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Energy+Environmental Economics

Modeling Tools to Maximize Solar + Storage Benefits

Case Study and Tool Demonstration

Public Workshop

08/19/2019

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Agenda

- Project Overview and Schedule
- Case study: a PV + storage system in Blue Lake, CA
  - Blue Lake Rancheria Pilot: Pilot project introduction
    - Peter M Alstone, Humboldt State University
  - Cost-effectiveness Analysis Results
  - Q&A
- Tool Demonstration
  - Tool Overview
  - Tool Demonstration
  - Q&A

About E3

- Founded in 1989, E3 is an industry leading consultancy in North America
- E3 operates at the nexus of energy, environment, and economics
- Our team employs a unique combination of economic analysis, modeling acumen, and deep institutional insight to solve complex problems for a diverse client base

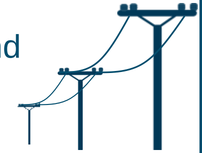
E3 Practice Areas

E3 has five defined working groups that create continual innovation from cutting edge projects and constant cross-fertilization of best practices across the groups

DERs & Rates

Analyzes distributed energy resources, emphasizing their costs and benefits now and in the future

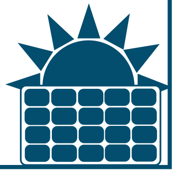
Supports rate design and distribution system planning



Clean Energy

Provides market and policy analysis on clean energy technologies and climate change issues

Includes comprehensive and long-term GHG analysis



Asset Valuation

Determines asset values from multiple perspectives

Uses proprietary in-house models and in-depth knowledge of public policy, regulation and market institutions

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Planning

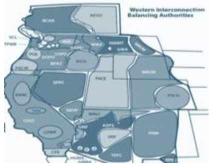
Develops and deploys proprietary tools to aid resource planners

Informs longer-term system planning and forecasting

Market Analysis

Models wholesale energy markets both in isolation and as part of broader, more regional markets

Key insights to inform system operators and market participants



Project Overview: EPC-17-004

+ Project Purpose

- Develop the Solar + Storage Tool that assesses the cost effectiveness of PV, storage, and other DER technologies for customers and ratepayers under different tariff and program designs
  - Simulate the operation of dispatchable DERs based on an optimization algorithm
  - Estimate value with a focus on location of the resource (Local Net Benefits Analysis (LNBA))

- Apply the tool to evaluate solar + storage systems being researched in other EPIC projects (GFO-16-309)
  - Results will be shared in the next workshop

Project Schedule

- **The tool is available for download in this website:**
  - https://www.energy.ca.gov/research/mod_tool_max_solar_storage/
  - User guide is also available, which contains a quick-start guide along with full instructions and methodology documentation
  - Pre-loaded example cases
  - No installation required
- **Three workshops**
  - June 13, 2019: **Tool and use cases overview**
  - Today: **Case study results and tool demonstration**
  - December 2019: **Final project presentation and wrap-up**
- **An additional webinar if needed:**
  - follow-up conversations on lessons learned and results from three EPIC projects

Energy+Environmental Economics

Case Study

Background

- **Blue Lake Rancheria Pilot: pilot project introduction**
  - Peter M Alstone, Humboldt State University

Pilot Site Overview

- **Pilot Site:**
  - **2018 Load:** average 32 kW load with summer afternoon to evening peak
- **DER technologies**
  - PV: 60 kW DC, 16.7% capacity factor
  - Energy storage: 110kW 1.6-hour battery (AC); 80% AC to AC round-trip efficiency
  - Demand response capability and future EV chargers are not modeled
- **Pilot site at an Indian Reserve, no tax thus no ITC**
- **Emergency Center for the community: value the reliability**

Month-Hour Average Site Load (kW)

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	32	32	31	31	30	32	32	32	28	28	28	29	30	30	30	30	29	33	34	34	32	32	32	32
Feb	33	32	32	32	31	32	32	31	28	28	28	29	30	31	30	31	29	32	34	34	33	33	31	32
Mar	33	33	32	32	31	31	32	30	29	28	28	28	30	30	31	31	31	30	32	34	34	33	33	32
Apr	33	33	33	32	32	31	32	29	30	29	30	29	31	32	32	32	32	30	31	32	35	33	33	31
May	33	33	33	32	33	31	30	30	31	31	32	31	33	34	34	34	33	32	33	33	35	35	33	32
Jun	34	34	34	33	33	32	31	31	33	32	33	32	35	35	36	36	36	34	35	34	35	36	34	33
Jul	34	35	34	34	34	33	32	32	33	32	33	33	35	36	37	36	36	35	35	34	35	36	34	33
Aug	35	36	36	35	35	34	34	32	34	33	34	34	37	37	39	38	38	36	37	36	38	37	34	33
Sep	36	36	36	35	34	33	34	32	33	32	33	33	36	36	38	38	37	36	37	38	39	37	34	33
Oct	33	34	34	32	33	31	33	32	31	31	30	29	32	32	34	33	33	31	34	36	36	35	33	31
Nov	33	34	33	33	31	33	32	32	30	31	29	31	32	33	33	32	31	34	35	35	35	34	31	32
Dec	31	32	31	31	31	31	30	30	28	27	28	28	29	30	30	30	31	33	32	33	32	31	31	31

Use Cases

SOC Increase

Backup Power

Serve as an emergency center during grid emergency (e.g. wildfire and storm)

No minimum battery SOC requirement during day to day operation due to forecastable extreme events

Value of Loss Load (VoLL) is assumed to be the fuel cost of the onsite backup diesel generator: $1/kWh*

SOC Decrease

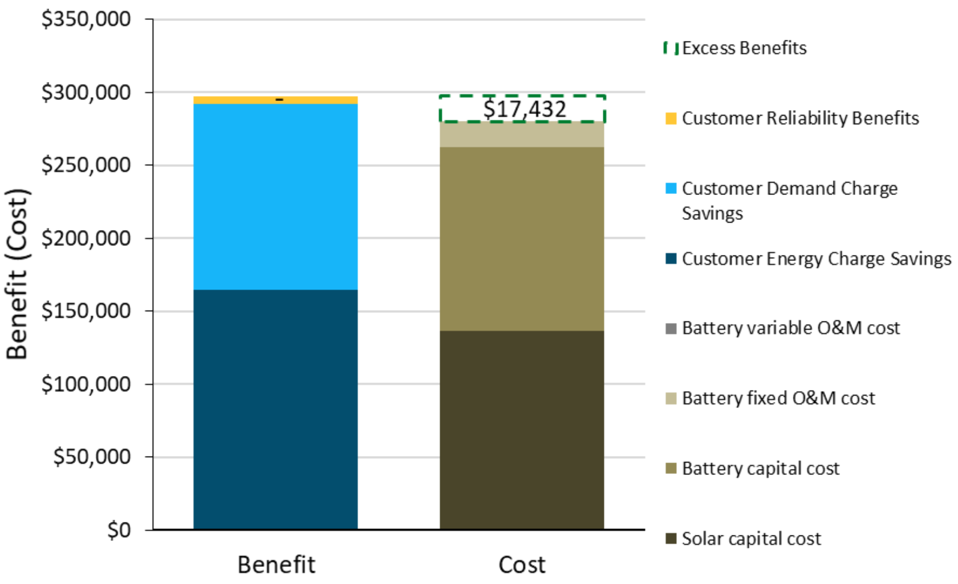
Bill Savings & Revenues

Current Rate: PG&E Medium General TOU rate: E19

*Local community values the green backup power provided by the PV + storage system; the VoLL estimate doesn't consider local community's preference

