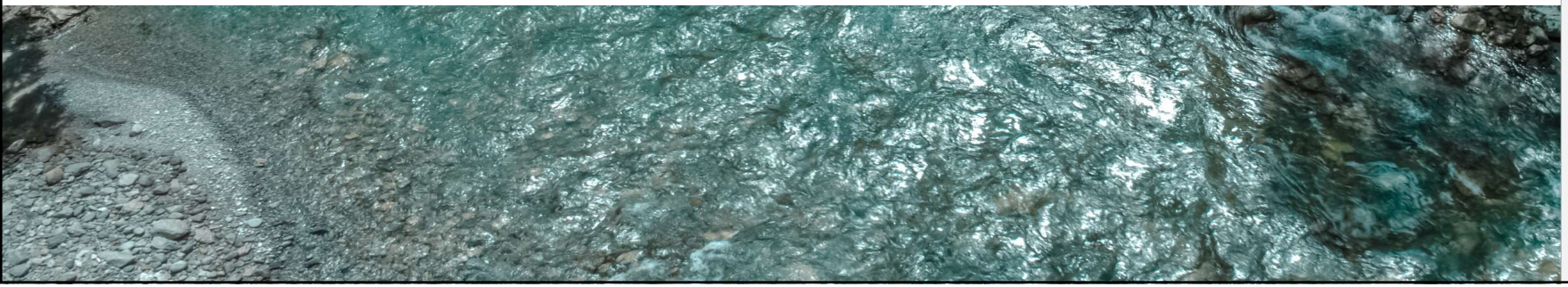
Research Agenda: Where are we going? (Some things we do and don't know)

Nick O'Miller
HickoryLedge



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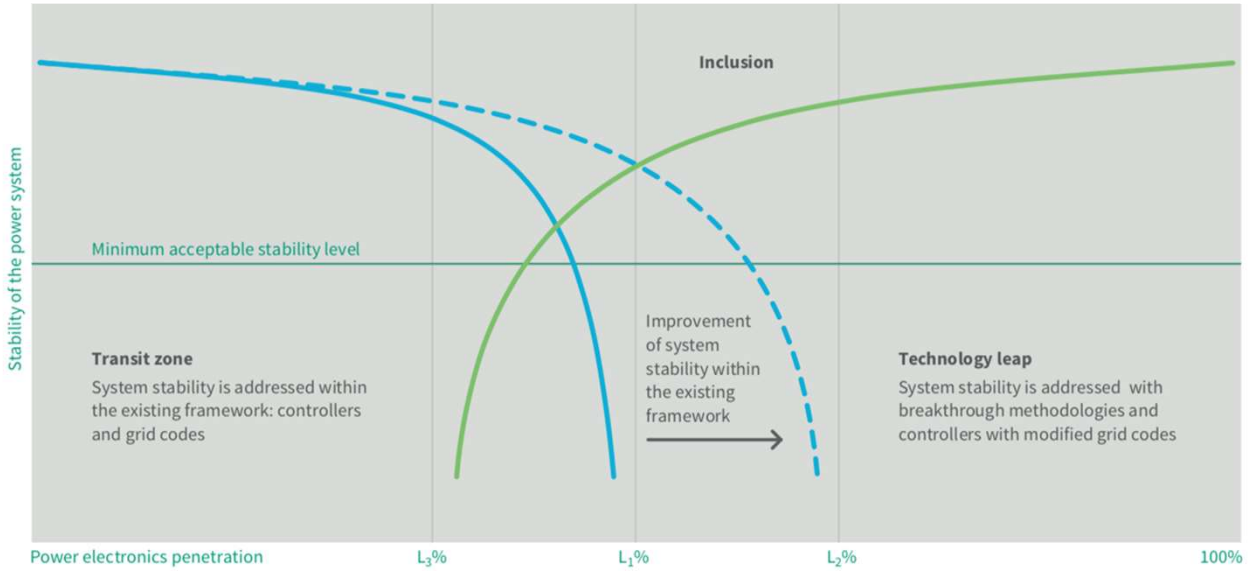
ESIG
ENERGY SYSTEMS INTEGRATION GROUP

