NREL Transforming ENERGY

Efficiency and Load Flexibility: What's the Right Mix?

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Getting to Zero Forum
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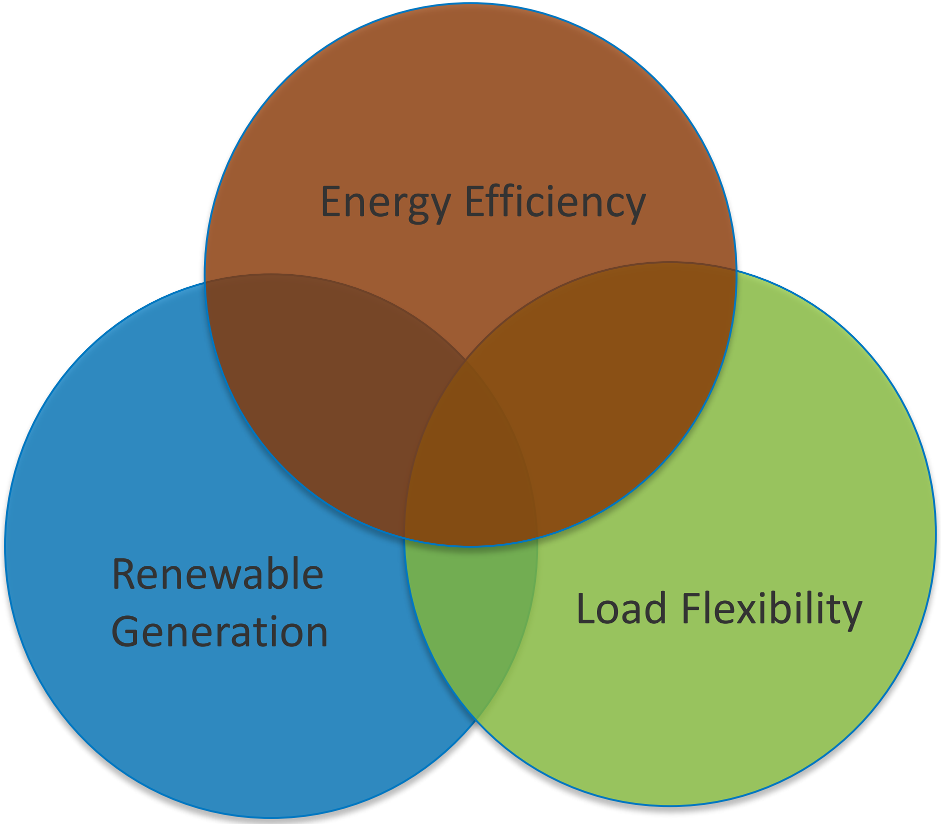
Is There Overlap?

Is one more important than another?



