Ascend Analytics
Better models. Better decisions.

Distributed Energy Conference: Assessment and Valuation of VPP Resources

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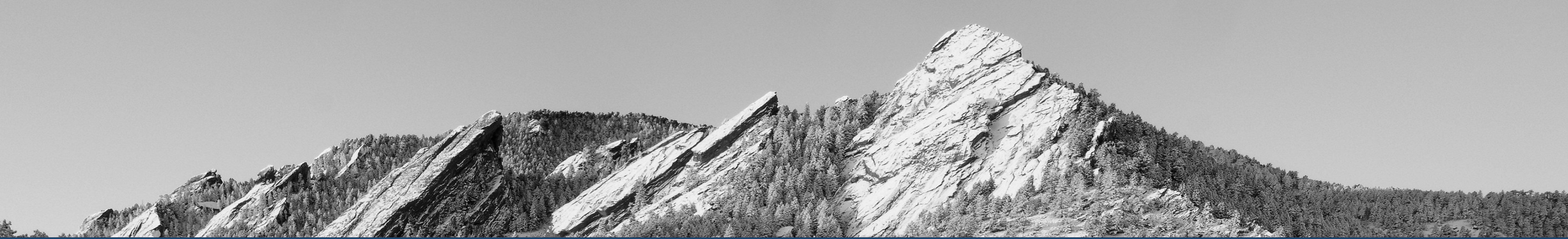
Silicon Valley Clean Energy



- Founded in 2002 with 50 employees in Boulder, Oakland and Bozeman
- Seven integrated software products for operations, portfolio analytics, and planning
- Consulting and custom analytical solutions

Proven and Broadly Adopted

New York Power Authority · nrg · Duke Energy · REU Redding Electric Utility · Silicon Valley Clean Energy · Austin Energy · AES Panamá · ipl an AES company · TID Water & Power · Ameren · Lansing BWL · NorthWestern Energy · LA DWP Los Angeles Department of Water & Power · City of Glendale Water & Power GWP · 8minute Solar Energy · ISO new england · Able Grid · Strata Solar Development · Shell · Terra-Gen · NextEra Energy

Differentiated Value for Enhanced Decision Analysis

PowerSimm OPS
OPERATIONAL STRATEGY

- Optimal short-term dispatch
- Determine operating strategies from position and financial exposure
- Track realized customer revenue and costs to settled day ahead and real time price
- Optimize financial exposure between day ahead and real time prices

PowerSimm Portfolio Manager
PORTFOLIO MANAGEMENT

- Portfolio management
- Generation asset management
- Hydro and renewable asset modeling
- Retail management & pricing
- Energy purchases and sales
- CFaR, GMaR, EaR

PowerSimm Planner
VALUATION & PLANNING

- Asset valuation
- Resource Planning
- Capacity Expansion Planning
- Reliability Analysis
- Renewable Integration
- Long-term Price Forecasting

BatterySimm Operations
STORAGE OPTIMIZATION

- Optimal offers to ISO
- Continuous adjust ISO offers
- Forecast probabilities of price spikes
- Renewables plus storage

BatterySimm Valuation
STORAGE VALUATION

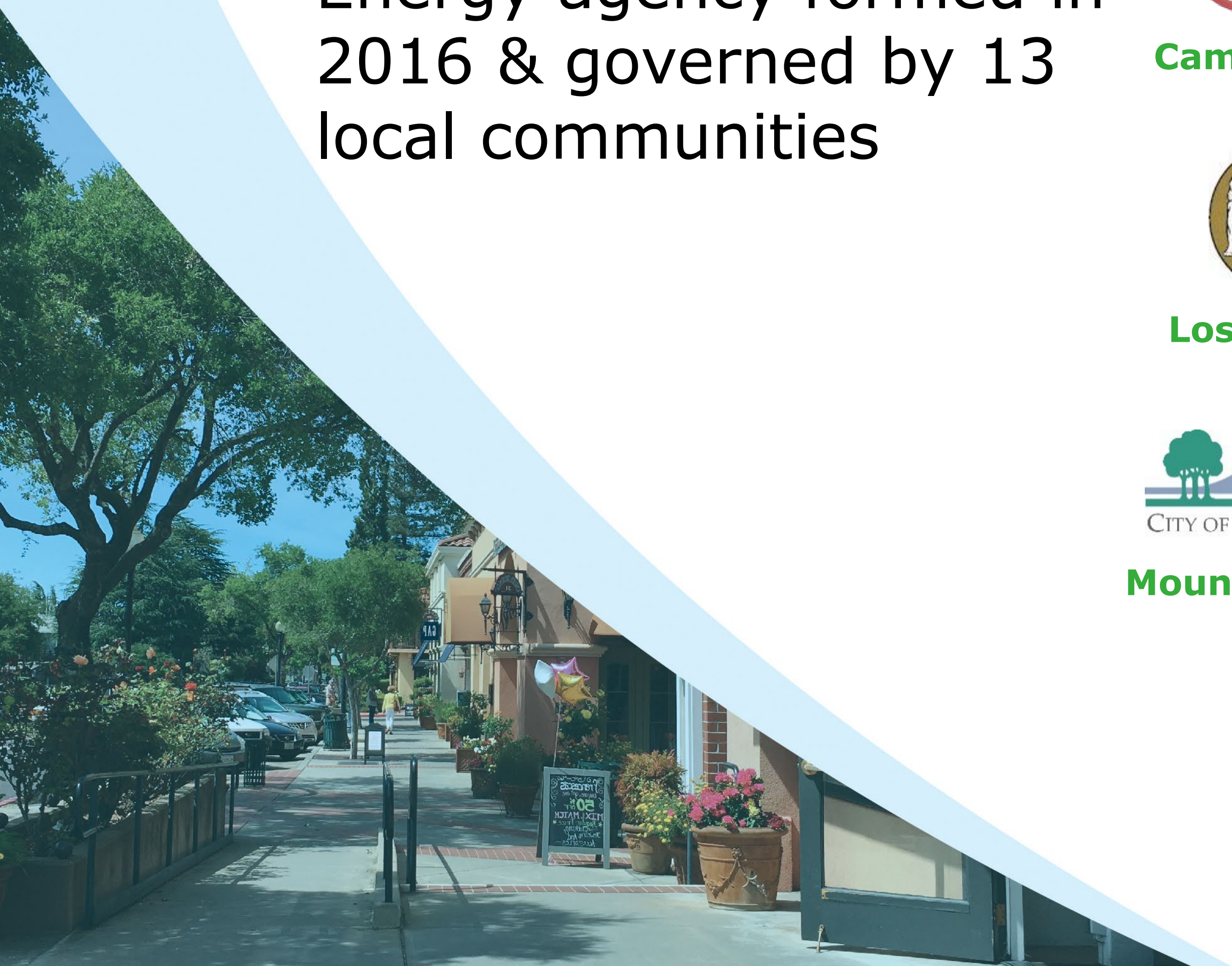
- Optimal siting and sizing
- Captures realistic revenues given imperfect foresight
- Battery cycle analysis

