



Private Advisors
November, 2018

Deciphering the Rhetoric of “Good and “Bad” Energy



Scott W. Tinker



The Western Narrative

Renewables and batteries are
“clean” and “good”...

Fossil energy and nuclear are
“dirty” and “bad”...

A Dilemma

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

But... they think they do!

Outline

- ❖ Energy
- ❖ Carbon
- ❖ Poverty
- ❖ Radical Middle

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

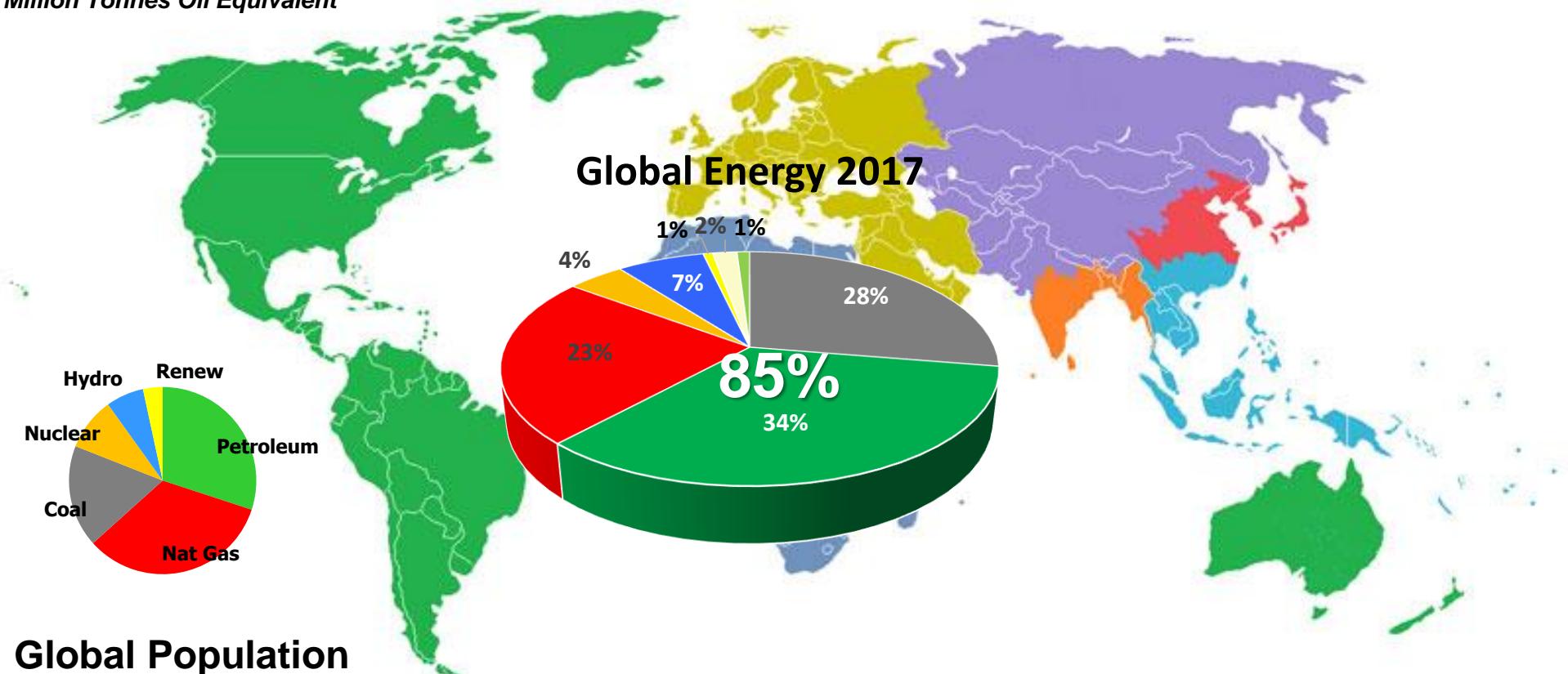
Clean: air and atmospheric emissions

Dense: energy per area, weight and volume

Dry: fresh water use/risk

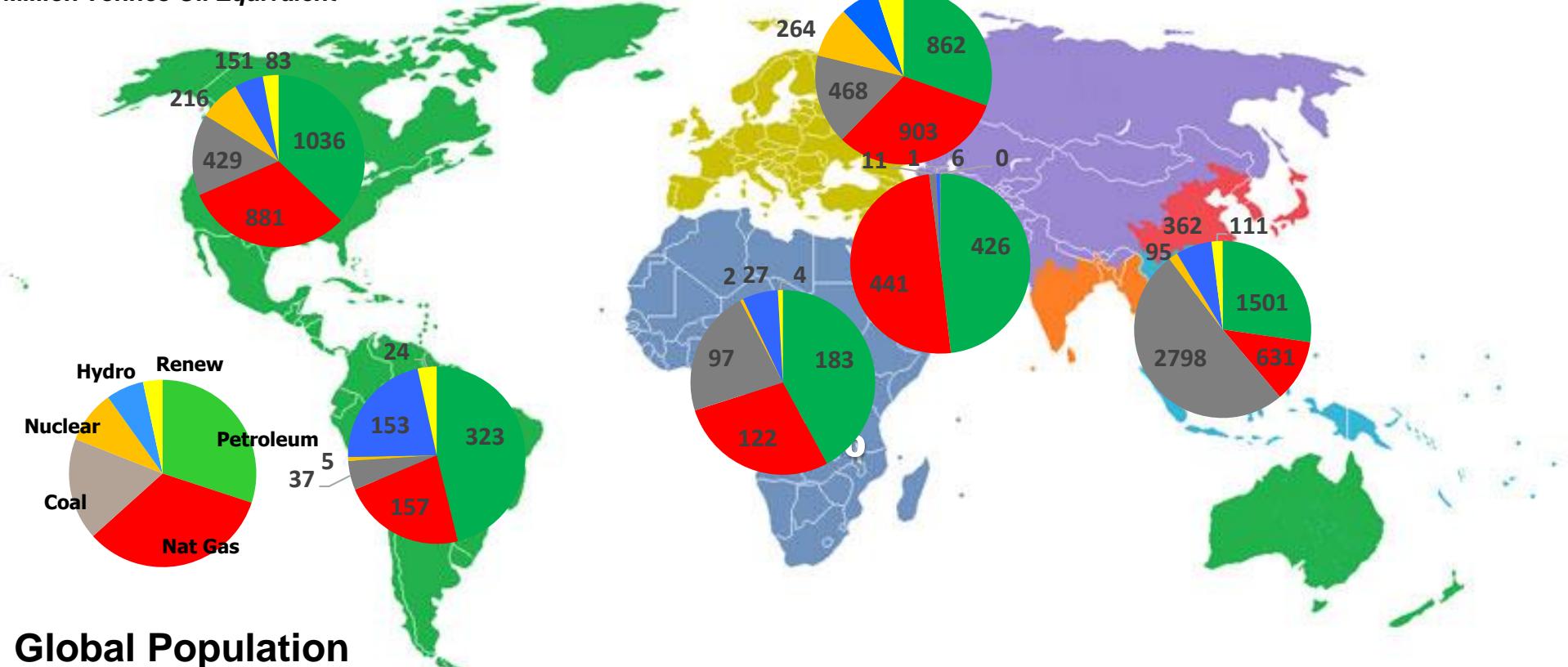
The Global Energy Mix

Million Tonnes Oil Equivalent



The Global Energy Mix

Million Tonnes Oil Equivalent



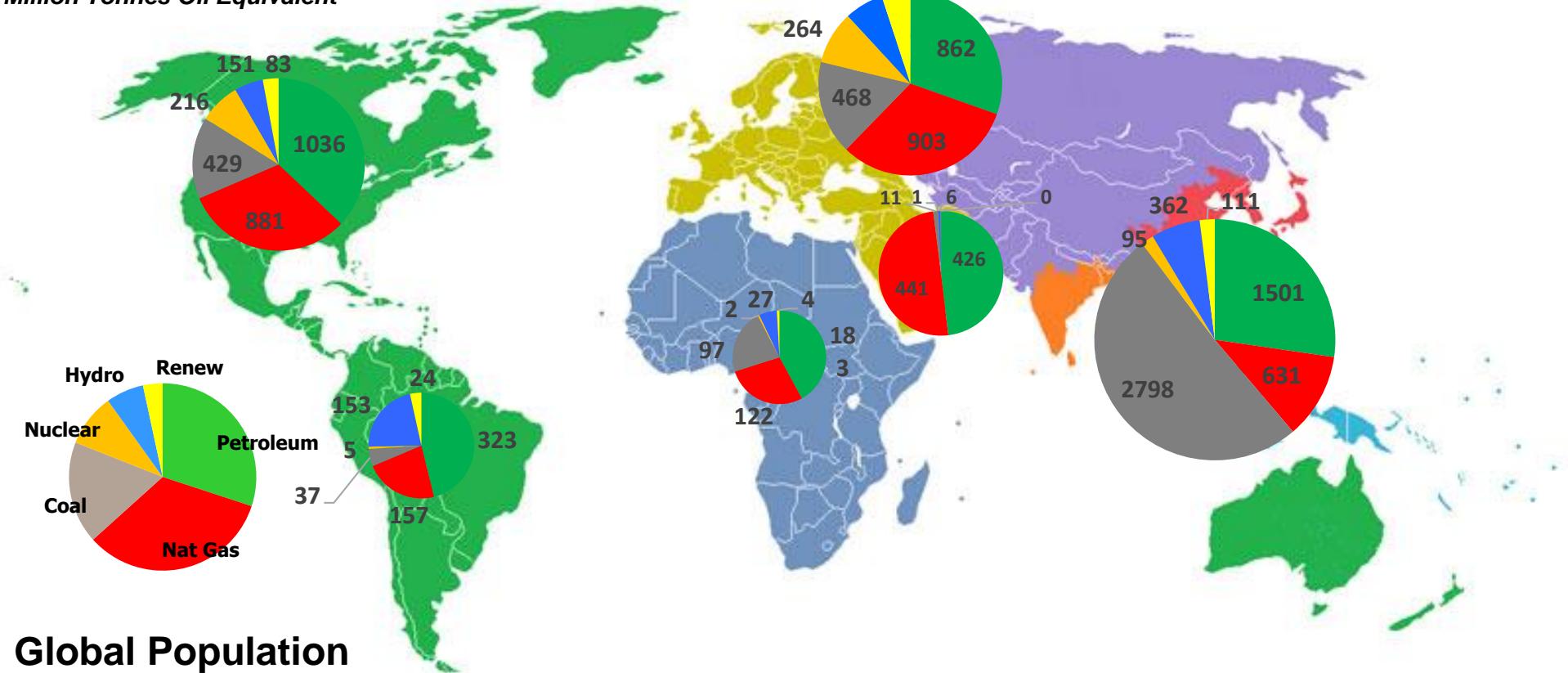
Global Population

Each color on the map represents ~ 1 billion people

Data: BP Statistical View of World Energy (2016)

Global Energy Demand

Million Tonnes Oil Equivalent

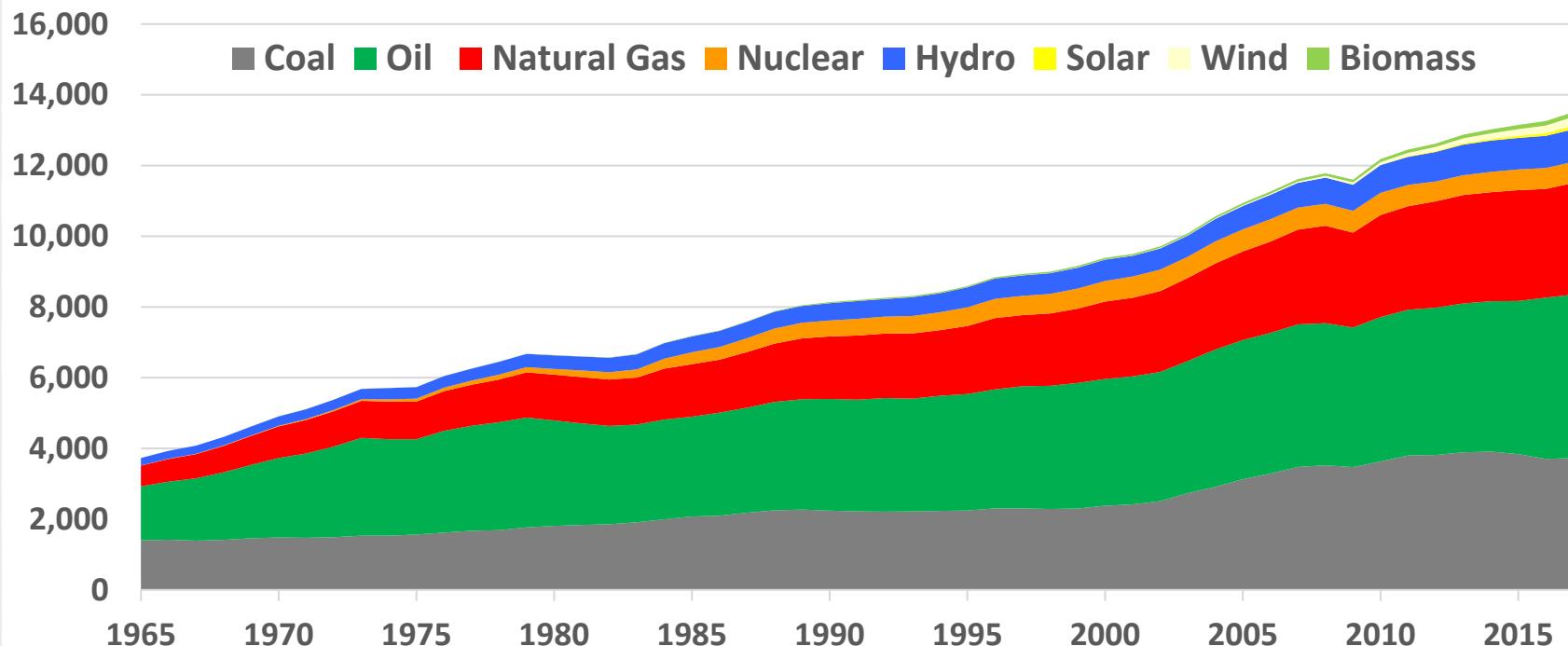


Global Population

Each color on the map represents ~ 1 billion people

Global Energy

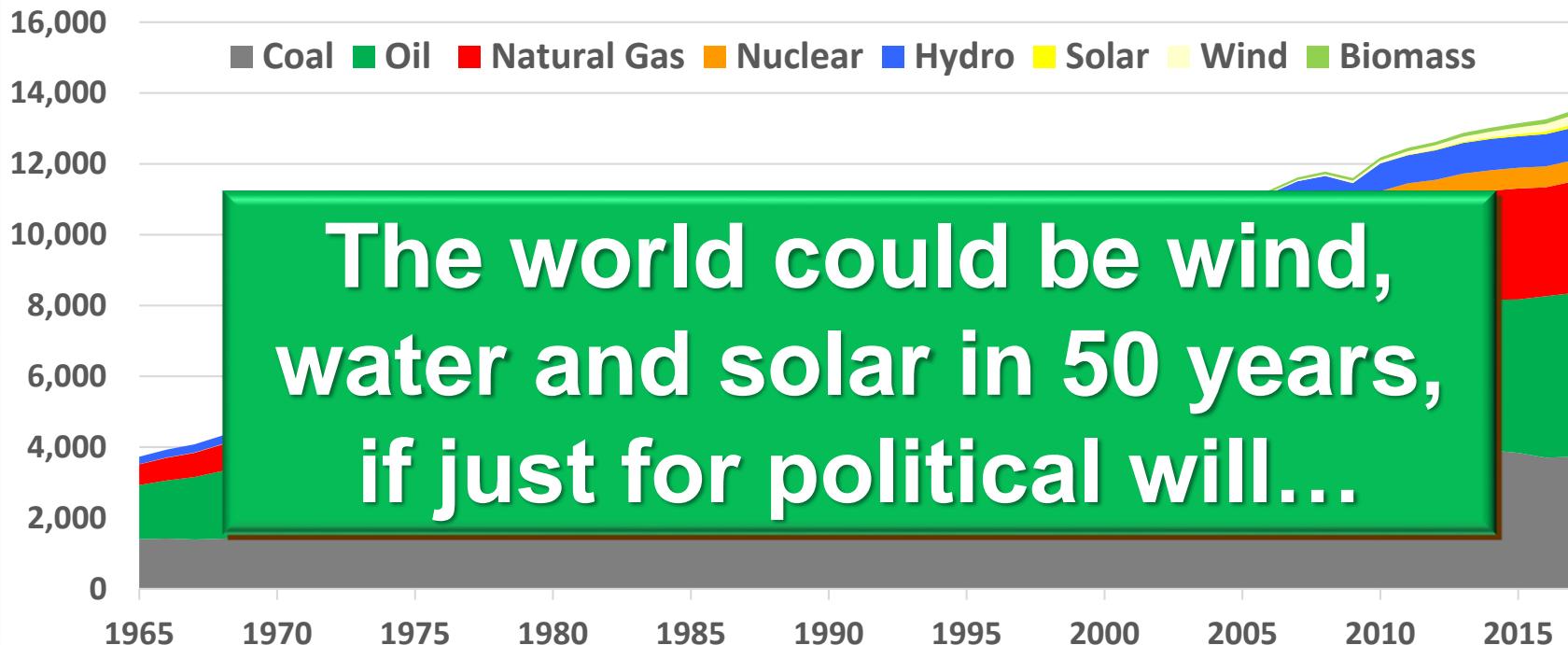
Global Energy (MTOE)



Data: BP Statistical View of World Energy (2018)

Global Energy

Global Energy (MTOE)

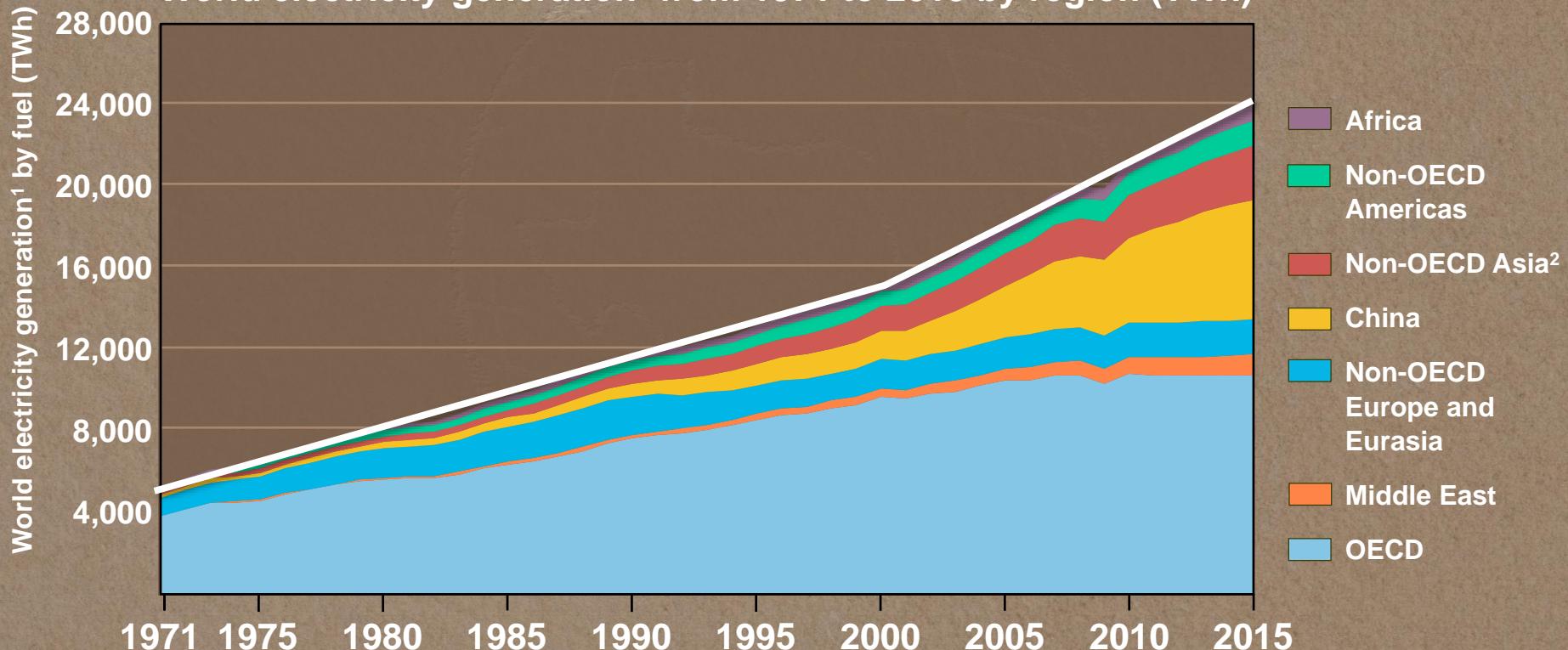


The world could be wind,
water and solar in 50 years,
if just for political will...

Data: BP Statistical View of World Energy (2018)

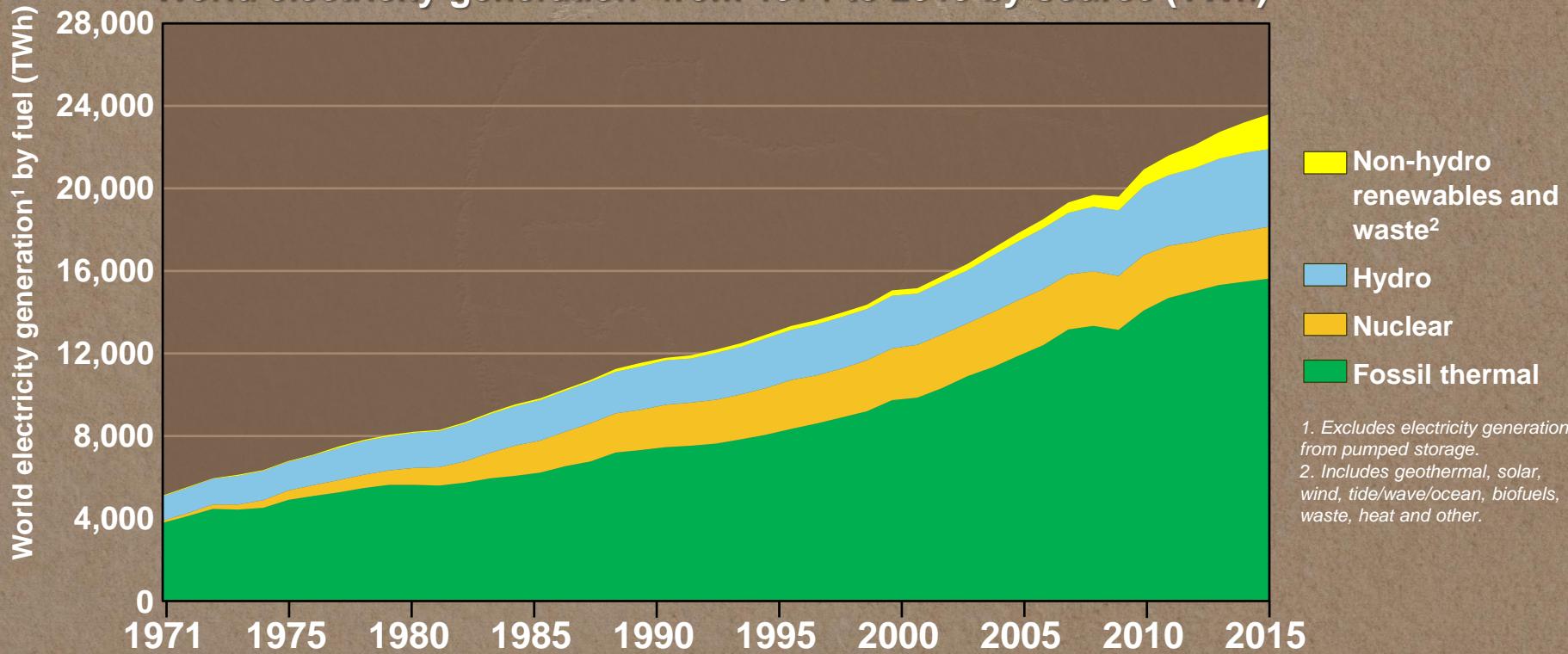
Electricity Generation By Region

World electricity generation¹ from 1971 to 2015 by region (TWh)



Electricity Generation by Source

World electricity generation¹ from 1971 to 2015 by source (TWh)

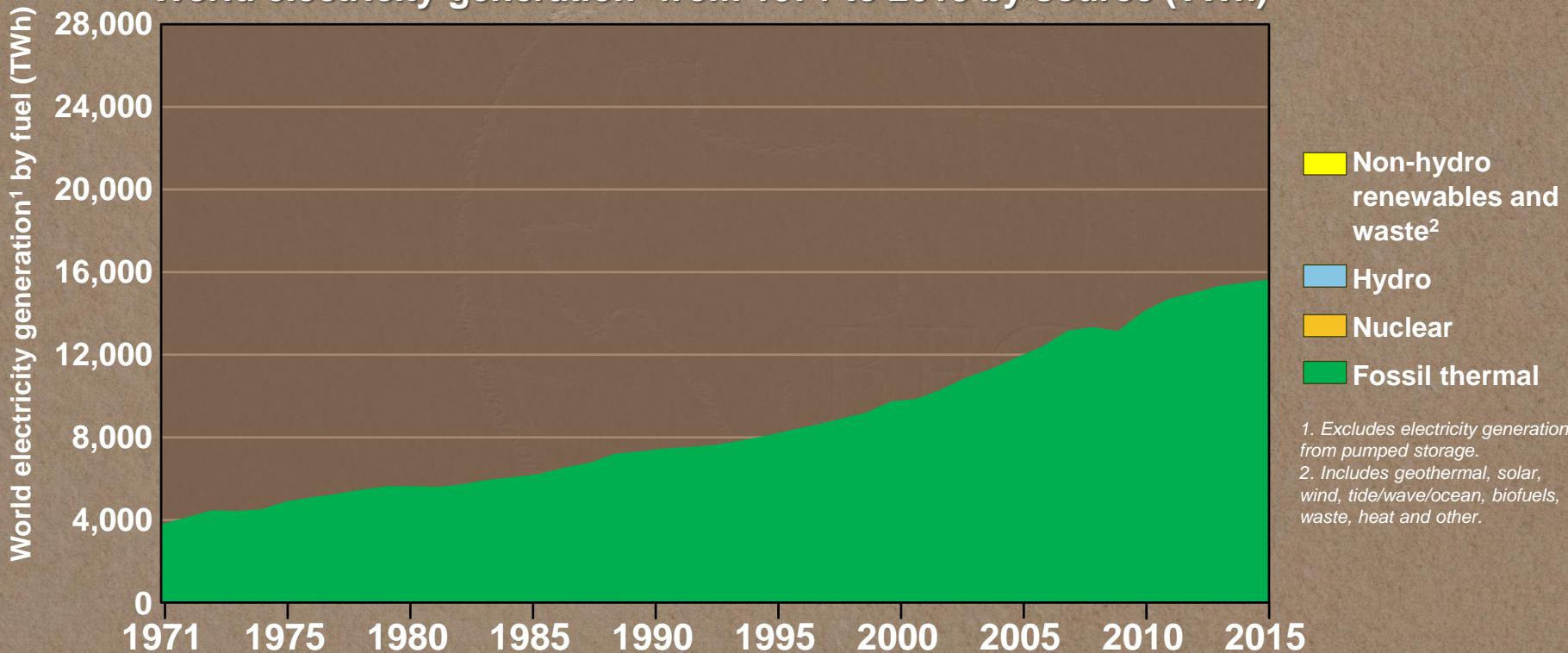


1. Excludes electricity generation from pumped storage.

2. Includes geothermal, solar, wind, tide/wave/ocean, biofuels, waste, heat and other.

Electricity Generation by Source

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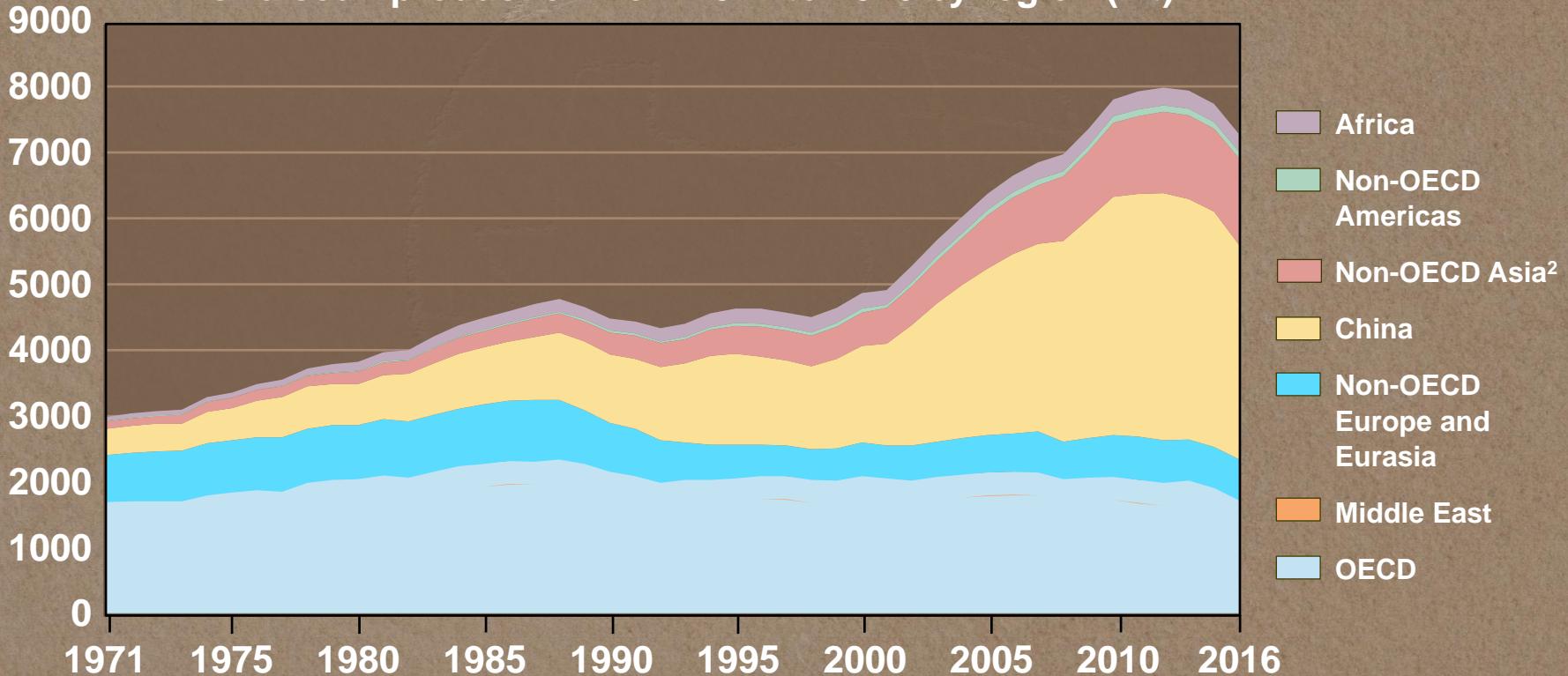


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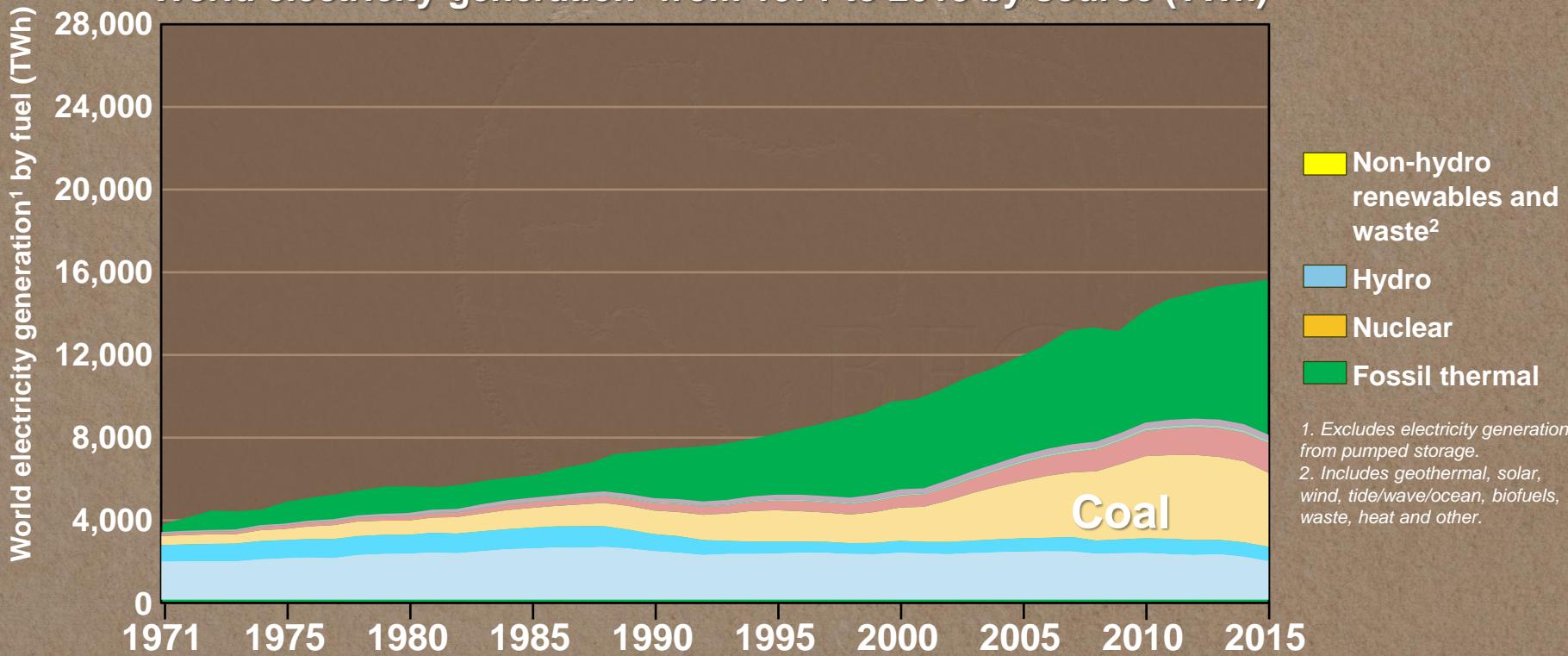
Global Coal Production

World coal¹ production from 1971 to 2016 by region (Mt)



