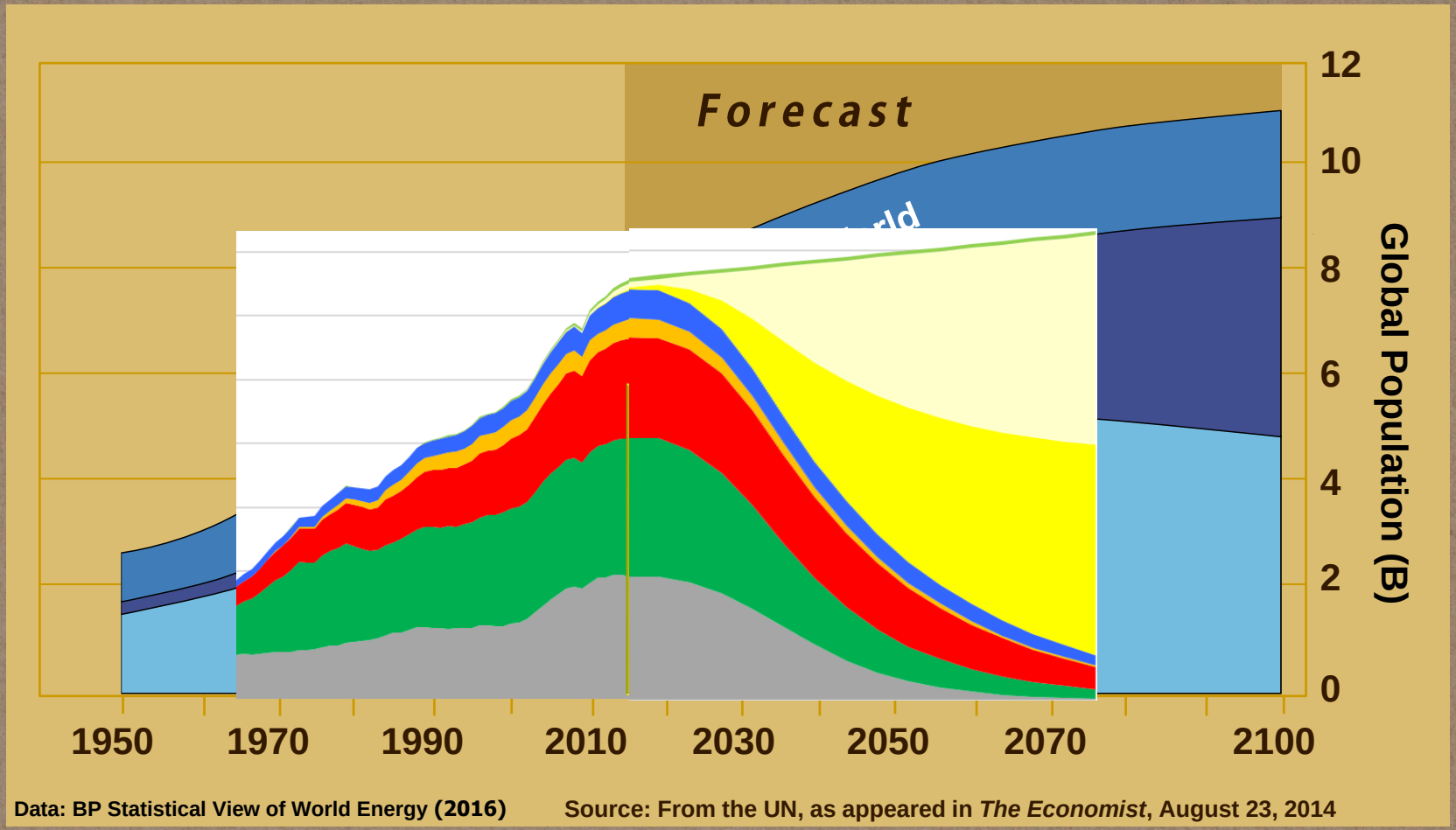

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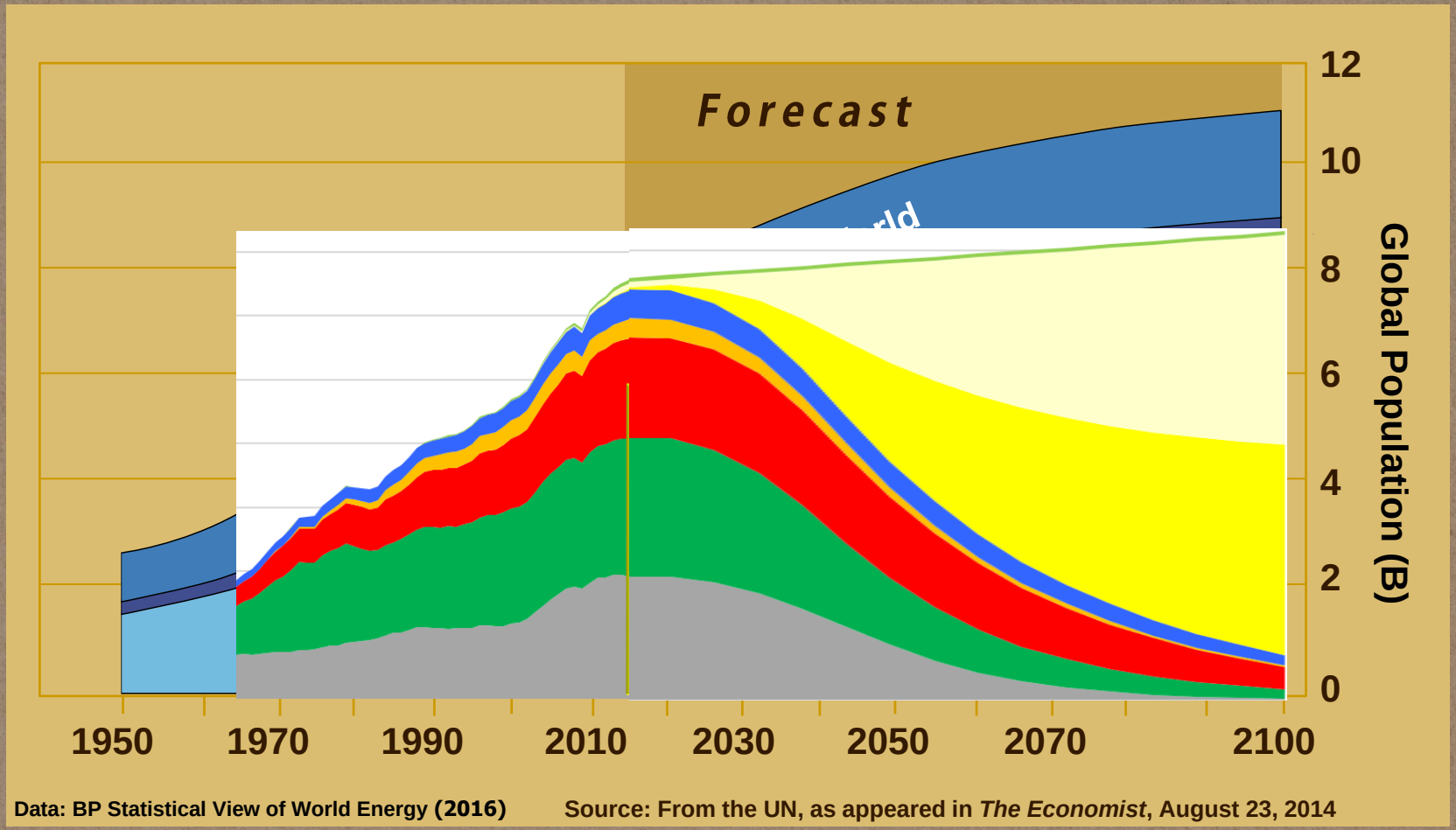


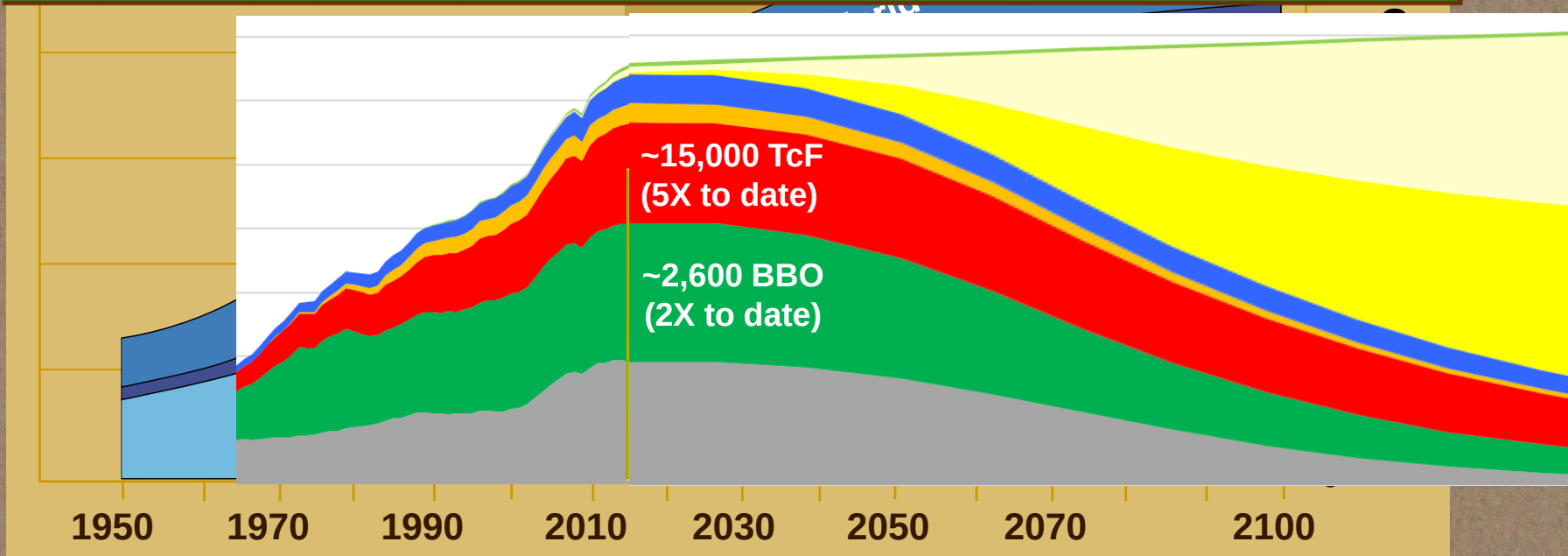
Data: BP Statistical View of World Energy (2016)

Source: From the UN, as appeared in *The Economist*, August 23, 2014

Population and Energy

Are there affordable, available, reliable and sustainable:

- **fossil energy and nuclear resources to meet this demand?**
- **renewable energy resources to meet this demand?**



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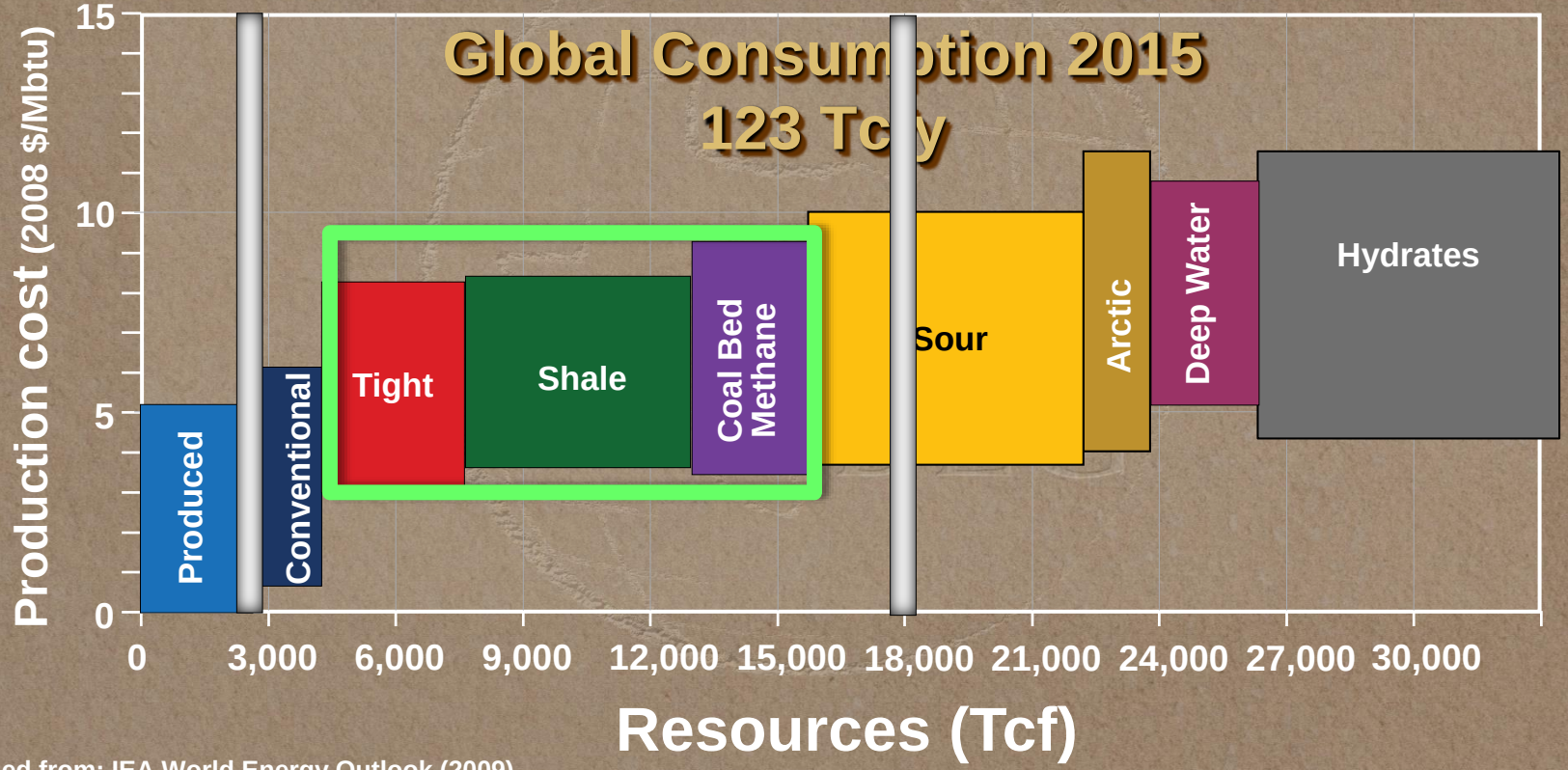
Natural Gas Cost of Supply

Resources v. Cost



Modified from: IEA World Energy Outlook (2009)

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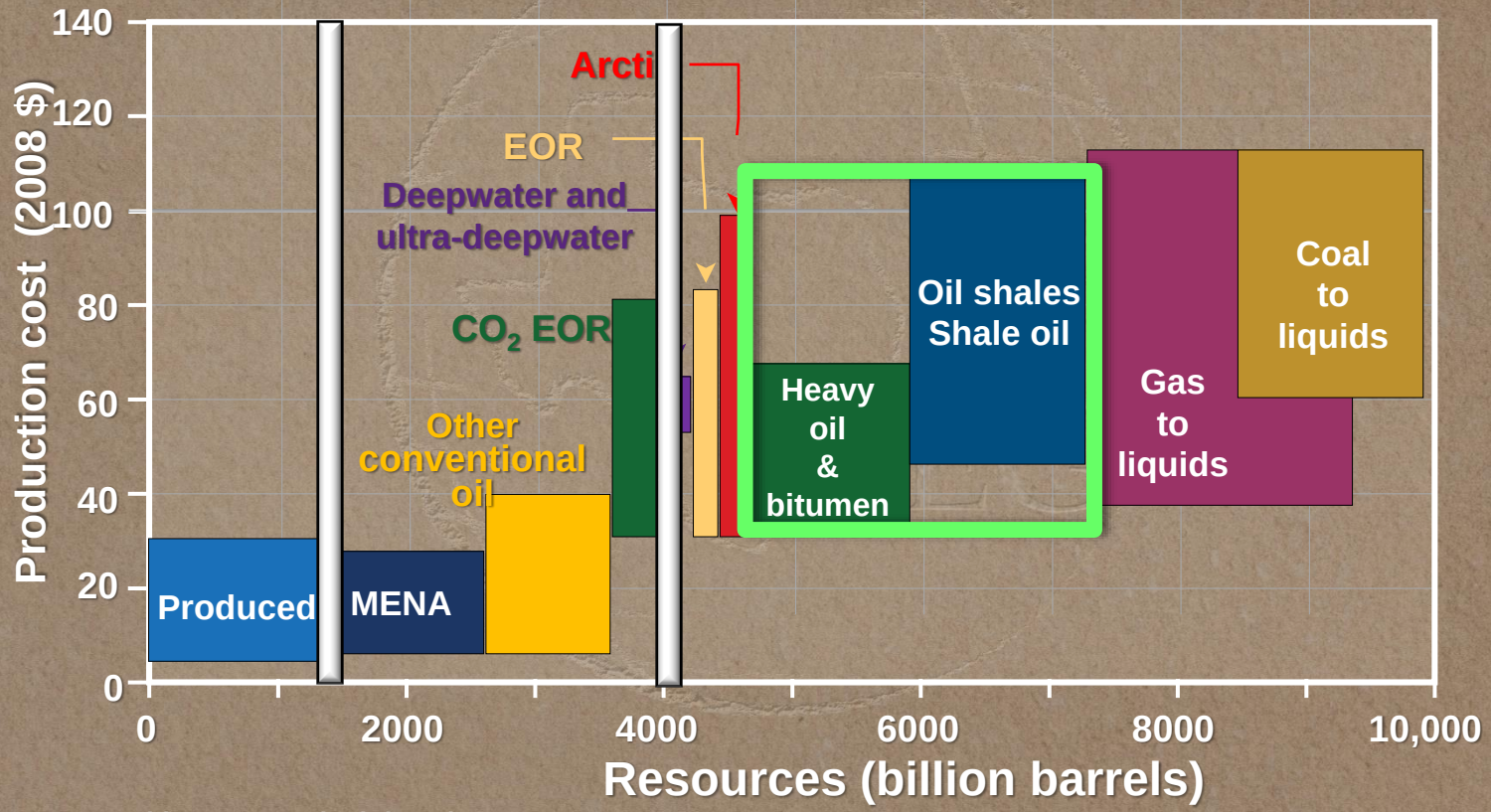
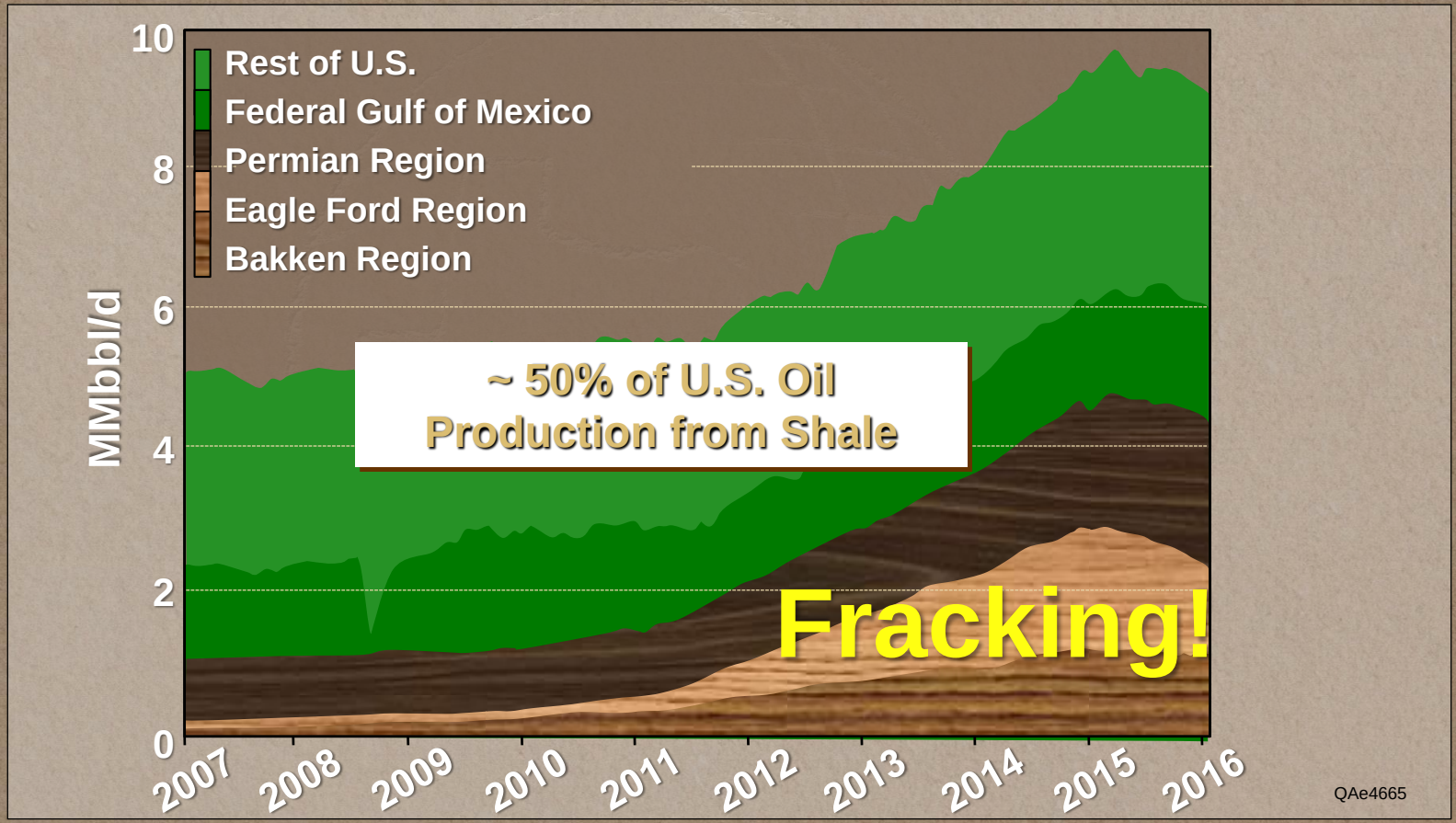
Oil Cost of Supply