You can’t get there from here without a paradigm shift



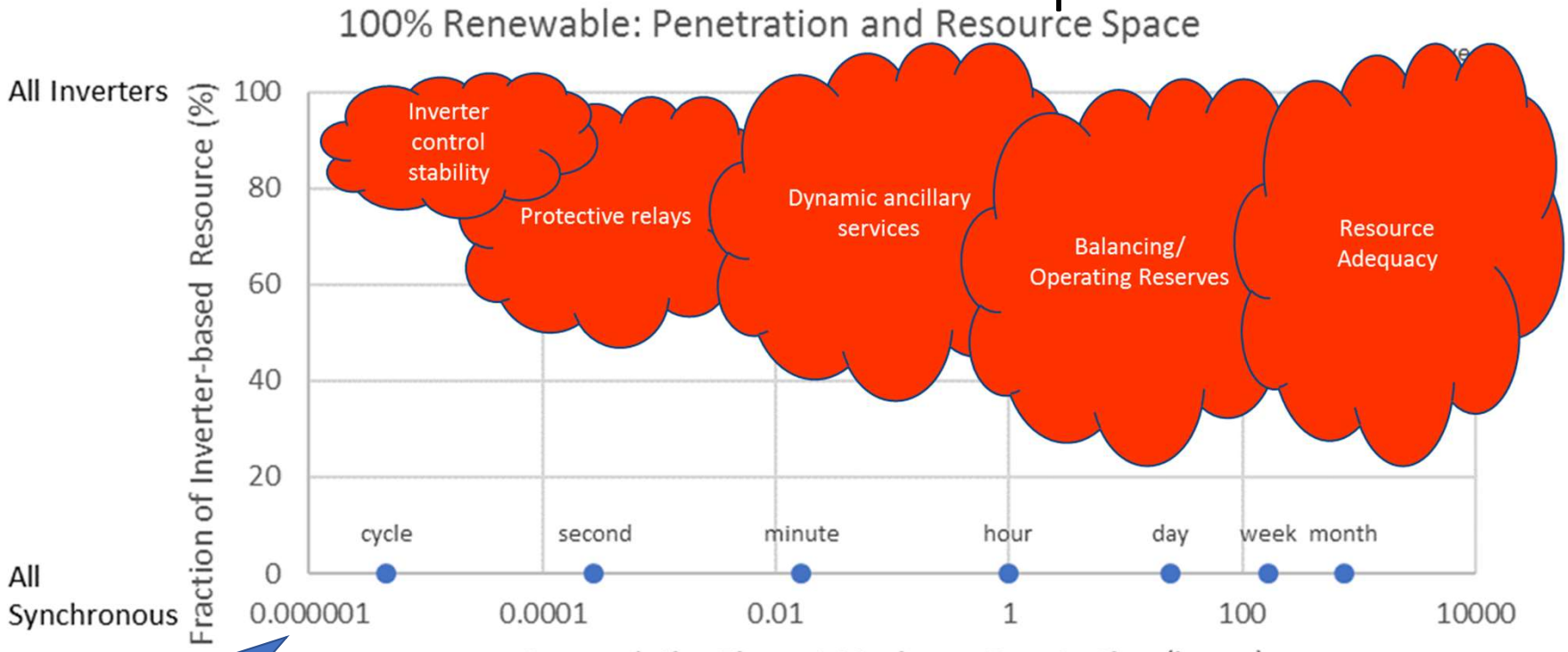
MIGRATE, 2016

Today we are on the blue line and working towards the dashed blue curve.

We don’t know what the green curve looks like or how to get there.