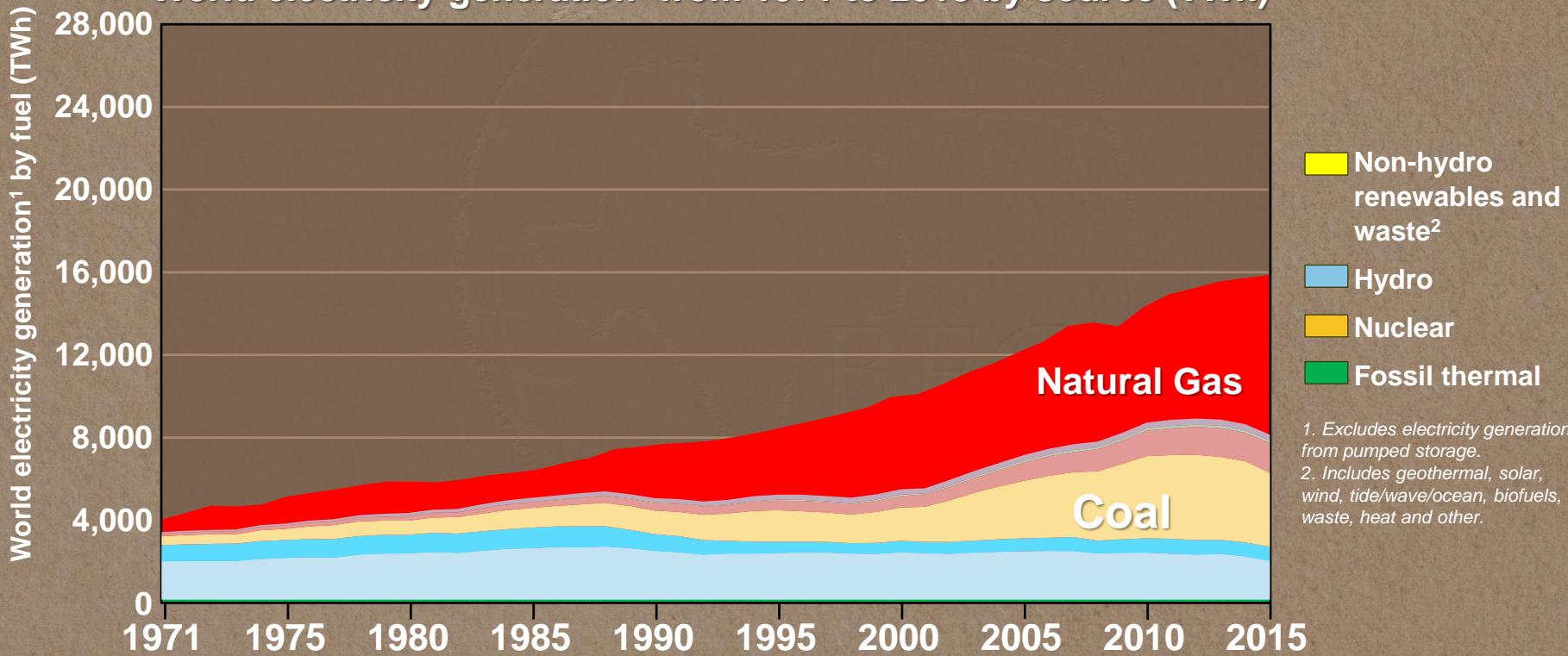
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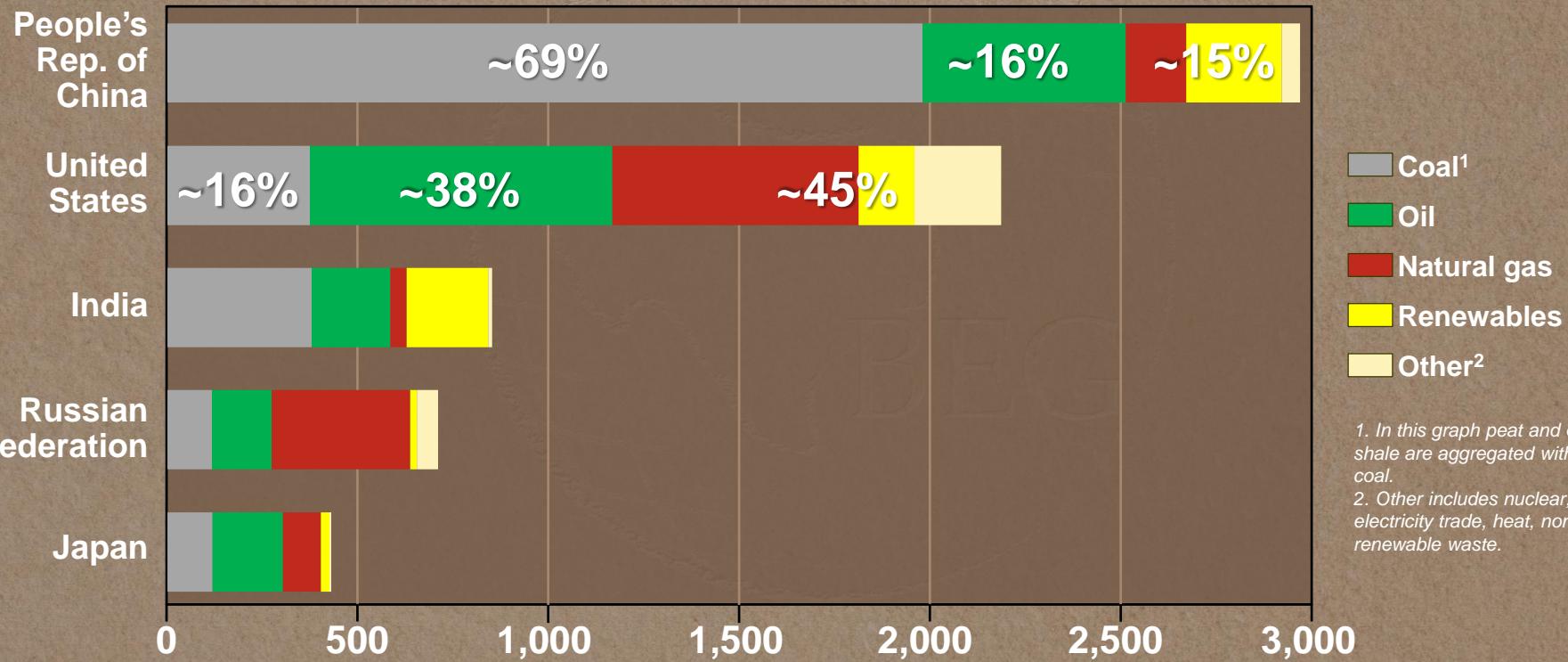
Global Electricity Generation by Source

World electricity generation¹ from 1971 to 2015 by source (TWh)



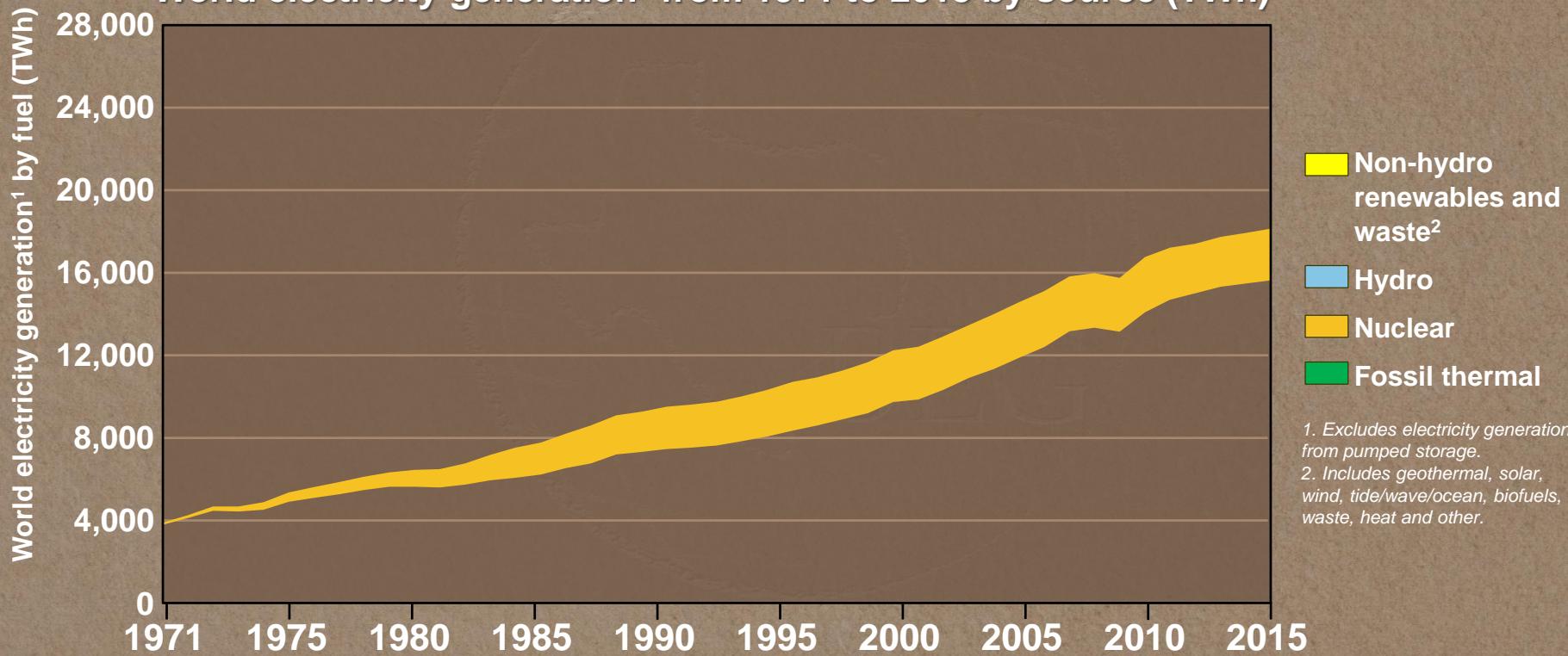
Total Primary Energy Supply (TPES)

by Energy Source (Mtoe)



Electricity Generation by Source

World electricity generation¹ from 1971 to 2015 by source (TWh)

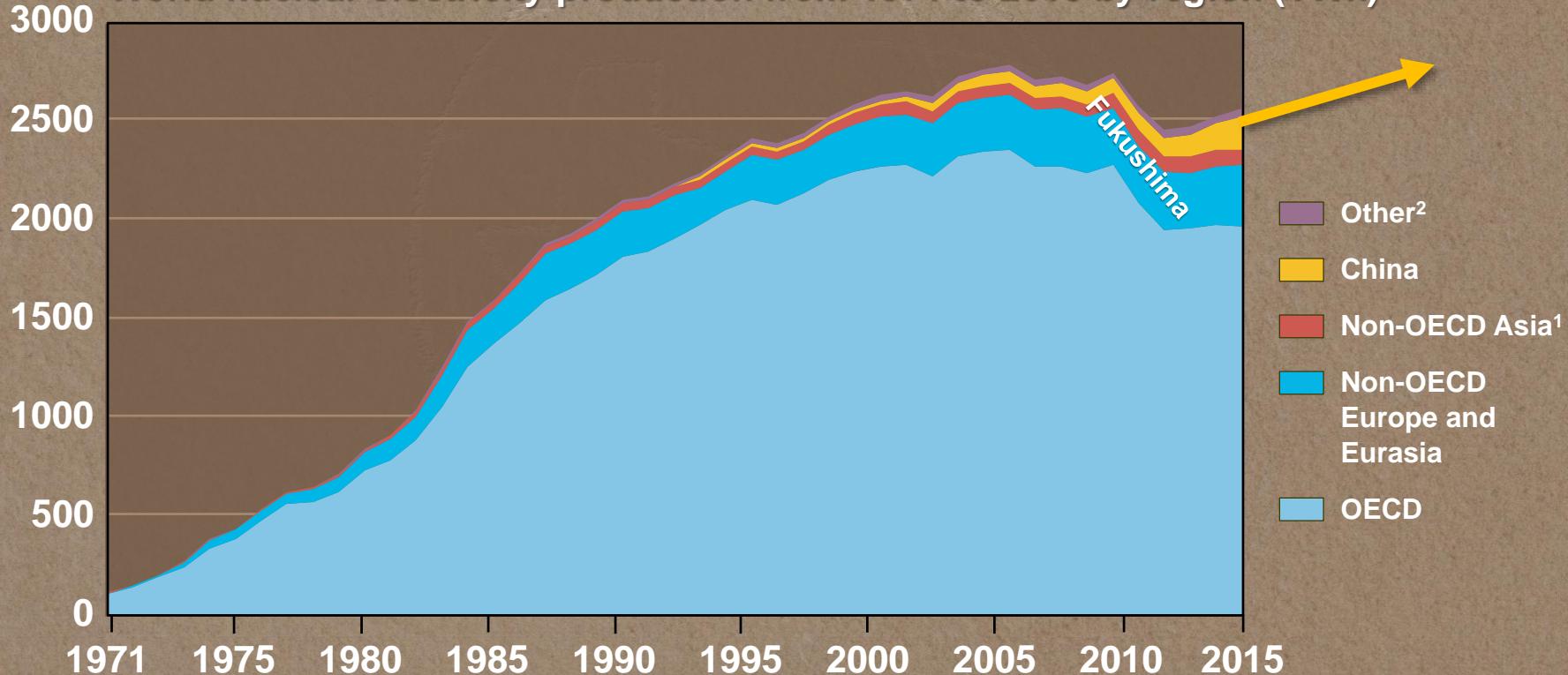


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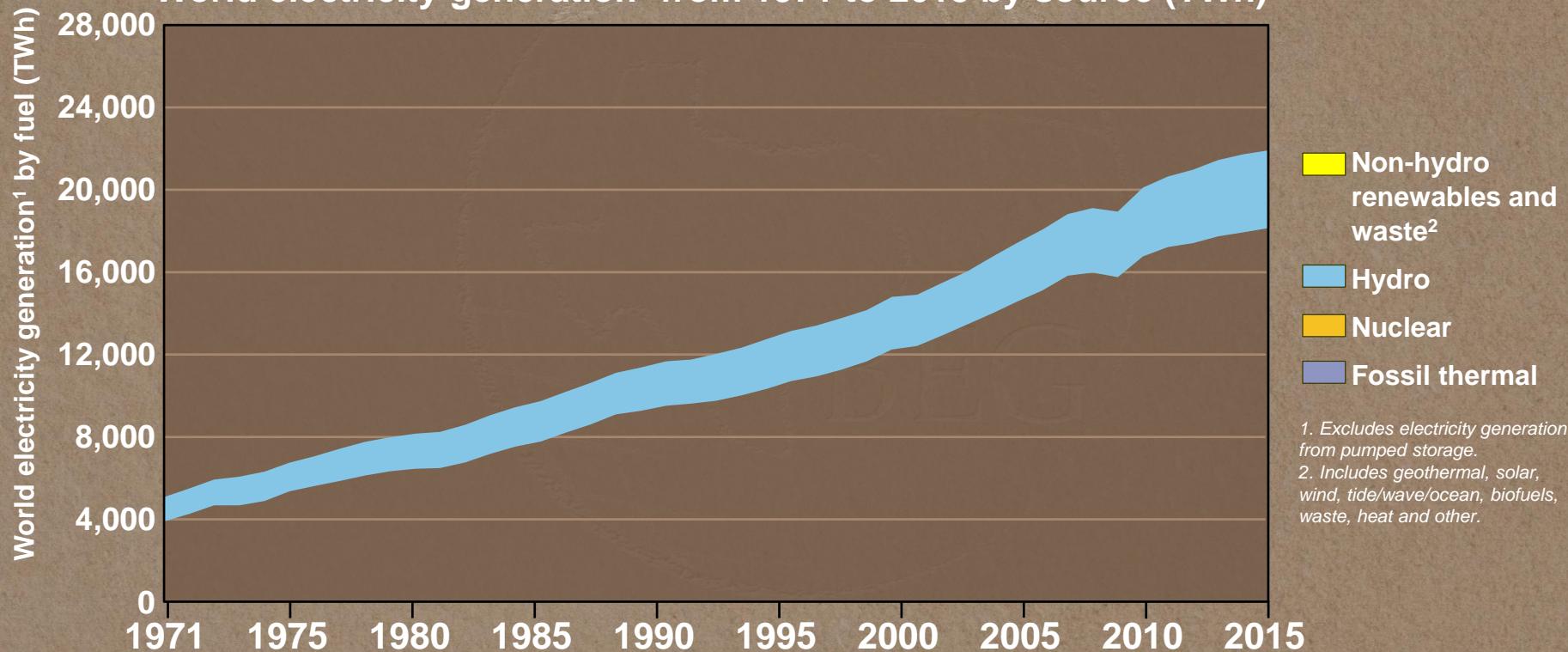
Nuclear Electricity Production

World nuclear electricity production from 1971 to 2015 by region (TWh)



Electricity Generation by Source

World electricity generation¹ from 1971 to 2015 by source (TWh)

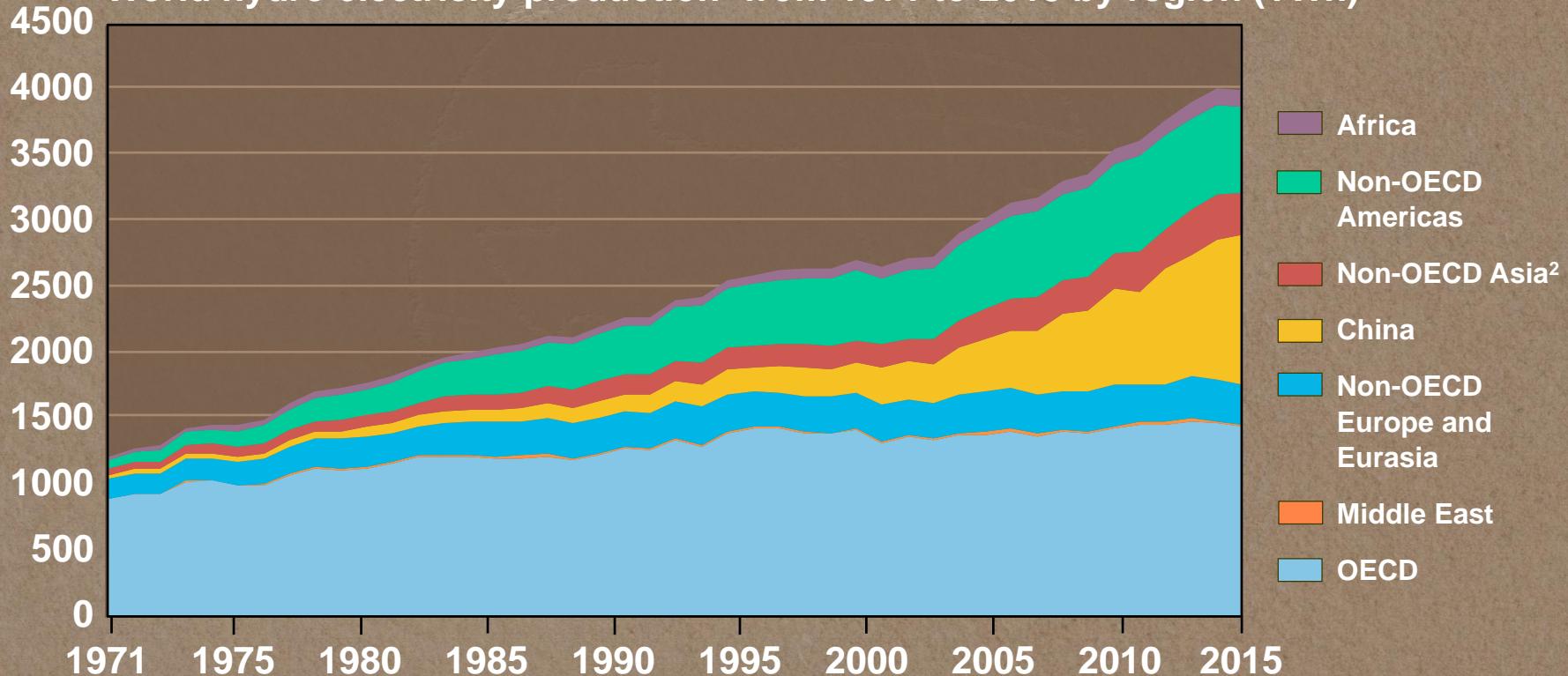


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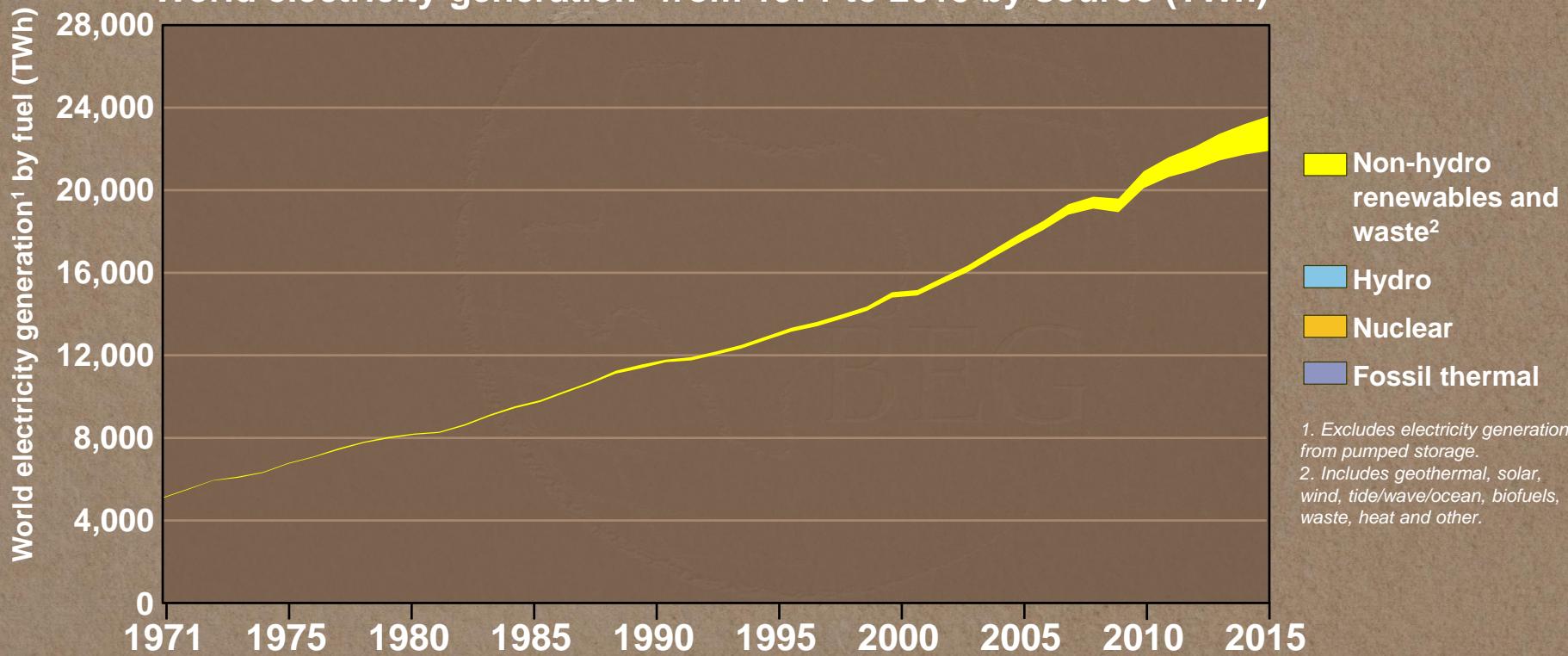
Hydro Electricity Production

World hydro electricity production¹ from 1971 to 2015 by region (TWh)



Electricity Generation by Source

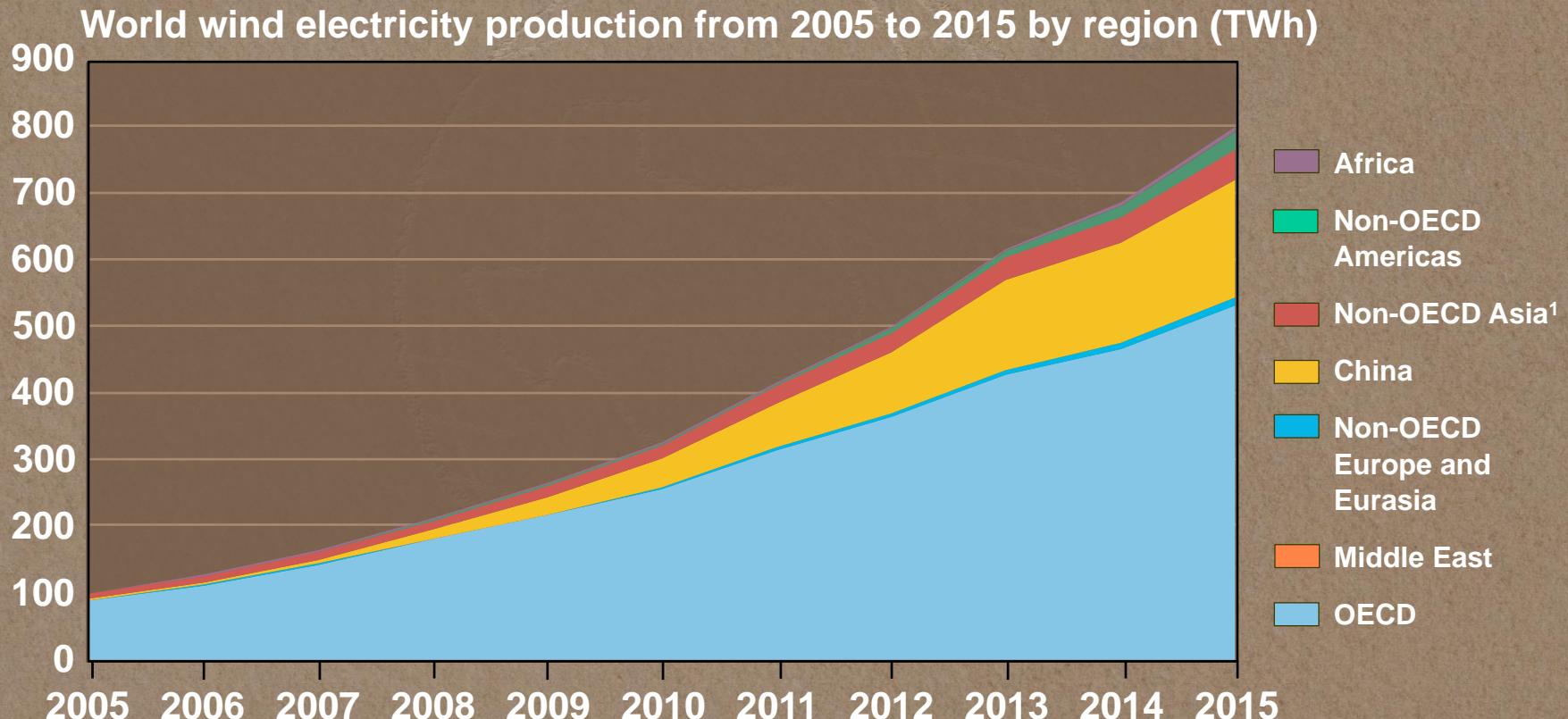
World electricity generation¹ from 1971 to 2015 by source (TWh)



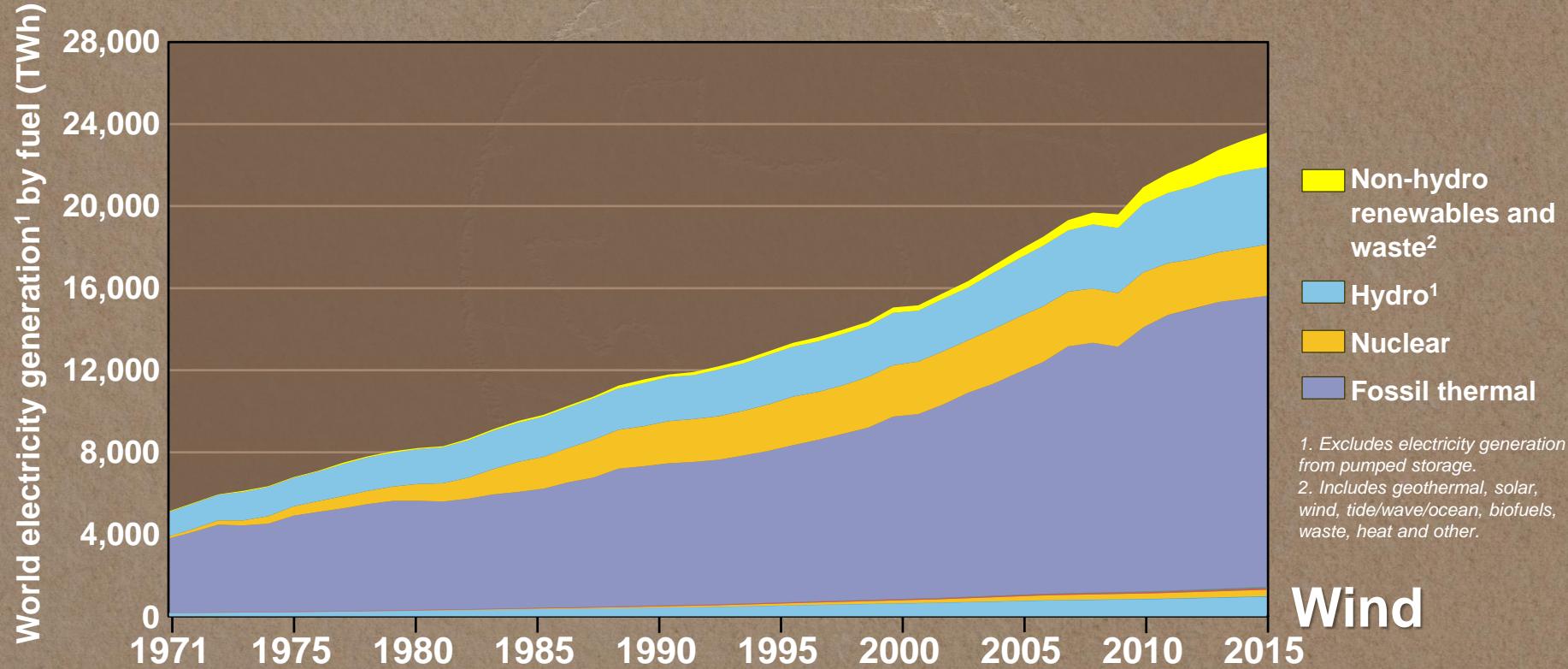
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Wind Electricity Production



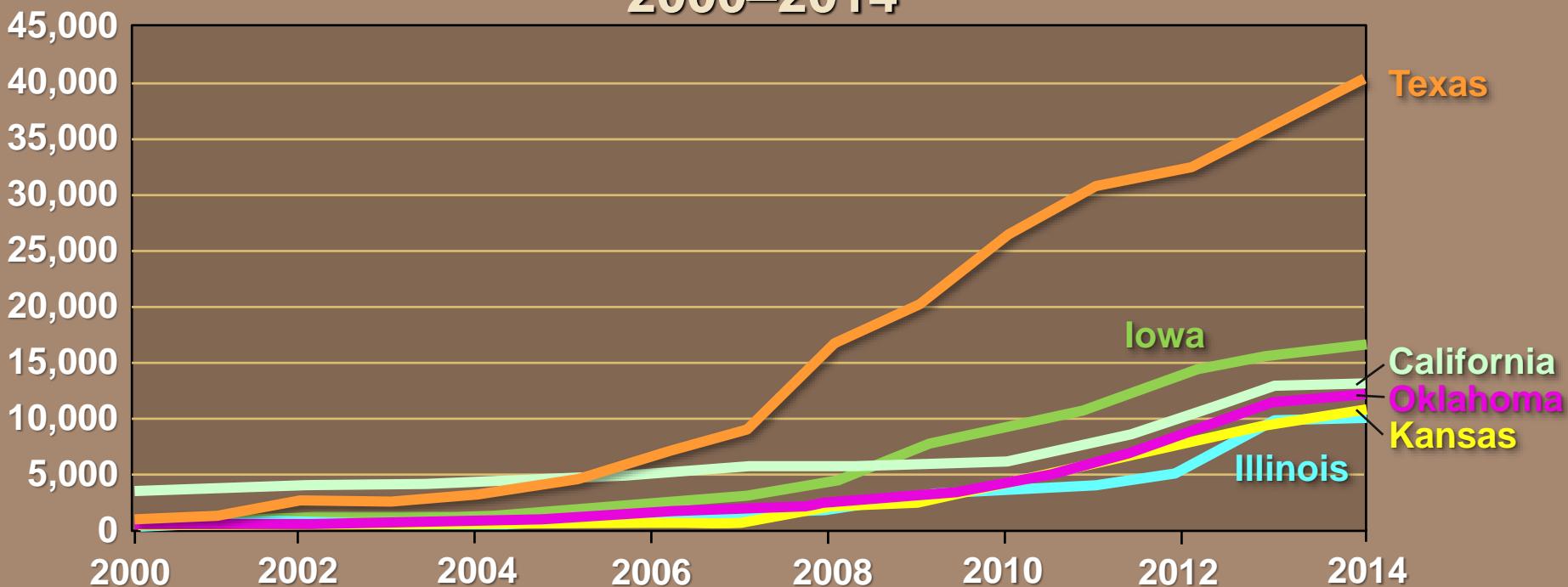
Global Electricity Generation by Source



Wind Electricity

Growth in U.S. Wind Generation 2000–2014

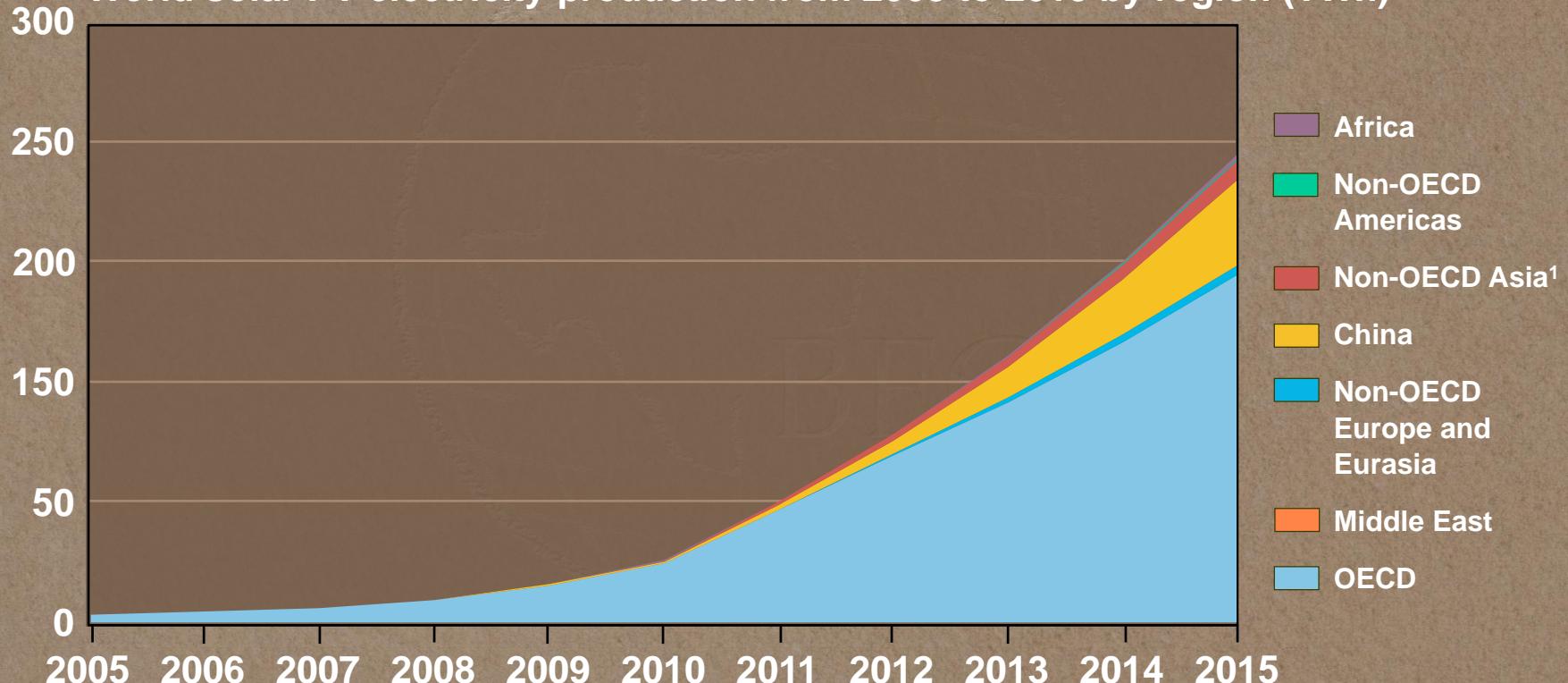
Million Kwh



QAe5771

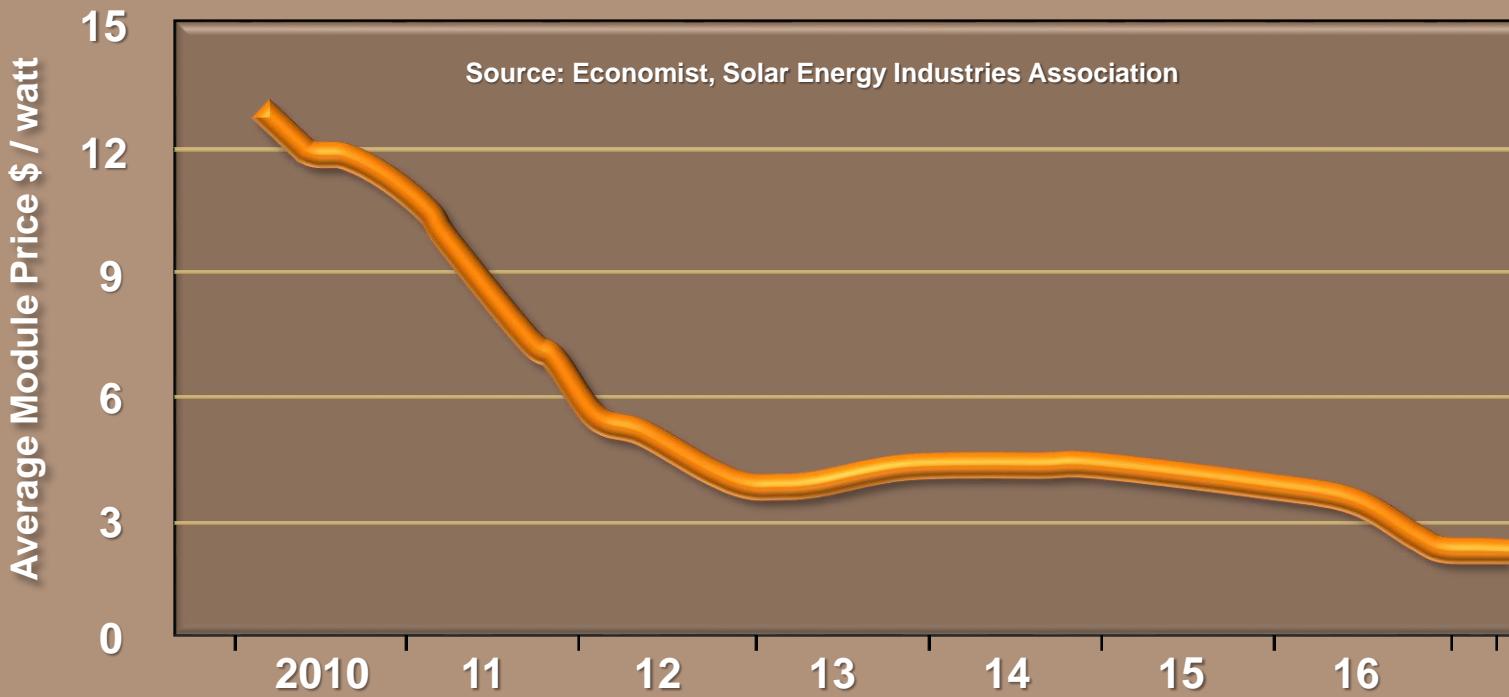
Solar Photovoltaic Electricity Production

