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

Scott W. Tinker¹

Search and Discovery Article #70268 (2017)**
Posted June 28, 2017

*Adapted from oral presentation given at Forum, “The Next 100 Years of Global Energy Use: Resources, Impacts and Economics,” at AAPG Annual Convention and Exhibition, Houston, Texas, April 4, 2017

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Preface

Forum Topics

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

Outline

Energy Security
  Energy Poverty
  Energy Reality

Summary

1. Oil, natural gas, and coal are secure sources of energy and will remain vital well into the 21st Century.
2. Secure energy is required to lift humanity from poverty.
Selected References


U.S. Primary Energy Demand

Petroleum 35
Biomass 4
Natural Gas 25
Coal 20
Nuclear 8
Geothermal 0.2
Hydro 3
Wind-Solar 1

Electricity Generation 39

Transportation 27
Residential 11
Commercial 8
Industrial 24

Energy Services 37

Waste Water Treatment 30

The Water-Energy Nexus: Challenges and Opportunities, DOE, July, 2014
The Next 100 Years of Energy

Population, Energy Demand and Future Technology
Steven E. Koonin

Petroleum Resources and Transportation Fuel Options
Cindy Yeilding

Power Fuel Mix and Carbon Transition
Mark Snell

Energy Density, Fake & True News about Energy and Environment
Jesse Ausubel

Energy Challenge: Diversity and Economic Realities
Kenneth Medlock
The Next 100 Years of Energy

Population, Energy Demand and Future Technology

Petroleum Resources and Transportation Fuel Options

Power Fuel Mix and Carbon Transition

Energy Density, Fake & True News about Energy and Environment

Energy Challenge: Diversity and Economic Realities
Energy Security

Affordable
- **Cost**: per unit of energy
- **Price Volatility**: stable or fluctuating
- **Infrastructure**: cost to build the plant

Available
- **Access**: substantial resources

Reliable
- **Intermittent**: source consistent or variable
- **Safe**: natural/human causes

Sustainable
- **Clean**: air and atmospheric emissions
- **Dense**: energy per area, weight and volume
- **Dry**: fresh water use/risk
Energy Security
Challenges

Transportation

I. Oil
   - Available, affordable, reliable
   - Land use, water, emissions

II. Natural Gas (CNG, LPG, LNG, GTL)
   - Available, affordable, reliable
   - Dirtier than certain electric fuels

III. Electricity
   - Benefits depend on fuel source
   - Mining, expensive, chemicals, range

IV. Biofuels
   - Scale, land use, water, cost

V. Hydrogen

From Tinker et. al. 2013, GSA Special Publication
Energy Security

Electricity Generation

Challenges

I. Coal
   - Available, affordable, reliable
   - Mining, water, air emissions, CO₂

II. Natural Gas
   - Available, affordable, reliable
   - Water, methane and CO₂

III. Nuclear
   - Available, affordable, reliable, sustainable
   - Radioactive waste, safety

From Tinker et. al. 2013, GSA Special Publication
Energy Security Challenges

Electricity Generation

IV. Hydro
- Affordable
- Water and topography

V. Geothermal
- Reliable, sustainable
- Energy density

VI. Wind
- Affordable, sustainable
- Intermittent, land and visual, transmission

VII. Solar
- Available, sustainable
- Expensive, intermittent, inefficient

From Tinker et al. 2013, GSA Special Publication
<table>
<thead>
<tr>
<th>Energy Security</th>
<th>Available</th>
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Tinker informal survey of experts
## Energy Security

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**No Form of Energy is Perfectly Secure**

Low: Low Mod: Mod Low: Low

Tinker informal survey of experts
Outline

- Energy Security
- Energy Poverty
- Energy Reality
Poverty and electricity access in selected developing countries, circles sized by total population.

- **Income % (<=$3.10 a day at 2011 PPP†, %)**
- **Electrification rate 2013, %**

* 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, circles sized by total population.

Income % (<$3.10 a day at 2011 PPP†)

Electrification rate 2013, %

Africa
Asia
Latin America

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

† Purchasing power parity

Photos Tinker, Ecuador, 2017
Poverty and electricity access in selected developing countries, circles sized by total population

Income % ($<3.10 a day at 2011 PPP†)

Electrification rate 2013, %

Africa
Asia
Latin America

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

† Purchasing power parity

Vietnam
China
India
Bangladesh*
Brazil
Nigeria
Tanzania
Kenya
Uganda
Ethiopia
Cameroon
Electricity does not end poverty.