Resources and Cost



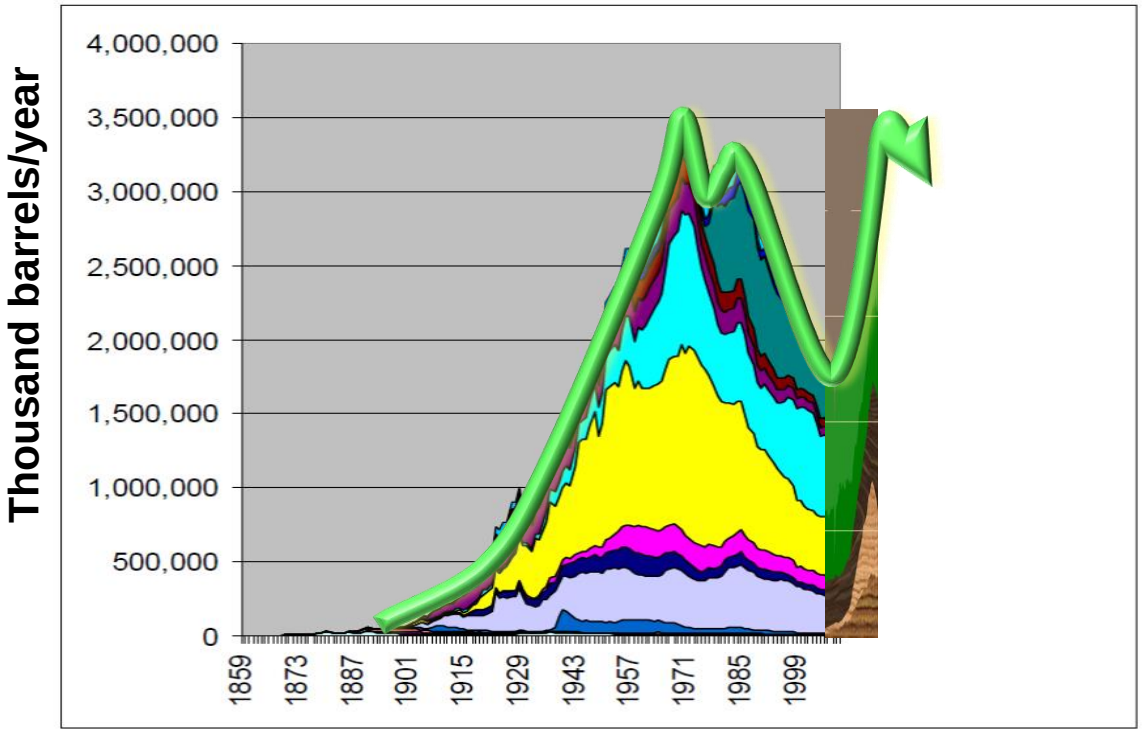
Modified from: IEA World Energy Outlook (2009)

U.S. Crude Oil Production



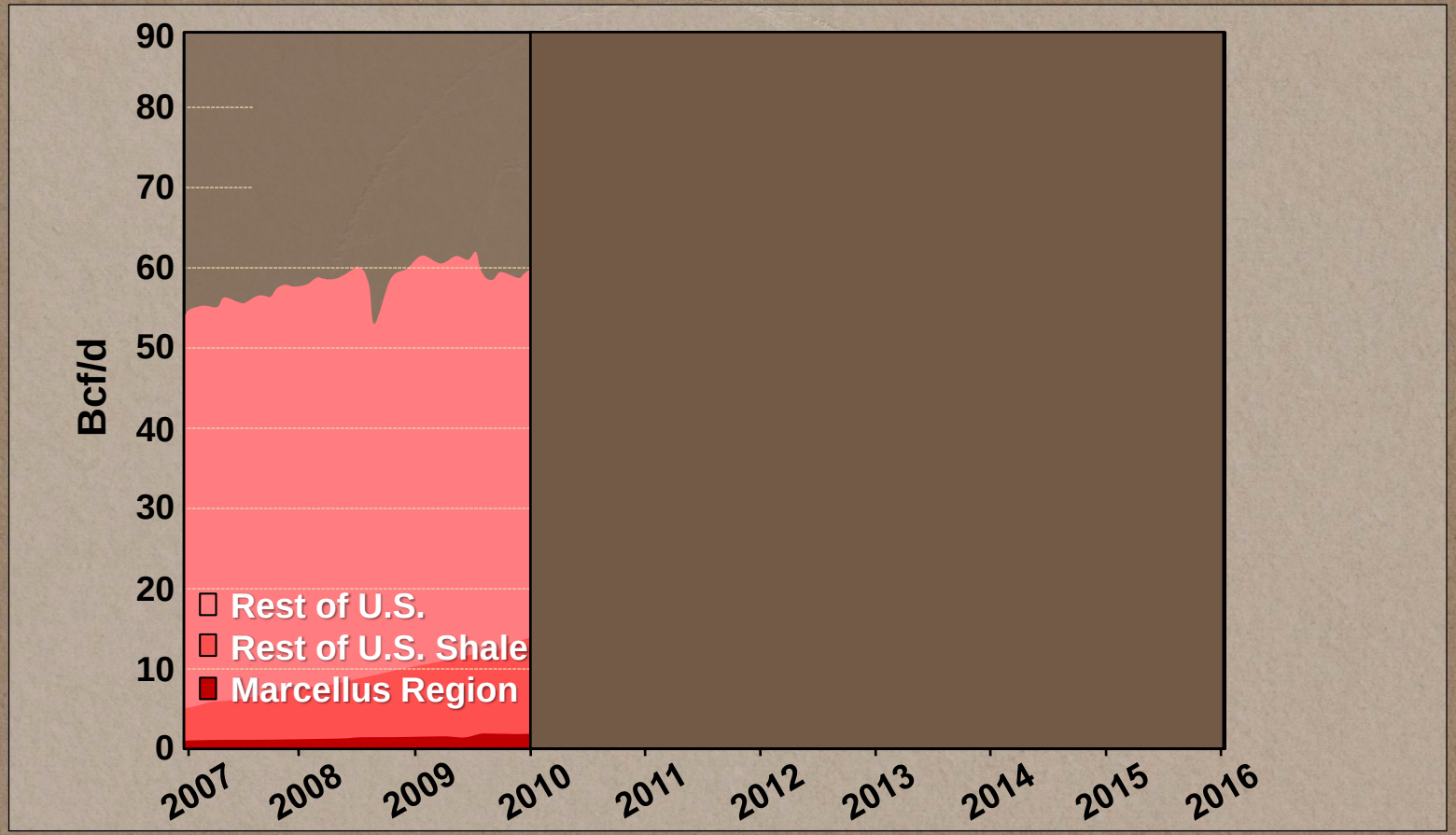
Source:
U.S. Energy Information Administration
Drilling Productivity Report regions, *Petroleum Supply Monthly*, *Natural Gas Monthly*

Annual US Oil Production



From: James D. Hamilton, Working Paper 17759, NATIONAL BUREAU OF ECONOMIC RESEARCH, 2012

U.S. Marketed Natural Gas Production



Source:
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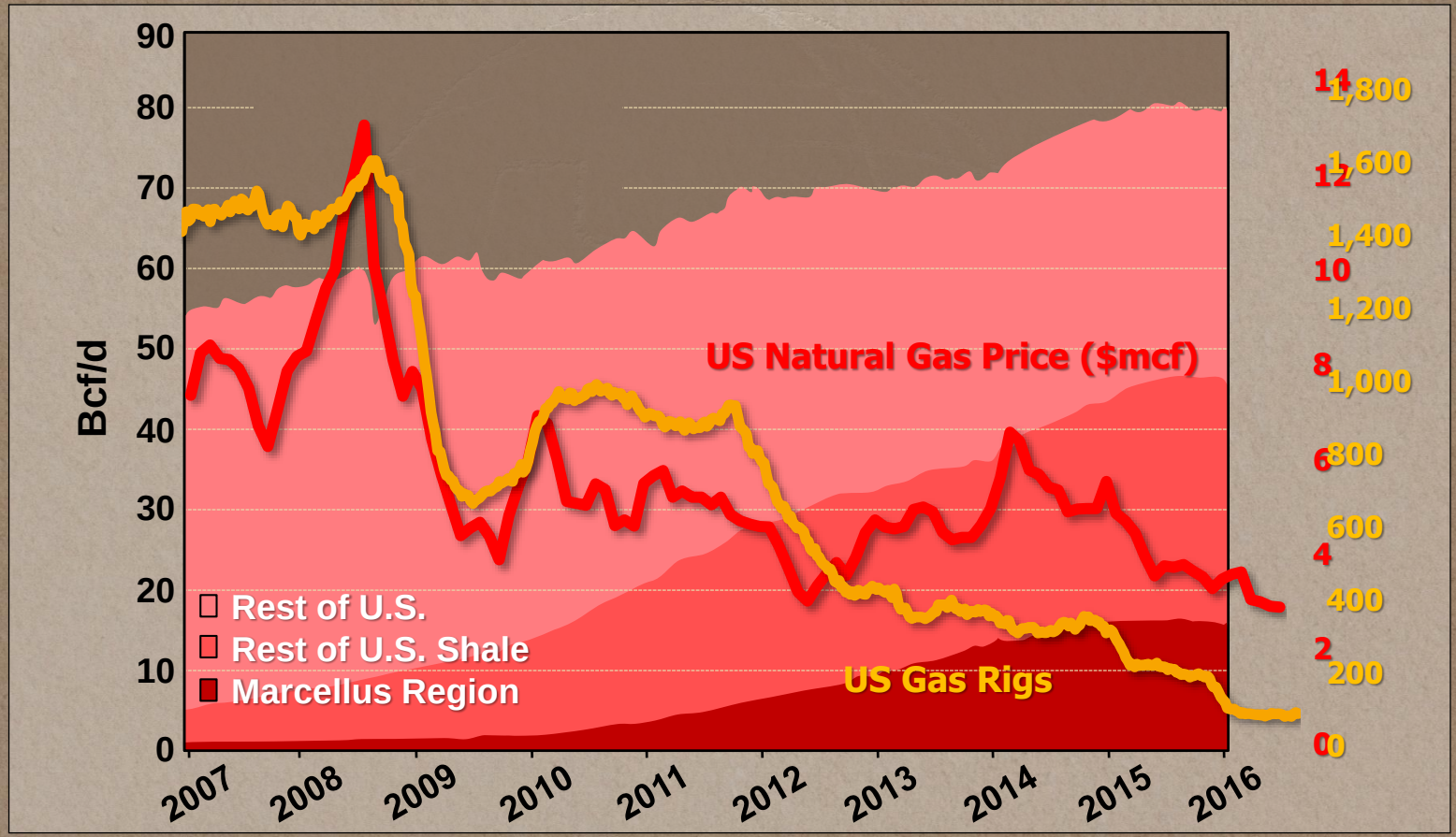
U.S. Marketed Natural Gas Production



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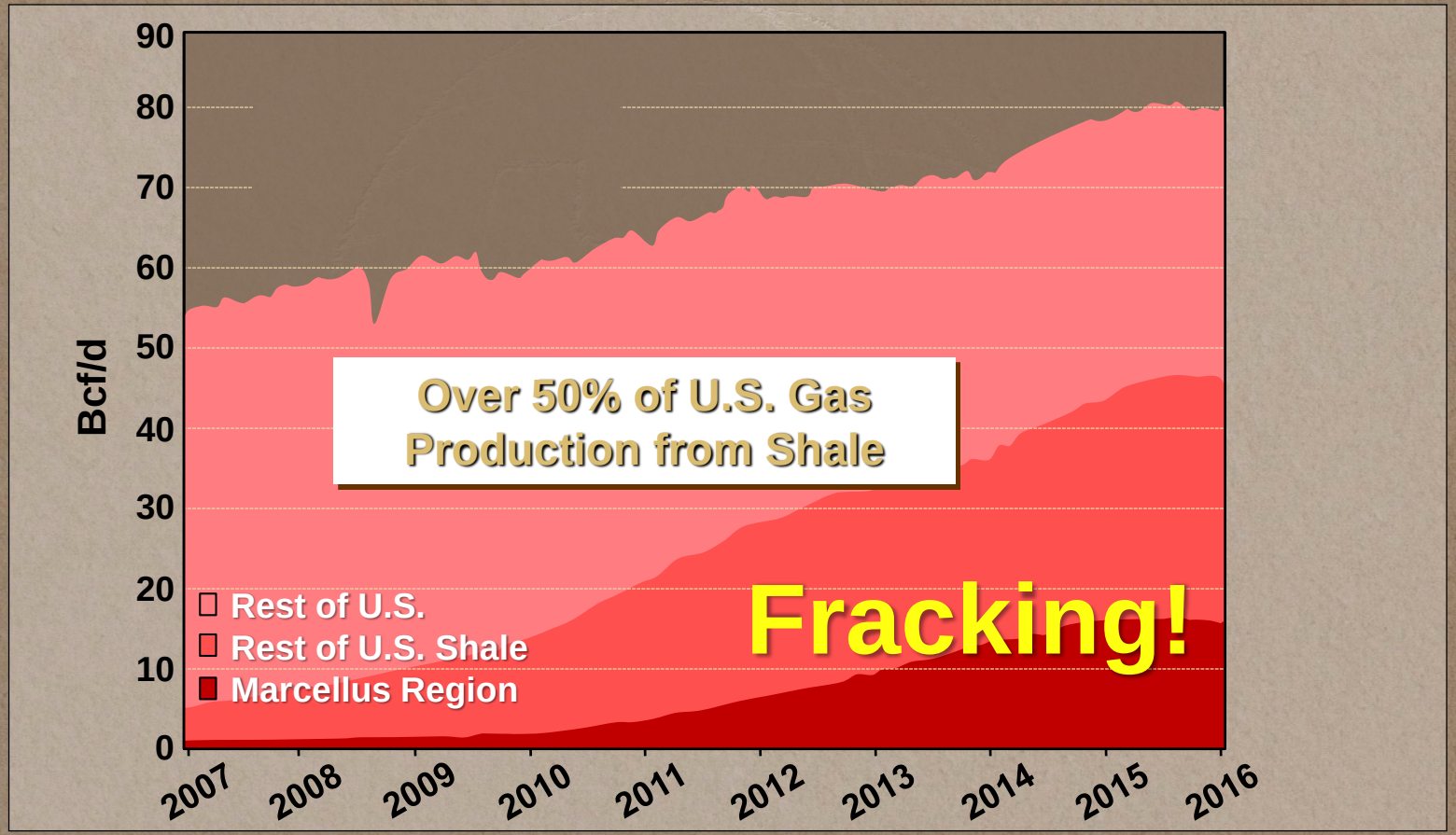

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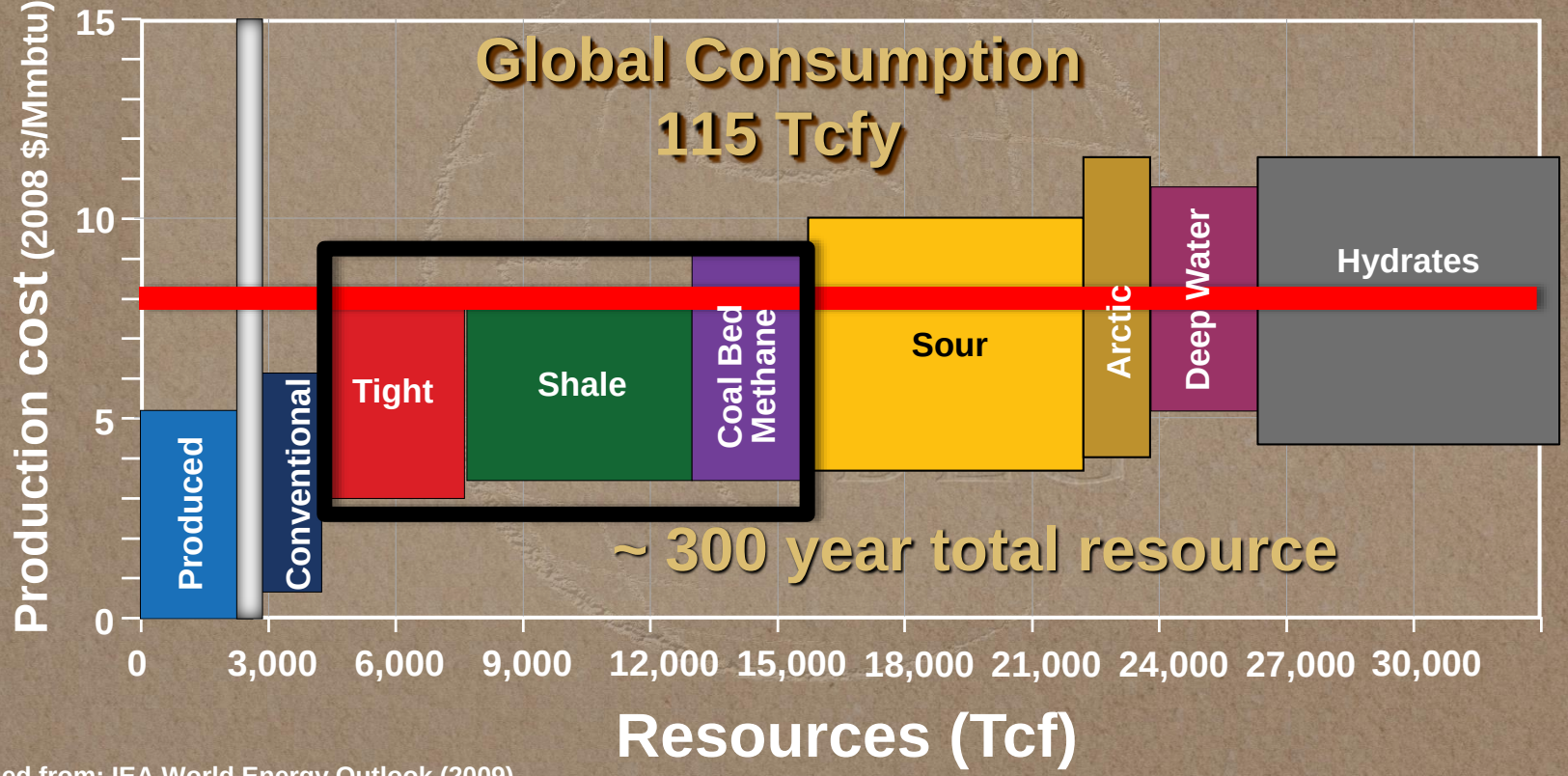
Drilling Productivity Report regions, *Petroleum Supply Monthly*, *Natural Gas Monthly*

Natural Gas Cost of Supply

Resources v. Cost



Modified from: IEA World Energy Outlook (2009)

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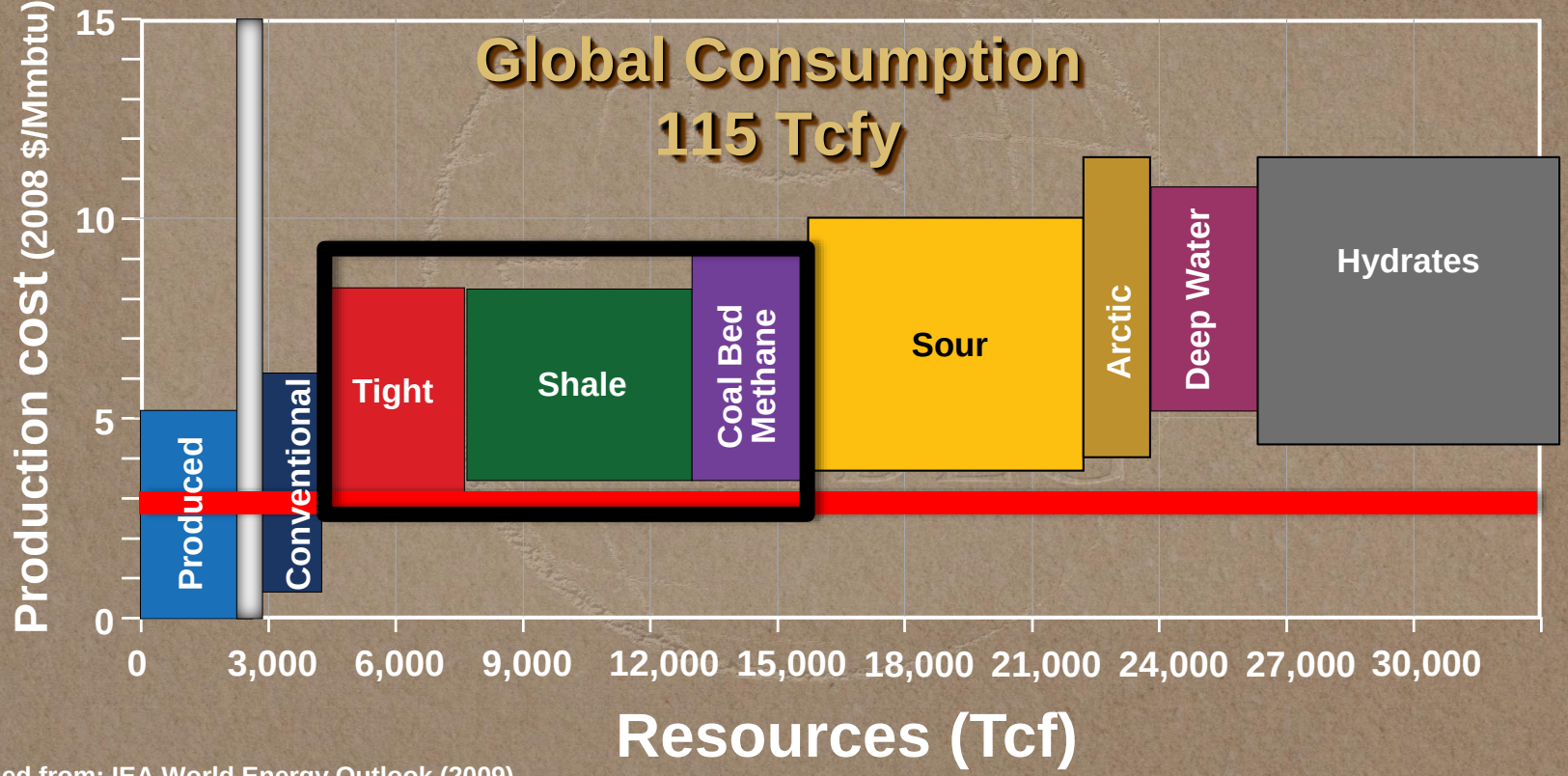

