


California Demand Response Potential Study Phase 3: The Potential for Shift Through 2030

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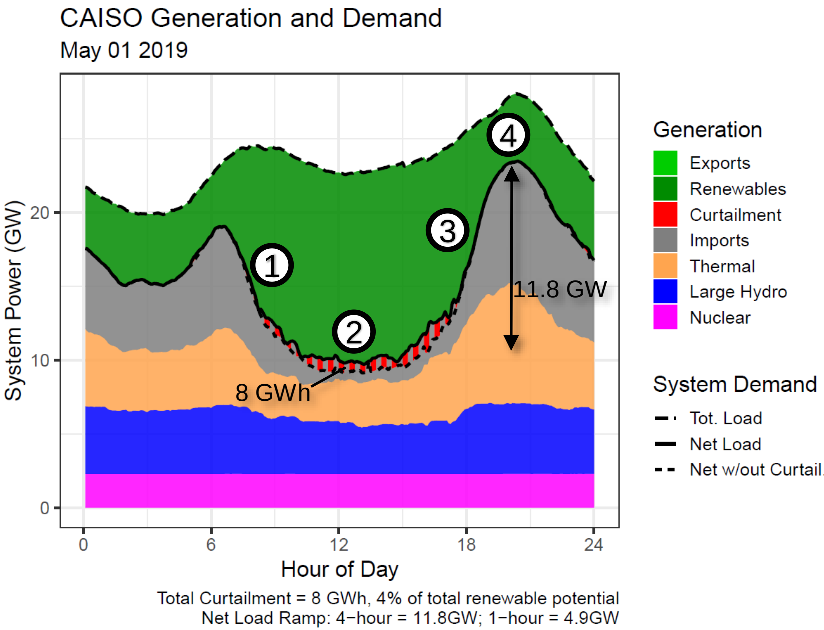
  - Please keep yourself on mute unless you are speaking.
- We will leave time for questions at the end of the presentation.
  - Please hold your verbal questions until then.
- You can use the chat feature to send questions, or use the “raise hand” feature at the end of the presentation.
- This webinar will be recorded, and the slides and recording will be posted at drrc.lbl.gov

The future is now
Challenges for California's *present* renewable grid

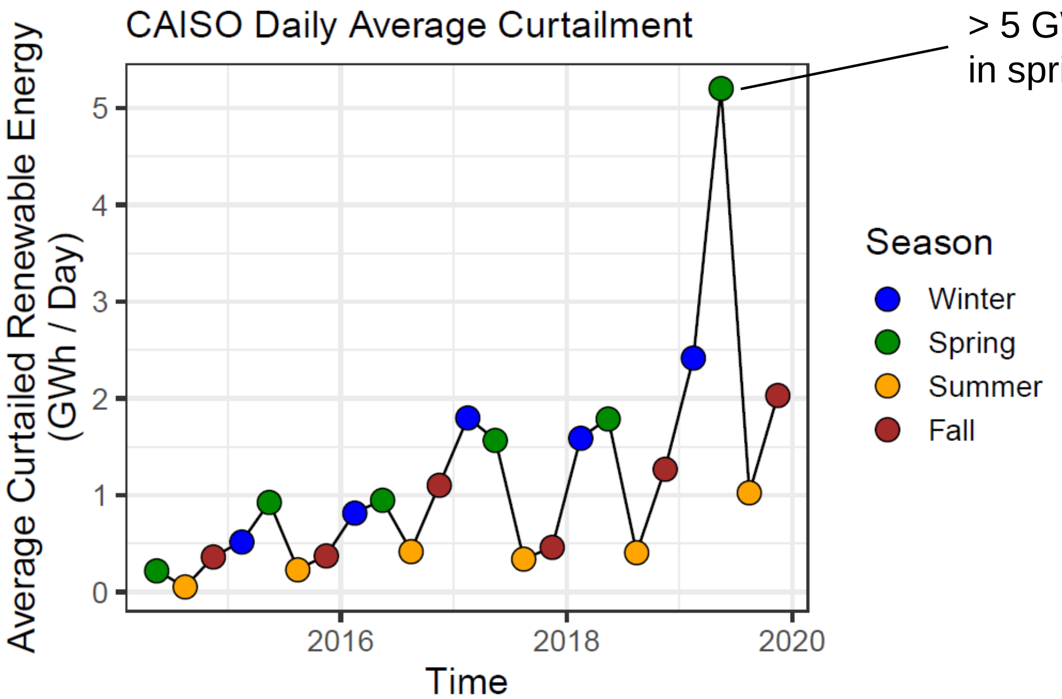
1. **Downward ramping**
   Thermal generation resources must ramp down rapidly or shut down at sunrise to make room for PV solar.
2. **Minimum generation**
   Limited generation flexibility can lead to overgeneration by renewables & curtailment.
3. **Upward ramping**
   Thermal generation resources must ramp up rapidly again at sunset as PV solar resources stop production.
4. **Peaking capacity**
   Must have generation capacity to meet highest evening peak loads.



Source: CAISO

The growing challenge

Curtailment (and other issues) increase every year



> 5 GWh/day in spring 2019

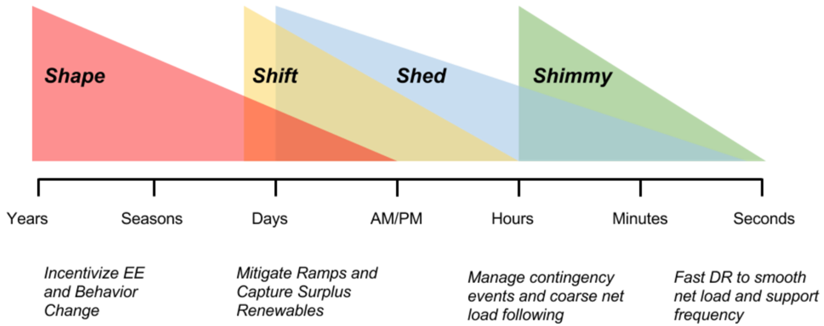
Presentation overview
The load shifting opportunity

- Conceptual overview: The need for Shift demand response (DR) in California.
- Review of the DR Potential Study modeling framework.
- Results—addressing three broad questions:
  - **How big** is the Shift resource?
  - **Where** is the Shift resource and **when** is it available?
  - How can we get **more** Shift?
- Key takeaway: Shift can play an important role in California's renewable grid, but it will need to grow. We can start trying it now and explore ways to bring down costs and drive participation.
- Brief overview of Phase 4 of the DR Potential Study

What is Shift?