World solar PV electricity production from 2005 to 2015 by region (TWh)



Solar Photovoltaic Electricity

United States Solar photovoltaics

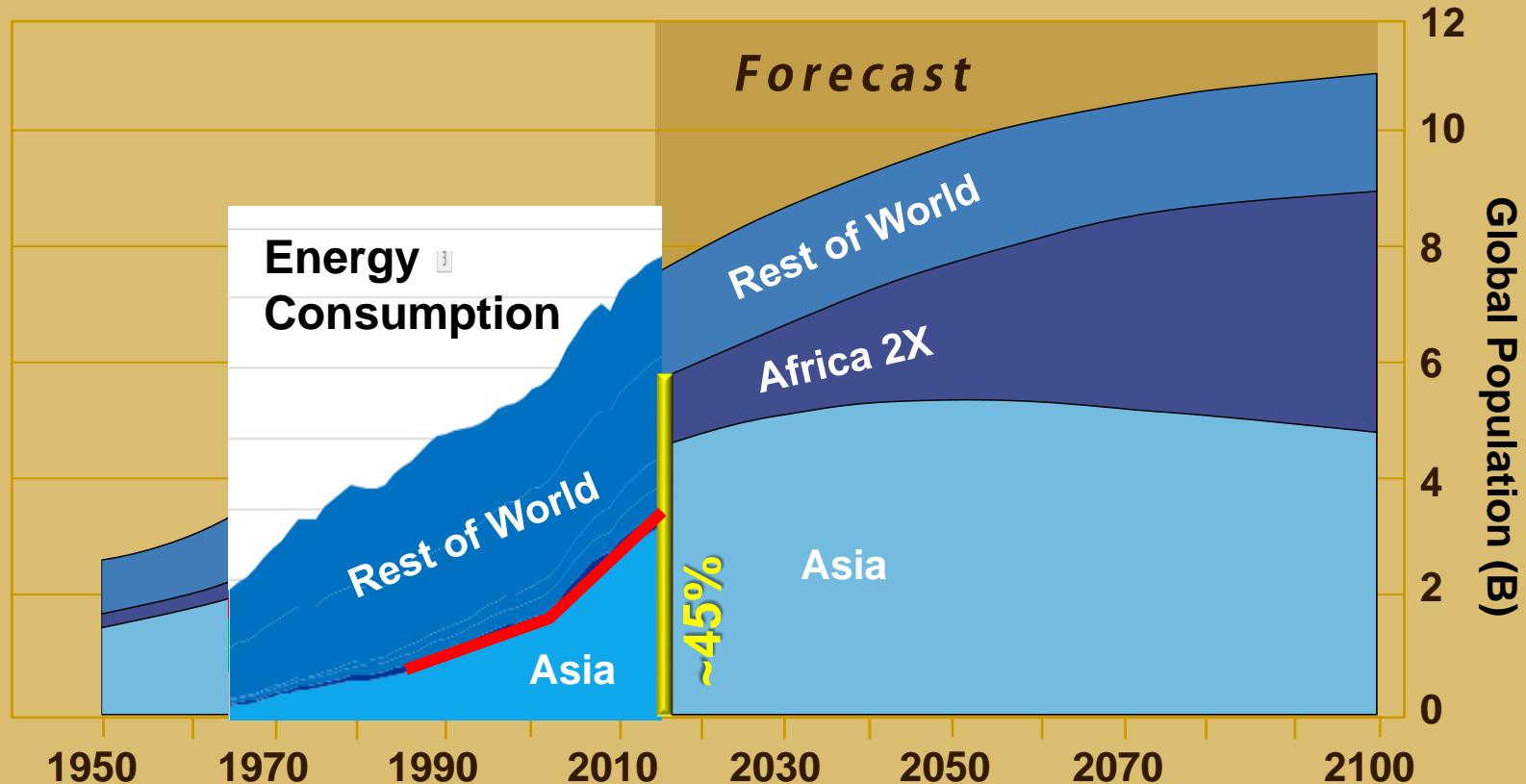


QAe5833

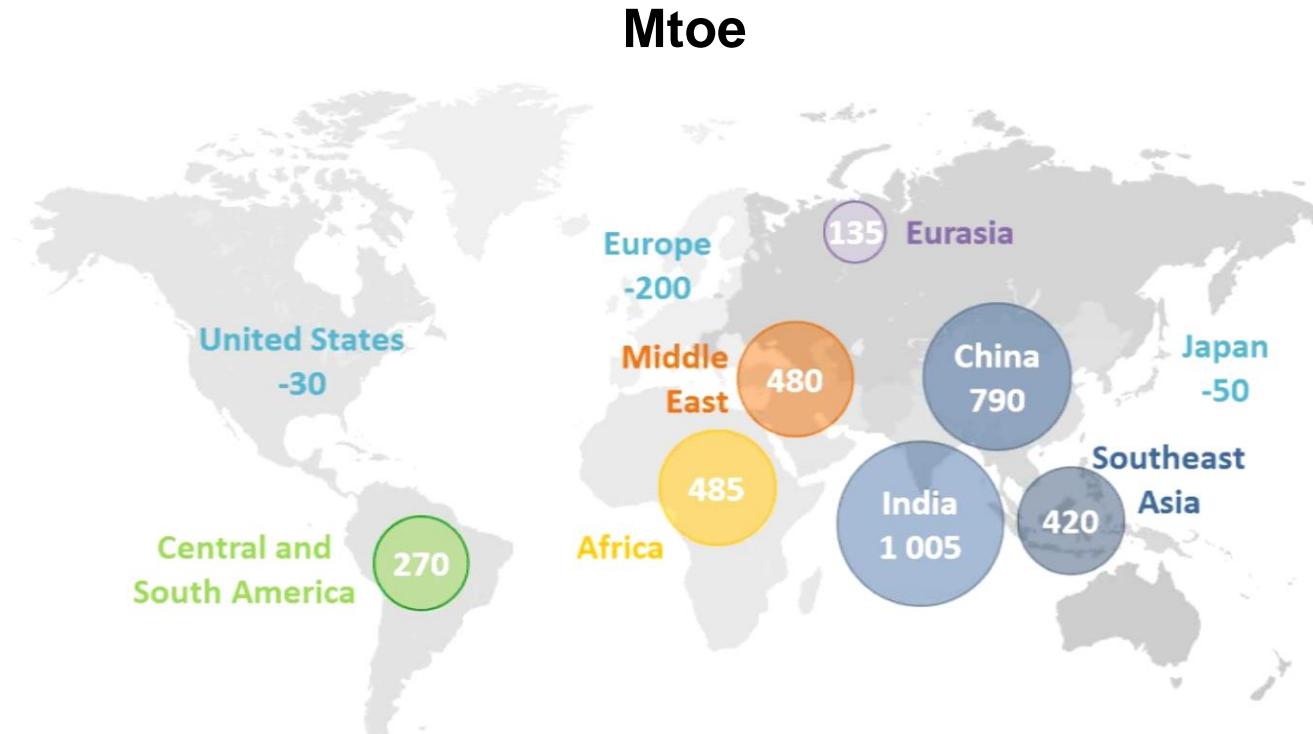
Global Electricity Generation by Source

It will take a tremendous amount of infrastructure for renewables to satisfy a moderate portion of electricity demand.

Population and Energy

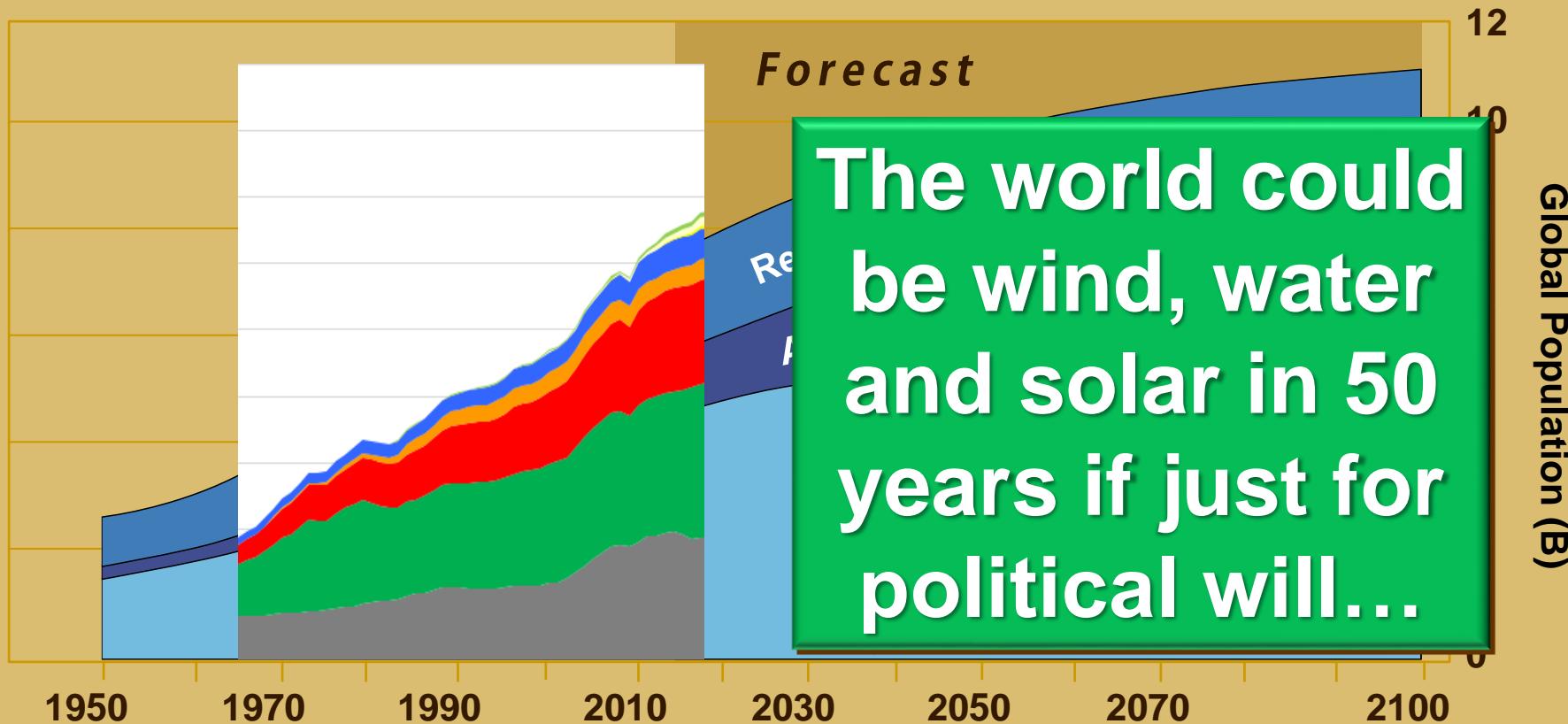


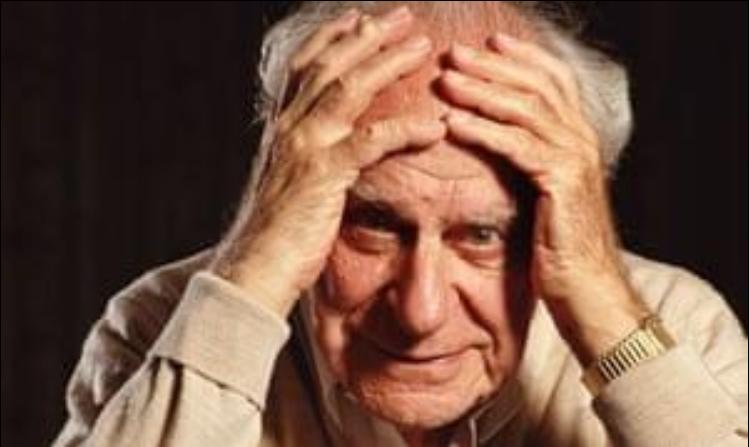
Change in Energy Demand 2016-2040



Source: OECD, IEA, 2017

Population and Energy

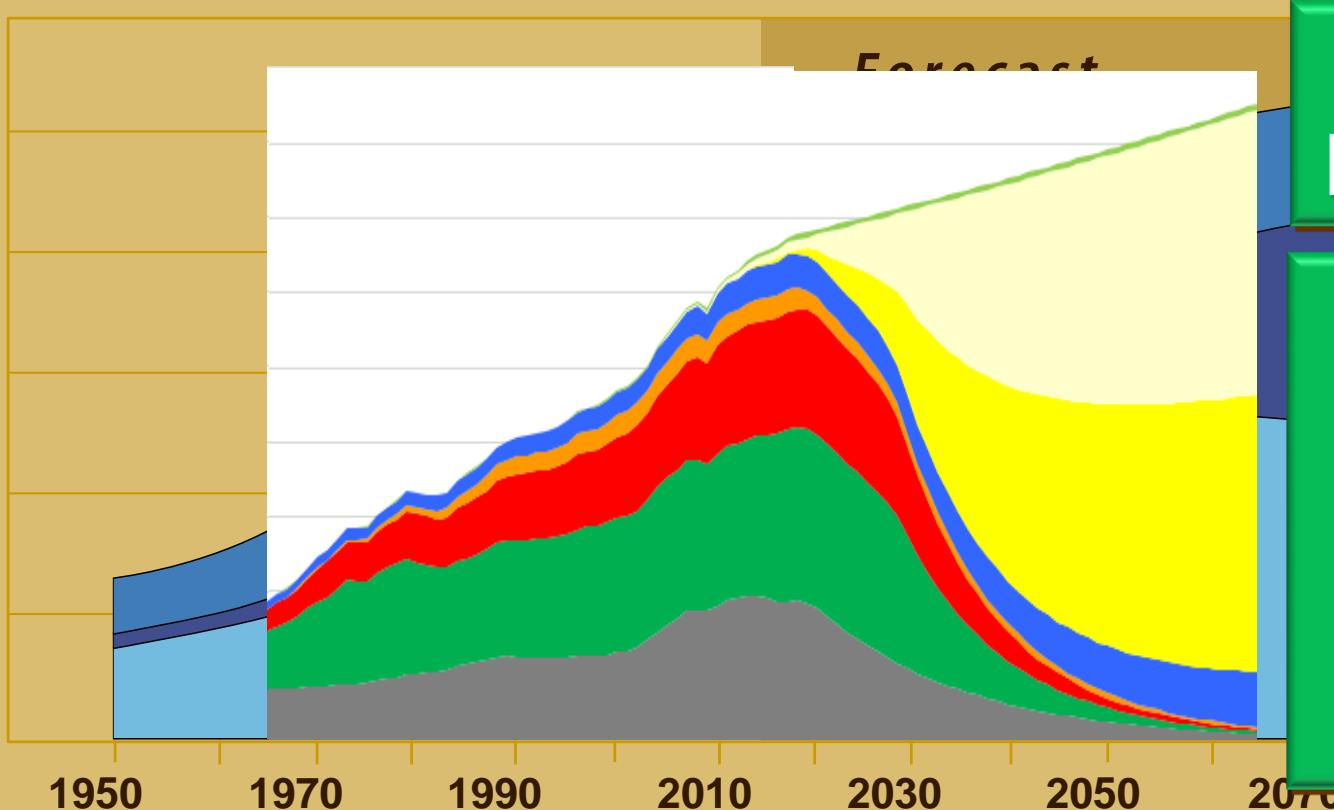




“No argument will have a rational effect on a [person] who does not want to adopt a rational attitude.”

-Karl Popper

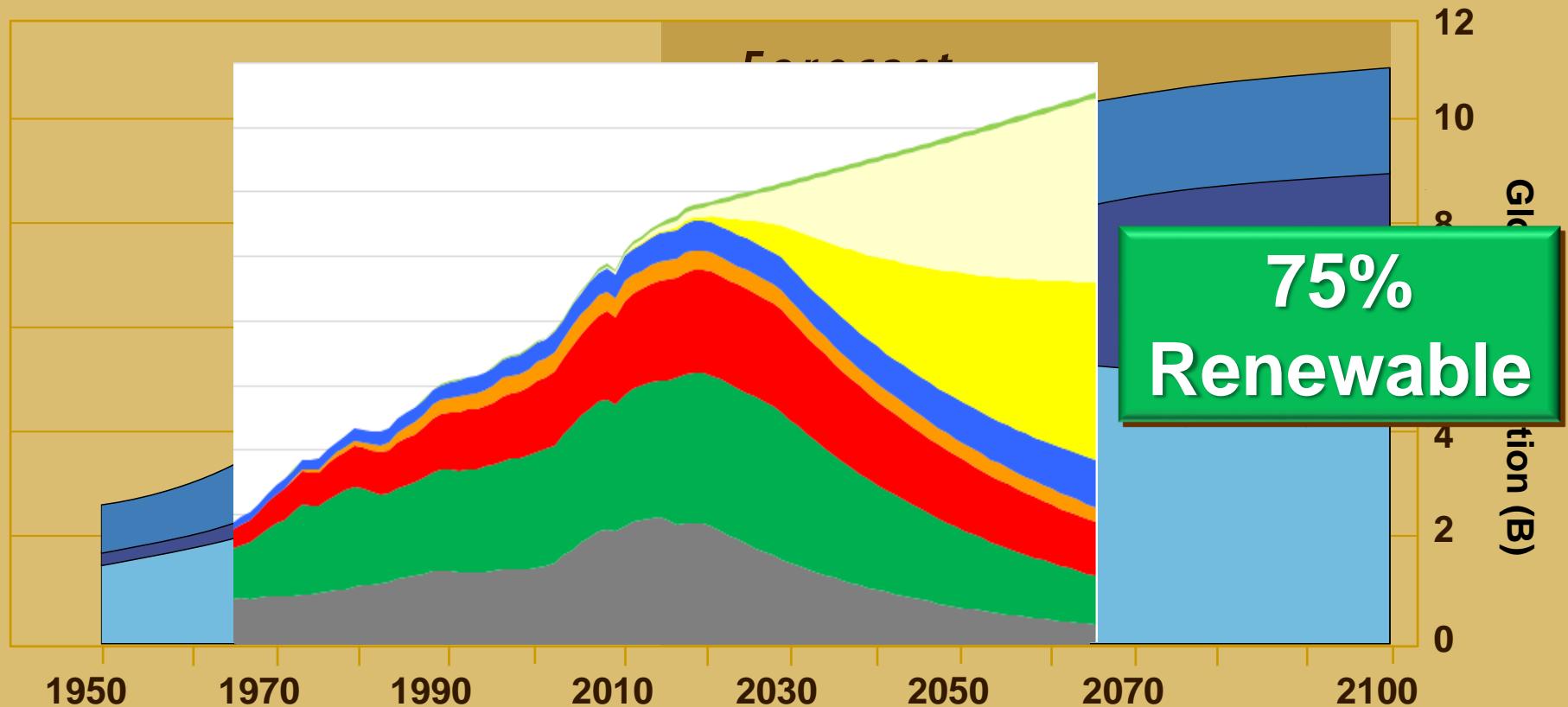
Population and Energy



98%
Renewable

Highly
unlikely,
and not
really
desirable

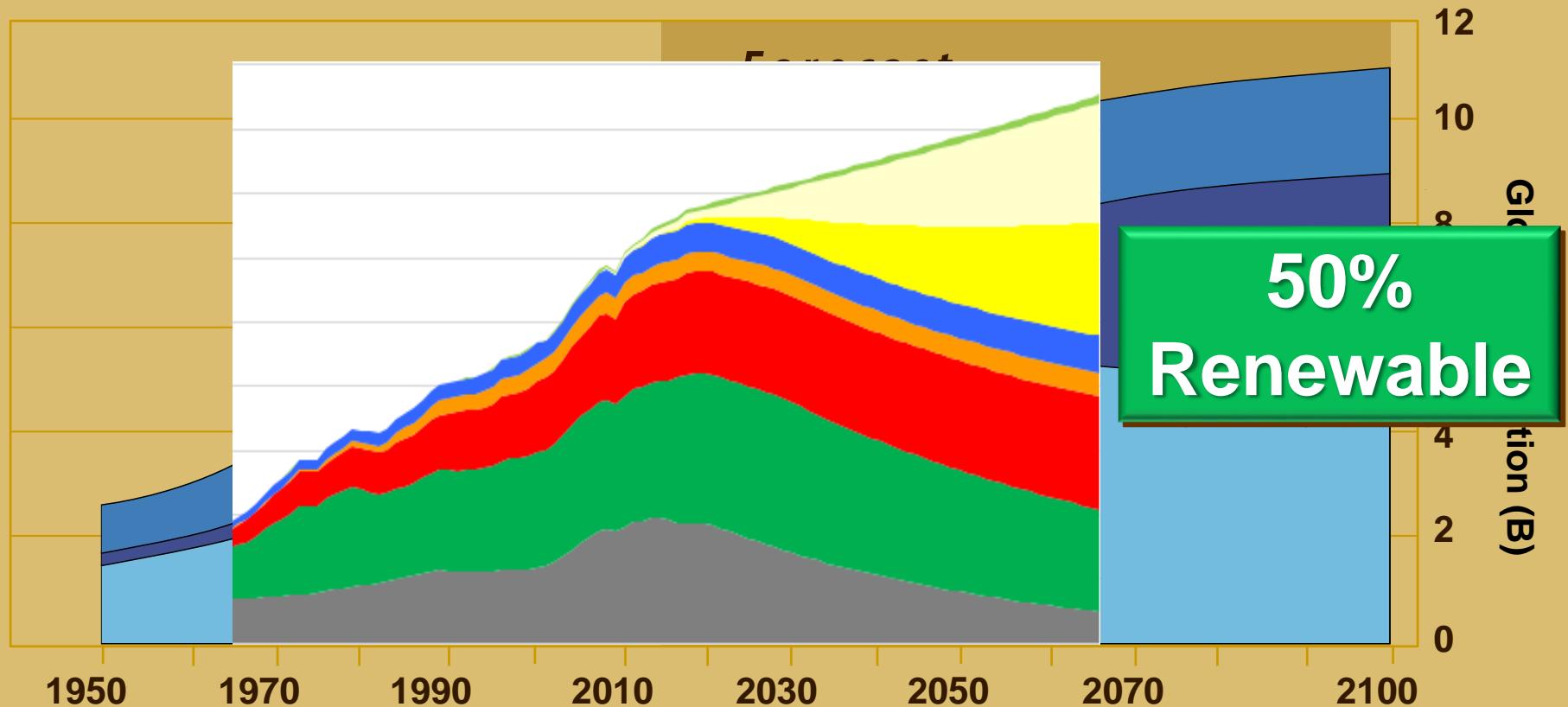
Population and Energy



Data: BP Statistical View of World Energy (2016)

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

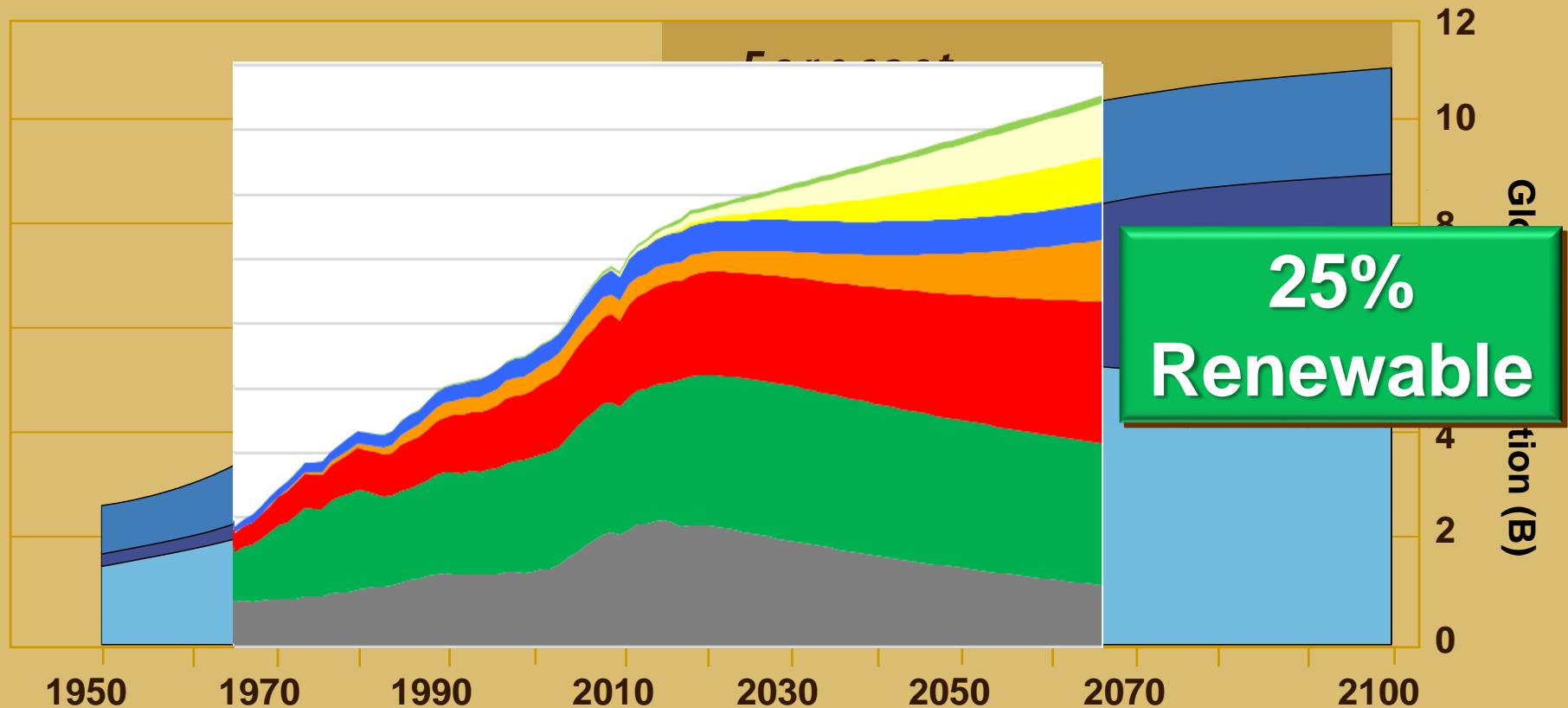
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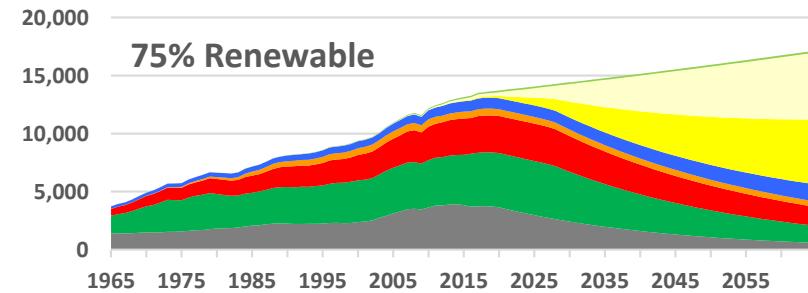
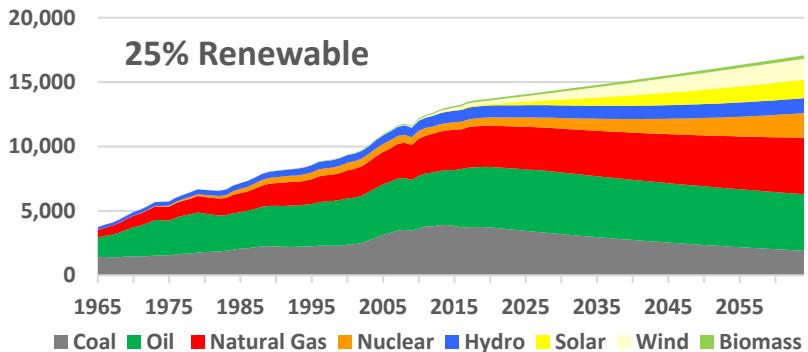
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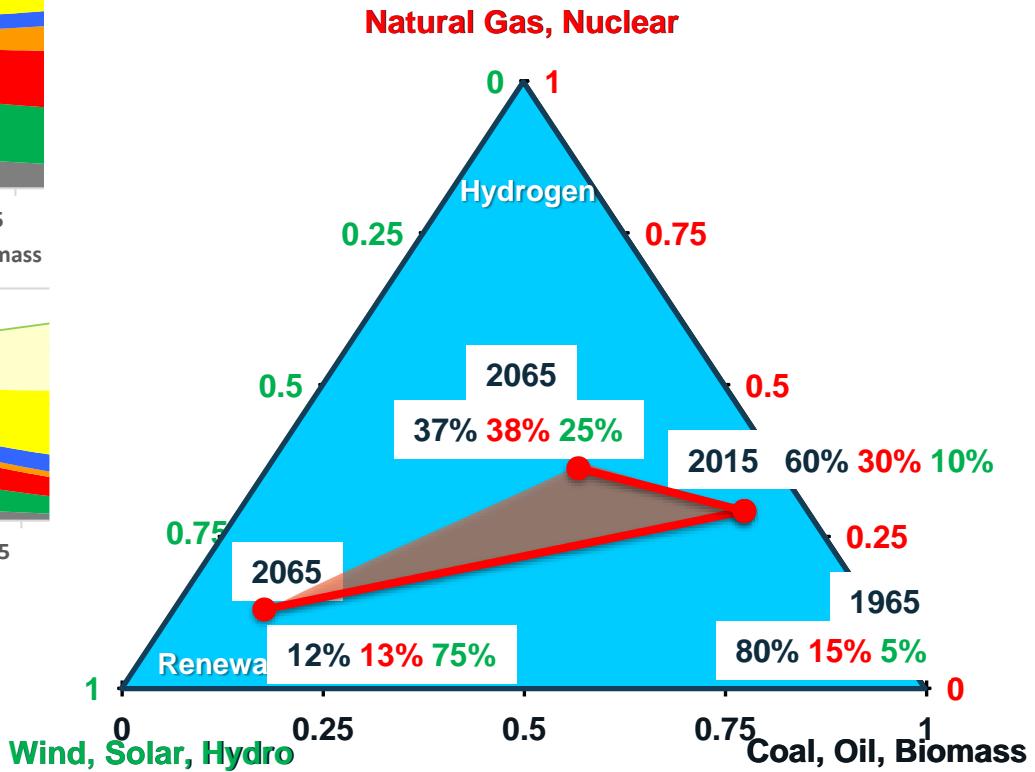


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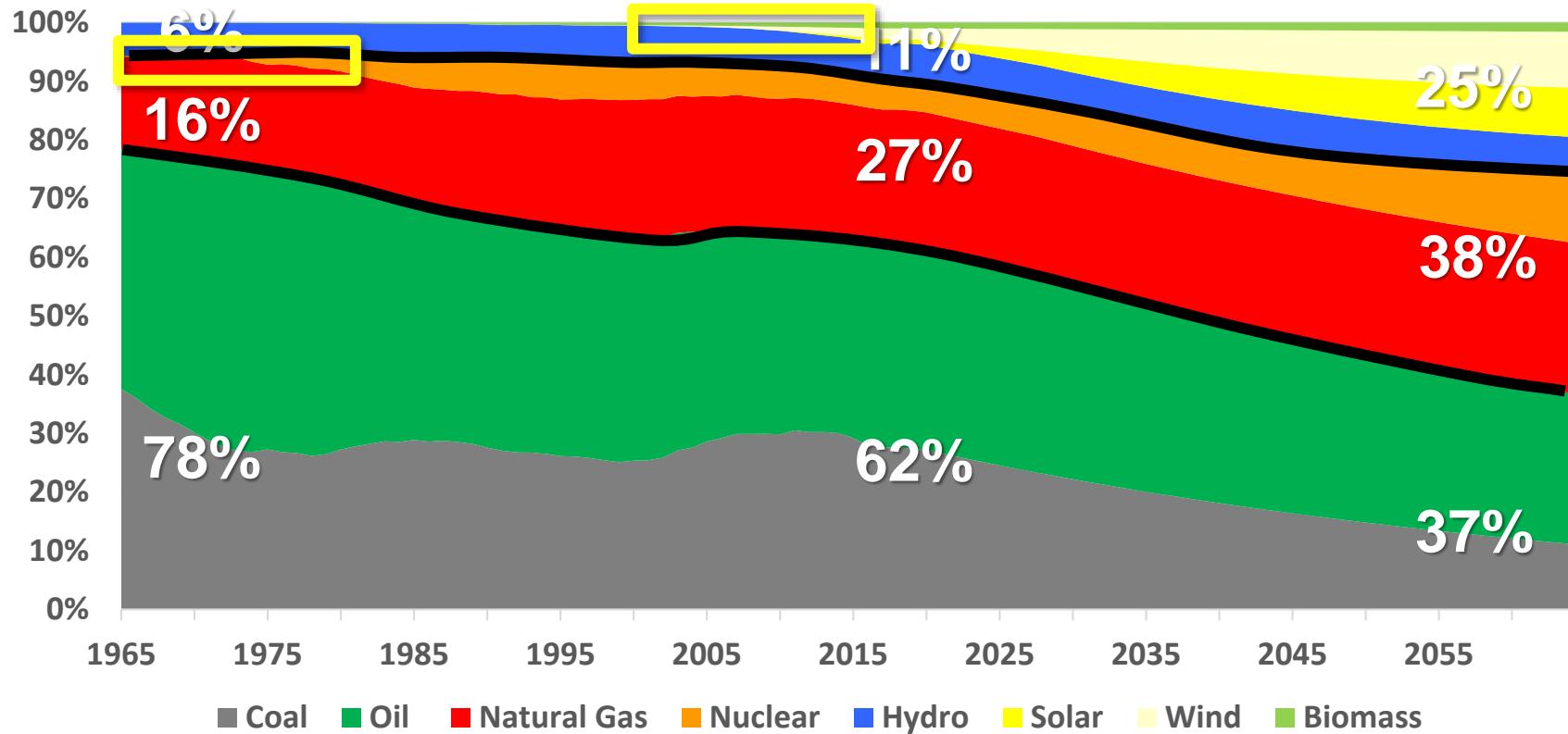
Global Primary Energy



Data: BP Statistical View
of World Energy (2018)

Global Energy 2065

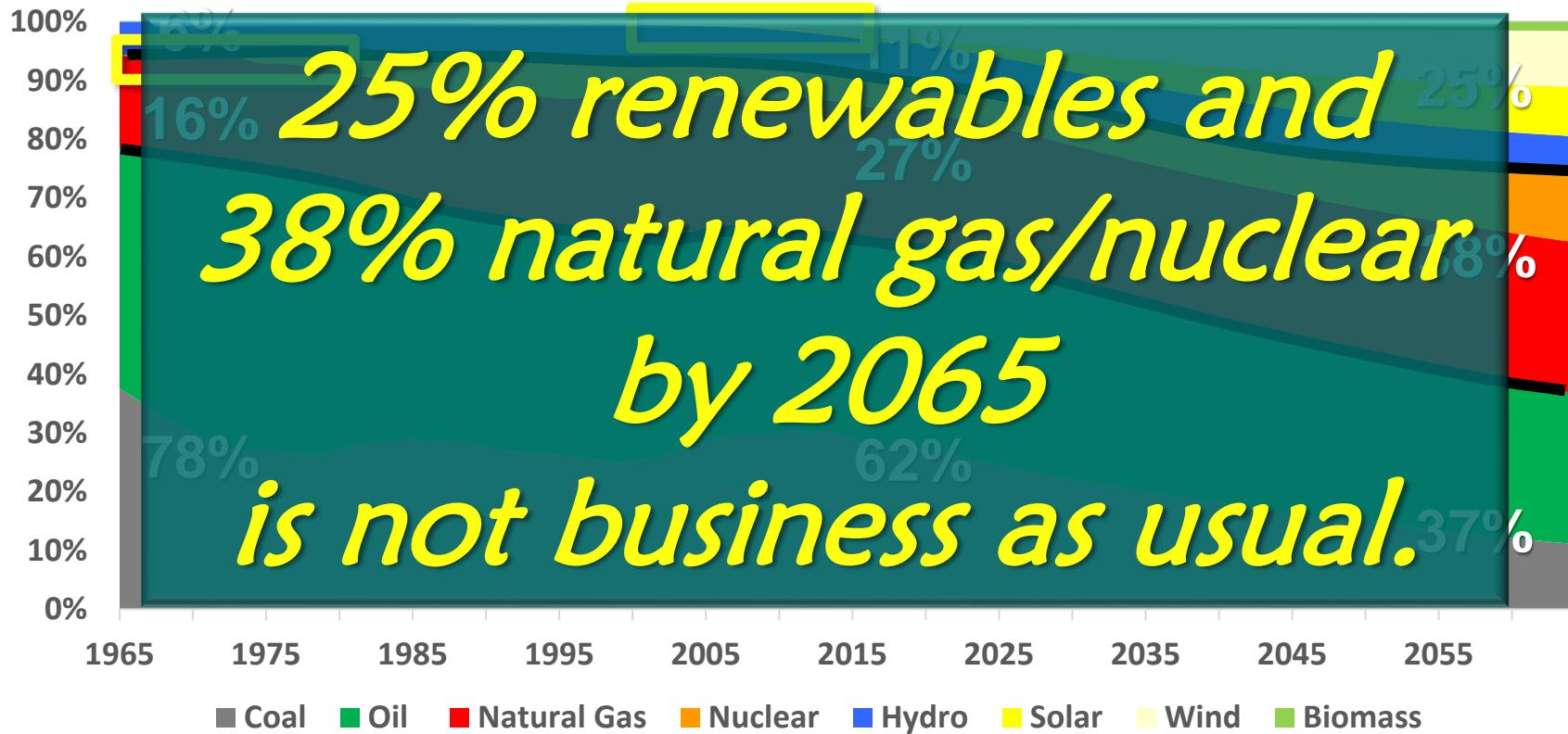
Global Energy Mix



Data: BP Statistical View
of World Energy (2018)

