The Western Narrative

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

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

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

Data: BP Statistical View of World Energy (2016)
The Global Energy Mix

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

Data: BP Statistical View of World Energy (2016)
Global Energy Mix

Global Energy Consumption (MTOE)

Data: BP Statistical View of World Energy (2016)
“The world could be 100% wind, wave and solar by 2030, if just for political will…”
Electricity Generation
By Region

World electricity generation\(^1\) from 1971 to 2015 by region (TWh)


1. Excludes electricity generation from pumped storage.
World electricity generation 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

World electricity generation\(^1\) from 1971 to 2015 by source (TWh)

- **Non-hydro renewables and waste\(^2\)**
- **Hydro**
- **Nuclear**
- **Fossil thermal**

1. Excludes electricity generation from pumped storage.
2. Includes geothermal, solar, wind, tide/wave/ocean, biofuels, waste, heat and other.

Nuclear Electricity Production

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

1. Non-OECD Asia excludes China. 2. Other includes Africa, Non-OECD Americas and the Middle East.
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.

Hydro Electricity Production

World hydro electricity production\(^1\) from 1971 to 2015 by region (TWh)


1. Includes electricity production from pumped storage.
Electricity Generation by Source

World electricity generation\(^1\) from 1971 to 2015 by source (TWh)

- Non-hydro renewables and waste\(^2\)
- Hydro
- Nuclear
- Fossil thermal

1. Excludes electricity generation from pumped storage.
2. Includes geothermal, solar, wind, tide/wave/ocean, biofuels, waste, heat and other.

Wind Electricity Production

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


1. Non-OECD Asia excludes China.
Electricity Generation by Source

World electricity generation by fuel (TWh)

- Non-hydro renewables and waste
- Hydro
- Nuclear
- Fossil thermal

1. Excludes electricity generation from pumped storage.
2. Includes geothermal, solar, wind, tide/wave/ocean, biofuels, waste, heat and other.

Wind Electricity

Growth in U.S. Wind Generation
2000–2014

Million Kwh


1. Non-OECD Asia excludes China.
Solar Photovoltaic Electricity Production

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


1. Non-OECD Asia excludes China.
Solar Photovoltaic Electricity

United States
Solar photovoltaics

Source: Economist, Solar Energy Industries Association

Average Module Price $ / watt

1. Non-OECD Asia excludes China.
Electricity Generation by Source


1. Excludes electricity generation from pumped storage.
2. Includes geothermal, solar, wind, tide/wave/ocean, biofuels, waste, heat and other.
“The world could be 100% wind, wave and solar by 2030, if just for political will…”

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

Data: BP Statistical View of World Energy (2016)
Population and Energy

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

Data: BP Statistical View of World Energy (2016)
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

Forecast

Global Population (B)

Data: BP Statistical View of World Energy (2016)
Source: From the UN, as appeared in The Economist, August 23, 2014
Are there affordable, available, reliable and sustainable:
• fossil energy and nuclear resources to meet this demand?
• renewable energy resources to meet this demand?

Data: BP Statistical View of World Energy (2016)
Source: From the UN, as appeared in The Economist, August 23, 2014

~15,000 Tcf (5X to date)
~2,600 Bbo (2X to date)
Natural Gas Cost of Supply

Resources v. Cost

Production cost (2008 $/Mbtu)

- Conventional
- Tight
- Shale
- Coal Bed Methane
- Sour
- Arctic
- Deep Water
- Hydrates

15,000 Tcf

Resources (Tcf)

Natural Gas Cost of Supply

Resources v. Cost

Global Consumption
115 Tcfy

Resources v. Cost

Produced
Conventional
Tight
Shale
Coal Bed Methane
Sour
Arctic
Deep Water
Hydrates

~ 300 year total resource

Production Cost (2008 $/Mmbtu)

Resources (Tcf)

Natural Gas Cost of Supply

Resources v. Cost

Global Consumption
115 Tcfy

Production cost (2008 $/Mmbtu)