- **Shift** DR is a means for moving electrical **energy** demand from one time to another, while providing equivalent energy service.
- **Shift** is achieved by a demand **Shed** coupled with an offsetting **Take.**
- **Shed/Take** cycle can occur over a period of a few hours, over a diurnal (AM/PM) cycle, or even across several days (e.g., shifting peak weekday loads to weekend) in principle.
- **Shift** can be **dispatchable** and market integrated (e.g., an ISO market product) or **market informed** (e.g., dynamic prices).
- **Persistent load shaping** arising from long-term changes in behavior and load schedules (e.g., TOU pricing) can provide many of the same benefits as Shift.

Shift in the broader DR ecosystem
A virtual storage resource



- **Shed:** acts like a virtual **generation** capacity resource
- **Shift**: acts like a virtual **storage** resource
- **Shimmy**: acts like a virtual **regulation**/ancillary services resource
- **Shape**: **persistent** daily load modifications (Shed & Shift combinations) arising from changes in behavior

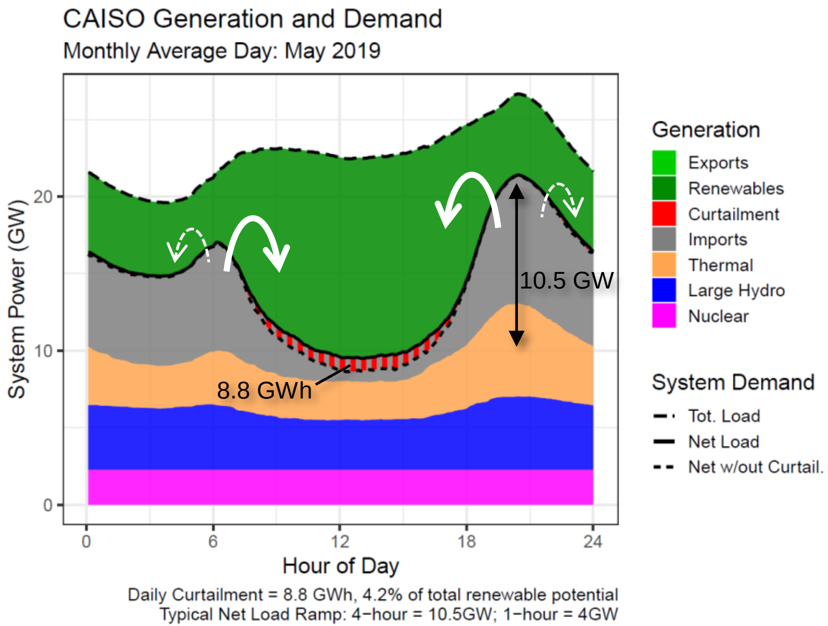
Shift: why and when?

WHY do we need **Shift**?

- To alleviate curtailment of renewables.
  - Curtailment in May 2019 alone represents ~$11M in value.*
- To ease ramping rates and flatten demand peaks.
  - Day-ahead prices spiked to near $1000/MWh at times in 2018.**

WHEN do we need **Shift**?

- **Shift** can potentially ease ramping rates every day
- Value may be greatest on days with curtailment or sharp peaks
- Typical need is to shift **away** from evening or morning peaks & **toward** mid-day or overnight.



Source: CAISO

*Based on approx $40/MWh LCOE for new solar build in 2023 https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf
**Compare to typical peak prices around $70/MWh (http://www.caiso.com/Documents/2017AnnualReportonMarketIssuesandPerformance.pdf)

A note on metrics
Measuring the cost and size of the Shift resource

- In Phase 2 (and in past presentations), we reported Shift costs in units of **$/kWh-year**, and the Shift resource in **kWh-year**, meant to represent a kWh of shiftable energy that has been procured as Shift DR for a contracting period of one year.
  - This unit has led to confusion, owing to the mixed time units (hours and years).
- In the Phase 3 report, we simplify and clarify by reporting **costs** in **$/year/kWh** and Shift **resource size** simply in **kWh**.
  - The quantities are the same, but we are expressing the contracting period differently.
- Example: at a marginal cost of **$100/yr/kWh**, an annualized outlay of **$100/yr** will secure **1 kWh** of shiftable energy to be available (on average at times of system need) for as long as the investment continues.
- In addition, where Phase 2 reported the kWh of shiftable energy **per day**, in Phase 3 we report the kWh of shiftable energy **per Shift event** (with potentially two or more events per day).
  - As a result, the supply curves from the two studies are not directly comparable.

Methodology overview

DR-Futures Modeling Framework

LBNL-Load forecasts hourly load profiles by customer type

- Groups IOU-provided demographic data (~11 million customers) into "clusters," based on observable similarities.

- Disaggregates customer load profiles (~220,000 customers) into different end uses.

- Forecasts future loads according to CEC Integrated Energy Policy Report.

DR-Path estimates available DR resource based on load forecast

- Pairs DR technologies with load shapes from LBNL-Load to generate a range of DR pathways.

- These pathways represent possible futures, given technology adoption, DR participation & cost.

Based on these pathways **DR-Path** builds a "supply curve" representing the DR quantity that can be brought online for a given levelized cost.

LBNL-Load

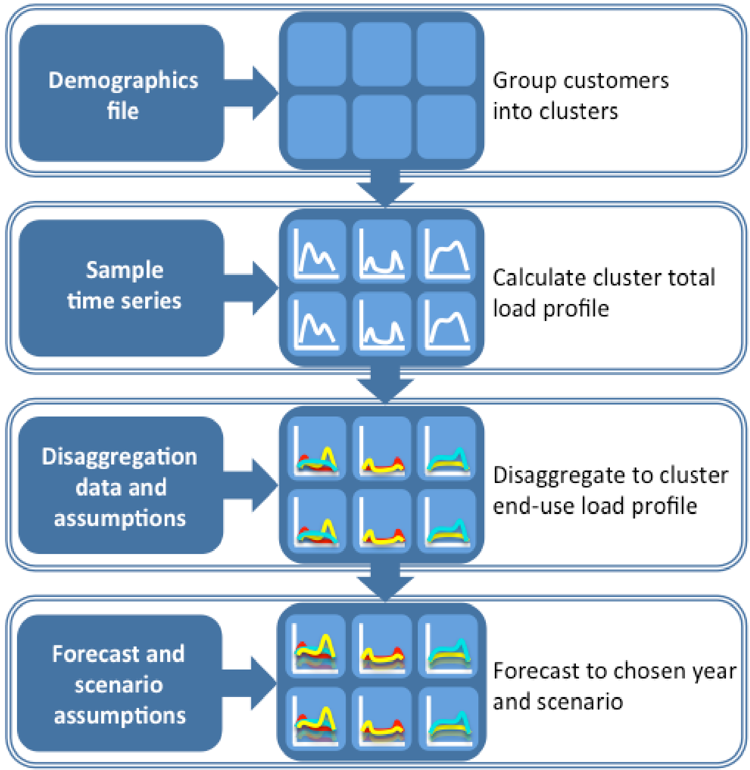
Overview of forecasting customer cluster load shapes

