Energy and Business:

Trends, case studies, policies and implications

by:
Richard A. Simmons, P.E.
Executive Director for Research,
Air Transport Institute for Environmental Sustainability- AirTIES

Presented to:
ACEC Indiana

September 17, 2015
Outline

- Key drivers for research
- Current trends
  - Global, U.S., Indiana
- Electricity generation
  - Comparative costs & impacts
- Transportation
  - Energy use, costs & impacts

Purdue University Locomotive Testing Plant, 1892

The Boilermaker Special
Constrained Energy Supply

“We might run out”

• Conventional fossil fuels are finite and becoming more scarce;
• Global production lags global demand

“We have plenty”

• Conventional fossil fuels are abundant;
• New methods and discoveries are coming on-line

Follow up question: What is your time horizon?
Environment/Climate

“Seems the same to me”
• Weather always fluctuates
  • The earth used to be covered in ice

“It’s Getting Warmer”
• Combustion of fossil fuels is the main culprit
  • CO₂ has steadily increased

“Risk is low”
• CO₂ concentrations and global temperatures are not tracking as expected

“Risk is irrelevant”
• How do we know humans are responsible?

“Risk is imminent”
• Irreversible changes can be avoided, but only by acting now

Follow up question: How to judge the risk?

Source: Keeling Curve, Scripps Inst. Of Oceanography http://keelingcurve.ucsd.edu/
Follow up question: How certain are we?

Global Population, 1800-2100

“Rapid ever-increasing growth”
- Population will double in 100 yrs
- Major transformations in food supply, water, energy and infrastructure are required

“Slow growth to a plateau”
- Extension of current policies will be sufficient to sustain global demands;
- Trade will self-stabilize in a global economy

Plot source: World population prospects, the 2012 Revision- Low and High variant values. UN 2012. [http://esa.un.org/unpd/wpp/]
Integrating our views & taking action

Individual, Business, Societal

Value Judgements vary & require context

Not Important

Energy

Environment

Population

Economics

Critically Important
Finding a balance & optimizing

Energy
• Fossil fuels are extremely effective
• But also finite, and far from perfect

Environment
• Cleaner is better than dirtier
• Efficiency is better than wastefulness

Population
• The world seeks more services
• And higher standards of living
• Population will probably not decline

Business
Economics
Engineering
Public Policy
## Key World Energy and CO₂ Statistics

<table>
<thead>
<tr>
<th>Country or Bloc</th>
<th>Population</th>
<th>Gross Domestic Product (GDP)</th>
<th>Total Primary Energy Supply (TPES)</th>
<th>TPES per capita</th>
<th>CO₂ Emissions</th>
<th>CO₂ Emissions per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(millions)</td>
<td>(2005$US)</td>
<td>(Mtoe)</td>
<td>(toe/capita)</td>
<td>(Mt)</td>
<td>(t/capita)</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>312</td>
<td>13,226</td>
<td>2,191</td>
<td>7.02</td>
<td>5,287</td>
<td>16.94</td>
</tr>
<tr>
<td>E.U. 27</td>
<td>503</td>
<td>16,626</td>
<td>1,654</td>
<td>3.29</td>
<td>3,543</td>
<td>7.04</td>
</tr>
<tr>
<td>China</td>
<td>1,344</td>
<td>4,195</td>
<td>2,728</td>
<td>2.03</td>
<td>7,955</td>
<td>5.92</td>
</tr>
<tr>
<td>Japan</td>
<td>128</td>
<td>4,622</td>
<td>461</td>
<td>3.61</td>
<td>1,186</td>
<td>9.28</td>
</tr>
<tr>
<td>Russia</td>
<td>142</td>
<td>947</td>
<td>731</td>
<td>5.15</td>
<td>1,653</td>
<td>11.65</td>
</tr>
<tr>
<td>Brazil</td>
<td>197</td>
<td>1,127</td>
<td>270</td>
<td>1.37</td>
<td>408</td>
<td>2.07</td>
</tr>
<tr>
<td>India</td>
<td>1,241</td>
<td>1,317</td>
<td>749</td>
<td>0.60</td>
<td>1,745</td>
<td>1.41</td>
</tr>
<tr>
<td>OPEC</td>
<td>417</td>
<td>1,700</td>
<td>842</td>
<td>2.02</td>
<td>1,806</td>
<td>4.33</td>
</tr>
<tr>
<td>World</td>
<td>6,958</td>
<td>52,486</td>
<td>13,113</td>
<td>1.88</td>
<td>31,342</td>
<td>4.50</td>
</tr>
</tbody>
</table>

