Energy, Carbon and Poverty

Seeking the Radical Middle

Scott W. Tinker
The Dilemma

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

But... they think they do!
Renewables and batteries are “clean” and “good”  
Fossil energy and nuclear are “dirty and “bad”…

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

The Global Energy Mix

Million Tonnes Oil Equivalent

- Petroleum: 4331
- Nat Gas: 3840
- Coal: 583
- Nuclear: 893
- Hydro: 365
- Renew: 342

86%

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

Million Tonnes Oil Equivalent

Hydro Renew Nuclear Coal Nat Gas

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 Consumption (MTOE)

Global Energy Mix

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

Renewable Consumption (MTOE)

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

Renewable Consumption (MTOE)

- Hydro
- Solar
- Wind
- Biomass

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

Renewable Consumption (MTOE)

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

Renewable Consumption (MTOE)

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

Installed Wind Capacity (MW)

Data: BP Statistical View of World Energy (2016)

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

Growth in U.S. Wind Generation
2000–2014

Million Kwh


Texas

Iowa

California

Oklahoma

Kansas

Illinois

0 5,000 10,000 15,000 20,000 25,000 30,000 35,000 40,000 45,000

Global Energy Mix

Installed Photovoltaic Capacity (MW)

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

United States
Solar photovoltaics

Source: Economist, Solar Energy Industries Association

Average Module Price $ / watt

2010 11 12 13 14 15 16

0 3 6 9 12 15

Tinker 2015
The chart illustrates the global energy consumption mix from 1965 to 2015. The data is sourced from BP's Statistical View of World Energy (2016). The percentages of energy consumption are as follows:

- **Oil**: 29% in 2015, 41% in 1965
- **Natural Gas**: 86% in 2015, 95% in 1965
- **Coal**: 24% in 2015, 16% in 1965
- **Nuclear**: 33% in 2015, 38% in 1965
- **Hydro**: 100% in 2015, 100% in 1965
- **Solar**: Not shown in the chart
- **Wind**: Not shown in the chart
- **Biomass**: Not shown in the chart

The chart shows a slight decrease in oil consumption and an increase in natural gas consumption over the years, with nuclear and hydro energy consumption remaining relatively stable.
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

Data: BP Statistical View of World Energy (2016)
Source: From the UN, as appeared in The Economist, August 23, 2014
"The world could be 100% wind, wave and solar by 2030, if just for political will..."
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

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
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

Natural Gas Cost of Supply

Resources v. Cost

Global Consumption
115 Tcfy

Resources (Tcf)

Production Cost (2008 $/Mmbtu)

~ 300 year total resource

Conventional
Tight
Shale
Coal Bed Methane
Sour
Arctic
Deep Water
Hydrates

Natural Gas Cost of Supply

Resources vs. Cost

Global Consumption
115 Tcfy

Production cost (2008 $/Mmbtu)

Natural Gas Cost of Supply

Resources v. Cost

Global Consumption
115 Tcfy

Production cost (2008 $/Mmbtu)

Resources (Tcf)

Conventional
Tight
Shale
Coal Bed Methane
Sour
Arctic
Deep Water
Hydrates

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

Resources and Cost

- Coal to liquids
- Gas to liquids
- Other conventional oil
- Deepwater and ultra-deepwater
- CO₂ EOR
- Oil shales
- Shale oil
- Heavy oil & bitumen

Production cost (2008 $)

Resources (billion barrels)

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
Global Primary Energy

Natural Gas, Nuclear

Wind, Solar, Hydro

Coal, Oil, Biomass

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

40% 40% 20%
Join BEG’s Tight Oil Resource Assessment (TORA) Consortium
http://www.beg.utexas.edu/tora

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

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<tr>
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<th>Gas Tcf</th>
<th>Oil Bbbl</th>
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</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>
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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

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

Gas Resource-in-Place
- Barnett ~16,500 ~63,000
- Fayetteville ~6,500 ~13,000
- Haynesville ~6,000 ~35,000
- Marcellus ~10,500 ~200,000
- Eagle Ford ~16,500 ~90,000
- Bakken/Three Forks ~18,000 ~100,000

Oil Produced to-date
- Barnett ~6,500 ~35,000
- Fayetteville ~6,500 ~13,000
- Haynesville ~6,000 ~35,000
- Marcellus ~10,500 ~200,000
- Eagle Ford ~16,500 ~90,000
- Bakken/Three Forks ~18,000 ~100,000
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Horizontal wells to date: ~75,000
Future wells (base case): ~500,000

Recovery to Date
2% of the natural gas
1% of the oil
Environmental Impact
Coal, Oil, Natural Gas

- Mining and Manufacturing \textit{Land, Water, Emissions}
- Drilling and Completion: \textit{Land, Water}
- Transportation: \textit{Pipelines, Trucks, Ships, Rail}
- Refining and Petrochemicals: \textit{Emissions}
- Combustion: \textit{Vehicle and Power Plant Emissions}
Is this a Shale Basin?
No, it’s 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
• 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

CO₂ Emissions (Million Tonnes)

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

Don’t blame Asia! They make products for the world!