Resources (Tcf)

Natural Gas Cost of Supply

Resources v. Cost

Global Consumption
115 Tcfy

Production cost (2008 $/Mmbtu)

Resources (Tcf)

The Global Resource is Vast

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

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

For presentation or publication, reference:
Bureau of Economic Geology Shale Resource and Production Project
http://www.beg.utexas.edu/research/programs/shale
## Tinker, 2015 vs. Tinker, 2018

<table>
<thead>
<tr>
<th></th>
<th>Gas Tcf</th>
<th>Oil Bbbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original In-Place</td>
<td>3100</td>
<td>450</td>
</tr>
<tr>
<td>Tech. Recoverable</td>
<td>700</td>
<td>27</td>
</tr>
<tr>
<td>Production to date</td>
<td>70</td>
<td>5</td>
</tr>
</tbody>
</table>

**Horizontal wells to date:** ~75,000  
**Future wells (base case):** ~500,000

**Recovery to Date**

- **2% of the natural gas**
- **1% of the oil**

### Reservoirs

- **Eagle Ford**
  - ~16,500
  - ~90,000

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

- **Bakken/Three Forks**

- **Haynesville**
  - ~6,000
  - ~35,000

For presentation or publication, reference: Bureau of Economic Geology Shale Resource and Production Project  
[http://www.beg.utexas.edu/research/programs/shale](http://www.beg.utexas.edu/research/programs/shale)
U.S. Crude Oil Production

~ 70% of U.S. Oil Production from Shale

Annual US Oil Production


40 years!
Global Energy Mix

Data: BP Statistical View of World Energy (2016)

Global Energy Consumption Mix

- Oil: 41% in 1965, 86% in 2015
- Natural Gas: 16% in 1965, 24% in 2015
- Coal: 38% in 1965, 33% in 2015
- Nuclear: 95% in 1965, 29% in 2015
- Hydro: 4% in 1965, 1% in 2015
- Solar: 0% in 1965, 0% in 2015
- Wind: 0% in 1965, 0% in 2015
- Biomass: 0% in 1965, 0% in 2015

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

Data: BP Statistical View of World Energy (2016)  
Source: From the UN, as appeared in The Economist, August 23, 2014
Population and Energy

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

Data: BP Statistical View of World Energy (2016)
Population and Energy

Data: BP Statistical View of World Energy (2016)
Source: From the UN, as appeared in The Economist, August 23, 2014
Global Primary Energy

- Natural Gas, Nuclear
- Coal, Oil, Biomass
- Wind, Solar, Hydro

- 1965: 80% 15% 5%
- 2015: 60% 30% 10%
- 2065: 40% 25% 35%

% Contribution to Global Primary Energy from 1970 to 2100

- Natural Gas, Nuclear: ~35%, ~25%, ~40%
- Coal, Oil, Biomass: ~60%, ~30%, ~10%
- Wind, Solar, Hydro: ~8%, ~15%, ~5%
Global Primary Energy

Natural Gas, Nuclear

Coal, Oil, Biomass

Wind, Solar, Hydro
Total Primary Energy Supply (TPES) by Energy Source (Mtoe)

People’s Rep. of China:
- Coal: ~69%
- Oil: ~16%
- Natural gas: ~15%
- Renewables: ~16%
- Other: ~38%

United States:
- Coal: ~16%
- Oil: ~38%
- Natural gas: ~45%
- Renewables: ~16%
- Other: ~15%

India:
- Coal: ~69%
- Oil: ~16%
- Natural gas: ~15%
- Renewables: ~16%
- Other: ~38%

Russian Federation:
- Coal: ~16%
- Oil: ~38%
- Natural gas: ~45%
- Renewables: ~16%
- Other: ~15%

Japan:
- Coal: ~16%
- Oil: ~38%
- Natural gas: ~45%
- Renewables: ~16%
- Other: ~15%