Step 1
Cluster

Step 2
Est. total load

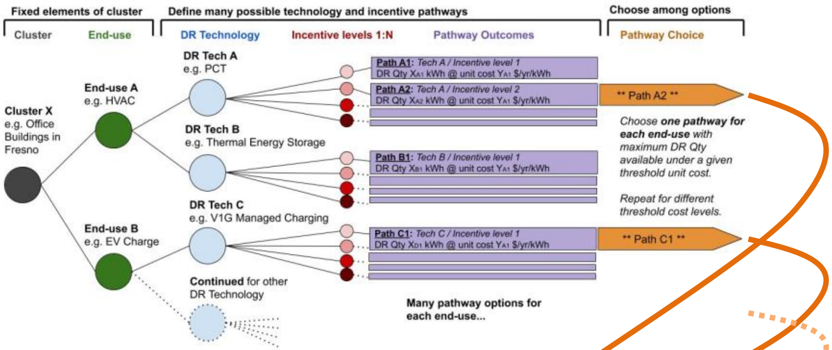
Step 3
Disaggregate load

Step 4
Forecast



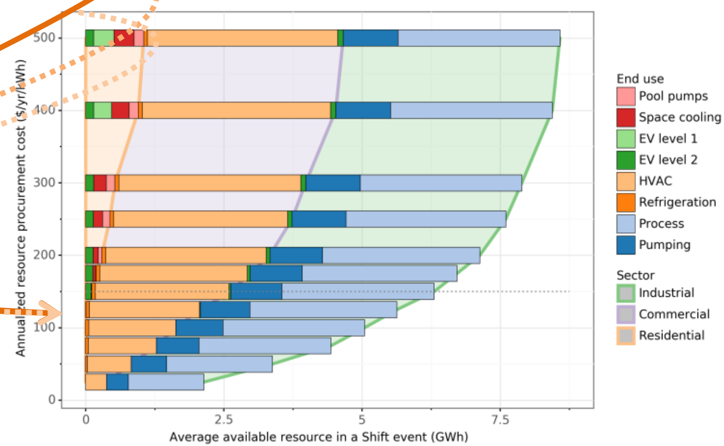
DR-Path

Building a DR supply curve from many pathways



Compute cost and Shift potential for all possible combinations of clusters, end uses, and DR technologies: <u>millions</u> of future **DR path**ways.

At each procurement price level, select the available pathways that maximize the DR resource and sum them up.

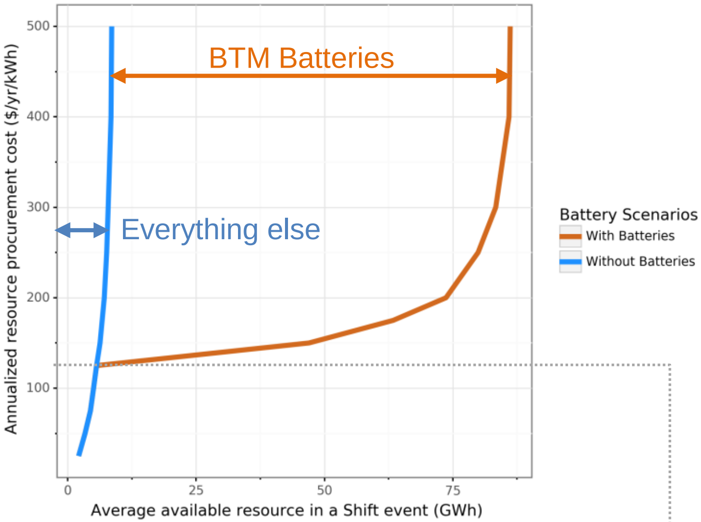


Results I
How big is the Shift resource

- Behind-the-meter (BTM) batteries as a point of reference.
- Shift resource and supply curve by year and technology scenario.
- Shift resource by sector, end-use, and utility.
- Potential impacts from future residential electrification

Modeling behind-the-meter (BTM) batteries:
Dedicated load-shifting batteries as a reference point

- Phase 2 assumed "typical" battery systems, installed primarily for non-DR purposes and used opportunistically for Shift.
  - The size of the battery at each site was limited to what is currently common.
- Phase 3 considers installing batteries *explicitly* to enable Shift.
  - Such batteries can *in principle* be very large (handling as much as the entire peak demand of a site) if Shift has a high enough value to support the cost.



At ~$150/kWh-yr, BTM batteries become affordable, unlocking a Shift potential that dwarfs other flexible loads.

We will typically exclude BTM batteries from our results hereafter.

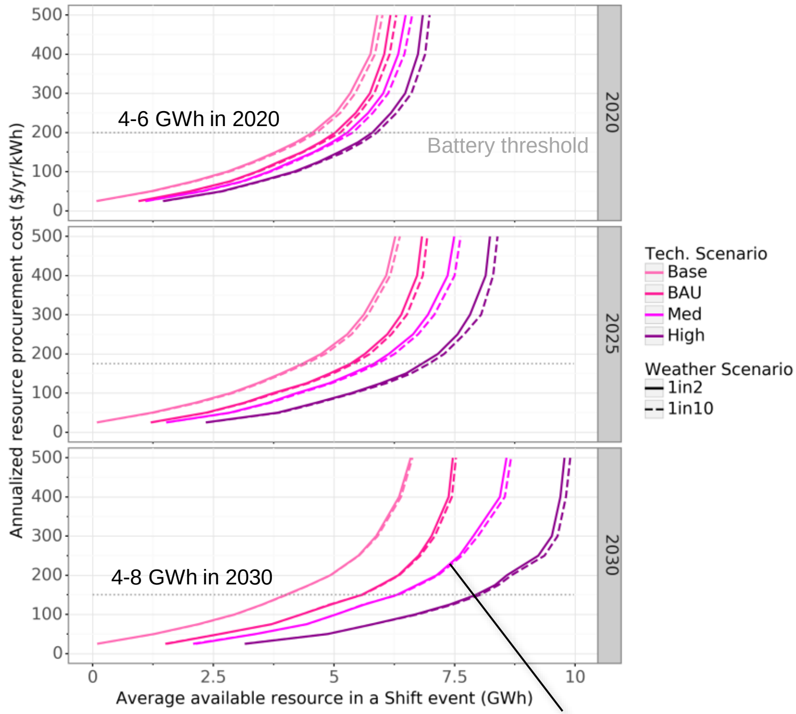
Shift supply curve by scenario and year

Several GWh of potential Shift, and growing

Four different scenarios for the evolution of DR-enabling technologies.