CurveDeveloper

- Complete set of forward curves and forecast curves for 30 years
- ISO settlement data
- Incorporate broker projections

About SV Clean Energy

A Community Choice Energy agency formed in 2016 & governed by 13 local communities



Campbell | Cupertino | Gilroy | Los Altos | Los Altos Hills

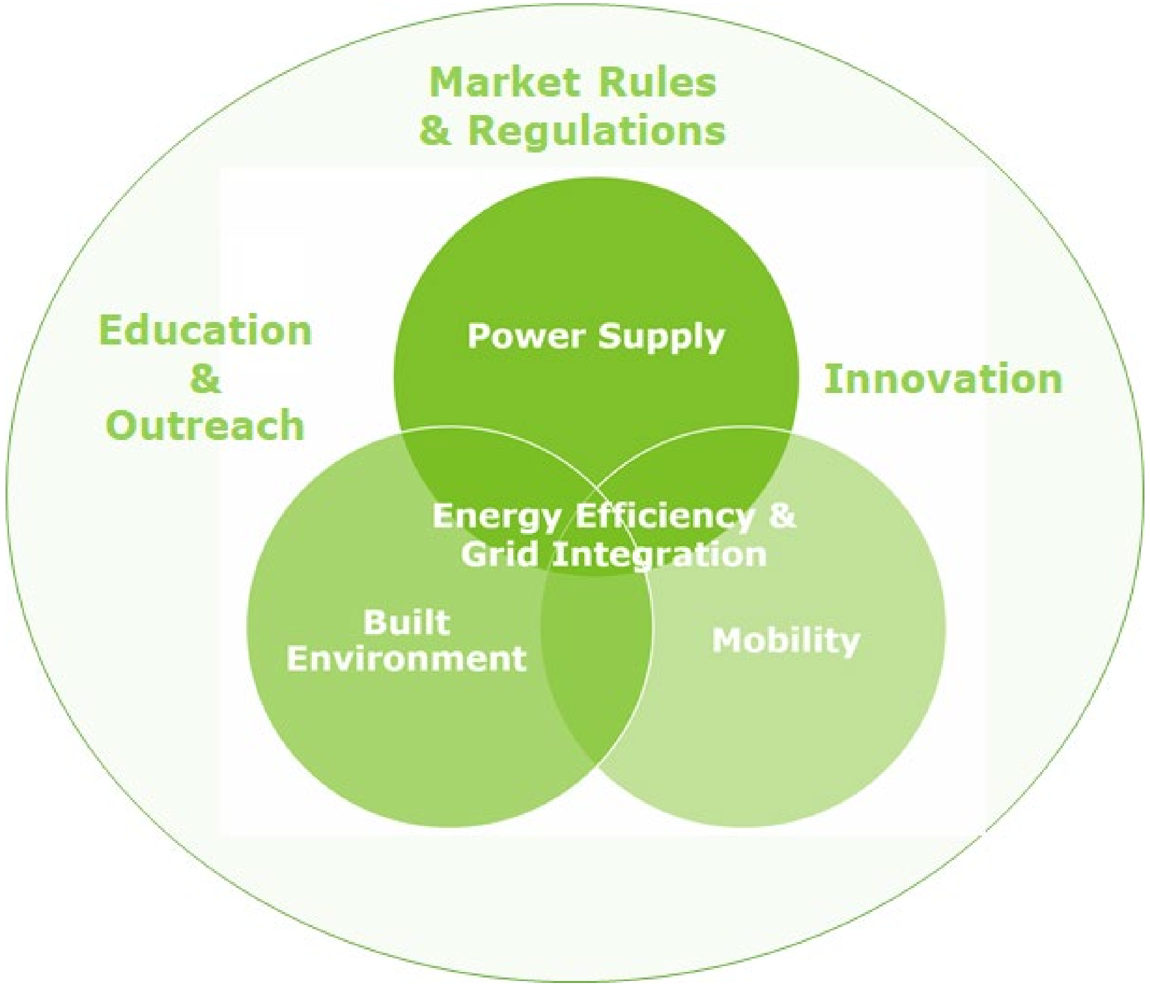
Los Gatos | Monte Sereno | Morgan Hill | Milpitas

Mountain View | Santa Clara County | Saratoga | Sunnyvale

SILICON VALLEY CLEAN ENERGY

Overarching Approach

- Procure & maintain a sustainable, affordable and carbon-free **power supply**
- Electrify the **built environment** and **mobility**
- Promote **energy efficiency** & successful **grid integration**



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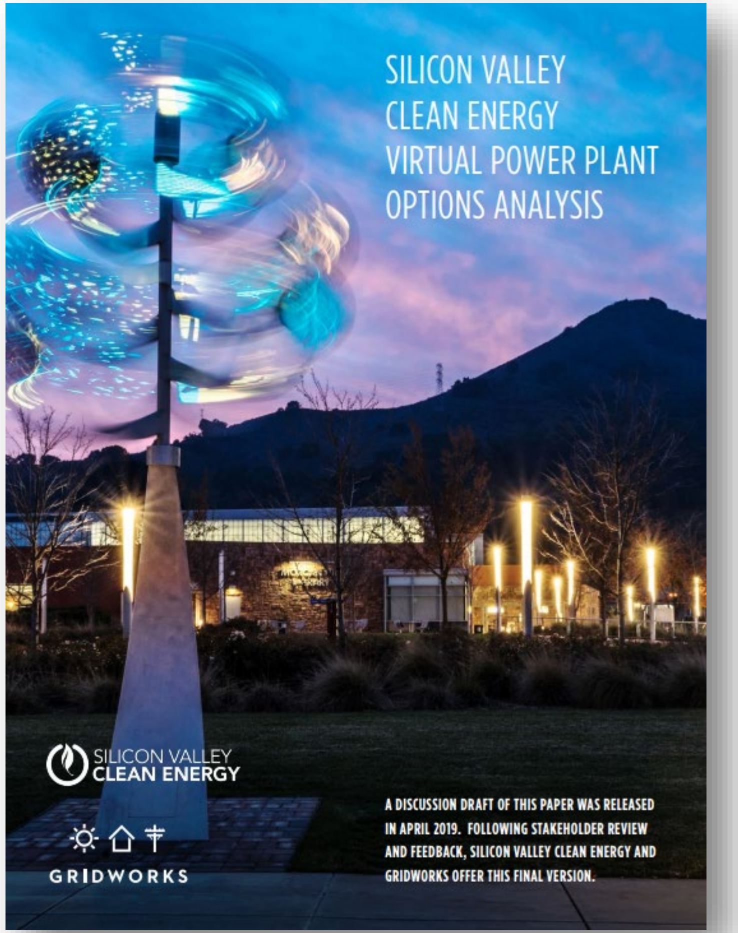
Grid Integration Activities