Base Case Results - PCT

- **Optimized against the current electric rate**
- **The benefit and cost ratio is slightly positive from the participant's perspective**
  - Solar provides the majorly of the energy savings and storage contributes to demand charge savings
  - B/C ratio is less than other commercial BTM installations due to oversizing for backup power

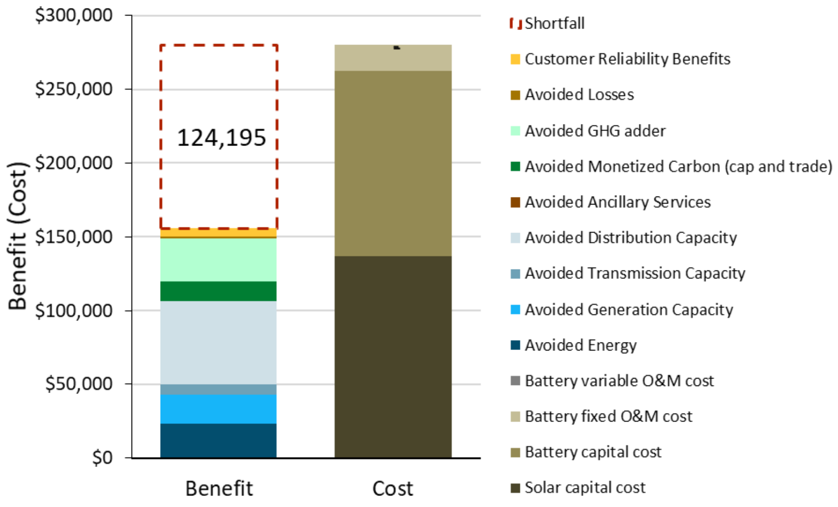


	Energy Charge Savings	Demand Charge Savings	Reliability Benefits	Total
Solar	$158,769	$24,399	$472	$183,640
Storage	$5,745	$103,099	$5,019	$113,863
Total	$164,514	$127,499,434	$5,491	$297,530

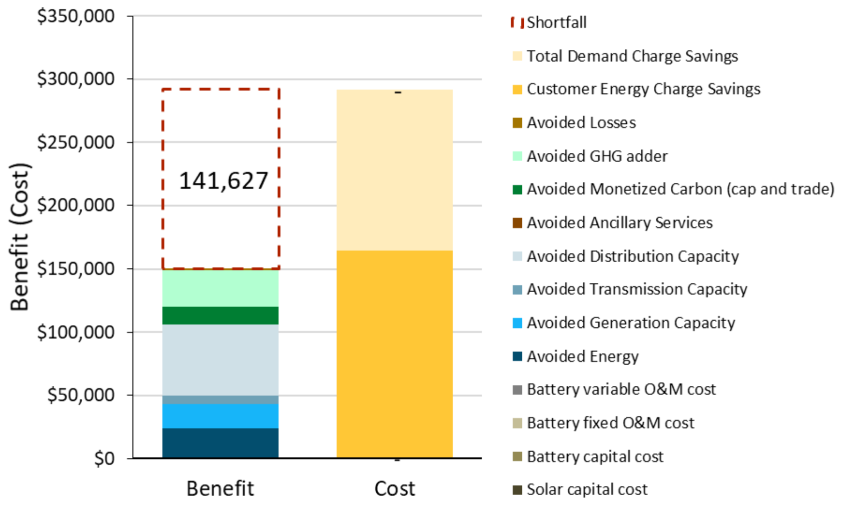
Base Case Results – TRC and RIM

- **The PV + Storage system is not cost-effective from TRC and RIM perspectives**
  - Avoided costs are from 2018 CPUC avoided costs - PG&E Climate Zone 1

TRC

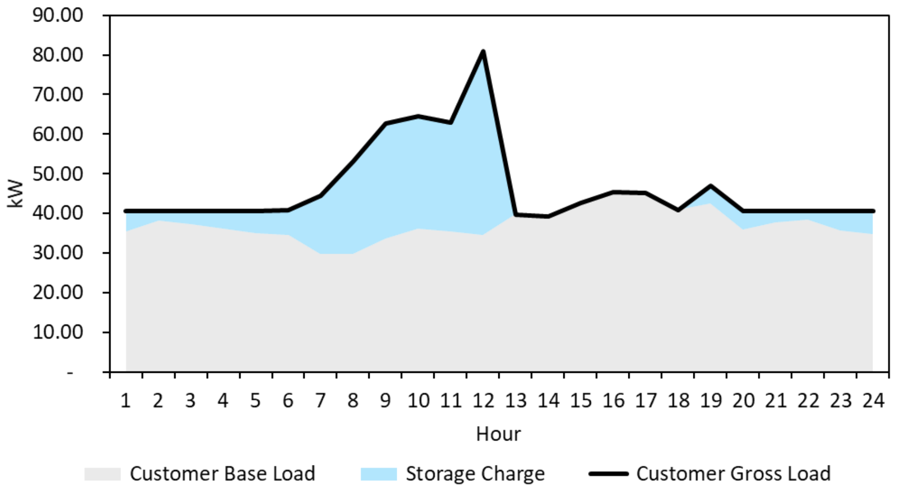


RIM

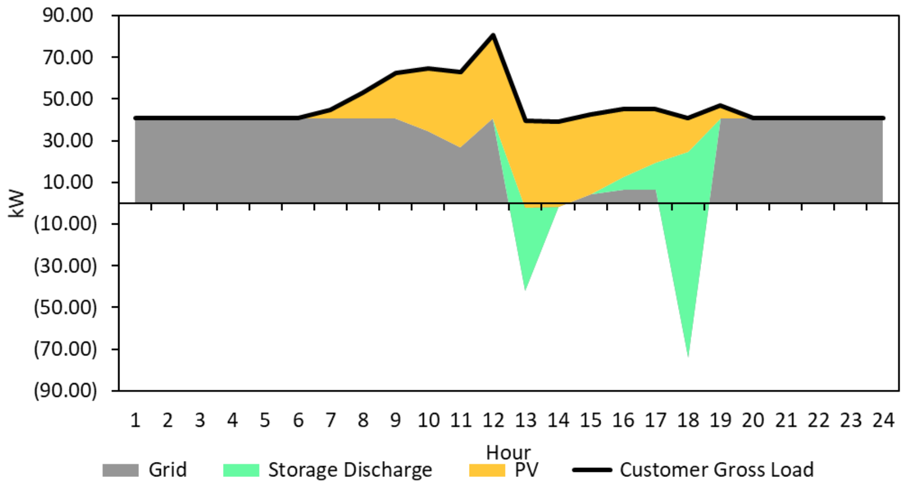


Energy Storage Dispatch

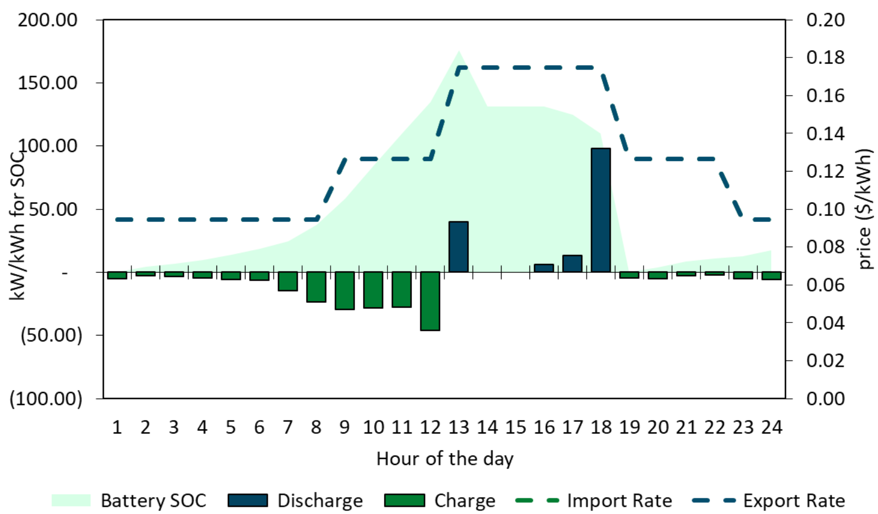
Pilot Site Energy Consumption on August 1, 2018