Listed countries/blocs account for ~75% of world:
- GDP
- Energy Supply
- Energy-related Emissions

Data source: IEA 2013 Key World Energy Statistics
Trends in Energy Emissions
2005 and 2011

<table>
<thead>
<tr>
<th>Country</th>
<th>USA</th>
<th>Russia</th>
<th>EU</th>
<th>China</th>
<th>Brazil</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>19.48</td>
<td>10.59</td>
<td>8.08</td>
<td>3.89</td>
<td>1.73</td>
<td>1.06</td>
</tr>
<tr>
<td>2011</td>
<td>16.94</td>
<td>11.65</td>
<td>7.04</td>
<td>5.92</td>
<td>2.07</td>
<td>1.41</td>
</tr>
</tbody>
</table>

Data source: IEA 2013 Key World Energy Statistics
Global Energy Matrix

"Traditional" fossil fuels (coal, oil & gas) $\approx 78.2\%$

Data Sources: REN21, Renewables 2013, Global Status Report and BP Statistical Review of World Energy, 2013
US Electricity Generation has benefited from extensive supplies of Shale Gas (via hydro-fracking)

Question: How can economic benefits be balanced against certain environmental impacts?
Dramatic Growth in Wind and Solar

Policy Incentives have helped, but may slow down
- Stimulus funding
- Tax credits
- Loan guarantees
- Feed-in tariffs (state and local)

Sources: US EIA, Electric Power Annual 2012.
Indiana Electricity Matrix

State–by–state generation by source 2009

Estimated lifecycle electricity emissions
by Generating Source (in gCO2 eq/kWh)

Notes: Variations of +/- 50 are typical; Water usage in kg/kWh: Wind:1, PV:10, Hydro:36, Coal:78, NG:78, Geoth:12-300

Comparison of average electricity emissions by state (in gCO2eq/kWh)

New EPA Carbon Reduction Goals

EPA received 4.3 million public comments.

States can comply with EPA 2030 goals in two ways:

- Reduce the carbon emission per MWh of electricity produced
- Reduce total carbon emission produced in the state

For Indiana, this would mean:

- **Reduce carbon emissions from electricity generation by 38%**
  - From 918 g/kWh (2012) to 565 g/kWh by 2030
- **OR**
- **Reduce total carbon emissions by 28%**
  - From 107 million tons in 2012 to 77 million tons in 2030

States have the flexibility to decide how to comply
Key Carbon Reduction Options

With a coal-intensive power generation sector, options include:

1. Implement **CAP & TRADE**
2. Deploy more **RENEWABLE ENERGY**
3. Implement **ENERGY EFFICIENCY** programs
4. Transition to more **NATURAL GAS**
5. Improve **COAL** technologies, even further

For more on item 5, visit: The Center for Coal Technology Research [http://www.purdue.edu/discoverypark/energy/CCTR/](http://www.purdue.edu/discoverypark/energy/CCTR/)
Electricity from renewables is intermittent, so storage and integration solutions are needed!

State of Indiana Carbon Reduction Plan

Strategic plans should:

- Diversify the energy matrix,
- Control long-term costs,
- Be practical and flexible
- Have near-, medium- and long-term steps

Indiana must submit a plan to EPA by Sept 2016

Recommendation:

Make this a priority for your trade associations and individual businesses; and

Write your State Rep or Senator...
Recent Notice: Indiana Office of Energy Development

For Immediate Release  
Tuesday, September 1, 2015

Indiana’s Office of Energy Development (OED) Opens Applications for the 2015 Indiana Wastewater Treatment Plant Grant Program

INDIANAPOLIS – The Indiana Office of Energy Development (OED) today announced that Indiana government-owned wastewater treatment plants can begin applying for a share of $500,000 through the OED’s 2015 Wastewater Treatment Plant (WTP) grant program.

