Renewable Energy and Policy



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- Renewable Energy: Background and History
- Wind and Solar
- Distributed Solar PV
- Renewable Energy Policies
- Renewable Economics

What is Renewable Energy?

Definition of "Renewable":

- "Capable of being replaced by natural ecological cycles or sound management practices" Merriam-Webster dictionary
- Not just Wind and Solar
- Hydro
- Wood and Biomass
- Geothermal
- Regulatory/Policy Definition is Often Different.

Renewable Energy Myths

- "Renewable Energy Is Always Environmentally Friendly"—
 - Wind—Migratory Bird and Bat Deaths
 - Biomass/Wood- Local Air Pollution
 - Hydro (except low-head)– Ecological Damage
 - Central Station Solar Large Land Footprint
 - "Renewable Builds Mean Zero Carbon Emissions"
 - Intermittent Renewables (Wind and Solar) require fossil fuel backup.

Wind and Solar Are Very Intermittent



of GLOBAL CHANGE

Renewable Energy as Share of U.S. Energy

Share of energy consumption in the United States (1776-2014)



Renewable Electricity Generation: EIA

Figure 34. Renewable electricity generation by fuel type in the Reference case, 2000-2040 (billion kilowatthours)



Wind Resources Not Evenly Distributed



Wind Farm



Wind Growth

Wind Power Represented 24% of Electric-Generating Capacity Additions in 2014







From 2007-2014, wind comprised 33% of capacity additions nation-wide, and a much higher proportion in some regions

ENERGY Energy Efficiency & Renewable Energy

AEP Renewable Energy: Wind Dominates



Solar Thermal Station



Solar PV Central Station



Solar by Geography



Utility Scale Solar Growing Rapidly



48% of cumulative PV capacity in population came online in 2014 (70% in 2013-2014)

- 50% of PV capacity that came online in 2014 was from just three large thin-film projects: Topaz (586 MW_{AC}), Desert Sunlight (563 MW_{AC}), Agua Caliente (348 MW_{AC})
- "Tracking c-Si" and "fixed-tilt thin-film" have been the predominant configurations over time, but this is changing: more tracking (12) than fixed-tilt (4) thin-film projects came online in 2014 (though fixed-tilt thinfilm *capacity* far outweighed tracking thin-film)



Utility Scale Solar Now More Competitive

Levelized PPA prices have fallen by more than two-thirds since 2009



- PPA prices are levelized over the full term of the contract, after accounting for any escalation rates and/or time-of-delivery factors
- Strong/steady downward price trend since 2006
- Smaller projects (e.g., 20 MW) no less competitive
- CPV and CSP largely competitive *at the time*, but little visibility recently
- >75% of the sample is currently operational
- Broadening of the market in 2015 (AR, AL, FL)

U.S. Renewables Policy- PTC

- Federal Production Tax Credit (PTC)
 - 2.3 cents per kwh produced for first ten years of project in service for Wind, Geothermal, Biomass ("closed-loop")
 - 1.1 cents per kwh for other technologies such as landfill gas, ex. hydro capacity additions, "open loop" biomass
 - PTC has been in place since 1998 with a number of expirations and extensions
 - Wind PTC can cut effective pre-tax cost of wind by 30-40%.
 - Very important for US wind development during 2007-2014 (capacity quadrupled) as it made it "economic" in a number of states -- e.g. Texas, Oklahoma, Minnesota, lowa.

Renewable Portfolio Standard Policies



U.S. RPS Issues

- Many types. A few voluntary; most mandatory.
- Some actually include non-renewables (e.g. all hydro, Energy Efficiency, Fossil greater efficiency, MSW-Municipal Solid Waste, CHP – Combined Heat and Power)
- Mostly pushes in greater central-station wind plants and some solar (often thru carve out).