Global Energy 2065

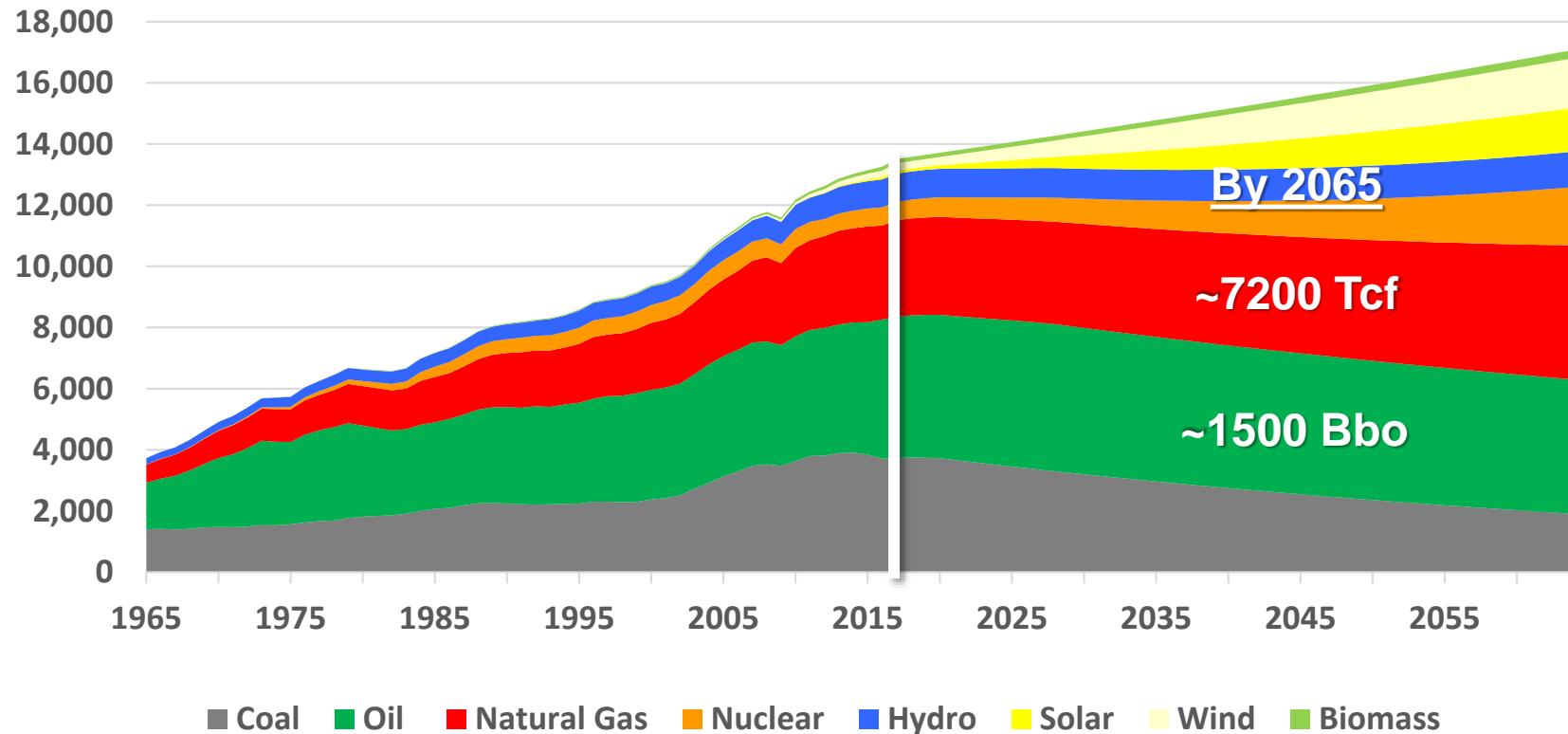
Global Energy Mix



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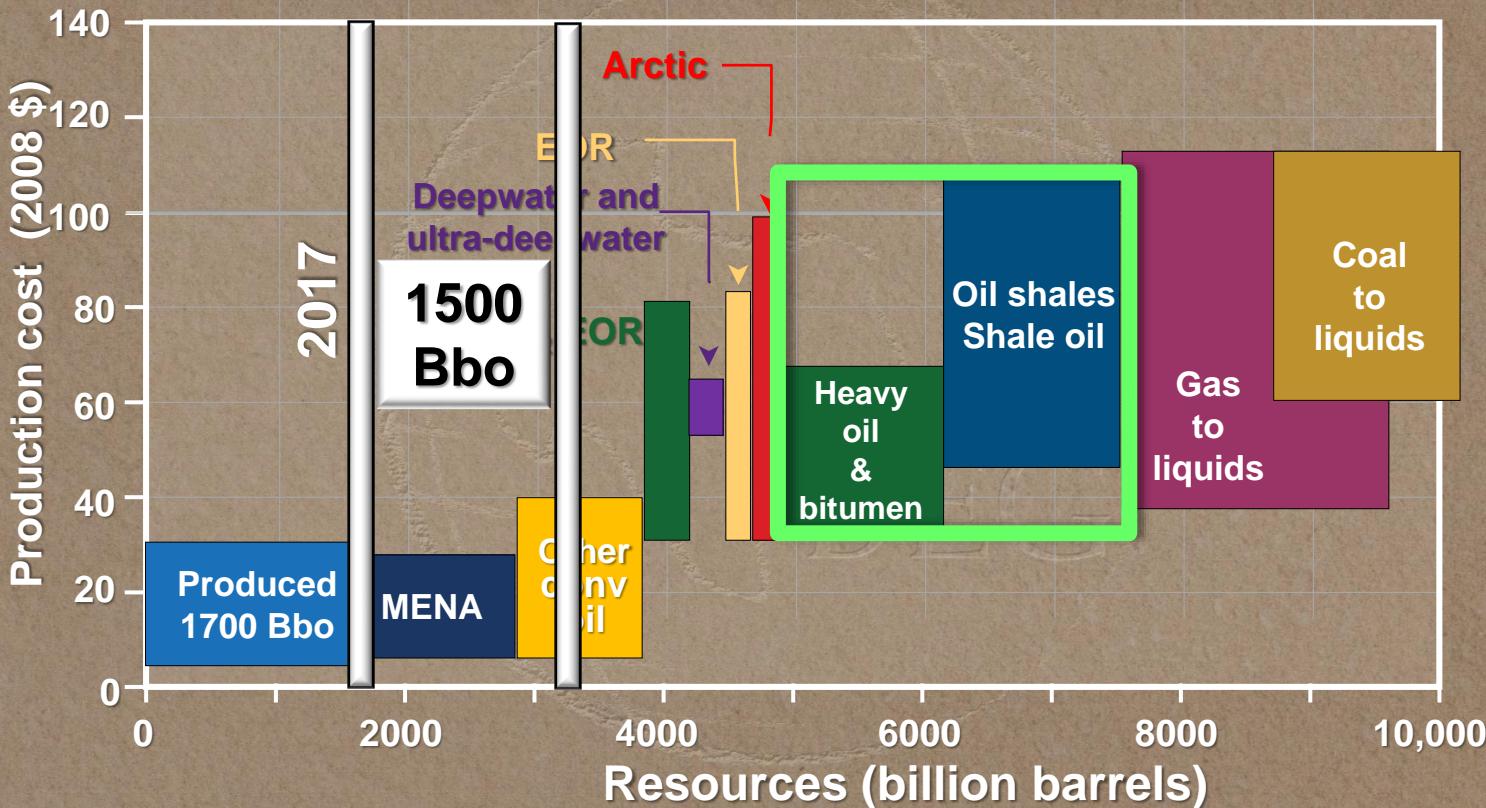
Global Energy 2065

Global Energy Consumption (MTOE)



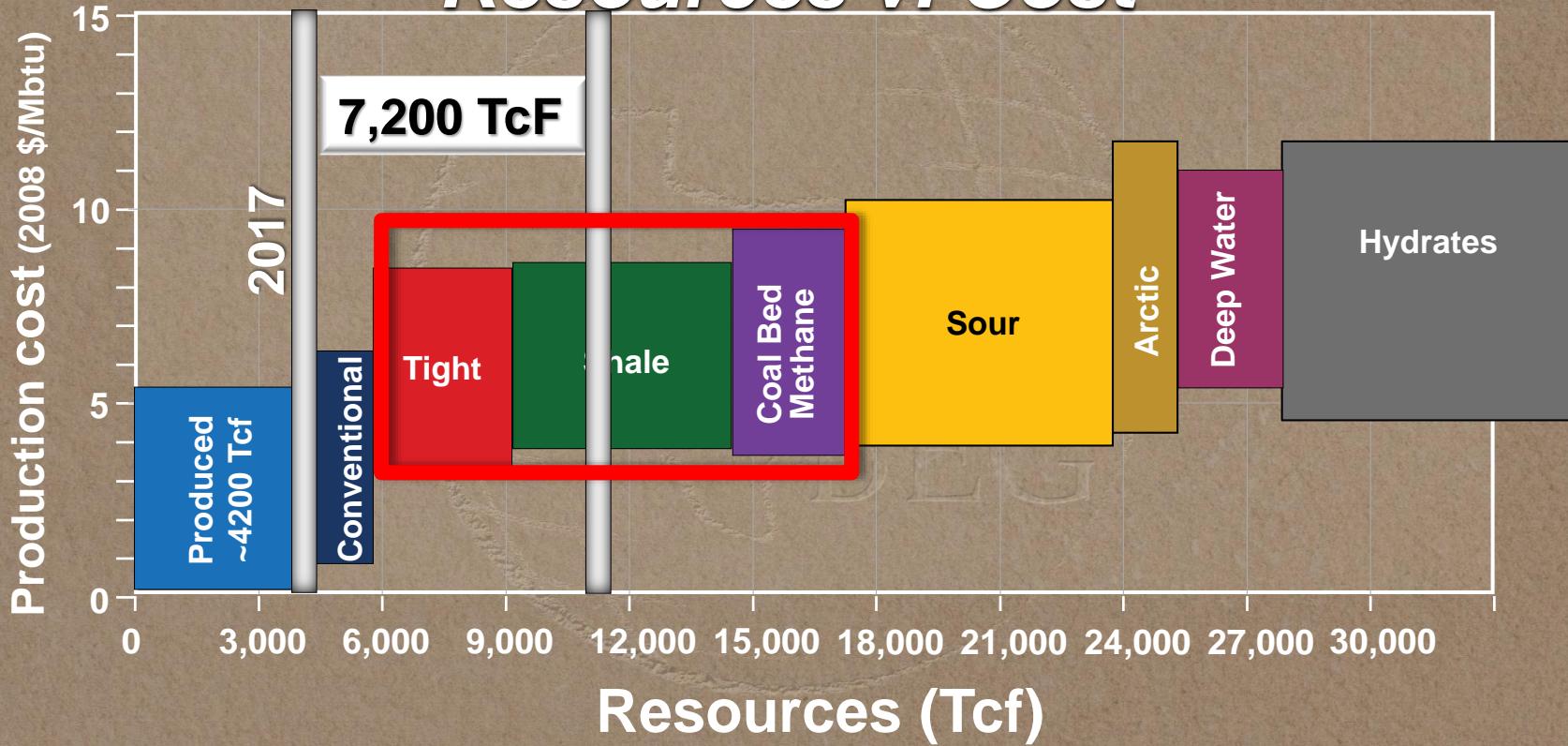
Oil Cost of Supply

Resources and Cost



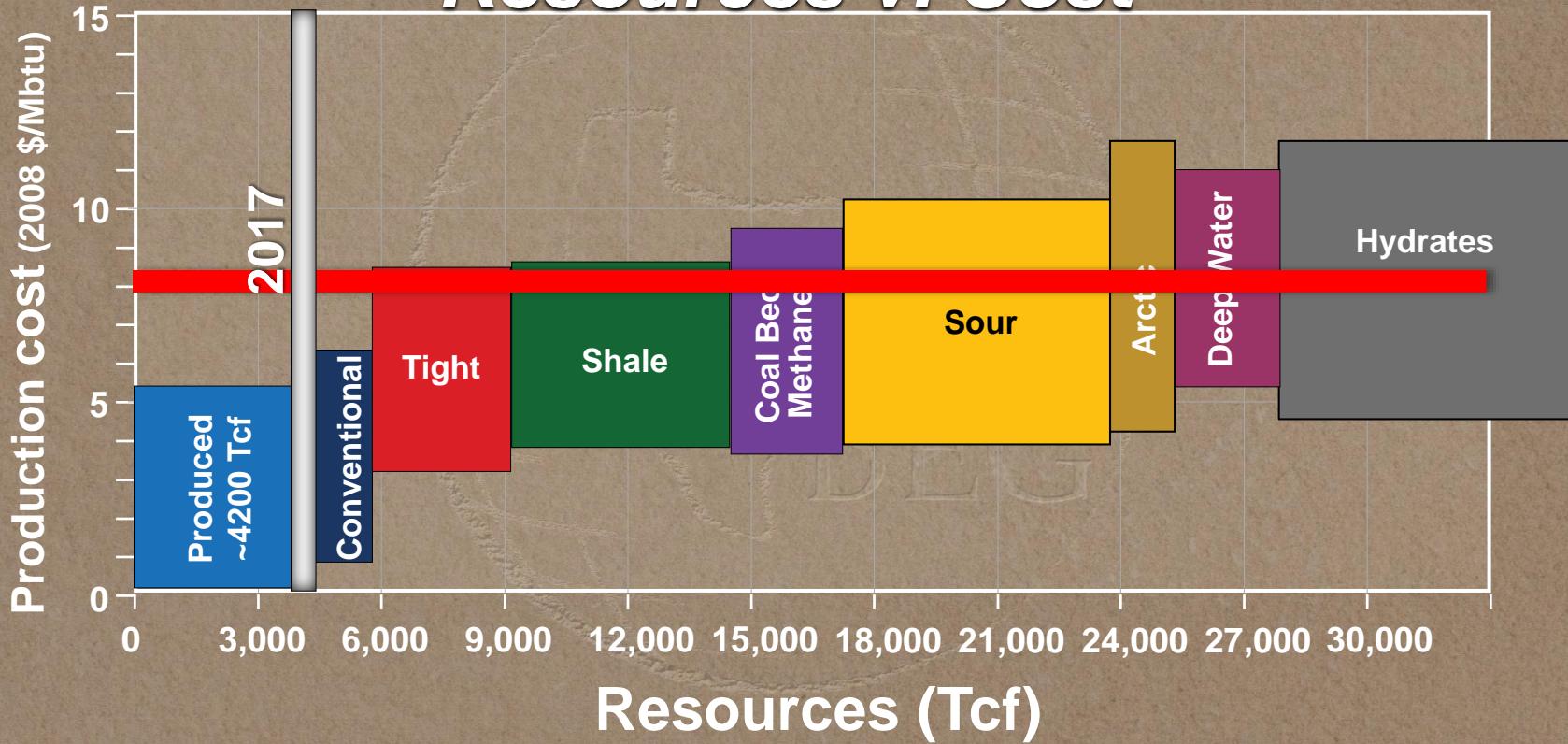
Natural Gas Cost of Supply

Resources v. Cost



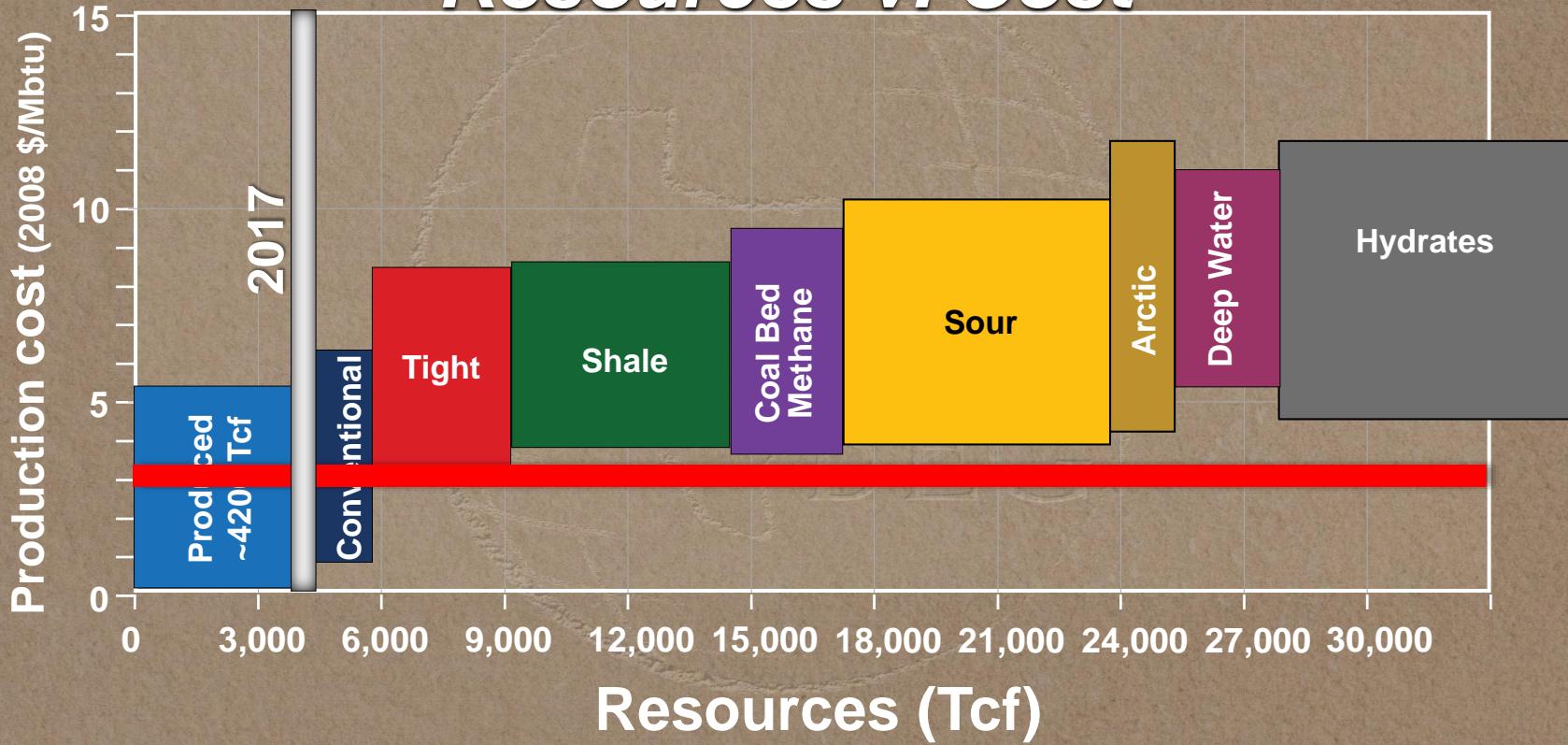
Natural Gas Cost of Supply

Resources v. Cost



Natural Gas Cost of Supply

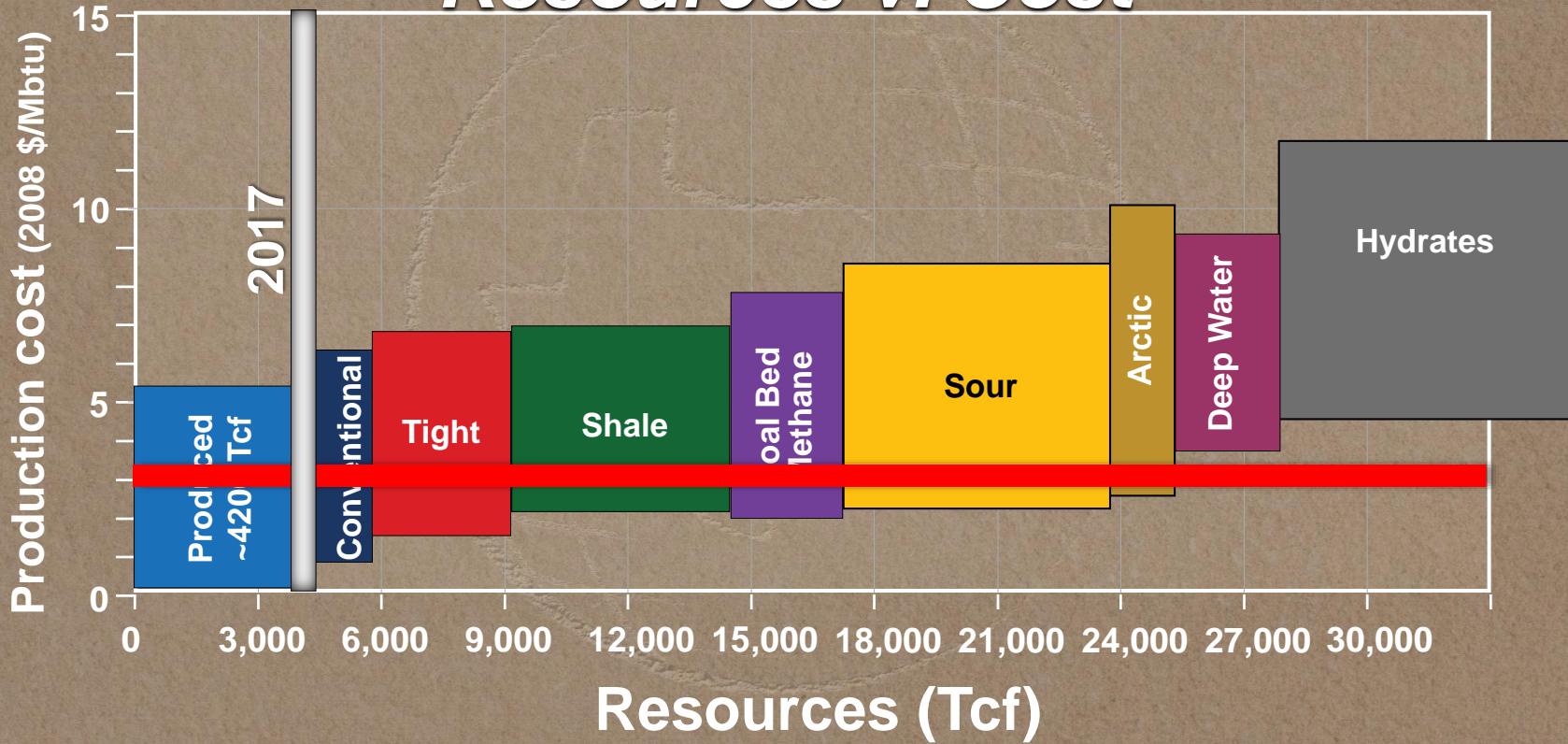
Resources v. Cost



Resources (Tcf)

Natural Gas Cost of Supply

Resources v. Cost



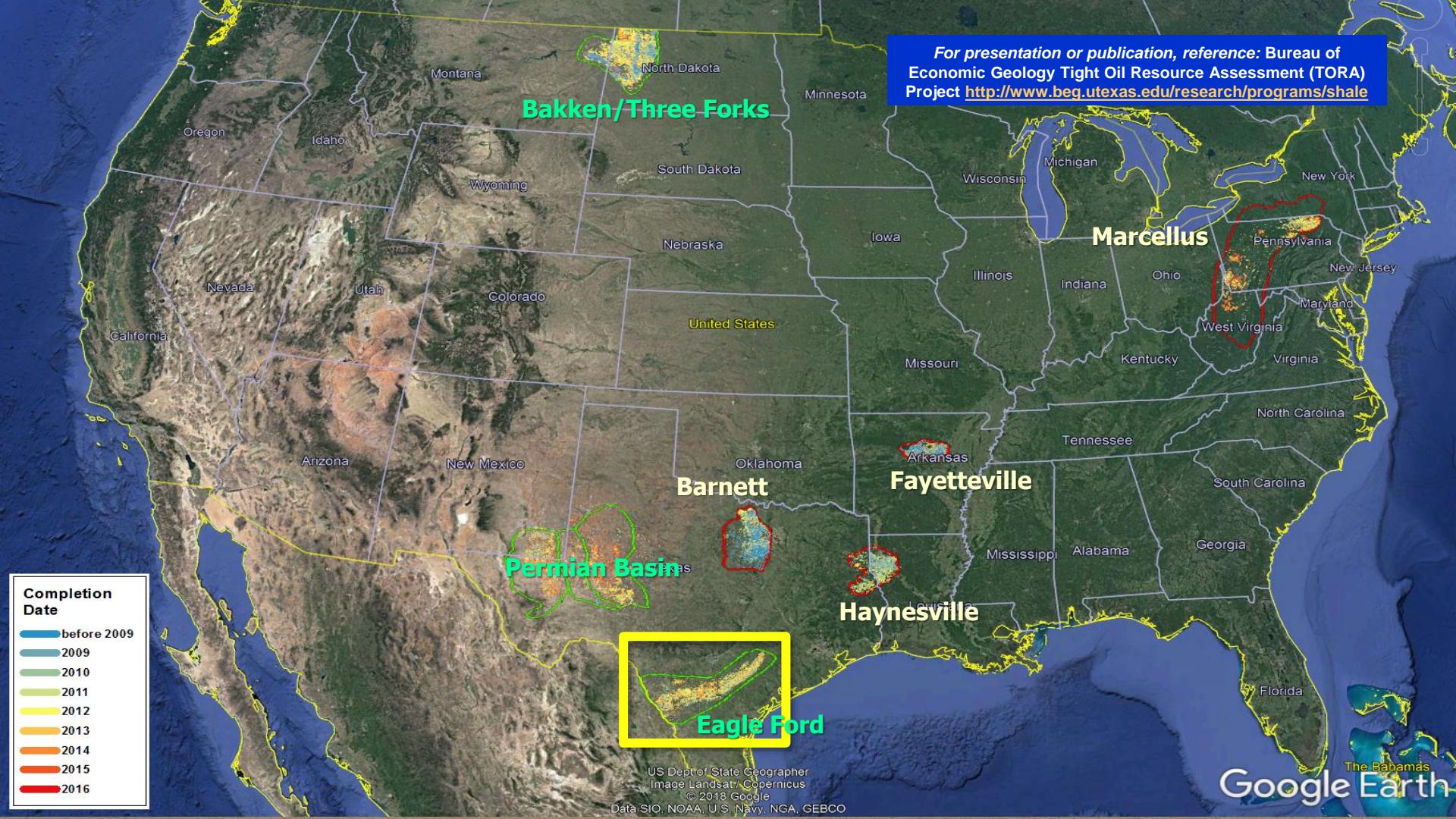
Natural Gas Cost of Supply

Resources v. Cost

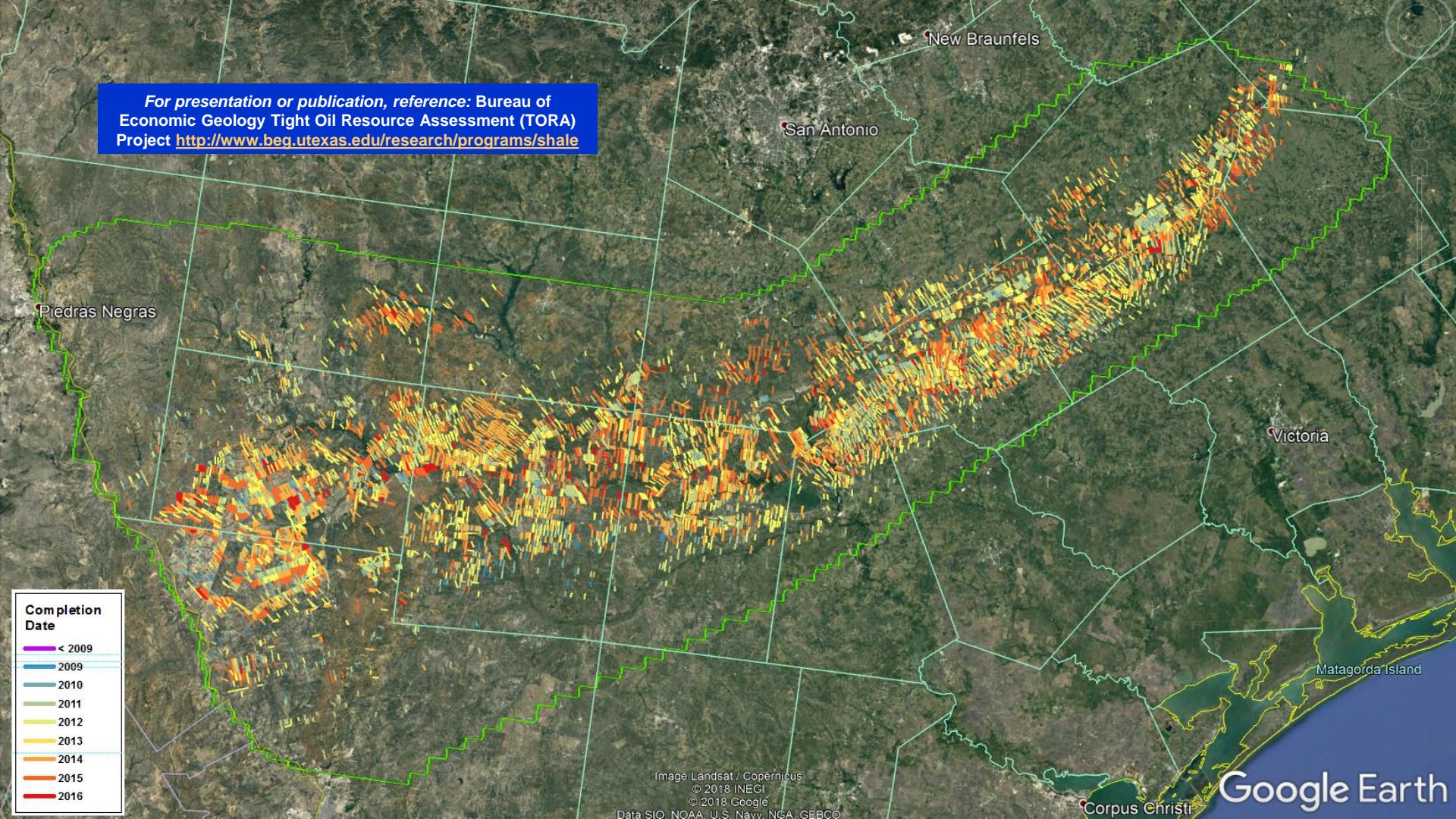
The Global Resource is Vast

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

*For presentation or publication, reference: Bureau of
Economic Geology Tight Oil Resource Assessment (TORA)
Project <http://www.beg.utexas.edu/research/programs/shale>*

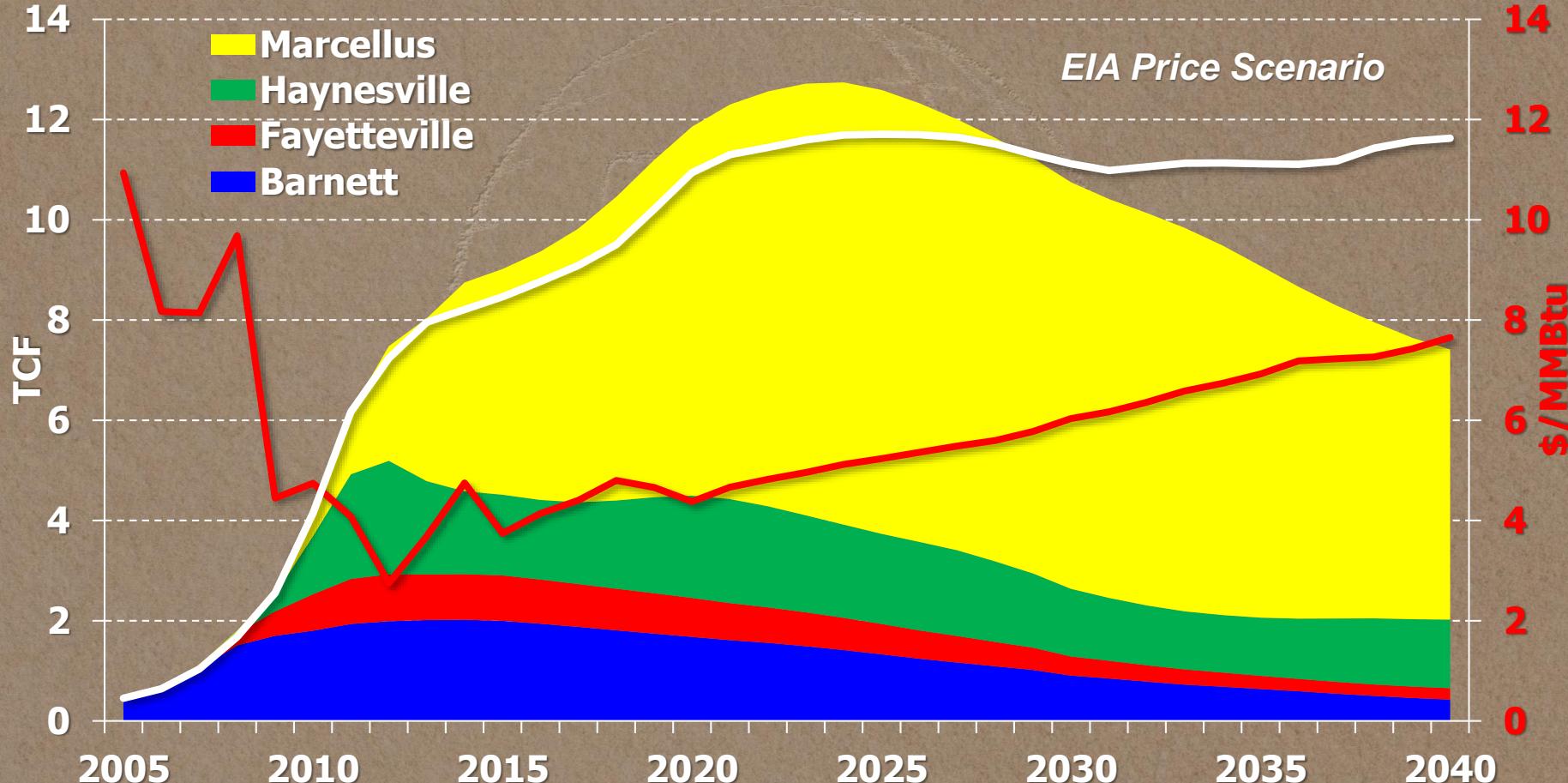


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US Shale Gas Production

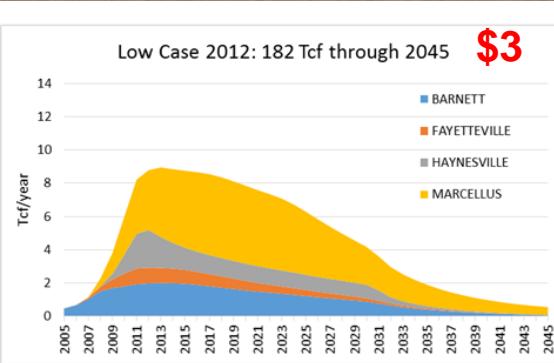
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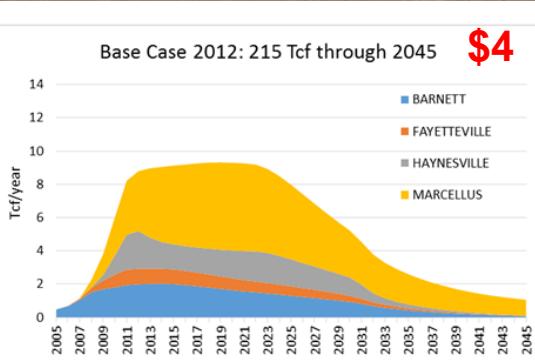
U.S. Shale Gas

2012

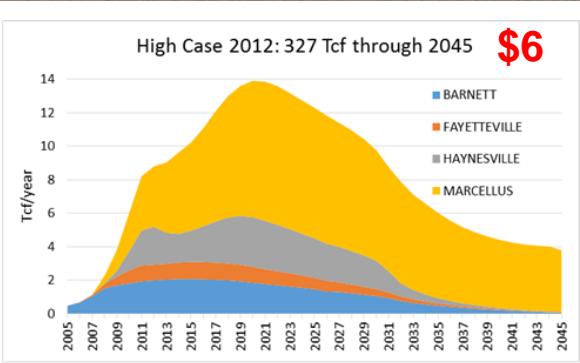
Low



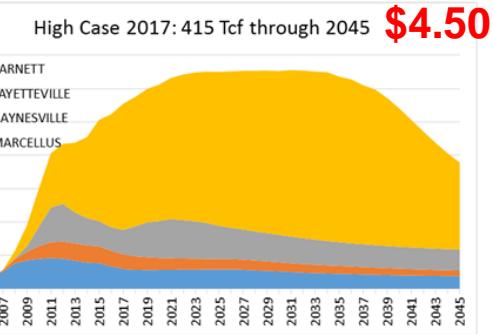
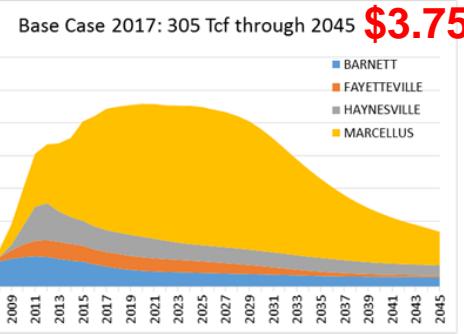
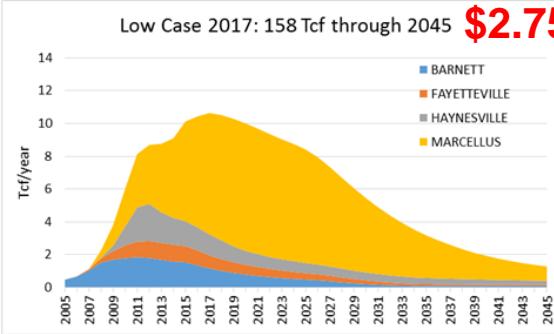
Base