OED’s grant is intended to help reduce energy demand and energy costs at wastewater treatment plants through investments in energy efficiency, combined heat and power, and/or waste heat recovery. By reducing energy demand and recovering waste heat, WTPs can mitigate rising energy prices. Anaerobic digesters are also eligible technologies under this grant, provided that projects pass review under the National Environmental Protection Act (NEPA).

“We’re excited to offer grants to help reduce costs at wastewater treatment plants,” said OED Director Tristan Vance. “Wastewater treatment plants often make up a large portion of a municipality’s energy bill, and reducing energy costs can help maximize taxpayer funds.”

Applications for the 2015 WTP grant program can be mailed to reports@oed.in.gov beginning today, September 1, 2015, through October 23, 2015. Program guidelines are available online at www.in.gov/oed/2734.htm. The winning recipients must provide 50 percent cost share for the project, and special consideration will be given to applications that leverage greater than 50 percent cost share. The maximum award per grant will be $100,000.

http://www.in.gov/oed/
“A year ago, America seemed to be on the eve of an electric car revival...”

A *Wall Street Journal* article that included this opening line appeared in:

- 2014
- 2009
- 2003
- 1996
- 1975

**Answer:** 1968
Valuing Green with Benefit-Cost Analysis

Benefit Cost Ratio (BC or B/C)
Acceptance criterion: 
B/C > 1.0

\[
B / C = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+i)^t}}
\]

Legend: NPV=Net Present Value; NBt=Net Benefit in period t; Bt=gross benefit in period t; Ct=cost in period t
Comparative consumer value

Technology value propositions are plotted relative to a breakeven line (B/C = 1.0)

7-year average fuel price = $5.60/gal
7-year average fuel price = $3.20

Note: baseline assumptions are 7% personal discount rate, 12,000 VMT per yr, gasoline at $3.50/gal. Simmons, Shaver, Tyner and Garimella, A benefit-cost assessment of new vehicle technologies in the U.S. market. Journal of Applied Energy, 2015
Energy use depends on vehicle type and locality

Simmons, Wang, Garimella, Groll. Hybrid, plug-in hybrid, and electric vehicle energy consumption sensitivity to the combined effects of driving cycle and ambient temperature–induced thermal loads. In Review, 2015
Emissions depend on vehicle type and locality

Wide variation for grid-recharged EVs

Implications for the future

Closing Thoughts

- **For the Future of Energy Supply:**
  - Diversity in the Energy Matrix is Imperative
    - Conventional, Non-conventional, Renewable, All-of-the Above
    - Low Carbon alternatives particularly essential

- **For the Future of Energy Consumption:**
  - Efficiency and Conservation more important than ever
    - Cheapest kWh is the one you don’t use
    - Efficiency technologies exist and are economically viable today!
    - Emissions reductions are immediate

- **The Next Generation needs Businesses & Universities to Lead:**
  - More inter-disciplinary experiences
  - Informed YET practical science-based action
  - Socially conscious YET economically viable decisions
  - Short and long-term steps: Need to walk and chew-gum!
Resources of potential interest

1. **Duke Energy Academy at Purdue**
   June 19-25, 2016

   Inspiring High School Students and Teachers with a hands-on program covering major aspects of energy sources, technology & research

   More information at:
   [http://www.purdue.edu/discoverypark/energy/energyacademy/](http://www.purdue.edu/discoverypark/energy/energyacademy/)

2. **“Understanding the Global Energy Crisis”**
   Edited by Coyle & Simmons
   Published by Purdue University Press, 2014

   Available for free download:
   [http://docs.lib.purdue.edu/purduepress_ebooks/29/](http://docs.lib.purdue.edu/purduepress_ebooks/29/)
Acknowledgements

- ACEC Indiana
- Lori Young, P.E., Curry & Associates
- Georgia Board of Professional Engineers
- Purdue University
Thank you!
Back-up Slides

Cost of electricity by state (¢/kWh)

Back-up Slides

Emissions from US power generation, 2002-2012

the “average” consumer that elected to invest in greater fuel economy spent $1490 to realize a 17.3% improvement in fuel economy, equating to estimated savings of $1070. Thus savings were, on average, insufficient to cover technology costs in the baseline scenario.

Estimated net IRPE_{model-specific} ($) \approx 67 \cdot (\% \text{ improvement in fuel economy}) + 451

Method for estimating value proposition for fuel-saving vehicle technologies.