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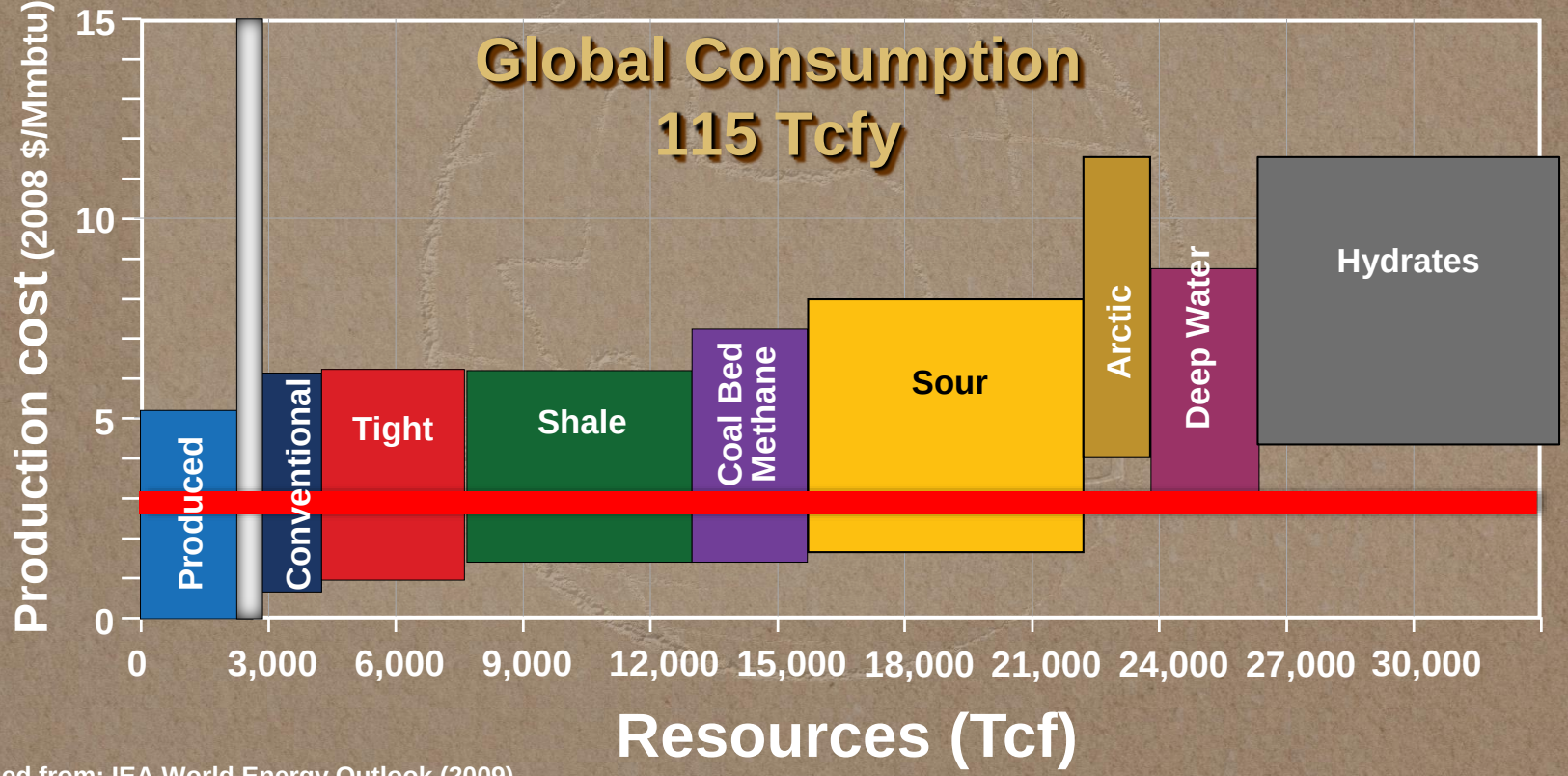


Modified from: IEA World Energy Outlook (2009)

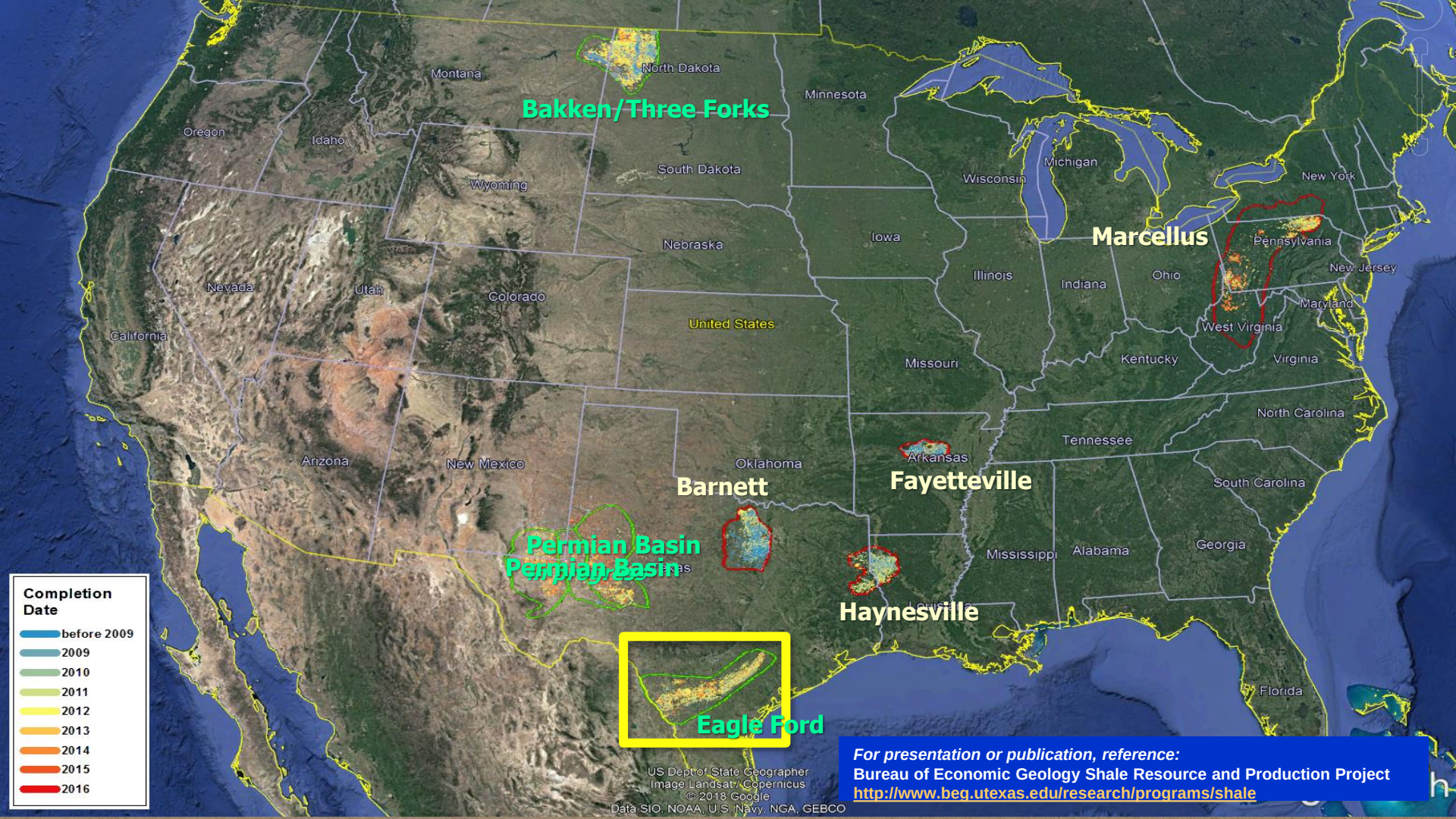
Natural Gas Cost of Supply

Resources v. Cost

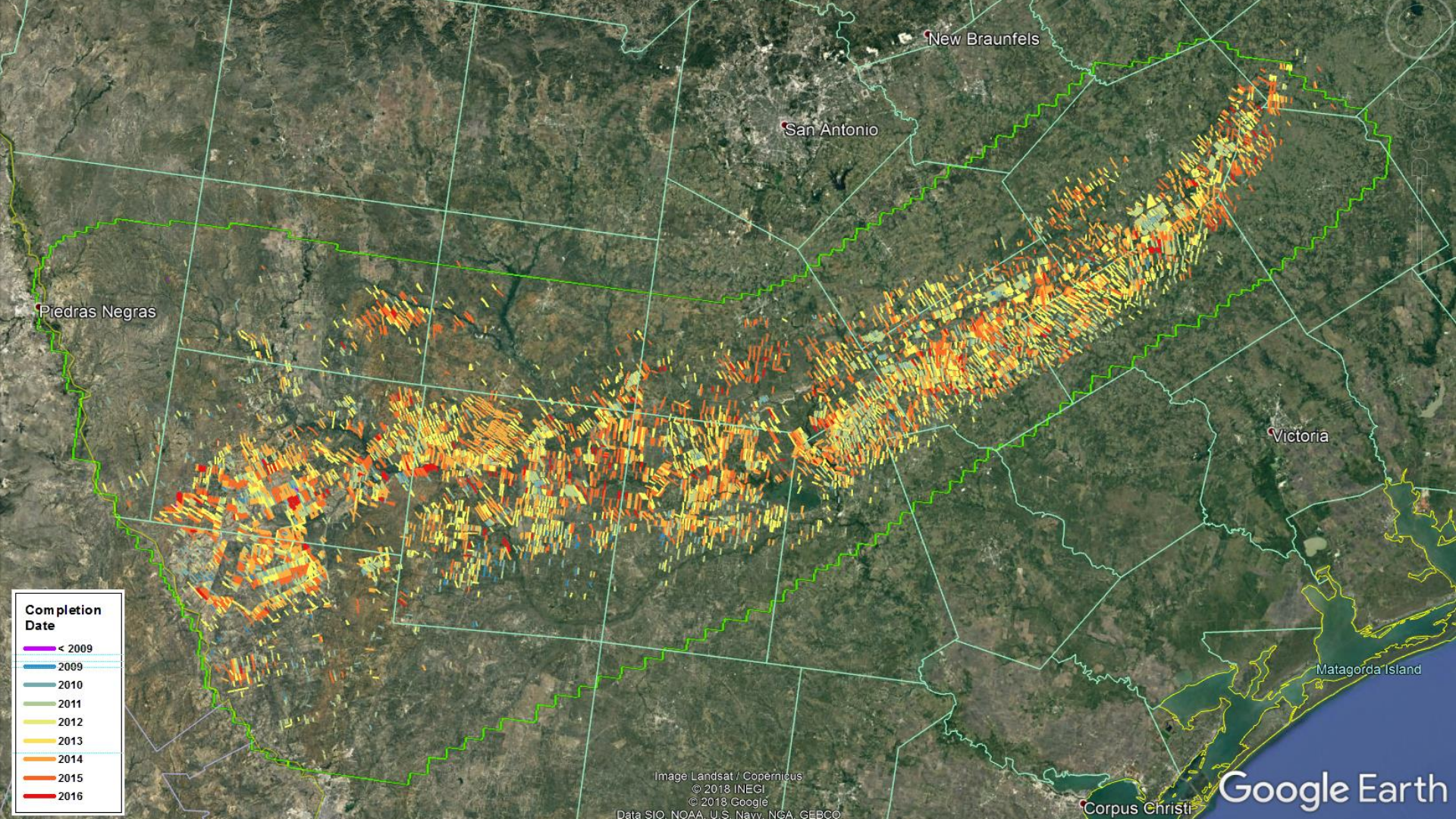
The Global Resource is Vast

Reserves and production are a function of Price, Cost, Technology, Policy and Demand

Modified from: IEA World Energy Outlook (2009)



For presentation or publication, reference:
Bureau of Economic Geology Shale Resource and Production Project
http://www.beg.utexas.edu/research/programs/shale


New Braunfels
San Antonio
Piedras Negras
Victoria
Matagorda Island
Corpus Christi
Completion Date
< 2009
2009
2010
2011
2012
2013
2014
2015
2016
Image Landsat / Copernicus
© 2018 INEGI
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google Earth

BEG Tight Oil Resource Assessment (TORA)

Tinker 2018

Integrated Study Workflow

Geologic Analysis

- Reservoir characterization
- Original-Resource-in-Place
- 3-D Geologic Model

Well Decline Analysis

- Production and its decline for gas/oil/water
- Stimulated/drained rock volume

Recovery and Productivity Statistical Analysis

Expected production

as a function of

- Well productivity drivers
- Location and Completion
- Inventory of future wells
- Technically Recoverable Resources

Well Economics

Expected well profitability

as a function of

- Well production profile
- Operational
- Market and regulatory parameters

Production Outlook

- **Pace of drilling** *by year and area,*
- **Expected gas/oil/water production** *depending on* **economics, technology, regulation**

For presentation or publication, reference: Bureau of Economic Geology Shale Resource and Production Project http://www.beg.utexas.edu/research/programs/shale

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US Shale Gas Production

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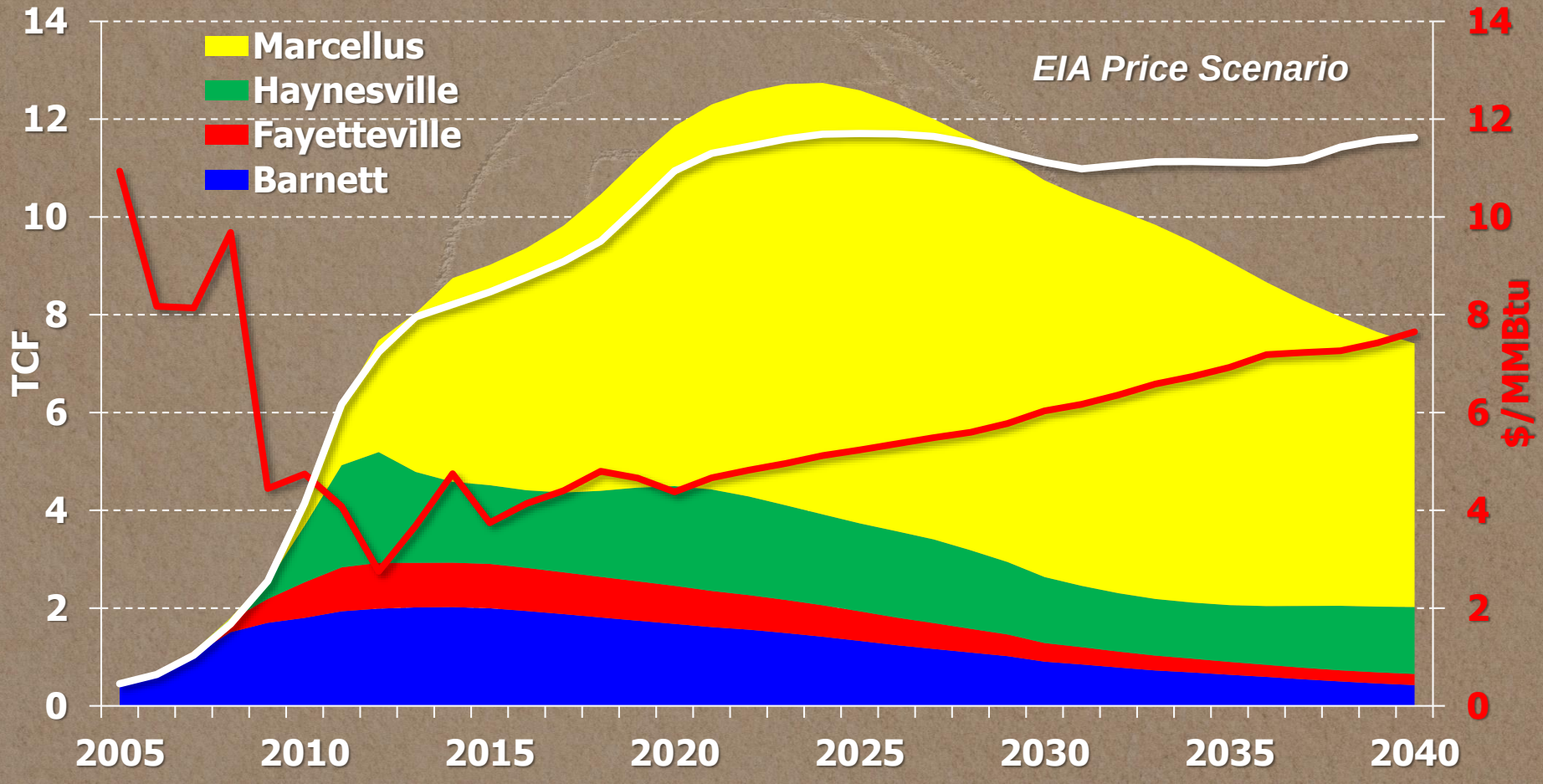

US Shale Gas Production

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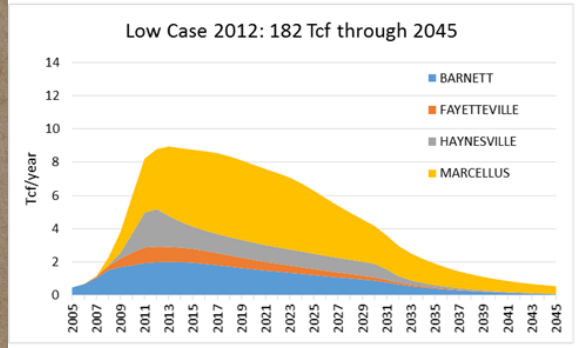
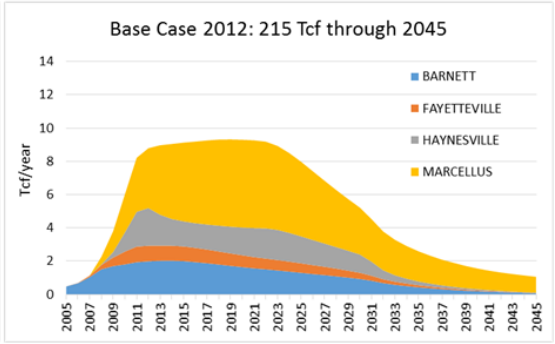
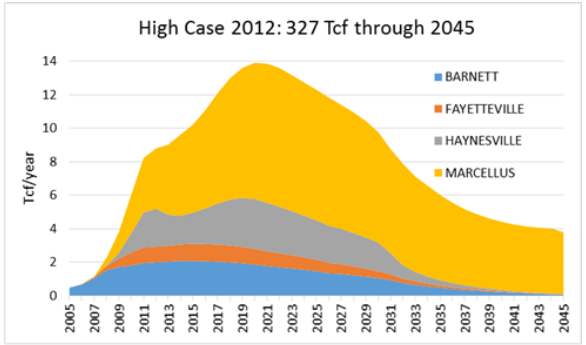
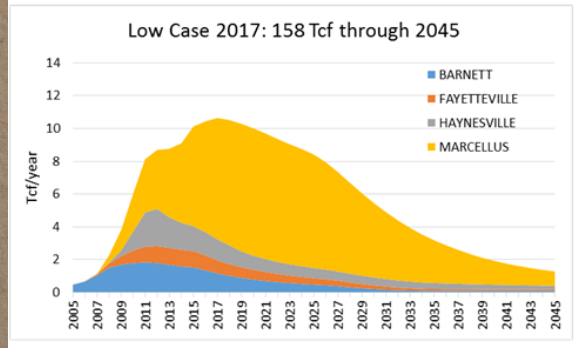
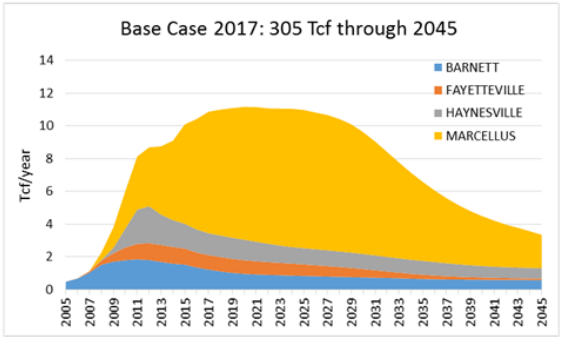
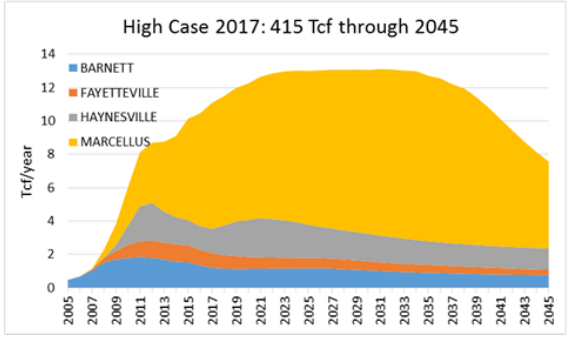
Formation	$OGIP_{free}$		Prod. through 2045		RF (P50)
		P10	P50	P90	
Barnett	444	37	47	57	11%
Fayetteville	80	12	18	23	23%
Haynesville	489	33	52	72	11%
Marcellus	2071	-	183	-	9%
	3084		**300**		**10%**

U.S. Shale Gas

For presentation or publication, reference: Bureau of Economic Geology Shale Resource and Production Project http://www.beg.utexas.edu/research/programs/shale

	Low	Base	High
2012			
2017			

	Gas *Tcf*	Oil *Bbbl*
Original In-Place	3100	450
Tech. Recoverable	700	27
Production to date	70	5
Horizontal wells to date	~75,000	
Future wells (base case)	~500,000	

Gas Oil

Resource-in-Place

TRR

Produced to-date

Completion Date
- before 2009
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016

