Economics of Solar Power

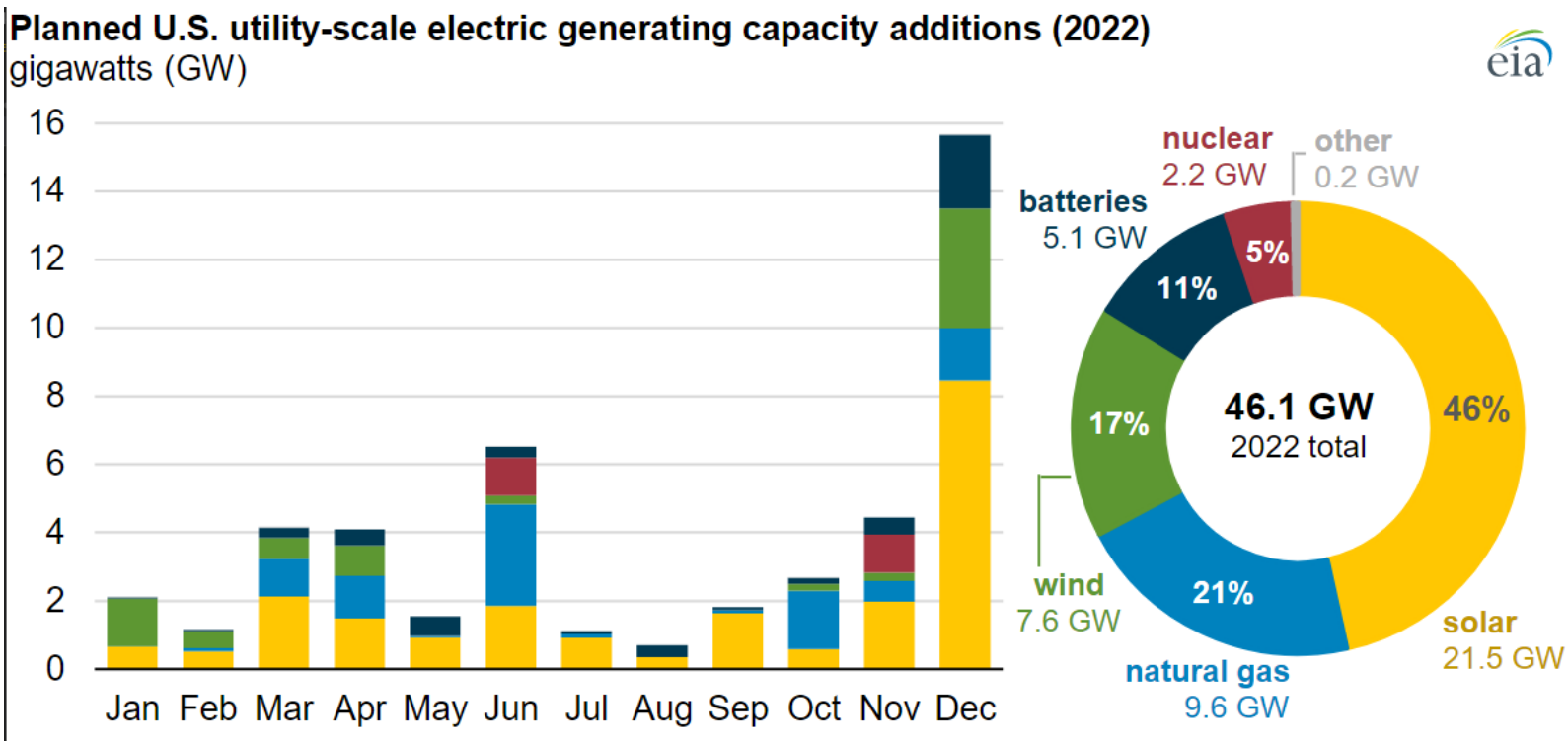
ECON3391.01, Boston College

Intro

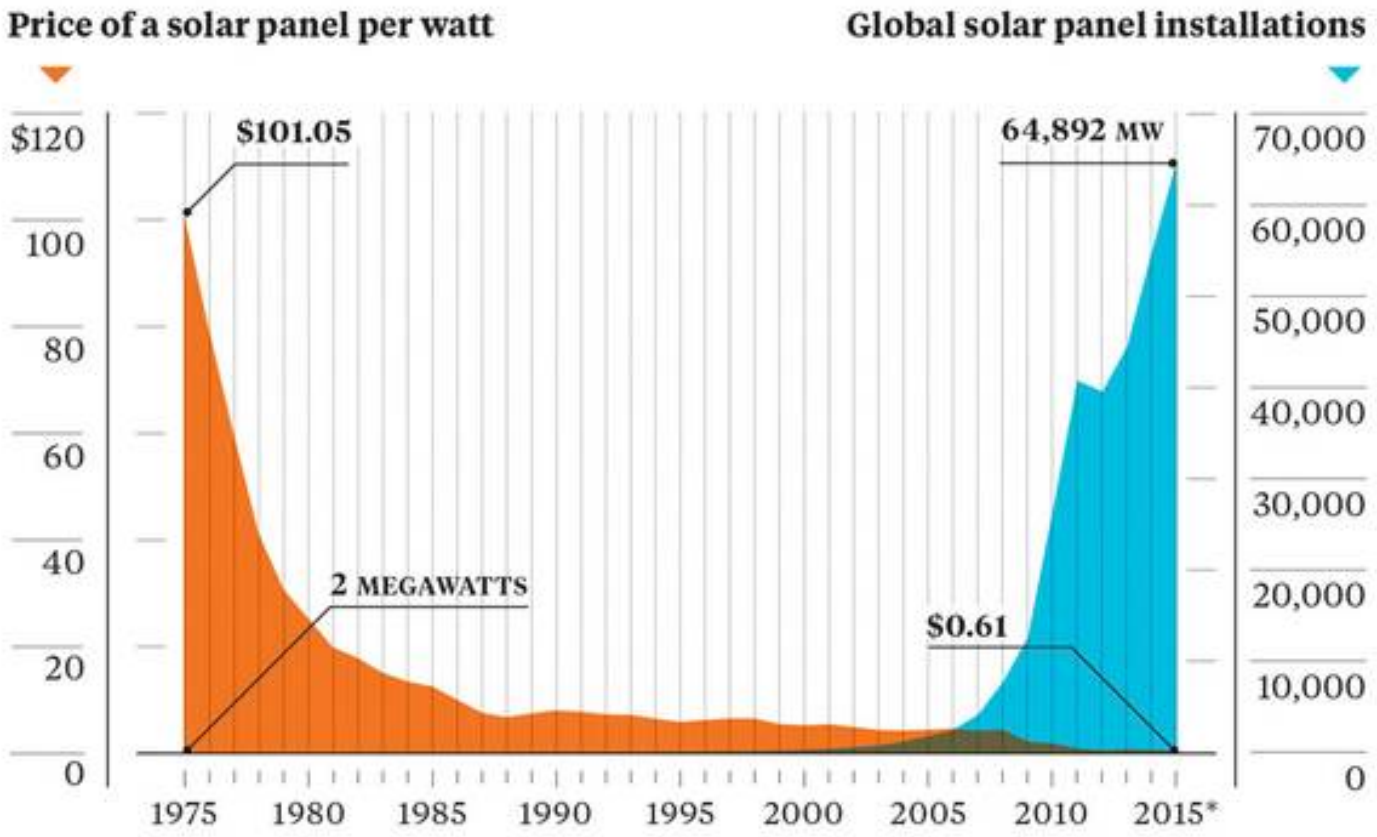
- Intro to solar power
- Private economics of PV
- Public economics of PV
- Current issues in PV policy design