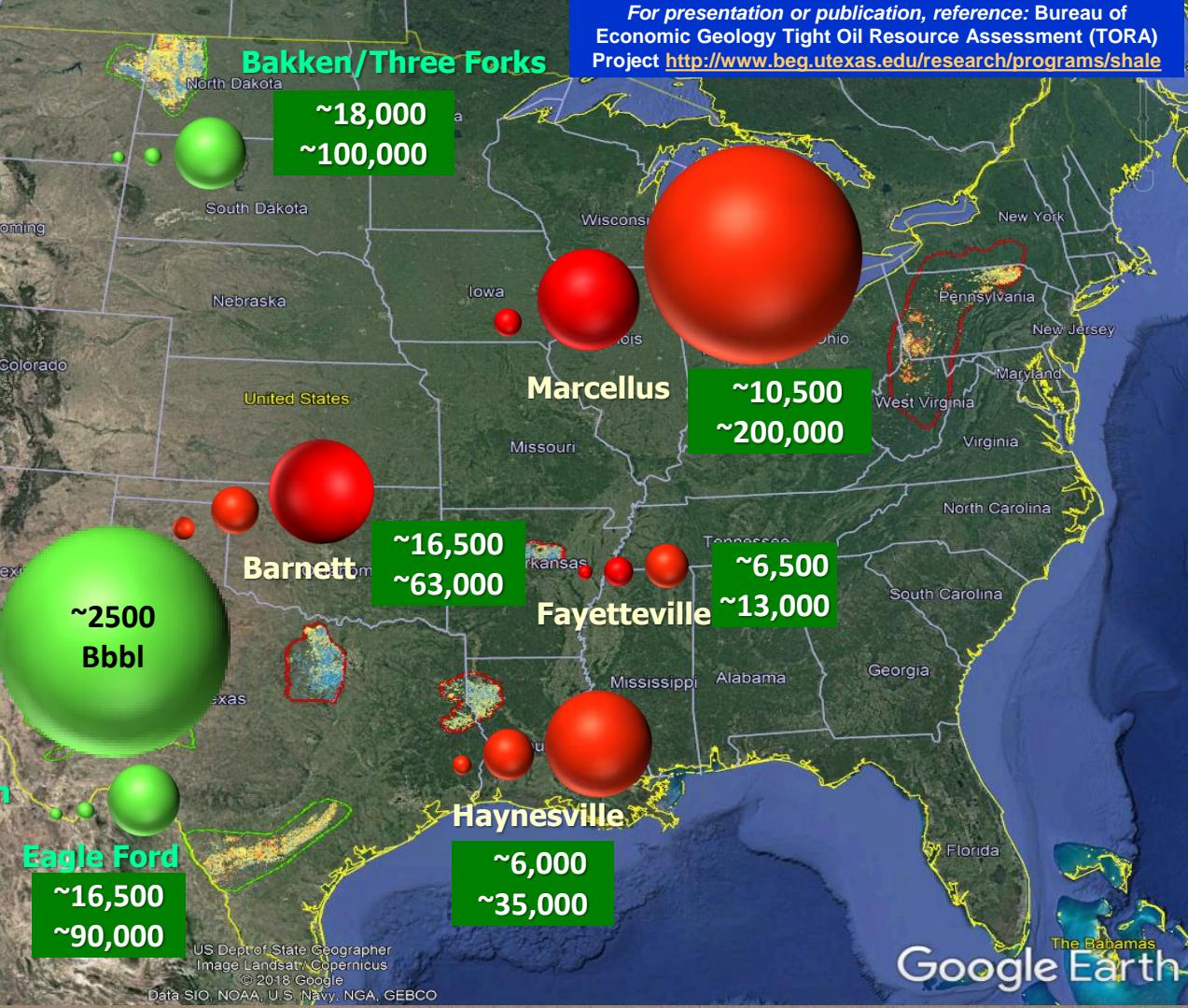
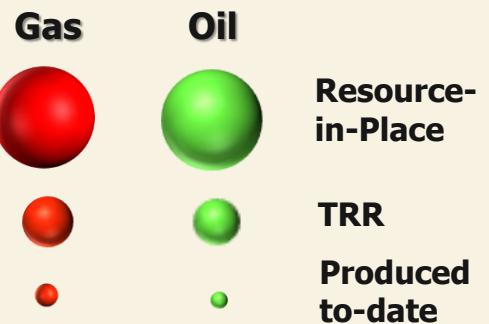
High



2017



<u>(excl. Permian)</u>	Gas Tcf	Oil Bbb/
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

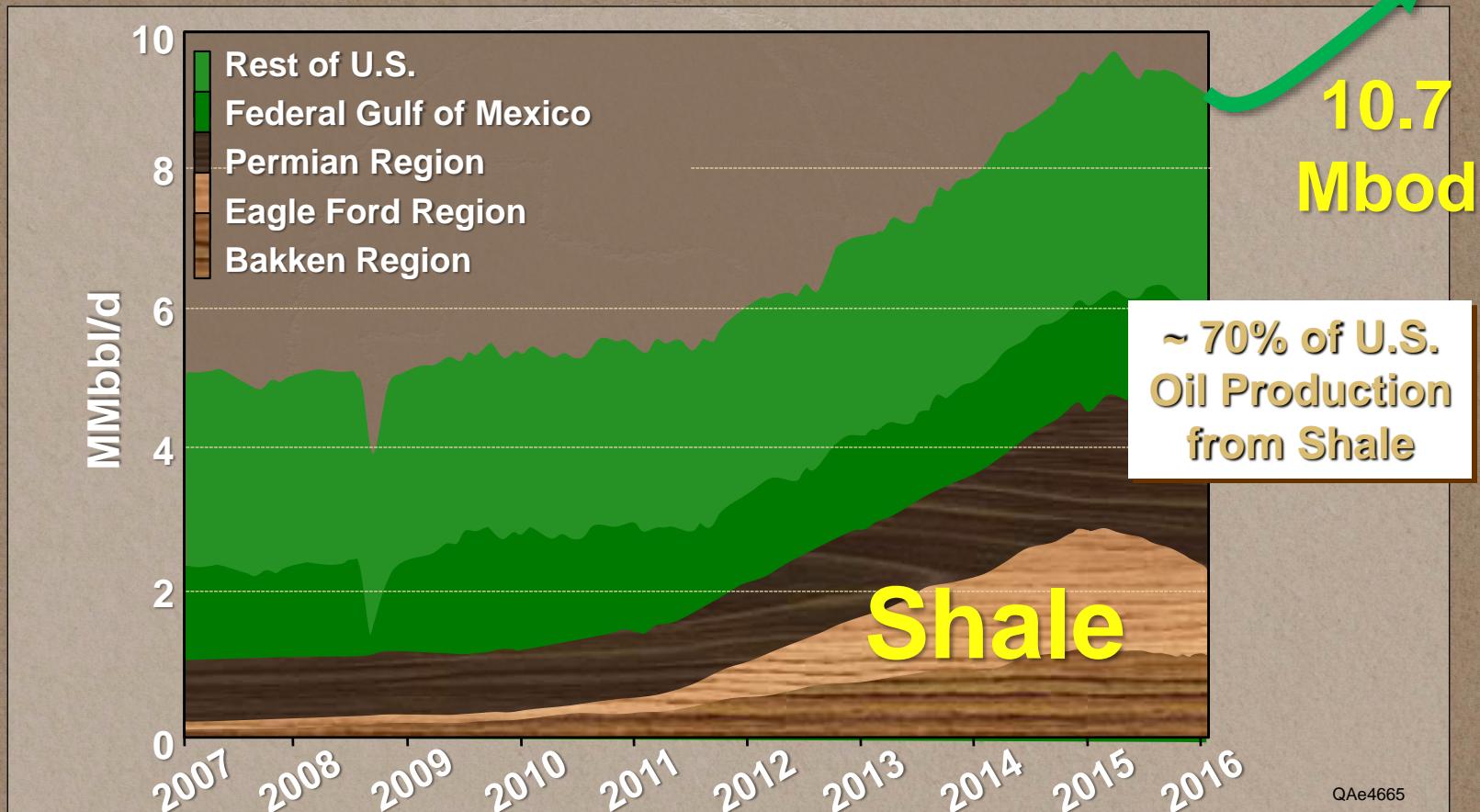


(excl. Permian)	Gas Tcf	Oil Bbl
Original In-Place	3100	450
Tech. Recoverable	700	27
Production to date	70	5
Horizontal wells drilled	1500	

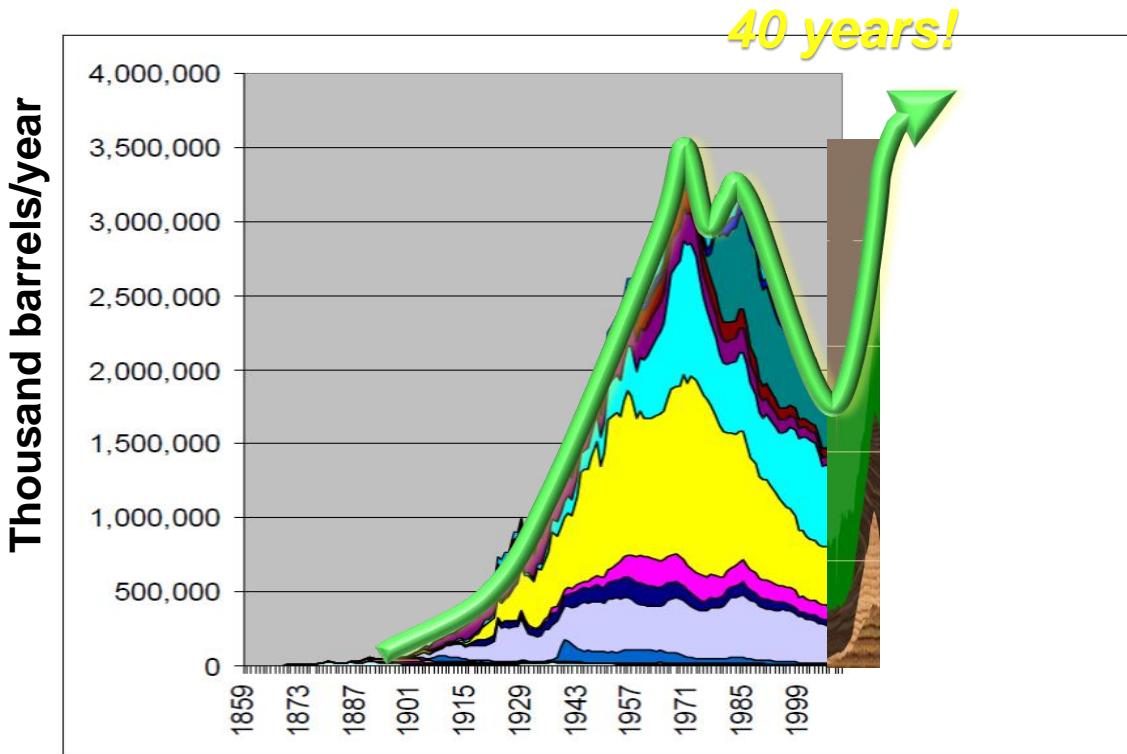


*Recovery to date of just 2%
of the natural gas and 1% of
the oil leaves a tremendous
remaining resource.*

U.S. Crude Oil Production

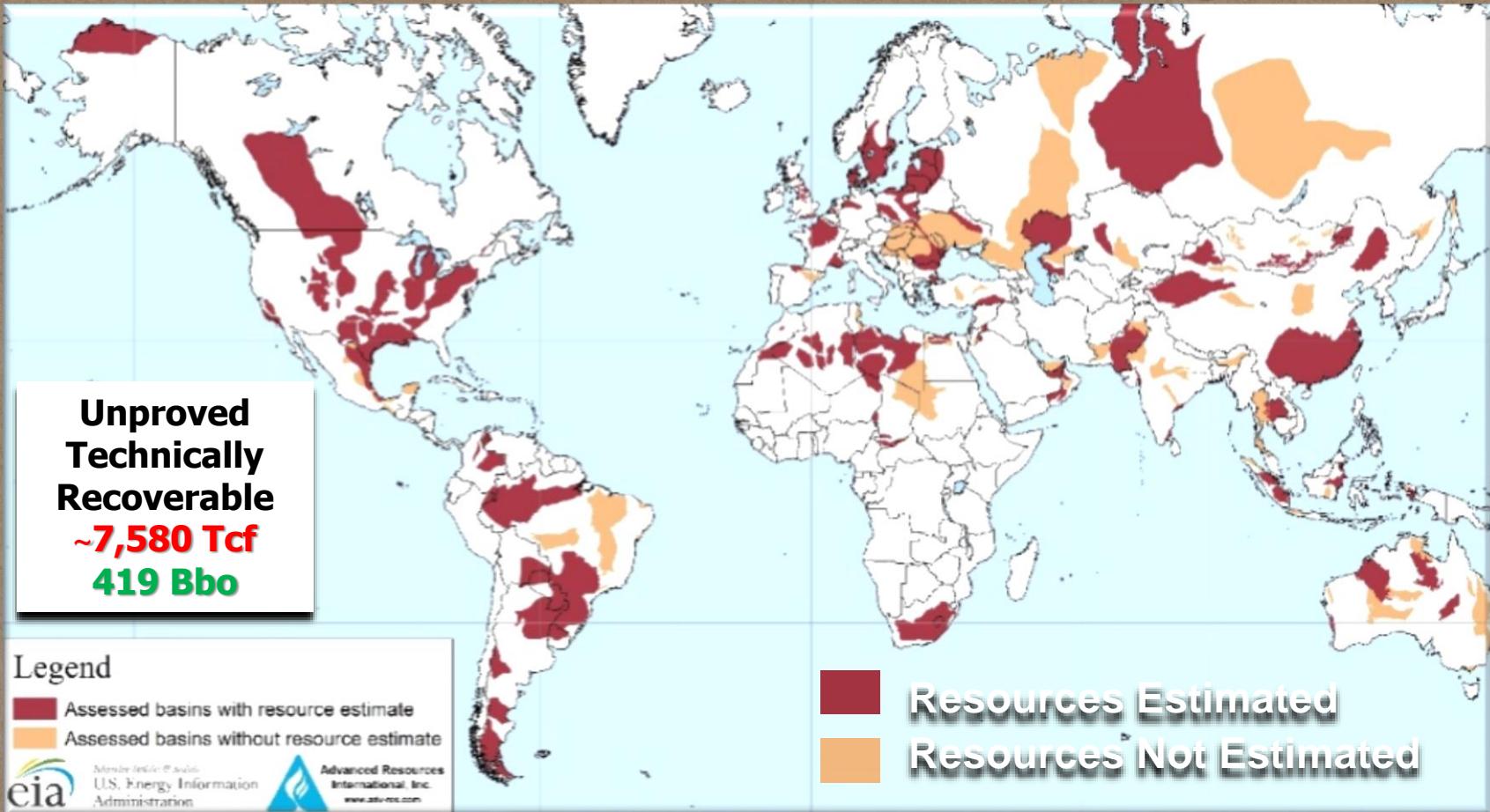


Annual US Oil Production



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

Global Shale Resource Plays



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*

Environmental Impact *Renewables and Batteries*

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

Environmental Impact Renewables and Batteries

- Mining and Processing *Land, Water, Emissions*
The sun and wind are renewable.
- Production *Manufacturing, Materials, Emissions*
The infrastructure to capture them is not.
- Transmission *Electricity*
- Disposal: *Landfill*

Energy Key Points

- Fossil energy demand remains strong, and resources are vast
- Wind and solar are a small component of the mix, but growing quickly in some regions
- No form of energy, at scale, is without environmental impact



Outline

- ❖ Energy
- ❖ Carbon
- ❖ Poverty
- ❖ Radical Middle

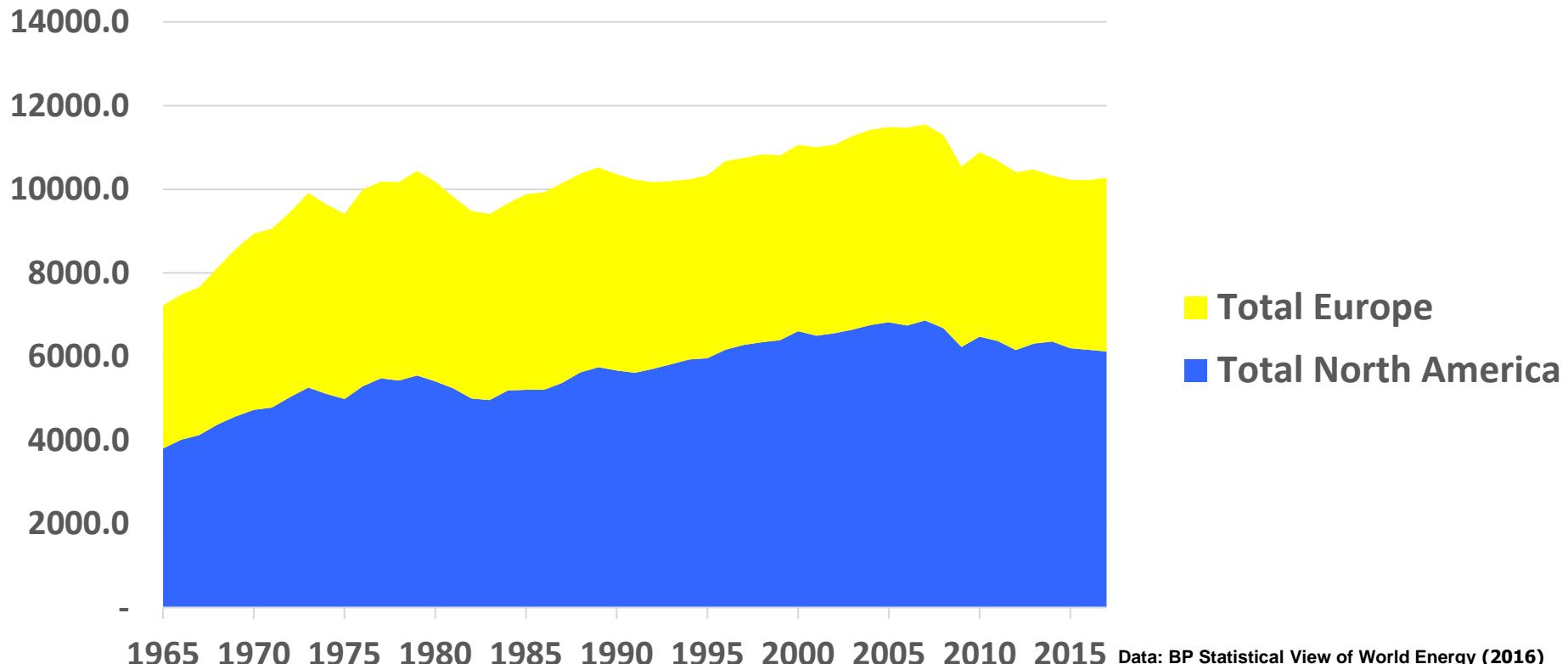


BUREAU OF
ECONOMIC
GEOLOGY

Photo Credit: Scott W. Tinker

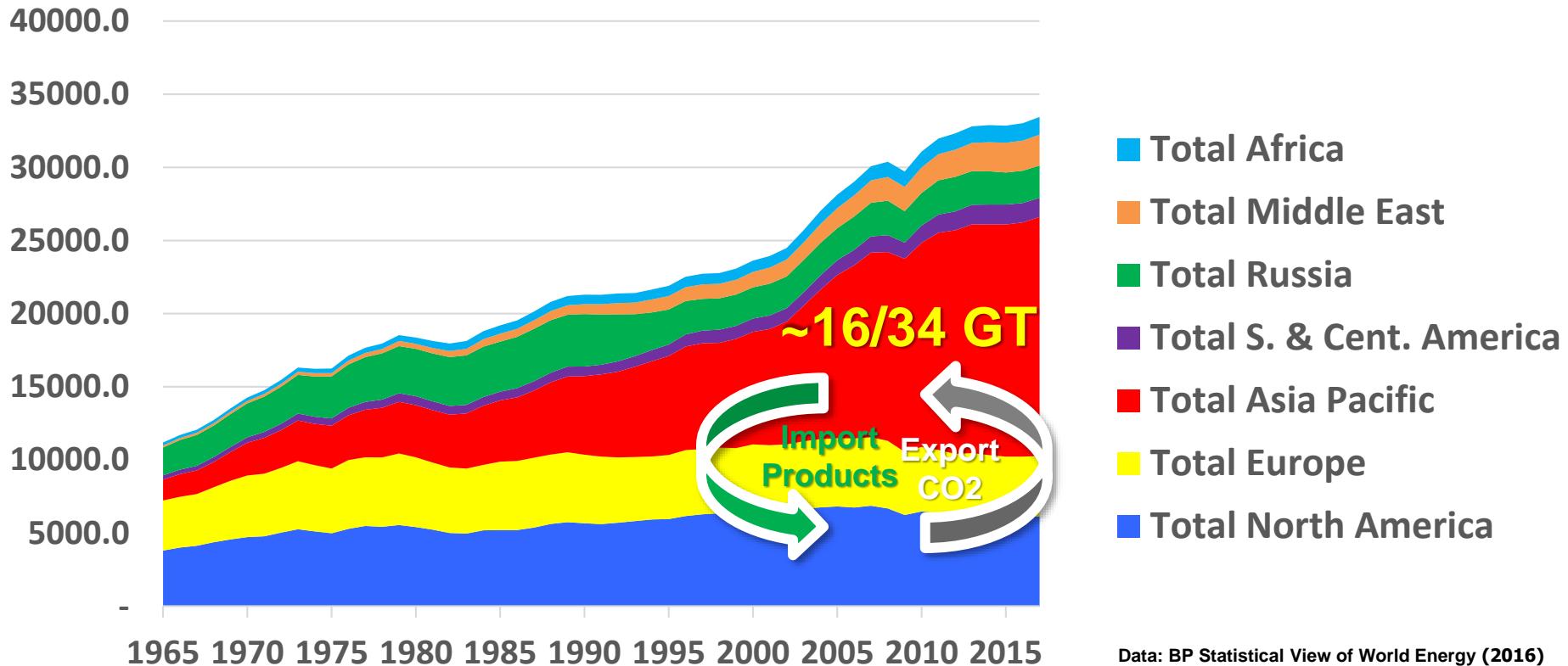
CO₂ Emissions

CO2 Emissions (Million Tonnes)



CO₂ Emissions

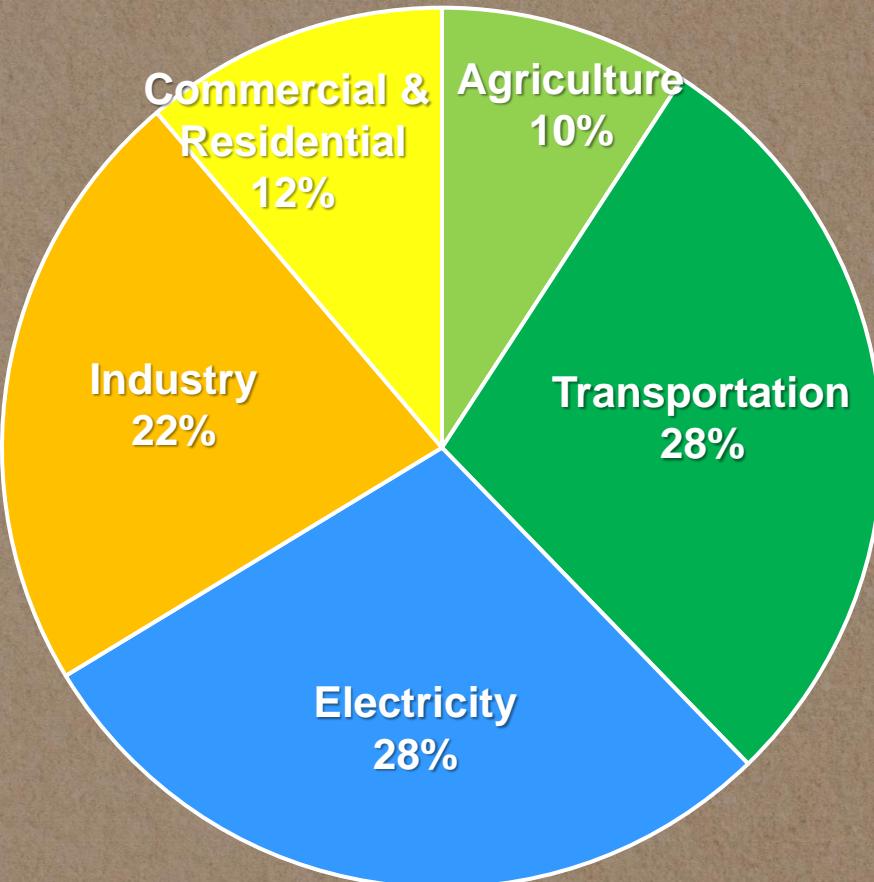
CO₂ Emissions (Million Tonnes)



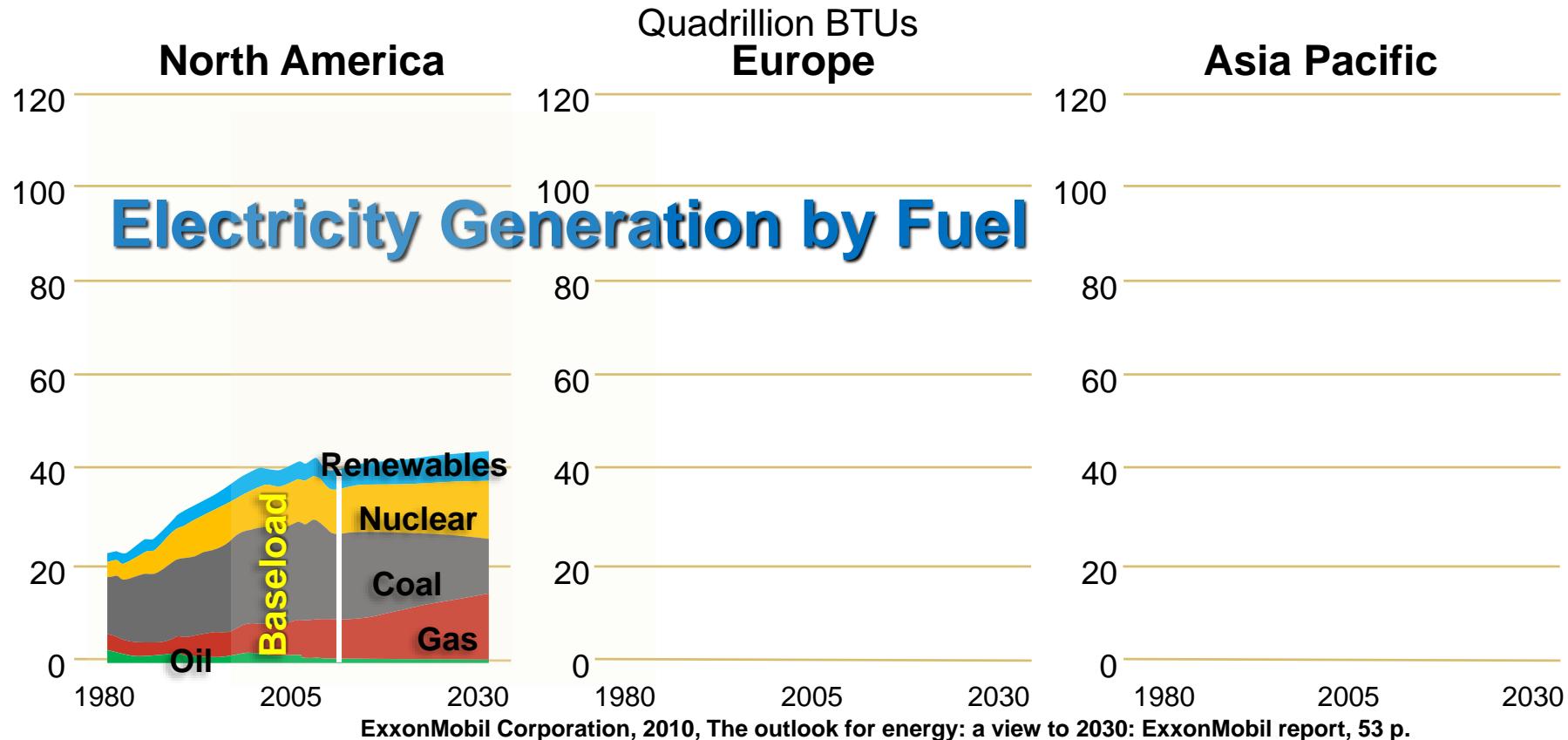
CO₂ Emissions



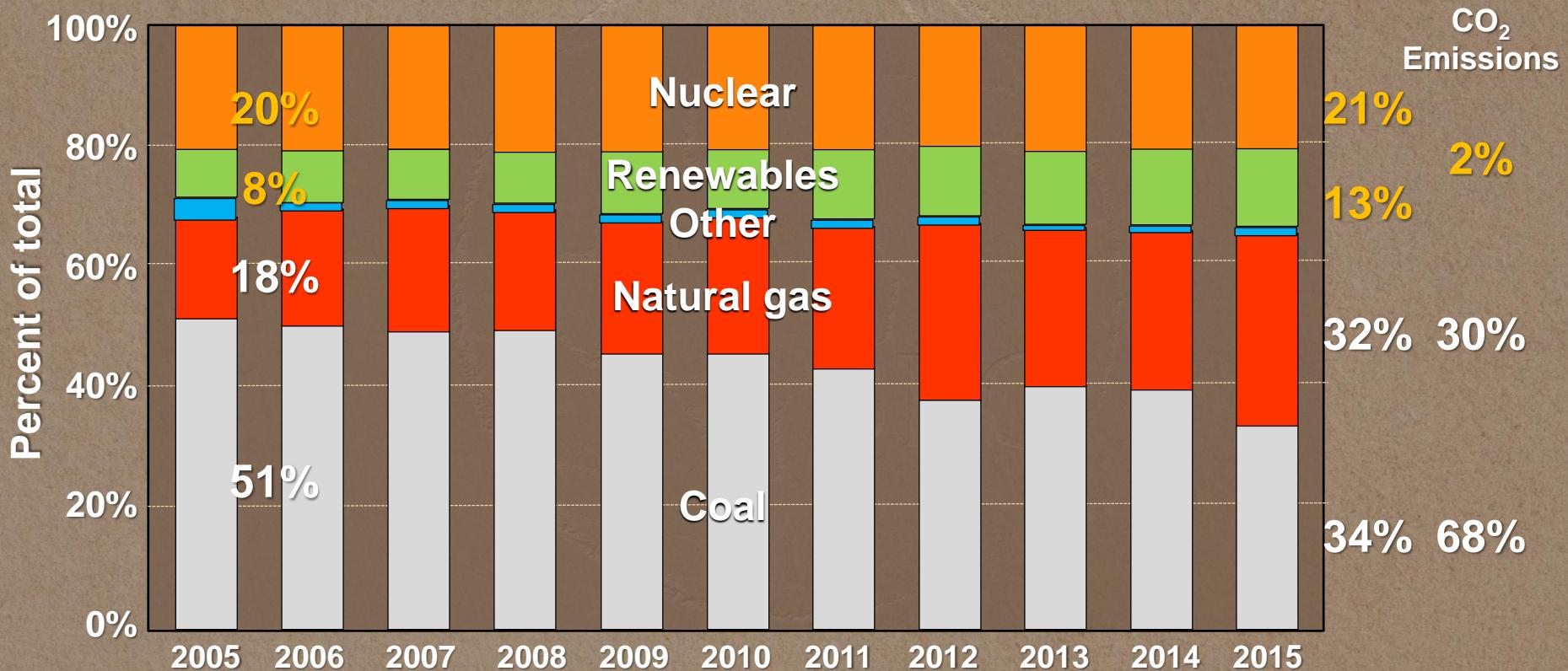
U. S. Greenhouse Gas Emissions (2016)



The Future Electricity Mix

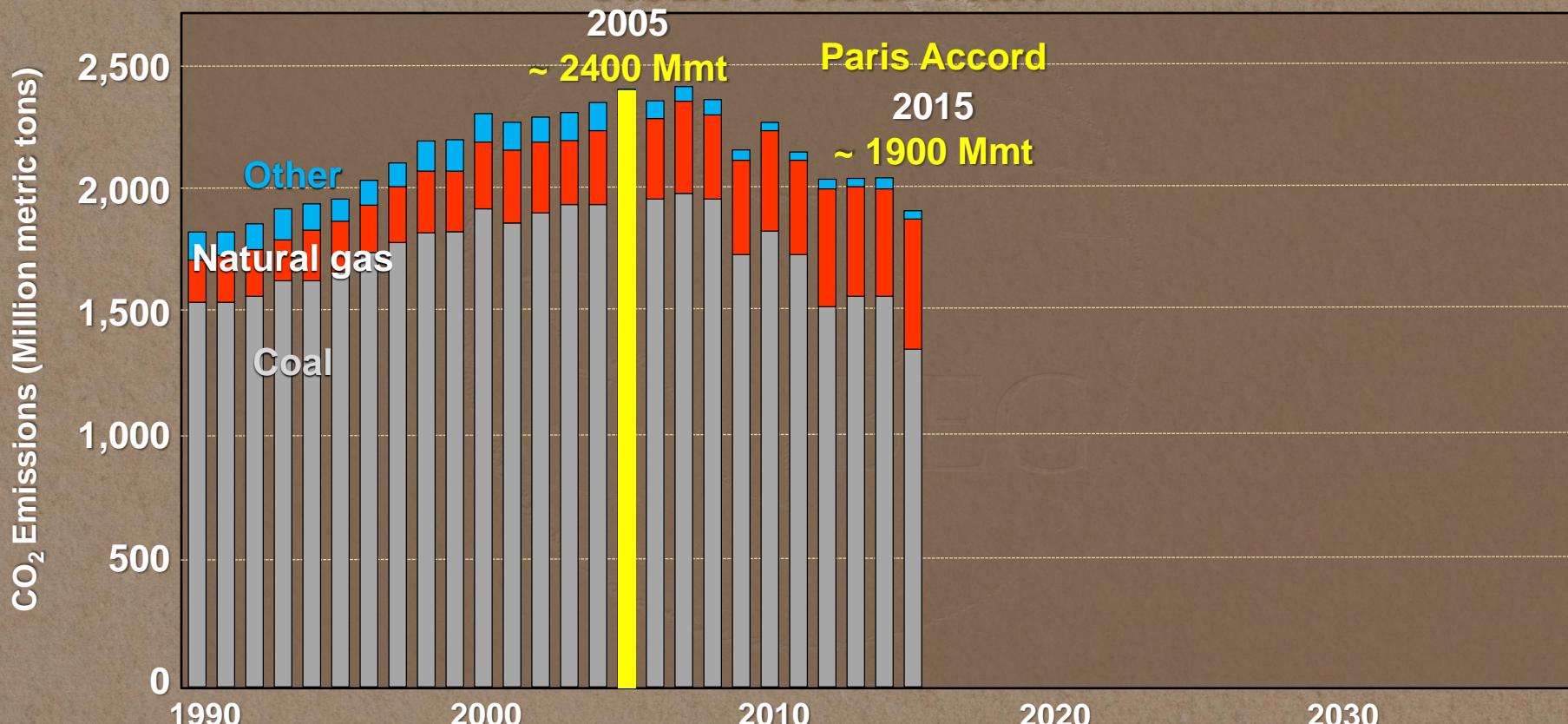


U.S. Electric Generation Shares (2005-15)