Bakken/Three Forks
~18,000
~100,000

Marcellus
~10,500
~200,000

Barnett
~16,500
~63,000

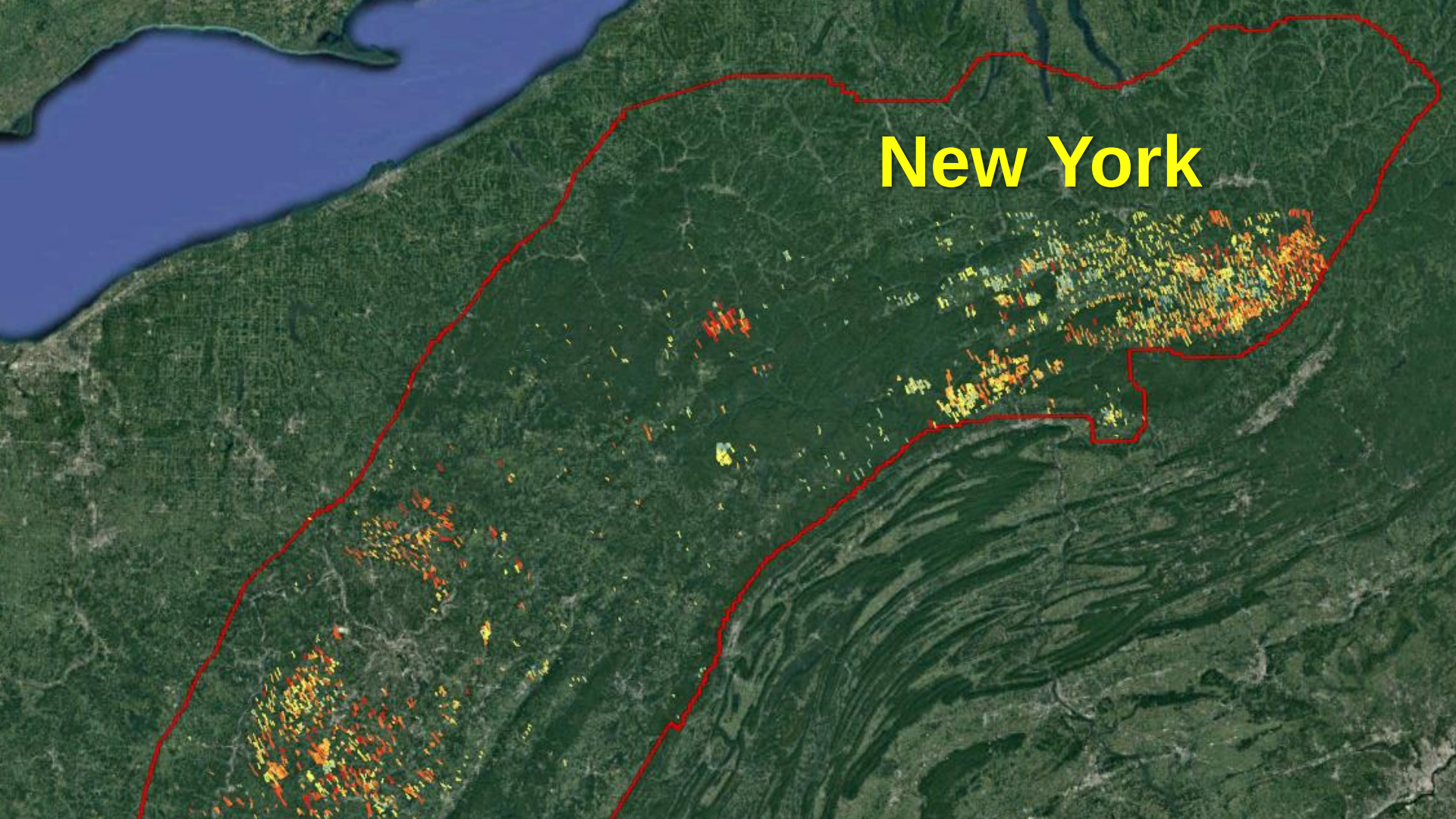
Fayetteville
~6,500
~13,000

Haynesville
~6,000
~35,000

Eagle Ford
~16,500
~90,000

Environmental Impact
Coal, Oil, Natural Gas

- Mining and Manufacturing ***Land, Water, Emissions***
- Drilling and Completion: ***Land, Water***
- Transportation: ***Pipelines, Trucks, Ships, Rail***
- Refining and Petrochemicals: ***Emissions***
- Combustion: ***Vehicle and Power Plant Emissions***


New York

Environmental Impact
Renewables and Batteries

- **Mining and Processing** ***Land, Water, Emissions***
- **Manufacturing:** ***Turbines, Panels, Batteries***
- **Production:** ***Land for "Farms"***
- **Transmission:** ***Electricity***
- **Disposal:** ***Landfill***

Energy
Key Points

- **Fossil energy demand remains strong, and resources are vast.**
- **Energy transitions take time.**
- **No form of energy, at scale, is without environmental impact.**

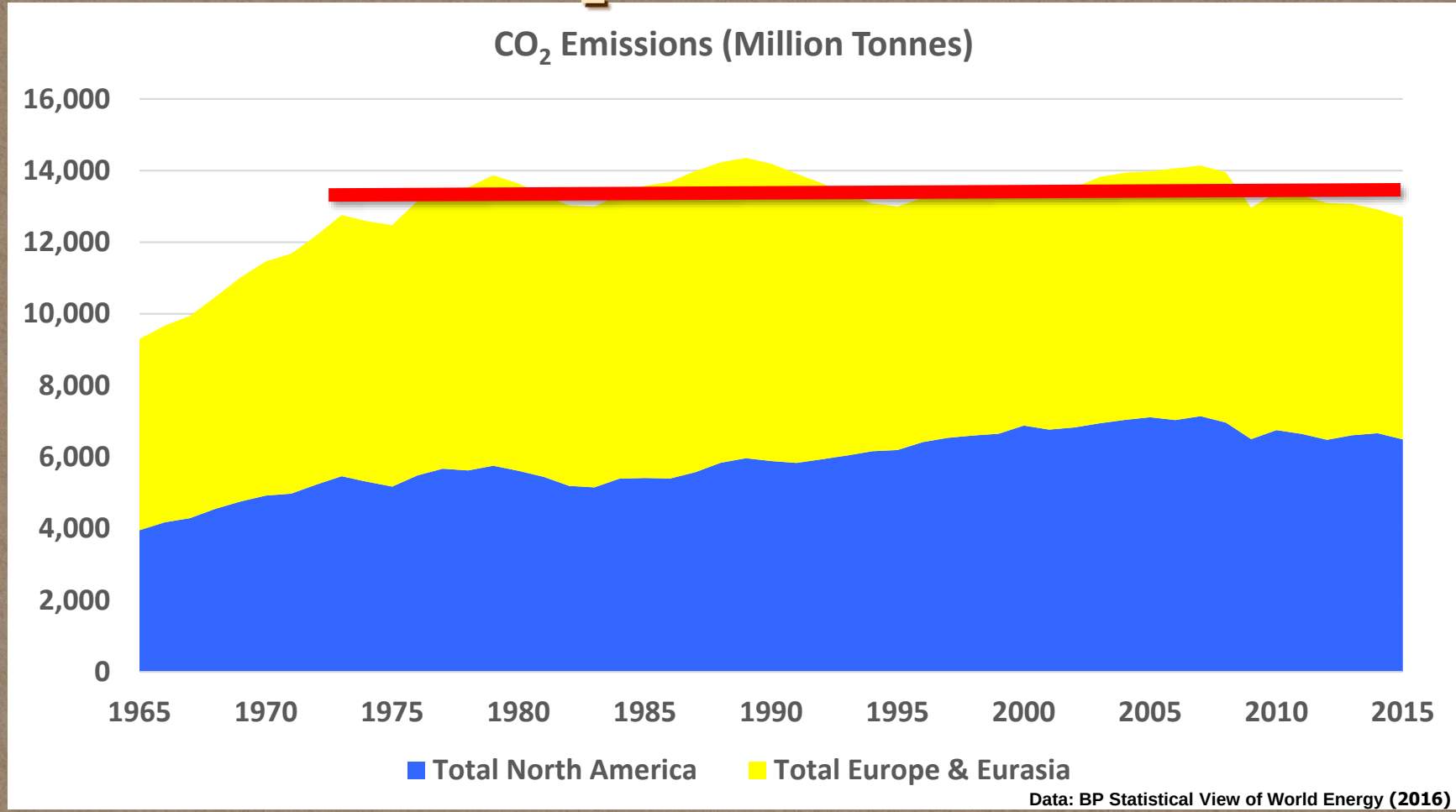
Bureau of Economic Geology

Outline

- Energy
- Carbon
- Poverty

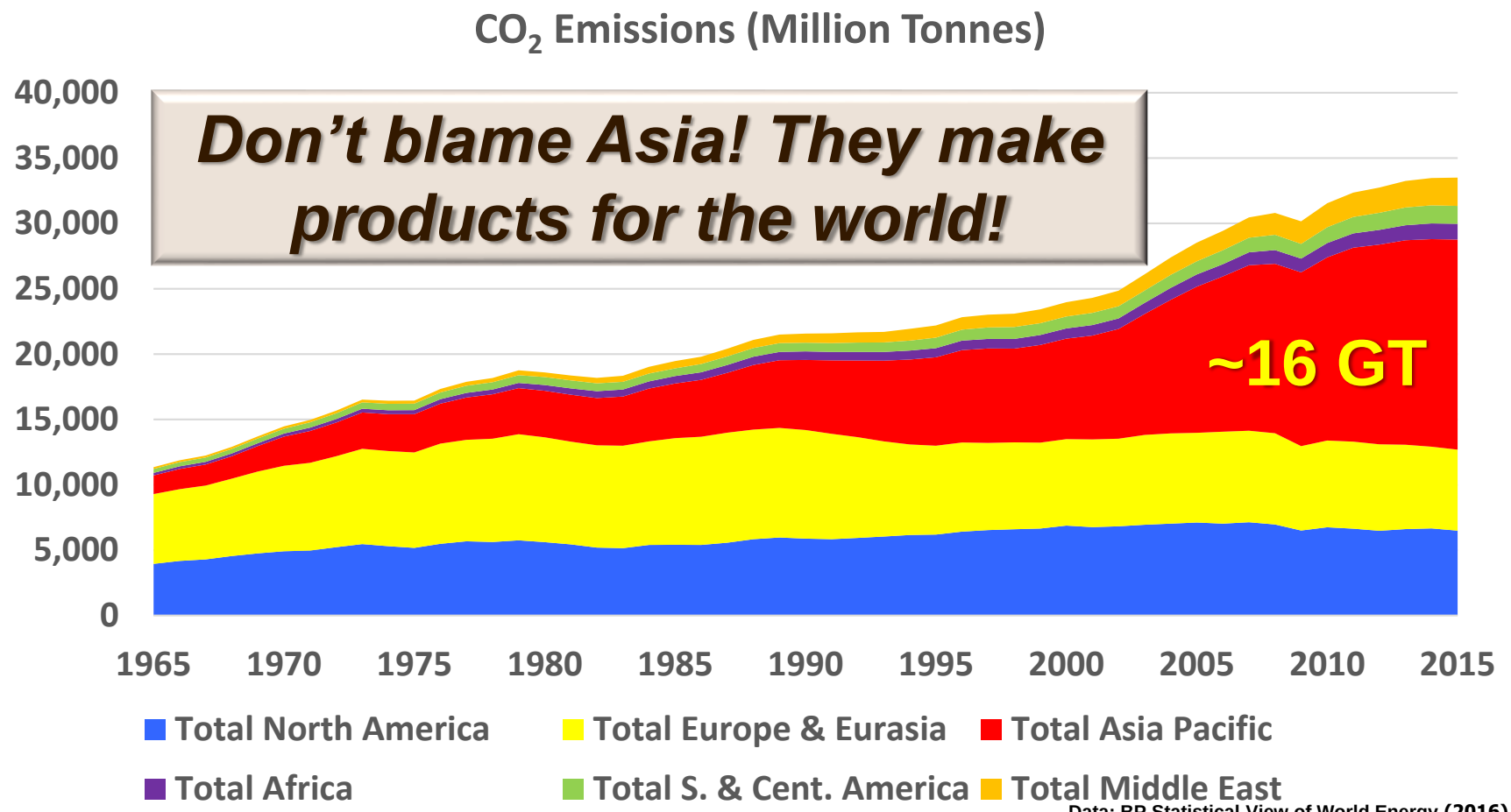
Bureau of Economic Geology

CO_2 Emissions



Data: BP Statistical View of World Energy (2016)

CO_2 Emissions

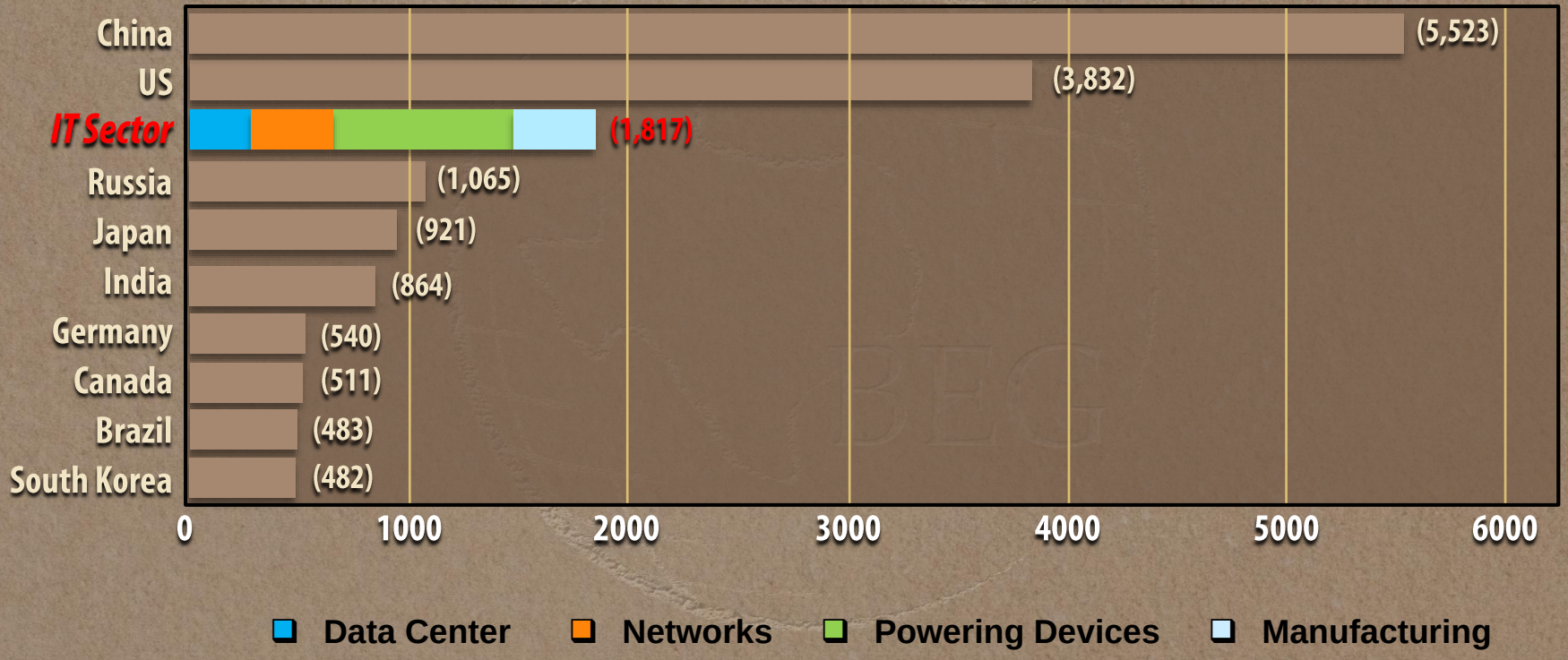



Electricity

Tinker 2018

Electricity Use

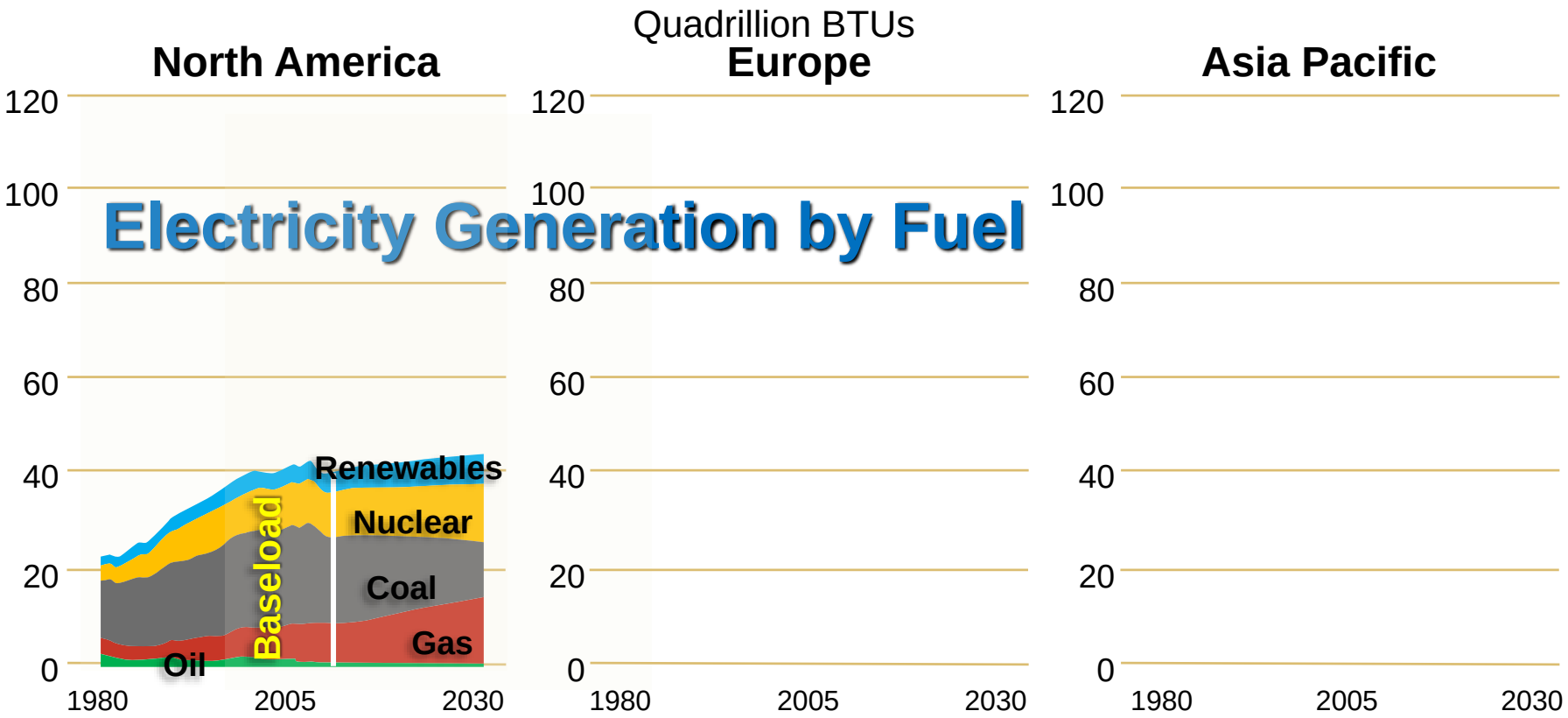
(2012: Billion KwH)



Source: Emerging Trends in Electricity Consumption for Consumer ICT, Peter Corcoran and Andres Andrae (2013) and CIA World Factbook. China/Russia/Canada figures are from 2014.

QAe5585

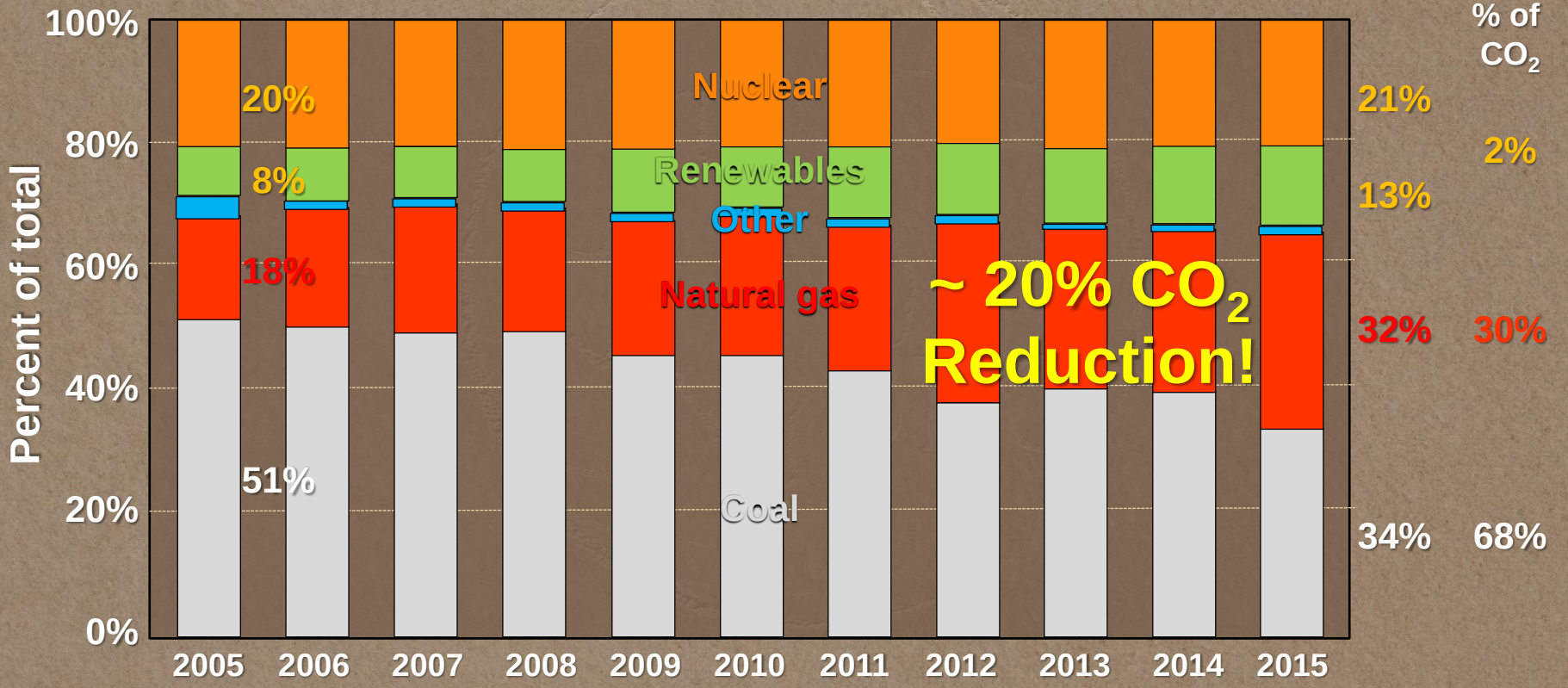
The Future Electricity Mix



ExxonMobil Corporation, 2010, The outlook for energy: a view to 2030: ExxonMobil report, 53 p.

