Is There a Business Case for Merchant Solar? or On the Business Case for Merchant Solar

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Goals of the Presentation

- Present motivation and background for the results reported in the paper.
- Present key results from paper.
- Indicate ongoing and future work in relation to the paper.

In short, not to present the paper, but to talk about what the paper is about, drawing upon the paper.

How to bring about deep penetration of renewables?

(For electricity generation and facing the fact of intermittency.)

- Three key aspects or kinds of performance properties for an electricity generation apparatus:
  1. Technical and operational performance
     Production profiles, costs, variability, reliability, etc.
  2. System performance
     Role in the larger system(s). Conflicts and complements with other components.
     Think: combinatorial optimization.
  3. Market (or institutional) performance
     Fit with markets, etc.? Need for subsidies?
- We focus on solar PV. Wind, etc. later.

And we focus on #3: market performance

- Observe: few if any merchant solar PV vendors.
- Solar PV (and other renewables) generally supported by mandates or subsidies of various kinds.
- Given the remarkable technical progress to date (and anticipated future progress) in improving the performance and economics of renewable energy, is it possible for solar PV to achieve deep penetration of electric power systems as an ordinary merchant supplier and without subsidies?
- A good question even for vertically integrated (not deregulated) utilities

Why not? What are the barriers?

- Our focus: institutional, especially market barriers
- Worry: In a world of 0 marginal costs, day-ahead and spot market supply curves become very flat and it is difficult for any merchants to prosper.
  The "missing money" problem.
- We are seeing this already in the US and, it seems, in Germany (and elsewhere).
- This is very much a concern going forward. How to organize the markets?

Basic business frame. Can it be profitable?

Table: Annual payments over 25 years for a 1 megawatt solar farm having present value P in millions and hurdle rate r.

	r					
P	0.030	0.048	0.066	0.084	0.102	0.120
0.60	34457	41722	49645	58140	67120	76500
0.80	45942	55630	66193	77520	89493	102000
1.00	57428	69537	82741	96900	111866	127500
1.20	68913	83444	99290	116280	134240	153000
1.40	80399	97352	115838	135660	156613	178500
1.60	91885	111259	132386	155040	178986	204000
1.80	103370	125166	148935	174420	201360	229500
2.00	114856	139074	165483	193800	223733	255000
2.20	126341	152981	182031	213180	246106	280500

Can it be profitable?

- Note: Our use of the insolation data $\rightsquigarrow$ underestimate of solar production
- Looking at PJM day ahead and spot prices, today and historically . . .
- Looking at German spot prices. . .
- Conclude: maybe.
  Yes with today's technologies and yesterday's prices.
  Close call at best with today's technologies and today's prices.
  Yes with tomorrow's technologies and today's prices.
- In fact the supply curves are flattening. Where will this stop? What will tomorrow's prices be?
  Good cause for worries.

Capacity markets: Another possible mechanism

- Controversial
- Introduced to deal with the “missing money” problem, so that gas peaker plants can be profitable
- Many conventional generators get most of their profits this way
- MISO example.
  Capacity payments currently about \$0.0625 kWh. (Not bad.) If you succeed in the auction, then for the year in question you must offer the capacity you bid every hour of the year (day ahead, spot).
- MISO’s wind solution. But no solar yet. PJM, no solar.
- How can solar PV possibly participate?

What to do? Observation: Over 20 years, solar minima

Table: Location key: 0:'Aquadilla',1:'Mercedita',2:'San Juan International Airport'.

Location	Total Annual	Minimum Annual	Ratio
(0,)	2746275	1729864	0.630
(1,)	2872763	1182034	0.411
(2,)	2743047	1637812	0.597
(0, 1)	2809519	1582986	0.563
(0, 2)	2744661	1794294	0.654
(1, 2)	2807905	1524207	0.543
(0, 1, 2)	2787362	1673467	0.600

More like 0.47 in Philadelphia. Lesson: Solar varies but can be relied upon hourly to a degree.

Suggests for solar: Certain + uncertain partition

- (See paper for tables.)
- Certain should be qualified for a capacity market, in principle.
- But does not fit with capacity markets we are aware of (PJM, MISO, e.g.)
- Consider now a more radical approach: optimization by vertically integrated utility.

From the paper

The objective function is: $\min z =$

$$(a^1 x^1 + a^2 x^2) + (b^1 \sum_{i=1}^{24} y_i^1 + b^2 y^2) + (c^1 z^1 + c^2 z^2) \qquad (1)$$