Pilot Site Energy Supply on August 1, 2018



Pilot Site Storage Dispatch on August 1, 2018

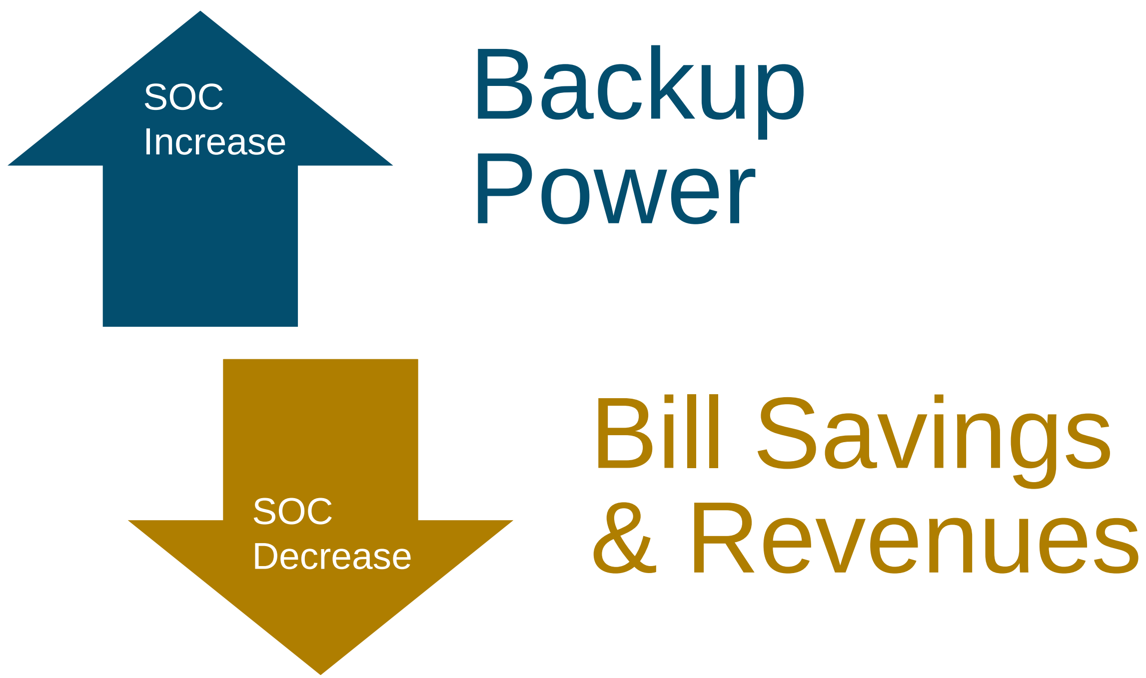


+ **The battery provides both energy and demand charge savings and carefully balances between the two**
  - It chooses to charge during shoulder hours to avoid overall peak increase

What if?

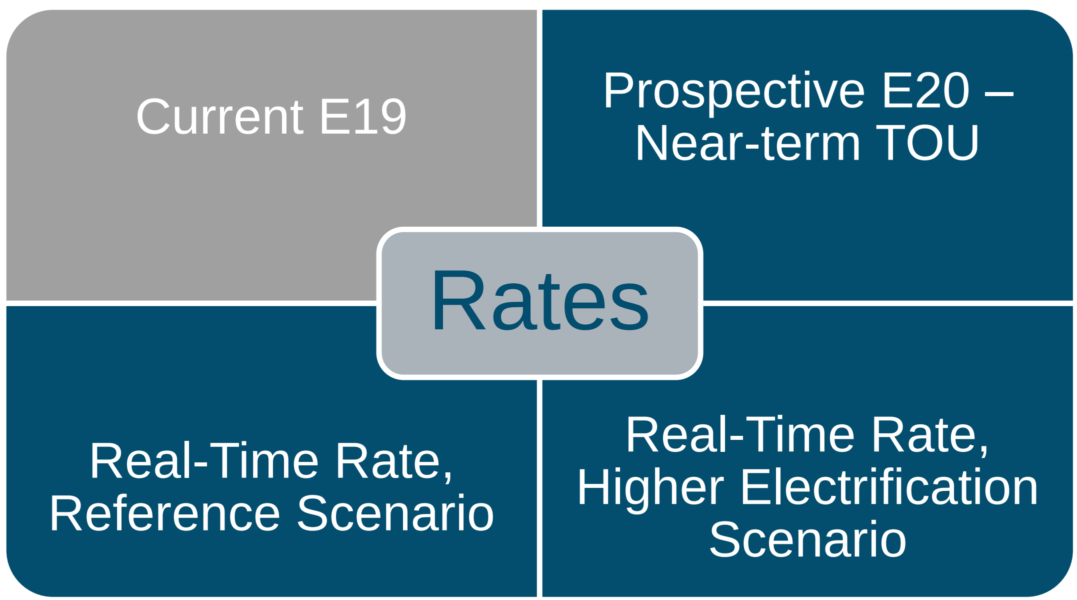
How would the cost-effectiveness change if…

- Future rate change?
- Additional revenue streams are available?
- Community prefers to use storage for backup and require the min SOC to be 50%



Sensitivities - rates

- **How would the cost-effectiveness change if future rate change?**
- **The following potential future rates are tested:**
  - E20 with the near-term TOU window change
  - Two real time rates



Near Term TOU period change

+ **E3 constructed a prospective E20 rate structure using the guidelines set out for the new TOU periods:**
  - Place the TOU peak later in the evening (moving from 12–6pm to 4–9pm)
  - Shorten the definition of summer from May–October to June–September.
  - Make the on-peak period applicable during both weekends and weekdays
  - Add the super off-peak period during March and April when net renewables are highest

Current E19 Energy Charges on Weekday (Cents/kWh)

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10
Feb	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10
Mar	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10
Apr	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10
May	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Jun	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Jul	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Aug	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Sep	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Oct	9	9	9	9	9	9	9	9	12	12	12	12	16	16	16	16	16	16	12	12	12	12	9	9
Nov	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10
Dec	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10