Solar intro

- Many think solar will be the primary energy source in the future
- Example: Elon Musk noted we could power all of the US by covering just a small corner of Utah with solar, and could power the entire world by covering Spain
- Less than 2% global capacity now, but BNEF predicts it will be 30% by 2040



Costs have come down tremendously



Grid scale vs distributed solar

Grid scale vs distributed solar

Today we'll be talking about distributed solar.

What are some pros and cons of distributed relative to grid scale?

Pros of distributed generation

- No line losses (7-9%)
- Cheap real estate
  - your roof is unused space anyways (may even provide shade)
- May reduce need for new transmission /distribution lines
- Spreading panels around reduces 'risk' of clouds
- "Freedom" / independence from the grid etc
  - strange coalition of environmentalists and anti-government types has emerged to support PV

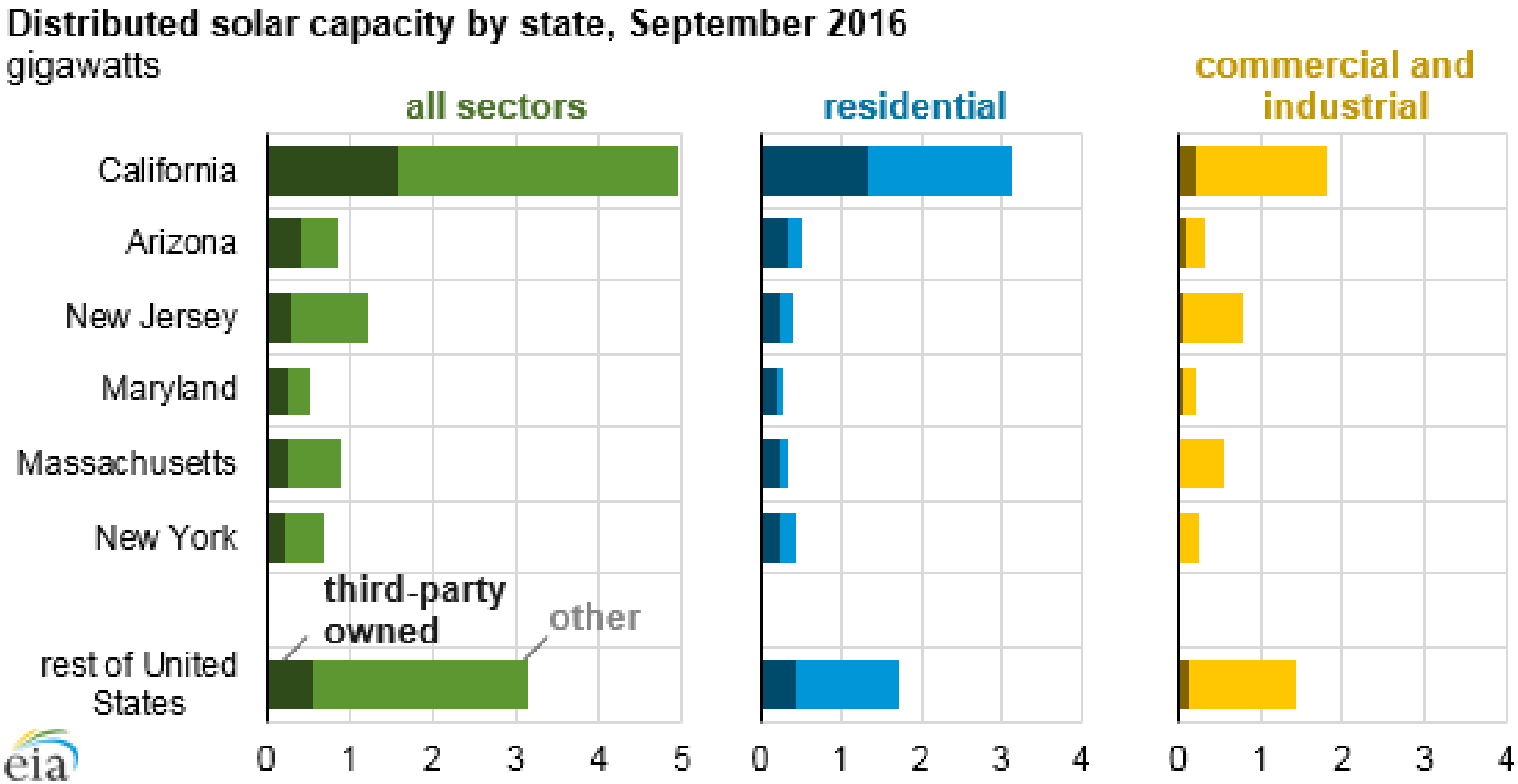
Source: Severin Borenstein

Cons of distributed generation

- Design and maintenance is MUCH more expensive
  - Lose all economies of scale
  - GS panels often move throughout the day to track sun
- DG installed where consumers choose, not grid operators
  - Feedback can seriously destabilize the grid (12% Hawaii)
- Also a lot of controversy over the true cost of DG and how it should be promoted

