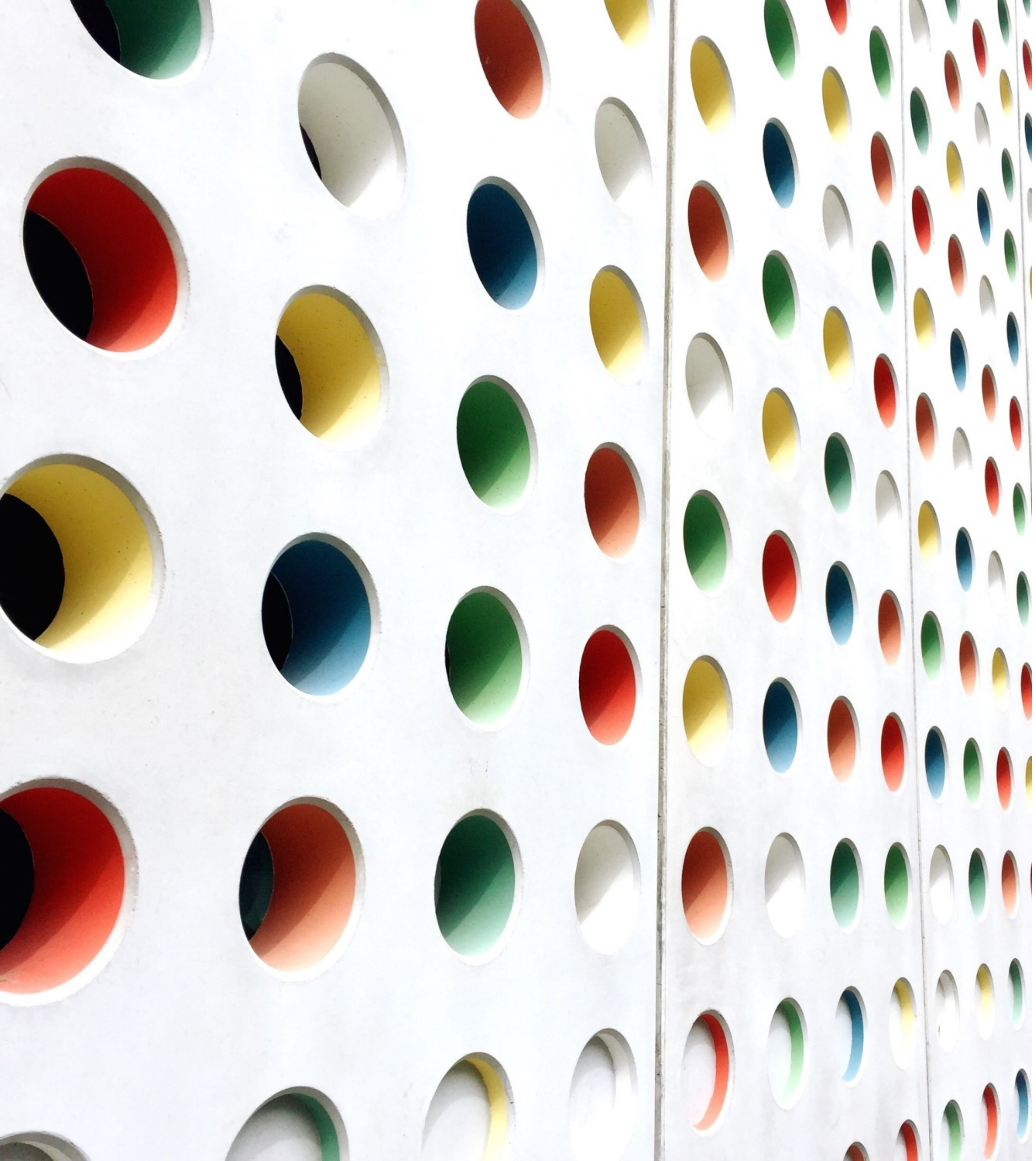


Criteria for evaluating market mechanisms

Consistent with NESCOE's Vision

Steven Corneli

January 25, 2021

Starting point

NESCOE Vision Statement PRINCIPLE # 1:

Use market-based mechanisms to

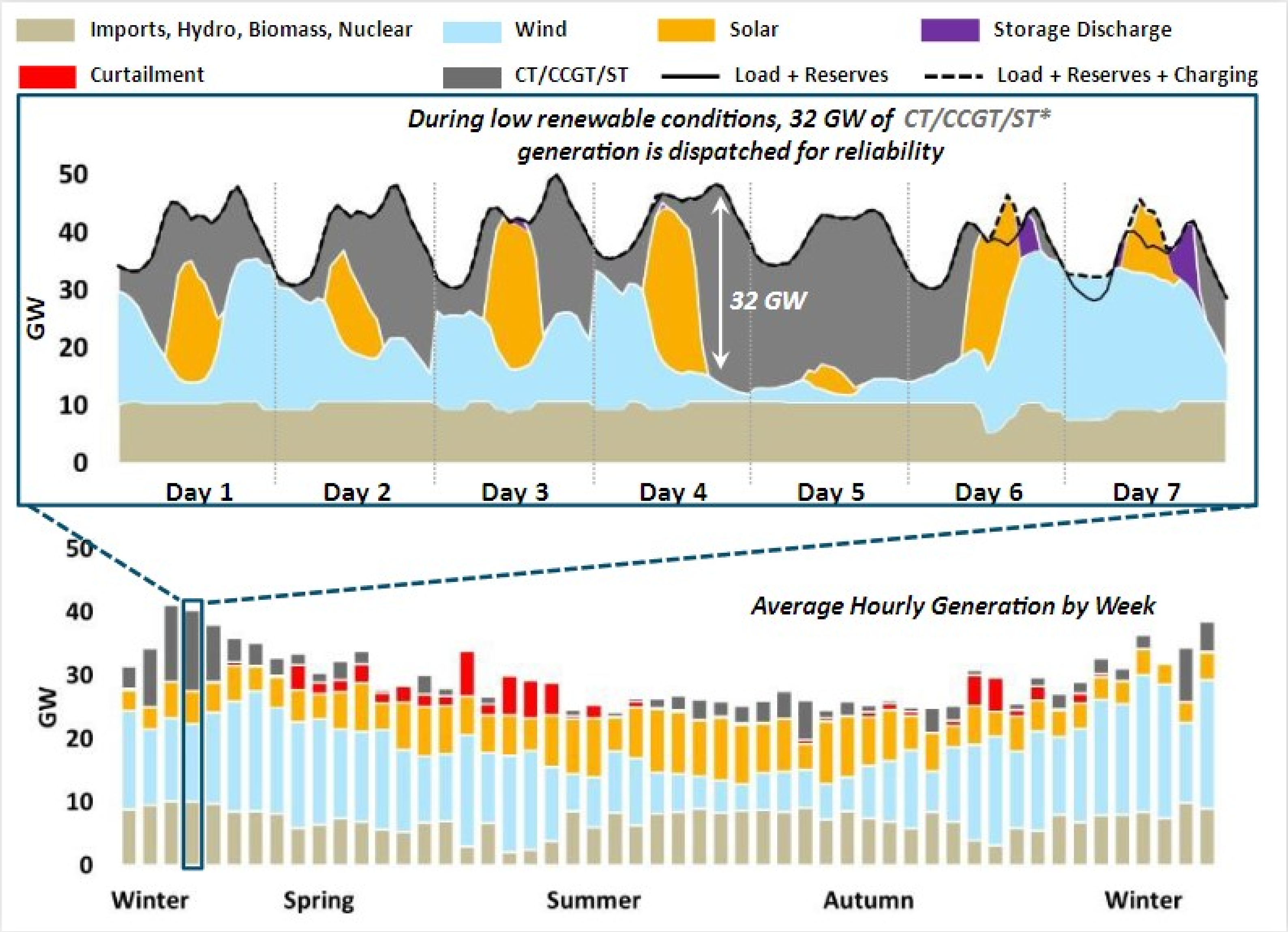
- Meet decarbonization mandate and
- maintain resource adequacy
- at the lowest cost.