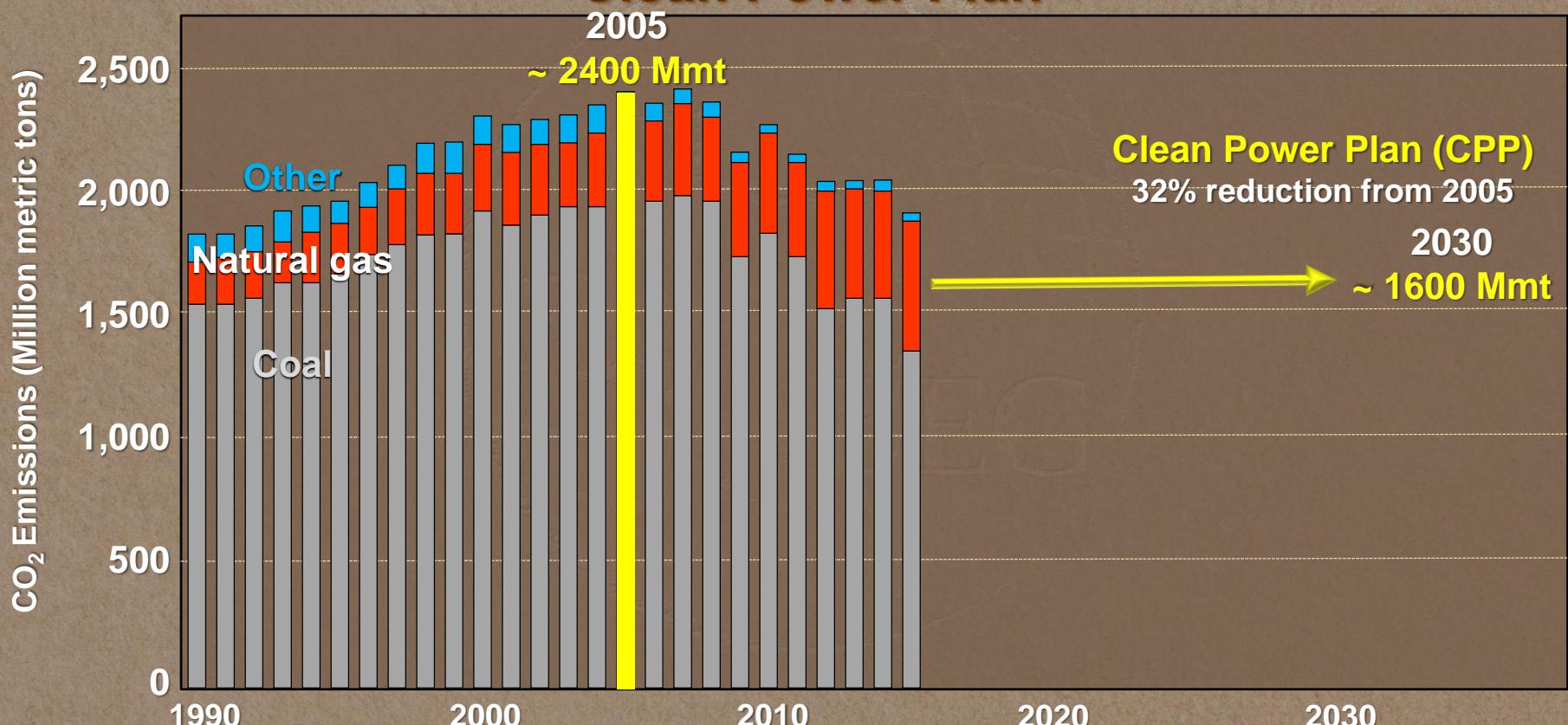
Electric Power Sector U.S. Carbon Dioxide Emissions

Clean Power Plan



Electric Power Sector U.S. Carbon Dioxide Emissions

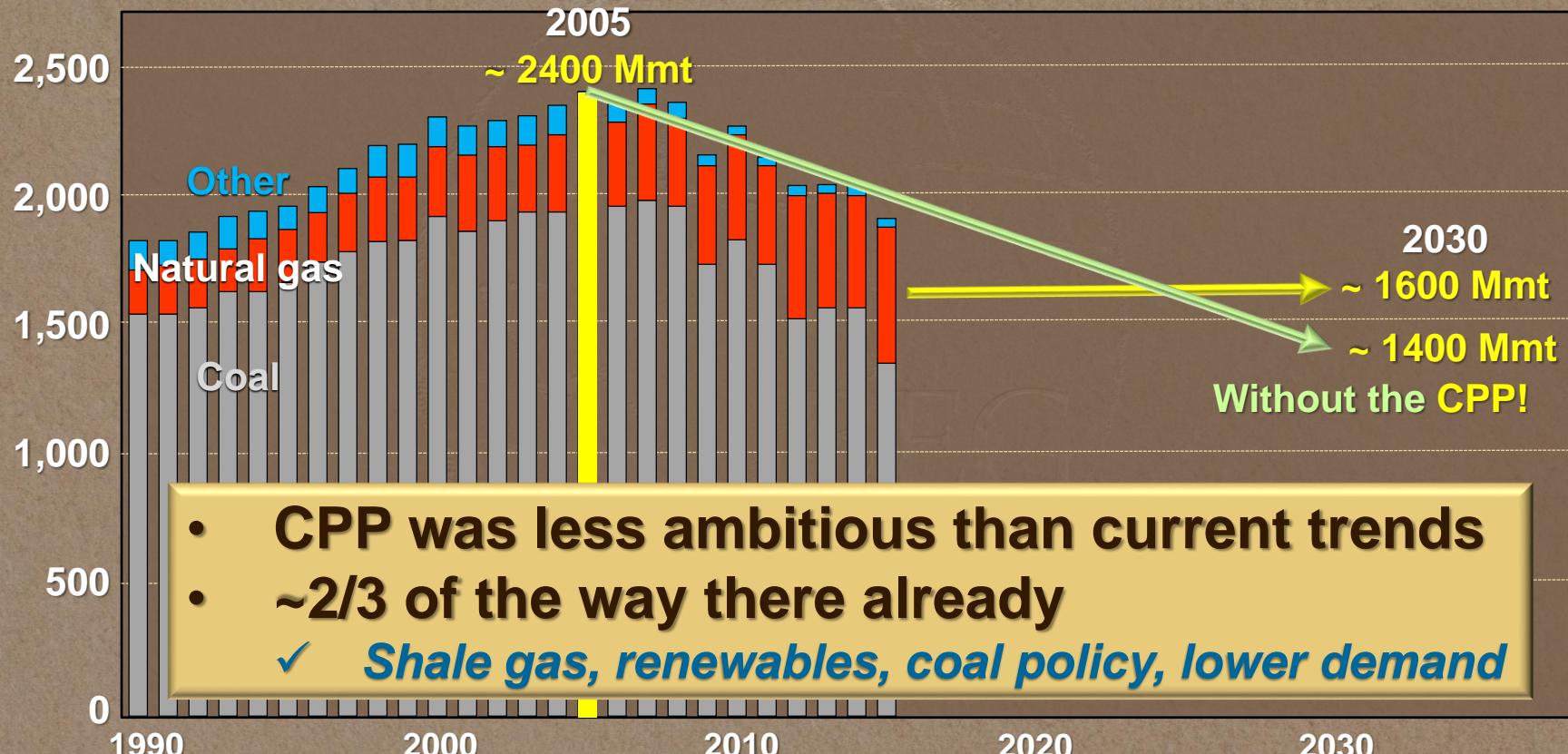
Clean Power Plan



Electric Power Sector U.S. Carbon Dioxide Emissions

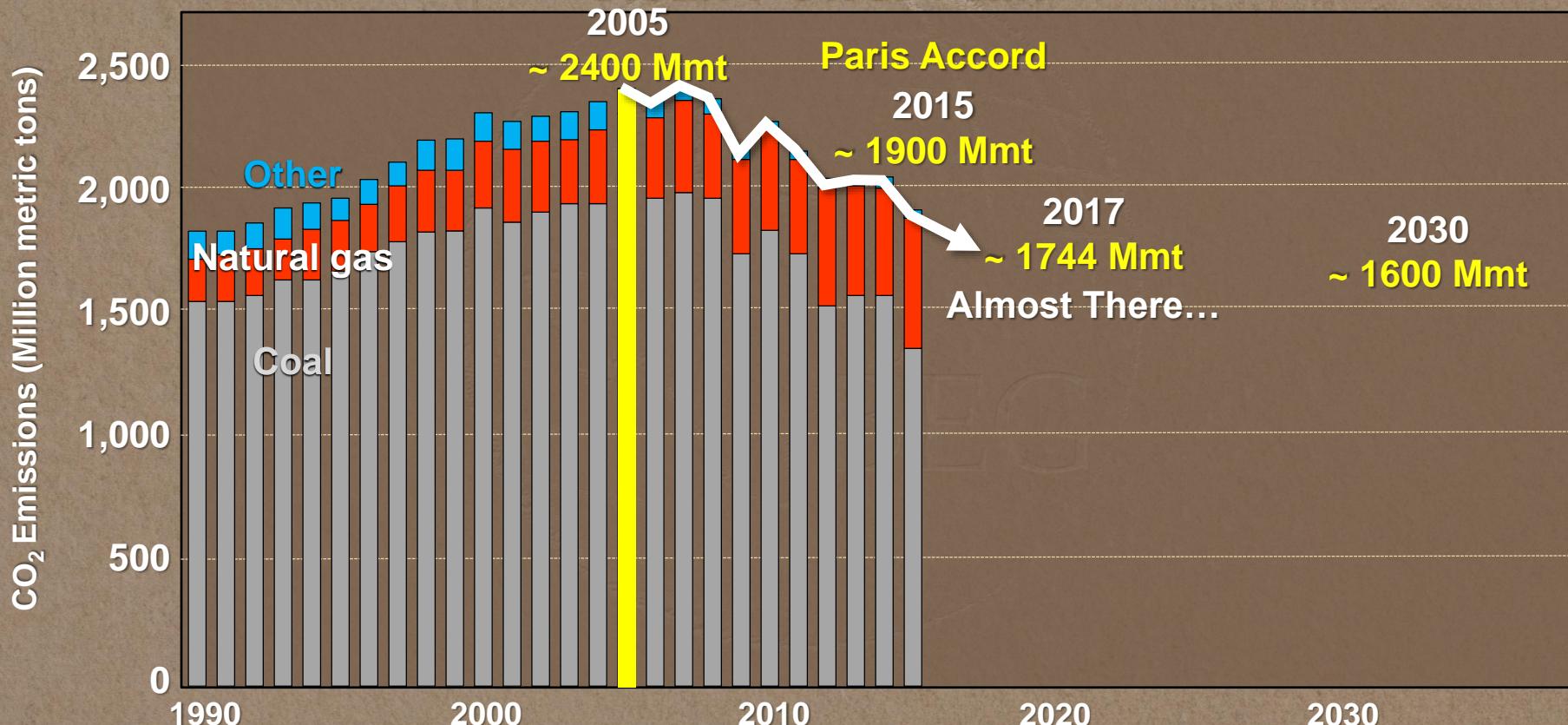
Clean Power Plan

CO₂ Emissions (Million metric tons)