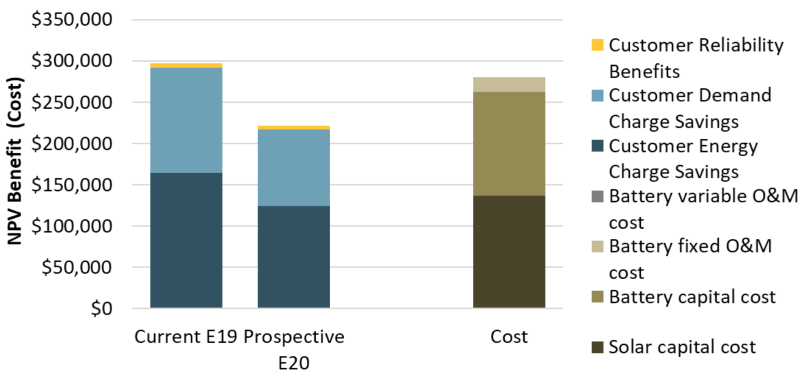
E3 Assumed Future E20 Energy Charges (Cents/kWh)

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	9	9	9
Feb	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	9	9	9
Mar	9	9	9	9	9	9	9	9	9	5	5	5	5	5	9	9	11	11	11	11	11	9	9	9
Apr	9	9	9	9	9	9	9	9	9	5	5	5	5	5	9	9	11	11	11	11	11	9	9	9
May	9	9	9	9	9	9	9	9	9	5	5	5	5	5	9	9	11	11	11	11	11	9	9	9
Jun	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	15	15	15	15	15	11	11	11
Jul	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	15	15	15	15	15	11	11	11
Aug	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	15	15	15	15	15	11	11	11
Sep	8	8	8	8	8	8	8	8	8	8	8	8	8	8	11	11	15	15	15	15	15	11	11	11
Oct	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	9	9	9
Nov	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	9	9	9
Dec	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	11	11	11	11	11	9	9	9

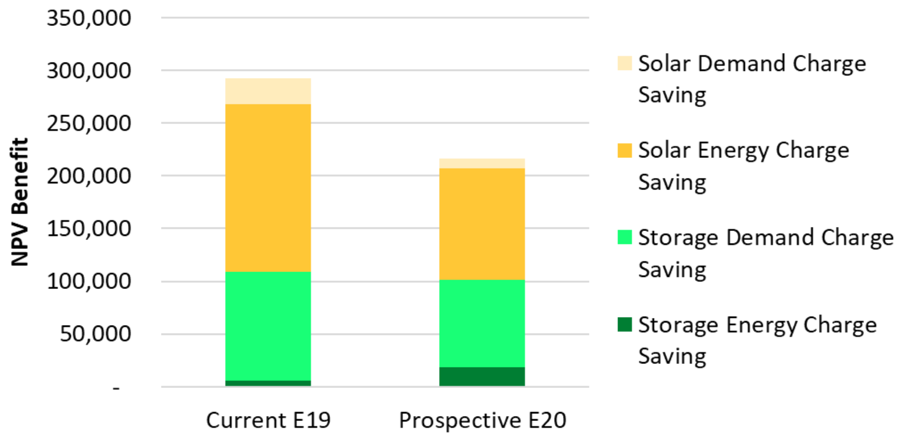
Prospective E20 Rate - Results

- **Total benefits decrease under the new TOU structure and it is largely driven by the solar contribution**
  - placing peaks later in the day means solar is less coincident with the on-peak TOU, and is therefore able to capture far less revenue
  - The revenues for battery stay similar

Benefits and Costs for PV + Storage



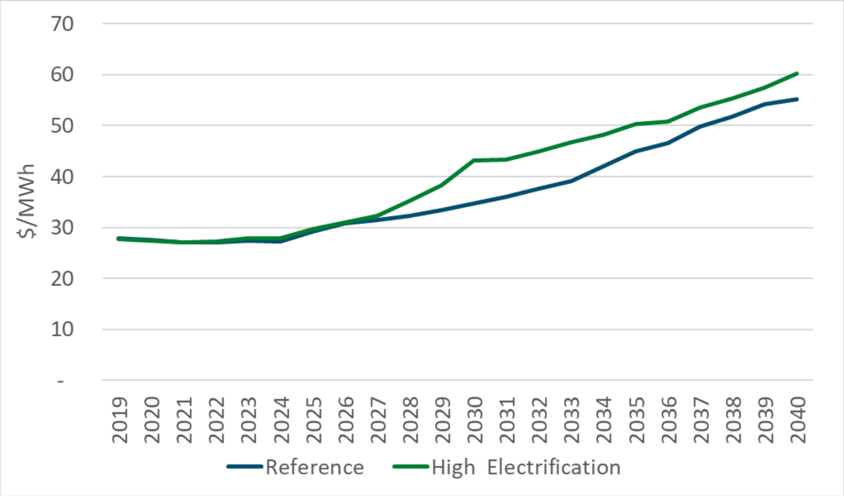
Bill savings breakdown



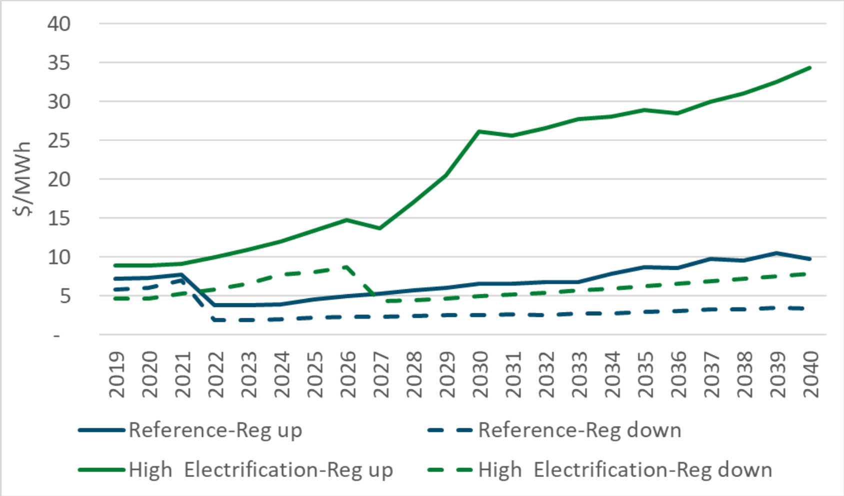
Real Time Rates

+ **Real time rate is linked to the system energy and capacity prices**
  - Wholesale market prices are generated using AURORA with E3's fine-tuned assumptions
  - Distribution avoided cost component is not included
+ **Sensitivities on participating in ancillary service markets**
+ **Two scenarios are modeled:**
  - **Reference Scenario**: current policy trajectory + AS markets saturate after 2022
  - **Higher Electrification Scenario**: A WECC-wide high electrification future + AS markets saturate after 2027