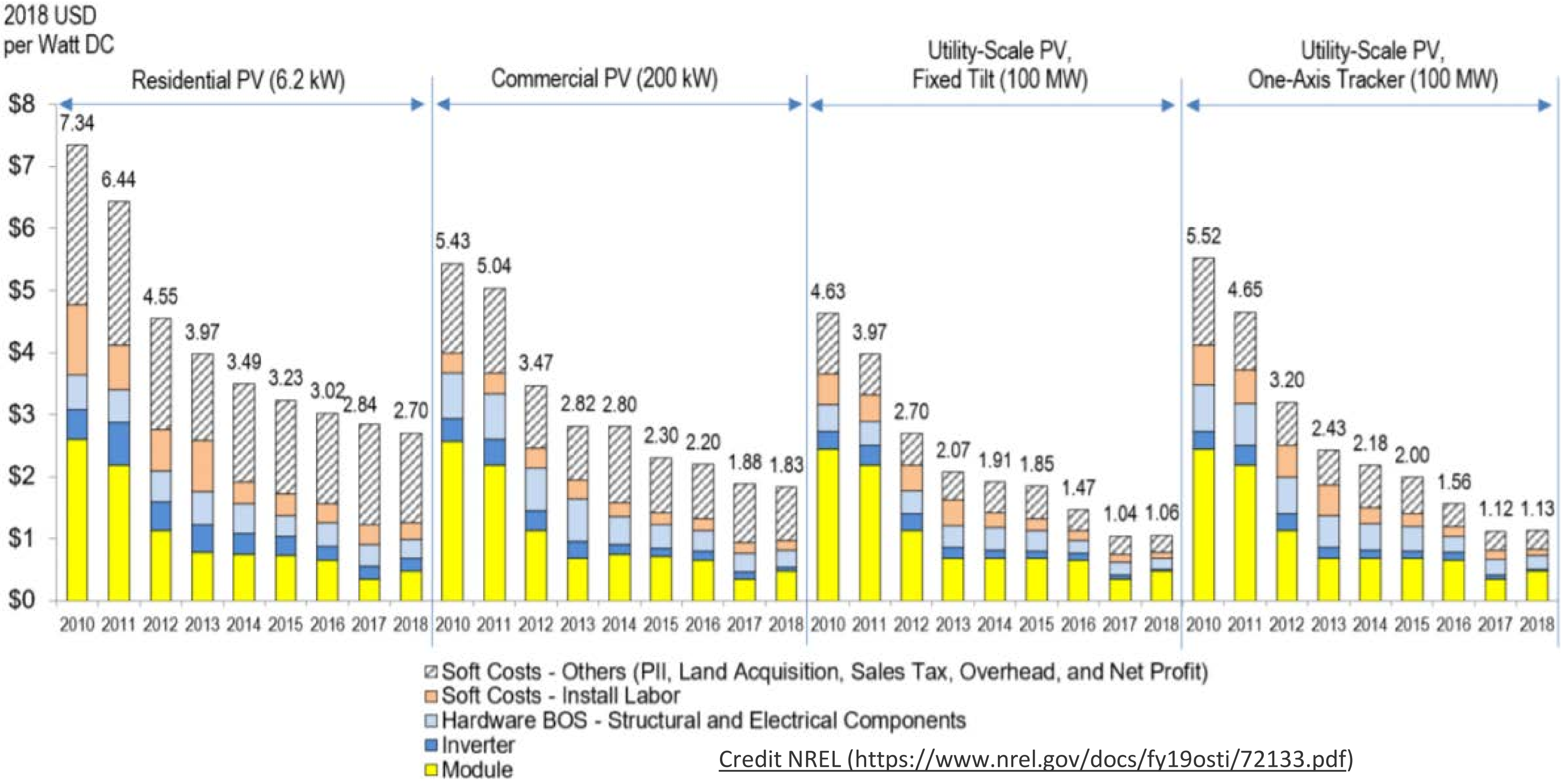
How Times Have Changed…

1995 Off-grid House

2000-First Net Meter in Utah

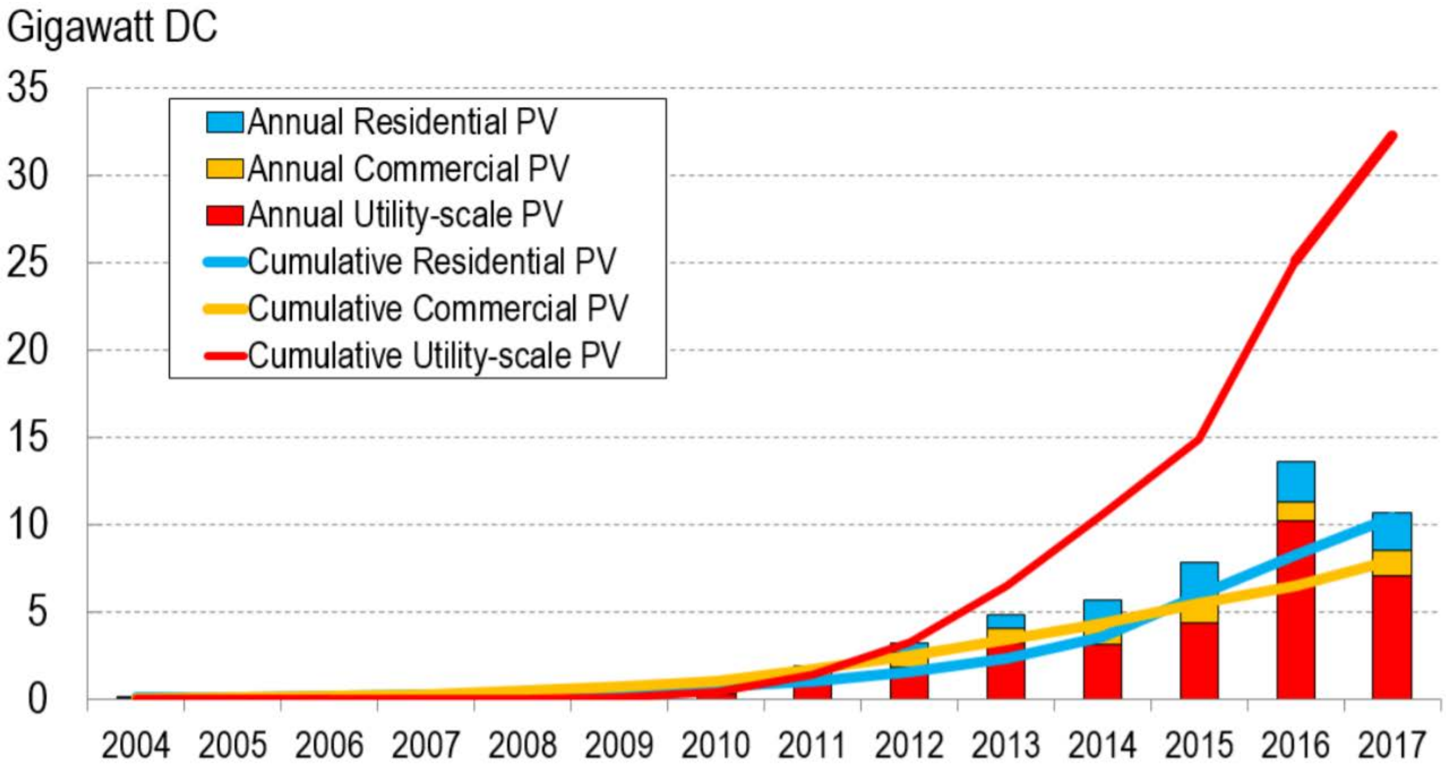
2010-Large Scale Utility PV

10-Year PV Installed Costs



Credit NREL (https://www.nrel.gov/docs/fy19osti/72133.pdf)