- **Base**: frozen price and performance.
- **BAU**: prices decline following historical trends.
- **Med**: faster price declines, better performance.
- **High**: aggressive price and performance trends.

With ~5 GWh of Shift per event, a morning and evening shift could offset much of the ~9 GWh of average daily curtailment in May 2019.*

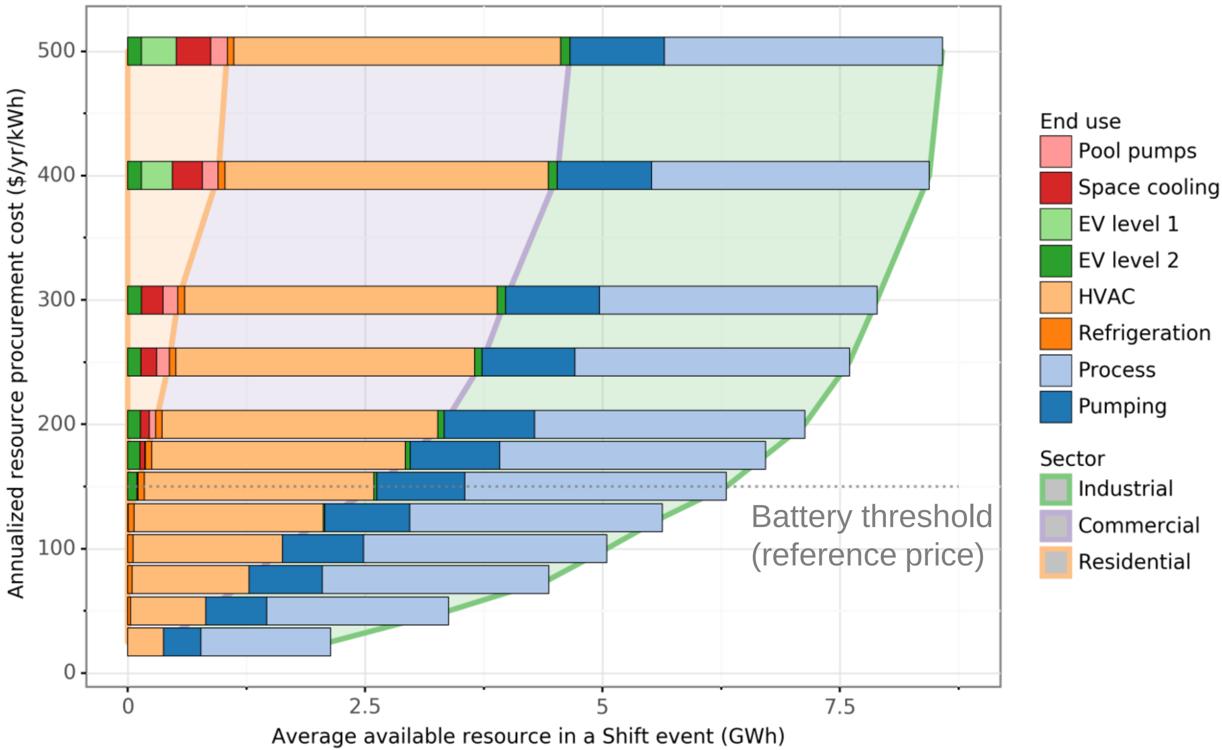


For the rest of this presentation, we'll look at 2030/Med/1in2 results

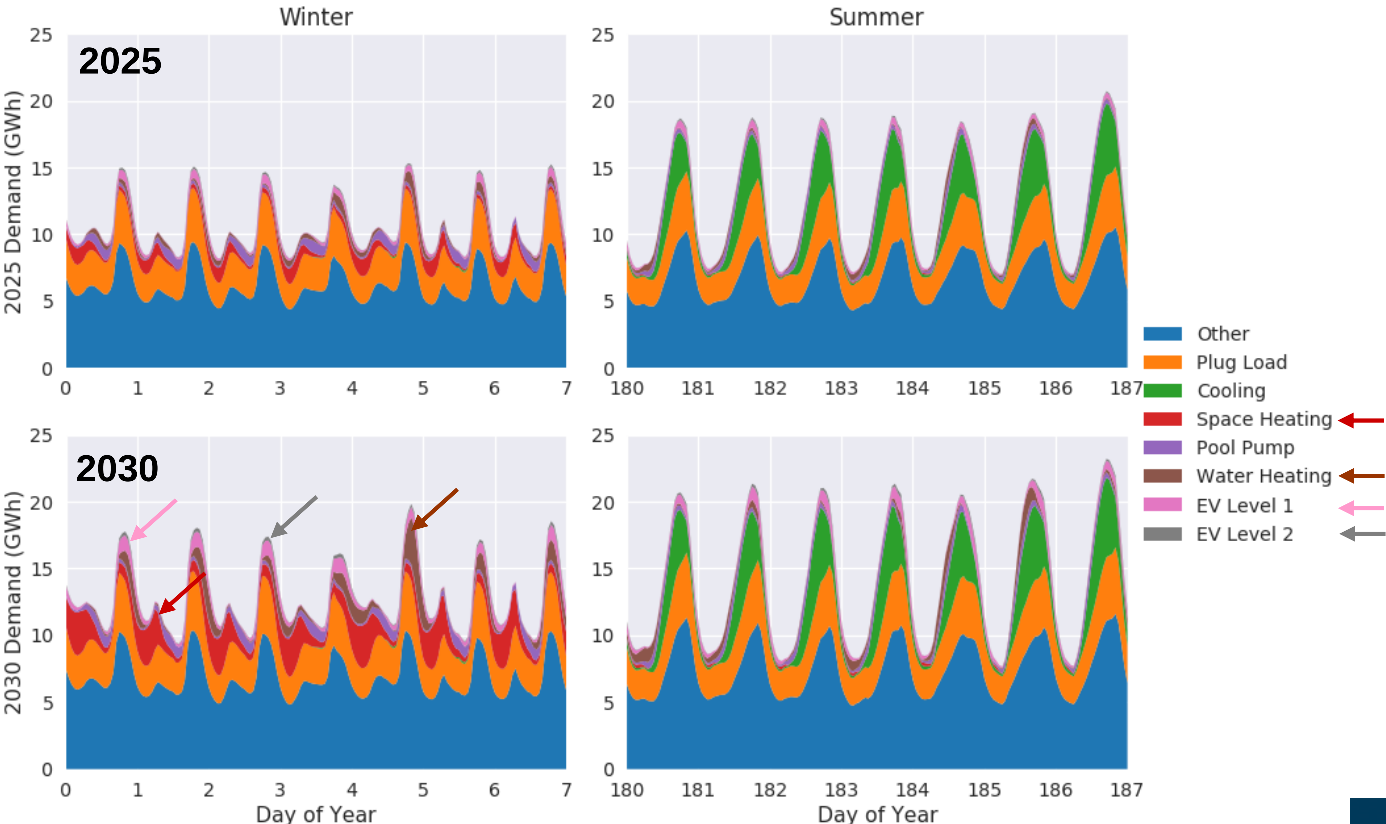
**Caveat: a portion of curtailment is driven by local transmission constraints. Shift resources would need to be appropriately located to offset this.*