Tinker 2018

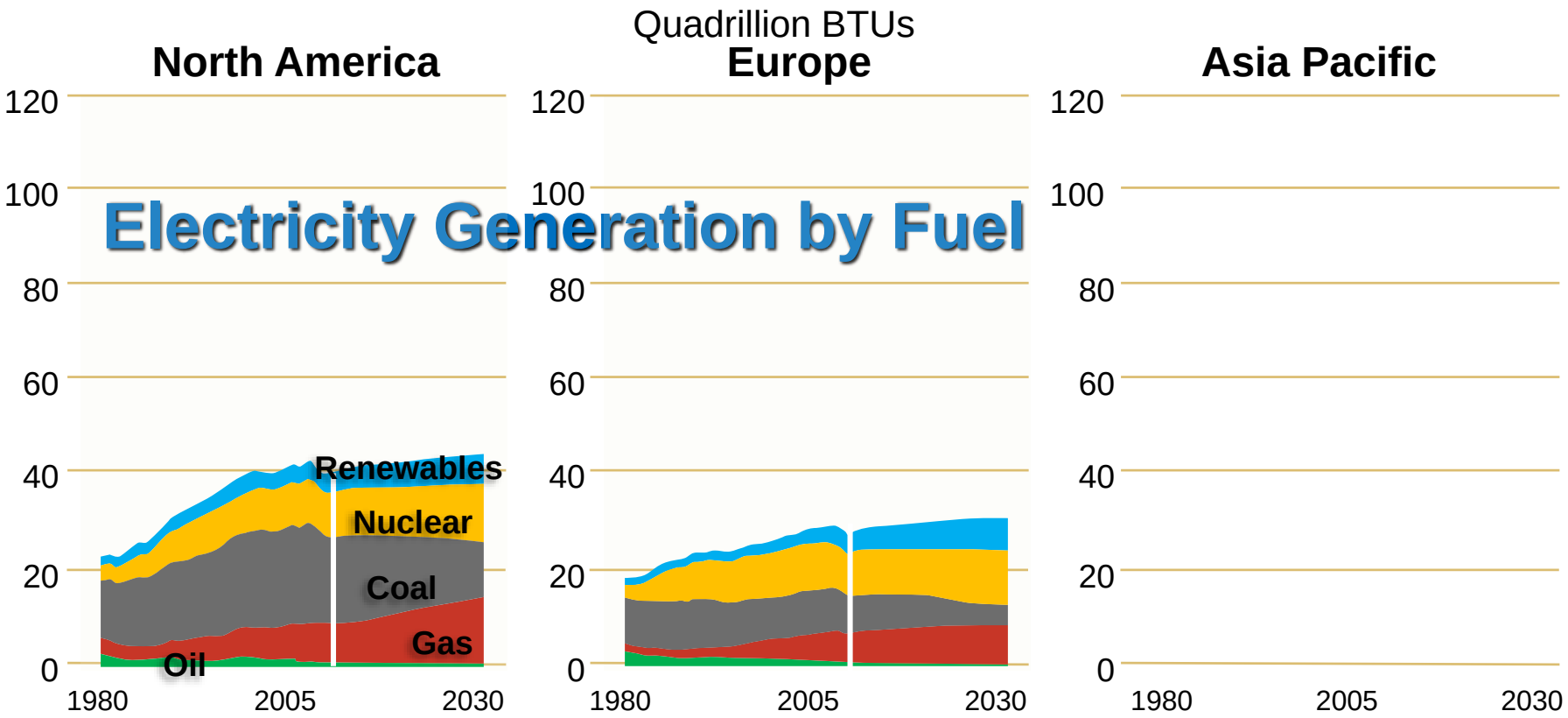
U.S. Electric Generation Shares (2005-15)



Source: EIA

QAe4744

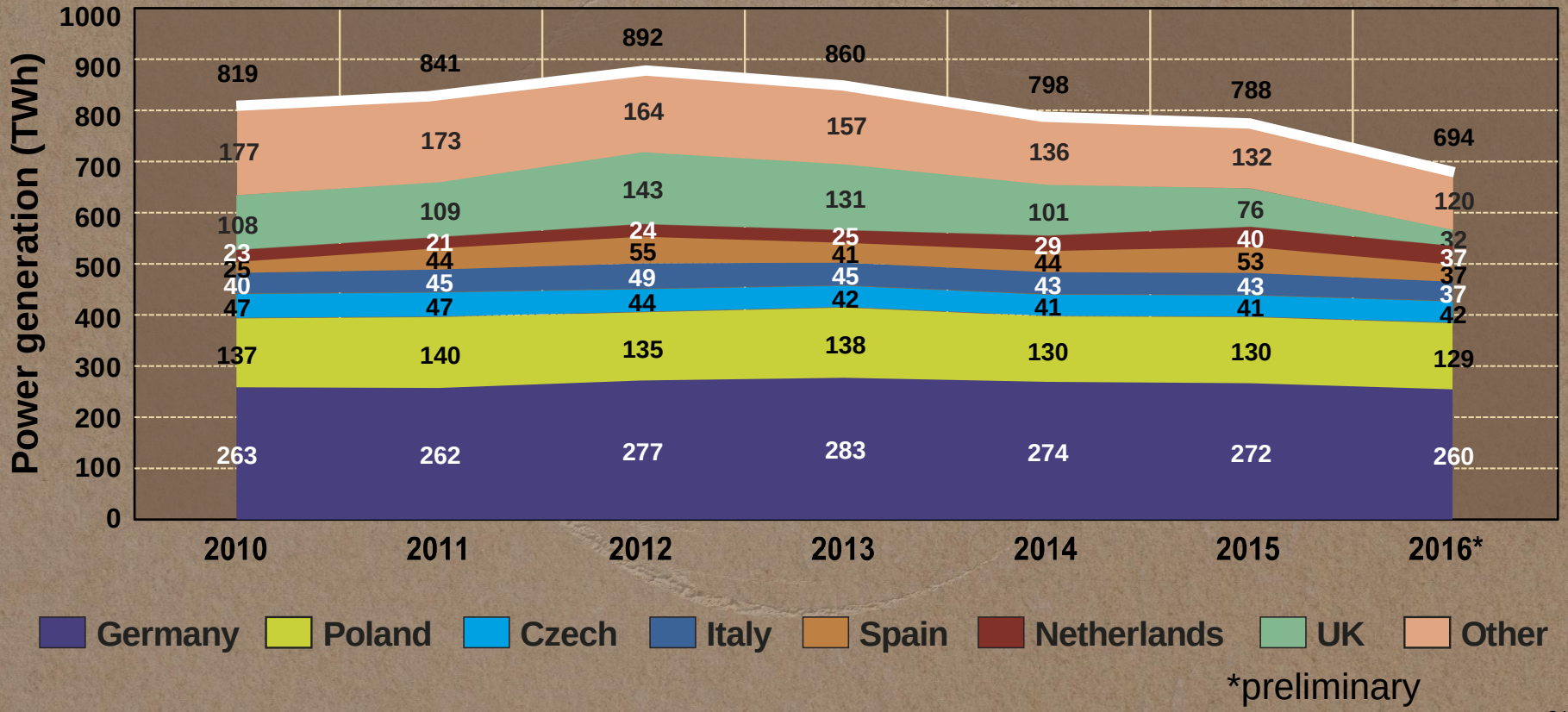
The Future Electricity Mix



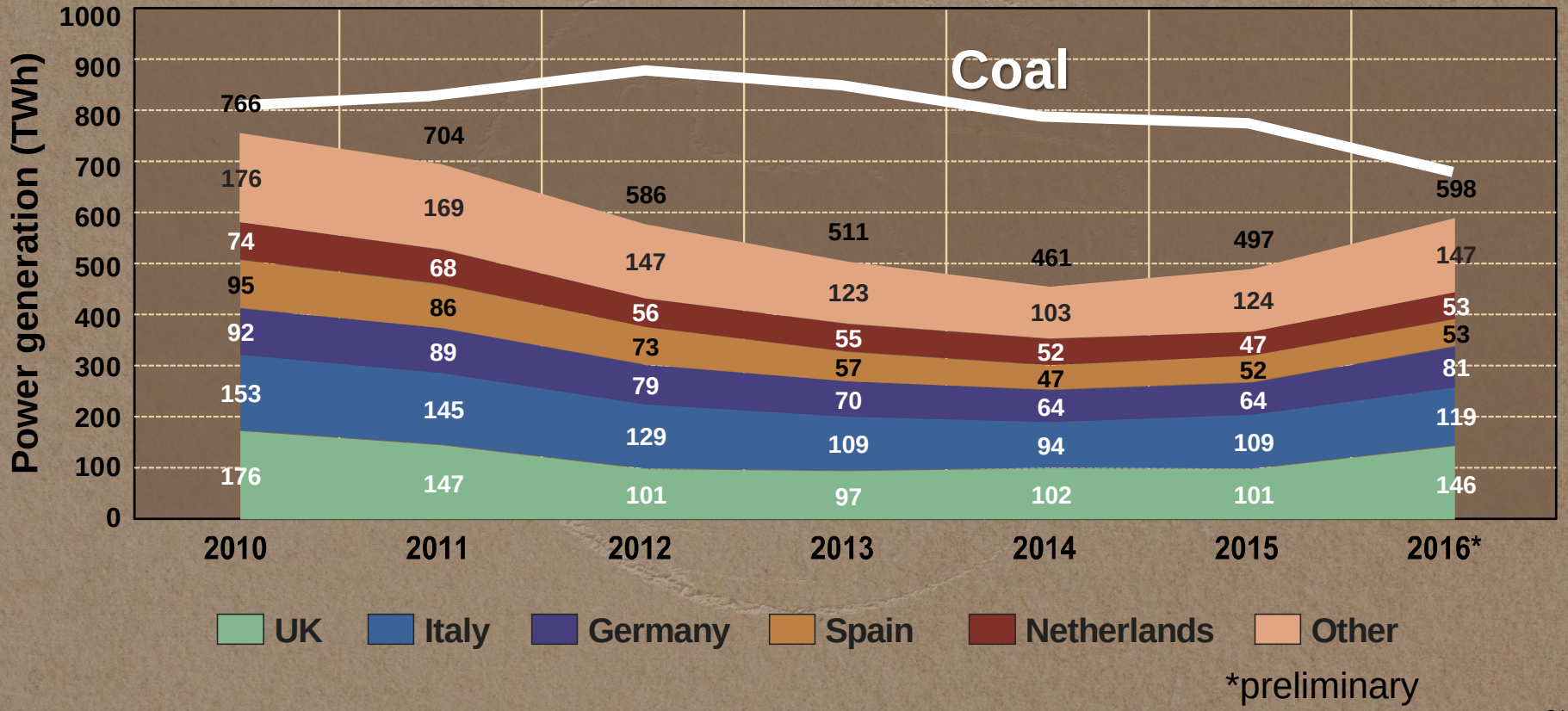
Electricity Generation by Fuel

ExxonMobil Corporation, 2010, The outlook for energy: a view to 2030: ExxonMobil report, 53 p.

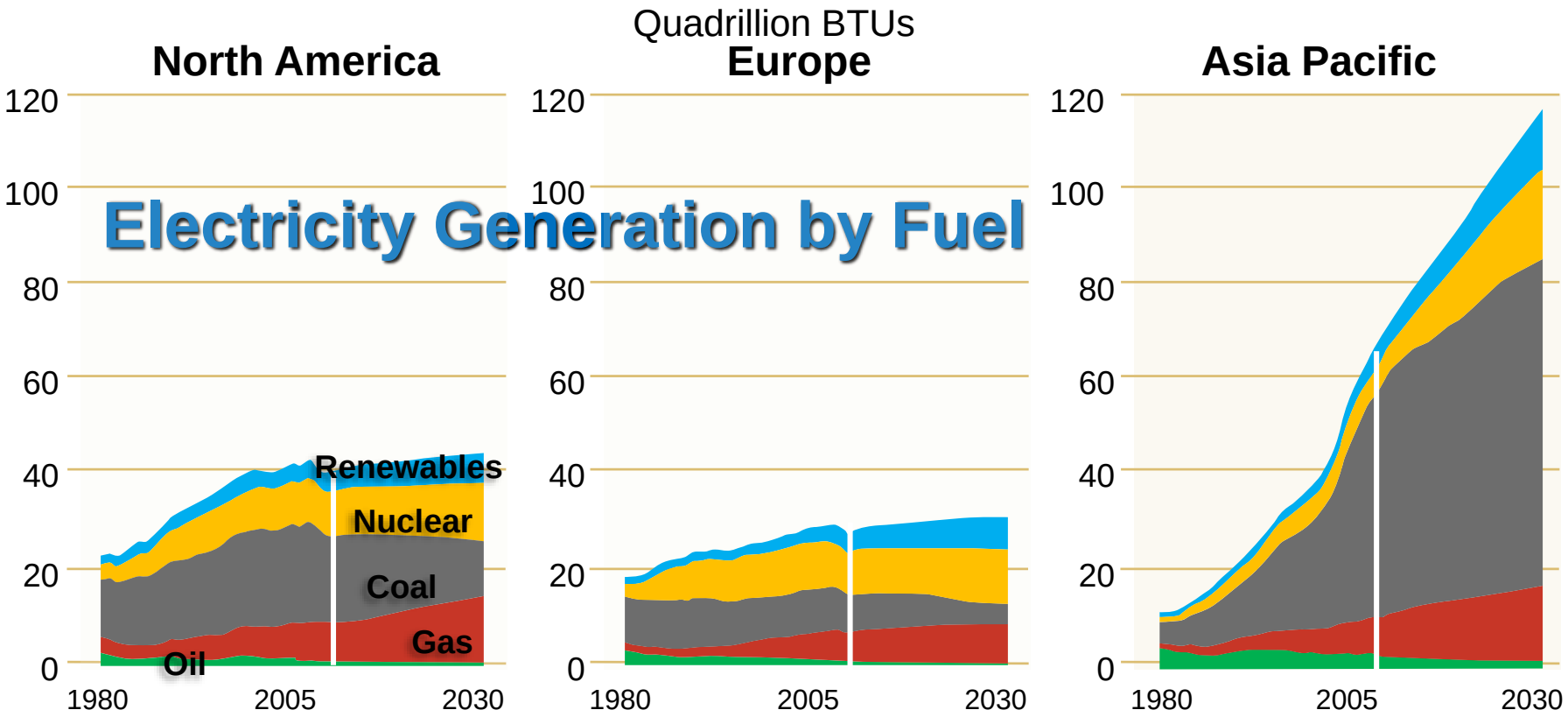
European Coal Generation



European Natural Gas Power Generation



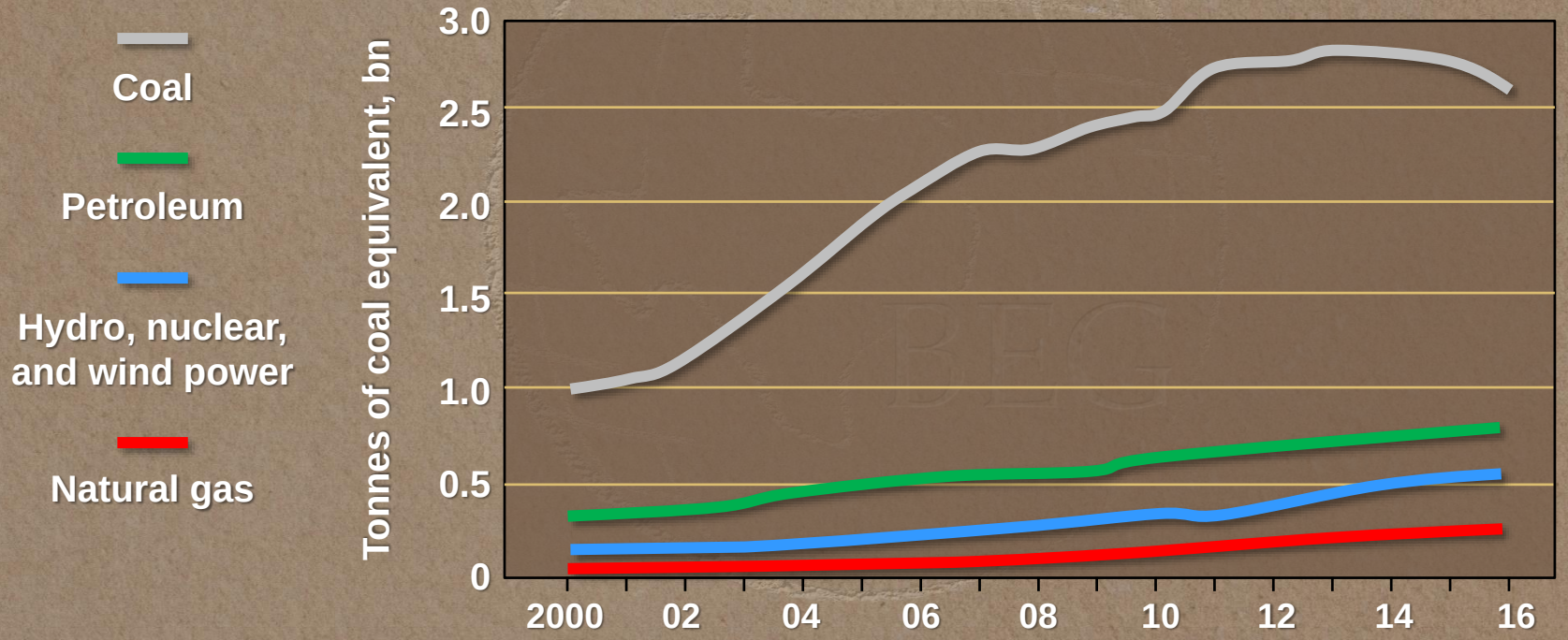
The Future Electricity Mix



ExxonMobil Corporation, 2010, The outlook for energy: a view to 2030: ExxonMobil report, 53 p.

