Prices, Prophecies, Principles, and the Future of Nuclear Energy

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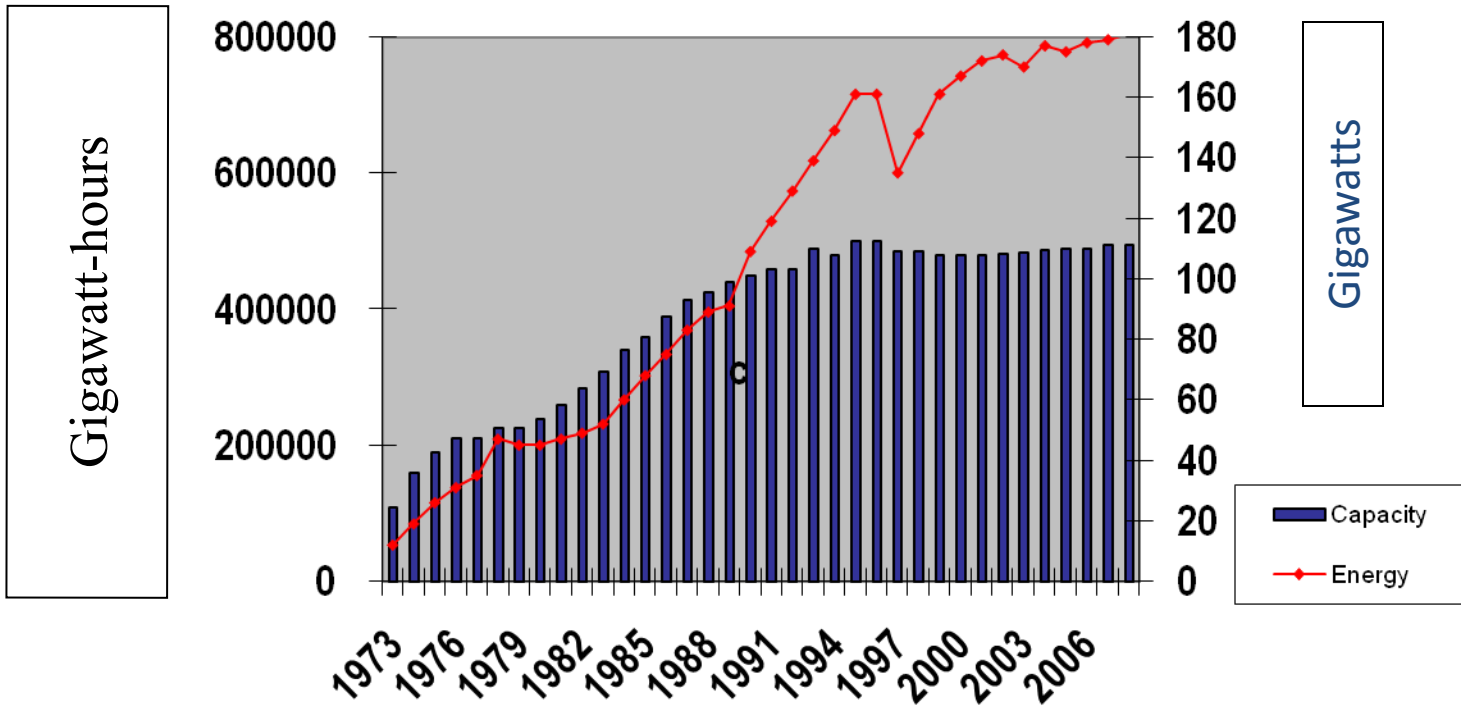
Nuclear Power in the U.S. in 2012: Operating Reactors

- One hundred four plants listed as “operating”, but three are in long term shutdown due to malfunctions.
- One NPP (Kewaunee) has just announced that it will close for economic reasons.