Key outcome	*What it means*	*What a successful market design candidate must do*
1. Maintain RA	Regional resource mix must be capable of always voluntarily balancing electricity generation and consumption (including at times of stress).	Identify resource mixes that do this; discourage or discard all that don't.
2. Decarbonize in time	Resource mix must increasingly be clean (zero CO2) resources until system is decarbonized.	Of the above mixes, only accept those with rapid growth in clean resources; discourage or discard all that don't.
3. Do the above at least cost	Resource mix must be one that results in lowest cost electric system • Avoid mixes that increase system cost • Too many of the **least expensive** resources can cause the **highest cost** system.	And, of the clean energy mixes that support RA: • Identify the mix that will result in the lowest total system cost, and • Ensure that those resources can obtain low-cost financing and be successfully developed.

New types of power system models can show us resource mixes that could provide least cost, reliable decarbonization.

E.g., See E-3, Evolved Energy, VCE, GenX .

Figure 4-10. Illustrative Dispatch over a Critical Week in 2050 (High Electrification Scenario)

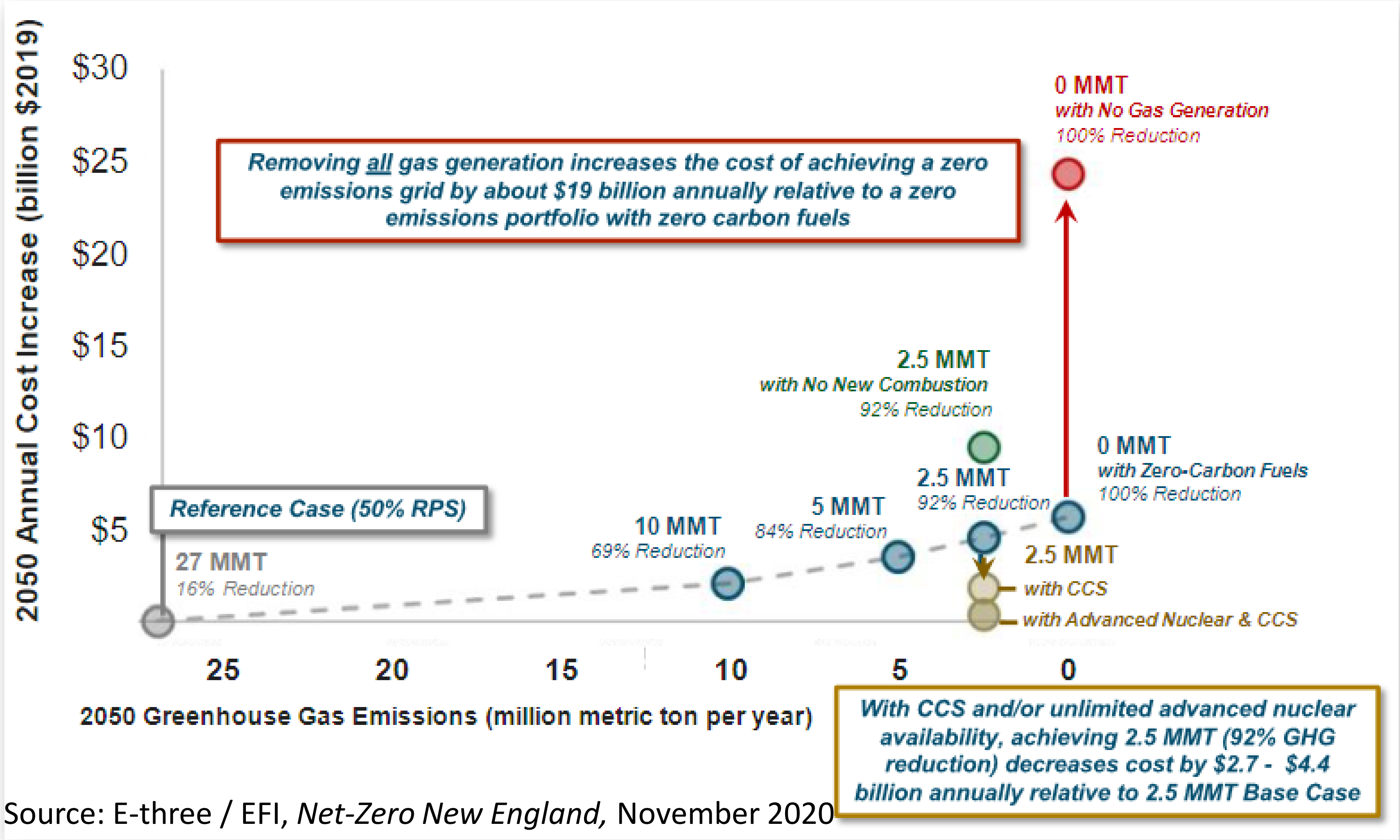


Such longer periods with limited wind and solar are why "clean firm" resources can dramatically reduce costs.

Source: E-three / EFI *Net-Zero New England,* November 2020

The cost of the wrong solution can be staggering

Figure ES-3. Increase in Electricity System Modeled Costs Relative to Reference Case Across Selected Set of Scenarios in 2050 (High Electrification)



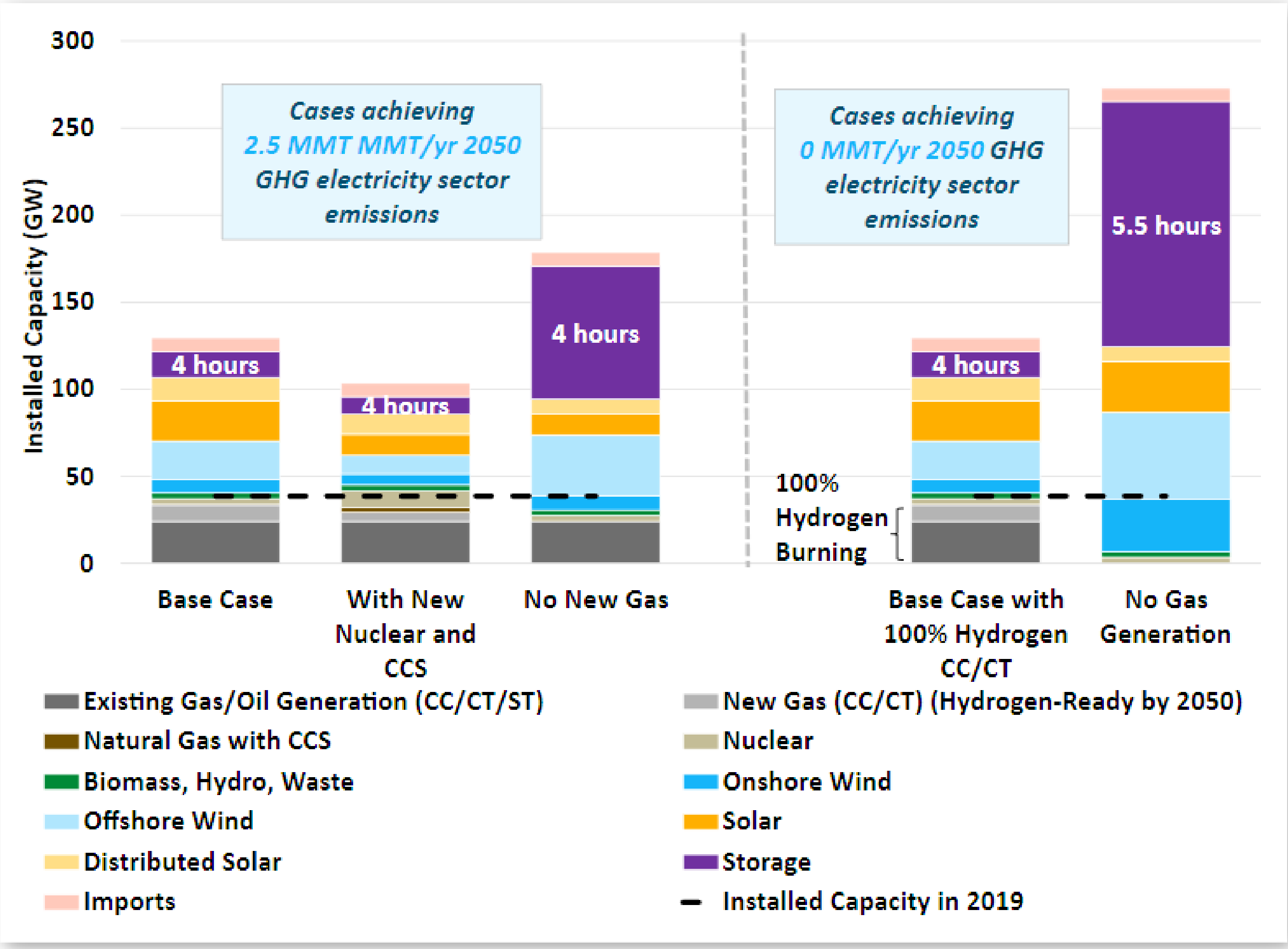
Source: E-three / EFI, *Net-Zero New England,* November 2020