Average Energy Price



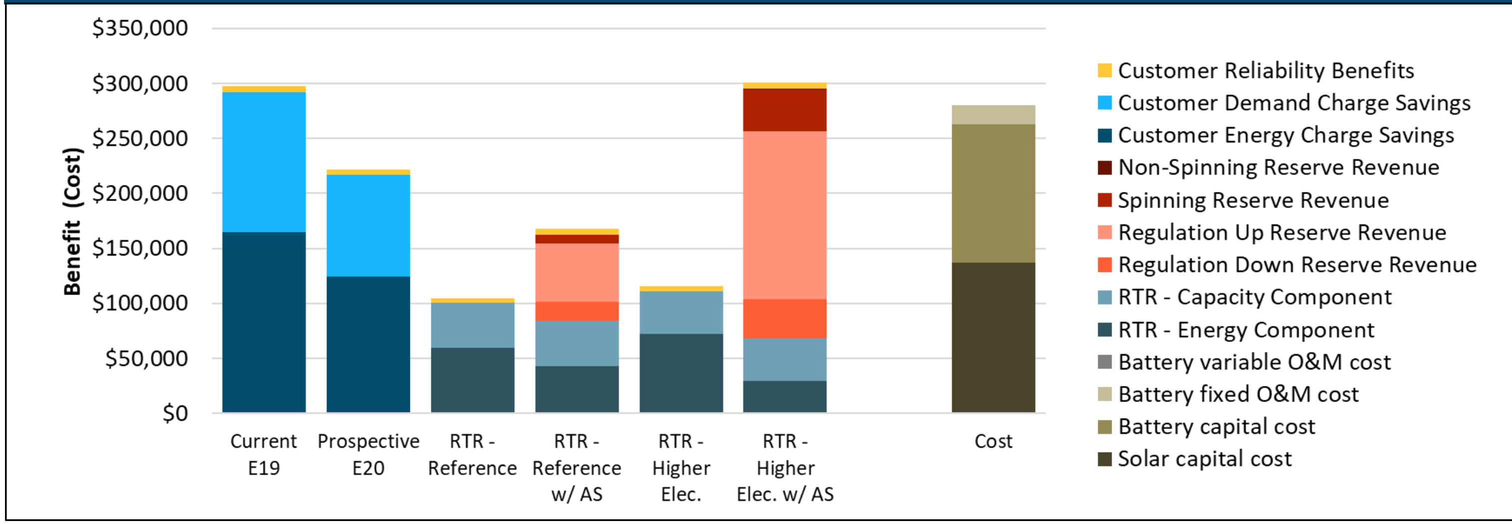
Average Ancillary Service Prices



Real Time Rate - Results

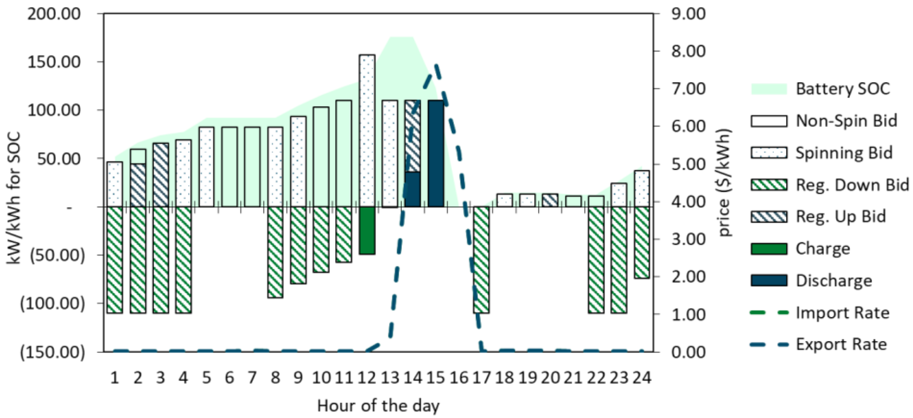
+ **A large percentage of benefits come from storage's ancillary service revenue**
  - Energy storage can be cost-effective if the ancillary service market is going strong
+ **The revenue will increase if the distribution component is included in the real time rate (RTR)**

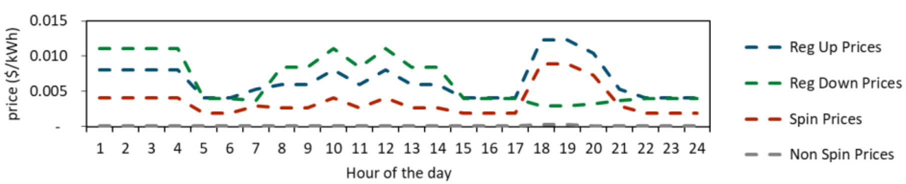
PV + Storage Benefits by Rates



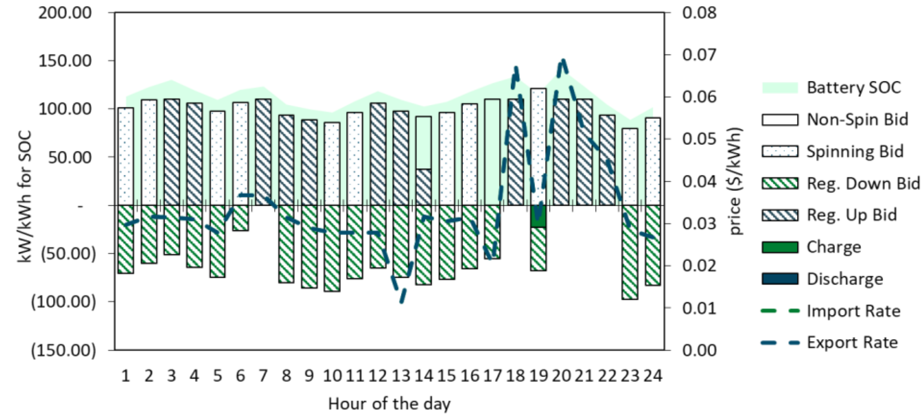
Real Time Rate – Battery Dispatch

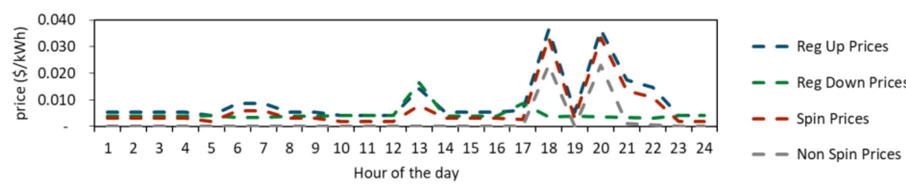
Storage Dispatch for energy arbitrage (9/29/2019)





Storage Dispatch for ancillary services (10/17/2019)

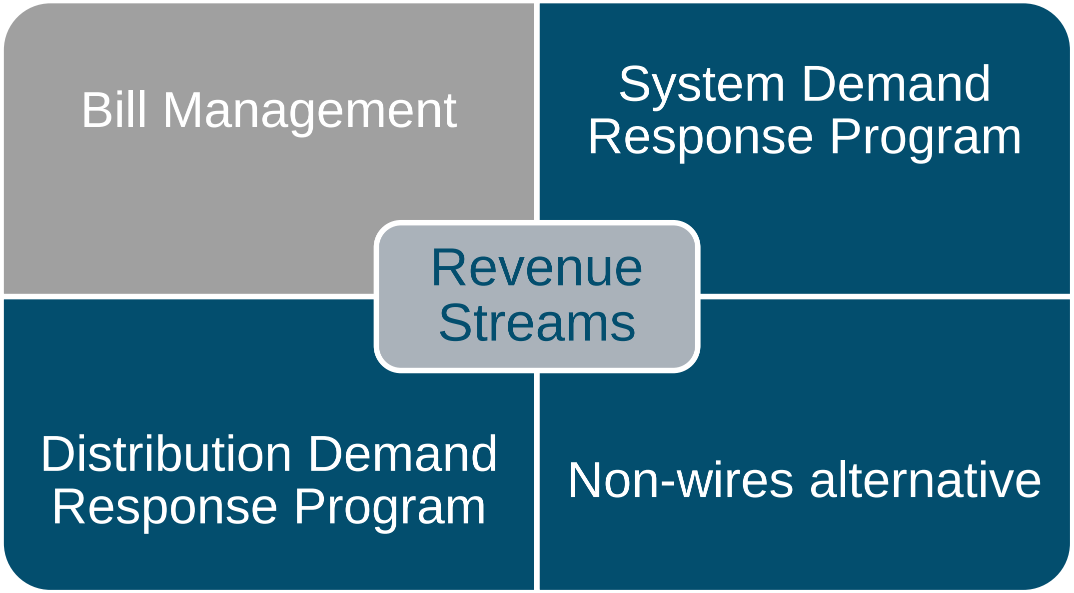




- **During the days with high energy prices, storage dispatch to earn energy arbitrage revenues. During most of the other days, providing ancillary services is the main revenue source**
- **Battery can simultaneously be earning revenue from reg and energy arbitrage**
  - provides spinning reserve to earn additional revenue
  - provides regulation down services and use this opportunity to charge and stays full

