The role of storage in a low-carbon California power system

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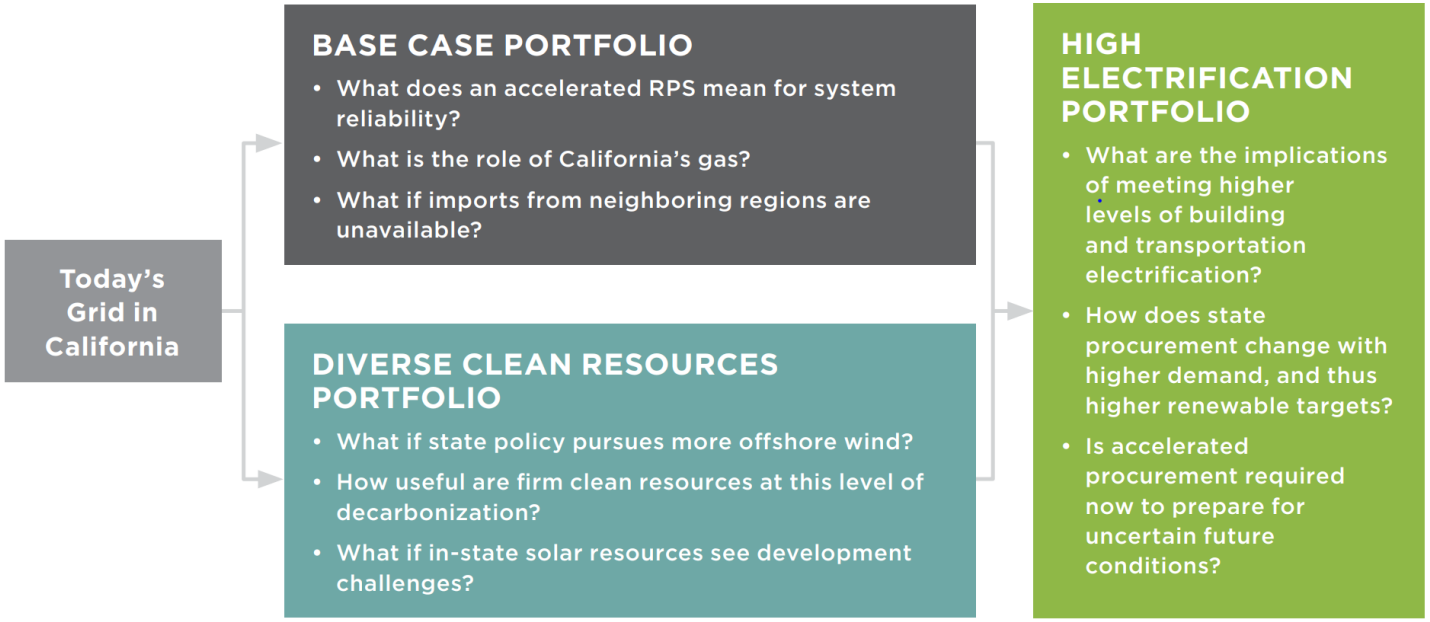
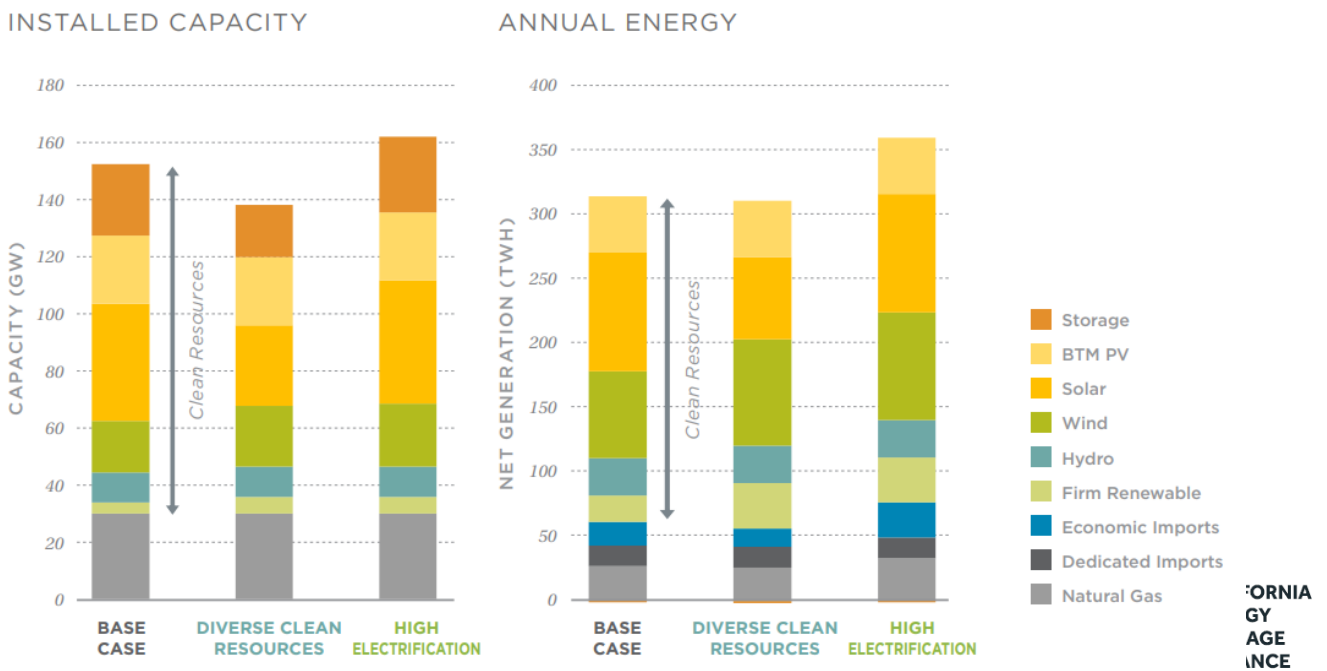
Our study