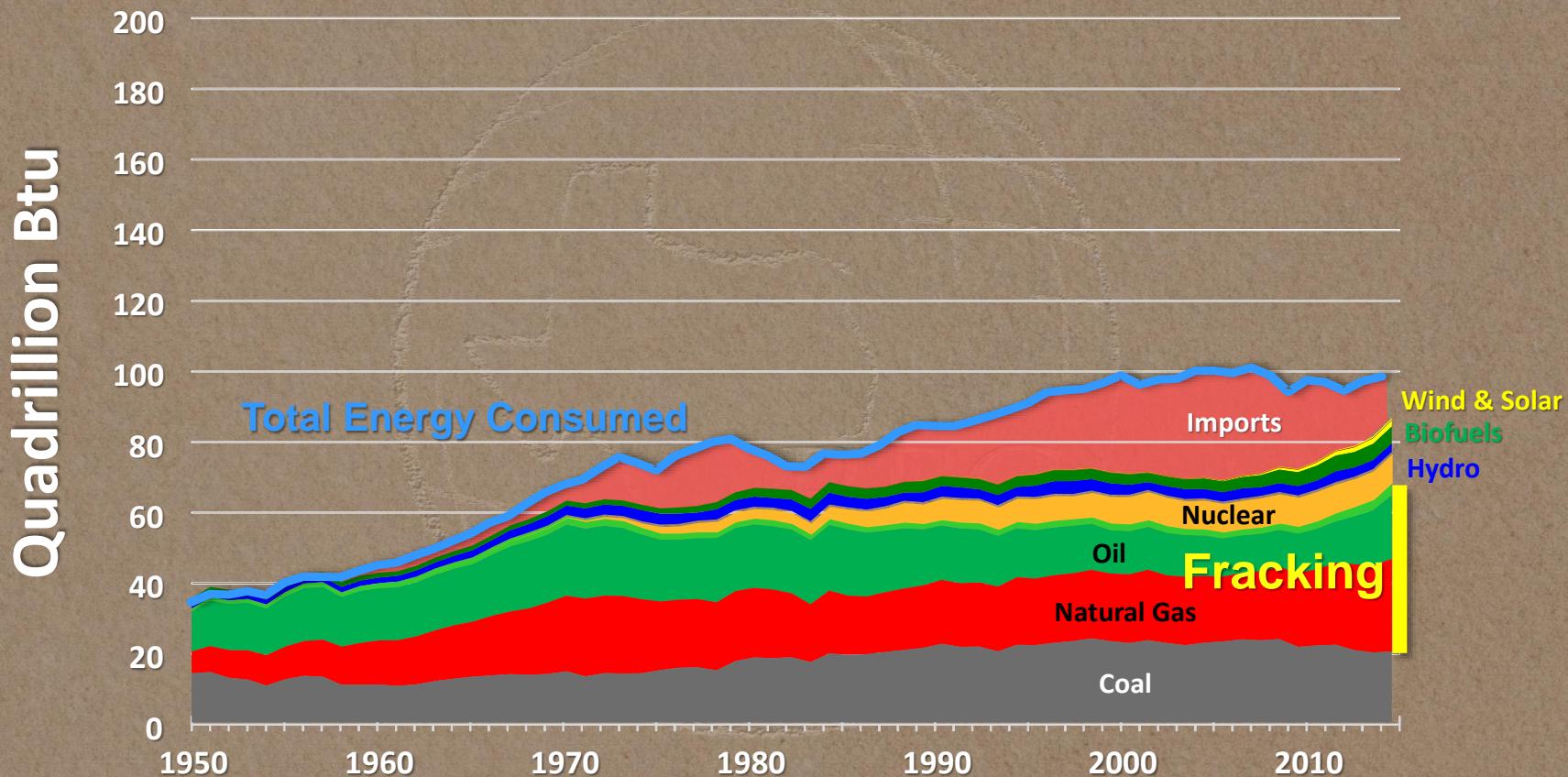


Electric Power Sector U.S. Carbon Dioxide Emissions

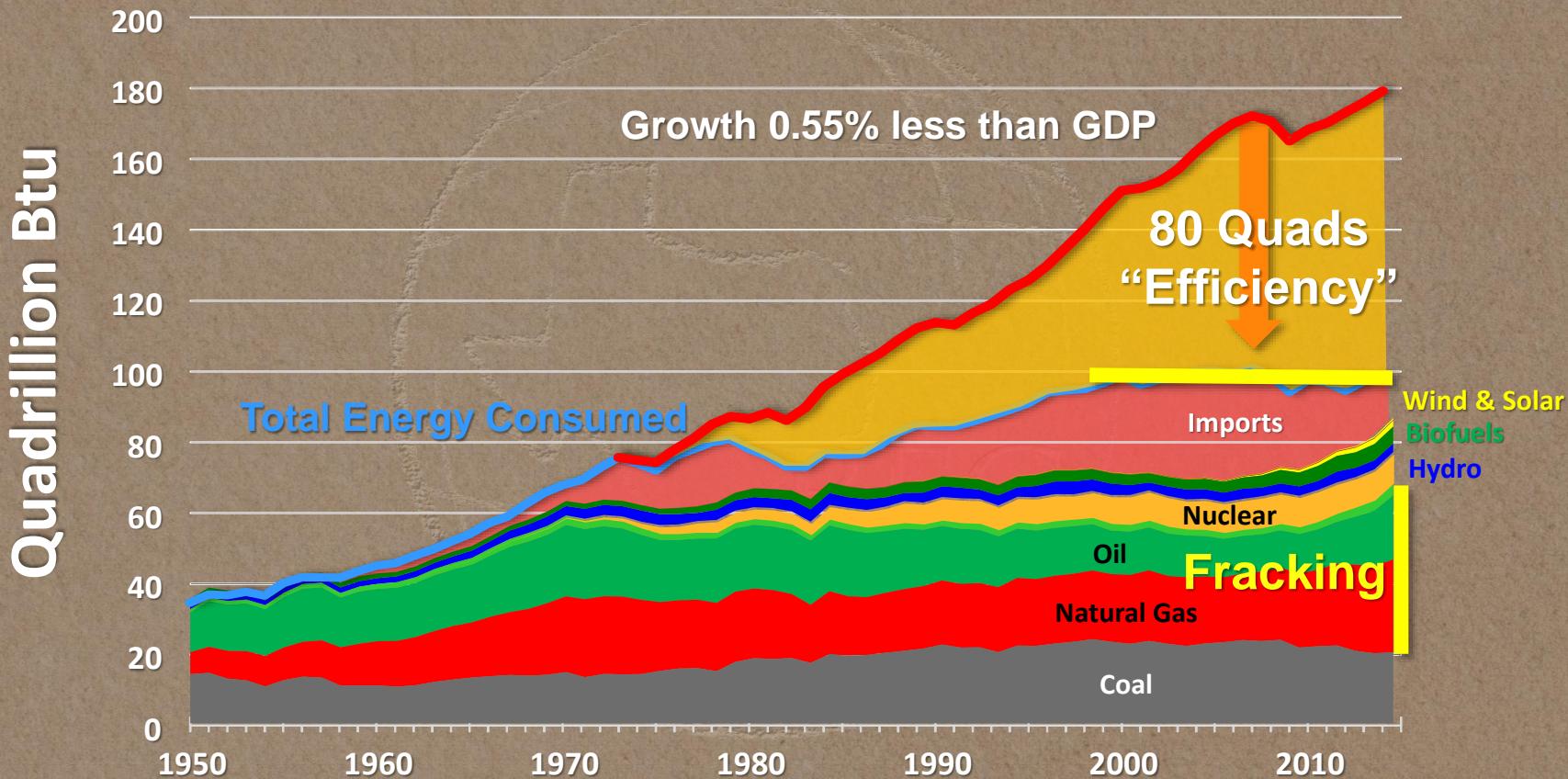
Clean Power Plan



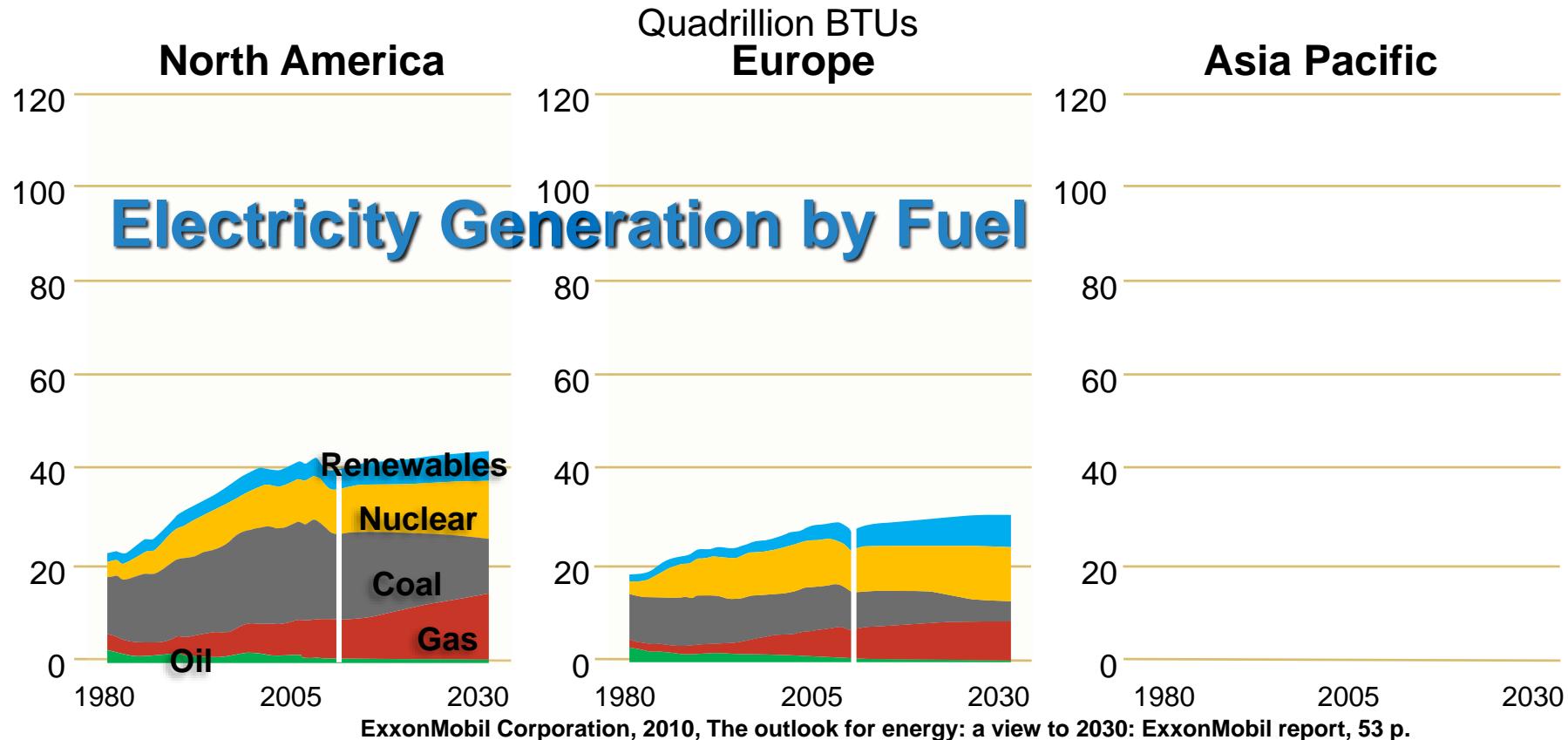
US Energy Mix



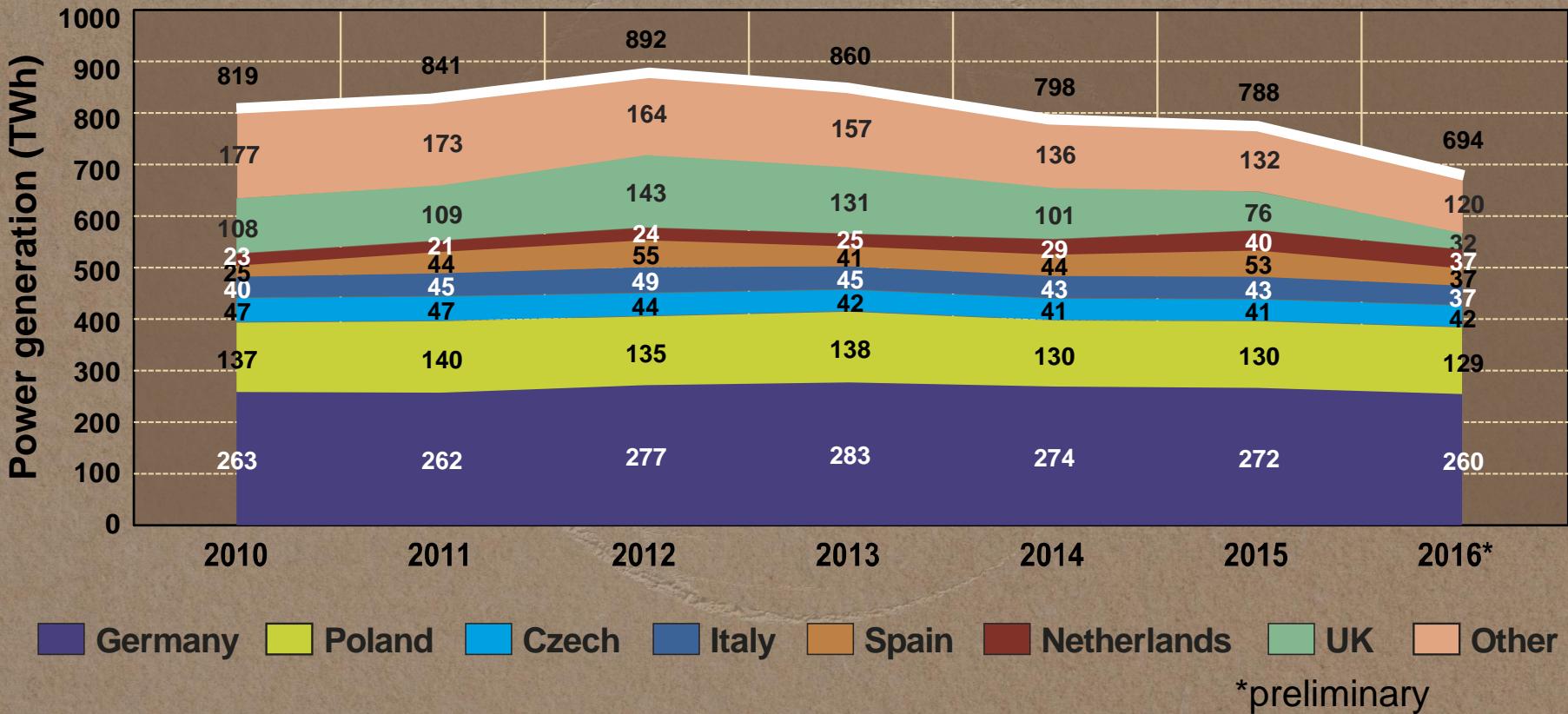
US Energy Mix



The Future Electricity Mix

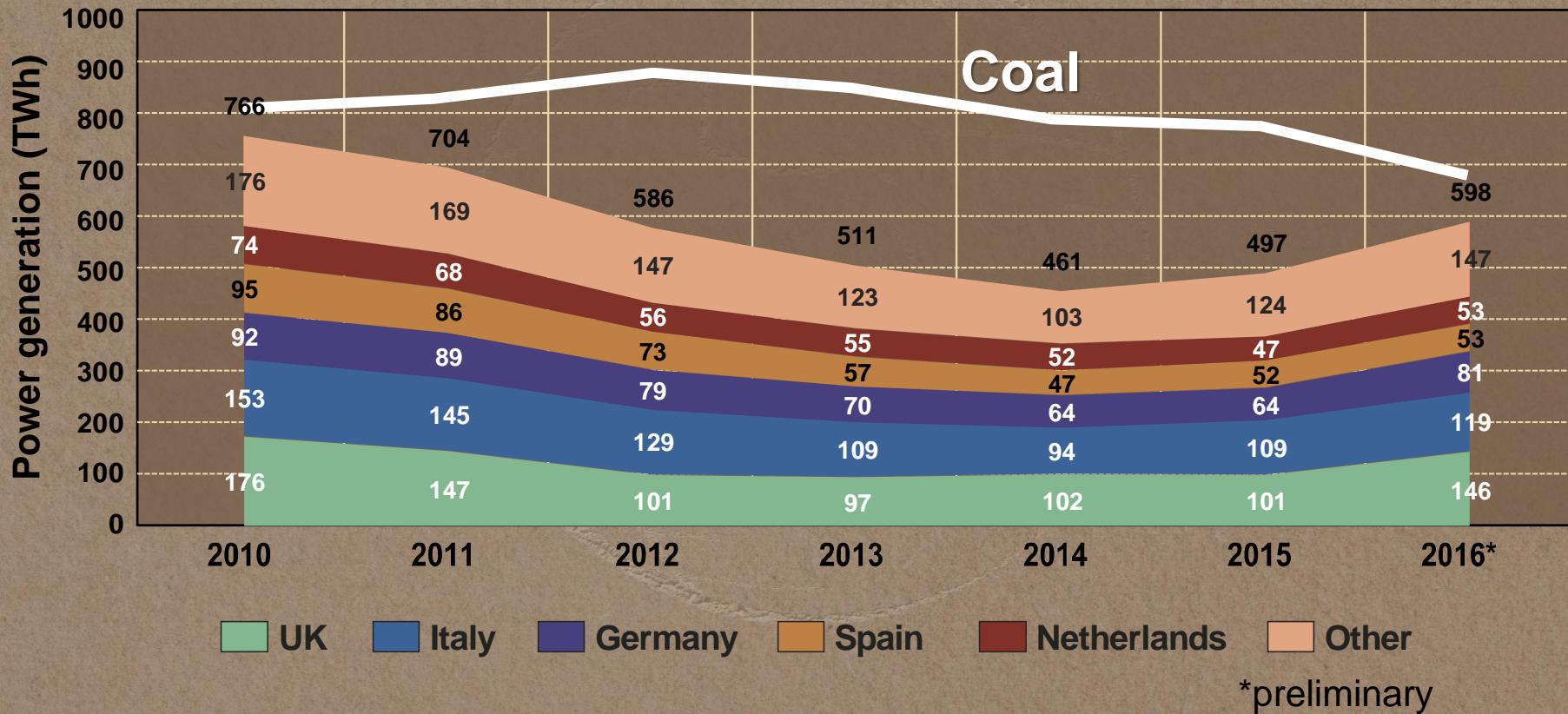


European Coal Generation

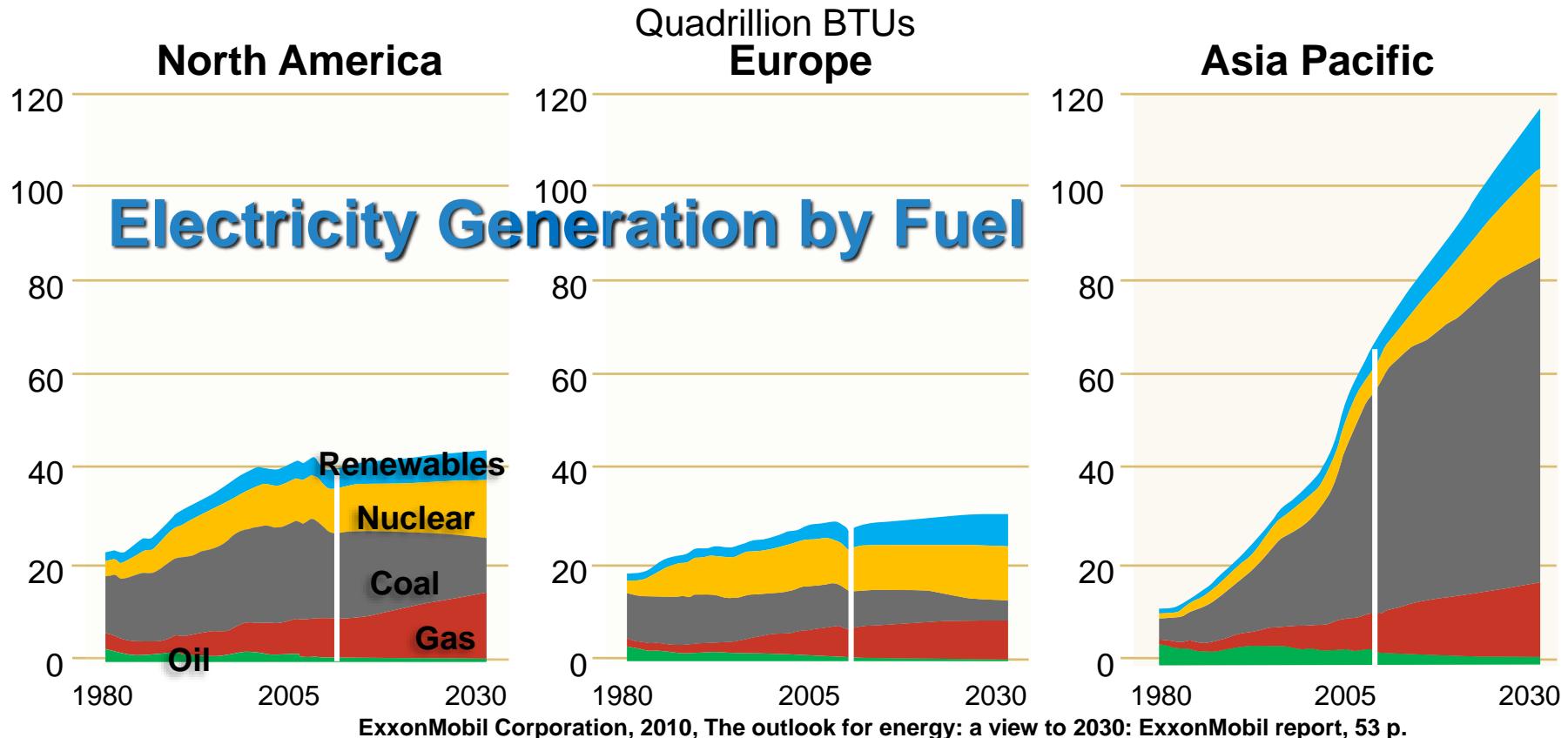


Germany Poland Czech Italy Spain Netherlands UK Other

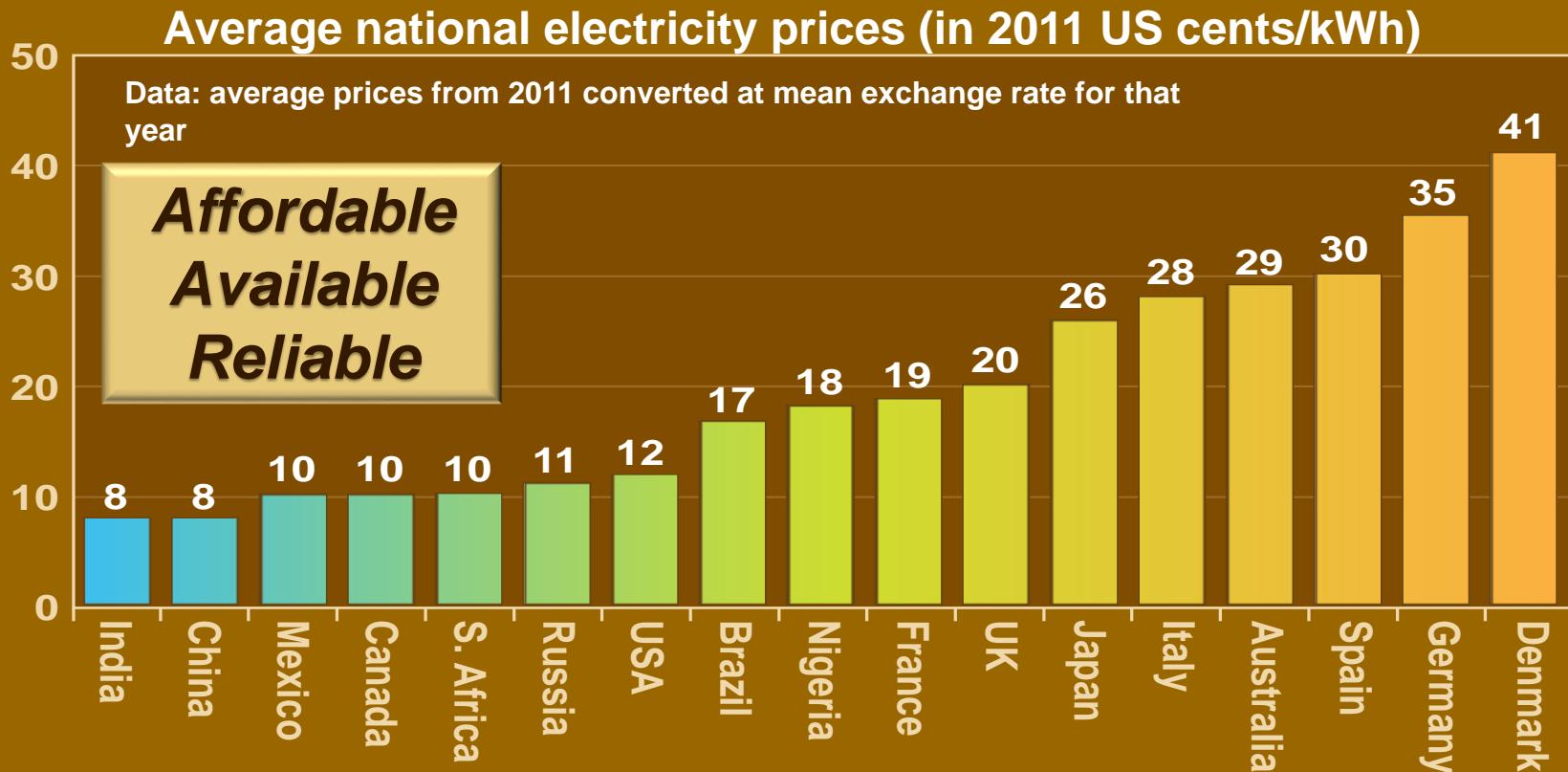
European Natural Gas Power Generation



The Future Electricity Mix



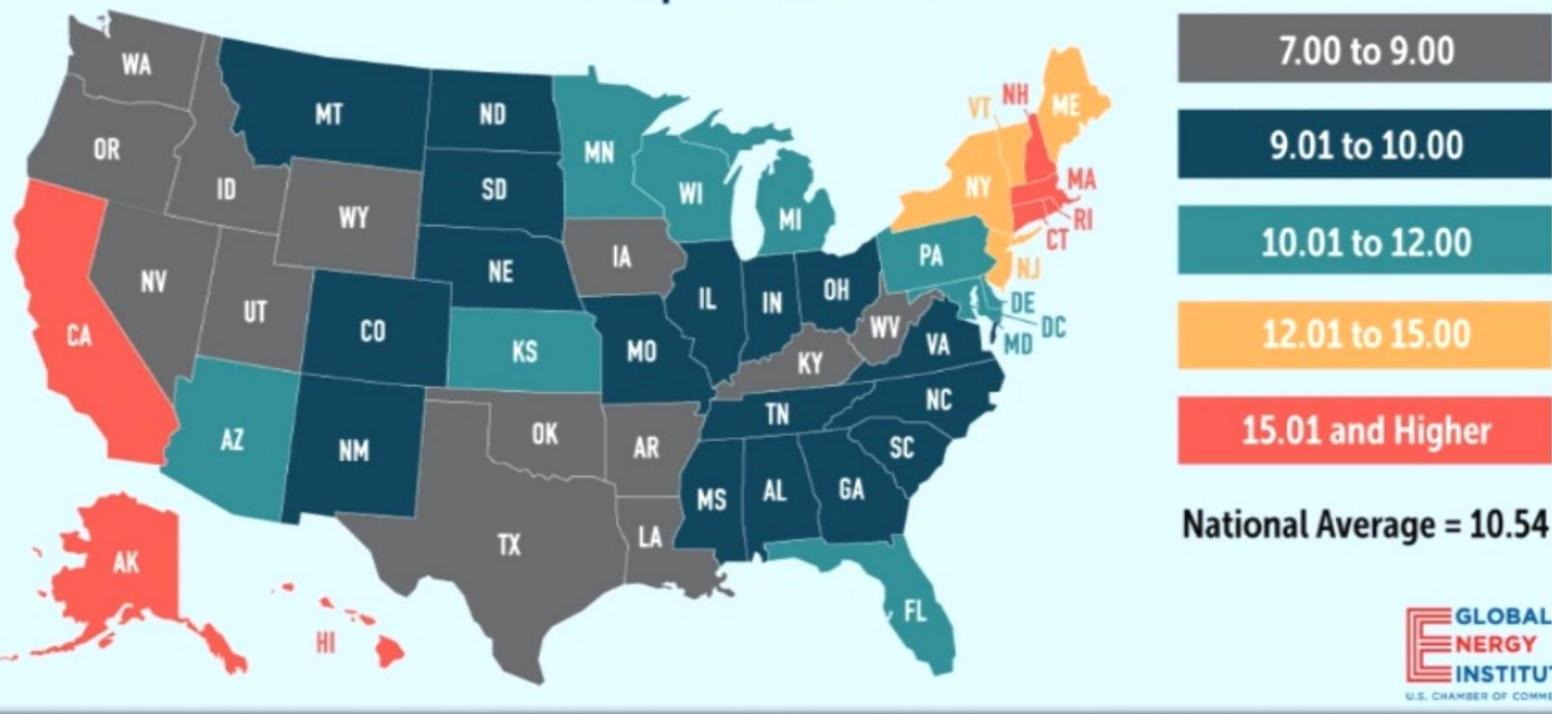
Actual Cost of Electricity



Sources: IEA, EIA, national electricity boards, OANDA, shrinkthatfootprint.com

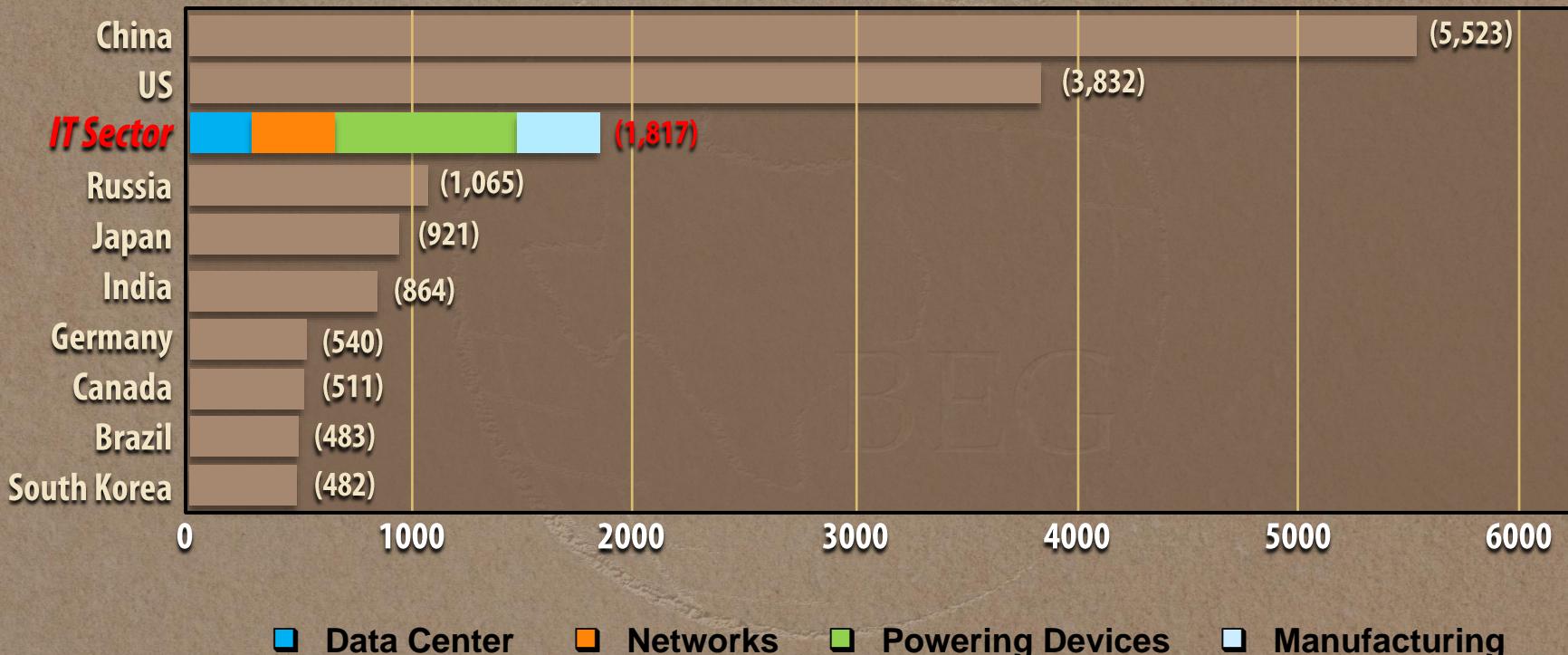
Actual Cost of Electricity

2017 U.S. Average Electricity Retail Prices (cents per kilowatt hour)



Electricity Use

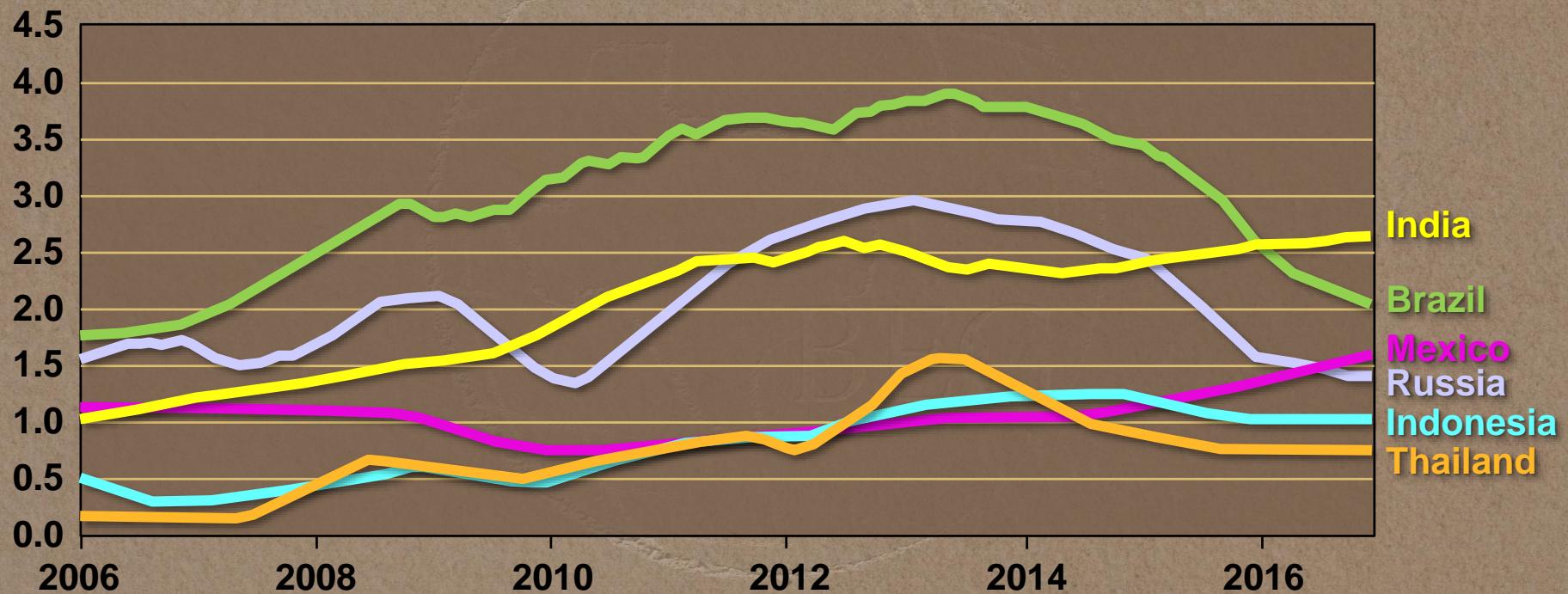
(2012: Billion KwH)



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.

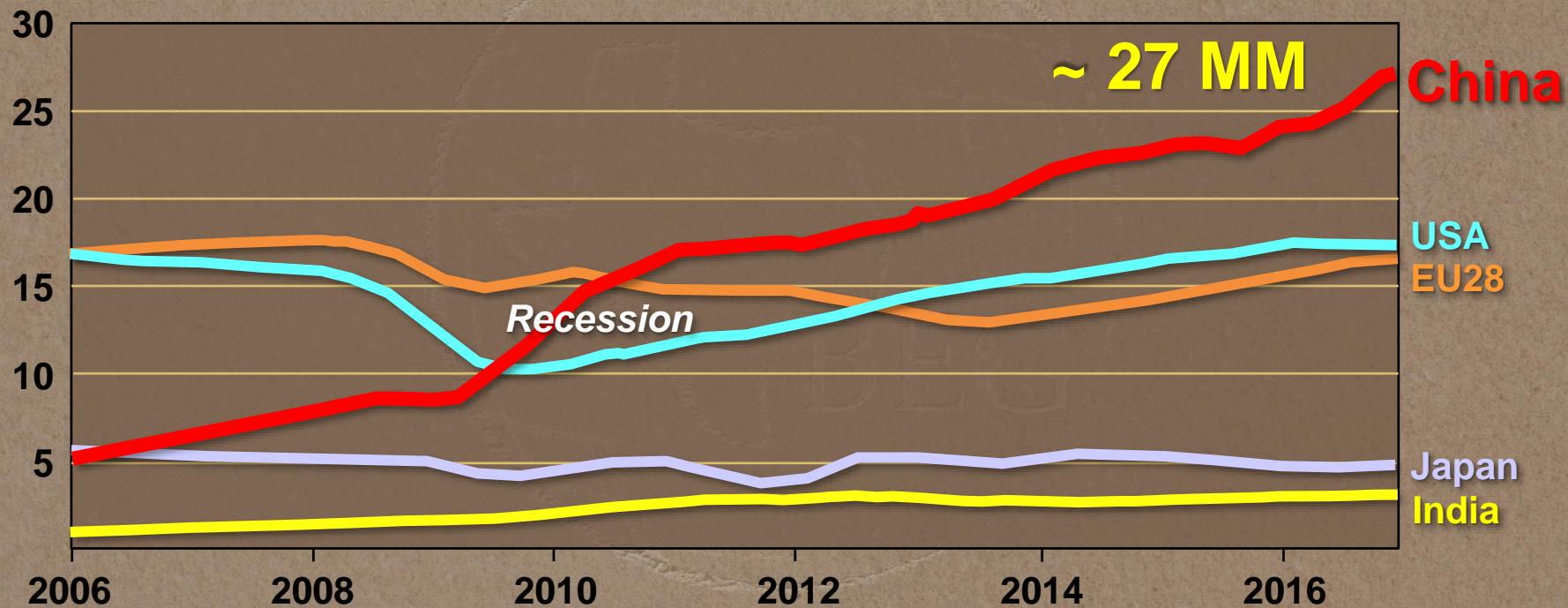
Auto Sales Developing Nations

Rolling 12-month (million)

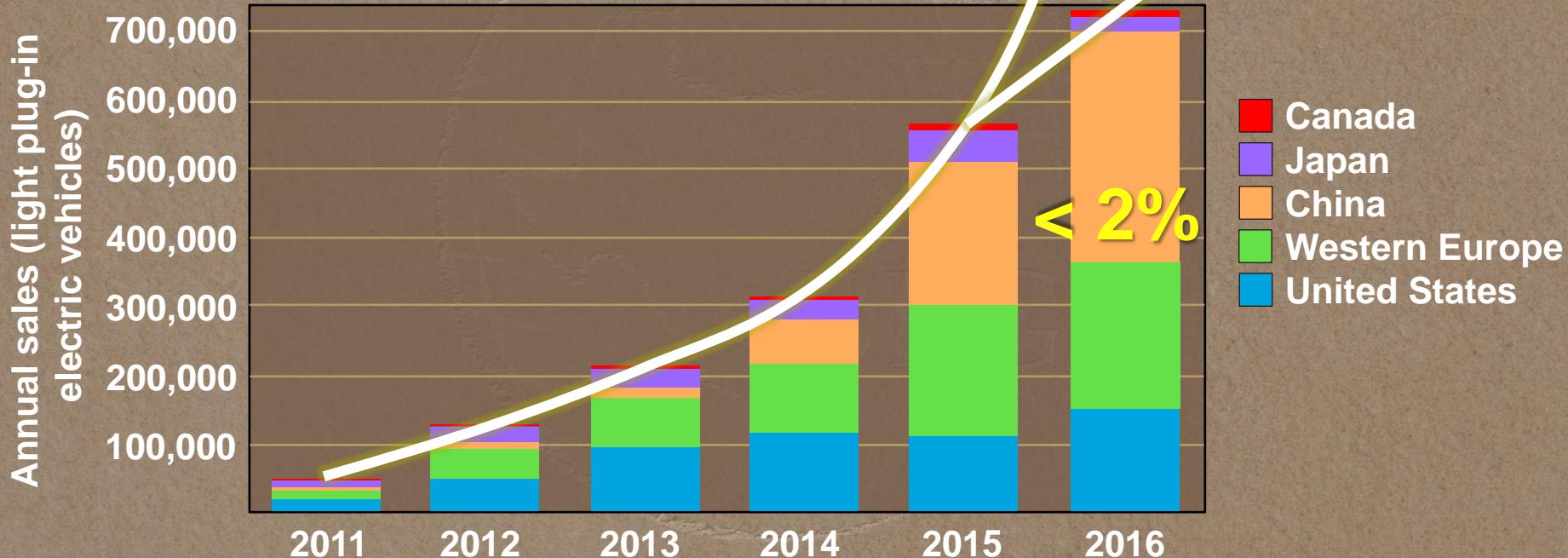


Auto Sales Developed Nations

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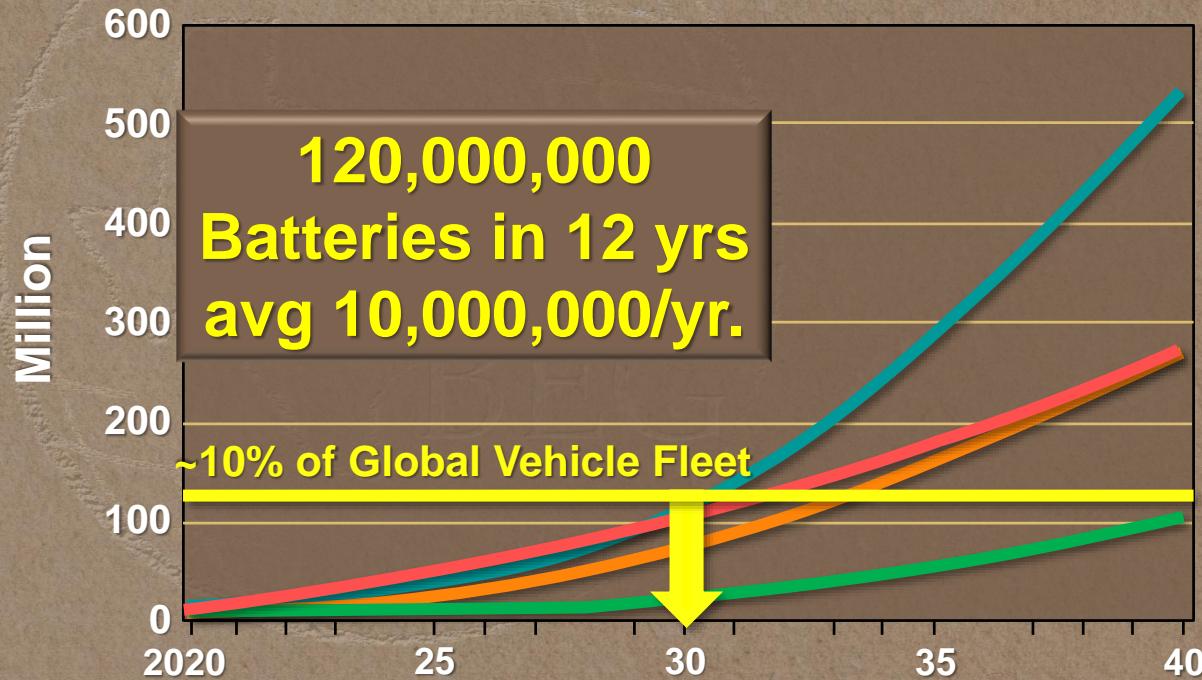


Global Annual Sales Light-Duty Plug-In Electric Vehicles (2011 – 2016)



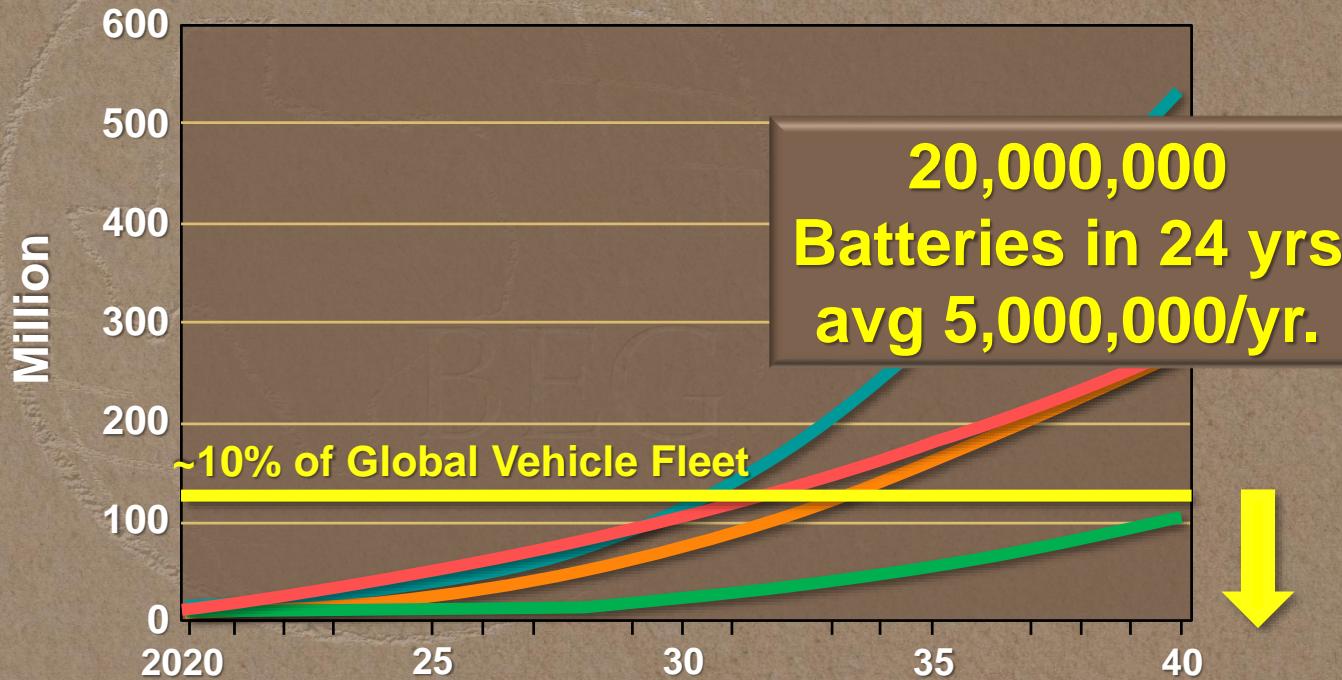
Cumulative Electric-Vehicle Forecasts

2016	2017	
		Bloomberg
		OPEC
		ExxonMobil
		EIA

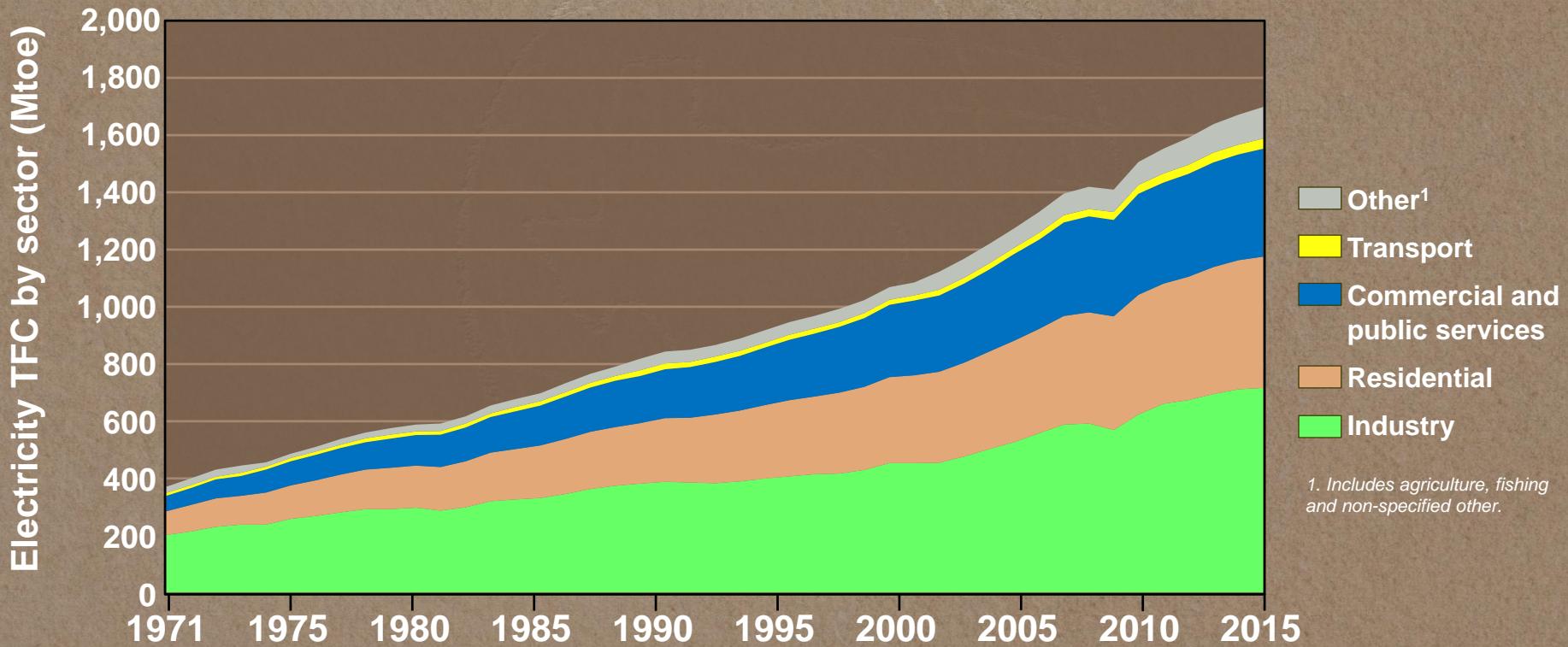


Cumulative Electric-Vehicle Forecasts

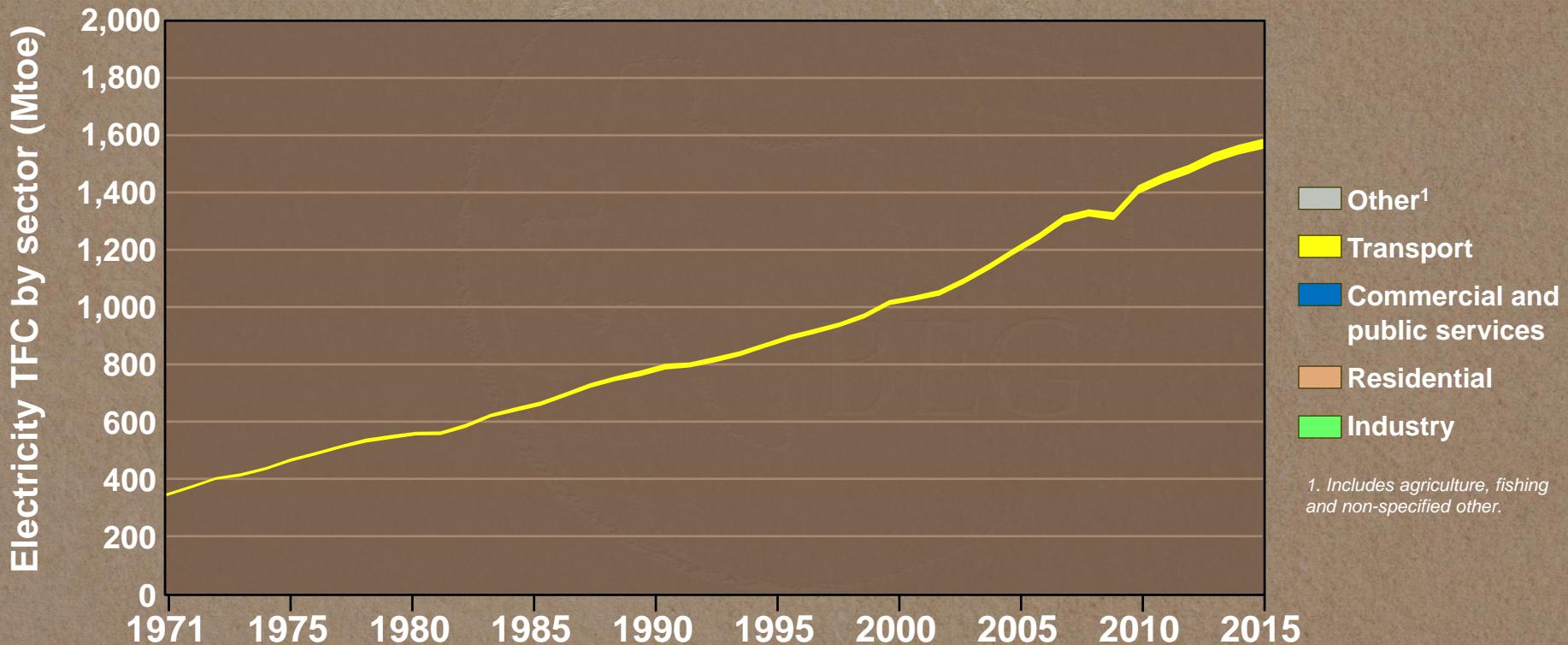
2016	2017
Bloomberg	~10% of Global Vehicle Fleet
OPEC	20,000,000 Batteries in 24 yrs avg 5,000,000/yr.
ExxonMobil	
EIA	



Total Final Consumption by Sector Electricity



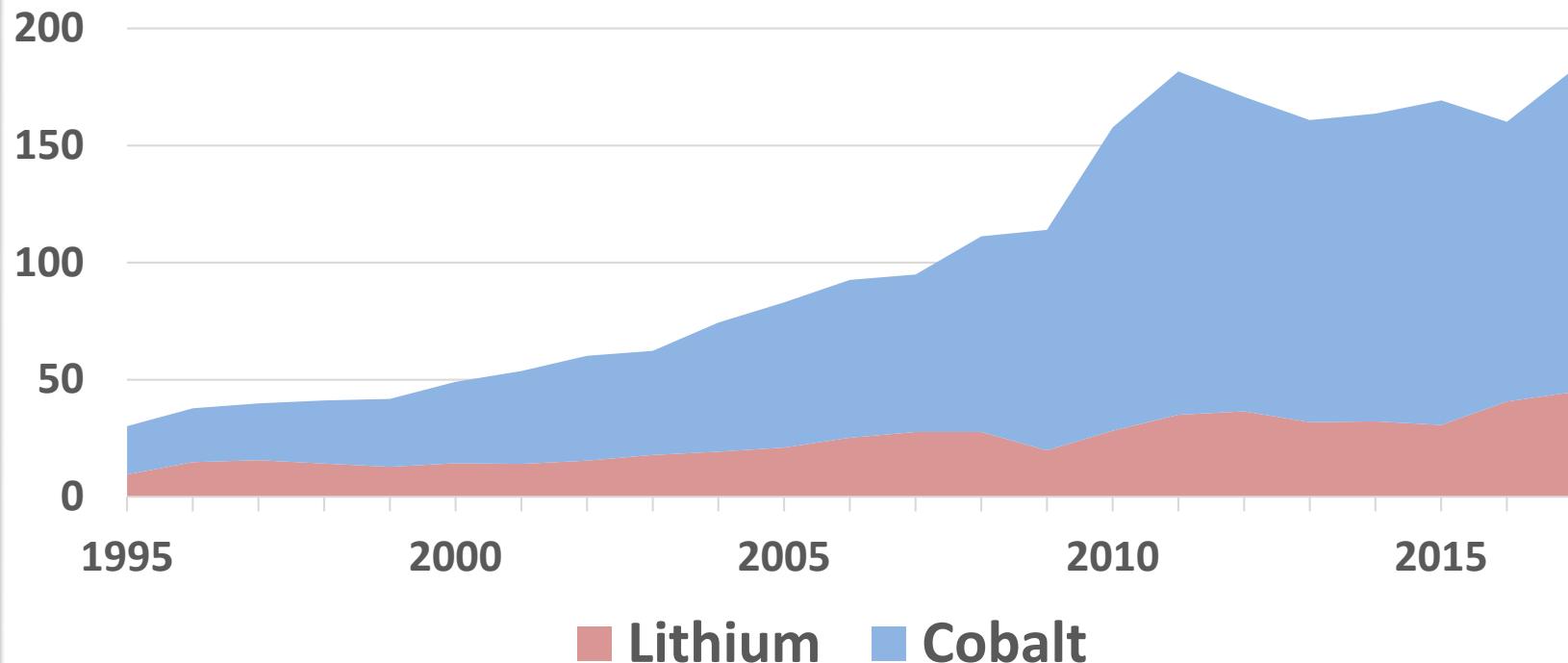
Total Final Consumption by Sector Electricity



1. Includes agriculture, fishing and non-specified other.

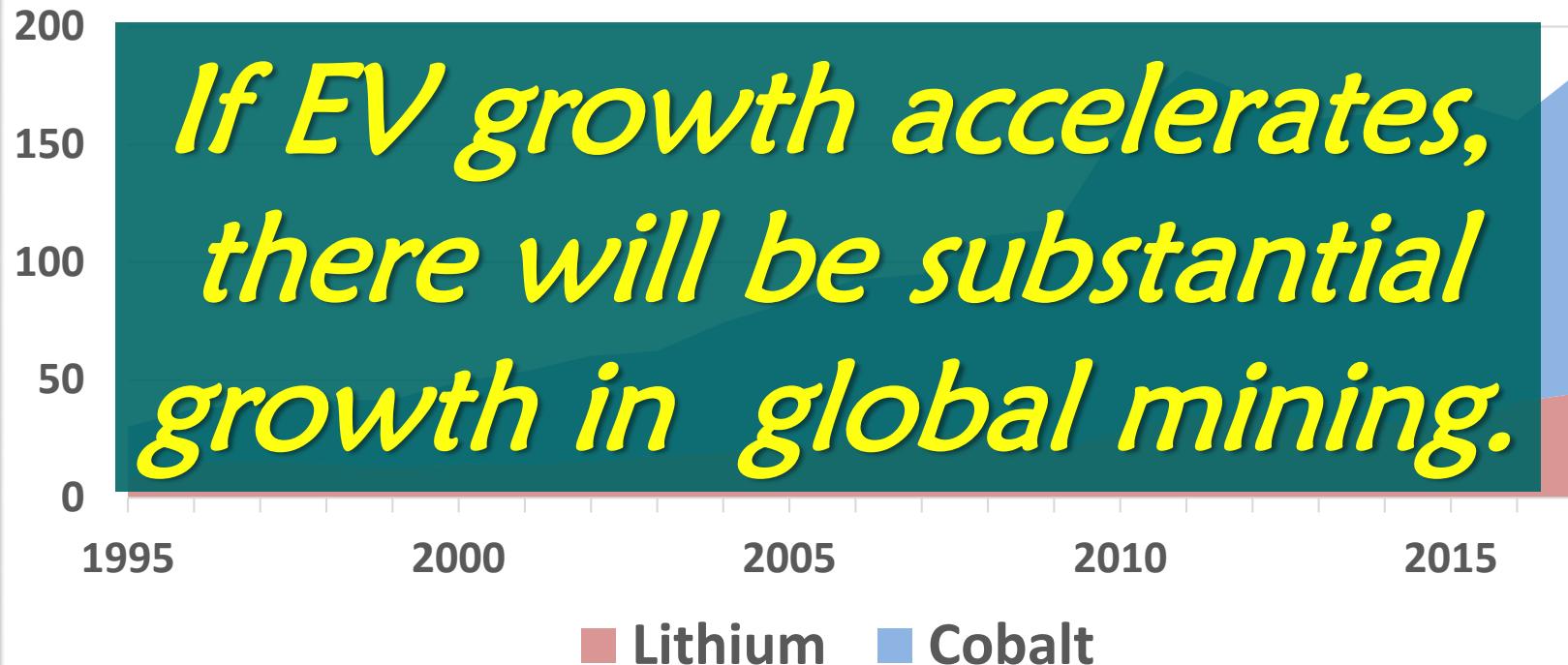
Battery Mining

Lithium and Cobalt Production (Thousand Tonnes)



Battery Mining

Lithium and Cobalt Production (Thousands Tonnes)



CO₂ Reduction Strategies

- Efficiency
- Fuel Substitution
 - ✓ Nuclear, Nat Gas, Renewables
- Carbon Capture and Sequestration



Carbon Key Points



- Renewables will grow, but not large enough or soon enough to impact climate change
- Natural gas and nuclear can reduce CO₂ emissions at scale in the needed time frames
 - ✓ Carbon sequestration and methane emissions
- Electric vehicle growth will not mitigate the demand for combustion engines

