

Capacity Credit, PRM, and the ERP

a reliability story

With Zen Buddhist Quotes

...now begins your training...

If your mind is empty, it is always ready for anything, it is open to everything. In the beginner's mind there are many possibilities, but in the expert's mind there are few.

Energy Resource Plan

- Any future look must pass two metrics
 - Does it reduce carbon by 80% by 2030?
 - Is there **firm capacity** in excess of the **Planning Reserve Margin**?

Not to exceed
5.5M* tons CO₂

Firm
Capacity of
8.5 GW**

We are going to spend
on time on this...

*Carbon accounting is complicated, especially when the baseline emissions includes big customers that will no longer be a PSCo customer by 2030. And then there's sales and purchases. Who's responsible for those? And beneficial electrification – can we get a credit please??? I'm not even going to try to describe this here. Ask Lauren Quillian...

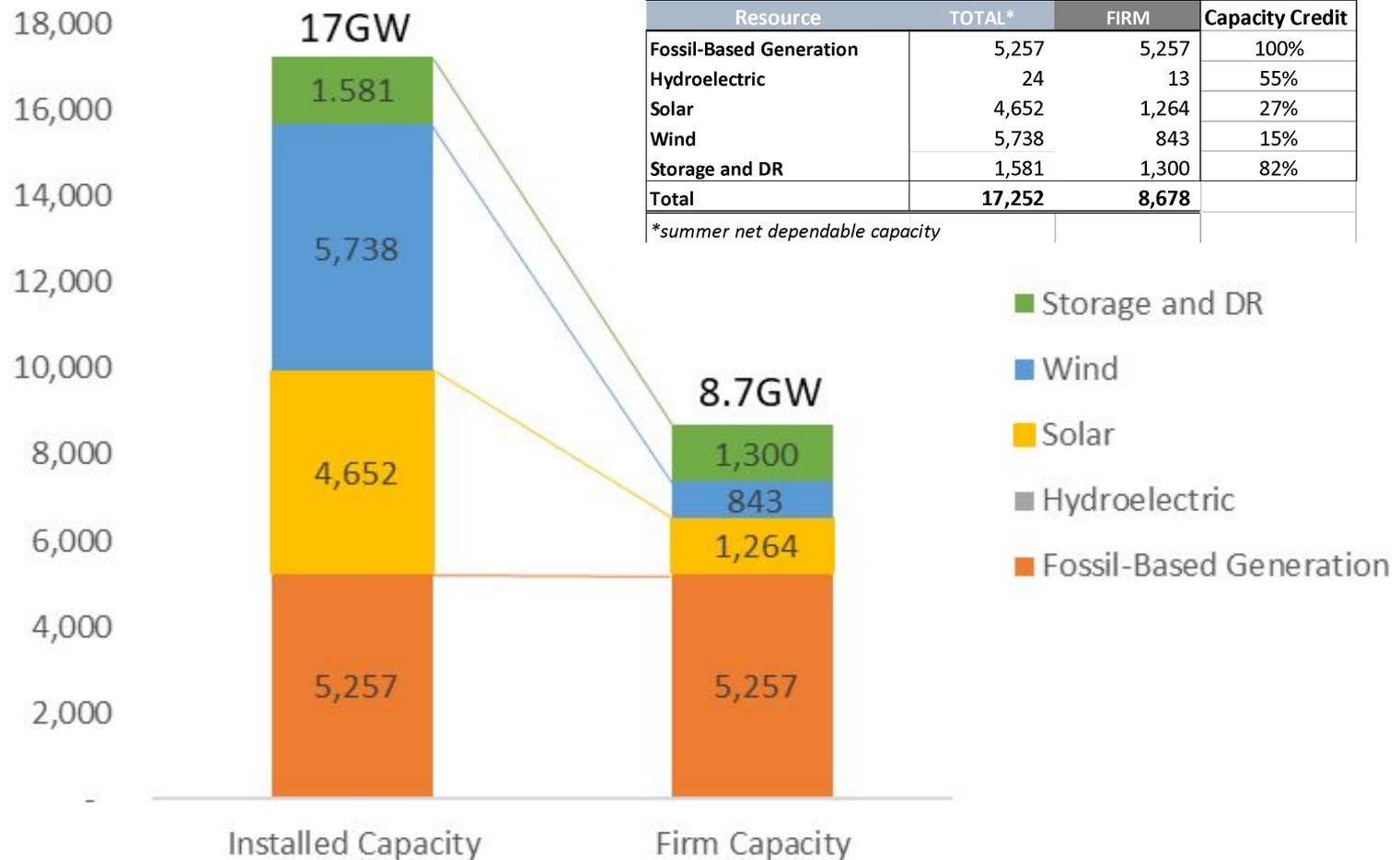
**The Planning Reserve Margin is 18.0%. 2030 forecasted peak load is 7,219MW. Therefore, firm capacity must be in excess of 8,518MW (i.e. Firm Capacity = (1 + PRM) * Peak Load). This isn't the exact number, but it's *real close* and the nuance will only confuse this conversation.

Planning Reserve Margin

- The amount of **firm capacity** required to meet the reliability metric (1 event in 10 years)
 - A *reliability model*, like E3's RECAP, or Astrape's SERVVM, considers load/wind/solar variance, unit outages, and market access to calculate a MW value that ensures reliability = 1 in 10 standard.
 - The studies identify a *MW value*, but is often (always?) expressed as a percentage above peak customer demand (e.g. 18%)
 - Okay, if you have distinct peak season.
 - problematic if this changes, for example...
 - *Lots of* winter loads (heating loads)
 - *Lots of* summer-only or summer-dominant resources (aka solar).