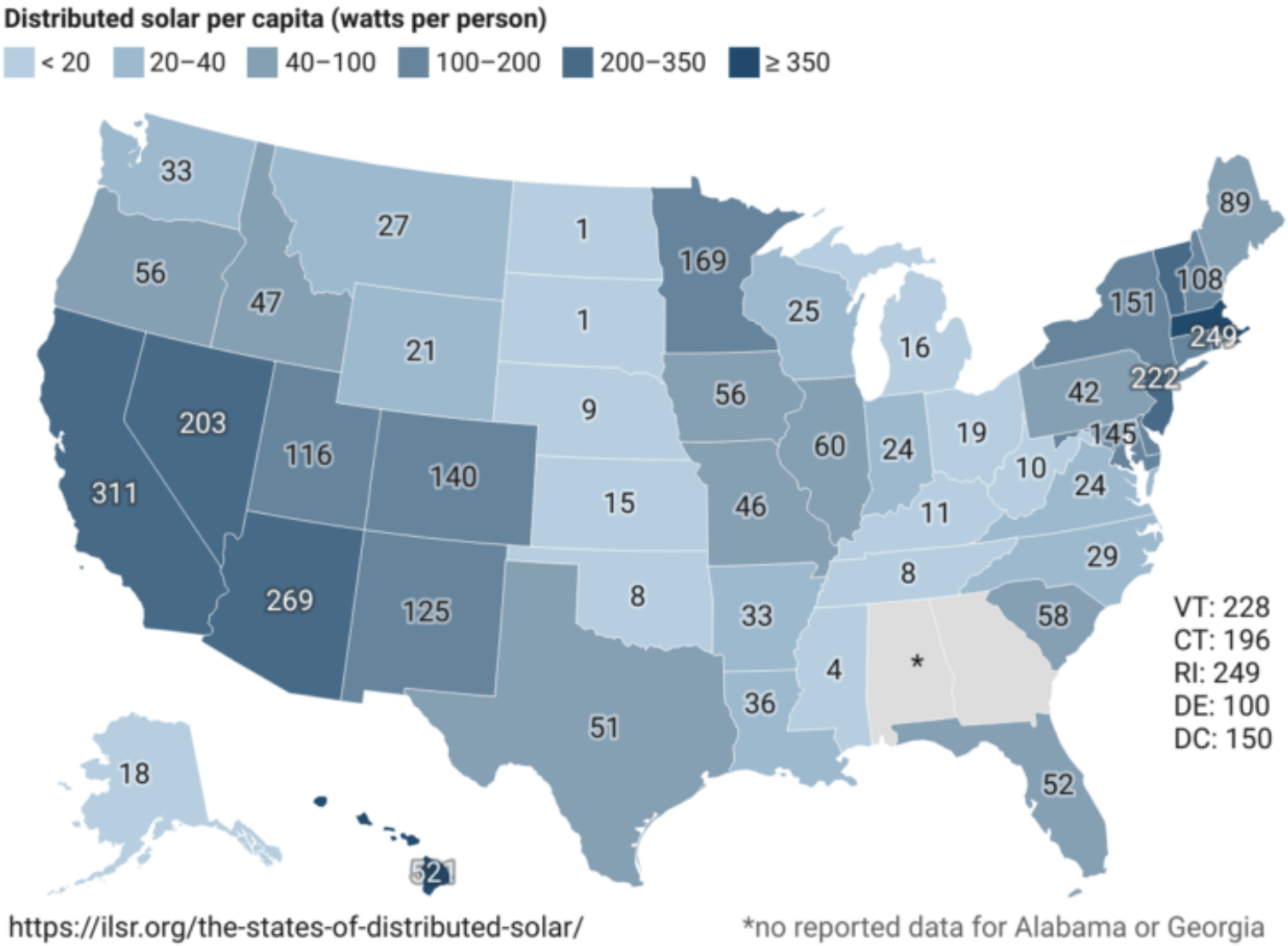
Source: Severin Borenstein

Where is solar happening in the US



State Distributed Solar Saturation 2021

Distributed solar generation capacity relative to state population



https://ilsr.org/the-states-of-distributed-solar/

*no reported data for Alabama or Georgia

Map: State(s) of Distributed Solar – 2021 Update • Source: U.S. EIA, U.S. Census Bureau, ILSR • Created with Datawrapper

The private economics of solar PV adoption

- Consumers have utility from electricity consumption

$$U = \sum_h (u_h - p_h) e_h$$

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- Installing solar panels reduces the need to buy electricity from the grid by the output of the panels (s) each hour.

$$U_s = \sum_h (u_h e_h) - \sum_h p_h(e_h - s_h) + \omega - F$$

  where ω represents the "green glow" of going solar and F is the fixed cost of the installation.

- Ignore discounting for now.

The private economics of solar PV adoption (cont)

- Assume the household faces a flat (time-invariant) energy price ($p_h = p$)
- Then it makes sense to adopt if: $\sum s_h p + \omega > F$

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- Then it makes sense to adopt if: $\sum s_h p + \omega > F$
- Note that this does not depend on e_h unless we impose that the customer cannot sell power back to the grid ($s_h < e_h$)
- Some consumers will find it profitable to adopt PV and some won't, depending on their (p,ω,e,s).