China

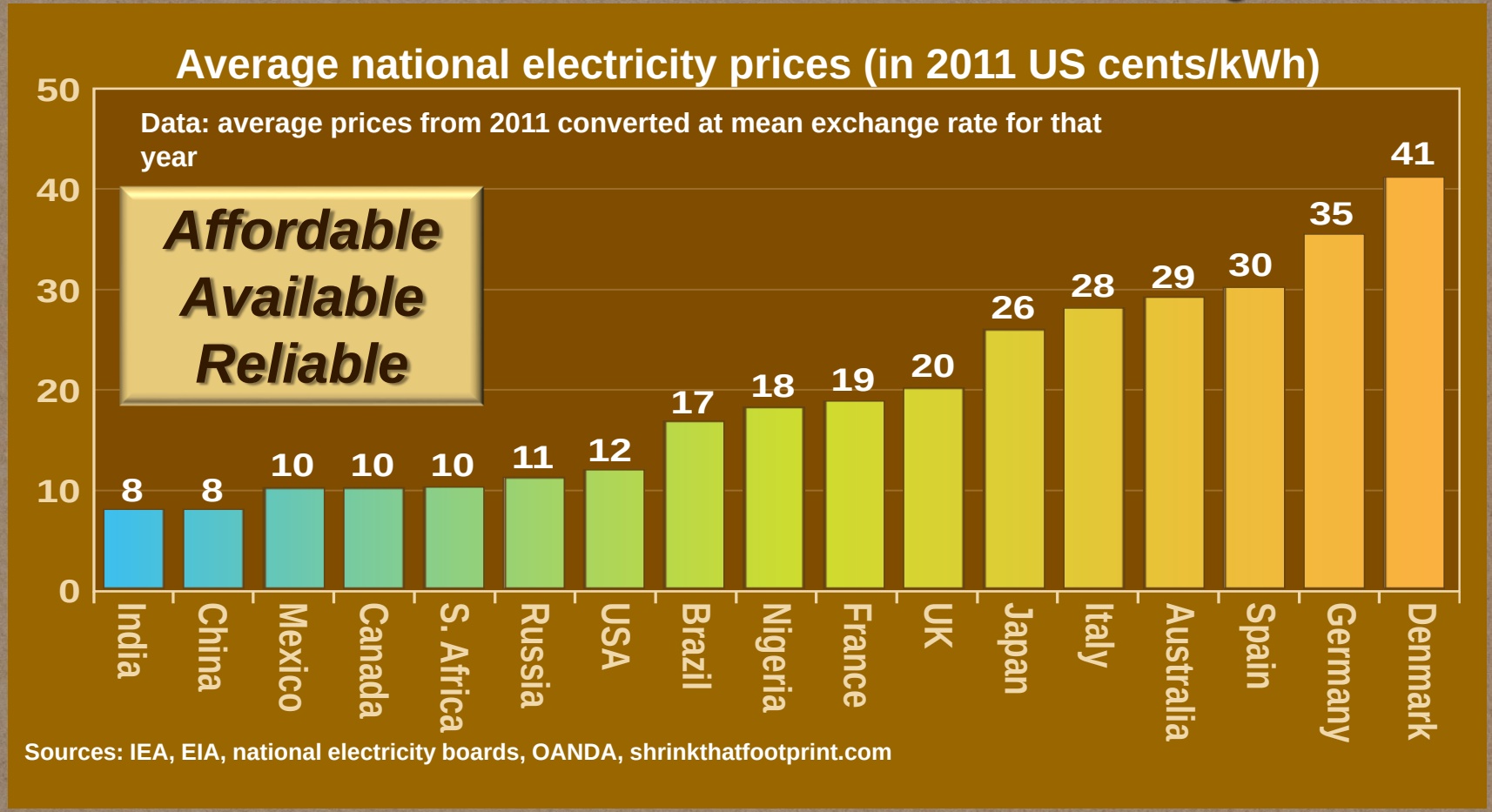
Energy Consumption by Fuel Type



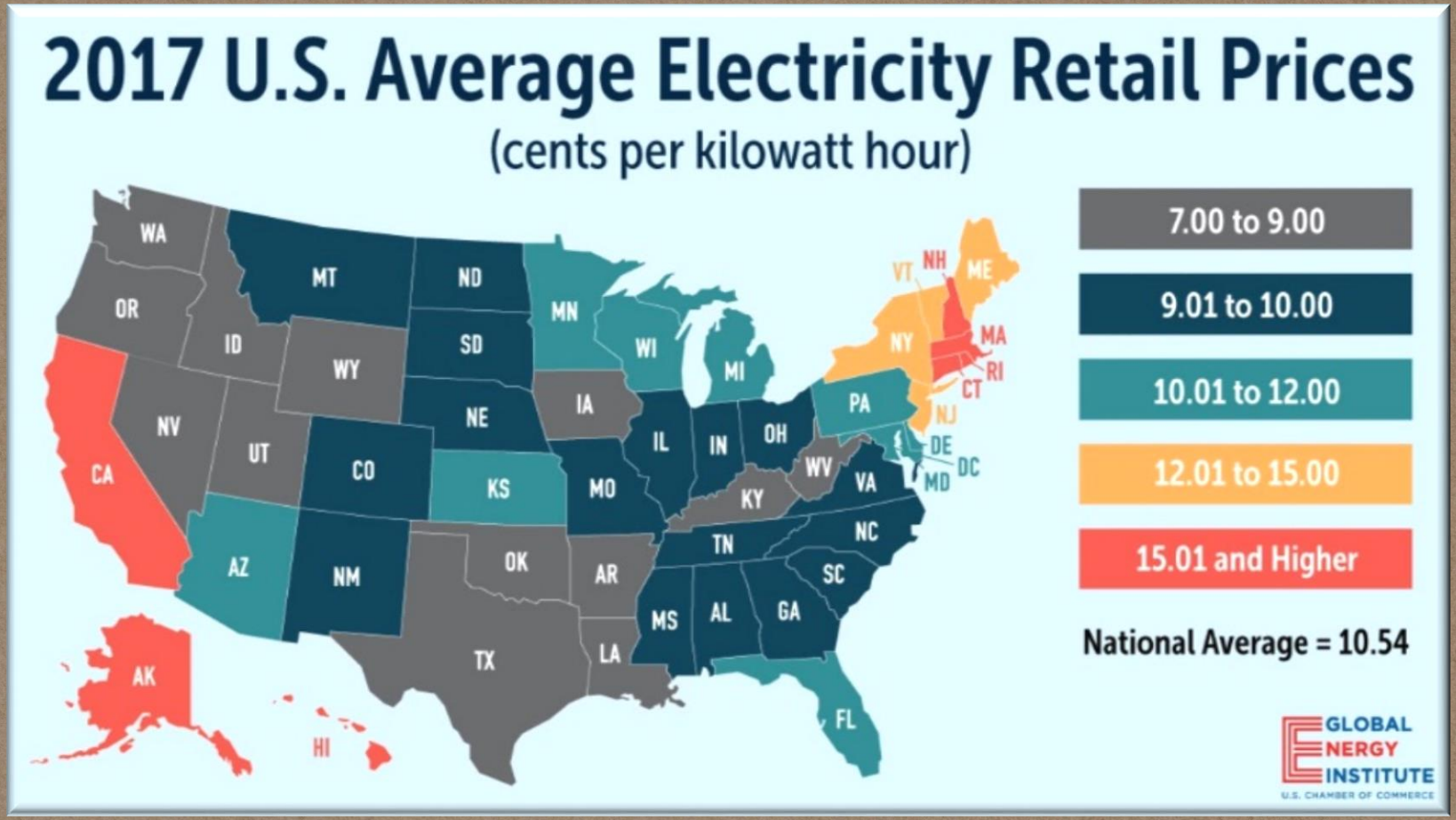
Source: Economist, National Bureau of Statistics

Tinker 2017

Actual Cost of Electricity

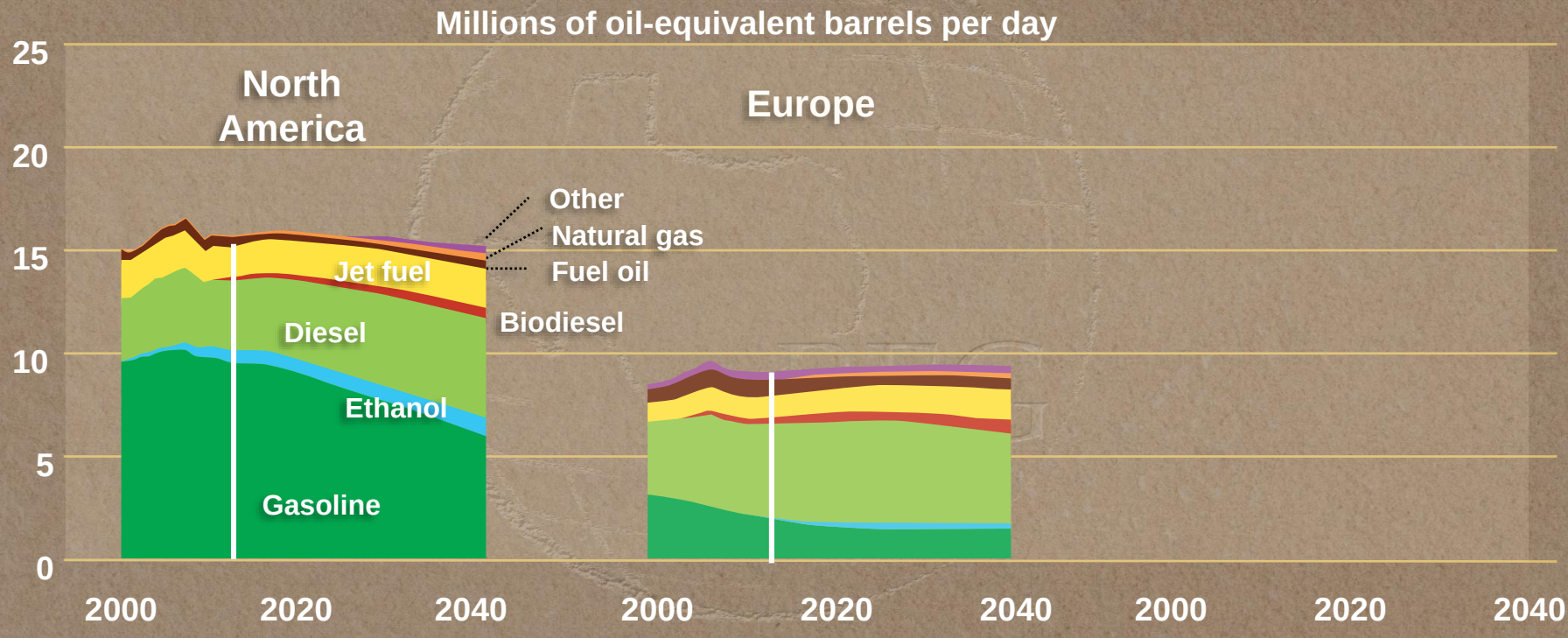


Actual Cost of Electricity




Transportation

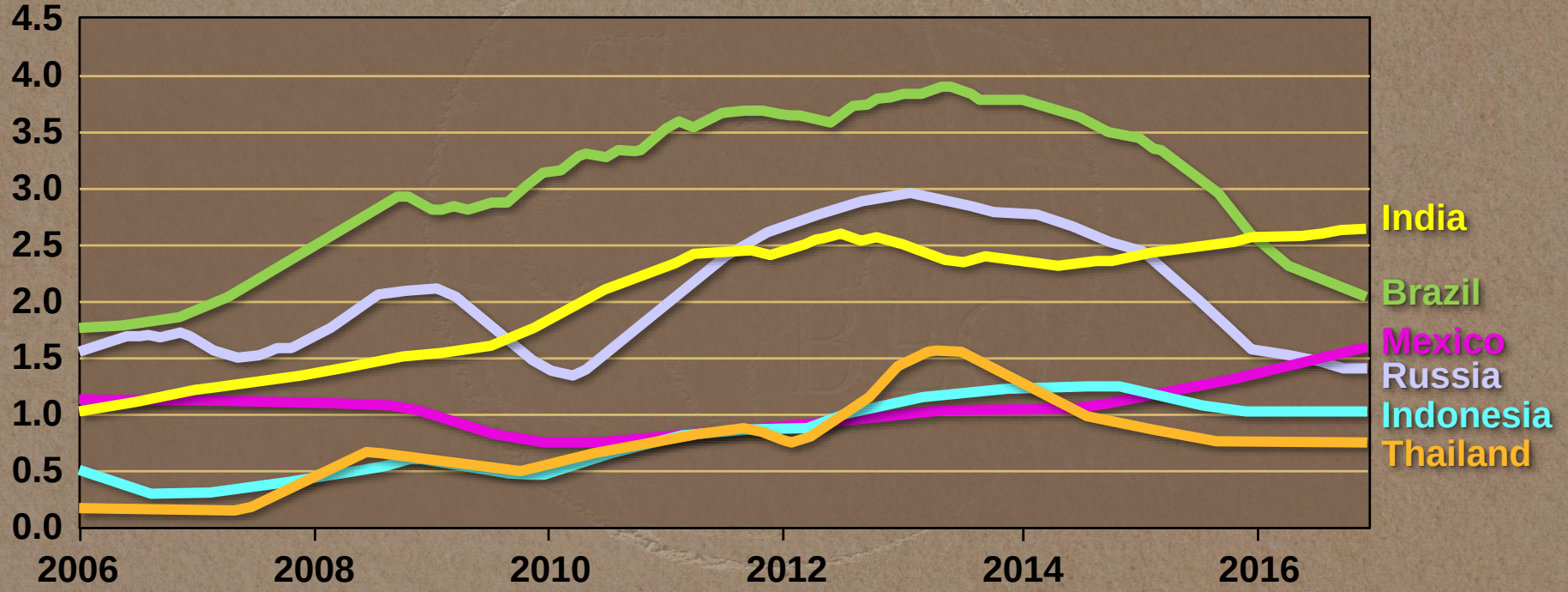
The Future Transportation Mix



ExxonMobil Corporation, 2013 The Outlook for Energy: A View to 2040, page 20.

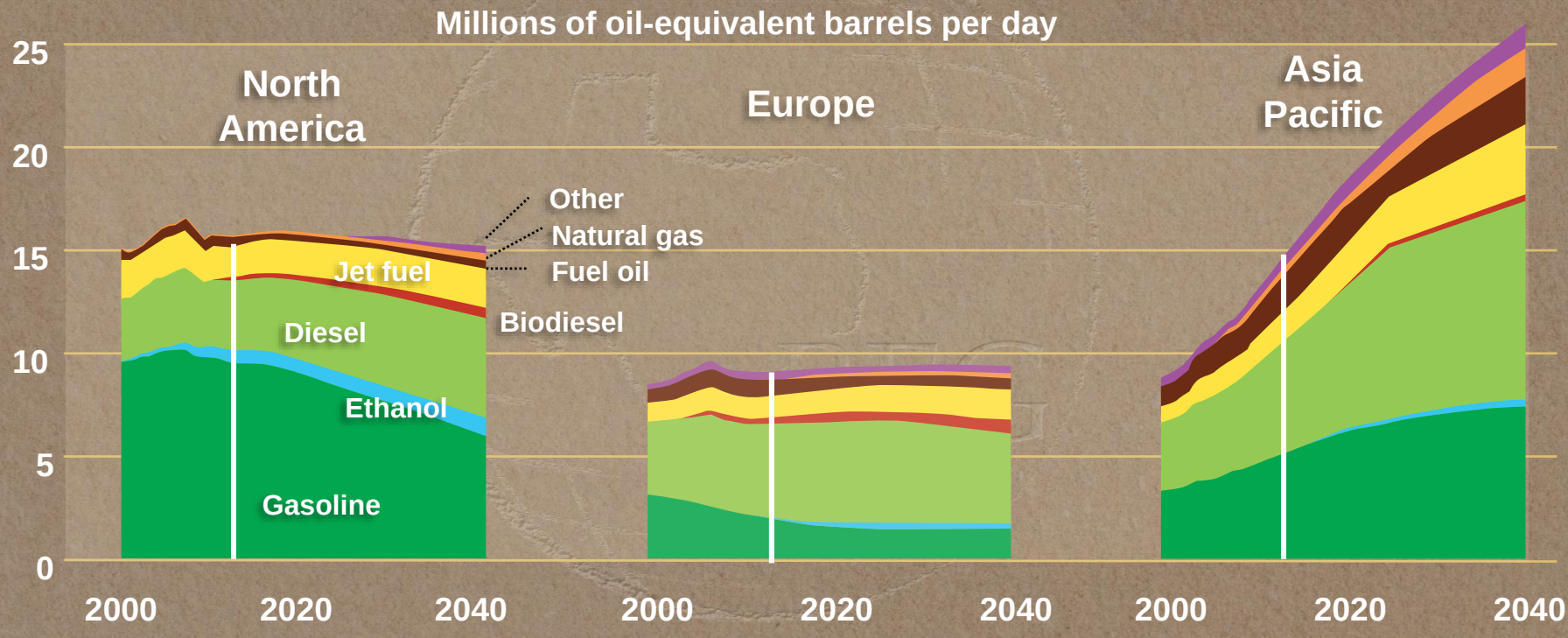
Auto Sales Developing Nations

Rolling 12-month (million)



Source: National car data, Macquarie Research, January 2017

The Future Transportation Mix



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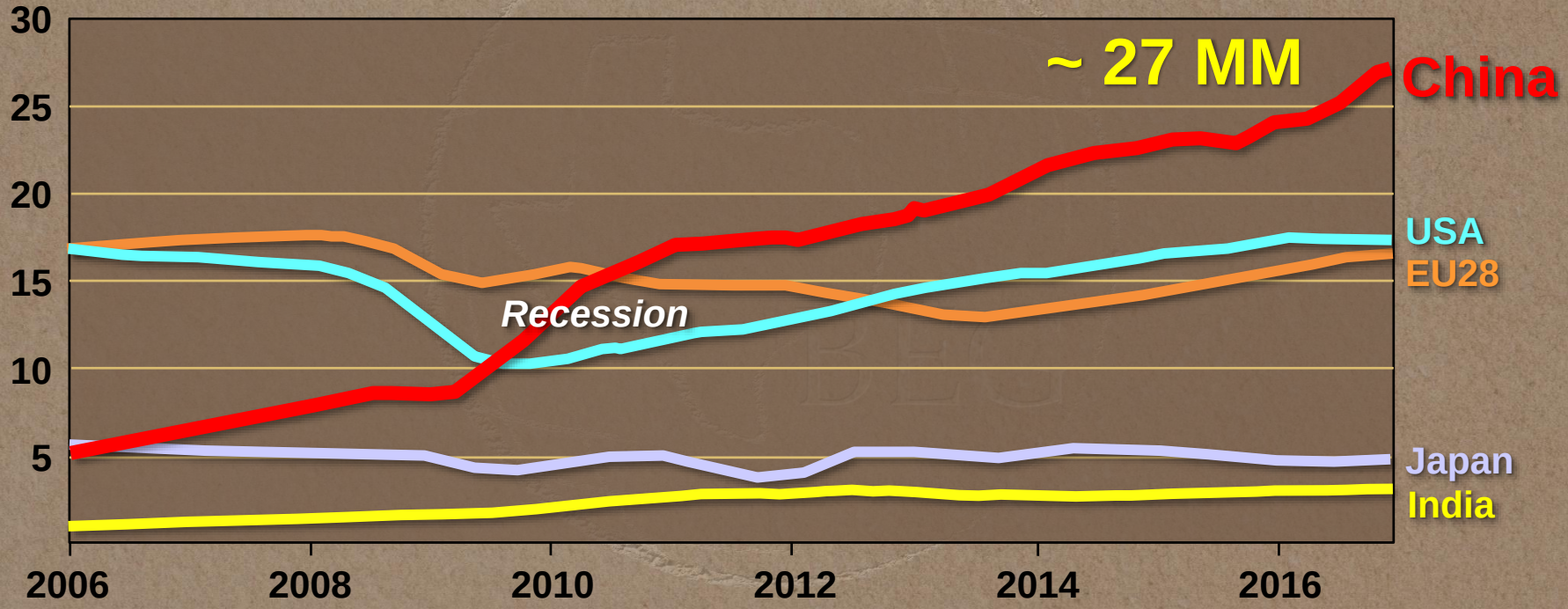
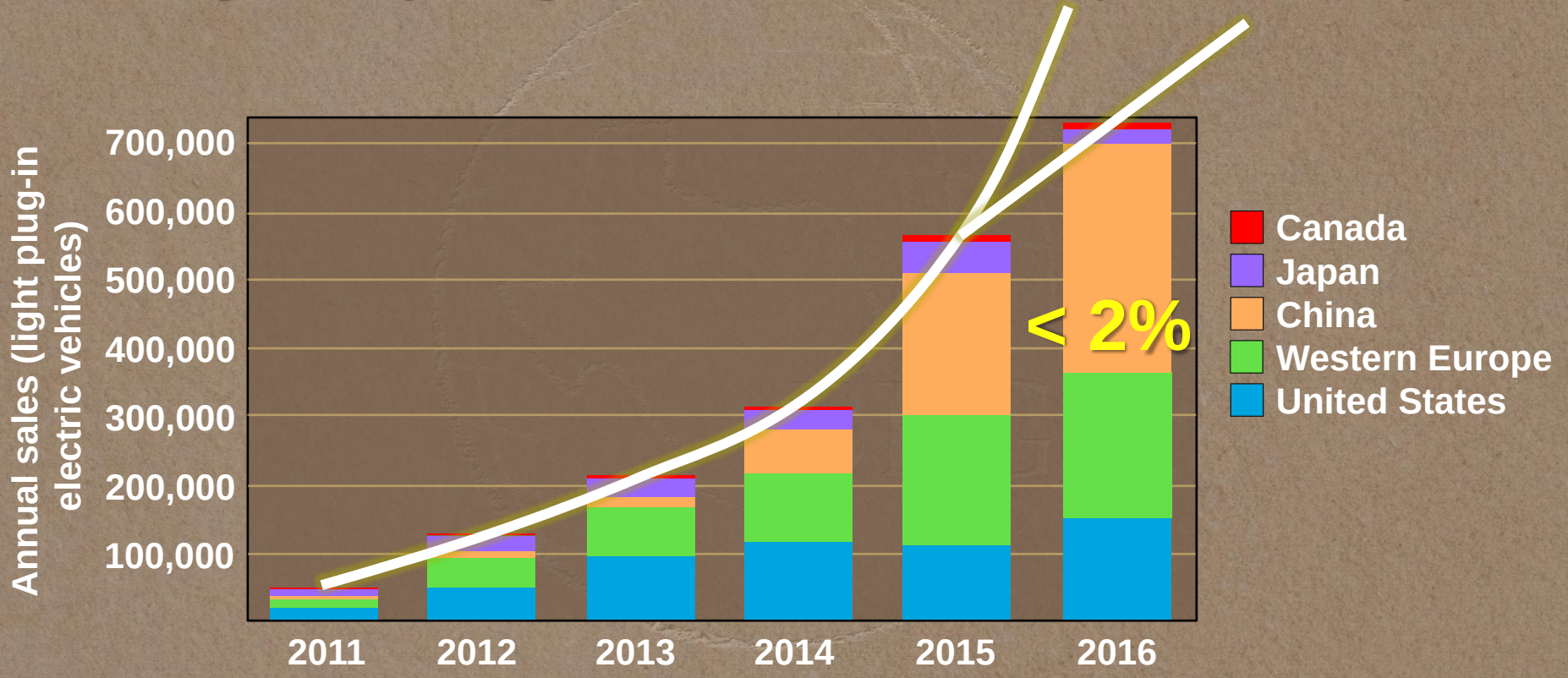


Source: National car data, Macquarie Research, January 2017

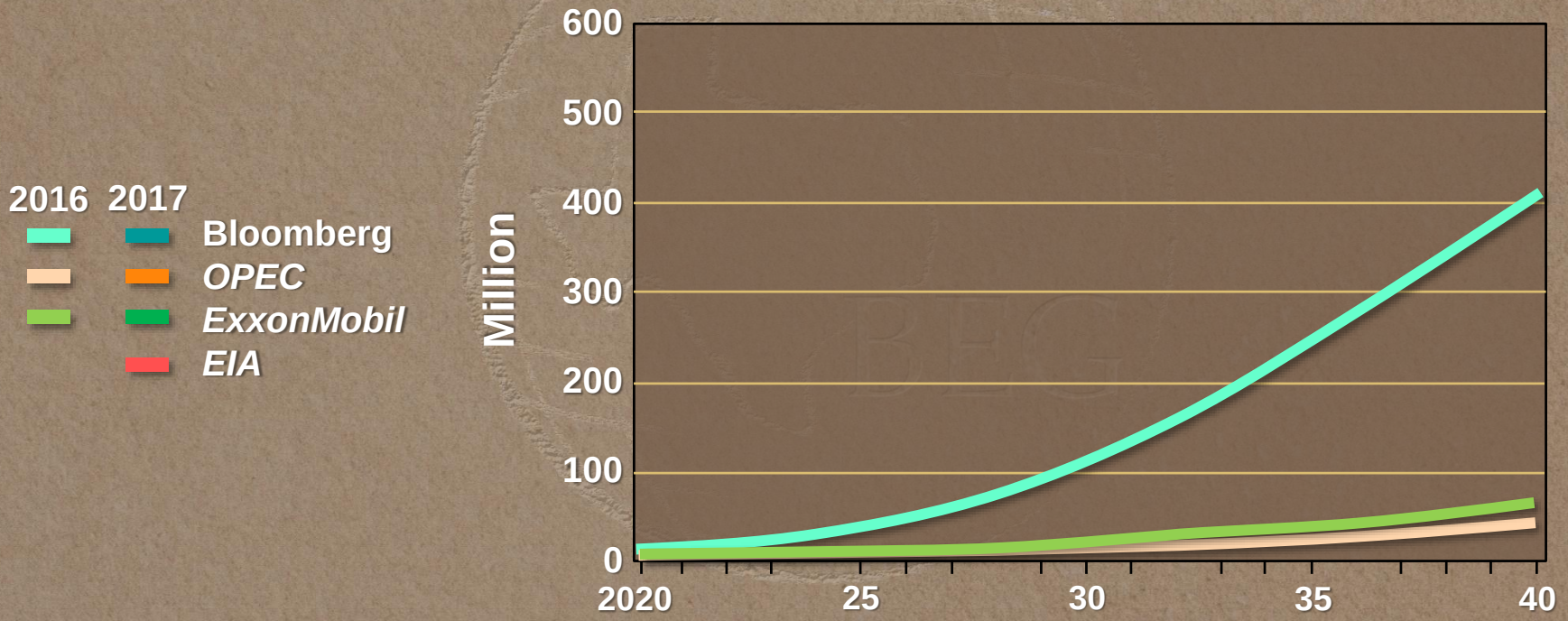
Global Annual Sales

Light-Duty Plug-In Electric Vehicles (2011 – 2016)