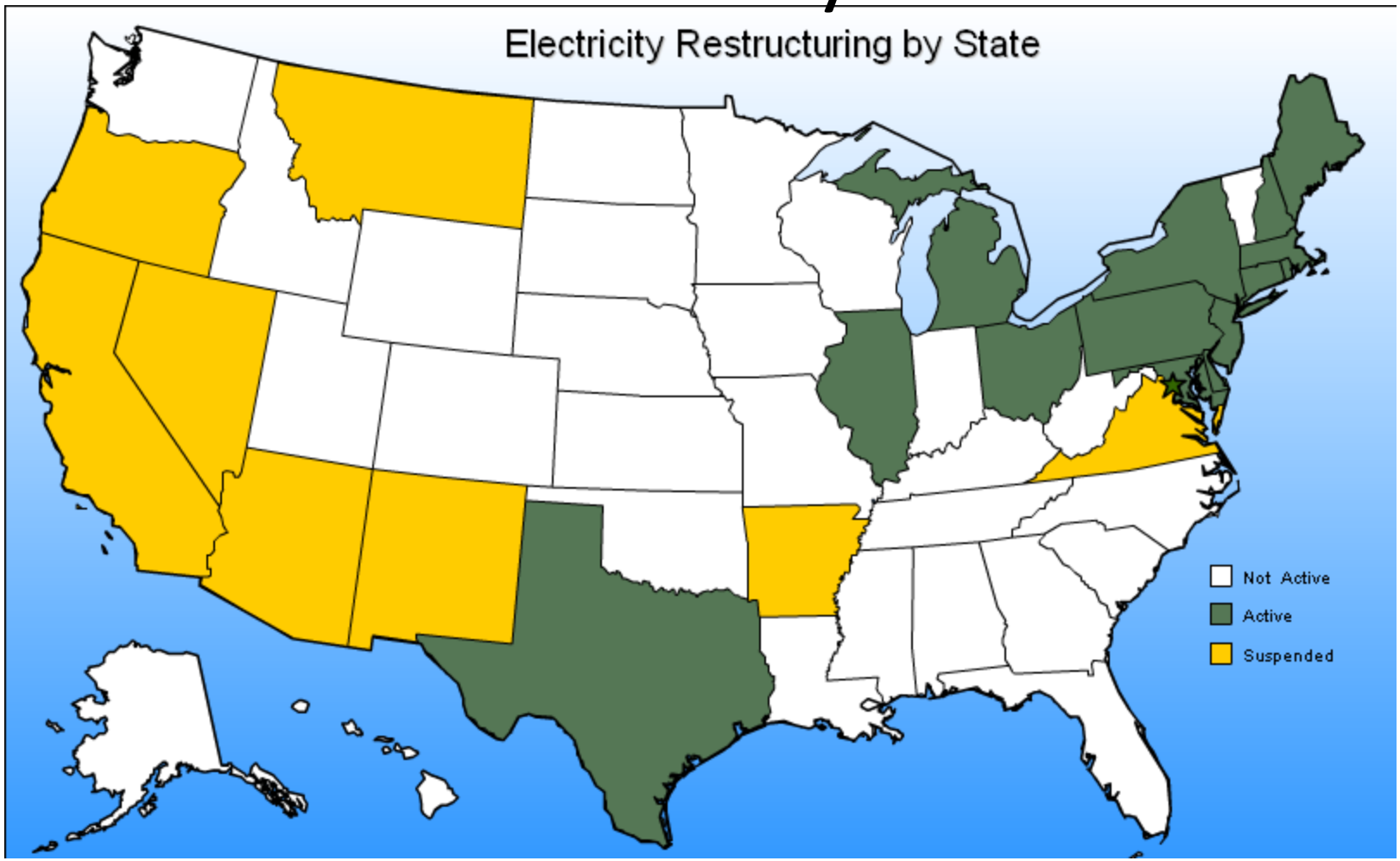
Trends Highlighted by Last Week's Kewaunee NPP Closing

- Capital costs and operating costs are rising as US NPPs age.
  - Cost of running most expensive 25% U.S. reactors in 2009-2011 was about 6 cents/kWh (4.8 Japanese yen)
  - These cost have increased at 13%/year since 2007
- At the +/- 5 cent/kWh electricity market prices prevailing in U.S. power markets today (and projected for some years), NPPs will face severely increasing pressure in U.S. restructured markets.
  - Older nuclear plants facing major investments may close.

U.S. Nuclear Output and Nuclear Capacity, 1973-2008: Productivity Improvement in the Face of Competition