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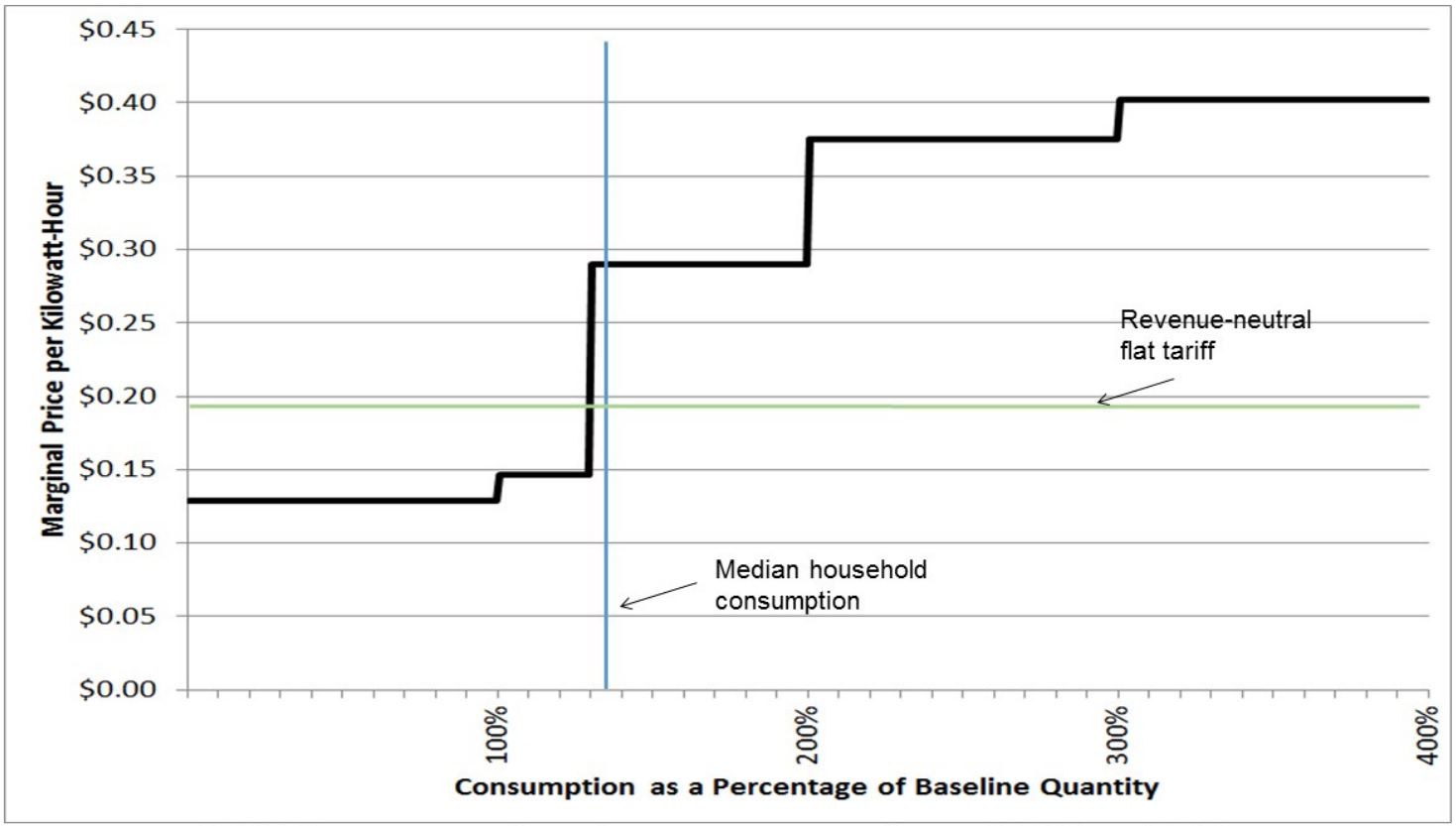
In practice we are doing all of these

- Congress just passed a 5 year extension of the investment tax credit
  - Reduces installation costs (F) by 30%
- 14 states also offer additional tax credits on top of that

Raising electricity prices will also increase solar adoption

- One of the reasons CA has half the PV in the US is its high prices
- CA also has tiered pricing
  - gives some customers a larger incentive than others