Poverty cannot be ended without electricity.
Limited Access to Electricity Restricts Standard of Living

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

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

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

Source: World Bank Databank
Limited Access to Electricity Propagates Inequality

1.2 billion people are being left behind

~1.2 billion people

Source: World Bank Databank
**Limited Access to Electricity Propagates Inequality**

**Stagnant Nations**
- Energy consumption and GDP are stagnant
- Economic focus on basic human needs:
  - Food
  - Housing
  - Clothing
  - Education
  - Healthcare
  - Primary Electricity

*The gap between Stagnant and Developed nations is growing*

~1.2 billion people

Source: World Bank Databank

- Ghana
- Haiti
- Niger
- India
- China
- Ecuador
- United States
- Korea, Rep.
- Japan
- Malaysia
- Mexico
- Germany
- Ghana
- Haiti

**ELECTRIC POWER CONSUMPTION, KWH PER CAPITA**

**GDP PER CAPITA, PPP CURRENT INTERNATIONAL $**
As we lift the world from poverty we create the conditions for peace.

Corruption slows progress and inhibits peace.
Limited Access to Electricity Propagates Inequality

ELECTRIC POWER CONSUMPTION, KWH PER CAPITA

GDP PER CAPITA, PPP CURRENT INTERNATIONAL $

Switch
4.5 billion

Source: World Bank Databank
It’s Time to Power the People
Outline

- Energy Security
- Energy Poverty
- Energy Reality
BEG Shale Resource, Reserve and Production Studies
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<td>444</td>
<td>37</td>
<td>47</td>
<td>57</td>
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<tr>
<td>Fayetteville</td>
<td>80</td>
<td>12</td>
<td>18</td>
<td>23</td>
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<tr>
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<td>33</td>
<td>52</td>
<td>72</td>
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<tr>
<td>Marcellus</td>
<td>2071</td>
<td>-</td>
<td>183</td>
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<td>9%</td>
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Total: 3084

Prod. through 2045

Tinker 2017
U.S. Electric Generation Shares (2005-15)

Source: EIA
Electric Power Sector U.S. Carbon Dioxide Emissions

Clean Power Plan

- 2020 Goal of Clean Power Plan (CPP) ~ 1600 Mmt: 32% reduction from 2005

Source: EIA
Electric Power Sector U.S. Carbon Dioxide Emissions

Clean Power Plan

- 2005: ~2,400 Mmt
- 2015: ~1,900 Mmt
- 2030 Goal of Clean Power Plan (CPP): ~1,600 Mmt: 32% reduction from 2005
- Without the CPP: ~1,400 Mmt: 42% reduction from 2005

- CPP is less ambitious than current trends
- ~2/3 of the way there already

Shale gas, renewables, coal policy

Source: EIA
US Energy Mix

Total Energy Consumed

Quadrillion Btu

Growth 0.55% less than GDP

80 Quads “Efficiency”

The Water-Energy Nexus: Challenges and Opportunities, DOE, July, 2014
The Global Energy Mix

Million Tonnes Oil Equivalent

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)
The Global Energy Mix Scaled to Consumption

Million Tonnes Oil Equivalent

1501
362
153
24
862
194
264
468
881
1036
216
83
151

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

Global Energy Consumption (MTOE)

Million Tonnes Oil Equivalent

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

Installed Wind Capacity (MW)

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

Renewable Consumption (MTOE)

- Solar
- Wind
- Biomass

Million Tonnes Oil Equivalent

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

Global Energy Consumption Mix

Data: BP Statistical View of World Energy (2016)
Total Energy Supply

Global Investment 2015 USD $ Billion

- T&D networks
- Nuclear
- Renewables
- Fossil fuel power generation
- Oil, gas, coal (supply)

Right Axis:
- Oil, gas, coal in total investment (%)

Total Energy Supply

Global Investment 2015 USD $ Billion

- T&D networks
- Nuclear
- Renewables
- Fossil fuel power generation
- Oil, gas, coal (supply)

Right Axis:
- Oil, gas, coal in total investment (%)

USD (2015) billion
- 2000
- 1800
- 1600
- 1400
- 1200
- 1000
- 800
- 600
- 400
- 200
- 0

Oil Price Brent ($/barrel)
- 2000
- 1800
- 1600
- 1400
- 1200
- 1000
- 800
- 600
- 400
- 200
- 0

Climate Change
Environment

Economy
Jobs

Energy

Electricity

Source: Tinker, EARTH, 2013
Source: Tinker, EARTH, 2013

Radical Middle

Academia/NGO

Government

Energy
1. Oil, natural gas and coal are secure sources of energy, and will remain vital well into the 21st Century.

2. Secure energy is required to lift humanity from poverty.

Thanks!