- **SVCE VPP Options Analysis*** explores how community energy can support grid integration (Summer 2019)
- **VPP valuation assessment**** quantifies value of load flexibility for multiple value streams, end uses (Winter 2019)

**https://tinyurl.com/SVCEVPPOptionsAnalysis*
***Focus of this presentation*

Big Picture

- Virtual Power Plant (VPP): Aggregation of various behind the meter resources, including flexible loads, energy efficiency, and behind-the-meter (BTM) solar and storage

- **Which VPP resources provide the greatest Value?**
- **How are these values realized operationally?**
- **How should a VPP program be strategized and prioritized?**

Brief Analysis Overview: Some Market Terminology

- Market mechanisms (how will value be realized):
  - Load-shaping (LS): using VPP resources internally to alter SVCE's net load to reduce costs
  - Market-integrated (Mkt): using VPP resources externally to sell into CAISO to generate revenues
- Value Streams (which ways can value be generated):
  - Capacity (RA) Value: capacity payment/avoided expense for providing peak capacity
  - Day Ahead (DA) Energy: arbitrage between high and low prices in DA energy market
  - Real Time (RT) Energy: arbitrage between high and low prices in RT energy markets
  - Ancillary Services (AS): revenues generated by selling ancillary services into CAISO
    - Only applies to market-integrated

Brief Analysis Overview

- **Step 1:** Calculate reference $/kW for each VPP asset for each revenue stream
  - Use 2018 data as a reference year
  - Define expected hourly availability (e.g. the EV must be plugged in to provide flexibility)
  - Determine value the asset can provide for each value stream
- **Step 2:** Estimate future $/kW value
  - Estimate future years based on long-term forecasts of changing price dynamics
- **Step 3:** Estimate available kW for each asset based on market size
  - Estimated future years based on resource potential estimates from various sources
- **Step 4:** Total annual value = ($/kW) * (kW)
  - Doesn't include diminishing returns at higher penetrations
- **Step 5:** Calculated NPV for 2020-2030

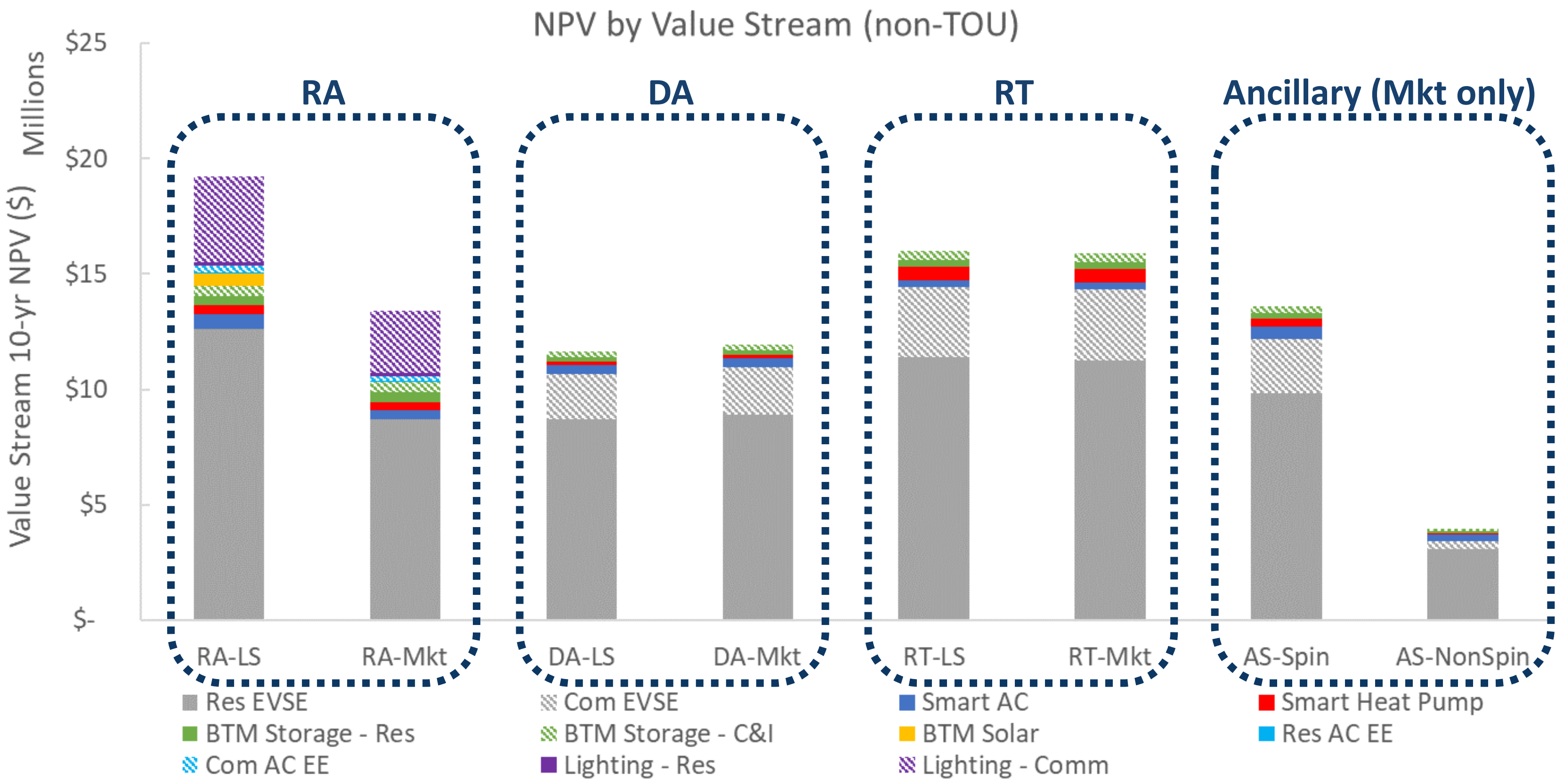
Summary of Key Takeaways

- **Mechanism:** *Load-shaping* enables the highest potential RA value and is significantly easier to manage compared to *market-integrated.*
- **Value Streams:** Highest value streams come from RA (load-shaping) and RT arbitrage. DA value is ~25%lower than RT but may be better able to value stack with RA in a load-shaping approach.
- **Assets:** The most valuable asset to control is EV charging. After EV charging, smart thermostats and BTM storage offer comparable value opportunities. Energy efficiency programs for commercial lighting may also offer significant RA value
- **TOU:** Helping Residential EV owners to follow TOU charging would provide significant value and significantly reduce much of the other value opportunity for coordinated EV charging/flexibility

