Rapidly Stopping Global Warming & Ending Imported Oil with Solar & Wind: A Thought Experiment

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Motivation

• Solar and wind have the resources to easily meet our energy needs
• Wind is nearly cost competitive, and solar is closer than people realize
• Methods of assuring timely supply for the needed uses may exist or are being developed
• Given this, we must ask ourselves if solar and wind can be much more powerful solutions than people realize
Size of Solar

- 120,000 TW on Earth’s disk
- Annually, 1 billion TWh of energy
- Global energy use: about 140,000 TWh (primary)
- Ratio of (solar/world energy use), about 10,000
- About ten 50-Megaton nuclear bombs per hour (largest nuclear bomb ever, “Tsar Bomba”)
  - 50 megaton, about 1.2 TWh
Key Solar Characteristics

• Solar is the largest non-CO$_2$ renewable resource available
  – E.g., it dwarfs the 2$^{\text{nd}}$ largest, wind, by about one hundred

• The conversion of solar into electricity is moving into proximity of economic parity
  – And no fuel escalation risks

• With electric transportation (which seems inevitable), solar electric can “do it all”

• Key bugaboos – intermittency and relatively narrow daytime availability curve
Meeting Our Needs by Combining Wind and Solar*

• Next 20 years, do we have enough economical wind and solar equipment and sites to:
  – Totally displace the conversion of our vehicles from internal combustion engines to plug in electric vehicles?
  – Eliminate import of foreign oil?
  – Lower carbon dioxide emissions significantly and put us on a path to completely eliminate additional CO₂ as a cause of global warming?

*Nuclear might also help with this approach.
How?

• Combine solar and wind on the same long-distance transmission lines starting in the US SW
  – Source and geographical diversity assure and smooth output

• Solar and wind are naturally complementary
  – Solar during the day, especially long days of summer
  – Wind at night and in winter

• Combined they
  – Improve the cost of transmission
  – Smooth output to nearly predictable curves and eliminate spikes

• And the much smoothed transmission output can be filled in and made reliable with conventional natural gas turbine electricity
How to get the solar and wind electricity

National Electricity Transmission System to Export Solar Electricity from Southwest and Wind Electricity from the Midwest.

16 ¢/kWh solar electric from the Southwest can be sent nationwide with under 15% losses, i.e., we can get solar electricity in Maine for about 20 ¢/kWh NOW (with transmission costs).
Transmission corridors will pick up wind along the way to East Coast.

Take Pickens idea one step further and include solar on the transmission line to the South or North East.
Full-Throttle Adoption

- Could provide about 3000 TWh of carbon-dioxide free electricity within about 15 years without the high cost of electric storage
  - 75% of today's electricity (4000 TWh)
- Could allow the removal of 2.5 times that much fuel (over 7500 TWh of primary fuel, or 25 Quads of oil) if we electrify transportation
- This would eliminate the need for any imported oil (22 Quads, but growing)
- And eliminate about half of the CO₂ from our transportation sector
Is this much solar and wind growth conceivable?

- Solar resource is no problem
- Strains wind resource
- Wind resource limit suggests about 2/3 solar 1/3 wind
- Wind growth acceptable (recent DOE study suggests 1000 TWh in 2030, but not 2023)
- Solar
  - PV growing at over 50% year
  - CSP restarting and very large potential growth
  - 1000 TWh each of PV and CSP, or 500 GW each installed in 15 years is about 35 GW/yr of new installations, each
  - Solar is ~5 GW per year now, growing 50%/yr is 6500 GW cumulative 2023
  - Issues will be supply chain and worthy of deep attention
How much does this cost?

• 20 ¢/kWh electricity is equivalent to about $2.5/gallon gasoline* – we SAVE money doing this (did you see that coming?)
• This includes paying for the HV DC transmission lines
• No, this is not as cheap as doing it with coal – that would save even more money (until the price of coal reached equivalent levels) – but at what CO₂ impact?

*Electric transport is the “killer app” of our times.
Summary

- Reduce CO$_2$ and demonstrate a path to getting rid of it as a problem
- Eliminate foreign oil in 15 years
- Save money
What are the pitfalls, weaknesses?

• A number of vague aspects that need work
  – Transmission capacity factor of solar/wind and availability of enough wind on the way East once this gets very big
  – Smoothness of geographically and source-diversified transmission – does it eliminate enough costly storage?
• Possible growth rates need validation and examination for pitfalls
• Timing of new electricity is mostly daytime
  – Somewhat matches daytime peaks
  – But not a good match for nighttime charging of plug ins
  – So some daytime natural gas can be reduced and shifted to nighttime
  – Perhaps daytime charging can be developed
• Worth examining if nuclear can be woven into this
  – Long transmission lines allow isolation from population
• All sorts of smaller components (biomass, geothermal heat pumps, passive and hot water solar, efficiency) need inclusion
First Solar has a contract to install a thin film PV System in S. CA (Blythe) and sell its electricity at 12 ¢/kWh (after incentives).

JUWI Group is installing 40 MW of First Solar modules in Waldpolenz, Germany. At the time of the announcement, it was both the largest and lowest-priced PV system in the world at €3.25/W, which was then equal to $4.2/W. A contract for large rooftop systems by Southern CA Edison has been signed for $3.5/W.

LUZ I 15 years ago
Nevada 1 Today
Solar Thermal: BrightSource/LUZ II has a contract to install a 400 Megawatts (expandable to nearly 1 GW) for Southern California Edison

Claimed to be in the same 15 ¢/kWh range as the best PV (prior to incentives)
Another way: Long Beach CA Convention Center, 700 kW
Unisolar PV Roofing Modules
GW Solar Institute

• Bring ambitious vision of the solar opportunity to fore
• Bolster facts and scenarios
  – Fill in gaps in this talk, add texture and depth
• Be a dependable source of information
  – Bring in mainstream scholarship
• Bring information to bear on US decision-making
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