PV Growth



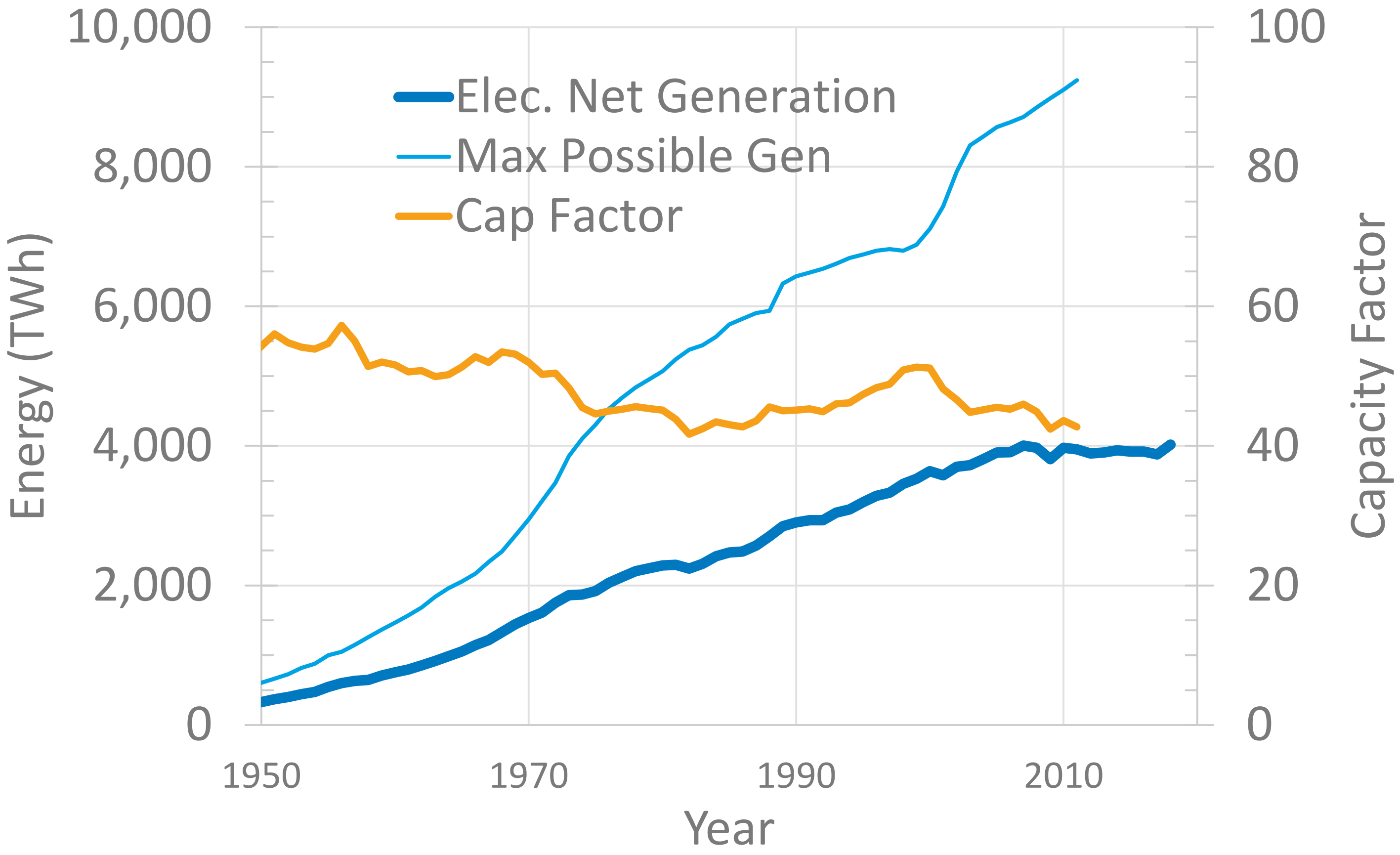
Gigawatt DC
35
30
25
20
15
10
5
0
Annual Residential PV
Annual Commercial PV
Annual Utility-scale PV
Cumulative Residential PV
Cumulative Commercial PV
Cumulative Utility-scale PV
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