- Developed portfolios reaching 85% clean (75% renewable) electricity by 2030
- Stress tested these portfolios for reliability risk using production cost modeling
- Found that CA can reliably meet an 85% clean electricity standard by 2030 through multiple resource pathways.
- Made recommendations to CEC, CPUC, others on how this can inform planning, procurement, and other policies





Portfolios & the role of storage

- High battery storage deployment between 14-19 GW by 2030
- Similar levels in the 2021 CPUC preferred system plan
- Storage is an important resource under different resource portfolios and demand forecasts

TABLE 2.

Renewable and Storage Compositions of each Portfolio

	CAPACITY ADDITIONS (GW) (1)			TOTAL CUMULATIVE CAPACITY (GW) (2)		
	BASE CASE	DIVERSE CLEAN RESOURCES	HIGH ELECTRIFICATION	BASE CASE	DIVERSE CLEAN RESOURCES	HIGH ELECTRIFICATION
Utility scale solar	25	12	27	41	28	43
Land-Based Wind	12	11	12	18	17	18
Offshore Wind	-	4	4	-	4	4
Firm Renewable	-	2	2	4	6	6
Battery Storage	15	11	15	19	14	19
Pumped Storage	2	-	4	6	4	7

1. Capacity additions refer to new build resources identified by RESOLVE; these are incremental to the planned (or announced) resources.

2. Refers to operational capacity (existing resources, planned and new build). Does not include existing RPS wind and solar units located outside of California, which is accounted for as an RPS Import in the model.

