The Energy-Economy Challenges Facing Us Today - Outline

- Challenge 1 – Energy prices have fallen below the cost of production for most energy producers

- Challenge 2 – High energy prices make an economy non-competitive

- Challenge 3 – Intermittency of wind and ground solar are barriers to expansion

- Potential solution: Space Solar Power would operate 24/7 and is planned to be low cost.
Challenge 1: Energy prices have fallen below the cost of production, for most producers

- We extract the easiest (and cheapest) to extract energy resources first
- Much more is available, if prices would keep rising

```
Least Expensive

Start at top and move to bottom

Most Expensive
```
Problem: Higher energy prices lead to recession

Workers have a problem

Cost of goods rises

Wages lag behind
Higher prices for goods and stagnant wages together lead to recession

- Workers buy fewer discretionary goods

- Discretionary sector workers get laid off
  - Layoffs lead to even more cutbacks in purchases

- Recession occurs
  - Prices of commodities, including oil, coal, and gas, drop

Note: Photos from Wikipedia
Underlying problem: *Energy is necessary to make and transport goods*

- If price of energy is higher, price of goods tends to rise
  - Oil and natural gas used in producing food
  - Oil used for transporting nearly all goods
  - Energy prices affect the cost of houses, cars, and factories

- Higher prices don’t come back to workers as higher wages
  - Higher energy costs indicate extraction process is “less efficient”
    - More workers, more fuel, to extract same quantity of energy products
    - Energy workers are “less productive”
    - This is a major reason for lower productivity growth in recent years
  - Economy tends to produce fewer goods in total
    - Reason why the economy shrinks
We need ever-cheaper energy products if the economy is to continue to grow

Source: Robert Ayres and Benjamin Warr, “Accounting for growth: the role of physical work.”
Energy prices are now too low for oil, coal, natural gas, and uranium

- Extraction limit is an **affordable price limit**
  - $100 per barrel was higher than the affordable price limit

![Diagram showing energy price limits]

- Real affordable price limit, $50(?) per barrel
- Temporary price limit, $100 per barrel
Central banks lower interest rates using QE – Make goods more affordable
It is a *myth* that oil prices keep rising as we reach oil limits

- Would be true if wages rose equally rapidly
  - Not true because wages for most workers stagnate

- Oil price at $50 per barrel is still far above historical prices
  - Infrastructure built when oil was $20 per barrel!
Challenge 2: High energy prices make an economy non-competitive

- World growth in energy consumption has been rapid
But growth in energy consumption varies significantly by region.
Next slides look at fuel mix in terms of usual cost level

- **Low priced**
  - Coal
  - Hydroelectric

- **Medium priced**
  - Natural gas
  - Nuclear
  - GeoBiomass (Geothermal, wood and waste burned as fuel)

- **High priced**
  - Oil, including biofuels
  - Wind + (ground) solar
Cost mix varies greatly by part of world.
Countries that can ramp up cheap energy supplies have a huge advantage.
Summary so far: Can’t expect higher cost fuels to solve our problems

- High-cost energy causes economies to shrink
  - Become uncompetitive
- Oil share *shrinks* as a % of total energy, because of high price

[World Energy Consumption - Cost Level Share graph]

Gail Tverberg
OurFiniteWorld.com
Any electricity solution must be economic at current price levels

- Electricity must be available at existing wholesale prices
  - About 3 cents per kWh – (dotted line)

Challenge 3: Intermittency of wind and ground solar are barriers to expansion

- Tiny share (1.9%) of world energy supply in 2015

Based on BP Statistical Review of World Energy 2016 data
As % of *electricity* generated, intermittent renewables are a slightly larger share

- Wind only 3.5% of electricity; solar only 1.1%

*Based on BP Statistical Review of World Energy 2016 data.*
Barriers to expansion typically reached at 10% to 15% of electricity generated

- Reach limits of regular operating reserves

Based on US Energy Information Administration data.
Problems occur as soon as intermittent generation exceeds a low percentage

- Includes grid problems, falling prices for other types of electricity, and overly high subsidy amounts
UK partial solution: Curtail wind production when too much (12% of total in 2015)

- Pay providers for **not generating** wind energy
Quantity of wind constrained and payments for curtailment are ramping up rapidly

Source: Euan Mearns http://euanmearns.com/uk-wind-constraint-payments/
If curtailment is not used, negative wholesale prices become a problem.

Negative energy prices indicating over-supply risk start to appear in the middle of the day.

Need to compensate non-intermittent electricity providers for low wholesale prices

- Can’t really get along without other electricity providers
  - Intermittent renewables need backup

- Intermittent renewables produce price distortions
  - One problem: Negative prices when too much generation
  - Second problem: Cuts off peak prices

- Problem: How to compensate other providers?
  - Some markets use “Capacity Auctions”
  - Tends to produce a large amount of natural gas capacity
  - Doesn’t help nuclear much
If subsidies are charged back, retail electricity prices become very high

Countries with the most intermittent renewable use have the highest rates

Europe Electricity Price v Installed Wind + Solar Capacity

\[ y = 0.0186x + 12.302 \]
\[ R^2 = 0.84624 \]

Source: Euan Mearns http://euanmearns.com/an-update-on-the-energiewende/
Subsidies are high and rising

- Subsidies rising both as currency amounts and %s

*Fig. 8 - Cost estimation based on spot prices and PSO projections by Danish Energy Agency (ens.dk)*

Auctions cannot fix the problem

- Problem is not price of solar PV or wind turbines themselves
  - These costs have tended to fall

- Problem is other costs that keep increasing
  - Greater transmission costs
    - Also “Smart Grid” to forcibly reduce demand
  - Greater need to subsidize other providers, because they can no longer operate profitably
  - Greater need to pay for curtailed intermittent electricity
  - Greater unanticipated future operating costs

- Alternative is storage to eliminate intermittency
  - Cost is still too high
Space solar has the possibility of providing a solution

- Would provide non-intermittent electricity 99+% of time
  - Exception – Midnight of spring and fall equinoxes

- Cost hopefully can be brought down to low level
  - Perhaps 3 cents per kWh

- Timing is most problematic issue
  - Need solution now
  - Intermittent renewables are not a very good bridge
  - Reasonable time-frame: 30 to 50 years
Contact information

- Gail Tverberg
- OurFiniteWorld.com

- Email: GailTverberg@comcast.net
- Cell Phone: +1 (407) 443-0505
- Twitter: @gailtheactuary