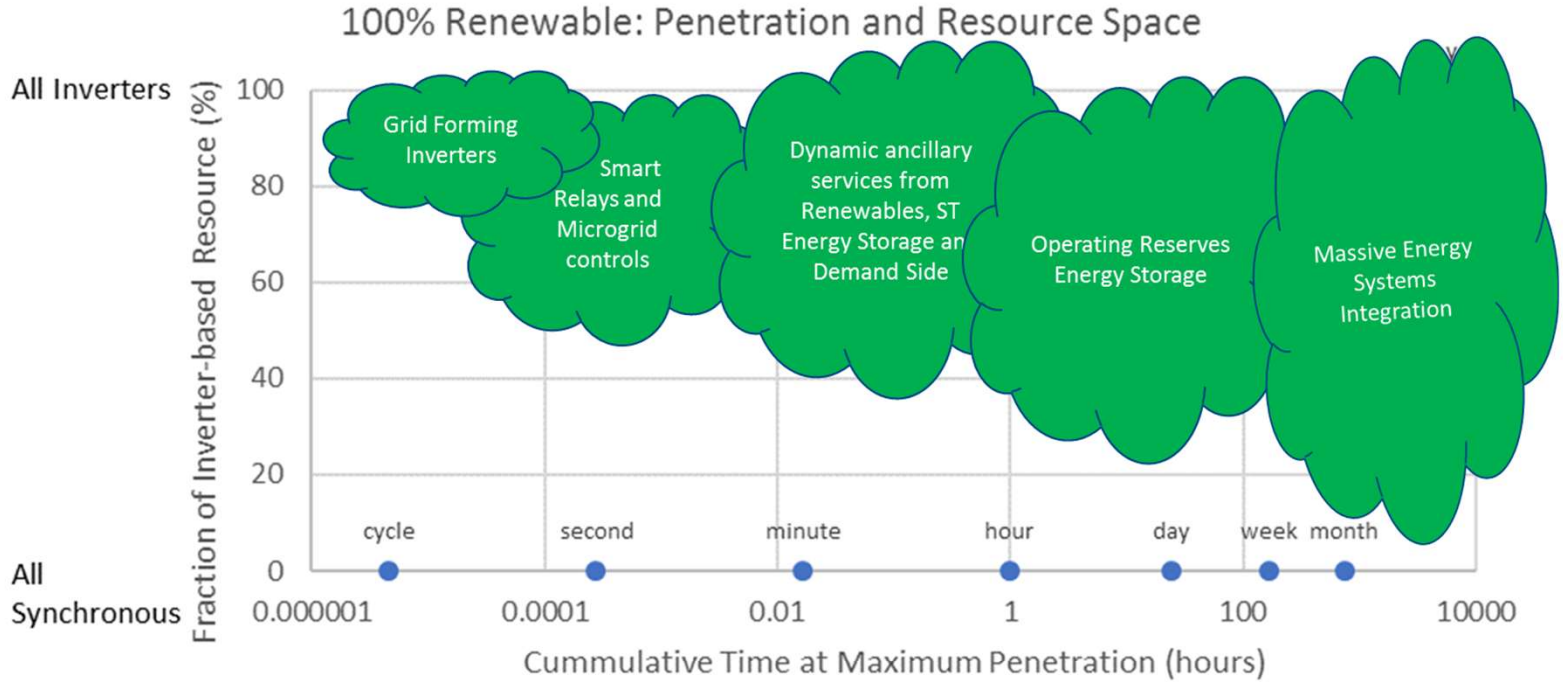
Courtesy of GE Energy Consulting

Pinch Points based on inverter penetration



Semi-log: “really Nick?”

Solution elements



Nick Miller, Hickory Ledge, 2018

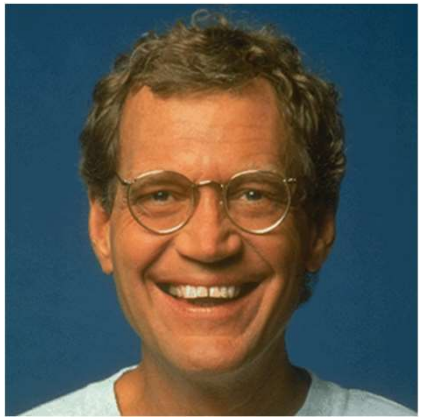
Top 10 Challenges:

Key pieces of the paradigm shift for which

(a) We aren't ready

(b) We must get right

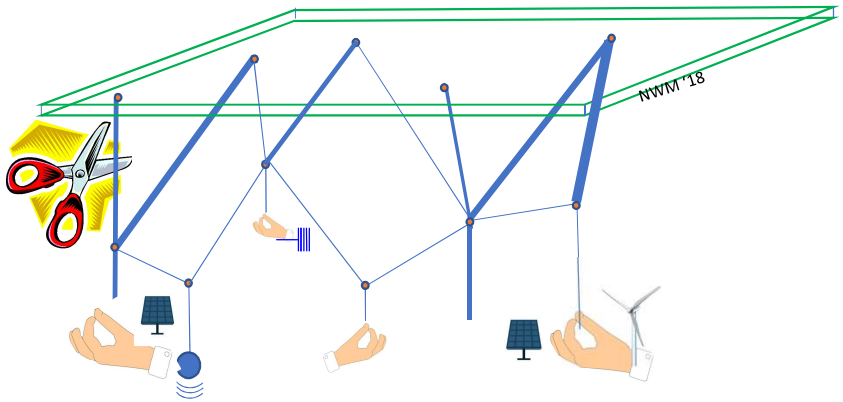
(c) We don't know enough



1. Is it stable?

One of the 1st hurdles

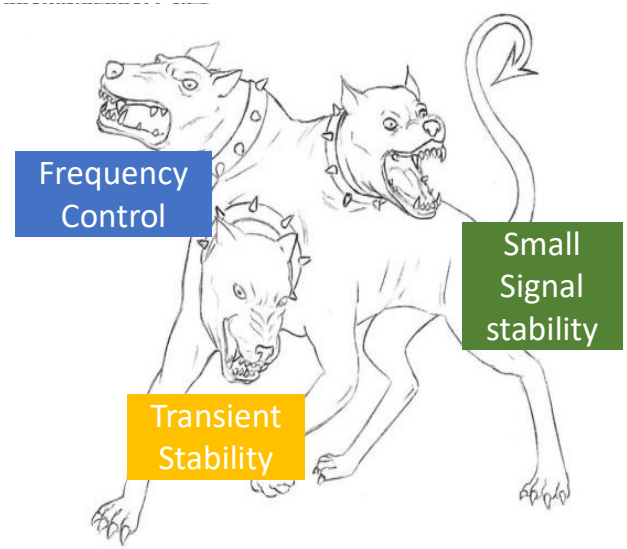
- Many exporting pockets of >100% today



A credible future for **large systems** in which there is ***never any*** synchronous machines?

Existential Questions

- Do we really need synchronous machines?



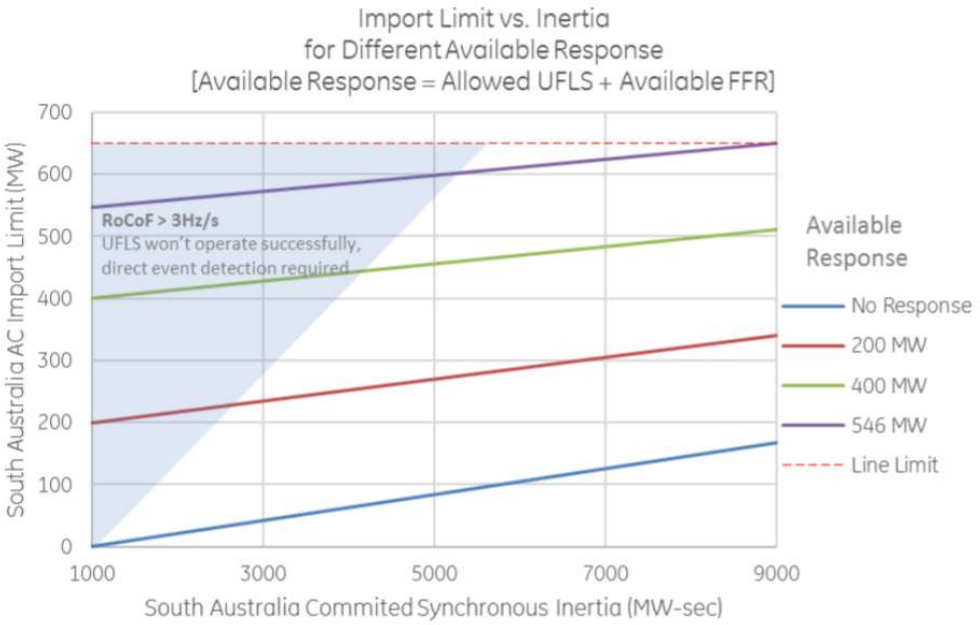
- Can't we do better? Many more control options than before - How to use them?
- Existing grid-following inverters are, in many respects, superior to synchronous machines
- How do we get the best of both from the grid-forming inverters on WTGs