$~20 Billion more per year for New England

Loss of existing nuclear units can have similar impacts

Figure 4-19. Sensitivity Results Limiting/Expanding Firm Capacity Options: Total Installed Capacity in 2050 (High Electrification Scenario)

Without “Zero Carbon Gas,” system can only be balanced by ~ 100 GW more batteries and substantially more wind and solar to produce enough extra energy to charge them.



Source: E-three / EFI *Net-Zero New England,* November 2020

This is why it costs ~$20 B more in 2050.

Getting RA right may well be the most critical step.

- **RA means the electric system is able to produce as much energy as is consumed, at all times -- including times of system stress (e.g., peak load and resource unavailability).**
- **Capacity (measured in MW) means the maximum rate of instantaneous energy production (i.e., power) a resource is capable of.**
- **Historically, resources with *firm* fuel availability (elevated reservoir, fossil fuel, nuclear fuel) could produce up to their full capacity output whenever it is needed, including at system peak and when other plants are suffering outages.**
- **As a result, "capacity" now generally means "firm capacity" or "firm MW" or "UCAP".**
- **Any mix of capacity (firm MW) that adds up to peak load plus reserves can provide RA.**

➢ ***Firm MW ("capacity") are the same across all firm resources. MW from one firm resource can always be added to other MW to meet higher load, or substituted for any other MW that become unavailable.***

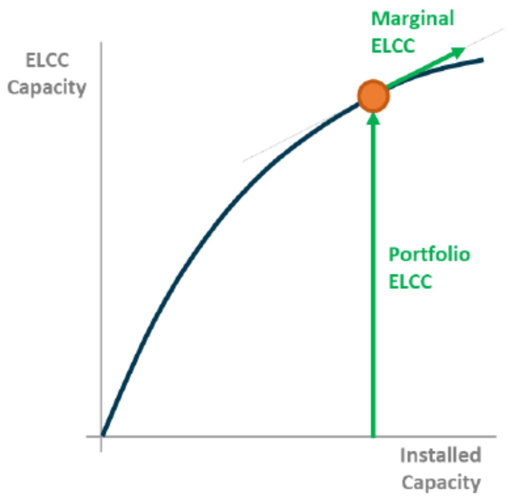
These characteristics ~~make~~ made it possible to design markets to buy the amount of "capacity" needed to meet a given RA standard.

Renewables and storage are not available in every hour.

- **Only some combinations are technically effective in balancing generation and load.**
- **Different combinations of clean resources provide more or less capacity.**
- **The amount of capacity a specific variable or time-limited resource provides varies**
    - **By its location**
    - **With the deployment of additional similar resources (capacity value declines)**
    - **With the deployment of complementary resources (capacity value increases)**
- **The cheapest combinations include the right amount of *clean firm* resources to enhance availability at the lowest cost.**
- **These problems are unlikely to be solved simply by buying enough UCAP or ELCC to add up to peak load plus reserve requirements.**