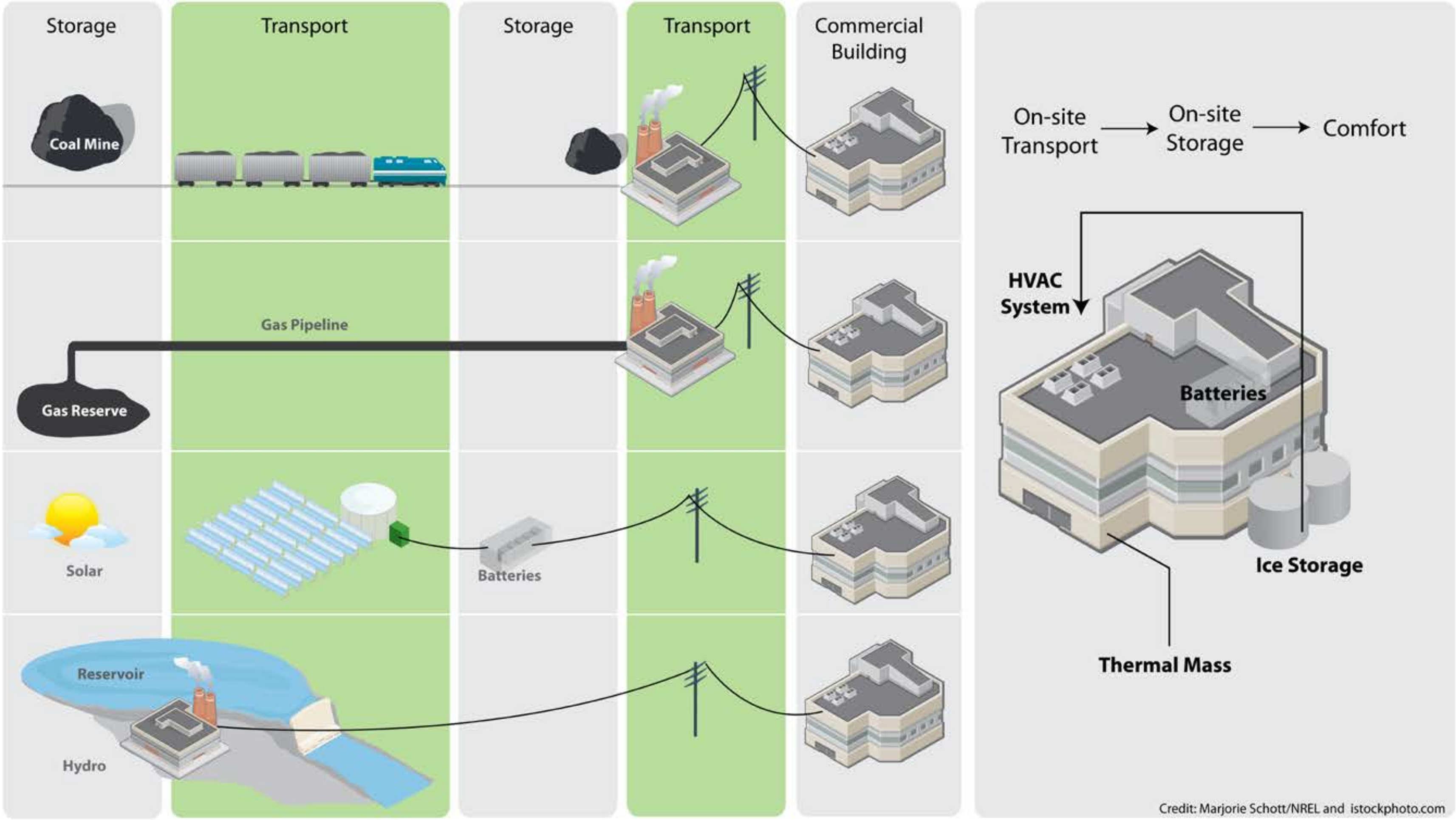
What has changed (or is changing)?