1. In this graph peat and oil shale are aggregated with coal.
2. Other includes nuclear, electricity trade, heat, non-renewable waste.
Total Final Consumption
by Sector (Mtoe)

People’s Rep. of China

United States

India

Russian Federation

Japan


1. Other consumption includes commercial and public services, agriculture/forestry, fishing and non-specified.
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
Is this a Shale Basin?
No, it’s New York!
The Western Narrative

Fossil energy and nuclear are “dirty” and “bad”…
Renewables and batteries are “clean” and “good”…
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

• 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
“In theory there ain’t no difference between theory and practice, but in practice there is.”
CO₂ Emissions (Million Tonnes)

Data: BP Statistical View of World Energy (2016)
CO\textsubscript{2} Emissions

CO\textsubscript{2} Emissions (Million Tonnes)

Data: BP Statistical View of World Energy (2016)
CO₂ Emissions (Million Tonnes)

Data: BP Statistical View of World Energy (2016)
Don’t blame Asia! They make products for the world.

CO₂ Emissions (Million Tonnes)

Data: BP Statistical View of World Energy (2016)
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.
The Future Electricity Mix

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

Source: EIA
U.S. Electric Generation Shares (2005-15)

- **Source:** EIA

**Percent of total**
- Coal: 20%
- Natural gas: 51%
- Renewables: 8%
- Nuclear: 21%
- Other: 13%

**Yearly Data:**
- 2005-2015
- ~ 20% CO₂ Reduction!

**Year:**
- 2005: 20%
- 2006: 18%
- 2007: 18%
- 2008: 18%
- 2009: 18%
- 2010: 18%
- 2011: 18%
- 2012: 18%
- 2013: 18%
- 2014: 18%
- 2015: 18%

**CO₂ Emissions (%):**
- 2005: 34%
- 2006: 30%
- 2007: 32%
- 2008: 32%
- 2009: 32%
- 2010: 32%
- 2011: 32%
- 2012: 32%
- 2013: 32%
- 2014: 32%
- 2015: 32%

Tinker 2018
US Energy Mix

Quadrillion Btu

- Total Energy Consumed
- Imports
- Nuclear
- Oil
- Natural Gas
- Coal
- Wind & Solar
- Biofuels
- Hydro

The Future Electricity Mix

Electricity Generation by Fuel

North America

Europe

Asia Pacific

European Coal Generation

Power generation (TWh)

- Germany
- Poland
- Czech
- Italy
- Spain
- Netherlands
- UK
- Other

*preliminary
European Natural Gas Power Generation

- **Coal**
- **UK**
- **Italy**
- **Germany**
- **Spain**
- **Netherlands**
- **Other**

*preliminary*
The Future Electricity Mix

Electricity Generation by Fuel

North America

Quadrillion BTUs
Europe

Asia Pacific

China

Energy Consumption by Fuel Type

- **Coal**
- **Petroleum**
- **Hydro, nuclear, and wind power**
- **Natural gas**

Source: Economist, National Bureau of Statistics
Coal Production

World coal\(^1\) production from 1971 to 2016 by region (Mt)

- Africa
- Non-OECD Americas
- Non-OECD Asia\(^2\)
- China
- Non-OECD Europe and Eurasia
- Middle East
- OECD


1. Includes steam coal, coking coal, lignite and recovered coal. 2. Non-OECD Asia excludes China.
Actual Cost of Electricity

Average national electricity prices (in 2011 US cents/kWh)

Data: average prices from 2011 converted at mean exchange rate for that year

Affordable
Available
Reliable

Sources: IEA, EIA, national electricity boards, OANDA, shrinkthatfootprint.com
Actual Cost of Electricity

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

- 7.00 to 9.00
- 9.01 to 10.00
- 10.01 to 12.00
- 12.01 to 15.00
- 15.01 and Higher

National Average = 10.54
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
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

120,000,000 Batteries in 12 yrs avg 10,000,000/yr.