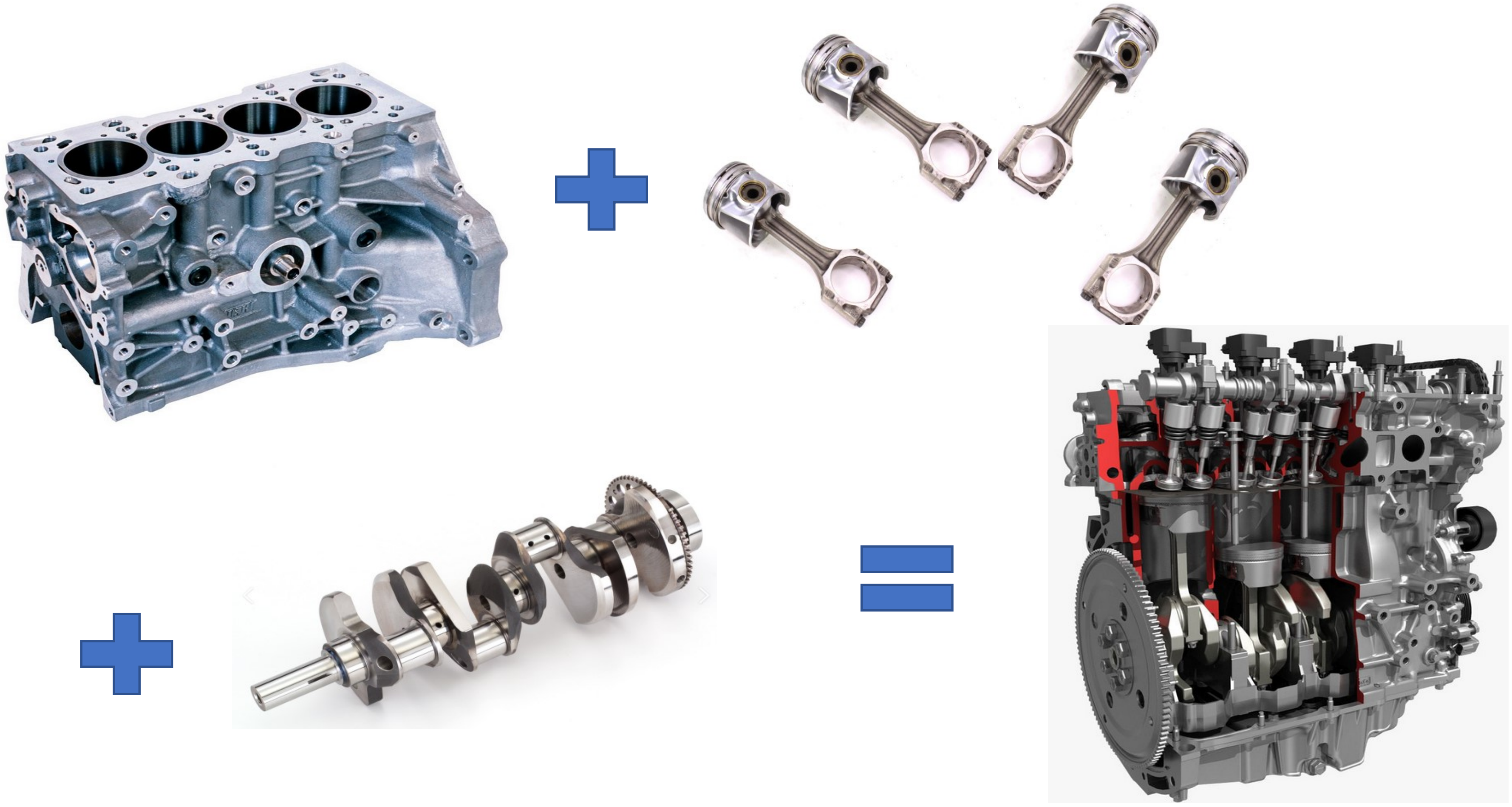
Measuring ELCC of a Portfolio and Individual Resources