- Grid looks the way it does because of how buildings (and other end users) use electricity
  - Who was "willing" to make the investment
    - Today's replacement cost is approximately $5T (US Grid)
    - $15,000 for each member of the US Population

- It is all about where the storage is located?

Capacity Factors




Storage
Transport
Storage
Transport
Commercial Building
Coal Mine
Gas Pipeline
Gas Reserve
Solar
Batteries
Reservoir
Hydro
On-site Transport
On-site Storage
Comfort
HVAC System
Batteries
Ice Storage
Thermal Mass
Credit: Marjorie Schott/NREL and istockphoto.com

Buildings are…

- The peaks are getting bigger, the valleys deeper.

Storage

- All systems need storage for reliability.
  - Weak link is the transfer from the storage to the end user.
- Closer the storage is to the end user, the more reliable
  - The more links, the more chances for something to go wrong
- Nature tends to distribute its storage

Load Flexibility

- Demand Response
- Three Options
  - Charging/discharging a storage element
  - Loss of service (or reduced service)
  - Inefficiency

The Building Footprint

- How much land resource is needed to power a building?
- If you don’t want the footprint to exceed the building, need to balance the energy received with the energy consumed.
- We have enough roof area to power this country

Zero Energy Building (ZEB) Definition

An energy-efficient building, where on a source energy basis, the actual annual delivered energy is less than or equal to the **on-site** renewable exported energy.

Boundaries

- Building
- Site
- District
- Community
- Town/city
- State
- Nation??

A Story…

- Total house energy consumption 10 MWh/year. All electric.
- PV production on the roof 10 MWh/year.
- Grid connected—my net meter cost is $120/year
- I export 87% of the energy produced on site and buy it back "later"
- 13% is used immediately in the house.
  - This is an important metric

Example, Continued

- I need storage of 4 MWh on the grid—which I currently pay $120/year for.
- Cost of this battery would be $2-4M and would fill a 40-foot shipping container

- If I double my PV and shed the excess (i.e. the utility won't buy it), my battery size would decrease 75% and the PV cost increase would be $7500.

Example #2 - Still My House

- Heat pump hot water heater 80-gallon tank
- Better COP's when it is hotter outside (1 kW to 2 kW draw)
  - Rather than 5 kW draw
  - Can match the PV with the 5 hours/day of runtime
    - Which uses less energy than running at night
    - 3 MWh annually or $2500 in PV panels

Solutions

- Storage can
- What can always be done at a building.
- Battery in the building… smart battery/storage
- Thermal storage always feasibility
- Thermal mass of the building (really a ratio of the thermal mass and the resistance of the building)
- Control system to manage charge and discharge efficiently.
- Rate schedules are not always conducive to end goals.
- Owners cannot make decisions based on variable rates (i.e. real time (or dynamic) pricing.
- Many more points of optimization and control the further downstream.
- How much energy does it take to save 5 W???