Which Market Strategy: Load Shape v. Mkt

Key Takeaways:

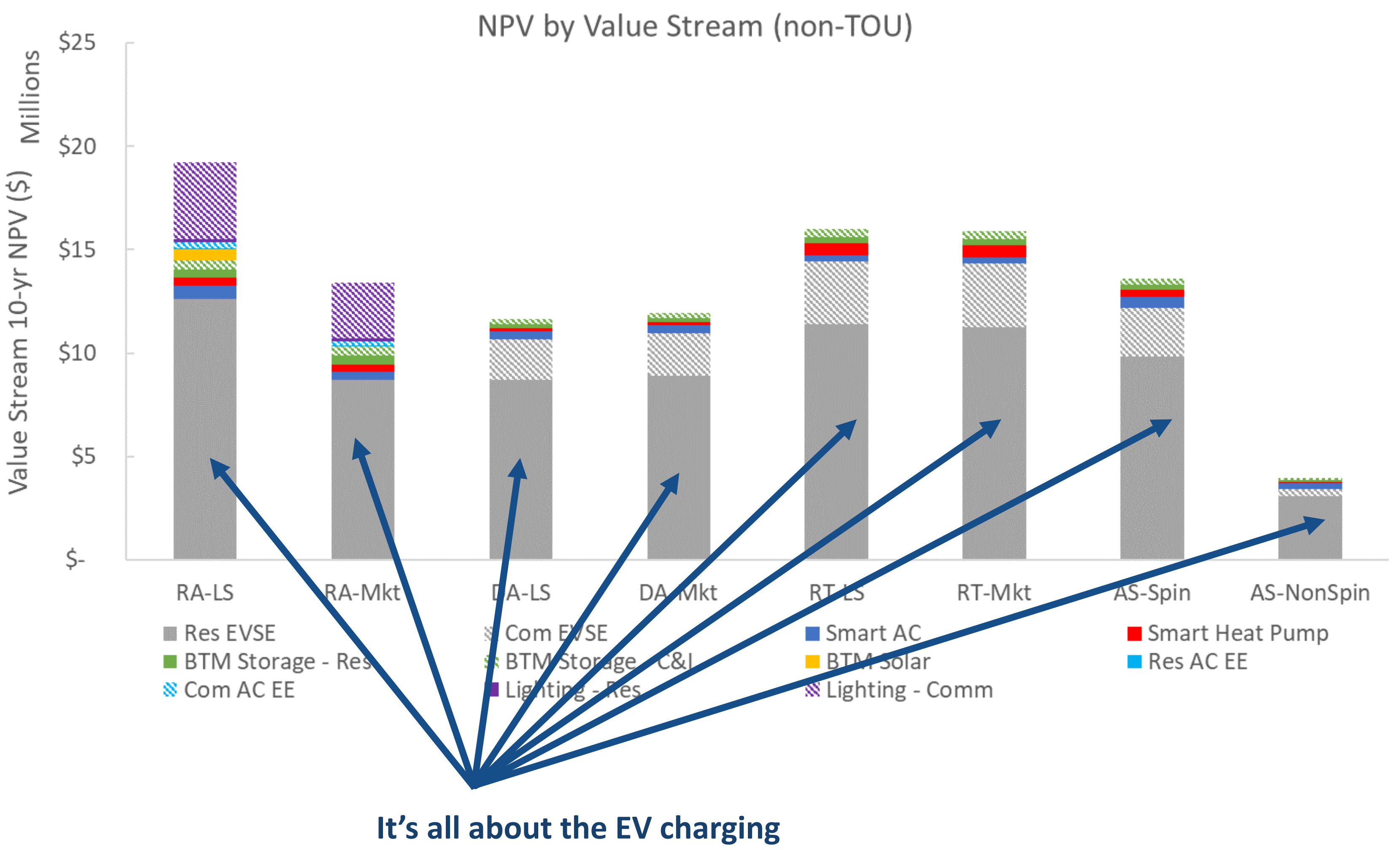
- RA value higher for load-shaping than market-integrated
  - Different qualification rules and durations
- Energy arbitrage yields similar value whether load-shaping or market-integrated
  - In CAISO, aggregations are large enough to diminish benefit of nodal volatility relative to load aggregation point (DLAP)



Which Resources?

Key Takeaways:

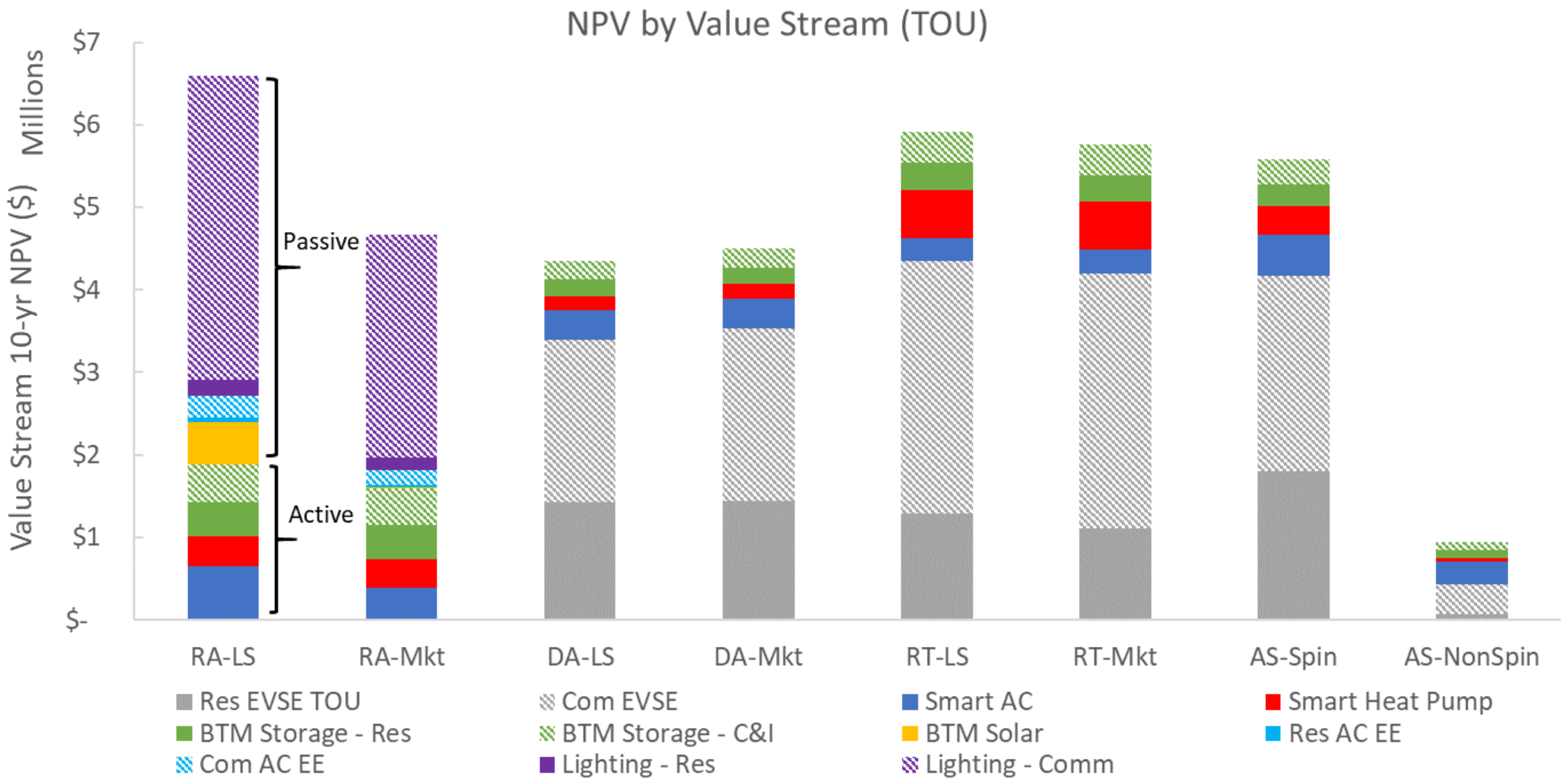
- Value stacks are dominated by the impact of flexible EV load
  - Commercial charging flexibility can provide energy arbitrage but not capacity value
- Commercial lighting may provide significant capacity value
  - Depends on assumptions around usage and existing adoption patterns