Firm Capacity

PSCo 2030 Preferred Plan



Capacity Credit

- The amount of the installed capacity that counts as firm capacity, often expressed as a percentage (firm/installed) *like this*

- Could be a rule of thumb (4hrs = 100%)
- Regulatory designation
- Approximate Generation Method
- **Effective Load Carrying Capability (ELCC)**
 - This is the gold standard

Resource	TOTAL*	FIRM	Capacity Credit
Fossil-Based Generation	5,257	5,257	100%
Hydroelectric	24	13	55%
Solar	4,652	1,264	27%
Wind	5,738	843	15%
Storage and DR	1,581	1,300	82%
Total	17,252	8,678	

*summer net dependable capacity

ELCC is a mathematical method for determining a *reliability-based* capacity credit

Reliability

Planning
Reserve
Margin



Capacity
Credit

The PRM and Capacity Credit are interwoven in high energy-limited resource systems

Energy-limited resources = Wind, Solar, Storage, DR, Emission Limited Plants

Capacity Credit for Energy-Limited Resources

Use of ELCC in the PSCo ERP

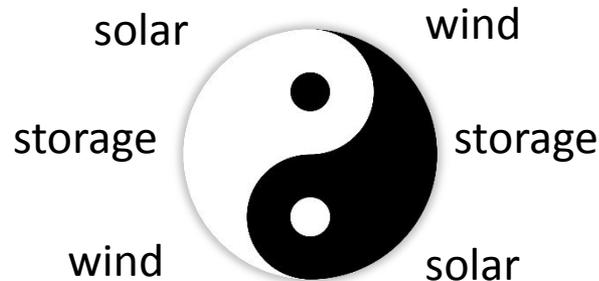
If something is boring after 2 minutes, try it for 4. If still boring, try it for 8, 16, 32, and so on. Eventually, one discovers that it is not boring, but very interesting.

The Dataset

- Effective Load Carrying Capacity...
 - Thermal generation capacity, scheduled outages, EFORs
 - Hourly load and renewable generation for six annual periods (2014-2019)
 - Hourly DR and storage dispatch to maximize LOLP reduction.
-

Like effects Like

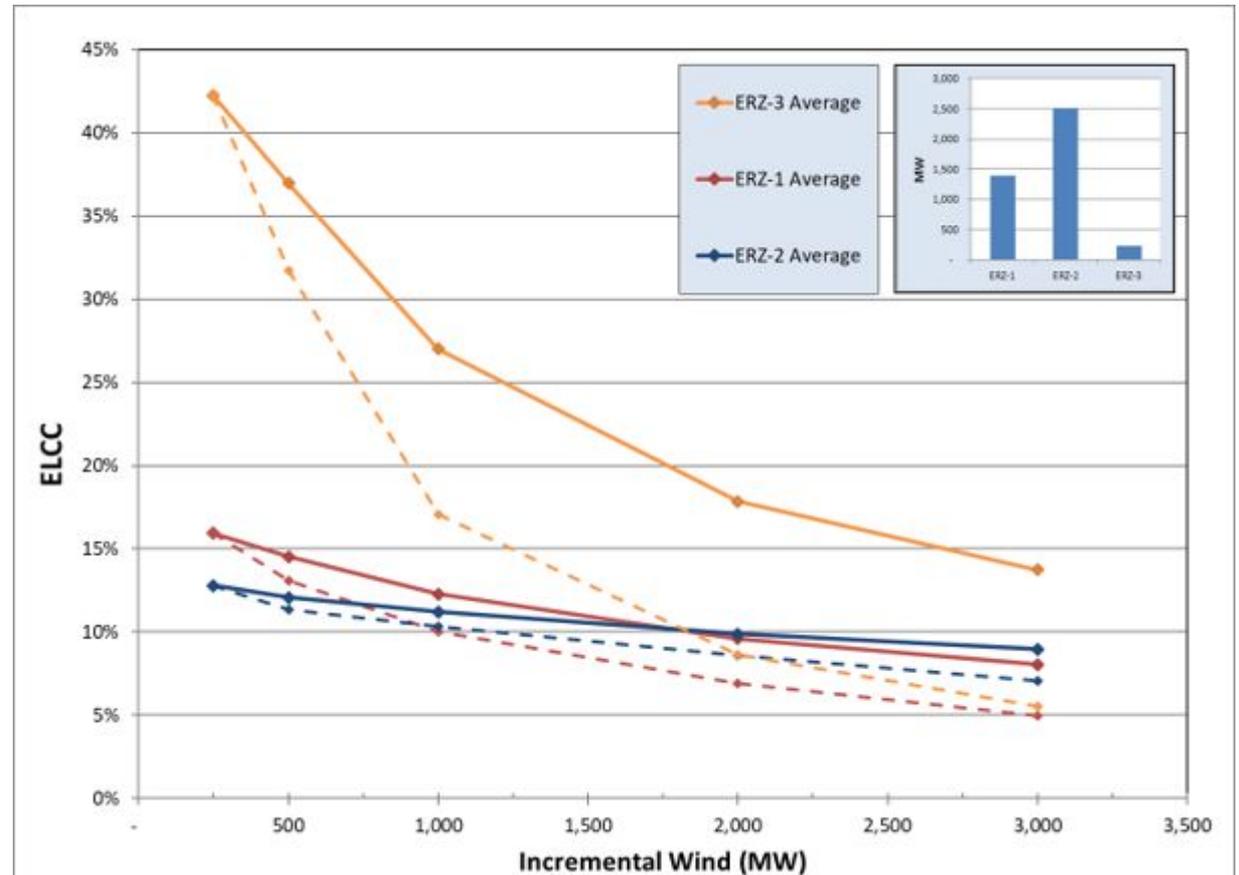
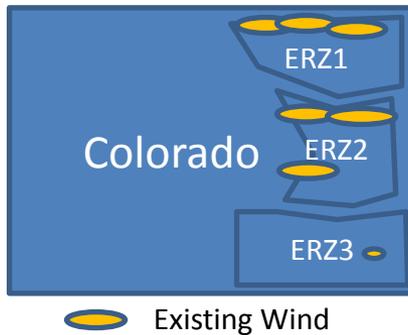
Hint: ELCC changes with increasing penetration of like resource