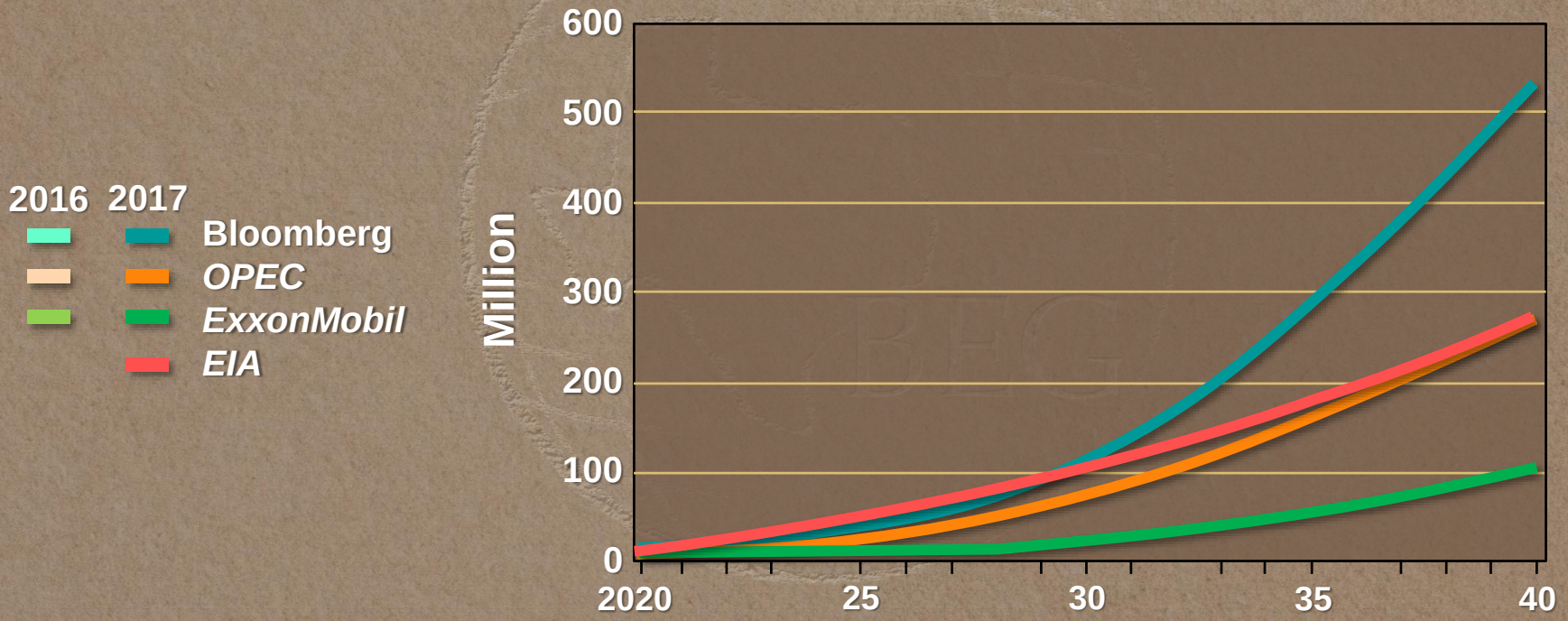
Source: Argonne National Laboratory, United States Department of Energy

Cumulative Electric-Vehicle Forecasts



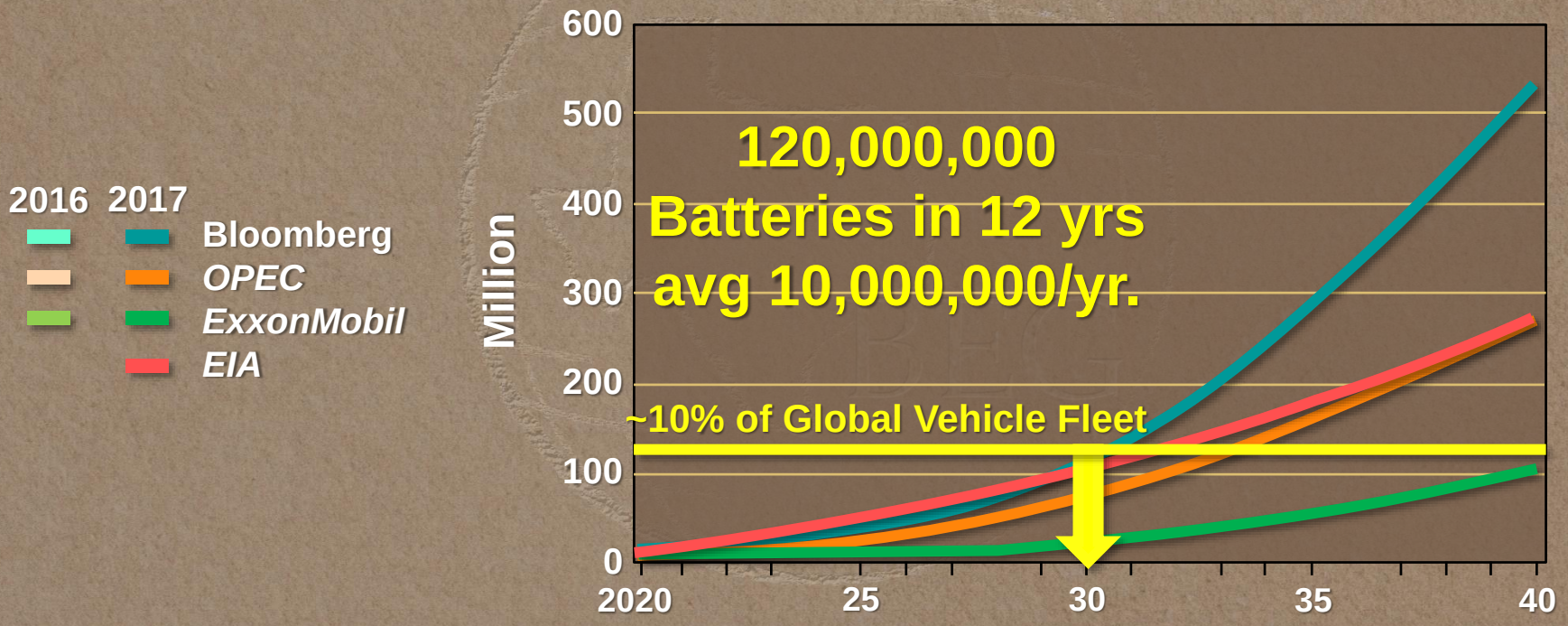
Source: Bloomberg New Energy Finance, Economist.com; EIA, WEO, 2017

Cumulative Electric-Vehicle Forecasts



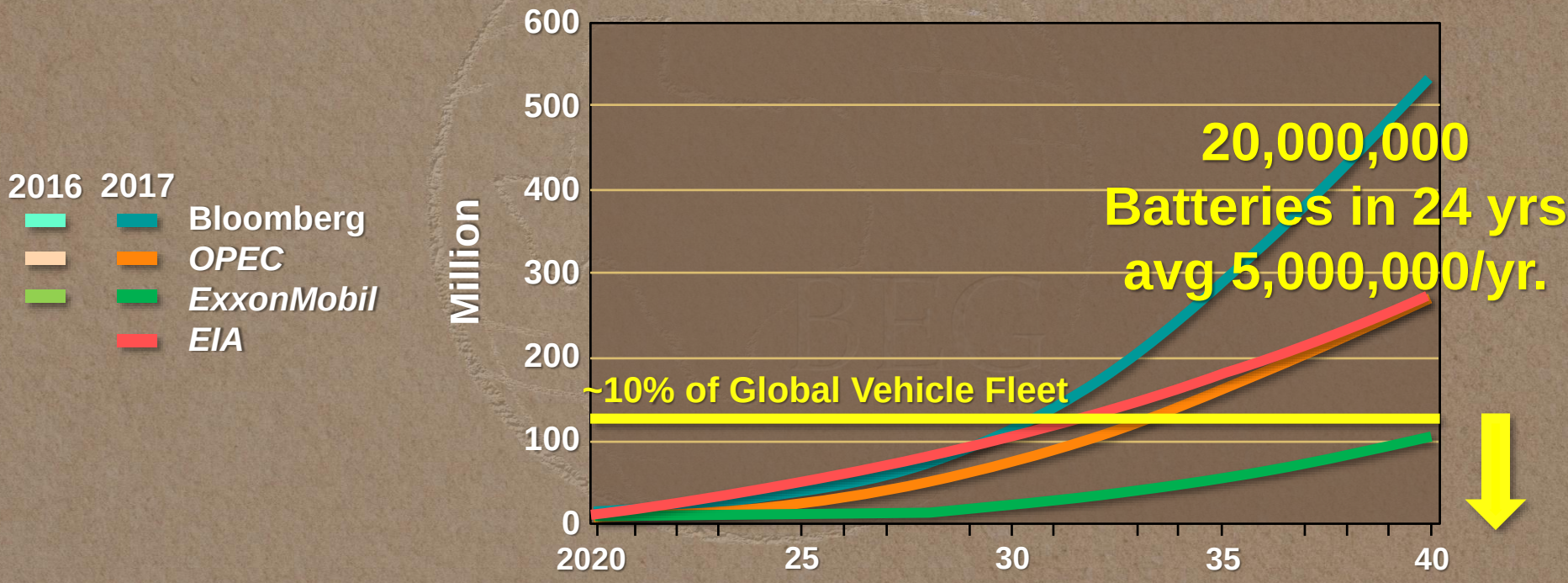
Source: Bloomberg New Energy Finance, Economist.com; EIA, WEO, 2017

Cumulative Electric-Vehicle Forecasts



Source: Bloomberg New Energy Finance, Economist.com; EIA, WEO, 2017

Cumulative Electric-Vehicle Forecasts



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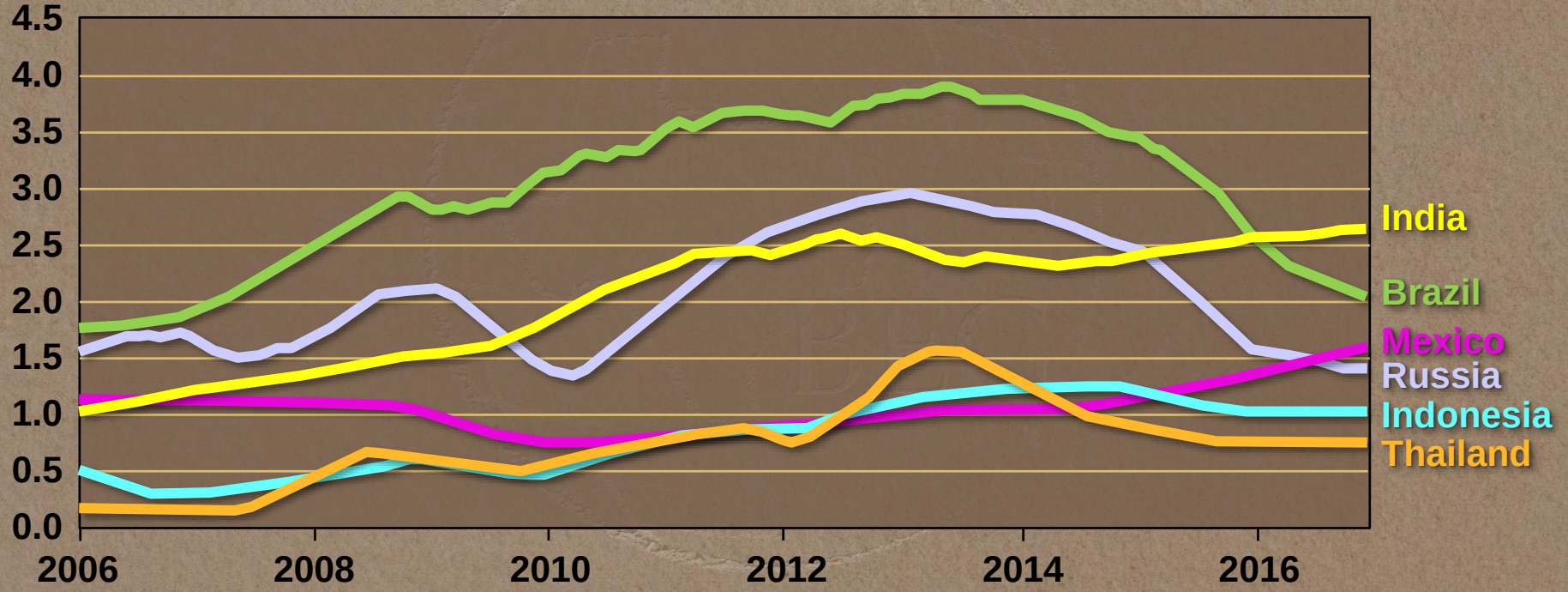
Auto Sales Developing Nations

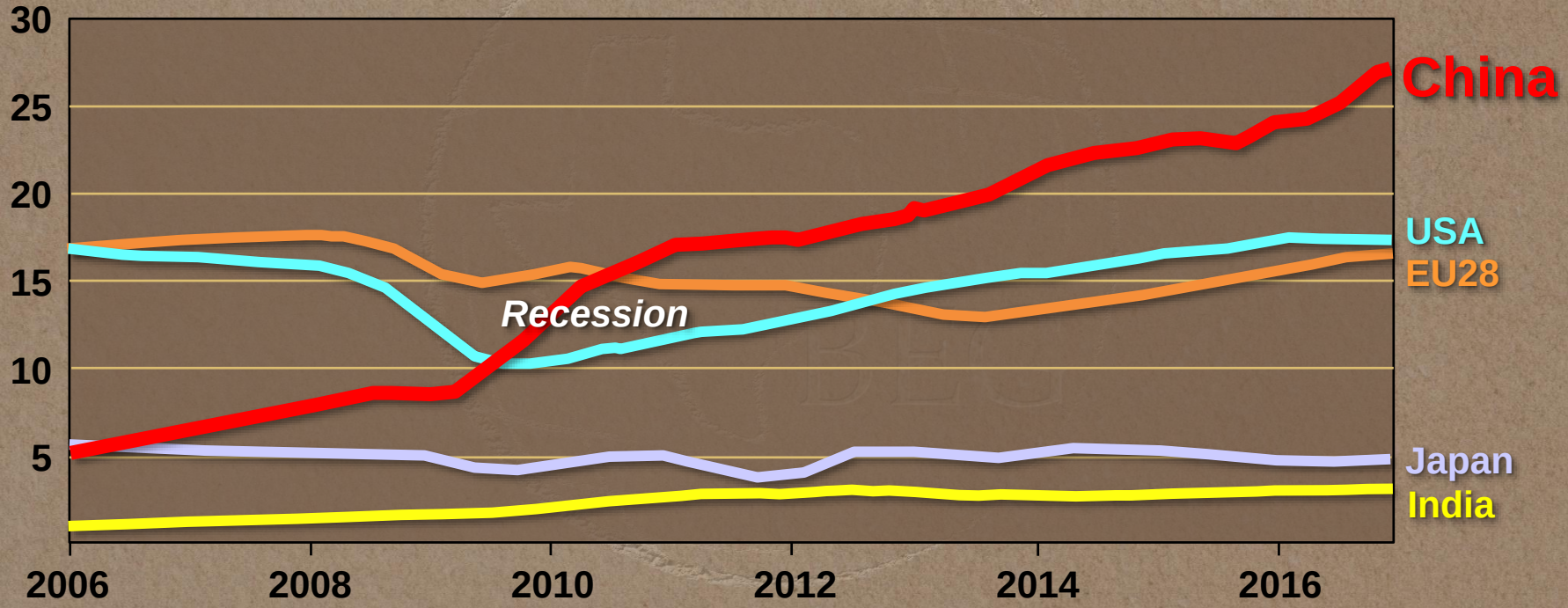
Rolling 12-month (million)



Source: National car data, Macquarie Research, January 2017

Auto Sales Developed Nations

Rolling 12-month (million)



Source: National car data, Macquarie Research, January 2017

CO_2 Reduction Strategies

- Fossil Fuel Substitution & Reduction
- Carbon Capture and Sequestration
- Atmospheric Removal of Carbon
- Efficiency

Carbon
Key Points

- Natural gas replacing coal reduces CO_2 emissions; gas leaks must be mitigated.
- Renewables reduce emissions, but have other environmental impacts.
- Electric vehicles shift CO_2 emissions from the tailpipe to the electricity source.

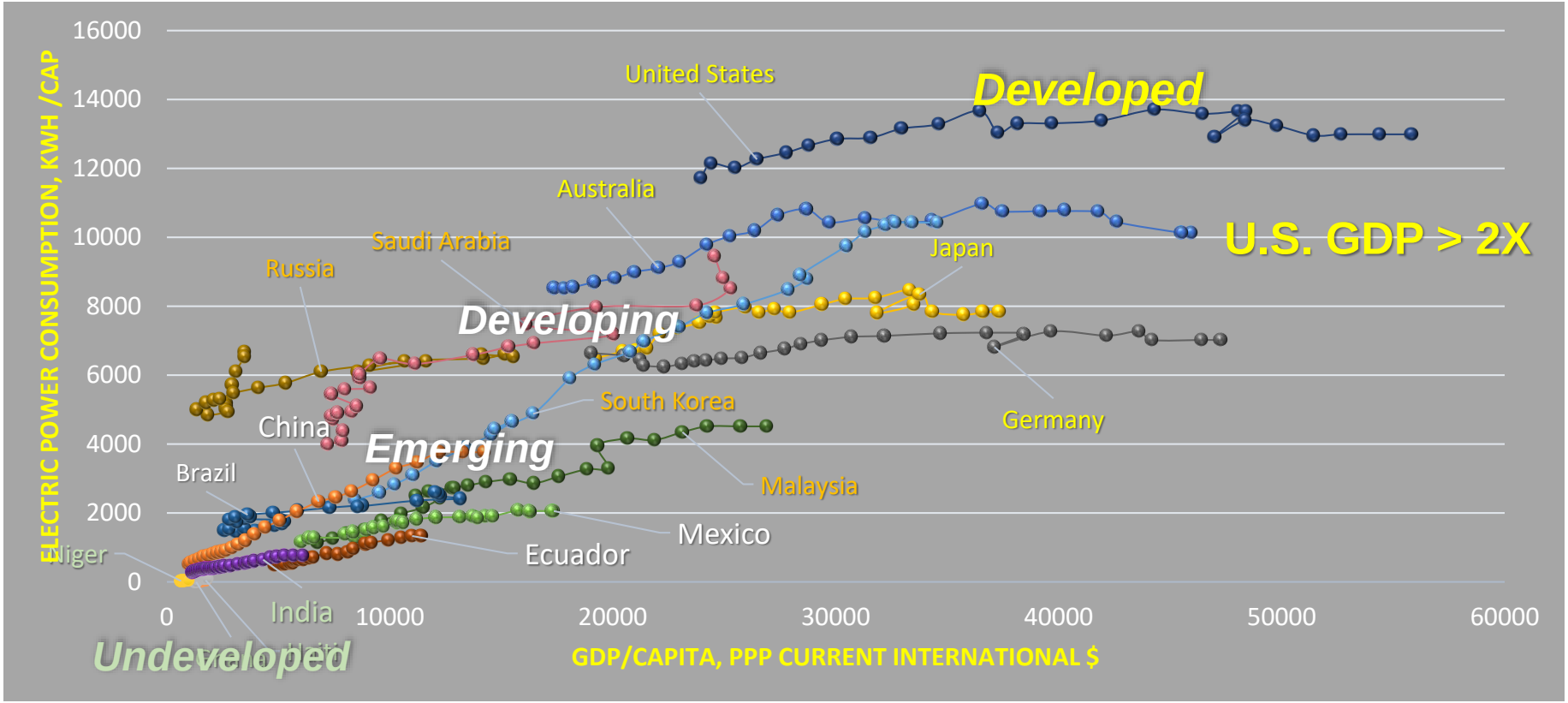
Bureau of Economic Geology

Outline

- Energy
- Carbon
- Poverty

SWITCH
ENERGY ALLIANCE

Limited Access to Electricity Restricts Standard of Living



Source: World Bank Databank

1990 '92 '93 '94 '95 '96 '97 '98 '99 2000 '01 '02 '03 '04 '05 '06 '07 '08 '09 2010 '11 '12 '13 '14 '15