This is subject to

$$c_i^a x^1 + c_i^b y_i^1 + c_i^c z^1 \geq L_i, \quad \forall i \in \{1, 2, \ldots, 24\} \qquad (2)$$

$$x^2 - x^1 \geq 0, \quad z^2 - z^1 \geq 0 \qquad (3)$$

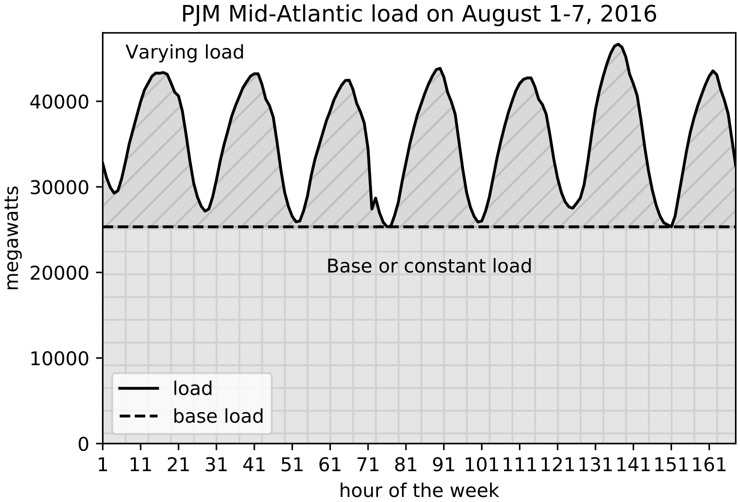
$$y^2 - y_i^1 \geq 0, \quad \forall i \in \{1, 2, \ldots, 24\} \qquad (4)$$

$$x^1, x^2, y_i^1, y^2, z^1, z^2 \in \{0, 1, \ldots u\}, \quad \forall i \in \{1, 2, \ldots, 24\} \qquad (5)$$

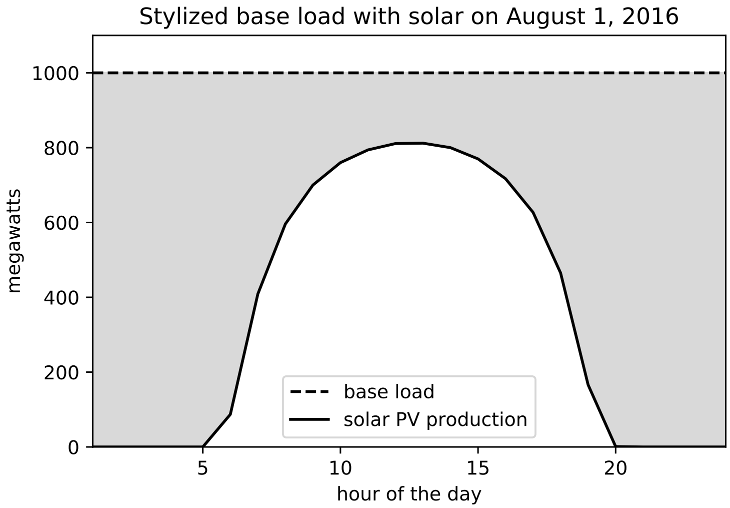
Comments

- Idea: Force consideration of both fixed and variable costs
- Unlike: day-ahead and spot market prices which are supposed to reflect only (mainly) variable, marginal costs.
- a^1, b^1, c^1 are variable costs, and a^2, b^2, c^2 are fixed costs allocated to the day. c_i^a is the capacity or power delivered by a base load plant during hour i; c_i^b is the capacity or power delivered by a load following plant during hour i; and c_i^c is the capacity or power delivered by a solar PV plant during hour i.
- "Stylized" or "toy" model, meant to communicate some simple points
- Taking a system point of view
- Recognizing both fixed and incremental costs
- How to translate this into a market design?

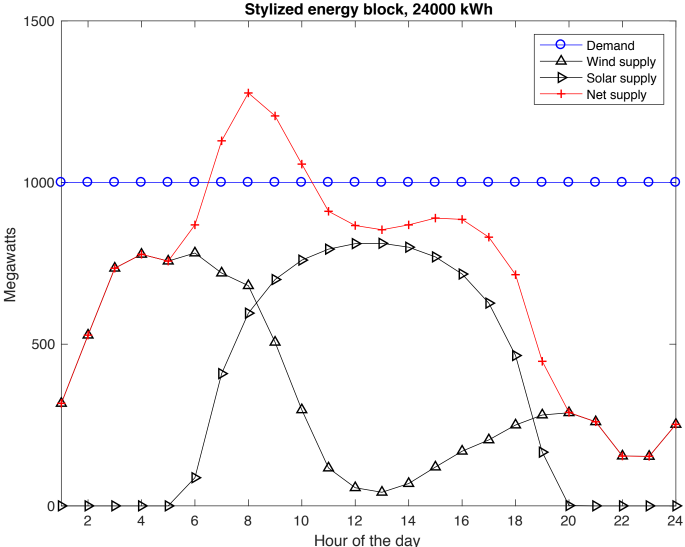
Load = varying + base



Synthetic base load



Synthetic base load: wind + solar



Conclusion

- Synthetic base load generation: a key concept for integration of renewables.
  See
  http://knowledge.wharton.upenn.edu/article/is-a-more-rapid-transition-to-renewable-energy-
  for the base load synthesis problem.
  Prospect is for rapid, easy accommodation of 50%+ renewables.
- Four basic approaches to market structure seem promising:
  1. As in the paper, optimization for a vertically integrated utility
  2. For "deregulated" utilities, virtual power plant merchants bid into existing capacity markets, etc. (as they exist)
  3. For "deregulated" utilities, design market structures that emulate the (sort of) optimization shown in the paper.
  4. Use futures markets

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