Diversity Matters

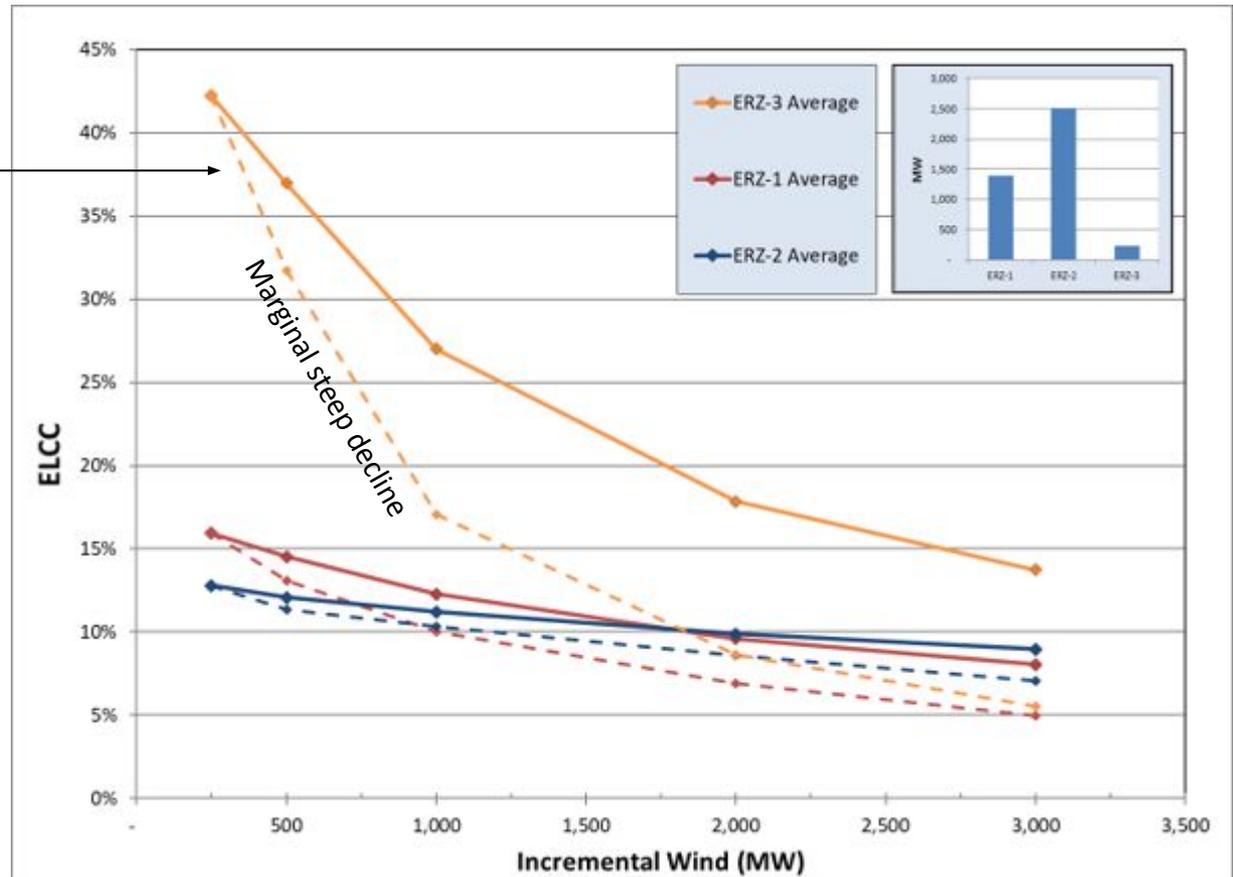
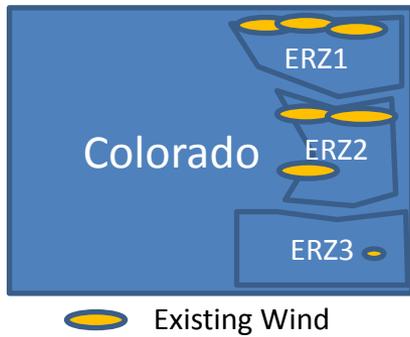
Hint: RE sited in the same location drives down ELCC faster than a geographically diverse portfolio.