U.S. Renewables Policy – Other Financial Incentives

- Federal Investment Tax Credit (ITC):
 - 30% of Capital Costs for Solar, Fuel Cells, Small Wind and PTC Eligible Technologies (in lieu of PTC)
 - 10% for Geothermal, Microturbines and Combined Heat and Power.
- <u>State ITC</u> in a few states (e.g. California)
- <u>Feed-in-Tariffs</u> (in CA, WA, OR, ME, VT, RI) for solar
- <u>Net Metering</u> for Res/Com Rooftop Solar---
 - Large Cross-Subsidy in Some States.

Distributed Generation & Net Metering

- <u>Distributed generation (DG) is small-scale, on-site power (e.g.</u> <u>solar panels)</u> located at or near customers' homes or businesses.
- Many DG customers are in states with "net metering" --allows them to "sell" any excess electricity at the full retail electric rate.
- The retail electricity rate (in cents/kwh) includes not only the cost of the power but ALSO the fixed costs of poles, wires, meters etc. to keep the grid safe/reliable AND to accommodate DG systems.
- Through the credit, net-metered customers avoid paying some of these fixed costs of electricity service to their home/business.
- Thus, All OTHER customers including those with low income and seniors, are subsidizing those with distributed generation.
- Some states have begun revising tariffs to deal with this problem.

Worldwide Renewable Measures

- **Tax credits ---Federal and State U.S.**
- Net Metering---U.S., E.U.
- RPS---30 States in U.S., Sweden, England, Italy, Poland and Belgium
- Feed in Tariffs- Germany, China, Spain, other European countries

Feed-in-Tariff in Germany

- Renewables (primarily wind and solar) receive Price= Annualized Cost of Technology + Return on Capital
- FIT is fed into retail rates. Difference between market rate and FIT is paid as bill surcharge by retail customers (excluding Industrial)

Feed-in-Tariff Impacts

- Successfully led to huge increases in renewable energy in Germany:
 - <u>2012 24% of Total Electric Output</u>
- But Large Household Rate Increases
 - 2000 \$0.18/KWh
 - 2012 \$0.38/KWh (More than 3X the US)
- \$412 Billion Cost to date; Over \$800 billion by 2022

Other FIT Impacts

- Green Job Gains but Net Macroeconomic Losses
- Falling Base Load Wholesale Prices (90-95 Euro/MWh in 2008 to 37 Euro/MWh in 2013). Less Investment in New and Existing Fossil Generation.
- Reliability Issues
- EU ETS (i.e. Europe's CO2 Trading Market) Also Negatively Affected.

Typical Chronological Load Curve



Levelized Cost of Electricity: New "Merchant" Wind Plant

- New Texas Wind 34.2% Cap. Factor or 3000hrs./yr.; CCR = 0.08;
- Capital \$1500/kw Ann. Cap.=1500 x0.08= \$120/kw-yr.
- Fixed O&M /kw-yr.=\$30/kw-yr.
- ■Total Cap & O&M Fixed Charges =(120+30)=\$150/kw-yr. \$150/kw-yr. x Yr./3000 Hrs. X 1000 kw/MW = <u>\$50/MWh.</u>
- Total Cost of Electricity(w/o PTC) = \$50/MWh
- Production Tax Credit(PTC) = -\$22/MWh
- ■<u>Total Cost of Electricity (w/PTC)</u> = \$28/MWh for first 10 years

Cost of Wind Electricity vs Alternatives

- Today, wind has the lowest annualized cost among "renewable" options though central station solar is increasingly competitive.
- However, wind must largely compete in the electric "energy" market since it provides very little "capacity" at peak.
- The electric energy market varies by region and market conditions but average annual prices are currently generally in the \$25-\$35/MWh range.
- Thus, new wind can compete in regions/states without renewable requirements (RPS) as long as there is a continuation of the Production Tax Credit (PTC).
- Once built, wind plants will always run when the wind blows, (except when curtailed), because of their negative marginal costs.

Renewables Future

- Wind and solar are likely to continue to grow in the US (even absent the PTC) driven by:
 - State RPS
 - EPA's Clean Power Plan (i.e.CO2 regulations on power generators)
 - Continuing technology improvement particularly for solar PV and central station solar.

Key Long Term Issue for Renewables is the Development of a Viable and Economic Storage Option (e.g. Batteries, Hydrogen etc.)