PG&E's average tiered rate structure from 2007 to 2013

Source: Severin Borenstein

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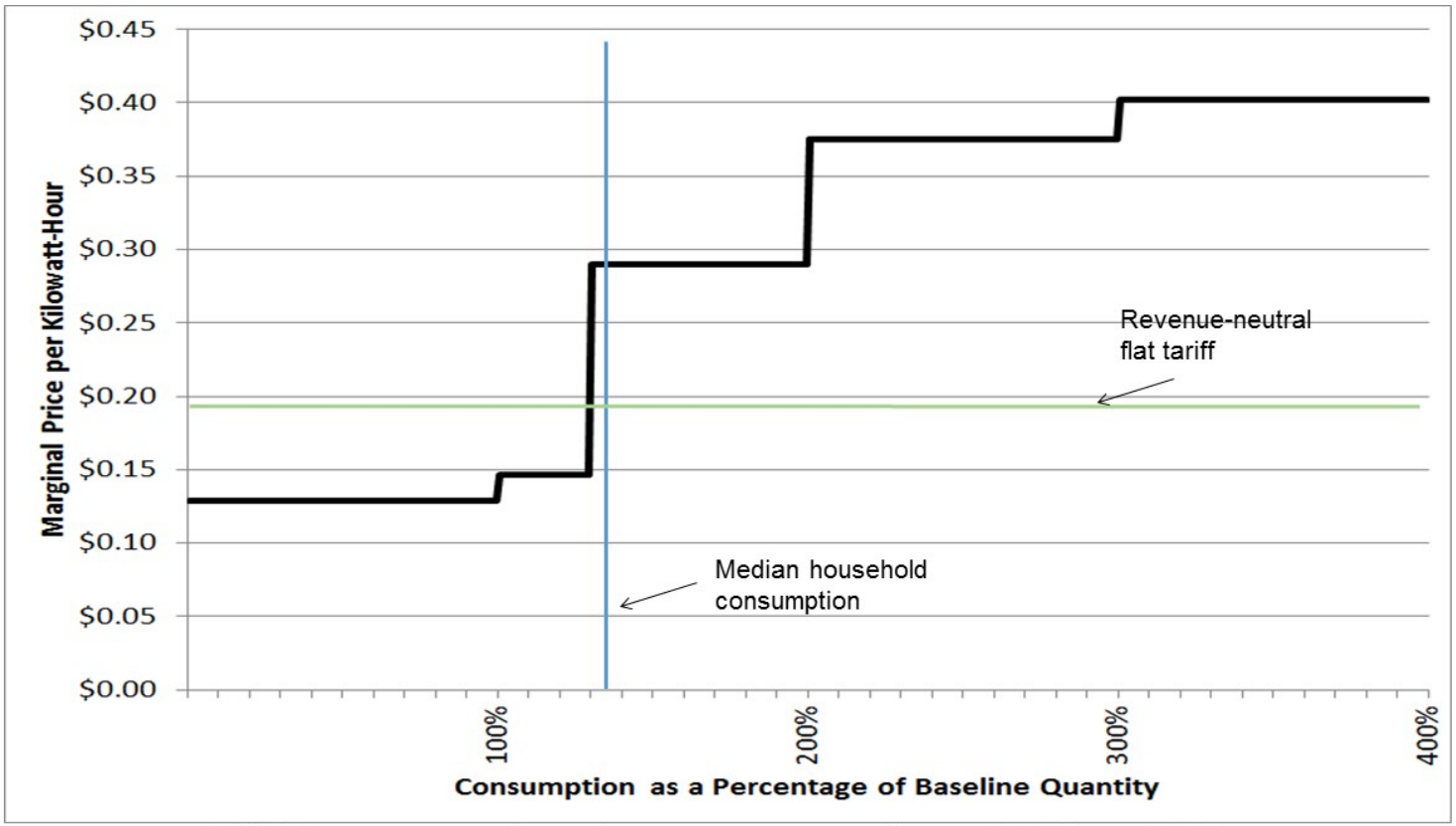

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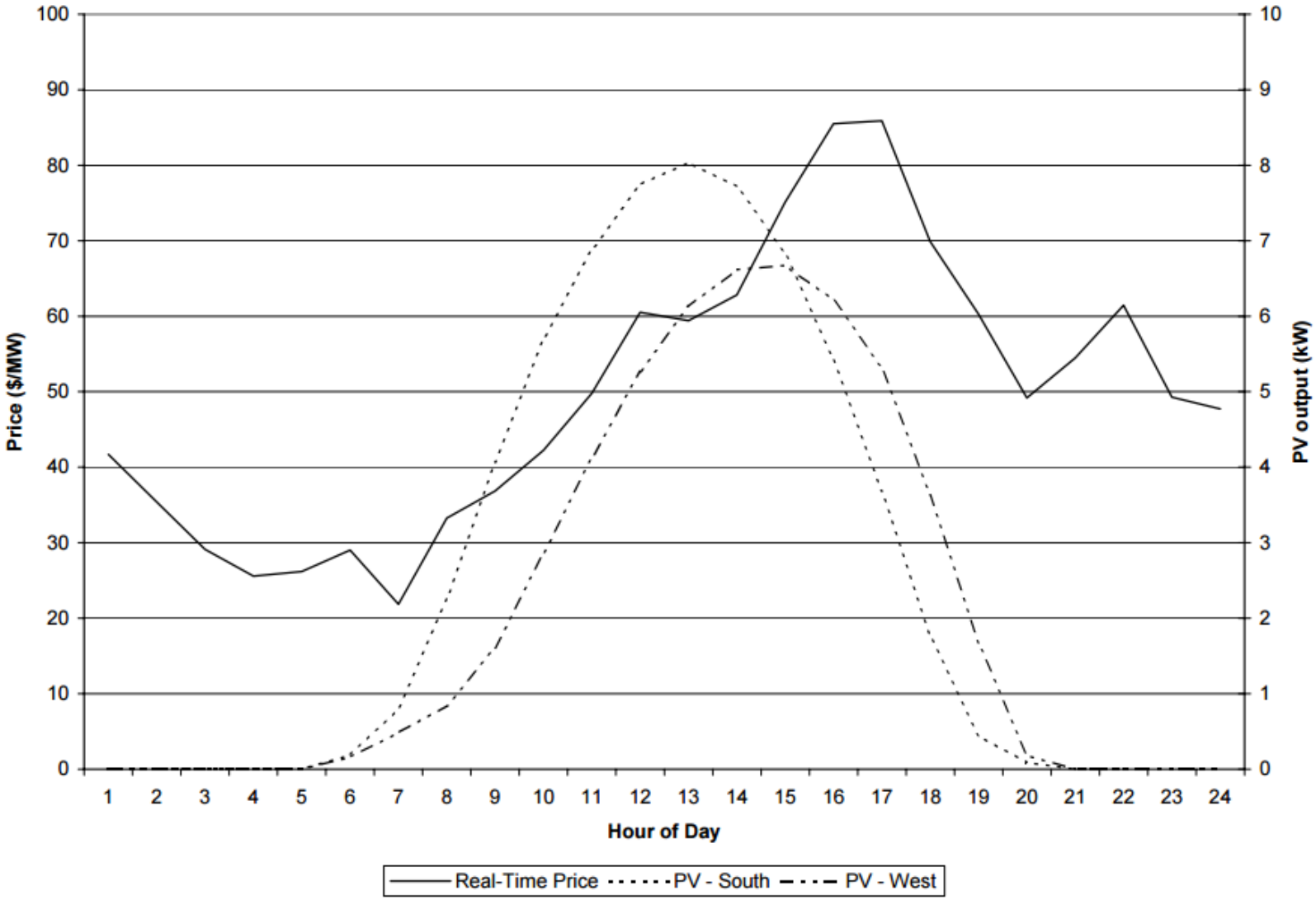
What do people think of this pricing structure?