Incremental Wind



Incremental Wind

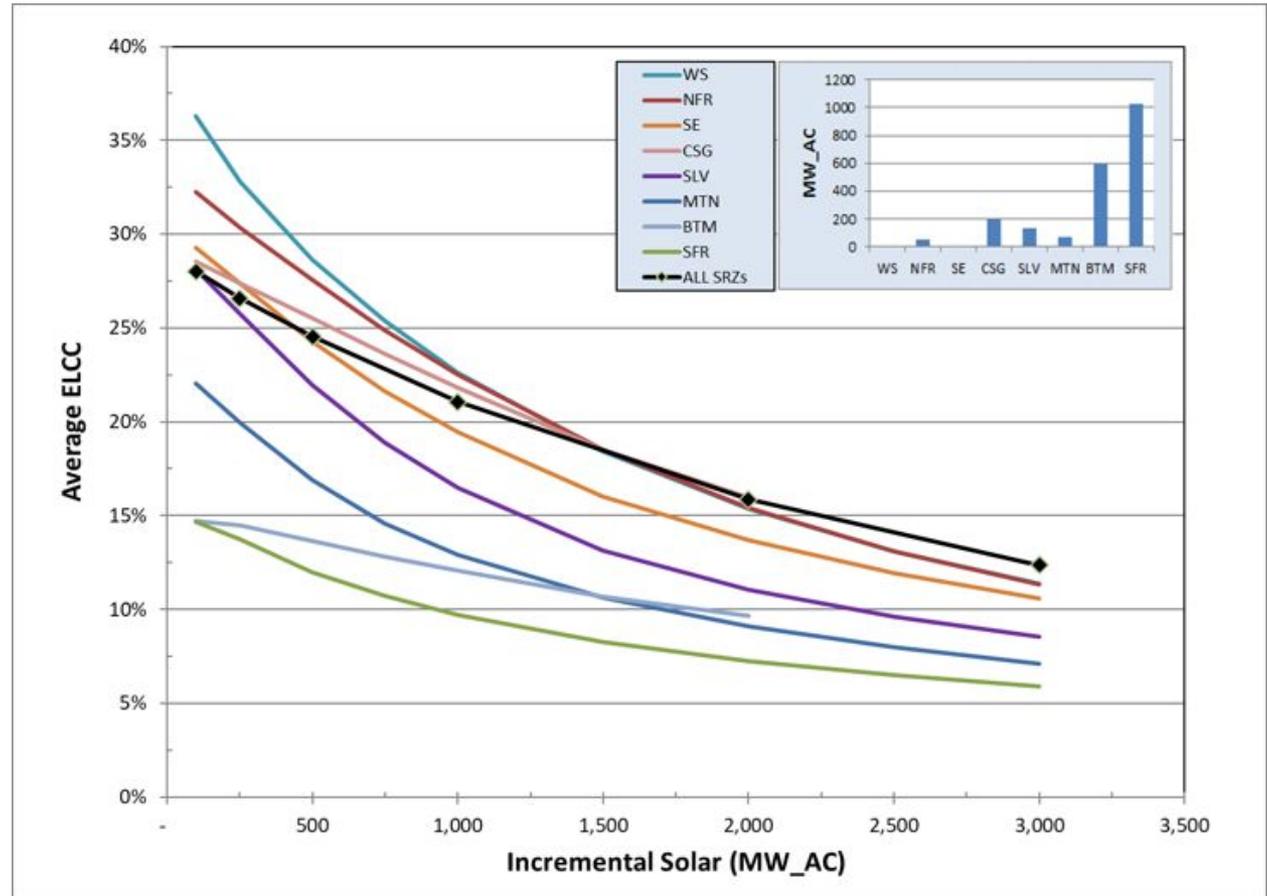
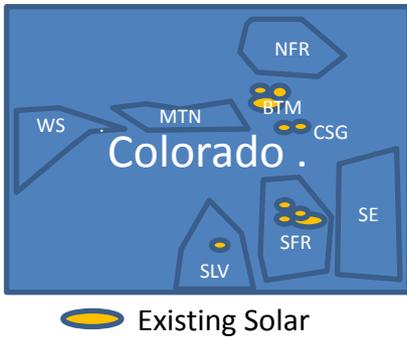
ERZ3 – Diverse! Unique! HIGH



More Wind = Declining ELCC →

How wondrous, how mysterious! I carry fuel, I draw water.

