Energy and physical resources are integral to the economy.

- Energy transforms raw materials (resources) into finished products
Over 99% correlation of energy consumption with GDP

GDP is in 2010 US$, as provided by USDA; energy use from BP.
Growth in GDP and growth in energy use correlate on a short-term basis as well.

- Energy growth tends to precede GDP growth.
  - Suggests energy growth is a cause of GDP growth; new recession ahead.

Gail Tverberg
OurFiniteWorld.com
Majority of long-term GDP growth seems to come from growth in energy use

- World economic growth peaked 1950-1965
  - Almost as high in 1965-1975, trending down since
Cheaper electricity production, 1900–1998, contributed to economic growth

Source: R. Ayres and B. Warr, Accounting for growth: the role of physical work.
Where does economic growth come from?

Two places:

1. *Cheap* energy supply
   - Oil less than $20 barrel, today’s prices
   - Also, growing use of coal at low prices

2. Growing debt
   - Allows customers to buy goods, even if they otherwise can’t afford them
World had oil for less than $20 per barrel prior to 1973

Source: Based on BP Statistical Review of World Energy 2015 data.
Growth in debt started at same time price run-up for oil occurred

Growth in Inflation Adj. World Debt and GDP

Gail Tverberg
OurFiniteWorld.com
Run up in debt was enabled by falling interest rates

Source: Board of Governors of the Federal Reserve System (US)
research.stlouisfed.org
Reason for Leveraging Impact of Cheap Energy on the Economy

- Benefit to Producer
- Sales Price
- Leveraging Benefit to Consumer
- Value to Society
My conclusions

- Cheap energy can lead to GDP growth
  - In this case, debt growth is “only” equal to growth in energy consumption

- Run-up in debt is needed to continue economic growth, if energy is expensive
  - Logical reason for this
    - Economic growth requires energy, even if it is expensive
    - Takes debt to get this energy

- Neither cheap energy nor debt run-up can last very long
  - Cheap energy => diminishing returns
  - Continued debt run-up => Ponzi scheme
Now, interest rates are about as low as they can go

- Federal reserve wants to raise rates
  - Meeting December 15-16

- Yields are now rising on bonds with low credit ratings

- Rising interest rates => less borrowing

- Future economic growth needs to come from “cheap energy,” alone
  - No help from rising debt levels
What do energy limits look like?

- Peak oil theorists have one theory
- Another view seems more likely
Peak oil theorists’ view: Based on Hubbert model

Cheap alternative takes over **well before** peak

Peak oil view

- Oil prices will rise endlessly
  - High-priced substitutes OK
  - Assumption: High prices aren’t a problem for the economy

- Down slope will be gradual
  - Based on geological decline
  - Assumption: Economy doesn’t matter; geology is all-important
My view

- Downslope comes when we cannot have one of the following:
  - (1) Energy prices that are low enough (< $20 barrel)
  - (2) Rising debt levels

- What happens in this case is
  - (1) Wages stagnate
  - (2) Loss of buying power not made up by more debt
  - (3) Prices of all commodities fall due to lack of “demand”

- We seem to be hitting energy limits, right now!
Falling affordability affects all commodities at once – including natural gas and coal

Based on IMF Pink Sheet data.
Potential for a near-term financial crash

- Financial crash may bring down supply of all commodities
  - Brought on by *low* prices
  - Food, metals, coal, oil, natural gas

- Likely to be hard to restart
  - May “take-out” electricity, too

- *Low prices* are what energy limits really look like
  - Many bankruptcies
  - Loss of jobs
Result is *energy and commodity costs* continuing to rise, but *prices* falling behind.
Need replacement energy supply

- Essentially now
  - If not now, very soon

- Inexpensively
  - Make electricity affordable
  - Keep down debt
  - Not use too much material

- Ideally, also make cheap liquid fuel, using electricity
  - Less than $20 barrel
How cheap? Probably 4 cents/kWh or less; if possible, make liquid fuels < $20 barrel.

Retail and industrial based on EIA data; wholesale estimated as 65% of industrial.
Affordability is the **first** energy-related limit of a finite world
There are many reasons why energy needs to be cheap

- Competition with other countries
  - High priced oil or renewables makes country uncompetitive

- Competition with free energy from sun
  - Cold countries have extra costs
  - Hard to compete with warm countries
  - High energy prices makes problem worse

- When energy costs are high, they tend to squeeze out other costs
  - Wages and interest costs
How does problem of increasingly high cost of energy products get resolved?

- Common belief is that oil prices will rise endlessly
  - Prices keep up with rising cost of extraction
  - This doesn’t really work

- Workers’ wages don’t rise
  - In fact, they tend to stagnate or fall

- At some point, debt stops rising fast enough to keep prices rising
  - Price for many commodities then falls below the cost of production
  - Big “Oops!”
Contact information

- Gail Tverberg
- OurFiniteWorld.com
- (407) 443-0505
- E-mail: GailTverberg@comcast.net
- Twitter: @gailtheactuary
Our economy is a networked system of businesses, governments, and consumers

- Grows over time, as new are added, old leave

Leonardo Sticks http://www.rinusroelofs.nl/structure/davinci-sticks/gallery/gallery-01.html
Higher energy costs of any kind squeeze budgets

Theory says oil price can increase—but our pocketbooks disagree
Family income has been falling since 2007, dipped between 1999 and 2007.
Labor force participation rate has been falling since 2000

Source: US. Bureau of Labor Statistics
Shaded areas indicate US recessions - 2015 research.stlouisfed.org
Coal prices are too low for most producers

- One cause—falling Chinese coal imports

- Bankruptcies likely
  - Alpha Natural Resources – already
  - Patriot Coal
  - Arch Coal
  - Glencore (international impact)

- Little reason for price condition to get better
  - Affordability of end products (houses, etc.) basic issue
  - Also over-production in face of falling demand
    - Derivatives, debt distort production incentives
Rise and fall of debt affected oil prices, 2008 - 2014

**World Oil Supply and Price**

- **Brent Oil Price in $ per Barrel**
- **Supply in Million Barrels per Day**

- **Begin US QE1**
- **End US QE3; Start China Debt Controls**

Gail Tverberg
OurFiniteWorld.com
Renewables provide only a small portion of world’s energy supply today.

Based on BP Statistical Review of World Energy 2014 data.
Overall cost of wind, solar PV (including transmission etc.) tends to be high.