3. Total cumulative capacity may be different than the changes in the capacity additions column due to rounding.

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Storage can solve the duck curve, shift reliability risk

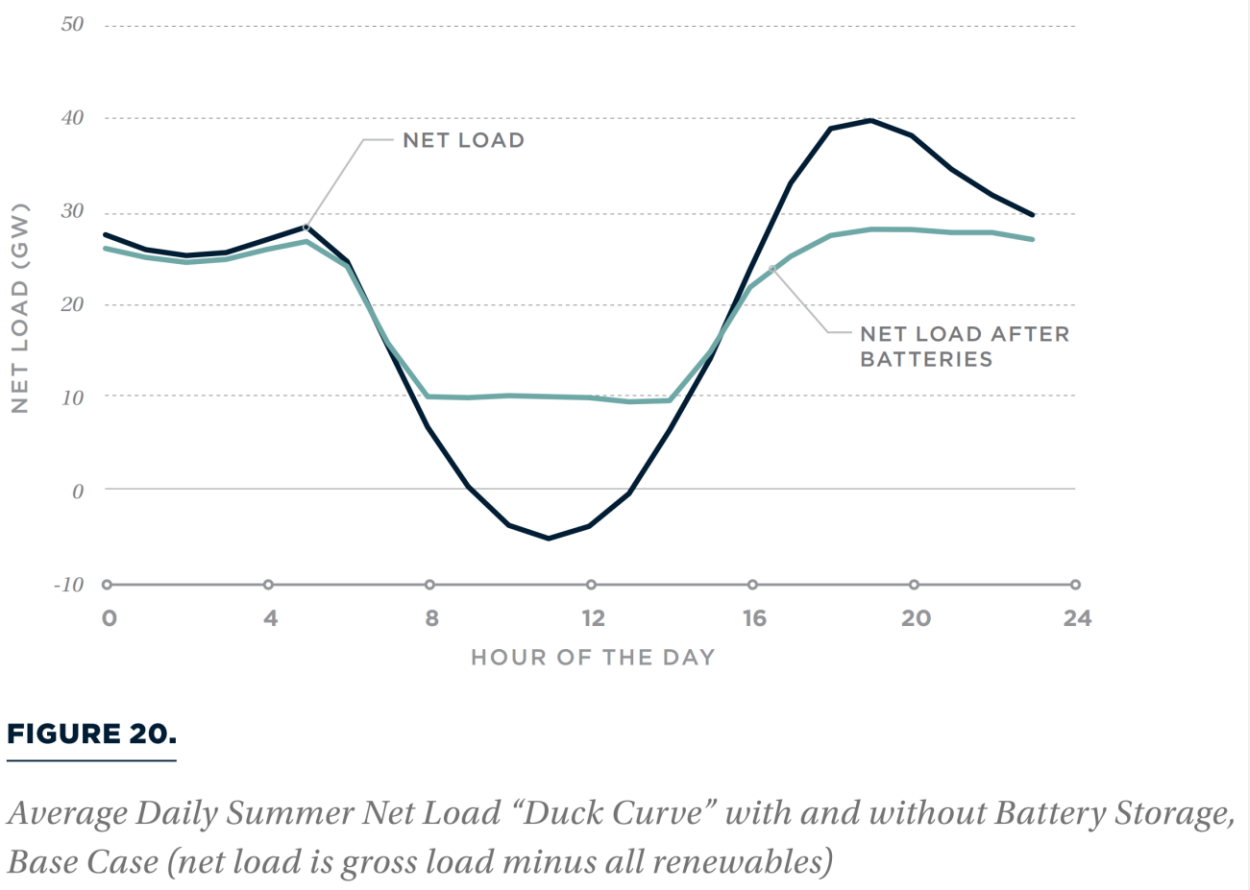

FIGURE 20.