Sensitivities – additional revenue streams

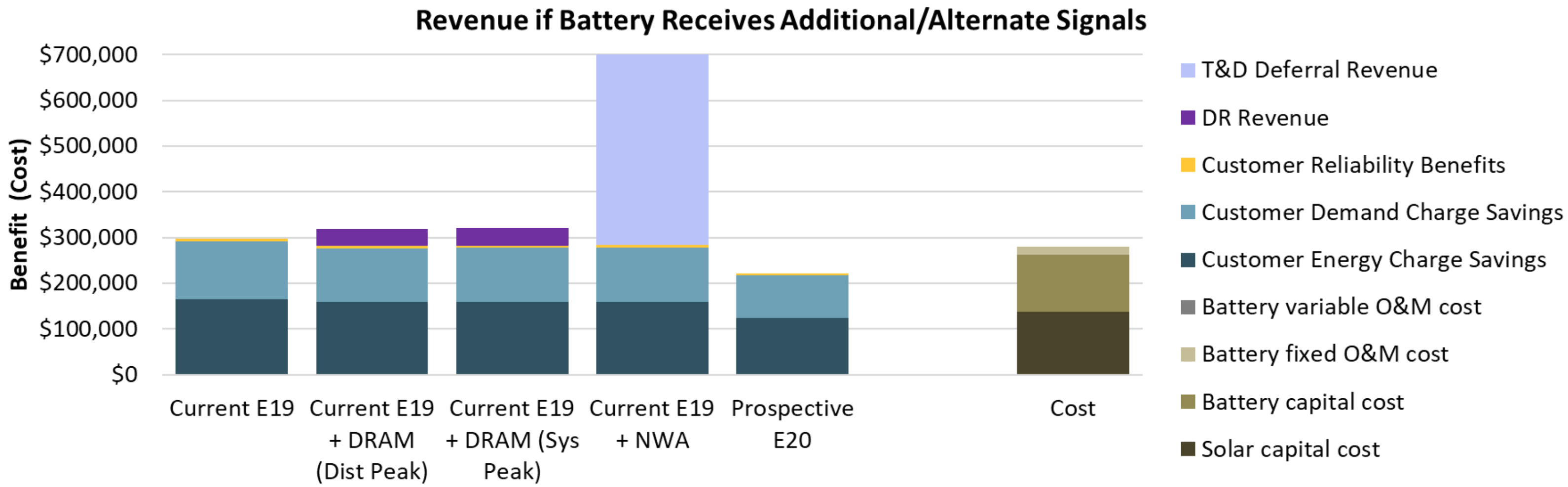
+ **How would the cost-effectiveness change if additional revenue streams are available?**
+ **The following additional revenue streams are tested:**
  - Two types of demand response program
  - A non-wires alternative program



Additional Revenue Streams - Results

- **Two DR programs are modeled:**
  - 8 1-hour calls per year, ~$55/kW-yr contract value
  - Call timing based on either system peak or distribution feeder peak
- **Assumed distribution deferral opportunities**
  - Applies generic feeder upgrade cost and shape to simulate high distribution locational value for storage
- **Both provide additional revenues:**
  - Receiving different DR signal doesn't have much impact on overall revenues
  - NWA values can be significant if sited in the constrained location

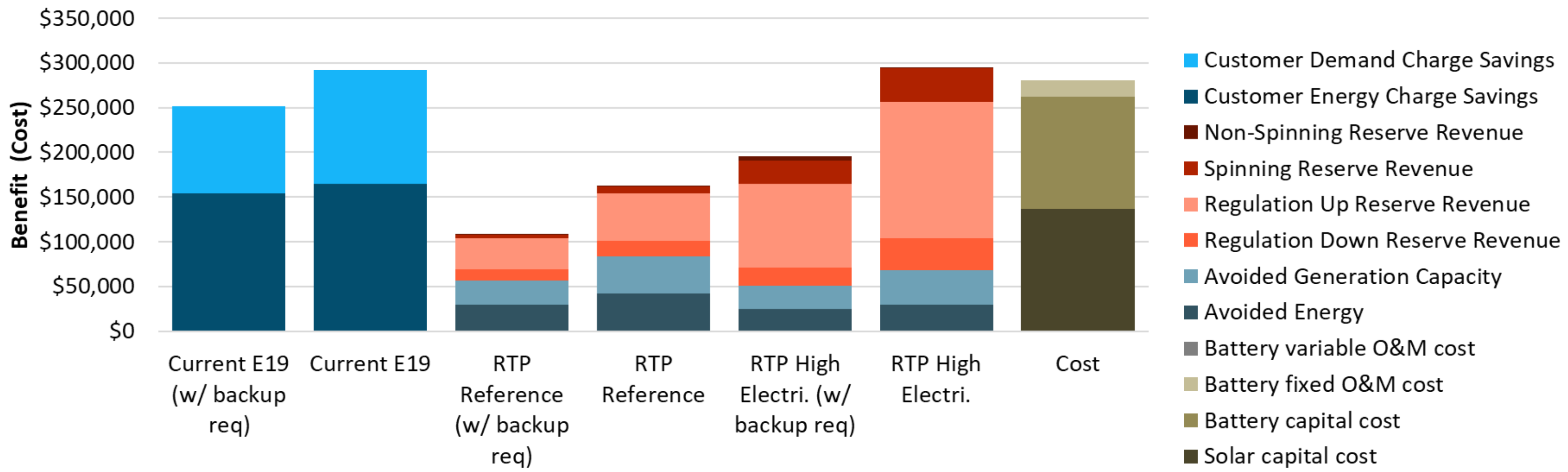
Benefits if additional revenue streams are applicable



Sensitivities – backup power

- How would the cost-effectiveness change if the community prefers to use storage for backup and require the min SOC to be 50%
- This sensitivity is tested on four rates: current E19, prospective E20, and two RTR rates
- The whole system can still capture ~66–86% of its otherwise-available revenue