What about if EV charging follows TOU rates?

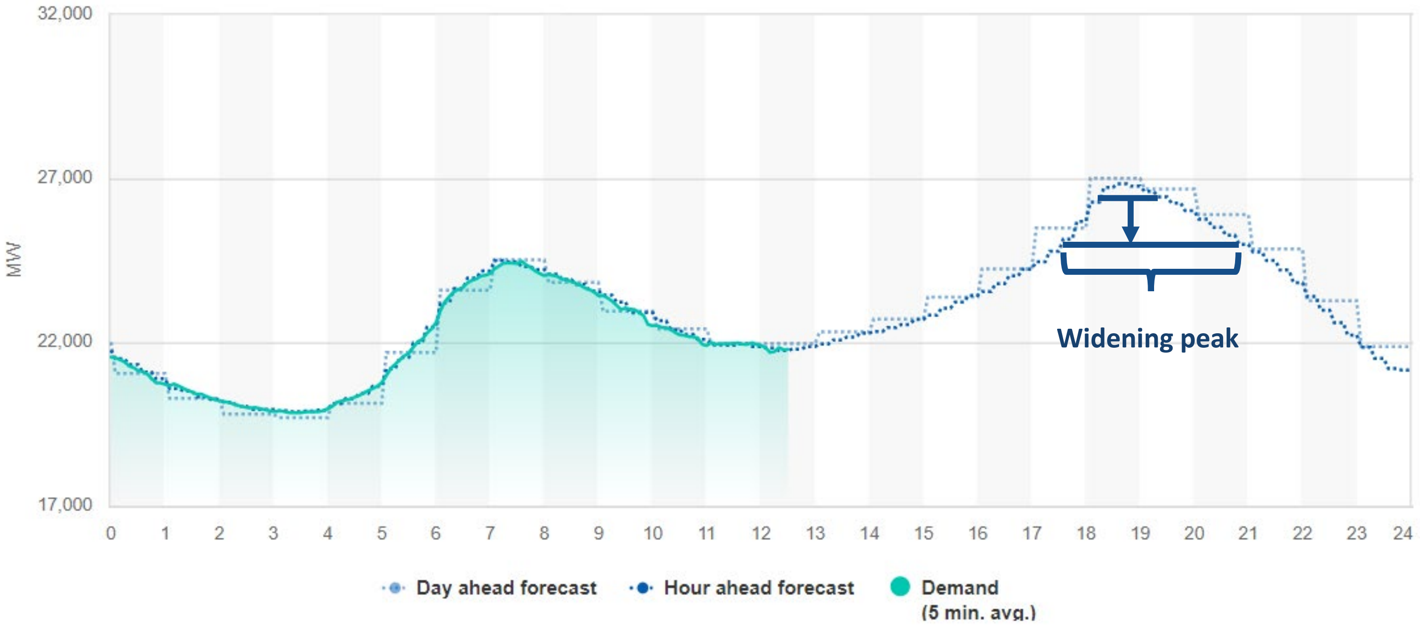
Key Takeaways:

- Value of EV flexibility is heavily reduced with TOU charging profiles
  - Capacity value disappears entirely
  - But *still* largest value resource for DA and RT energy arbitrage
- Smart thermostats, BTM storage, and commercial lighting offer next highest values



Some Additional Complications

- This analysis looked at value streams in isolation, but there is opportunity to **stack value**
  - RA and DA stack well: high probability of alignment between high DA price and peak load
  - RA and RT less clear: RT price spikes are shorter and more volatile/variable
  - DA can stack with RT revenues outside of peak DA price hours
    - If RT price spikes align with high DA price, can only choose one
  - Spin can stack with RT (under current CAISO rules)
- This analysis ignored diminishing returns at higher penetrations
  - SVCE peak shaving requires 2-3h of duration for the first ~20-30MW
  - Most of the analyzed VPP assets have durations >3h



How SVCE Has Used the Results

Pursuing VPP pilot roadmap using study results:

- **Mechanism**: Focus on load-shaping approach for VPP
- **Value streams**: Initial pilots target capacity & RT value streams. Additional emphasis on *resilience* value to customer.
- **Assets**: Initial focus on EV charging & BTM storage
- **TOU**: One of two initial VPP pilots is telematics smart charging pilot to help EV customers respond to TOU rates