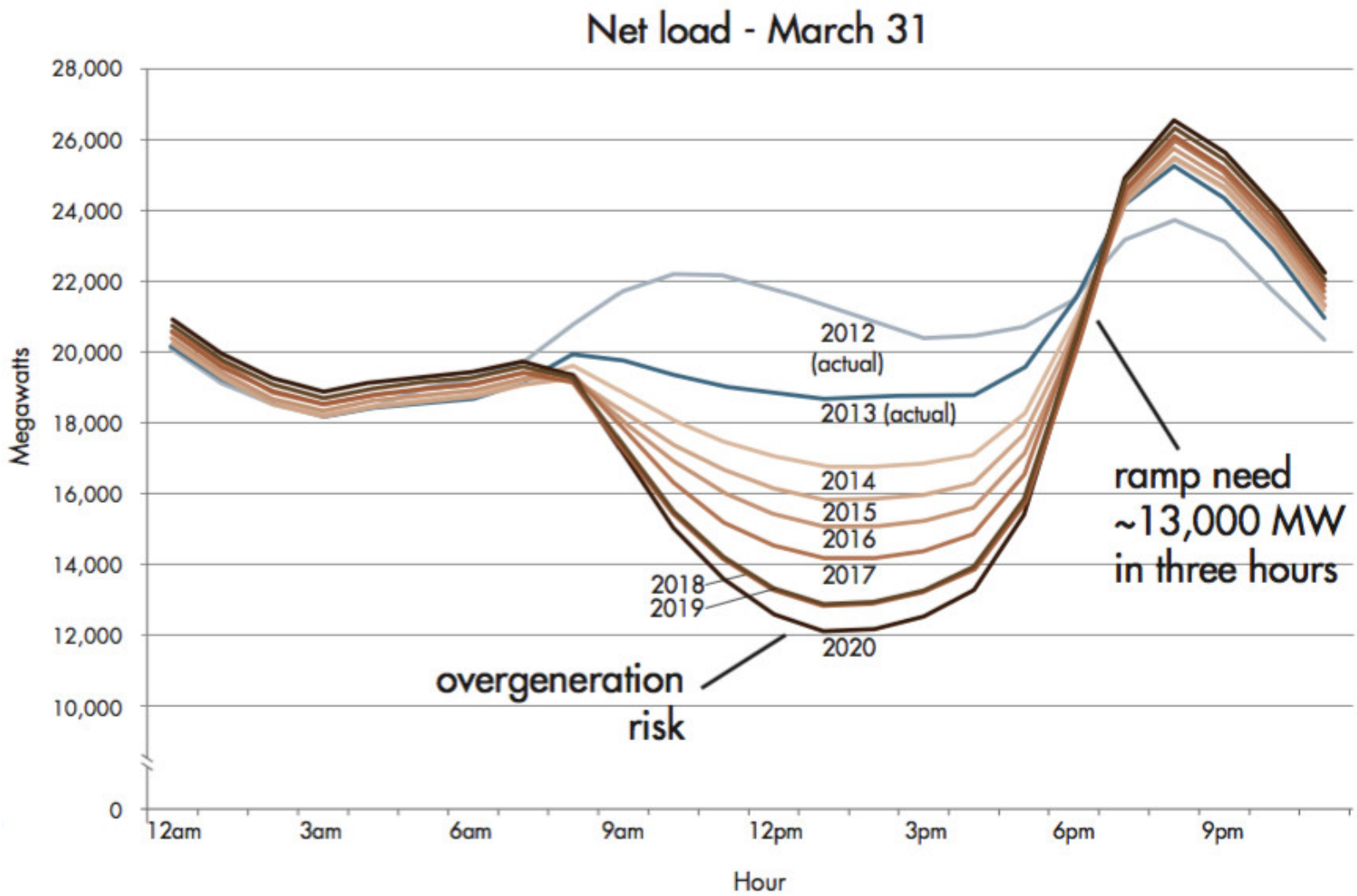
Conventional wisdom used to be that real time pricing could also encourage solar



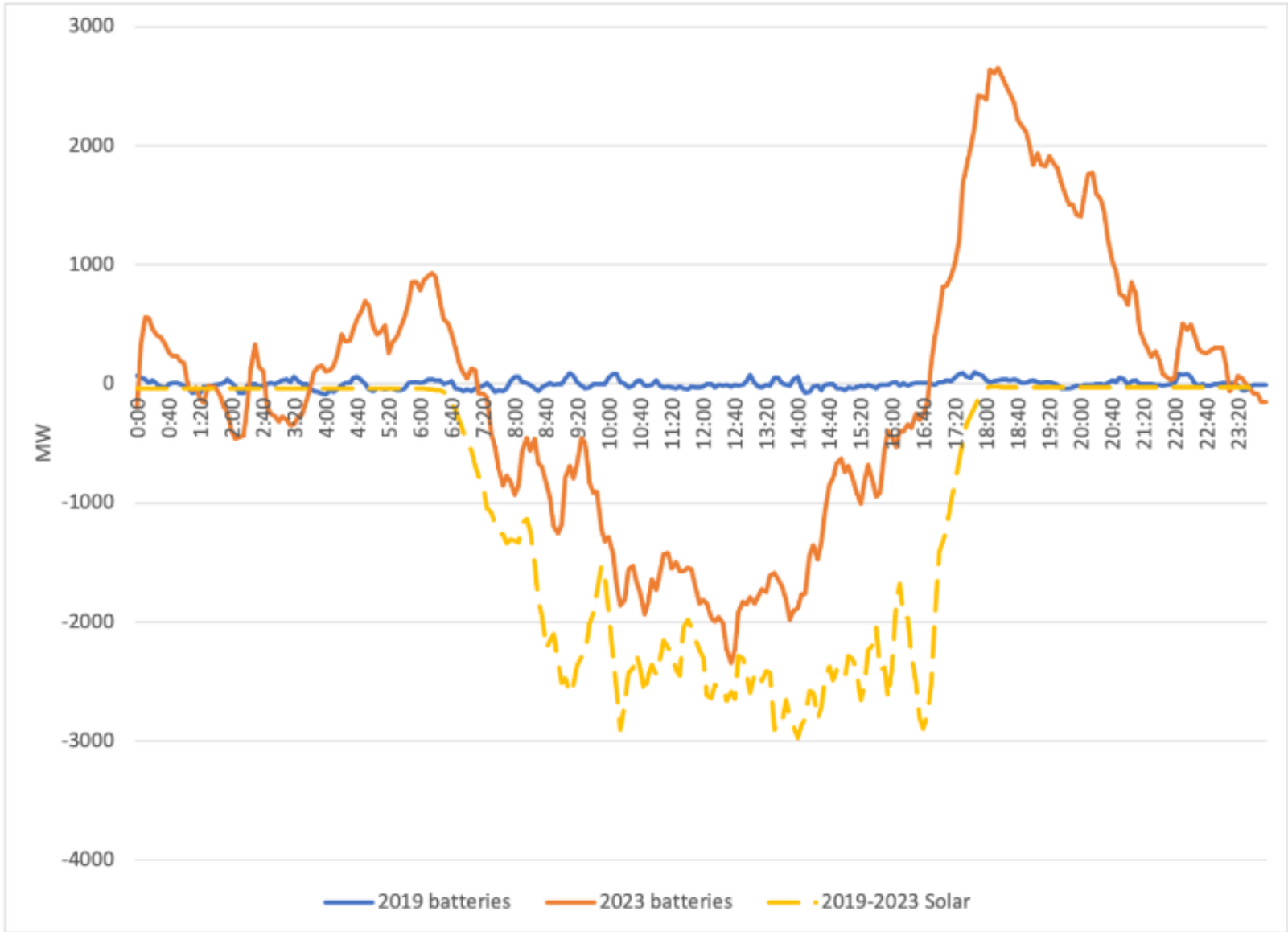
Source: Borenstein (2009)