Supply curve for Shift DR in 2030

Shift resource by sector and end use



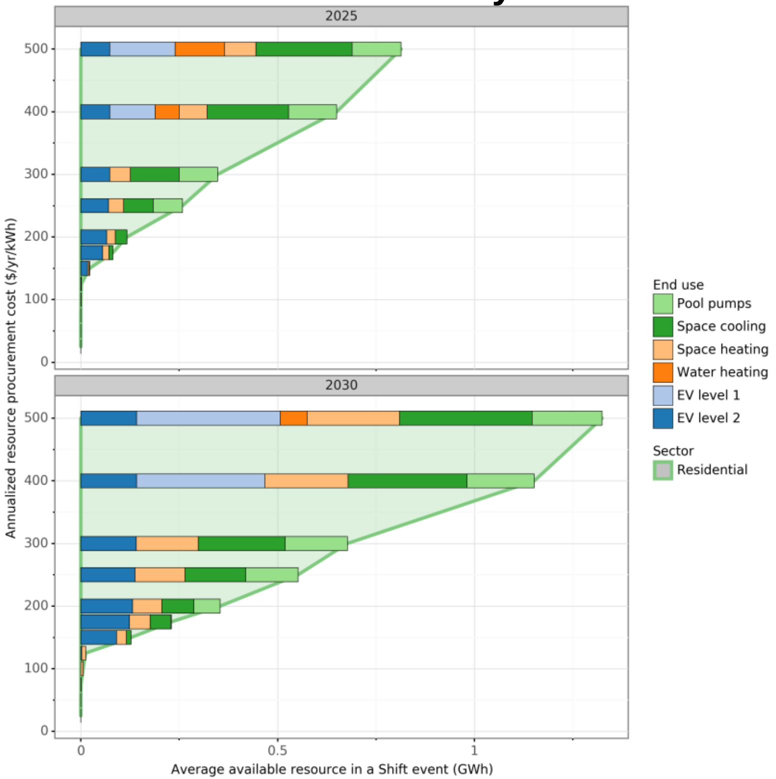
New loads from residential electrification
Statewide residential demand with electrification



New loads from electrification

Residential supply curve for shift with electrification

Residential sector only

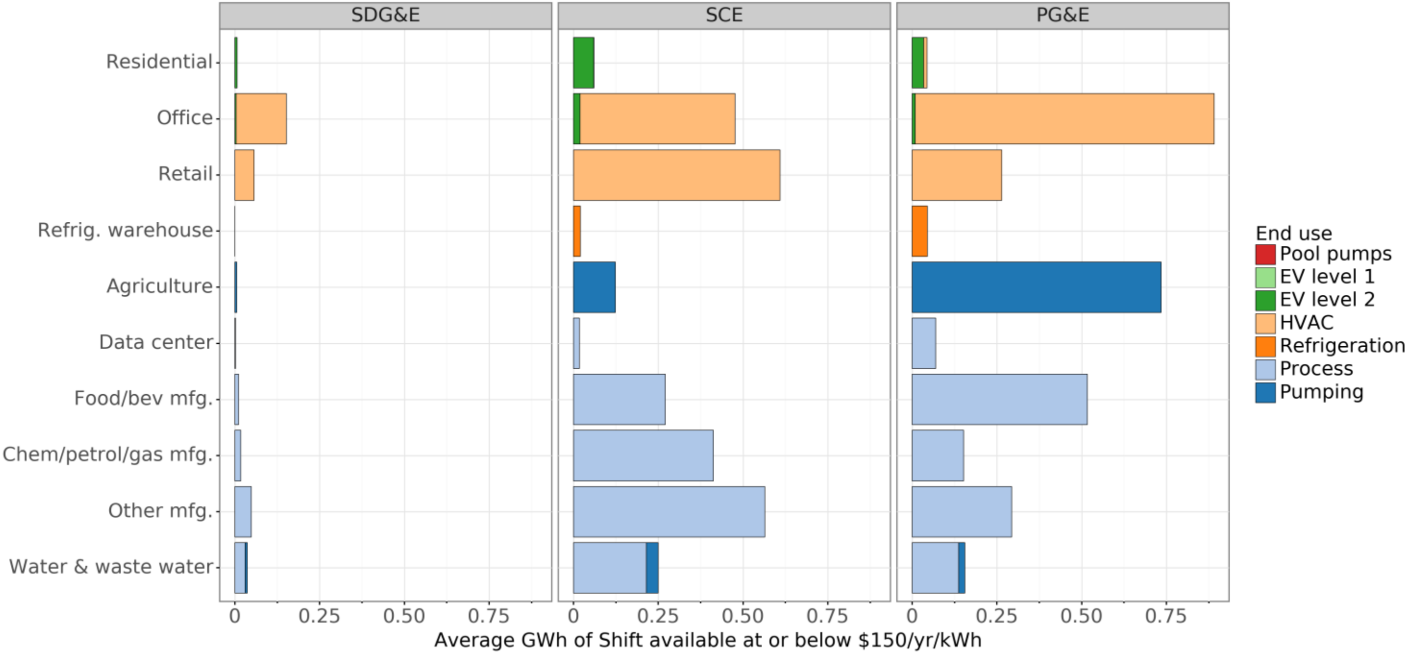


- Water heating resource is relatively small.
- Space heating resource is similar in size to space cooling by 2030.
- Residential fast EV charging also provides a significant resource.
- All residential resources are relatively expensive.