SILICON VALLEY CLEAN ENERGY

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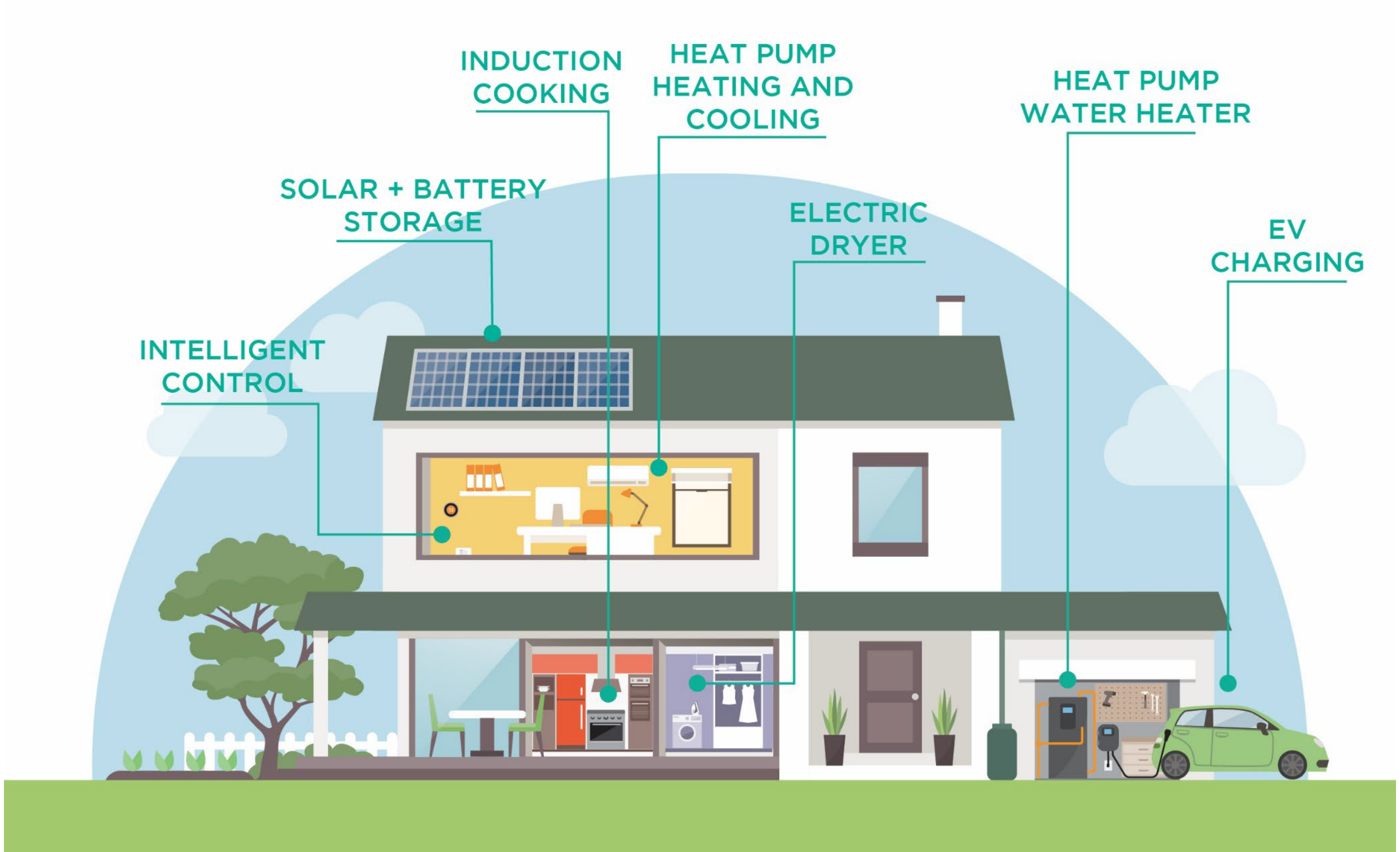
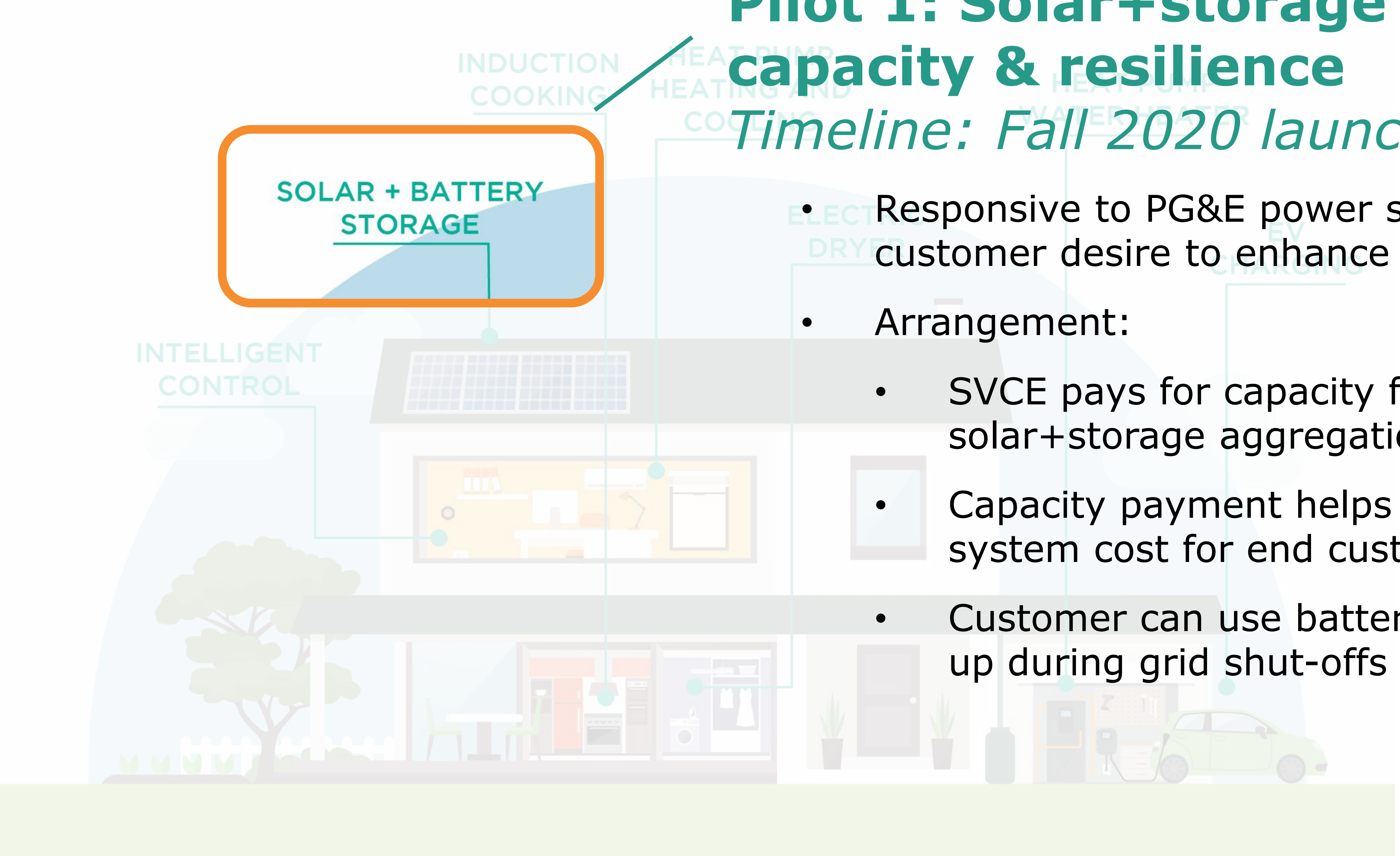
SVCE VPP Pilot Roadmap