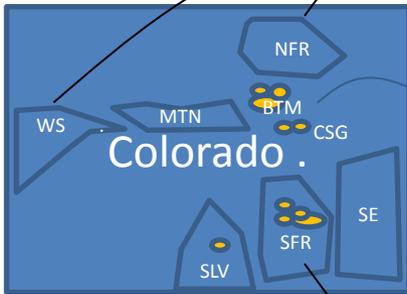
Incremental Solar



Incremental Solar

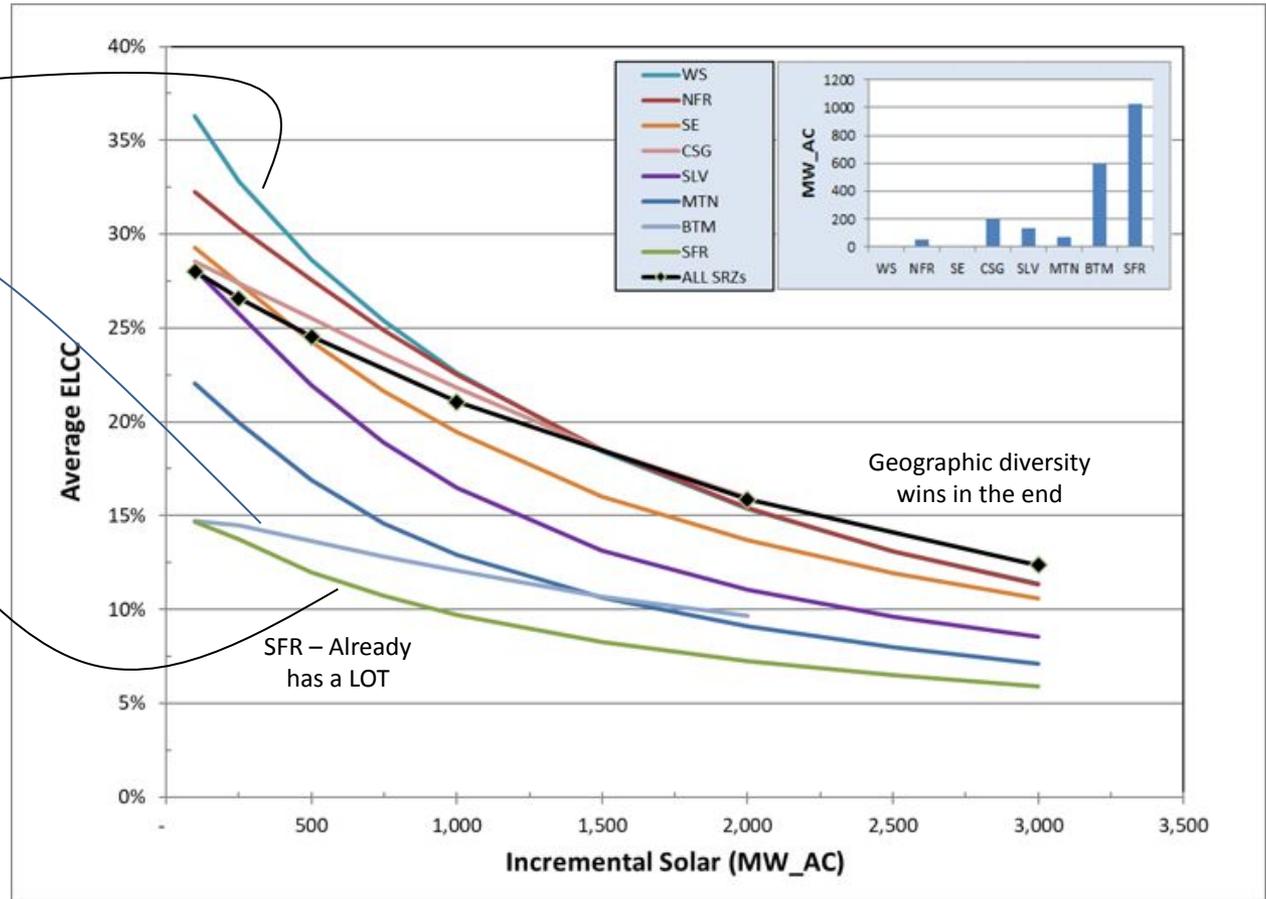
WS/NFR – Diverse! Unique!

HIGH



Existing Solar

BTM (behind the meter)
– Concentrated in Denver
Metro area; technology
disadvantage (fixed pane)