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

Percent of total


Nuclear

20% 8% 18% 21%

Renewables

8% 18% 51% 34%

Other

18% 51% 32% 30%

Natural gas

51% 30% 21% 2%

Coal

68% 40% 20% 13%

Fracking!

~ 20% CO₂ Reduction

% of CO₂

21% 2% 13% 32% 30% 34%
The Future Electricity Mix

Electricity Generation by Fuel

North America

Quadrillion BTUs

Europe

Asia Pacific

European Coal Generation

Power generation (TWh)

<table>
<thead>
<tr>
<th>Year</th>
<th>Germany</th>
<th>Poland</th>
<th>Czech</th>
<th>Italy</th>
<th>Spain</th>
<th>Netherlands</th>
<th>UK</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>819</td>
<td>177</td>
<td>263</td>
<td>25</td>
<td>40</td>
<td>137</td>
<td>17</td>
<td>108</td>
</tr>
<tr>
<td>2011</td>
<td>841</td>
<td>173</td>
<td>262</td>
<td>24</td>
<td>44</td>
<td>140</td>
<td>19</td>
<td>109</td>
</tr>
<tr>
<td>2012</td>
<td>892</td>
<td>164</td>
<td>277</td>
<td>24</td>
<td>49</td>
<td>135</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>2013</td>
<td>860</td>
<td>157</td>
<td>283</td>
<td>25</td>
<td>45</td>
<td>138</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>2014</td>
<td>798</td>
<td>136</td>
<td>274</td>
<td>29</td>
<td>43</td>
<td>130</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>2015</td>
<td>788</td>
<td>132</td>
<td>272</td>
<td>44</td>
<td>41</td>
<td>130</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>2016*</td>
<td>694</td>
<td>120</td>
<td>260</td>
<td>29</td>
<td>41</td>
<td>129</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>
The Future Electricity Mix

Electricity Generation by Fuel

North America

Quadrillion BTUs

Europe

Asia Pacific

China

Energy Consumption by Fuel Type

Source: Economist, National Bureau of Statistics
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

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

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

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

~ 27 MM
China
USA
EU28
Japan
India

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

Annual sales (light plug-in electric vehicles)

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

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
CO$_2$ Reduction Strategies

- Efficiency
- Coal Substitution
- Carbon Capture and Sequestration
- Atmospheric Removal of Carbon

...Adaptation
Carbon

Key Points

• Renewables will grow, but are not enough to reduce CO$_2$ emissions at scale
• Natural gas and nuclear can reduce CO$_2$ emissions at scale
  ✓ Limit methane emissions
• Electric Vehicle growth will not mitigate the demand for liquid petroleum fuels
Outline

- Energy
- Carbon
- Poverty
- Radical Middle
Limited Access to Electricity Restricts Standard of Living

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

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

**2.5 billion people**

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**ELECTRIC POWER CONSUMPTION, KWH/CAP**

**GDP/CAPITA, PPP CURRENT INTERNATIONAL $**

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

Switch On
2.5 billion

Source: World Bank Databank
Limited Access to Electricity Propagates Inequality

Switch On
2.5 billion

ELECTRIC POWER CONSUMPTION, KWH PER CAPITA
GDP PER CAPITA, PPP CURRENT INTERNATIONAL $

Source: World Bank Databank

Limited Access to Electricity Propagates Inequality

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
Limited Access to Electricity Propagates Inequality

It's Time to Educate & Power the People

http://switchon.org
Limited Access to Electricity Restricts Standard of Living

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

**Electric Power Consumption, KWH/CAP**

**GDP/CAPITA, PPP CURRENT INTERNATIONAL $**

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

> 2.5 billion people

Source: World Bank Databank
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
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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.
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?

Environment

Economy

Energy

Radical

Middle
Towards a Radical Middle

• Understand that no form of energy is perfect
• Focus energy policy on energy security
• Make energy efficiency and energy storage tactical
• Assess the environmental impact of all energy
• Recognize energy poverty as a critical challenge

Engage in Energy Education!
There are those who want to.....

...keep It in the Ground.
But it will keep Them in Poverty.
Lift Them from Poverty!
Tinker, 2015
Tinker 2018

Environment

Economy

Energy

Radical Middle
Environment

Economy

Energy

Radical Middle
SWITCH
ENERGY ALLIANCE
Gracias!

Join the Switch Energy Alliance

SwitchOn.org

Inspire an Energy Educated Future