Customer Choice in the U.S. Electricity Industry



Nuclear Power in the U.S. in 2012: New Construction

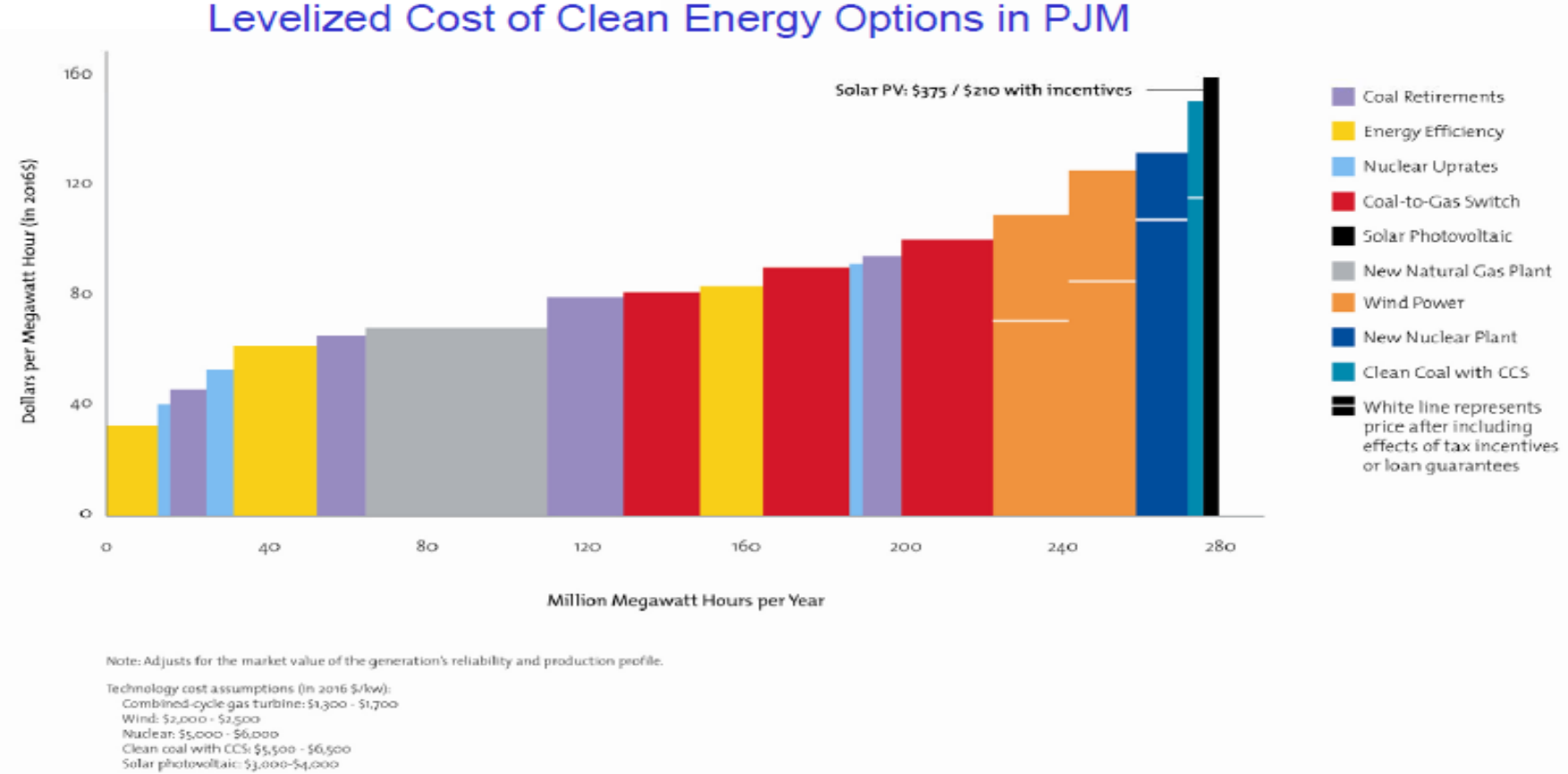
- The revival in construction of nuclear plants forecast in 2002 has collapsed from a forecast of 30 new units as recently as 2009 to five today.
  - Even those five are dependent on very large subsidy from customers and perhaps taxpayers and will not demonstrate that new nuclear is competitive

Proximate Causes of the Collapse of New U.S. Nuclear Construction

- Low natural gas prices projected many years into the future;
- Diminished projected growth rates;
- Rise in cost estimates for nuclear construction;
- Absence of meaningful U.S. national climate policy;
- Ambivalence about further energy subsidies
  - Very different from 2008 presidential campaign

Exelon's Low Carbon Electricity Options

There are Cheap Ways and Costly Ways to Clean the Generation Fleet



Note: Adjusts for the market value of the generation's reliability and production profile.

Technology cost assumptions (in 2016 $/kw):
- Combined-cycle gas turbine: $1,300 - $1,700
- Wind: $2,000 - $2,500
- Nuclear: $5,000 - $6,000
- Clean coal with CCS: $5,500 - $6,500
- Solar photovoltaic: $3,000-$4,000

Role of Fukushima in U.S. Nuclear Policy

- Not very important as to new construction, which had collapsed before Fukushima;
- Of some importance for operating units under cost pressure, especially in power markets;
- Of some importance in political debates over additional subsidy.

Some Lessons from Recent U.S. Experience

- Prophesy makes a weak basis for nuclear energy policy;
  - Many sincerely held beliefs from ten years ago have proven expensively wrong (again)
- Nuclear power is vulnerable to economic risk, not just to the actual events that have occurred. Investors understand this.
- Economics will probably not tolerate gaps like the current “Asian Premium” indefinitely, so falling Asian gas prices but rising world gas demand will influence the competitive role of gas

Some Lessons from Recent U.S. Experience II

- Our happier surprises have occurred when market forces have been allowed to work freely, but many of these surprises have benefitted customers without benefitting nuclear power.
  - Exelon options suggest that this will still be true under stronger climate policies.
- Waste “solutions” like reprocessing that impose additional costs inevitably make nuclear plants less competitive with other alternatives.
- Public trust, transparency and nuclear governance vary greatly by U.S. region.

Some Lessons from Recent U.S. Experience III

- Support targeted specifically to preferred technologies is likely to be less successful than the implementation of market economic principles modified to reflect environmental and security goals through carbon taxes or cap-and-trade.