SVCE VPP Pilot Roadmap



Pilot 1: Solar+storage for capacity & resilience

Timeline: Fall 2020 launch

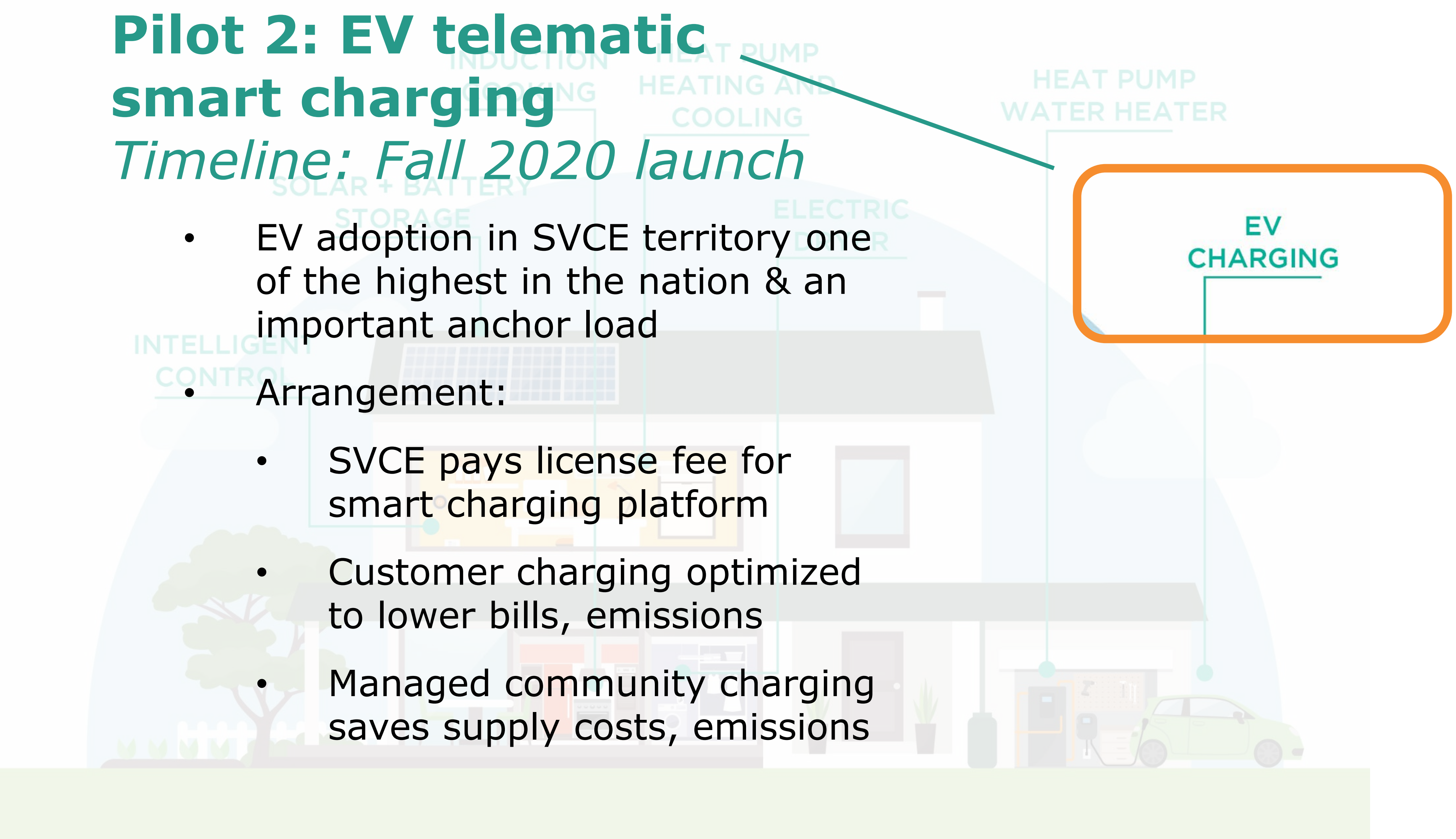
- Responsive to PG&E power shut-offs & customer desire to enhance resilience
- Arrangement:
  - SVCE pays for capacity from solar+storage aggregation
  - Capacity payment helps buy down system cost for end customer
  - Customer can use battery for back-up during grid shut-offs