SWITCH
ENERGY ALLIANCE

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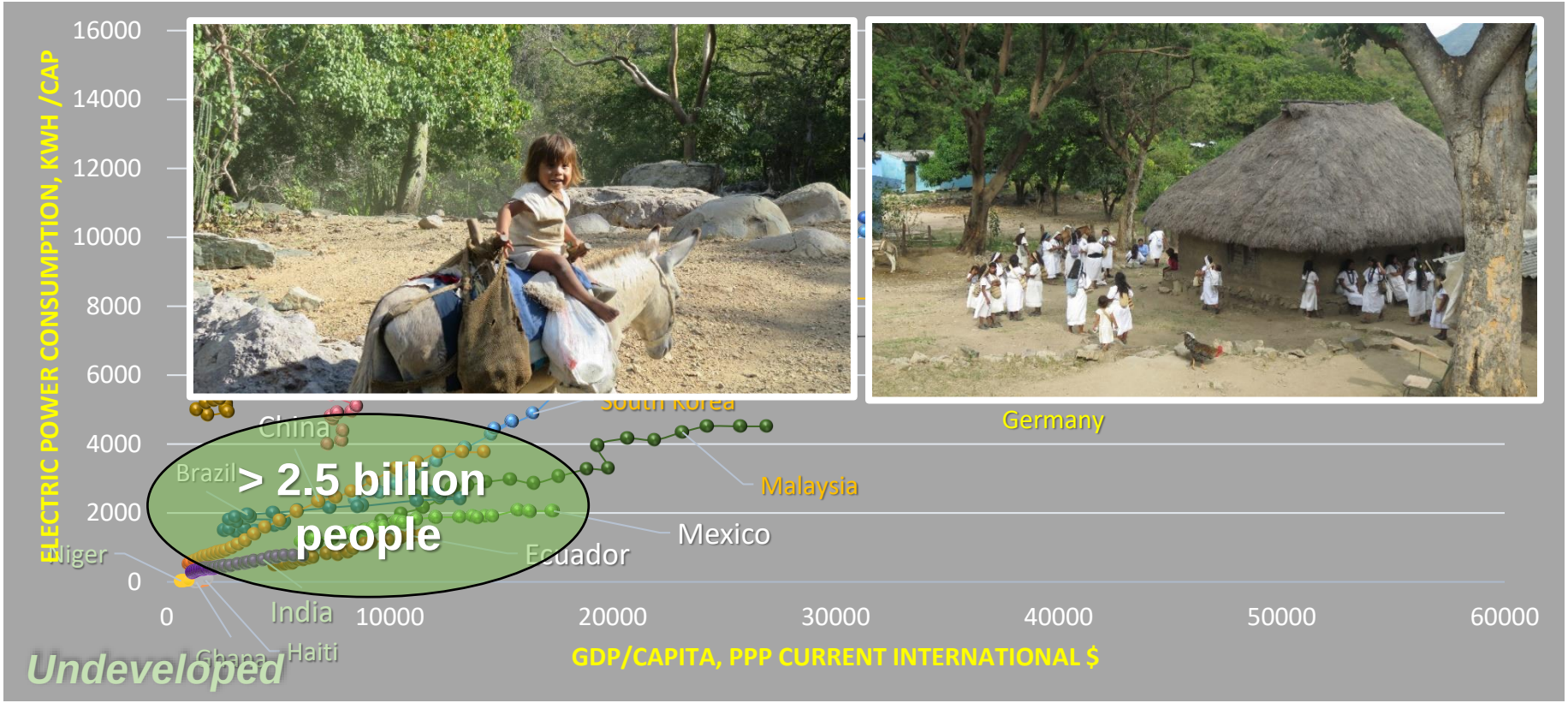

Source: World Bank Databank

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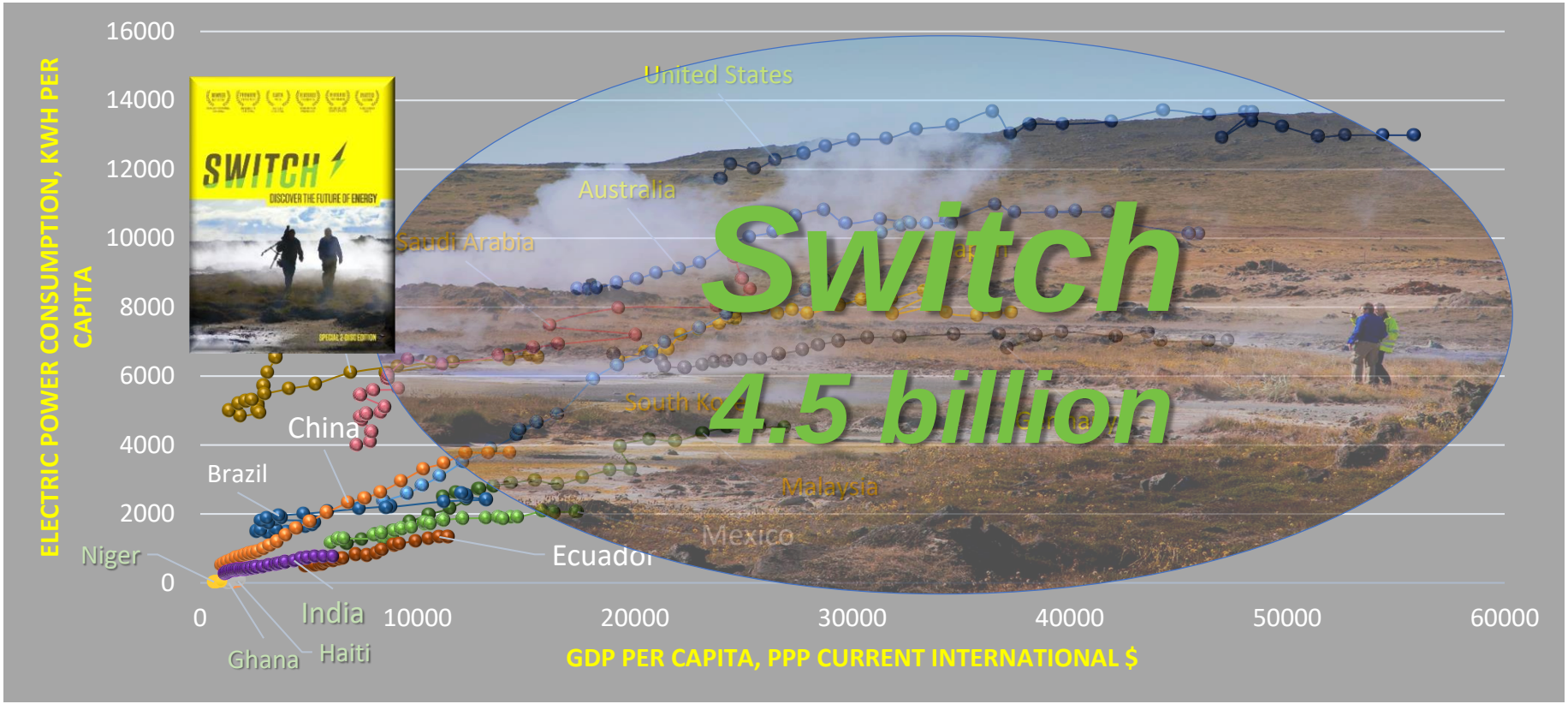
SWITCH
ENERGY ALLIANCE

Limited Access to Electricity Propagates Inequality



Source: World Bank Databank

Photo: Tinker, Ecuador, 2017

1990 '91 '92 '93 '94 '95 '96 '97 '98 '99 2000 '01 '02 '03 '04 '05 '06 '07 '08 '09 2010 '11 '12 '13 '14 '15 '16

SWITCH
ENERGY ALLIANCE

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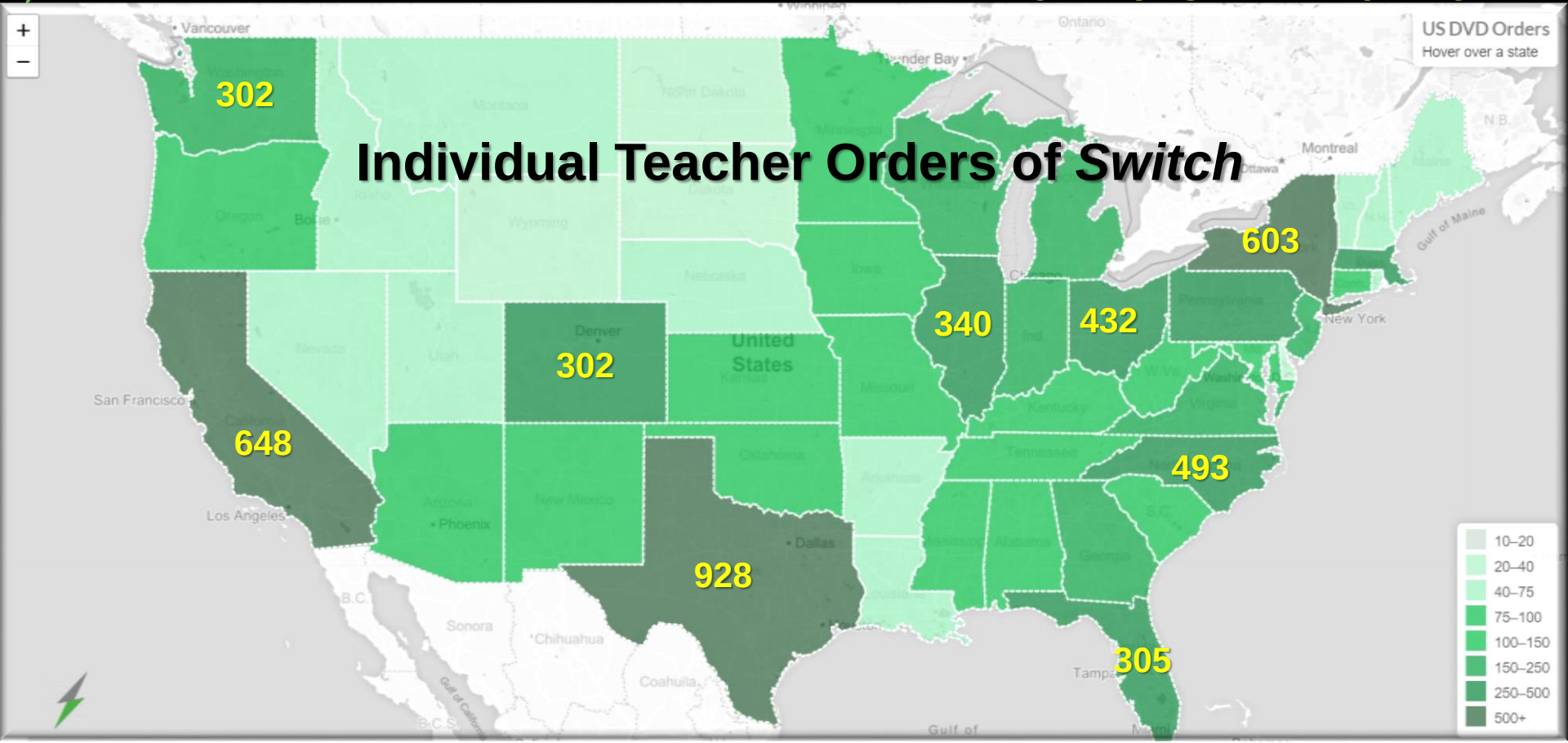

Photo: Tinker, Ecuador, 2017

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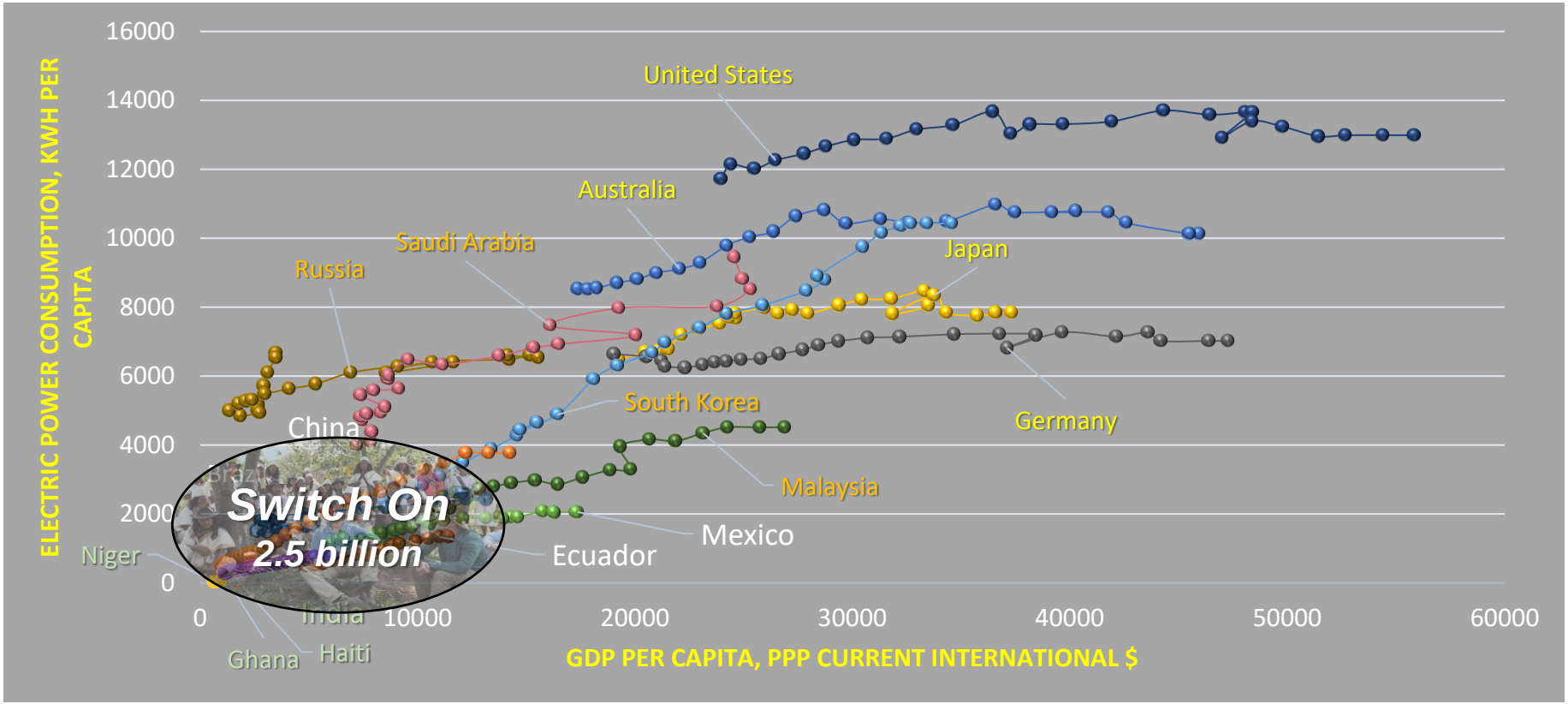

Source: World Bank Databank

Photo: Tinker, Ecuador, 2017

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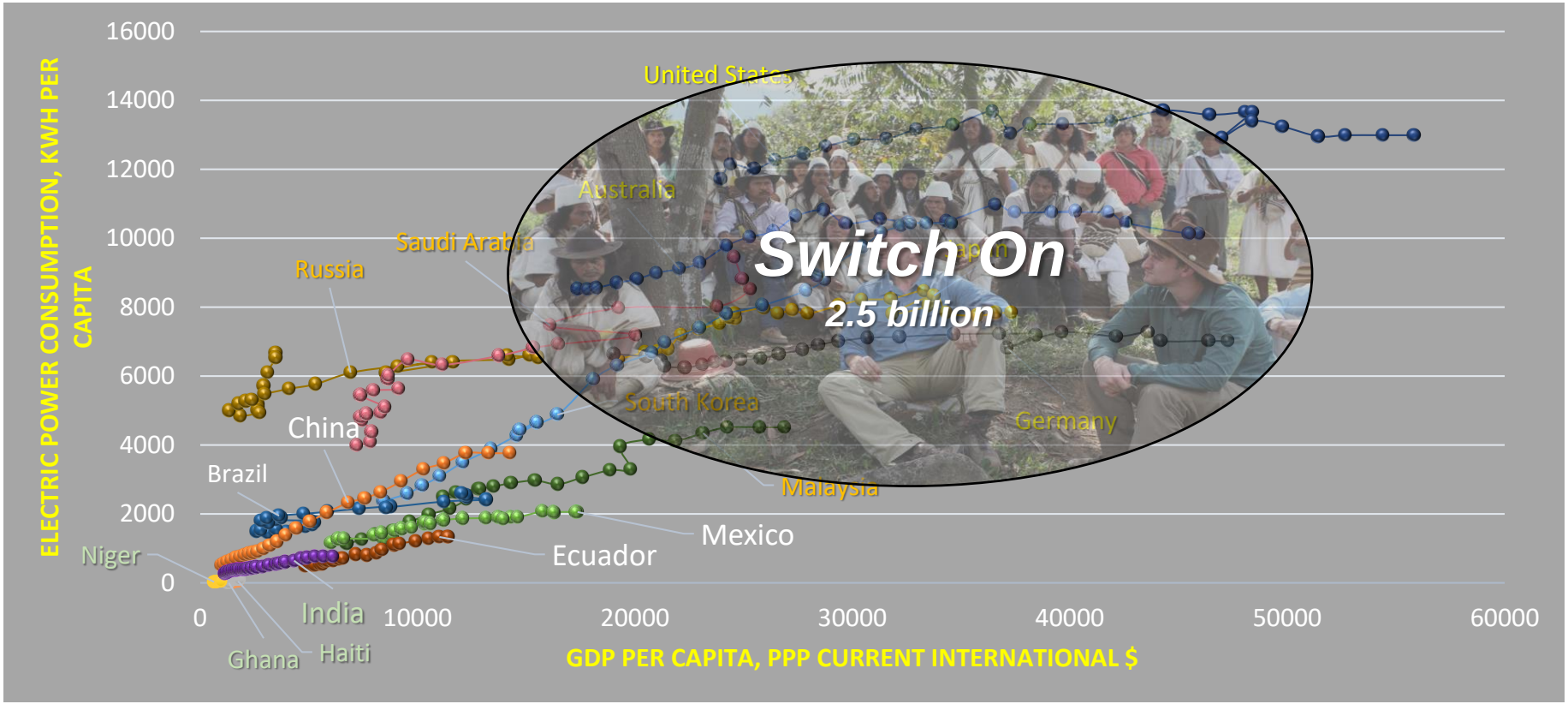


Source: World Bank Databank

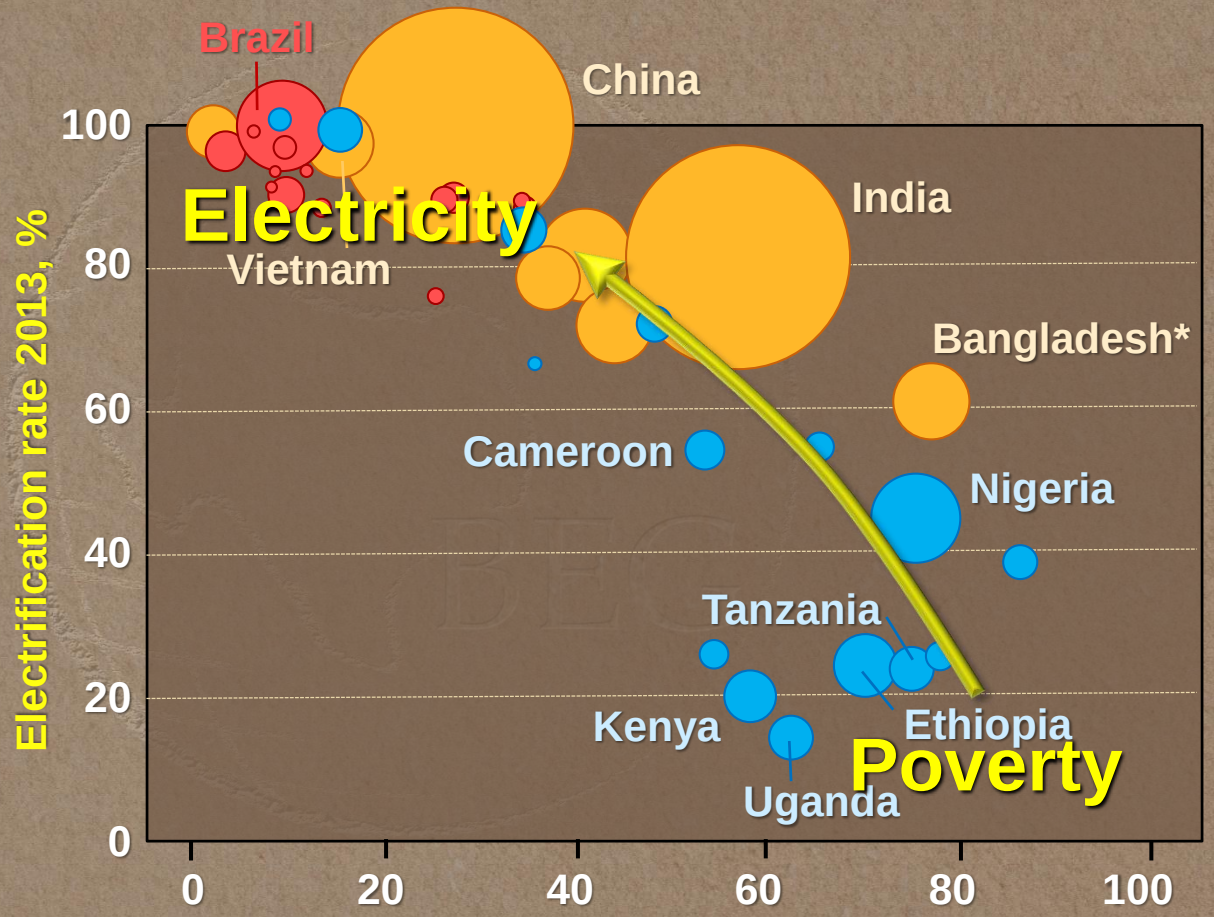
Photo: Tinker, Ecuador, 2017

1990 91 92 93 94 95 96 '97 '98 '99 2000 '01 '02 '03 '04 '05 '06 '07 '08 '09 2010 '11 '12 '13 '14 '15 '16

It's Time to Educate & Power the People

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

Sources: World Bank; IEA; World Energy Outlook 2015

Photos: Tinker, Lynch, Ecuador, 2017

QA03021

Economy
Key Points

- **Energy underpins modern economies and helps lift the world from poverty**
- **The energy mix varies by region; no form of energy is “good” or “bad”**

Bureau of Economic Geology


Keep IT in the Ground. Keep THEM in Poverty.

Energy Education

SWITCH
ENERGY ALLIANCE

Towards a Radical Middle

- Natural gas (w/CCS) & nuclear for dense urban
- Renewables for rural electrification; backup required
- Electric vehicles for cities
- Efficient combustion engines for rural & long haul

Energy education is a contact sport; engage!

Bureau of Economic Geology


Thank You!
Join the Switch Energy Alliance
SwitchOn.org