- In reality, an electricity system is comprised of multiple resources that are all interacting with one another, making interactions difficult to disentangle
- As penetrations of intermittent and energy-limited resource grow, these interactive effects will grow significantly and cannot be ignored or rounded away
- The ability of ELCC to capture interactive effects, leads to the observation that **ELCC is a property of a portfolio of resources, not of individual resources themselves**
  - It is not a straightforward exercise to calculate the ELCC of an individual resource
- There are two measurable types of resources
  - Portfolio ELCC: the combined capacity contribution of a combination of intermittent and energy-limited resources. This method inherently captures all interactive effects
  - Marginal ELCC: the incremental capacity value of a resource (or a combination of resources) measured relative to an existing portfolio



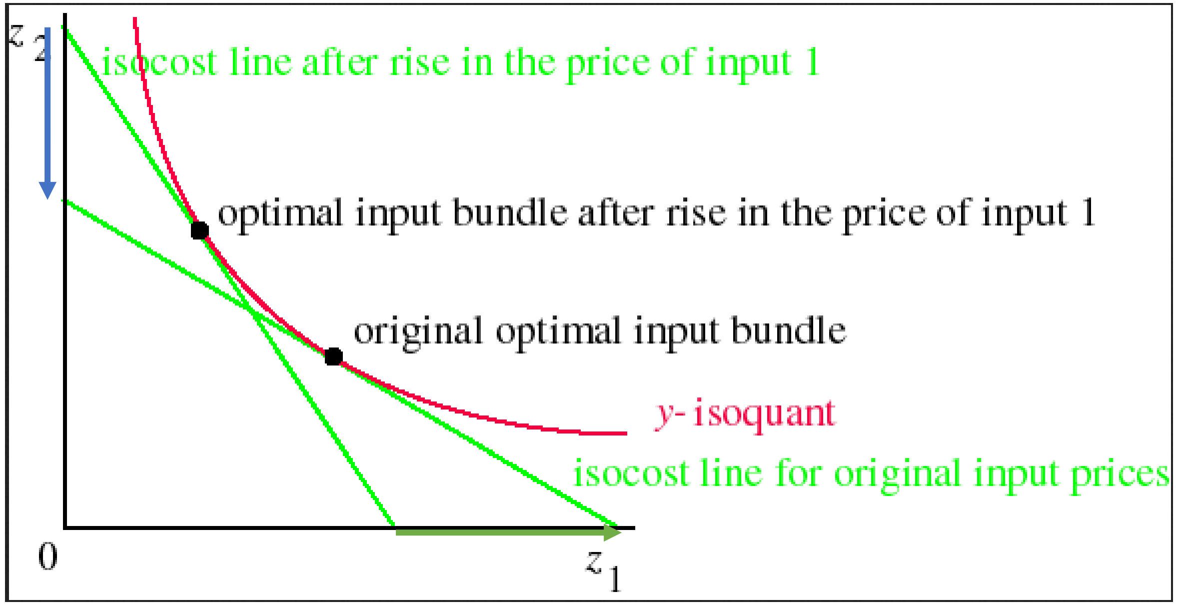
Source: E-three, "Practical Considerations for Application of ELCC", PJM Capacity Capability Senior Task Force Meeting, 8/7/20
Available at: https://www.pjm.com/-/media/committees-groups/task-forces/ccstf/2020/20200812/20200812-item-05b-pjm-proposal-for-using-e3-delta-method.ashx

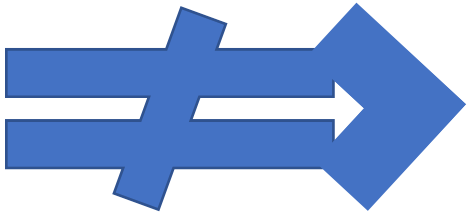
A successful energy market for rapid decarbonization will need to find efficient *portfolios of complementary clean energy resources*