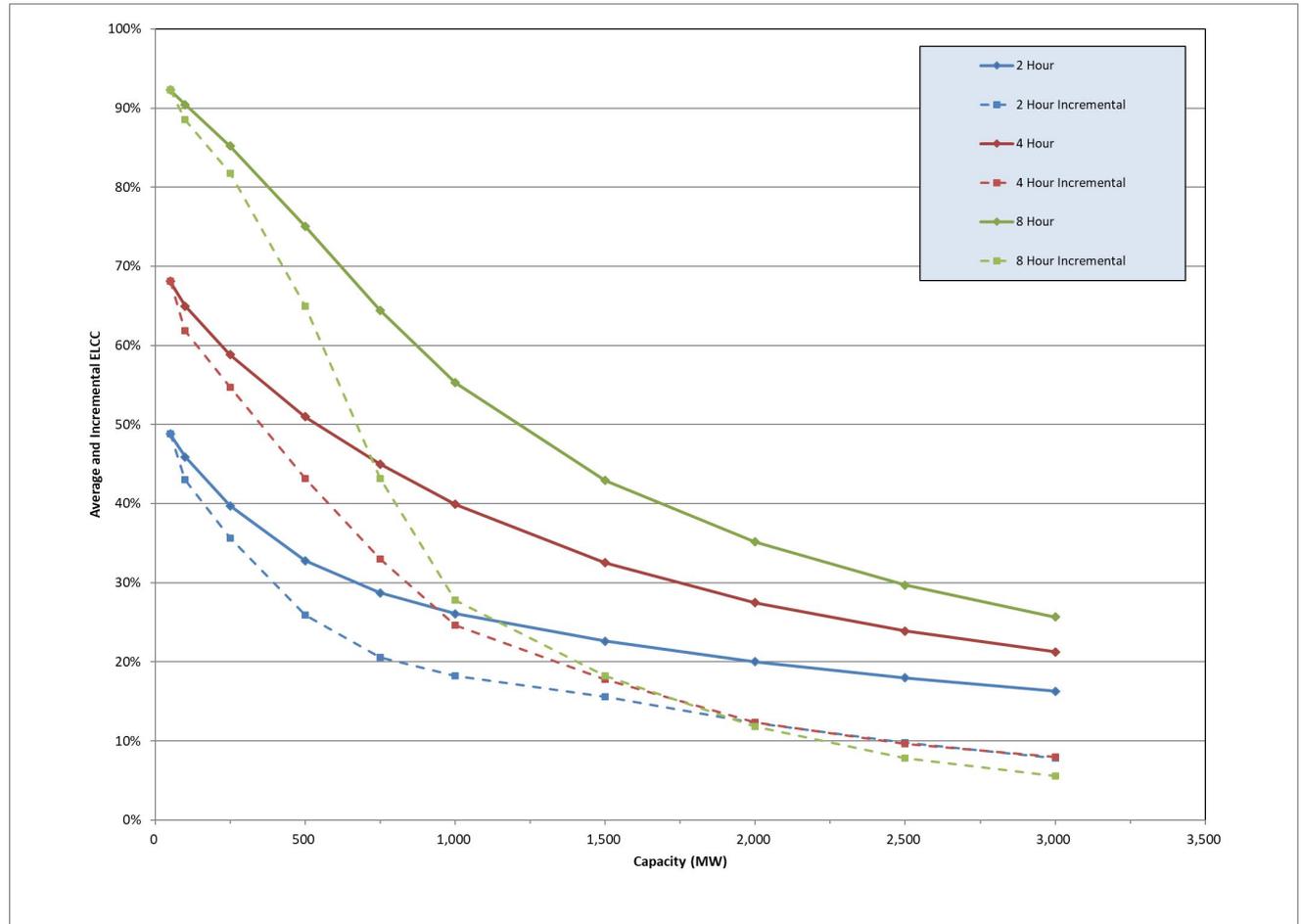
Geographic diversity
wins in the end

SFR – Already
has a LOT

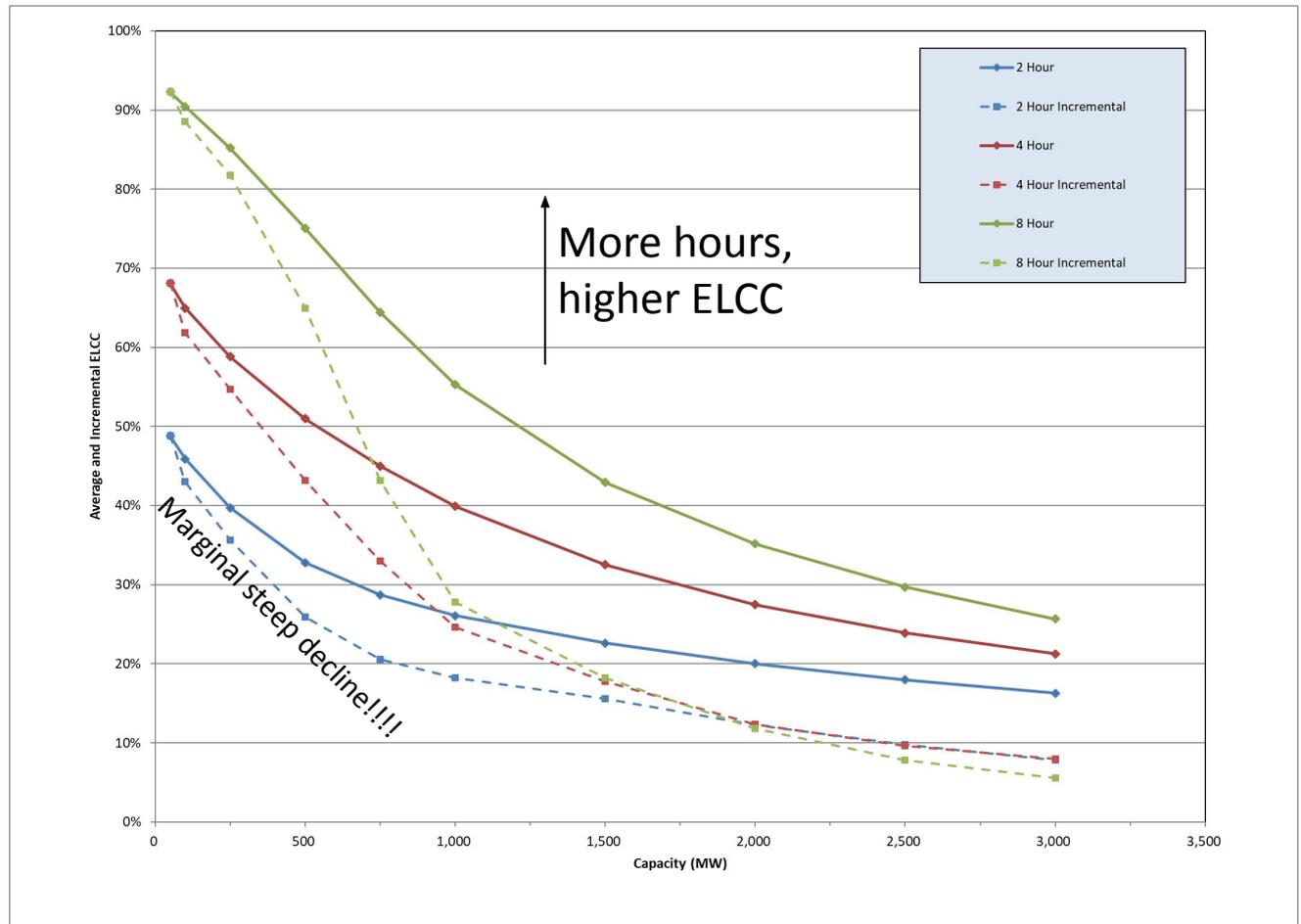
More Solar = Declining ELCC →

If you understand, things are just as they are...If you do not understand, things are just as they are..."