Average Daily Summer Net Load "Duck Curve" with and without Battery Storage, Base Case (net load is gross load minus all renewables)

- **Storage is the key enabler for reliable operation of 85% clean energy portfolios**
- **Reduces average evening ramps 42%**
- **Defers or reduces the need for installed gas capacity to reduce net peak demand, significantly reduces the additional ramping requirements on the system.**
- **Becomes the primary balancing resource for wind and solar variability and provider of spinning and regulation reserves.**
- **More research needed on how longer storage durations provide complementary resource adequacy value**

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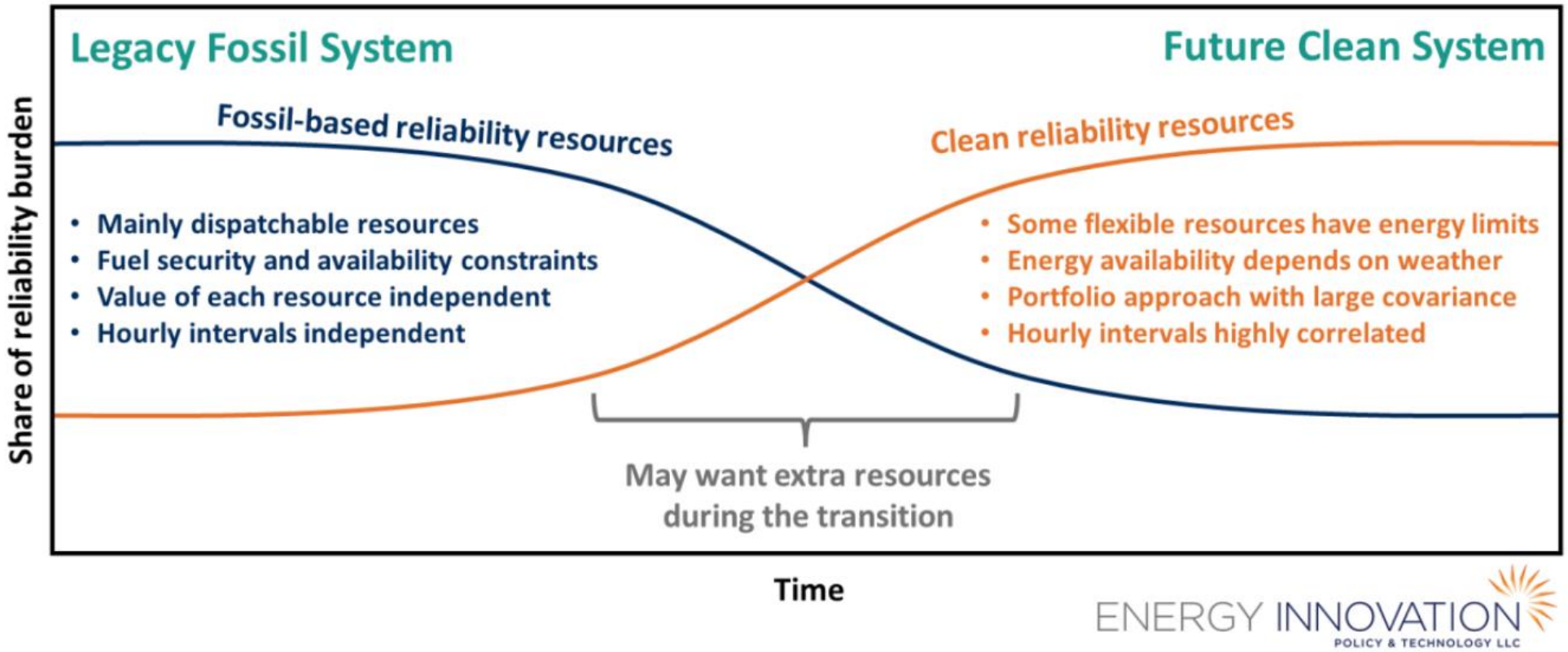
Managing the transition becomes a primary risk