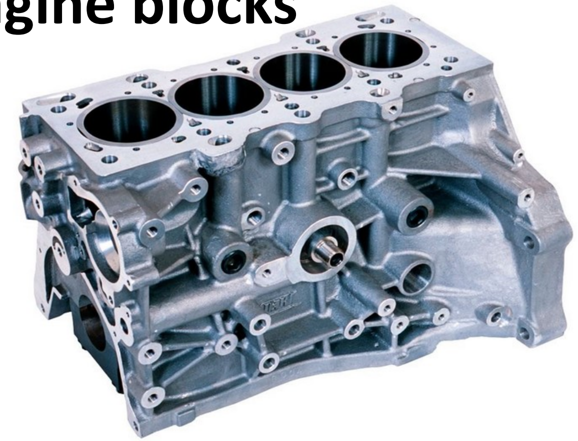
It may be as unrealistic to measure complementary clean energy technologies in MW as it is to measure engine parts in horsepower

Without a stable, accurate and unambiguous way to measure clean energy capacity, *capacity* markets may fail to provide either least cost decarbonization or RA.





A market that buys more cheap pistons and **fewer engine blocks**



won't save money **- - - -** **it will produce cars *that don't work***

Is there a better approach?

How about doing it like automobile makers do -

1. **Identify technically efficient combination(s) of inputs**

2. **Issue a competitive RFP for those inputs**

3. **Buy the inputs that produce the lowest cost, technically efficient mix.**

The end result is a car that works and has the requisite horsepower.

This is achieved efficiently and predictably, without estimating -- and paying for -- the inputs' "unforced HP" or "Expected Car Accelerating Capability"

Such “hybrid market”* concepts are emerging for electricity markets:

- Stage 1 uses planning tools to identify reliable combinations of clean resources.
- Stage 2 uses competitive procurement to source the least cost mix of resources.
- Stage 1&2 could be combined in a “competitive IRP” or “configuration market”: **
  - Bids are elicited first, and used as inputs to the planning tools to find the least-cost mix of projects, based on the real costs of available resources.
  - Winning projects are then awarded long-term power-purchase agreements.
- Such hybrid markets could solve for resource adequacy, decarbonization and least-cost resource mix, without using “capacity” as the market product.

* See Paul Joskow presentation on hybrid markets at WRI – RFF long-term market design workshop (Dec. 16, 2020), available at: https://files.wri.org/s3fs-public/joskow_rff_presentation-12-16.pdf?cheKLe66OWrgB1cPtOZxCjxYXVEmzUoK

** See Steve Corneli, “A PRISM-based configuration market for rapid, low-cost and reliable decarbonization of the electric power sector,” available at: https://files.wri.org/s3fs-public/corneli-prism-markets-for-rapid_decarbonization-final_word_version.pdf?F4wH_vPKbMICE8gYyD90jcQ.X9mOD6.2

Example evaluation matrix (my initial views)

	ICCM	Residual Capacity (SPP)	Hybrid Market
RA	? UCAP / ELCC approach likely to interfere with reliability and cost minimization at high penetrations of VRE and time-limited resources.	? Same as ICCM; but implicit vertical demand curve jeopardizes much existing investment needed for RA w/o out-of-market cost recovery.	✓ Competitive planning + procurement can select a mix of clean resources that will achieve RA, without buying "capacity" or "firm MW".
Decarbonize in time	✓ Yes, if CES is stringent enough and CEAC price is not capped at a binding level.	? Clean energy resources likely to need OOM cost recovery. Efficient mix would likely need to depend on planning. Planning + OOM contracts => a hybrid market.	✓ Procurement can carried out at pace and scope to achieve goals, with contracts for all procured resources to ensure revenue sufficiency and low-cost debt.
Least cost mix	✓ ? With enough new and low cost "clean firm" and "clean flex" resources. This would also help avoid an RA measurement market failure.	? Energy market plus vertical demand curve capacity market unlikely to incent or finance new nuclear, ZCG, ETF or other "clean firm" technologies; high cost mix is more likely without explicit OOM support for clean firm.	✓ Periodic competitive planning + procurement would identify and select tranches of the least-cost mix, and can assure a highly affordable, reliable mix.
Rapid Implementation	✓ Relatively easy to implement by modifying pre-existing FCM / RPM and RPS constructs.	? Hard to implement in restructured RTOs due to lack of COS-based cost recovery.	? Hard to implement soon due to relative novelty. Requires proof of concept / beta testing first.