Incremental Storage



Incremental Storage



More Storage = Declining ELCC →

Incremental Storage

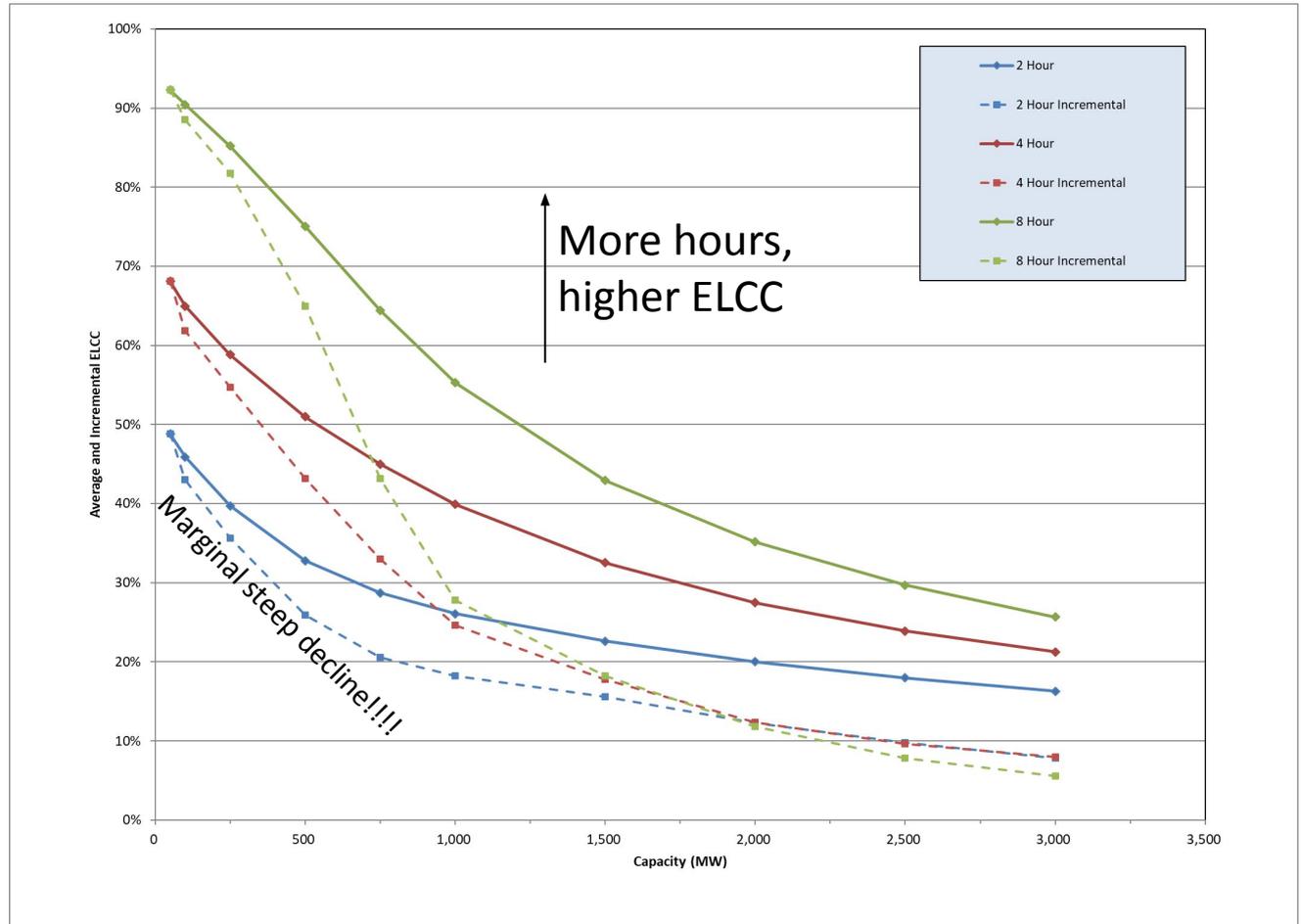
Storage is complicated by penetration of other resources – especially DR and Solar