In some places we have "too much" solar (during the day)

Figure 2: The duck curve shows steep ramping needs and overgeneration risk



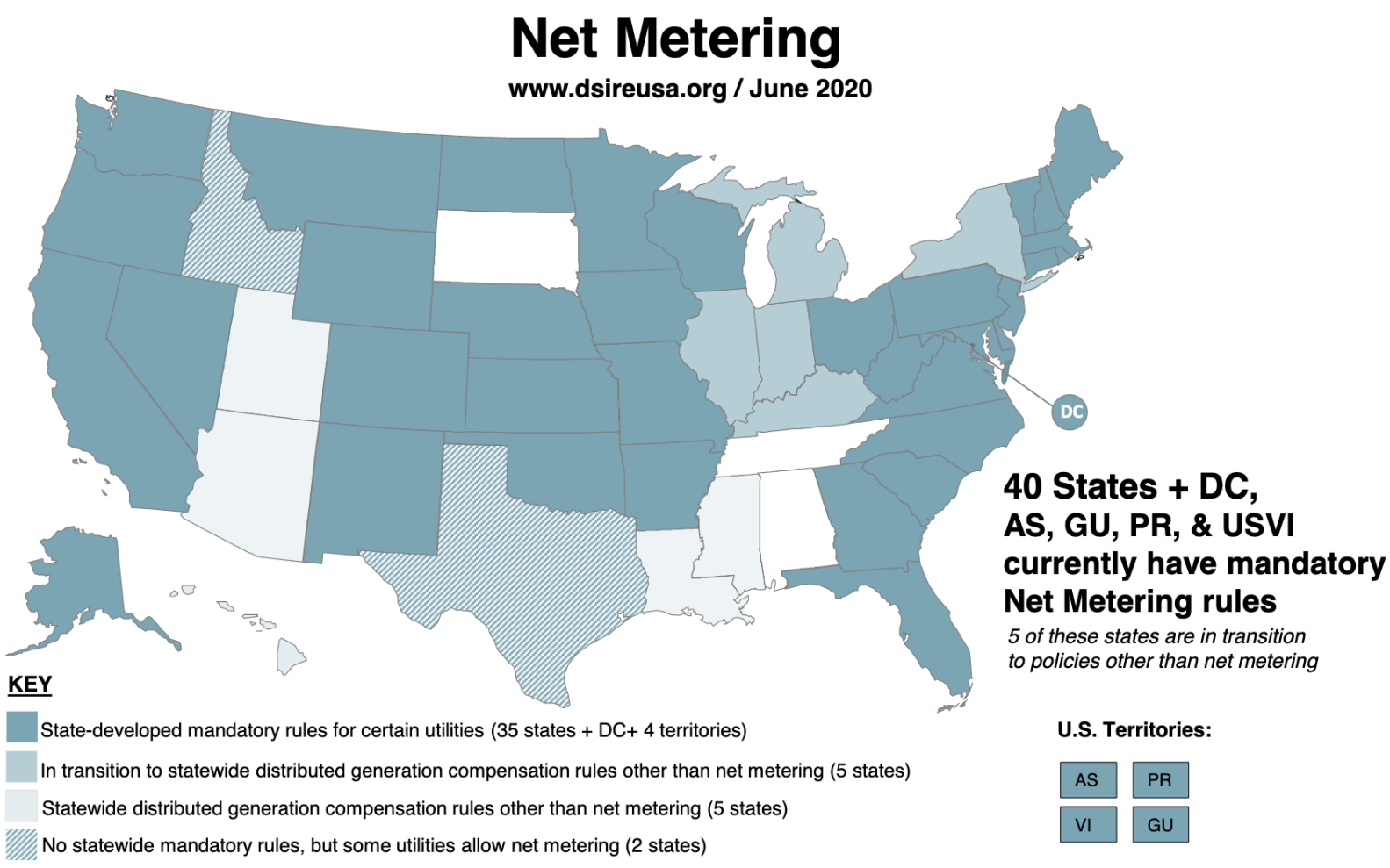
What are some solutions to the duck curve?