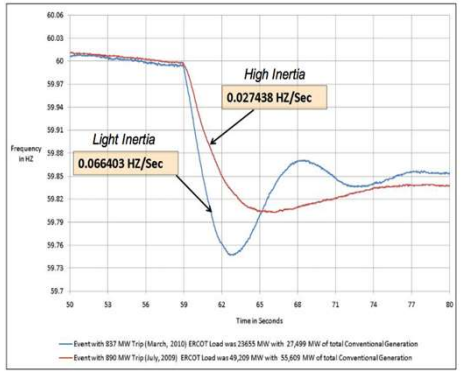
Source: Drawingforall.net

ESIG

2. What about Frequency?

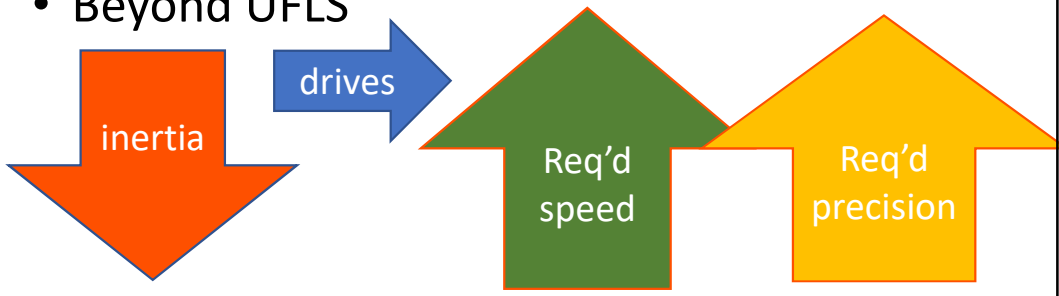
Inertia. Shorthand for all ills frequency. Wrong





There's more to it

- But, we've got to get through the 1st cycles and seconds, in order to worry about everything after.
- Beyond UFLS



3. Spinning in our graves?

Rethinking "old" rotating technology.

- Synchronous condensers
- 'conventional' hydro
- Flywheels
- Throwing money at it…

Front and center today

- vs. GFI?
- Asymptotically approaching zero synchronous.
- Stepping back and forth across the boundary?
- (re) creating stability problems?
- Putting the pieces back together

4. Protection?

A looming crisis?

- NERC and IEEE. Not a crisis (yet)
- Sinusoids. Not so much.
- Dropping short-circuit levels: differentiation between
  - load & fault
  - Healthy & sick
  - Increasingly difficult

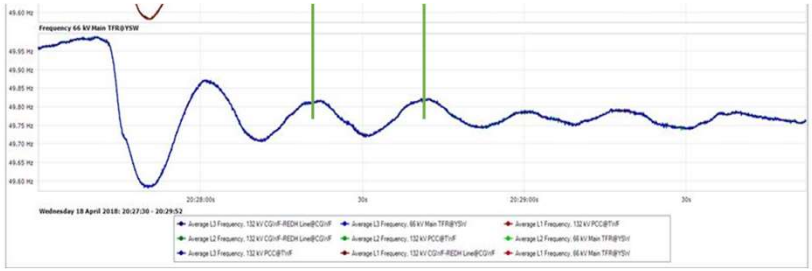
Yes, 'relaying' has to be part of the paradigm shift

- RASes and other, further blurring of the (already thin) line between protection and control.
- Institutional challenges…("who remembers how this bloody thing works?")
- Can't we do better? Not just replace but improve upon existing protection paradigms?

5. Too cheap to meter. What happens when every resource is zero marginal cost?

Cracks in the present market structures

- Price formation?
- BTM: General agreement that NEM is unsustainable at high penetrations
- Fairness? Sunk costs, Cross-subsidies and other gremlins…



And now for something completely different

- User Tariffs: Encourage change (vs. force vs. economic neutrality)
- Drive investment behind the meter? The right holistic answer?
- Lotteries and other blunt instruments
- Is it (the market) stable?

6. Capacity. If not MW, then what?

Traditional installed capacity metrics increasingly inadequate

- Including flexibility
- "It ain't capacity unless it can do XYZ…"

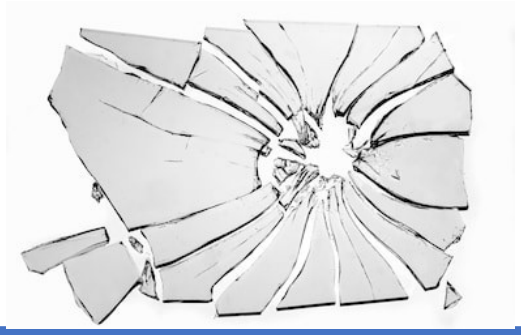
BLCOE (beyond levelized cost of electricity)

- ERS… new participation models
- Improving stability; higher disturbance tolerance; faster restoration…how to value; reward; encourage?
- Public good?
- Droopy $ signals?