Outline

- ❖ Energy
- ❖ Carbon
- ❖ Poverty
- ❖ Radical Middle



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GEOLOGY

Photo Credit: Scott W. Tinker

**“Capitalism has worked
very well. Anyone who
wants to move to North
Korea is welcome.”**

-Bill Gates



People Without Access to Electricity and Clean Cooking Facilities

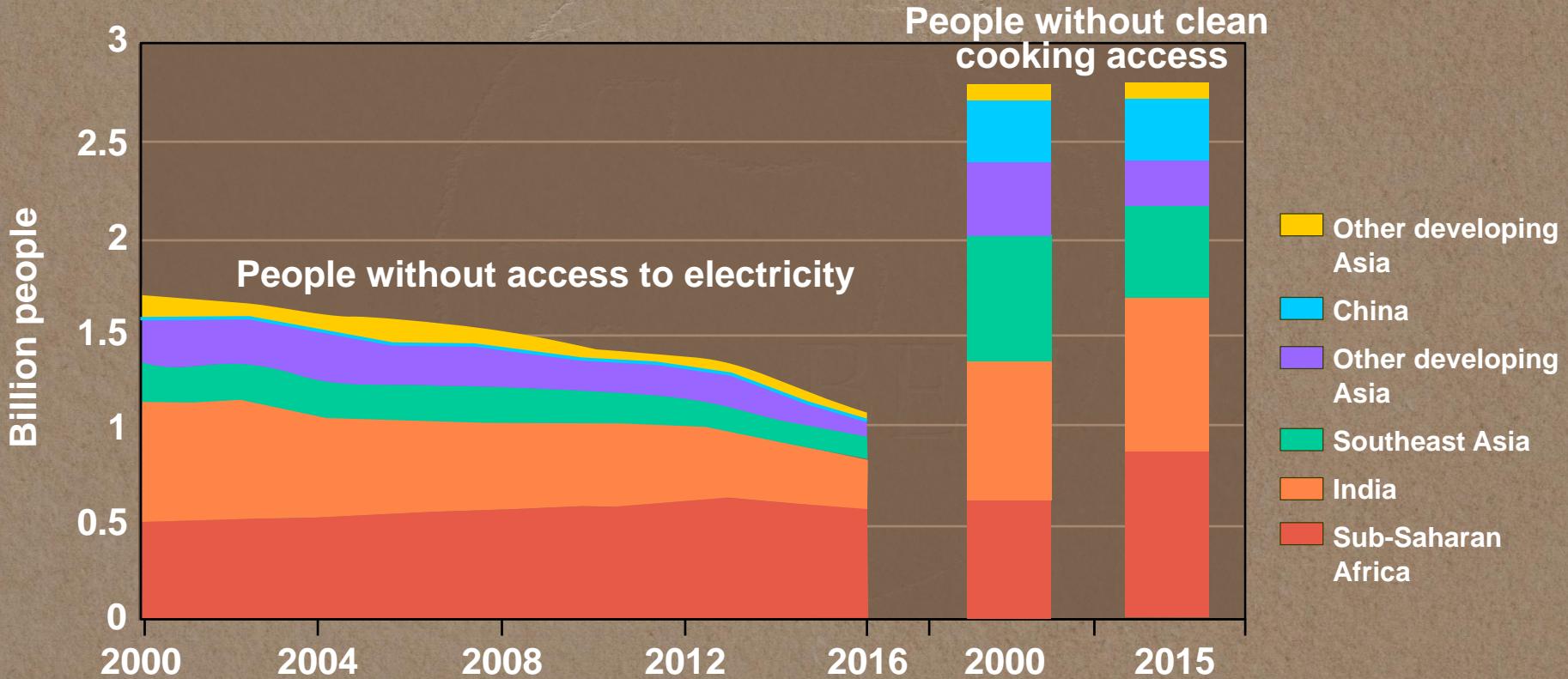




Photo Credit: Scott W. Tinker

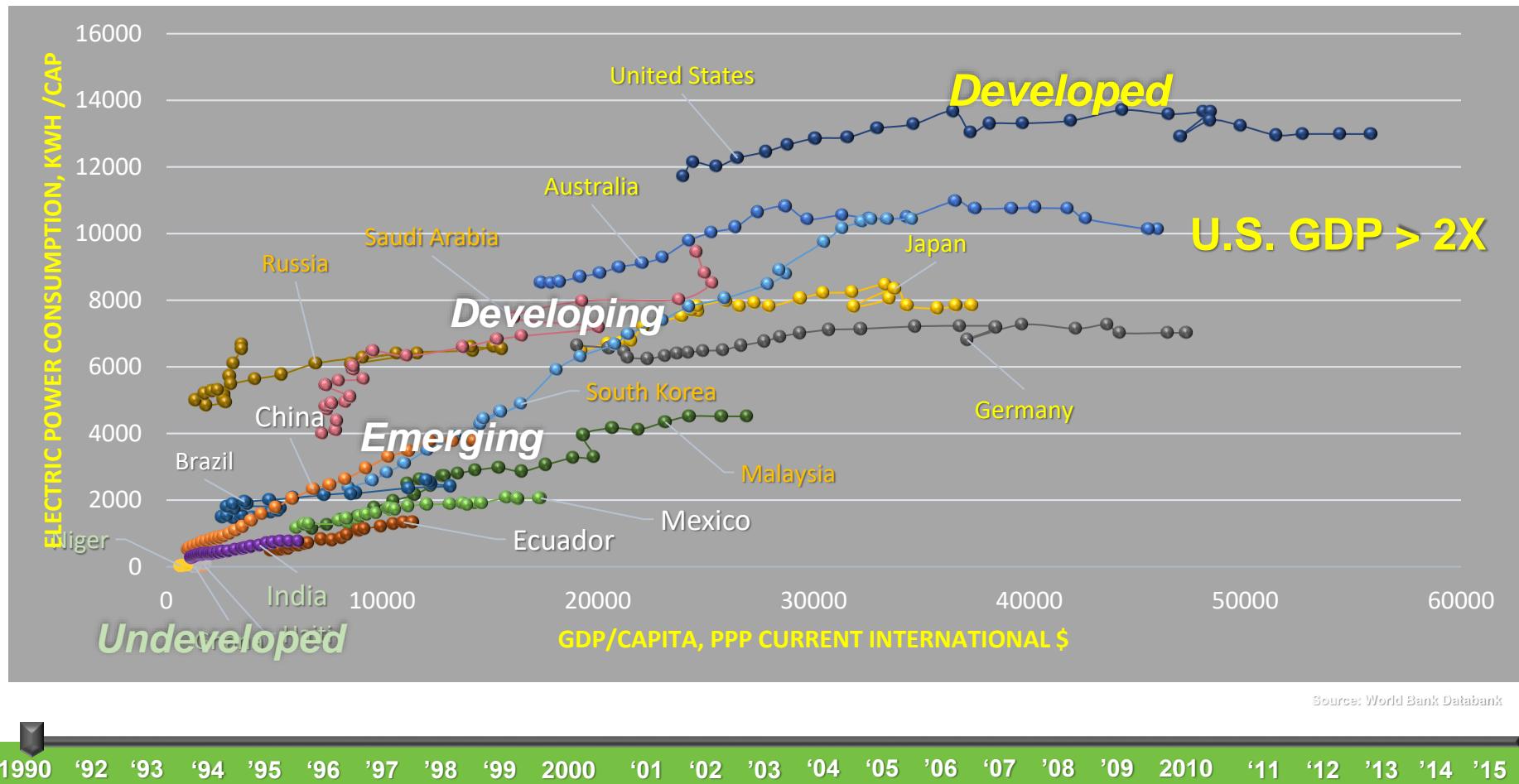
Photo Credit: Harry Lynch



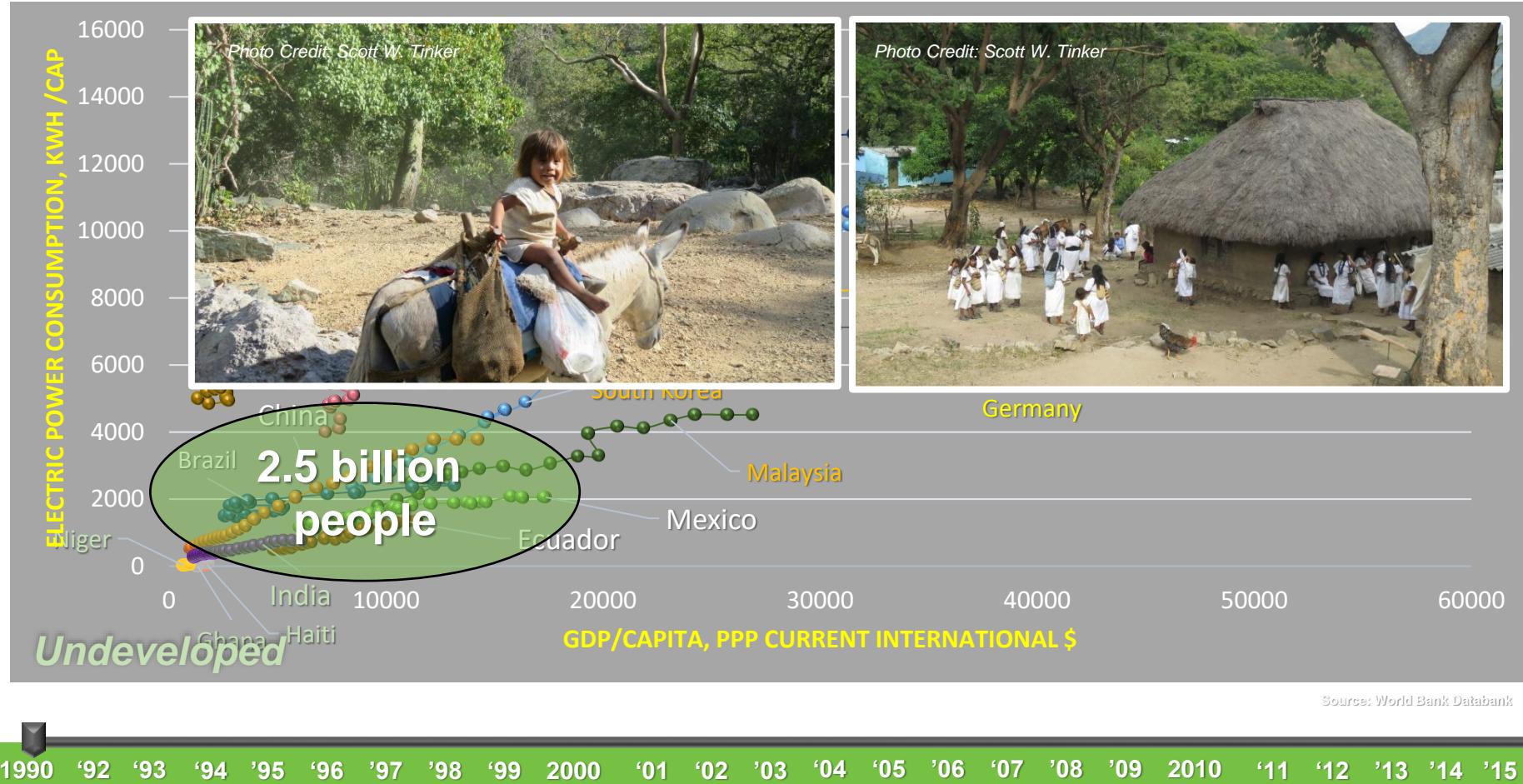


Photo Credit: Scott W. Tinker

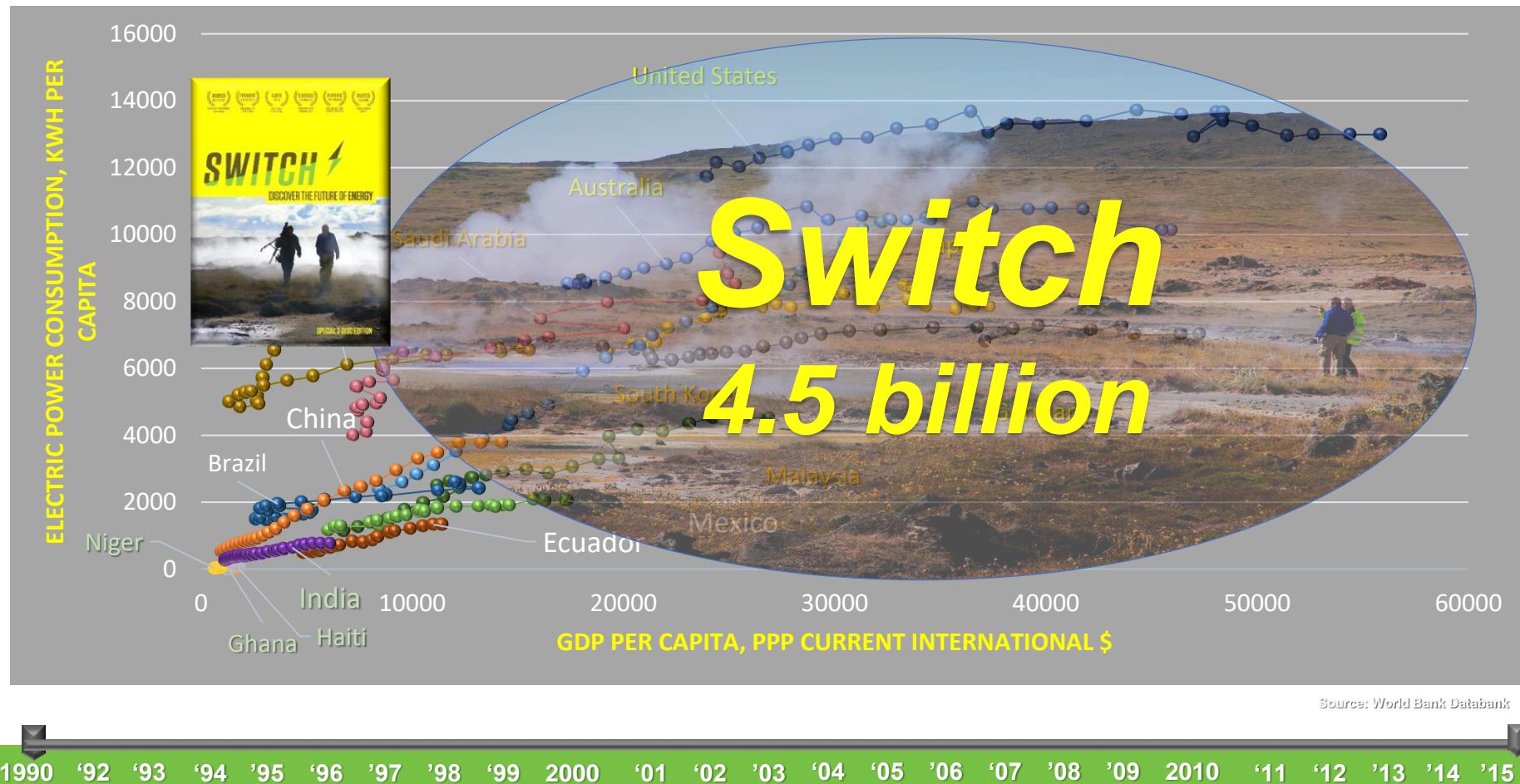
Limited Access to Electricity Restricts Standard of Living



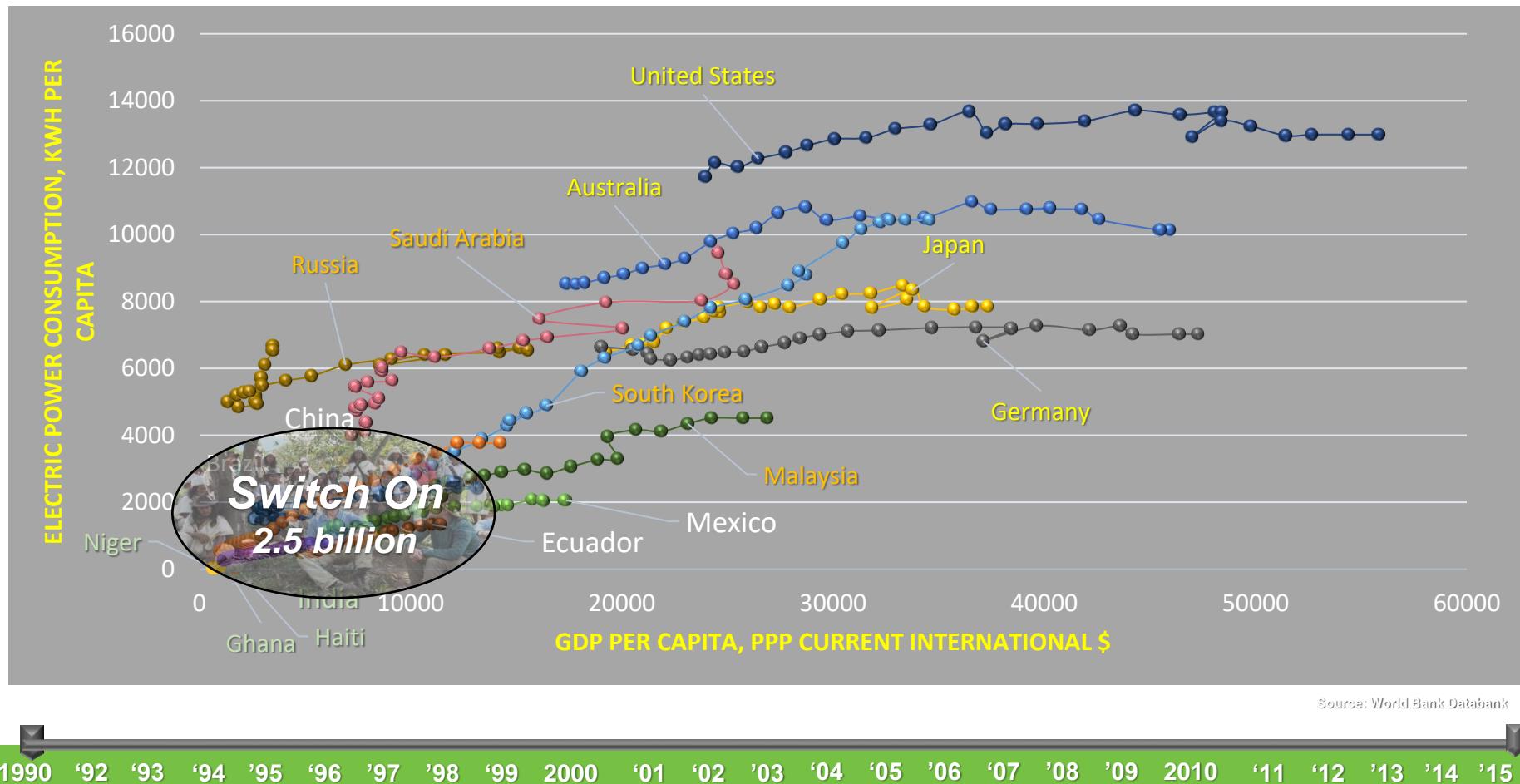
Limited Access to Electricity Restricts Standard of Living



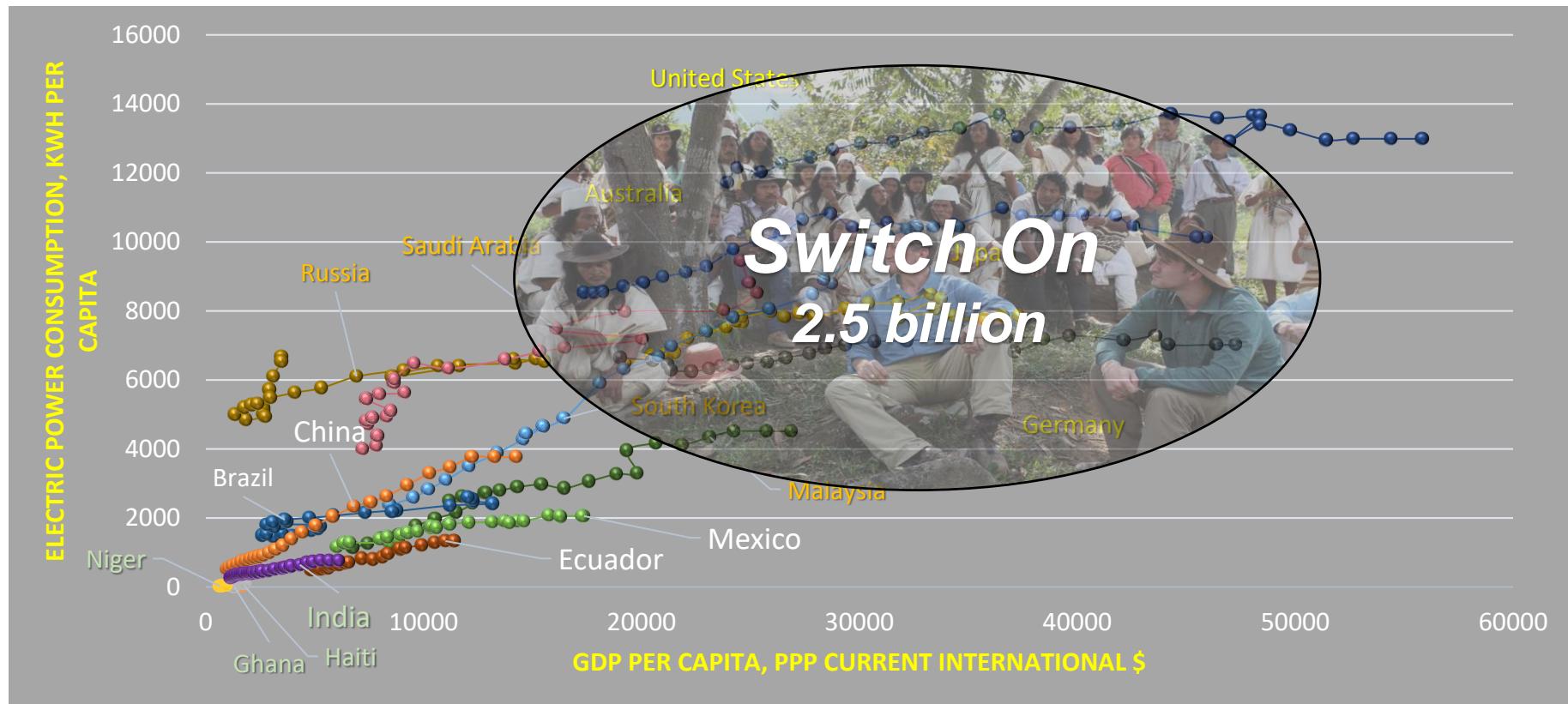
Limited Access to Electricity Propagates Inequality



Limited Access to Electricity Propagates Inequality



Limited Access to Electricity Propagates Inequality



Source: World Bank Databank

It's Time to Educate & Power the People



Photo Credit: Scott W. Tinker

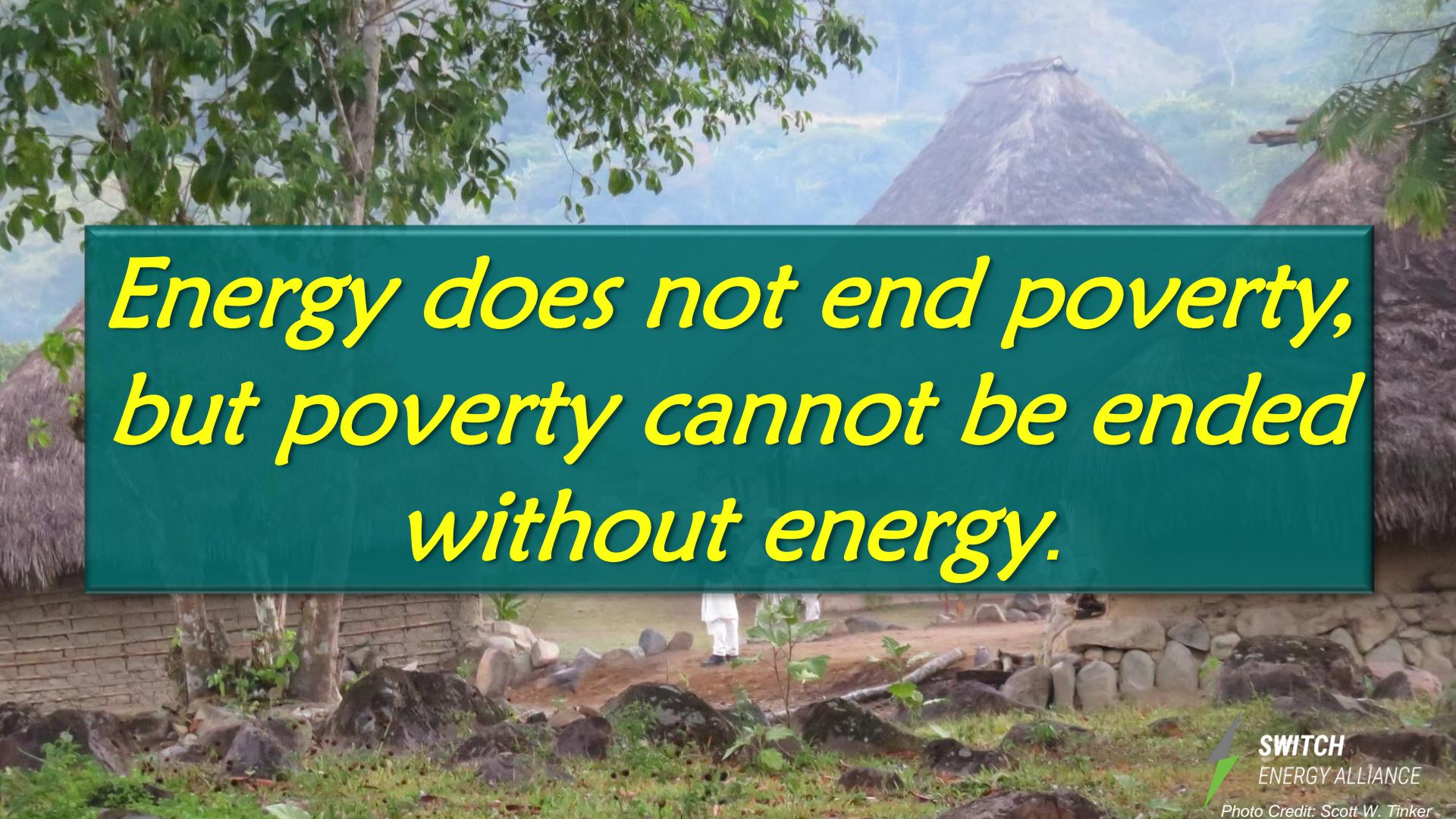


Photo Credit: Scott W. Tinker





Photo Credit: Sterling Richard



*Energy does not end poverty,
but poverty cannot be ended
without energy.*



Photo Credit: Scott W. Tinker

Poverty Key Points



- Energy underpins modern economies and helps lift the world from poverty
- Nations will use the energy resources that they have to reduce energy poverty
- Objective, non-partisan energy education is vital to solve the “radical middle” challenges



Outline

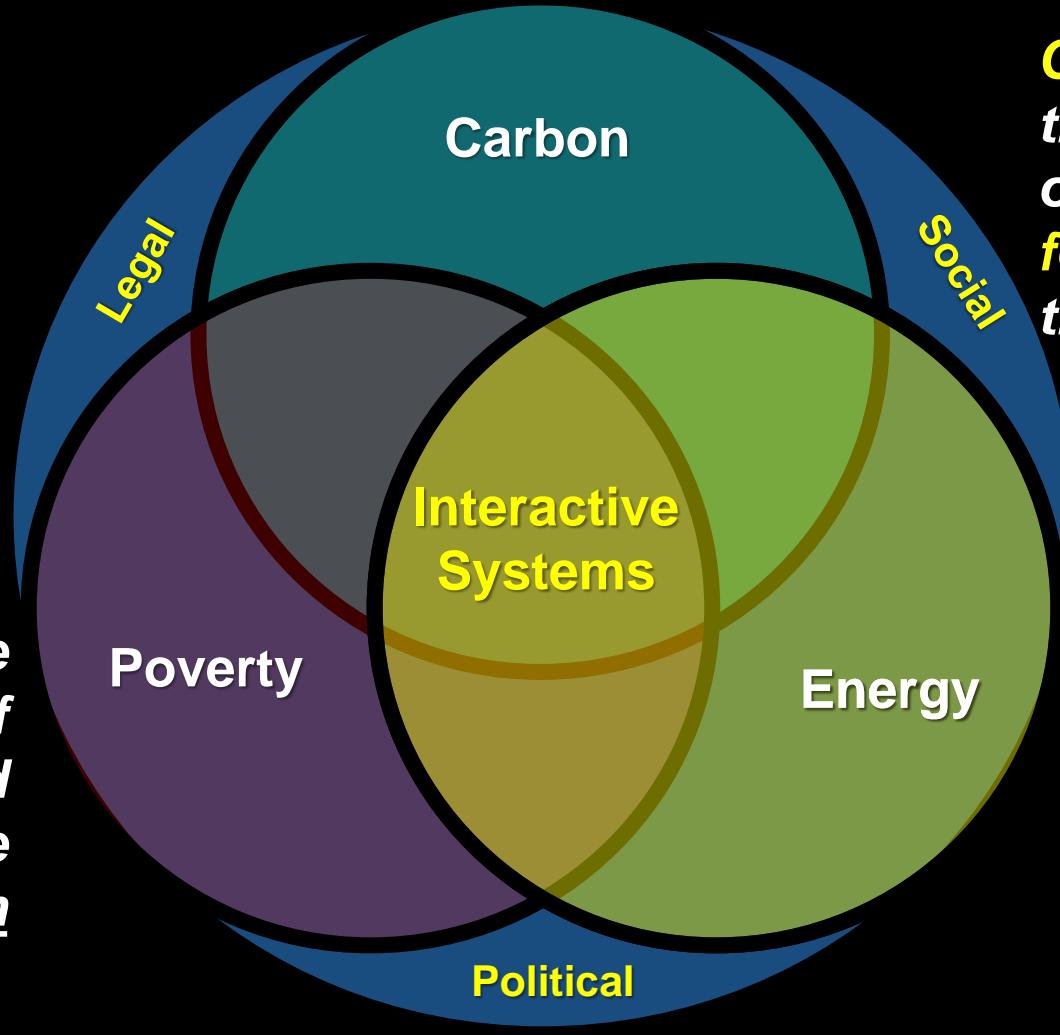
- ❖ Energy
- ❖ Carbon
- ❖ Poverty
- ❖ Radical Middle



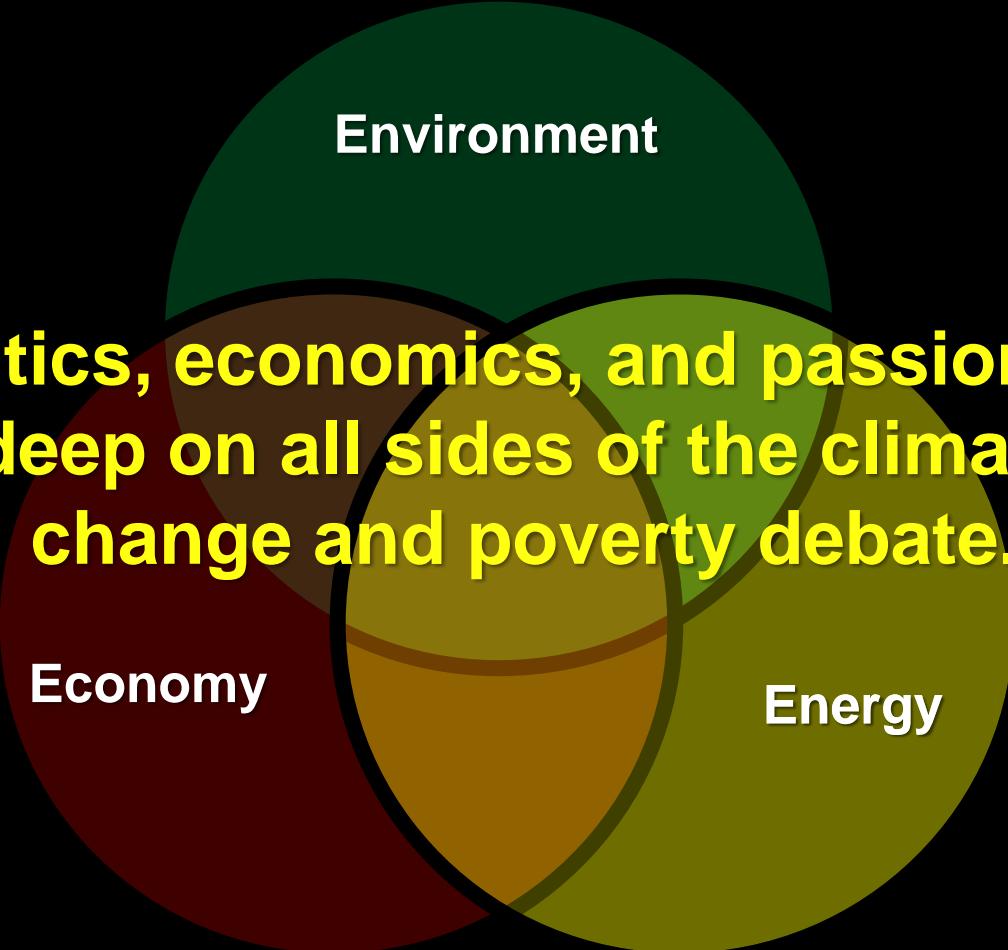
**“Only when they must
choose between
competing theories do
scientists behave like
philosophers.”**

-Thomas Kuhn

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



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

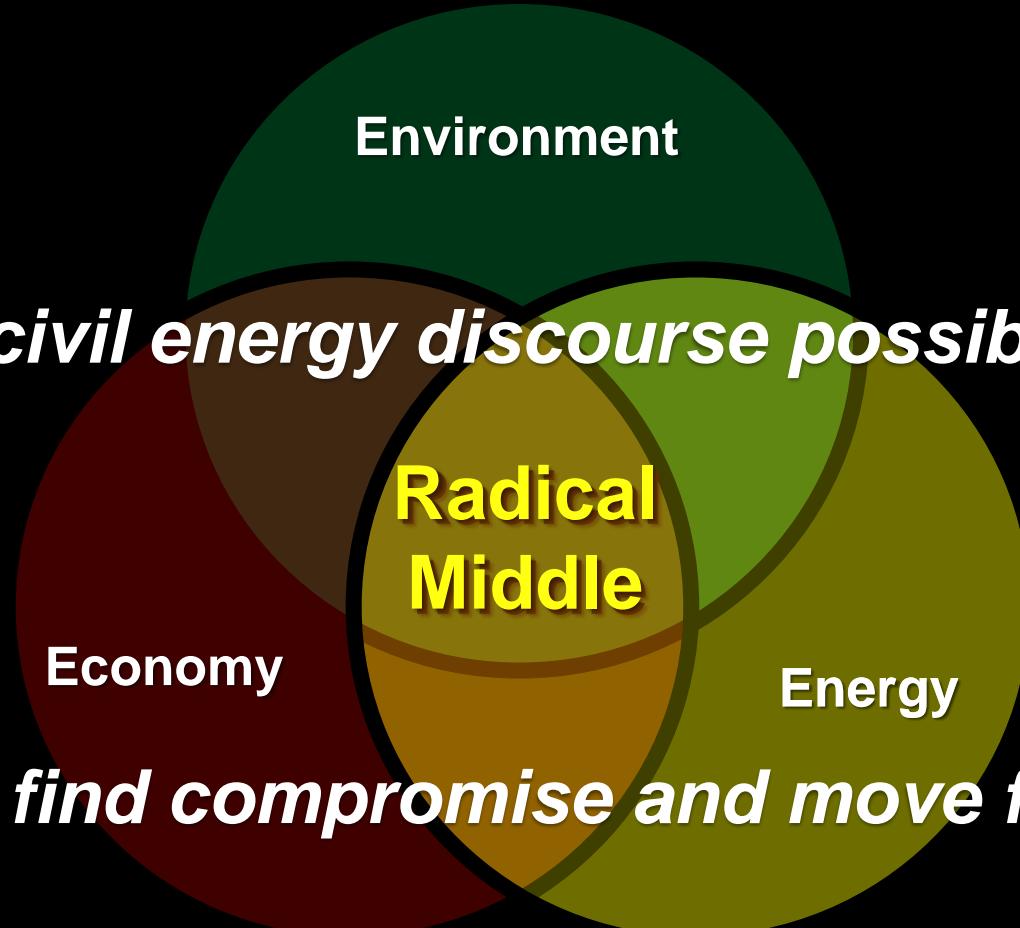


Environment

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

Economy

Energy



Is civil energy discourse possible?

Can we find compromise and move forward?

Towards a Radical Middle

- **Assess the environmental impact of *all* energy**
- **Focus energy policy on energy security**
- **Make energy efficiency and energy storage tactical**
- **Recognize energy poverty as a critical challenge**
- **Understand that no form of energy is good or bad**

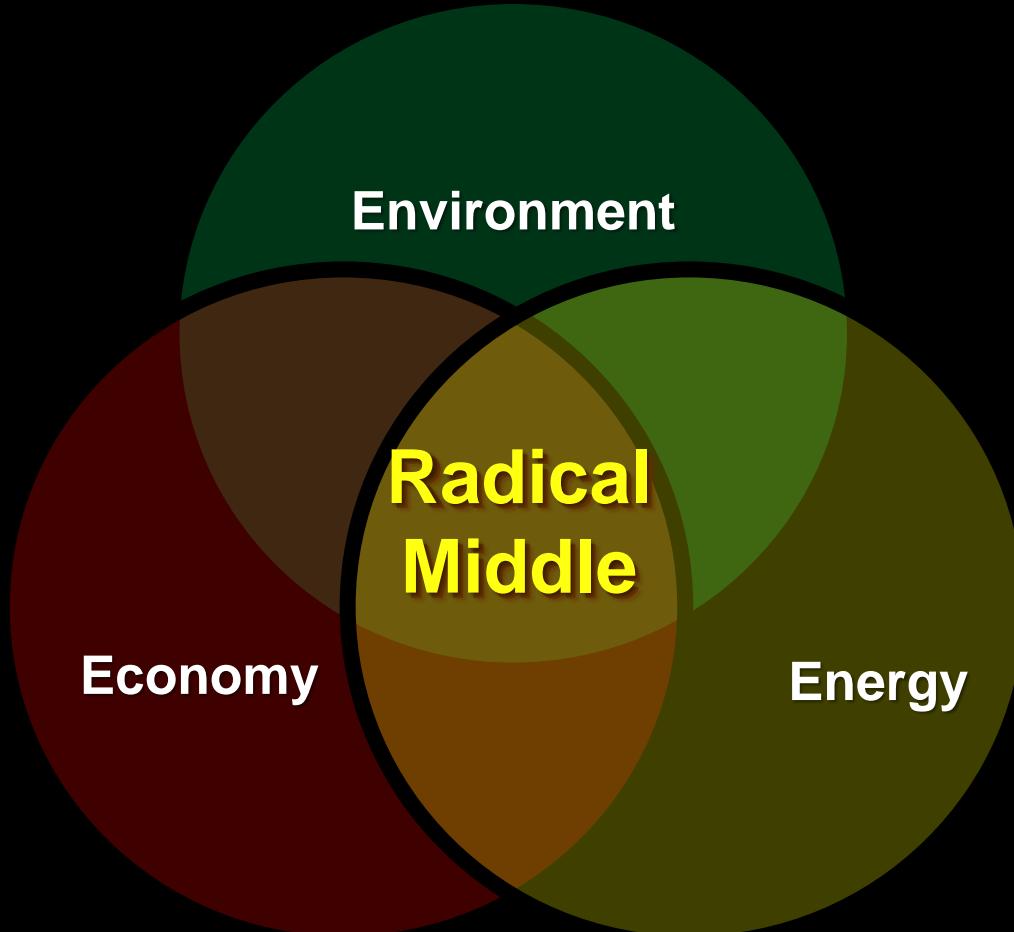
Engage in Energy Education!



Keep *them* in Poverty.



Lift
them
from
Poverty!





SWITCH
ENERGY ALLIANCE



Thanks!

Join the Switch Energy Alliance

SwitchOn.org

Inspire an Energy Educated Future

For potential conflicts of Scott Tinker see

<http://www.beg.utexas.edu/people/scott-tinker>



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Photo Credit: Scott W. Tinker