Revenues if the battery is reserved for backup power

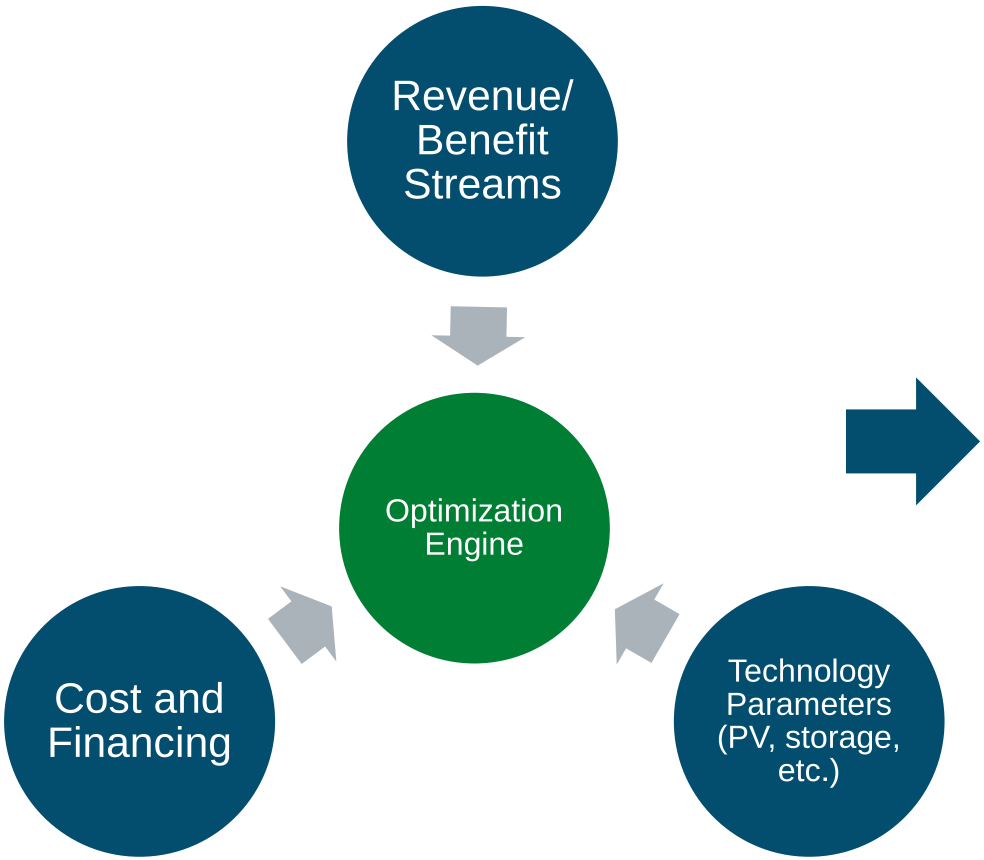


Key Takeaways

- **If operated optimally, the PV + storage system is cost-effective under the current E-19 rate**
- **The PV + storage system is not yet cost-effective from TRC and RIM perspectives**
- **Total benefits decrease under the new TOU structure and it is largely driven by the solar contribution;**
  - placing peaks later in the day means solar is less coincident with the on-peak TOU, and is therefore able to capture far less revenue
  - The revenues for battery stay similar
- **The PV + storage system can be cost-effective in the future if ancillary service prices stay high**
- **Having a high distribution value greatly improves revenue if the system is sited in the constrained area**
- **Saving 50% of the battery SOC for backup power reduce the total revenue to ~66–86% of its otherwise-available revenue**

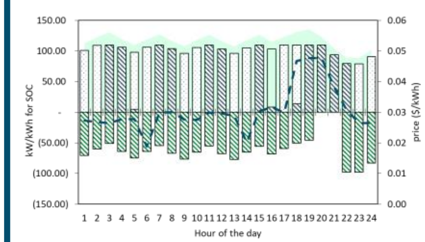
Tool Demonstration

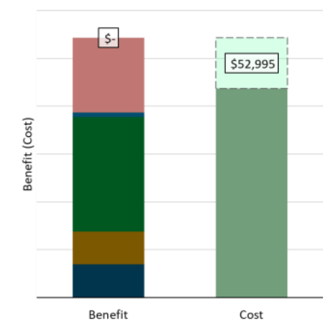
+ **A DER valuation tool with an optimization engine for dispatch**

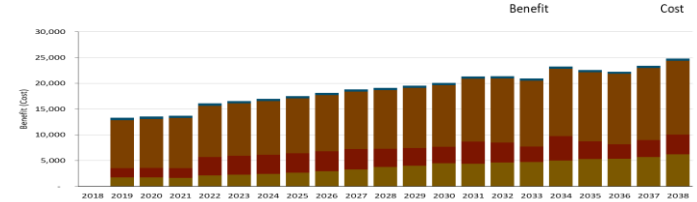


Results:

- NPV and annual benefits and costs
- Cost tests
- DER optimal dispatch
- …





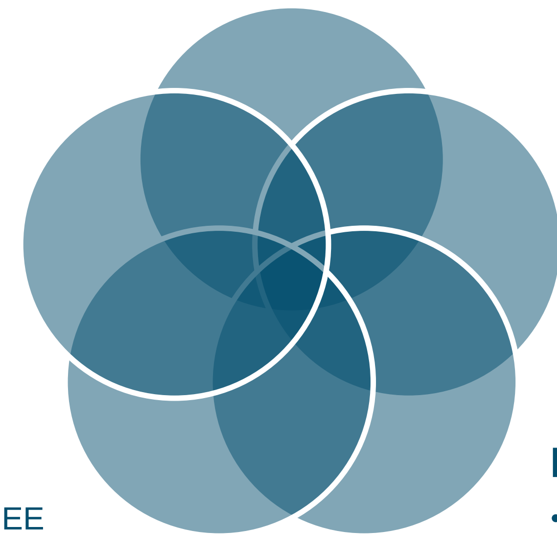


Use Cases

Individual Level

DER Portfolio
- Distribution investment deferral
- Smart home operation

DR
- DR value study



PV + Storage
- Investment analysis
- Peaker replacement
- Transmission and Distribution deferral

EE
- System and local EE potential and cost-effectiveness study

EV
- Managed Charging and V2G Benefits Analysis

State & Utility Level

All DERs
- Tariff and program analysis
- SGIP program evaluation
- Distribution bottleneck screening
- Electrification study

Compare with the other public tools

+ Similar public tools

- **REopt Lite from NREL**: a web-based tool for PV + storage BTM use cases
- **Storage-VET 2.0 / DER – VET from EPRI**: in general a more similar tool in the future, but details on the flexibility and methodology of some features are different