SVCE VPP Pilot Roadmap

Pilot 2: EV telematic smart charging

Timeline: Fall 2020 launch

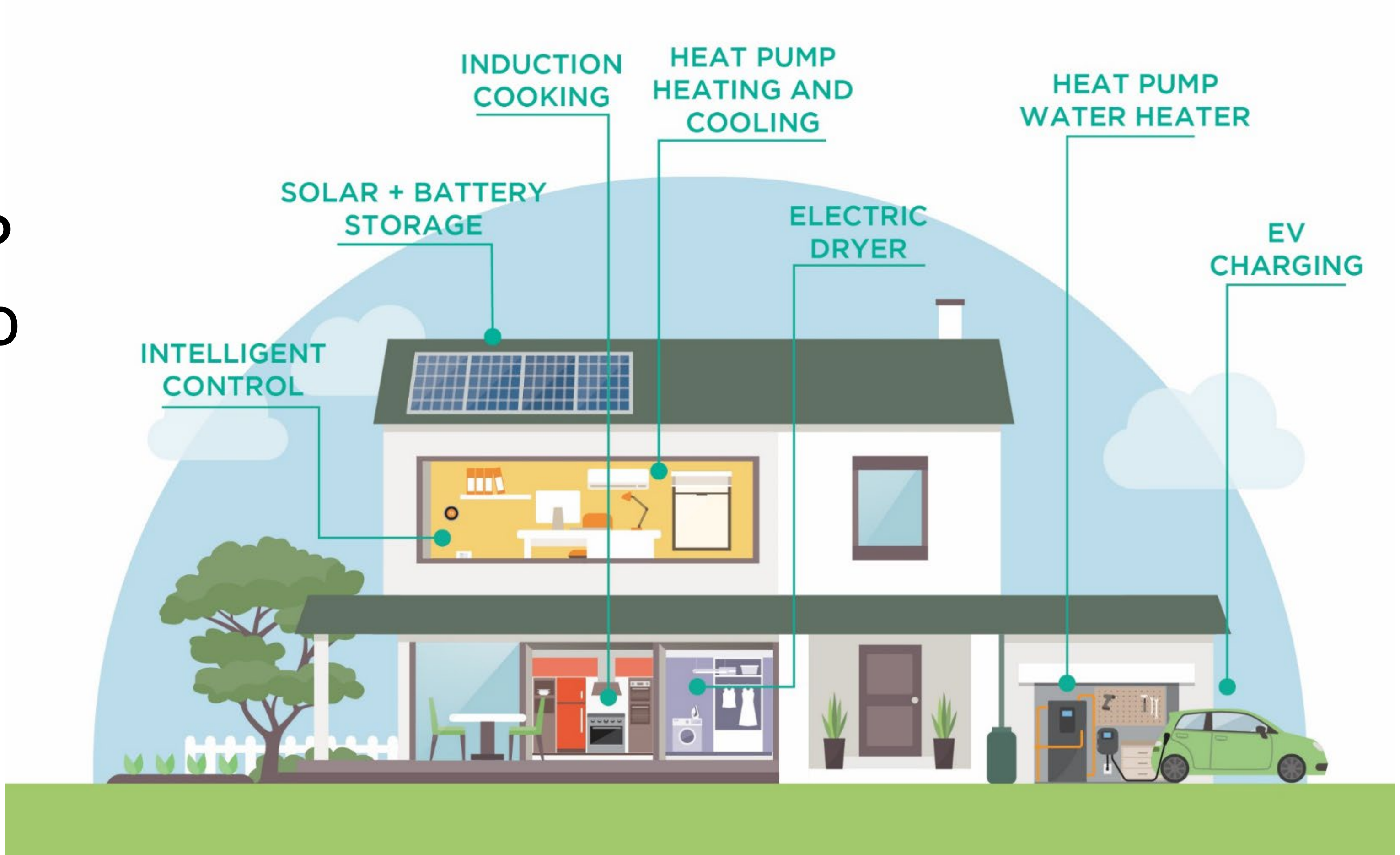
- EV adoption in SVCE territory one of the highest in the nation & an important anchor load
- Arrangement:
  - SVCE pays license fee for smart charging platform
  - Customer charging optimized to lower bills, emissions
  - Managed community charging saves supply costs, emissions



SVCE VPP Pilot Roadmap

Pilot concepts under development:

- Whole-home connected community
- Expansion to C&I
- Comprehensive VPP platform agnostic to aggregator & end use



Appendix A

Detailed Analysis Description

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Detailed Analysis Overview: Assets

- Residential and Workplace Electric Vehicle Supply Equipment (EVSE)
  - Residential considered both TOU and non-TOU charging patterns
- Residential and Commercial BTM Storage
  - Assumed restrictions generally reflective of SGIP & ITC
  - Not currently included: demand charge mitigation (would eliminate most commercial BTM)
- BTM solar
  - Treated as passive resource only (modification of net load)
- Smart thermostats controlling **residential** AC and heat pumps
- Energy efficiency for:
  - Residential and commercial AC
  - Residential and commercial lighting
  - Treated as passive resource only (modification of net load)
- Hourly availability determined from publicly available Energy+ load profile simulation

Detailed Analysis Overview: Value Streams

- Resource Adequacy (RA)
  - Load-shaping: single-hour coincidence between monthly peak and asset availability
  - Market-integrated: lowest sustained 4h availability between 4-9pm
- Day-Ahead energy value (DA)
  - Load-shaping: Best arbitrage within asset availability window for DLAP prices
  - Market-integrated: Best arbitrage within asset availability window for SLAP prices
- Real-Time energy value (RT)
  - Load-shaping: positive and negative price spike revenue using DLAP RT prices
  - Market-integrated: positive and negative price spike revenue using SLAP RT prices
- Ancillary Services value (AS)
  - Load-shaping: no revenue opportunity
  - Market-integrated: sum of SLAP AS prices coincident with asset availability
- Total Values: Consider the SIZE of assets potentially available

Detailed Analysis Overview: Total Values Overview

- Estimated a normalized power available per site for each asset
  - E.g. demand reduction per smart thermostat under control
  - Use Ascend forecasts for revenue changes over time
- Estimated number of sites available annually from 2020-2030
  - Use E3 forecasts where available
  - Use adjustable inputs for other resources
- (Power per site) * (# of sites) = total power available
- (total power available)*(penetration)*($/kW) = total value
  - Penetration adjustable in spreadsheets, currently set at 10% of available sites
  - Neglects effects of diminishing returns

Detailed Analysis Overview: Total Values Assumptions

- EVSE
  - Power based on normalized NREL 2025 charging profiles (mix of Res/Work/Public & L1/L2/L3)
  - Size based on E3 forecast
- Smart Thermostats
  - Power based on information from Uplight on power reduction per household
  - Site numbers were adjustable inputs
- BTM Storage
  - Size based on E3 forecast
- BTM Solar
  - Size based on E3 forecast

Detailed Analysis Overview: Total Values Cont'd

- EE for AC
  - Power numbers: ($Power_{oldAC}$ – $Power_{energystar}$)
    - Res = 2.5 tons
    - Com = 15 tons
  - Site numbers: Res assumed same as for smart thermostat; Com assumed all customers have AC
  - Assumed only 5% are due for replacement/upgrade (i.e. once every 20 years)
- EE for lighting
  - Power numbers:
    - Res: typical # of lights * (CFL – LED Wattage)
    - Comm: typical lighting load * (1- LED Wattage / Fluorescent tube wattage)
  - Site numbers:
    - Res: guess 10% not already using LEDs in 2020
    - Com: guess 40% not already using LEDs in 2020

Appendix B

Additional Takeaways

Load-Shaping v. Market-integrated (by value stream)

- RA
  - Load shaping: avoids must-offer obligations, avoids PDR qualification
  - Market-integrated: clearer and more immediate revenue path for RA
    - For load-shaping, changes in peak will be slower to translate to decreased RA requirements
- DA
  - Load shaping: avoids having to qualify resources as PDRs and run a dispatch desk
  - Otherwise mostly neutral (similar value for SLAP and DLAP)
- RT
  - Load shaping avoids having to qualify as PDR
- AS
  - Only available for market-integrated, can value stack with other revenue streams

Load-Shaping v. Market-integrated (by participation type)

- Load shaping
  - Avoids must offer obligations for RA
  - Avoids PDR qualification
  - Avoids need for dispatch desk
- Market-integrated
  - Clearer and more immediate revenue path for RA
  - Enables ancillary services revenue, which can stack with other values

Some Additional Considerations

- RT likely to require less customer compensation than DA due to shorter events
- Commercial BTM storage unlikely to have available SOC if customers are meeting ITC+SGIP+Demand Charge goals
  - Customer compensation will likely have to be high to move out of demand charge mitigation
- Value stacking and co-optimization required to generate a recommended VPP supply stack