Results II.
Where is the Shift Resource and When is it Available?

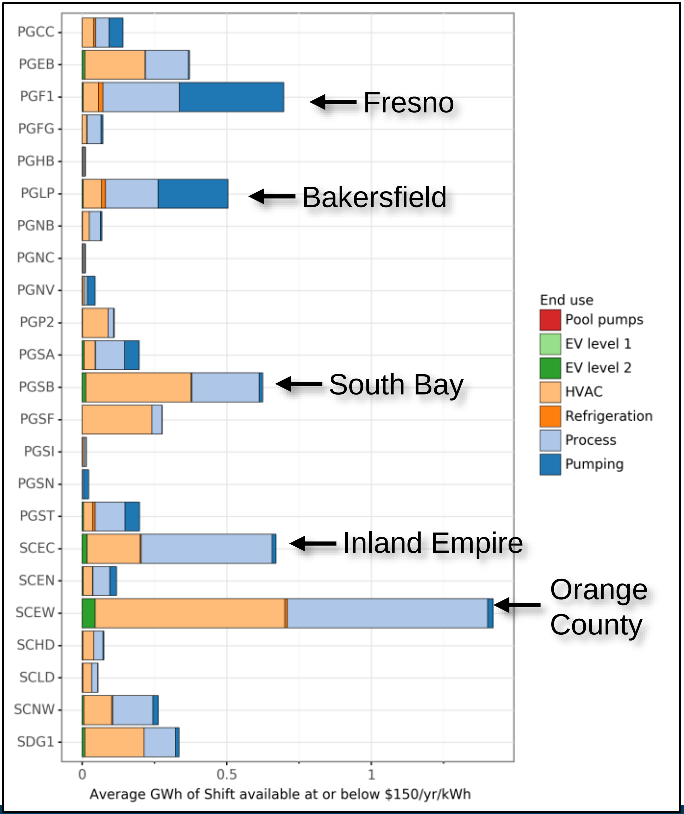
- Shift resource by building type and utility
- Shift resource by region (SubLAP)
- Seasonal effects on Shift

Shift resource by utility, building type, and end use
For technologies that are less expensive than batteries



Regional Shift resource by SubLAP*

For technologies that are less expensive than batteries

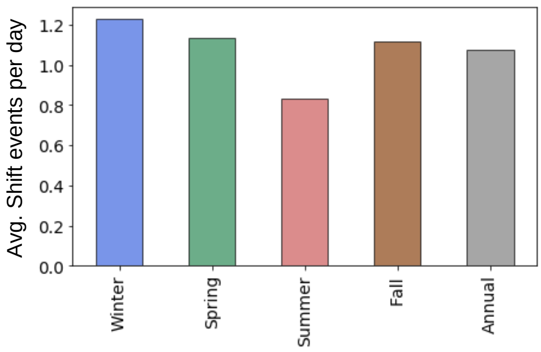


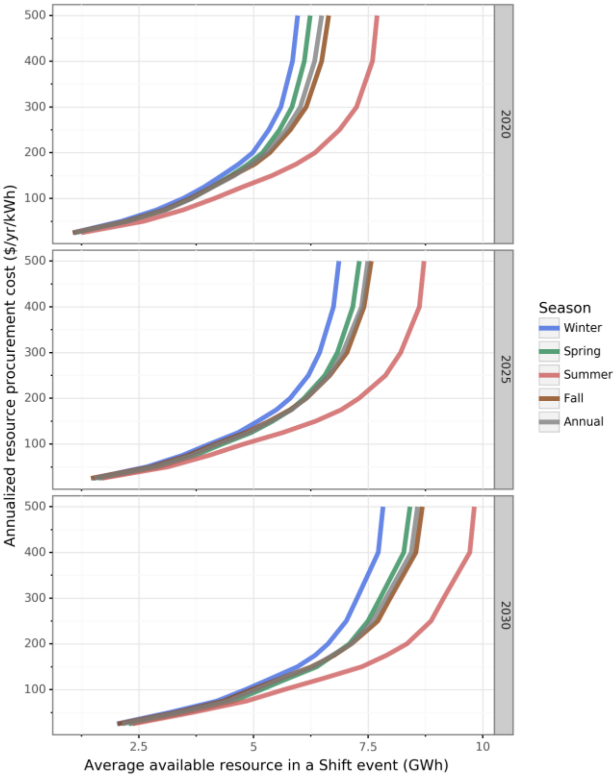
*Circa 2014 subLAP definitions

Seasonal effects on Shift

Variation in the need for and the supply of Shift

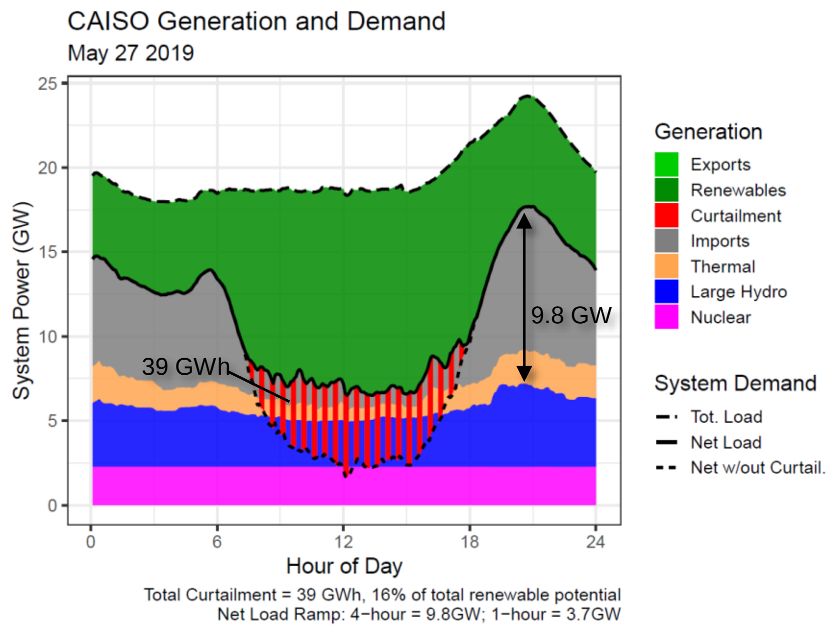
There is a competition between the ***need for*** and ***availability of*** Shift by season. The most frequent need occurs in winter, when the resource is smallest.