7. What about Extreme Weather?

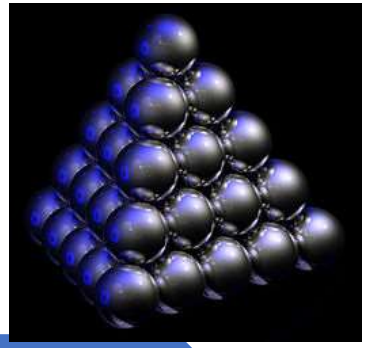
Growing sense that the tails are going to bite us

- Extremes seemingly more common
- Bomb cyclones, Polar Vortex,…
- Water, Wind, Sun .. Droughts;
- “we weren’t ready defense”…at what cost?



Paying for fire hydrants by charging by the liter

- Different market/social contracts
- More options/replacing options from the “emergency toolkit”
- More/better “alert” states
- Going to pieces

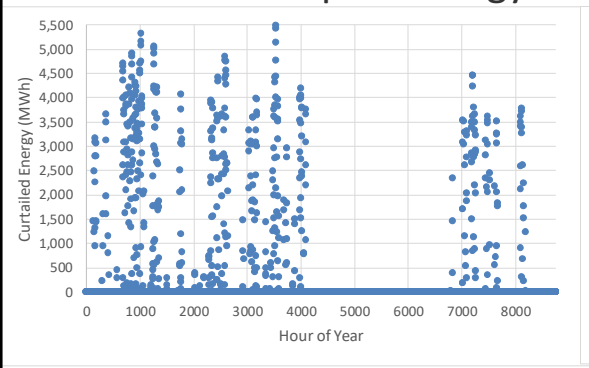


8. Turn, turn, turn: Seasonal solutions?

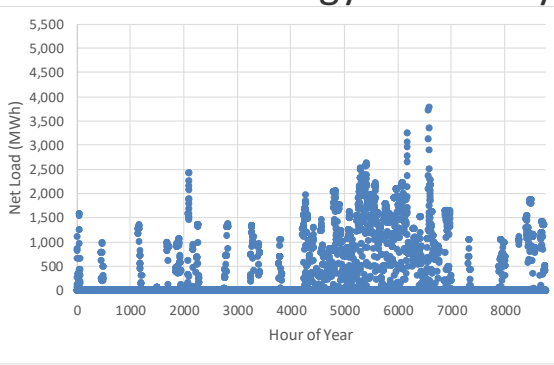
At some point, seasonal mismatch becomes an issue

- And beyond… wet/dry … wind and solar droughts. *(Just ask Brazil)*

Hours of Surplus Energy



Hours of Energy Deficiency



ESI is arguably the lynchpin

- Massive storage
- Massive economic & societal shifts
- P2F (and a dozen variations)
- "for most of human history, work has followed the seasons…"*

* Observation by Socrates Miller at 17th WIW

Source: Paul Denholm; Los Angeles 100% Renewable Energy Study

9. Barely a dent: why isn't Demand Side Participation taking off?

Market signals alone?

- "ISO spent 10's of millions implementing various DR programs including allowing load to bid in like a generators (price responsive demand) and letting them play in the capacity market. After all that expense to implement all these market mechanisms, so few MW's play its sickening."*

Are we even asking the right questions?

- Real-time pricing?
- Understanding the human(oid)s. Societal issues; acceptance?
- New technology & methods needed?
- What do "customers" really want?
- What's a "customer" anyway?

*direct quote from our favorite Doug

10. Reliability: does one size fit all?

Nagging questions

- Social contract ("we're all in this together"): Obligation to serve
- Can we/should we afford it?
- Is all load really equally important?
- Reliability for a fee

Heresy

- Is the social contract breakable?
- Are the mechanics doable? Practical? Affordable?
- Time scales?
- Is this ultimately just another face of Demand Side Response ?

Thanks

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