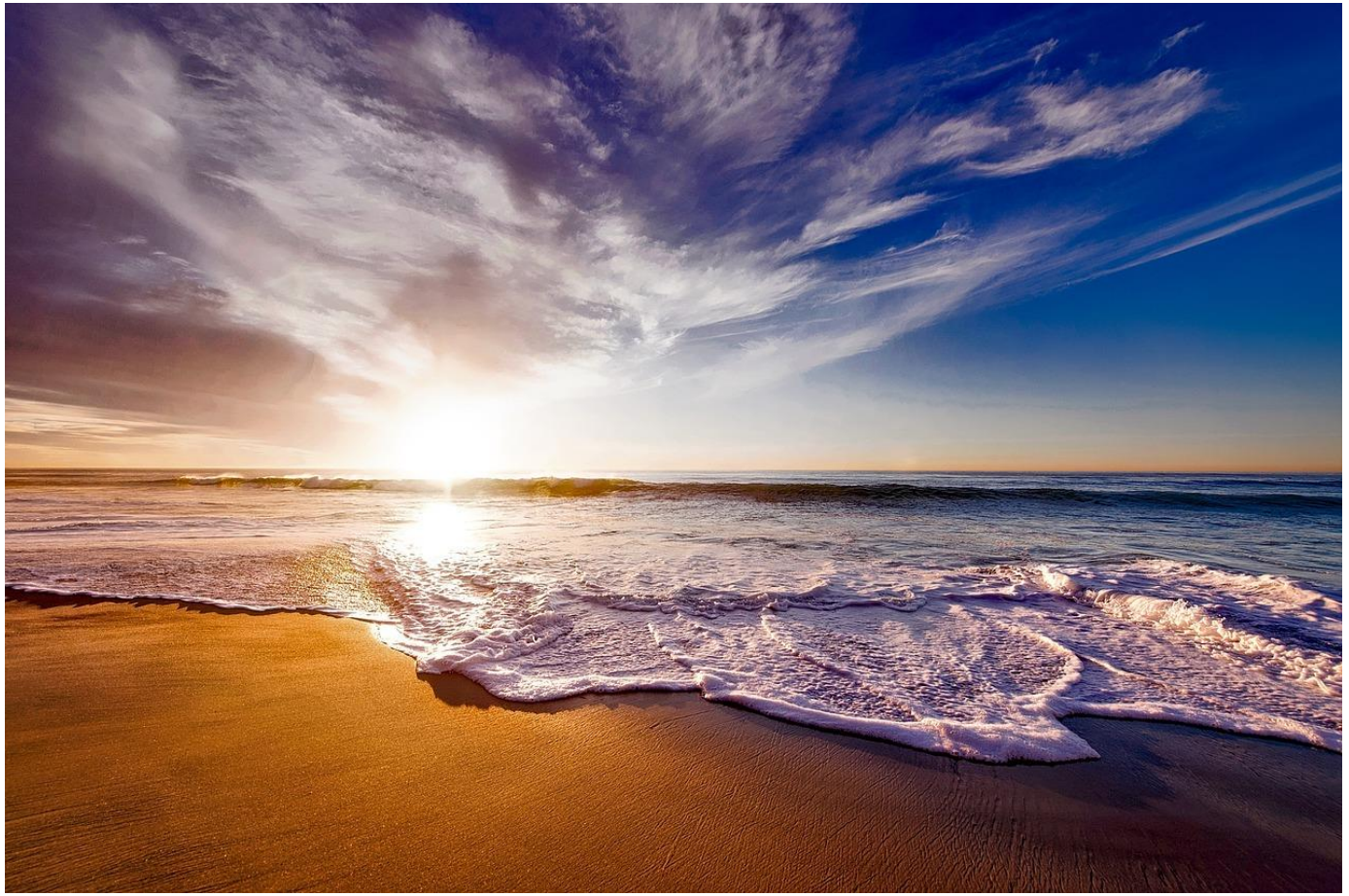
Figure 6. The paradigm shift in RA under the energy transition



California may benefit from overprovisioning resources to maintain a buffer through this transition.

Key takeaways

- Storage is a key enabler of reliable system operation in a high-renewables system
- Rapid storage deployment remains low-regrets resource option for CA. Location can enhance benefits.
- Key risks to reliability include failure to address deployment delays and diversify our electricity mix.
- Diurnal batteries encounter limits in getting us beyond 85% clean. We need other solutions including long-duration energy storage too.



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