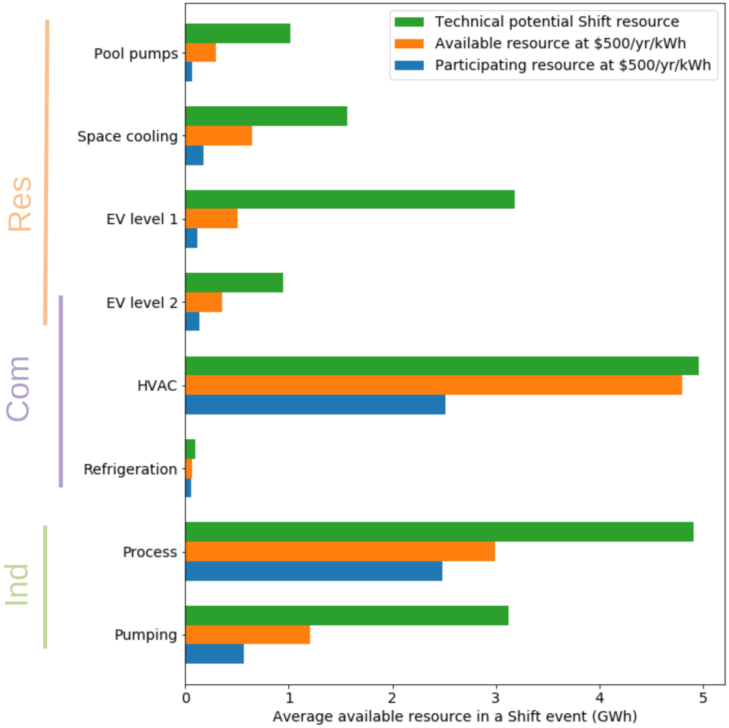
Results III.
How can we get more Shift more cheaply?

- The importance of costs and participation rates.
- Enhancing TOU response.
- The need for pilots.



Source: CAISO

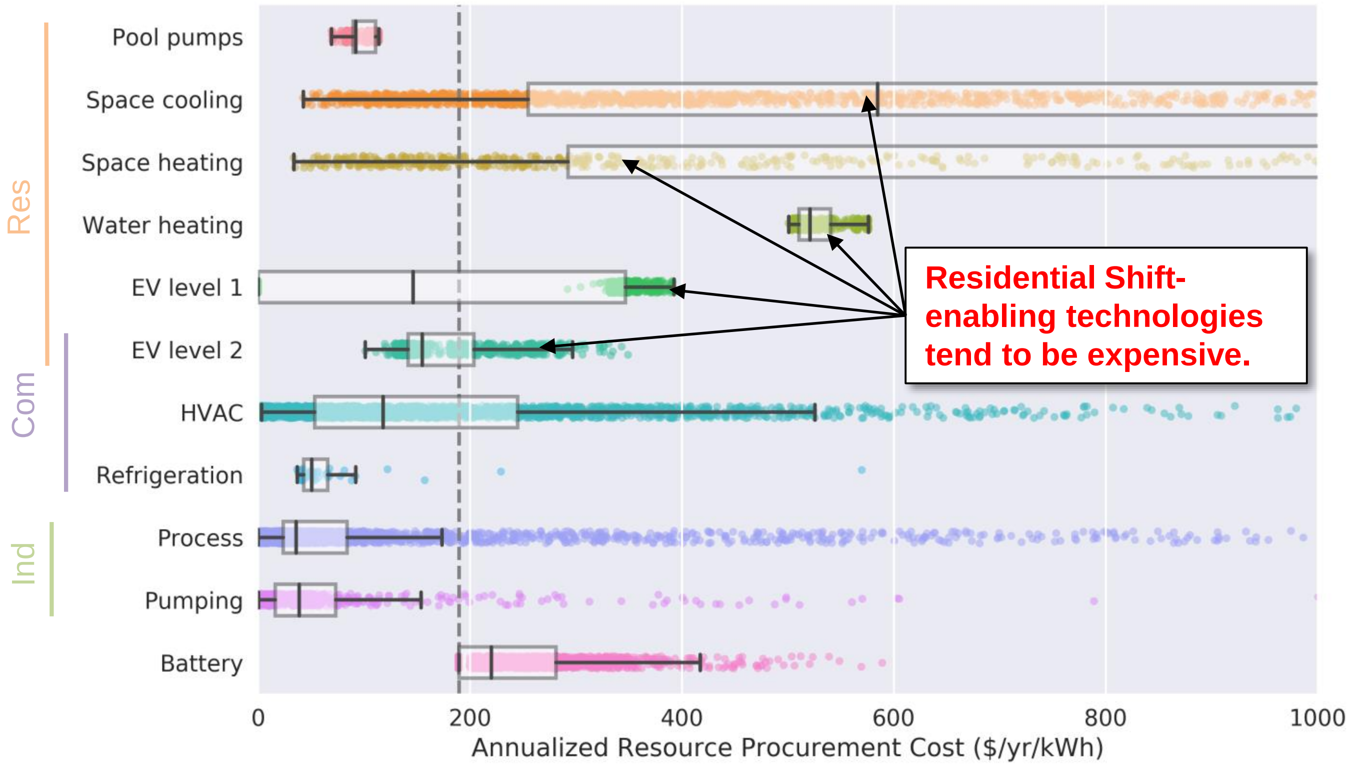
Participating vs. total Shift potential
The importance of customer participation rates



Technology cost and performance constrain how much of the total shiftable load can be made available.

DR-Path includes a customer participation model based on historical participation rates, which sharply constrains residential participation. New engagement models may help.

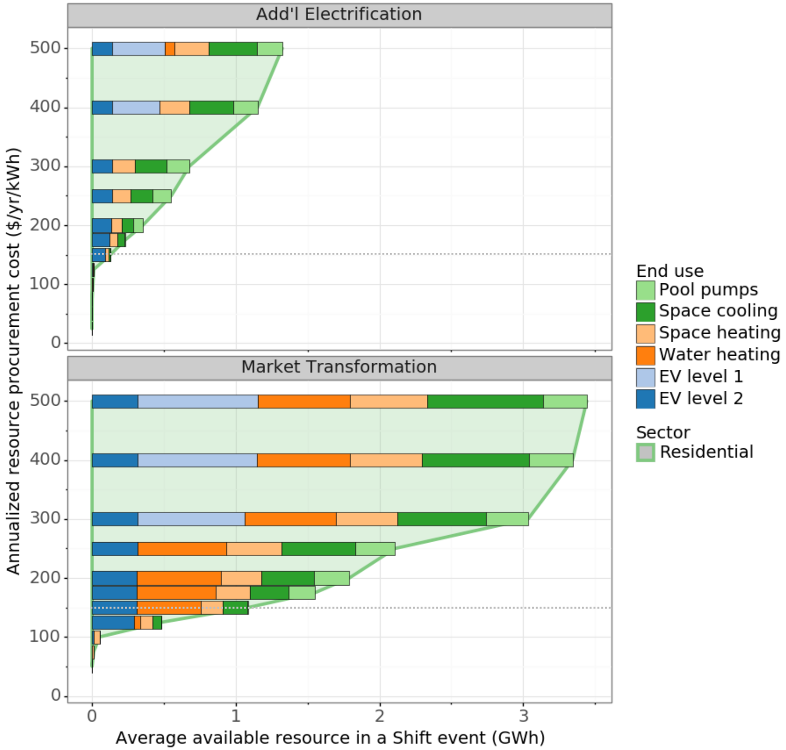
Cost barriers to enabling Shift
Reducing technology costs can unlock new resources