Observations

- Blurring of the lines between efficiency, renewable energy, and storage
- Need the right long-term economic drivers to make change
- To get building designers and owners to change—metrics need to be simple and easy to understand (and tied to costs) Note: we struggle with TOD and demand charges!
- Storage in many forms helps the flexibility and the penetration of renewables and the ability to increase efficiency
- Answer: We need them all!

Questions

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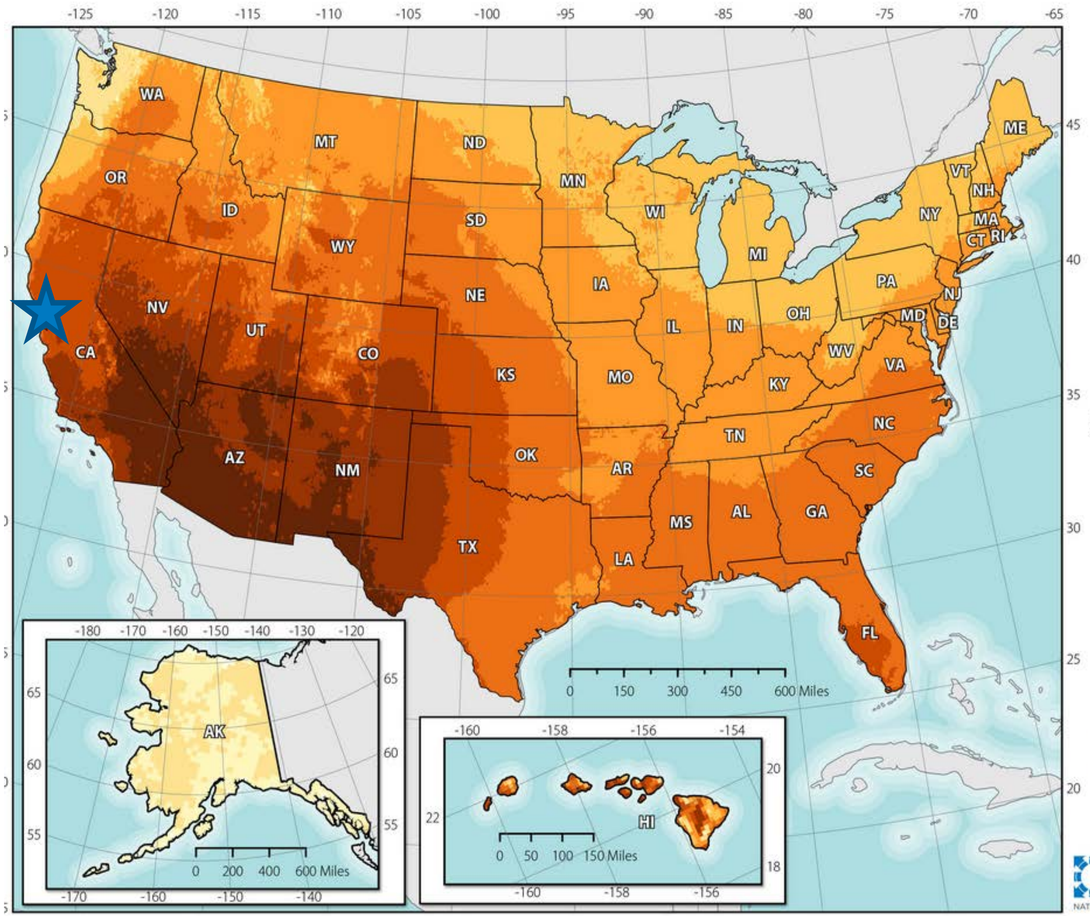
PV Development

- In 2016, PV accounted for the largest segment of development on undeveloped land in CT.
  - Farms and forest
  - Just over 1500 acres
  - While it is discussed that solar farms “borrow the land” for 30 years
    - It is an industrial process—will it return to farmland/forest?
    - What will replace this capacity of you “get rid of the PV”?

Site energy use intensity targets to meet the available rooftop PV annual energy production (75% roof PV, 2 floors)



Site EUI (kBtu/ft²/yr)

44
41
37
34
31
28
24
21
18

Assumptions:

- 75% of Roof area available for PV
- 2 floor office

Storage to End User

- Power plants “were” a cheap way to move storage energy to a building exactly when it was needed
  - “Easy” to ramp up/down
- Renewable energy “was” expensive—the mindset is that you must maximize its output because of high capital cost
  - The storage is sitting at the sun—the reliability is the ability to harness that energy.