solar



DR

storage



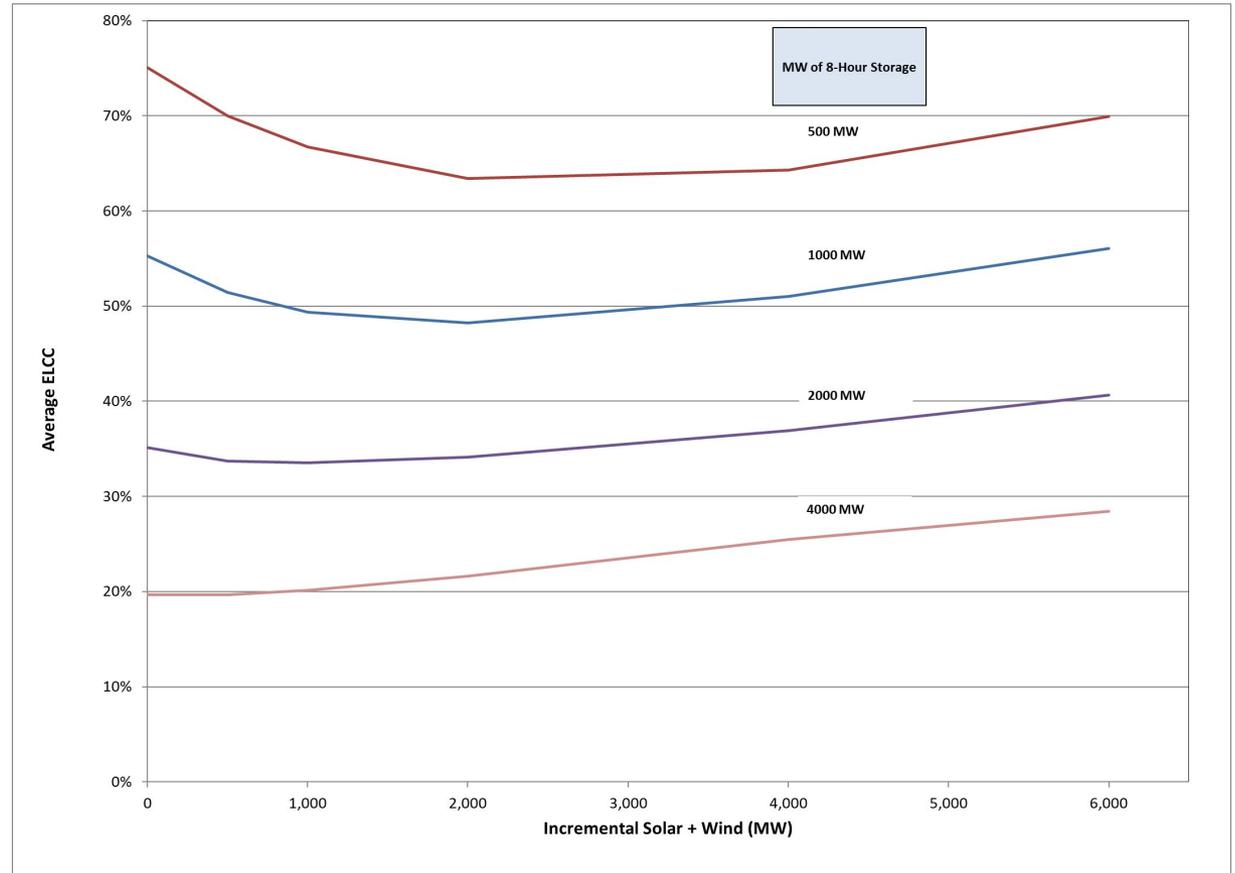
More hours,
higher ELCC

Marginal step decline!!!!

More Storage = Declining ELCC →

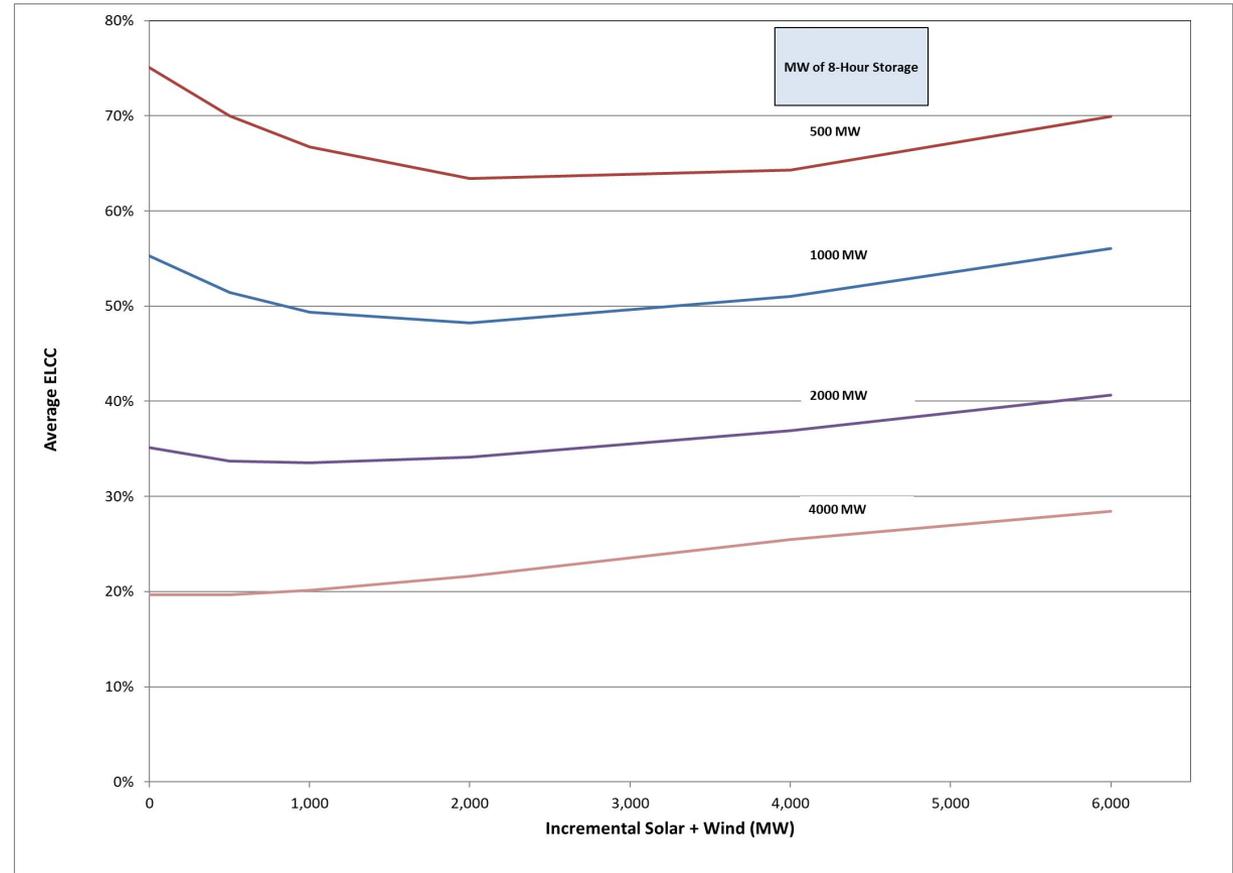
Let go, or be dragged

The Whole Tamale



Solar Effects Storage

More Storage = Declining ELCC



More Solar = Increasing ELCC!



Not shown:
DR competes directly
with storage to
provide capacity in
the highest value
hours.

More DR = Decreasing ELCC for Storage

Pop. Mind blown.