Imagining a transformed market for Shift
With much lower costs and higher participation

- We modeled a market-transformation scenario with large (3-10x) reductions in cost and increases in customer participation.
- Dramatic increases in the available Shift resource are possible.

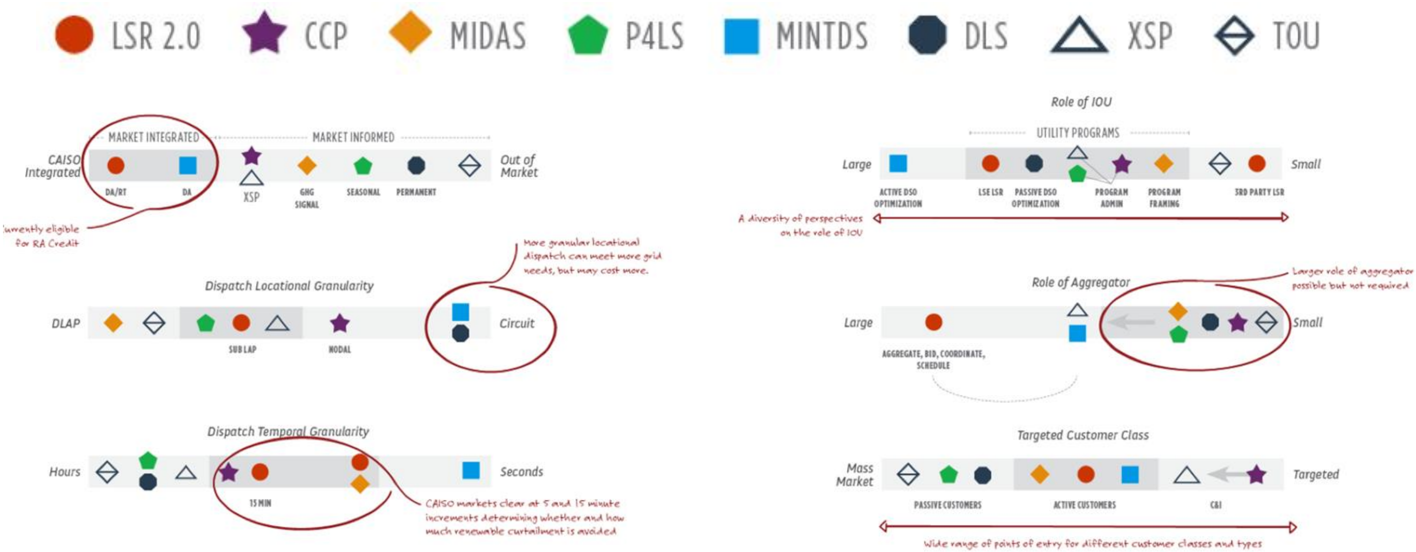
Residential sector only



Pathways to Shift as a Resource

Diverse pilot options to try soon

- **Load Shift Working Group Identified 6 new pilot concepts** with diverse levels of market integration, granularity, organizational roles & customer class targets.
- Data from pilots would provide essential new data to chart a course for Shift through modeling and program development



Read more at: https://gridworks.org/initiatives/initiatives-archive/load-shift-working-group/

How to move forward with Shift?
Recommendations for research and policy

Research and policy can proceed on several fronts in the near future to capitalize on the Shift opportunity.

- **Pilots and technology demonstrations** as a proving ground for technology and pathfinding effort for programs.
- **Focus on enabling electrification loads and new DERs** (e.g., EVs, BTM batteries) to grow the Shift resource during the deployment phase.
- **Dynamic tariffs**, especially with machine-readable broadcast, can incentivize load shifting at lower cost and without the challenges of full market integration (e.g., baselines).
- **Clear standards for communication and controls** to ensure interoperability and reduce enablement costs.
- **Field research on customer load flexibility** to understand the full extent of Shift capability at the customer level.
- **Carbon benchmarking** for buildings to measure GHG impacts of Shift.
- **Integrating EE, DR, and BTM storage** to take advantage of synergies (e.g., controls and active load management strategies)

Phase 3 summary

- In **Shift DR**, California has 4-6 GWh of *virtual storage* that is cheaper than BTM batteries—enough to address a significant portion of present-day grid challenges.
- The upgraded **DR-Futures** modeling framework enables a highly granular and flexible understanding of the Shift resource.
- **Electrification** of California buildings and cars will introduce a significant new Shift resource that could also mitigate seasonal variation.
- The Shift resource could be **much larger** than estimated here, if customer participation in Shift is higher than observed historically for Shed DR.
- New data from **pilots** and other research are essential to better understanding the Shift resource
- Targeted research and policy efforts have a major role to play **now** in shaping the future of Shift in California.

Next steps
Overview of the DR Potential Study, Phase 4

LBNL is embarking on Phase 4 of the CA DR Potential Study.

- Updated potential estimates for both **Shift** and **Shed** DR.
- Report expected in late 2021.
- Key data and modeling updates will include:
  - New customer load data (updating from 2014 to 2019): **Data request to IOUs will be forthcoming in spring 2020**.
  - Improved customer clustering, load disaggregation, and forecasting.
  - Expanded modeling of electrification (e.g., commercial space and water heating, medium/heavy-duty EVs).
  - New modeling framework for customer participation.
  - Improved integration of outputs into IRP capacity expansion modeling.
  - Coordination with EE Potential and Goals Study to yield **integrated EE/DR inputs** for inclusion in the IRP.
- We welcome input on relevant data or studies to support this work.

Contact

We welcome your comments on the Phase 3 draft final report. Please submit written comments to jingjingliu@lbl.gov by COB on **Friday, March 6th**

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Questions

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