Another common policy is net energy metering (NEM)

- NEM allows PV owners to sell power back to the grid
- This breaks the temporal cap on solar ($s_h < e_h$)
  - Most places in the US still require $\sum_h s_h < \sum_h e_h$
- The big current policy question is what price customers should receive for their solar

44 states currently allow net metering



When customers sell solar back to the grid, what price should they receive?

- Grocery store analogy (from Severin)
- What if you showed up to the grocery store and took a zucchini, and promised to grow your own and return it some time next month?
- What price would the store manager pay you for your zucchini?
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- Probably not retail. Why?
  - they buy their produce wholesale
  - part of the price includes fixed costs
- If the utility just bills you for net energy consumption, that's like showing up to the checkout line with a zucchini

Some of the variable price on your bill covers *fixed* costs

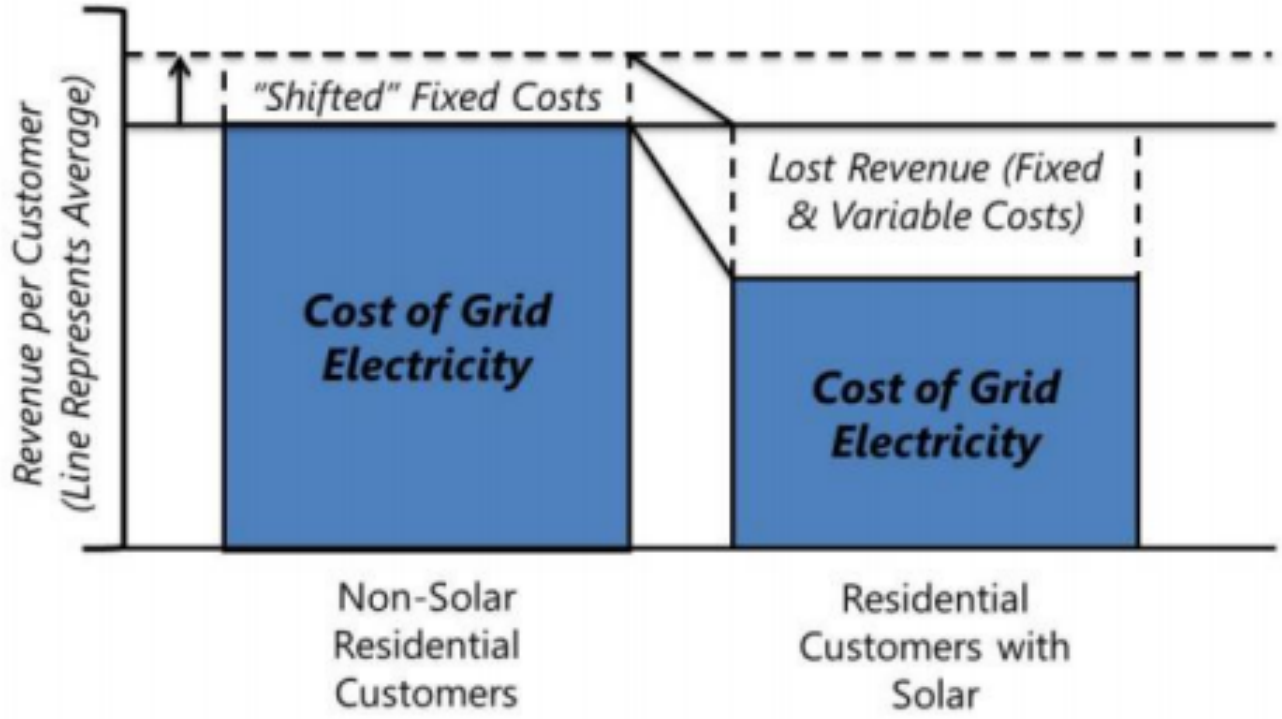
Cost of Electricity

Delivery Services				
Customer Charge				6.43
Distribution	.06681 X	565	KWH	37.75
Transition	.00227 X	565	KWH	1.28
Transmission	.02526 X	565	KWH	14.27
Renewable Energy	.00050 X	565	KWH	0.28
Energy Conservation	.00250 X	565	KWH	1.41
Delivery Services Total				61.42
Supplier Services				
Generation Charge				
Basic Svc Fixed	.10844 X	565	KWH	61.27
Total Cost of Electricity				**122.69**

THANK YOU FOR GOING PAPERLESS.

- I paid \$0.217/kWh, but only half of that was for generation.
- Fixed charges $\approx$ total system cost independent of quantity consumed, divided by anticipated sales.
- If sales decline, prices actually go up....

As PV owners buy less electricity, the burden of those fixed costs will be shifted onto other households



Source: Kennerly et al., 2014[10]

- That increase in prices will incentivize even more households to install PV.....
- This is known as the utility "death spiral"

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- If you start a garden, the grocery store still drops off a bill every month to the option to buy fresh produce
    - sidenote: analogies are almost never useful when analyzing policy

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- If you start a garden, the grocery store still drops off a bill every month to the option to buy fresh produce
  - sidenote: analogies are almost never useful when analyzing policy
- Of course this would also be regressive/ unjust
- Another option is to charge customers a minimum bill
- But this is equivalent to a policy that charges a fixed charge and gives everyone a set amount of electricity for free
  - Either the fixed cost is small, and irrelevant
  - Or its large, and encourages low-use households to use more electricity

So what's the answer?

How should we compensate / encourage solar PV?

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How should we compensate / encourage solar PV?

- efficient solution would
  - charge a fixed fee for everyone that uses (or may use) the grid
  - incentivize people to reduce consumption at times when it is more valuable
    - but that value is the wholesale price
- pricing externalities makes subsidizing solar irrelevant

Editorial: California can't enact a 'solar tax' and still be a climate leader

A crew installs solar rooftop panels on a home in Watts. (Gary Coronado / Los Angeles Times)

Summary on Solar

- Solar value proposition closely related to subsidies, sun, and the price you pay for electricity.
- Subsidies have been generous, not obviously correlated with social value, and very volatile.
- Letting people sell back to the grid makes sense, but at what price?
- When large parts of the population install solar, we need to rethink how we cover the fixed costs of a reliable power system.