~10% of Global Vehicle Fleet

Source: Bloomberg New Energy Finance, Economist.com; EIA, WEO, 2017
Cumulative Electric-Vehicle Forecasts

Source: Bloomberg New Energy Finance, Economist.com; EIA, WEO, 2017
Total Final Consumption by Sector
Electricity

Electricity TFC by sector (Mtoe)

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

CO$_2$ Reduction Strategies

- Efficiency
- Fuel Substitution
- Carbon Capture and Sequestration

...Adaptation to Warming
Carbon Key Points

• Renewables will grow, but not soon enough or large enough to reduce CO$_2$ emissions at scale.

• Natural gas and nuclear can reduce CO$_2$ emissions at scale and in needed time frames.
  ✓ Reduce methane emissions!

• Electric Vehicle growth will not mitigate the demand for liquid petroleum fuels.
Outline

- Energy
- Carbon
- Poverty
- Radical Middle
People Without Access to Electricity and Clean Cooking Facilities

Limited Access to Electricity Restricts Standard of Living

- United States
- Australia
- Japan
- Germany
- South Korea
- Russia
- Saudi Arabia
- Malaysia
- Brazil
- Mexico
- Ecuador
- India
- Niger
- China
- Haiti
- Ghana
- Brazil
- Mexico
- China
- Ecuador
- India
- Niger
- Brazil
- Mexico
- Ecuador
- India
- Niger

ELECTRIC POWER CONSUMPTION, KWH / CAP

GDP/CAPITÀ, PPP CURRENT INTERNATIONAL $

Developed

Developing

Emerging

Undeveloped

Source: World Bank Databank
Limited Access to Electricity Restricts Standard of Living

2.5 billion people

Source: World Bank Databank
Limited Access to Electricity Propagates Inequality

Switch
4.5 billion

Source: World Bank Databank

Photo: Tinker, Ecuador, 2017
Limited Access to Electricity Propagates Inequality

ELECTRIC POWER CONSUMPTION, KWH PER CAPITA

GDP PER CAPITA, PPP CURRENT INTERNATIONAL$

Source: World Bank Databank

United States
Australia
Saudi Arabia
Russia
Japan
South Korea
Germany
Malaysia
Mexico
Niger
Ghana
Haiti

Switch On 2.5 billion

Photo: Tinker, Ecuador, 2017
Limited Access to Electricity Propagates Inequality

Switch On
2.5 billion

Source: World Bank Databank

Photo: Tinker, Ecuador, 2017
It’s Time to Educate & Power the People
Limited Access to Electricity Propagates Inequality

It's Time to Educate & Power the People

Source: World Bank Databank
Limited Access to Electricity Propagates Inequality

It's Time to Educate & Power the People

http://switchon.org
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
Poverty and electricity access in selected developing countries,

Energy does not end poverty.

Poverty cannot be ended without energy.

Sources: World Bank; IEA; World Energy Outlook 2015

† Purchasing power parity
Poverty
Key Points

• Energy underpins modern economies and helps lift the world from poverty

• Energy resources vary by region and nations will use the energy resources that they have to reduce energy poverty
Outline

- Energy
- Carbon
- Poverty
- Radical Middle
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.

Interactive Systems
Politics, economics, and passion run deep on all sides of the climate change and poverty debate.
Is civil energy discourse possible?

- Radical
- Middle
- Economy
- Environment
- Energy
Tinker, 2015
Tinker 2016

Environment

Radical
Middle

Economy

Energy
Tinker, 2015
Tinker 2016

Environment
Economy
Energy

Radical Middle
Towards a Radical Middle

• Understand that no form of energy is good or bad
• 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

Engage in Energy Education!
...keep it in the Ground.
Keep *them* in Poverty.
Lift them from Poverty!
Tinker, 2015

Economy

Energy

Radical Middle

Environment
Thanks!

Join the Switch Energy Alliance

SwitchOn.org

Inspire an Energy Educated Future