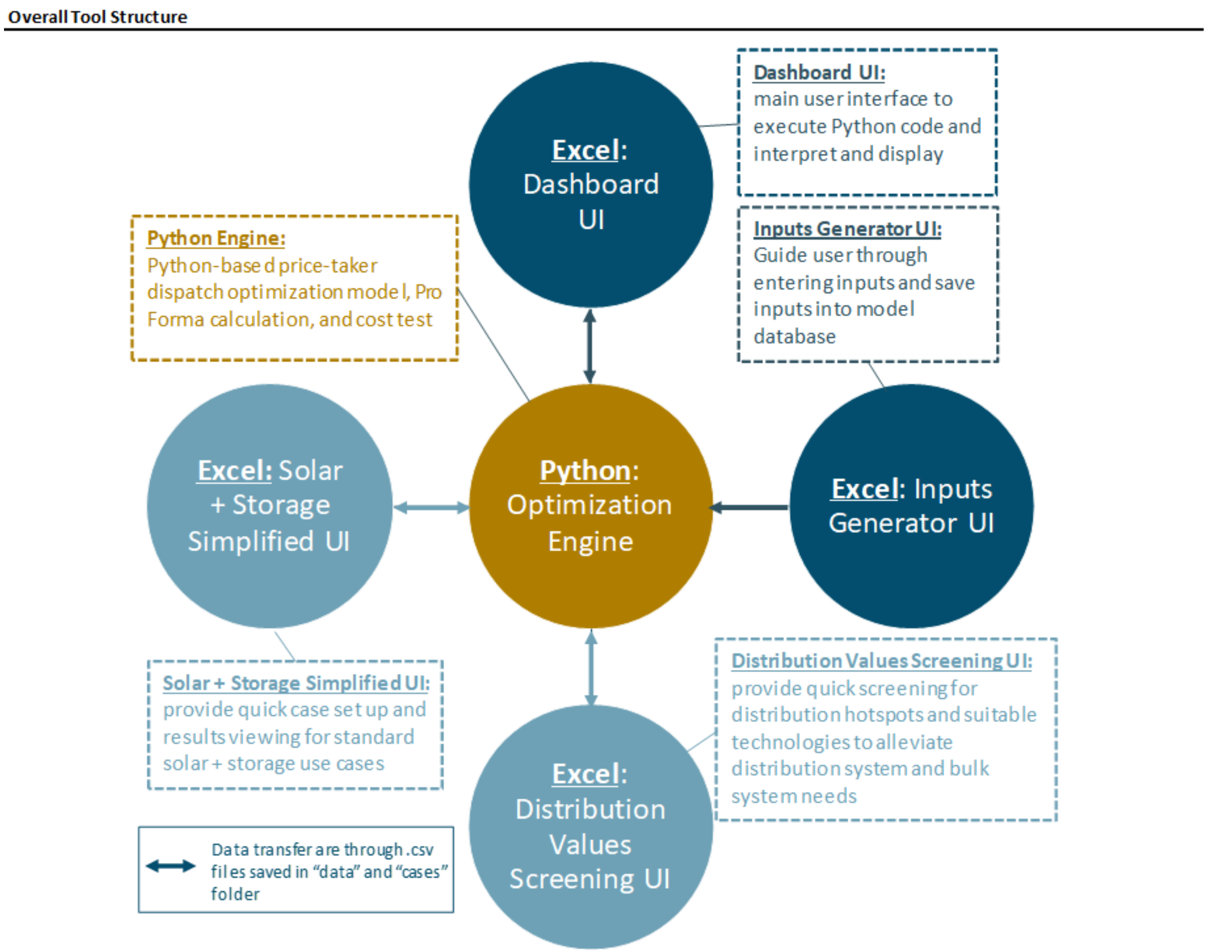
Category	Current Common Features	Additional Features	
		Solar + Storage Tool	Storage-VET 2.0/DER-VET
Platform	n/a	Excel frontend + Python backend	Python backend (web-based tool by end of 2020)
DER Technology	PV, storage, and PV paired with storage	EV, fuel cell generator, smart water heater, smart HVAC, DR, energy efficiencies, and microgrid	EV*, CT*, Building Management System*, and microgrid*
BTM use cases	Customer bill management	Flexible utility programs (DR, customized signals), and back-up power	DR* and back-up power*
FTM use cases	Wholesale energy market (DA and RT)**, ancillary services revenue, avoided costs, and asset upgrade deferral	Resource adequacy, LNBA style T&D deferral, and interconnection costs reduction	Resource adequacy* and voltage management

*under construction
** DA and RT markets are not modeled simultaneously

Tool Structure

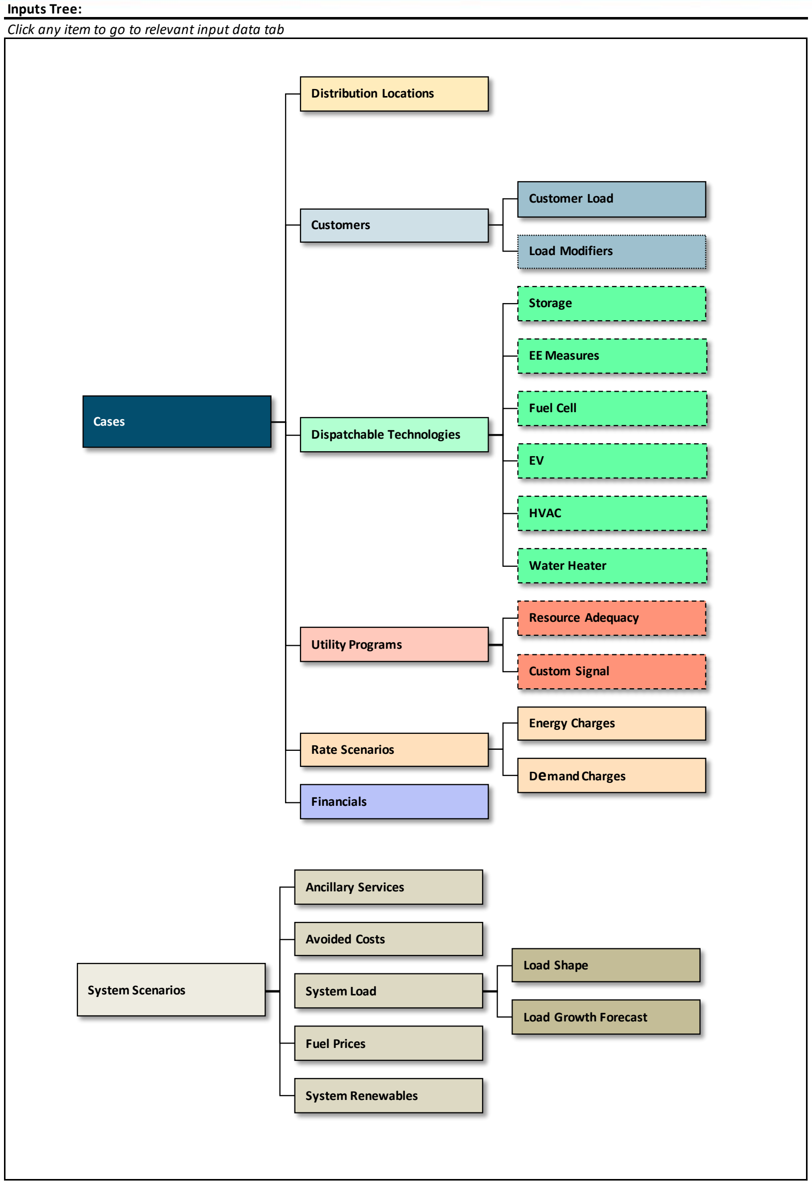
+ An Excel-frontend and Python-backend model

- communication between Excel and Python is through .csv files saved in the data and cases folder



Inputs Generator UI

- **The UI to guide user in entering and saving inputs into the data folder/database**
- **Input Categories**
  - Bulk System
  - Distribution System
  - Customer
  - Technology
  - Utility Programs (e.g. DR)
  - Rates
  - Financials



Dashboard UI

+ Main user interface to execute Python code and display results

- Detailed and comprehensive settings
- The UI to enable the full suite of functionalities

Case Configuration

System Scenario Setup

Load Saved System Scenario | 1. Save Active System Scenario

Attribute Name	Value
Name	NP15
Avoided Cost Prices	E3_NP15_2_percent_escalation
Ancillary Service Prices	historic_escalated
Historical Load Profile	2016 CAISO Load
Load Growth Forecasts	2018_4_23_RESOLVE_case
Renewables Forecasts	2018_4_23_RESOLVE_case
Fuel Price	pgande_gate
Temperature Metric	sanfrancisco-mean-temperature
System Marginal Emissions	SDGandE

Case Control

Case Name
BTM Bill Savings

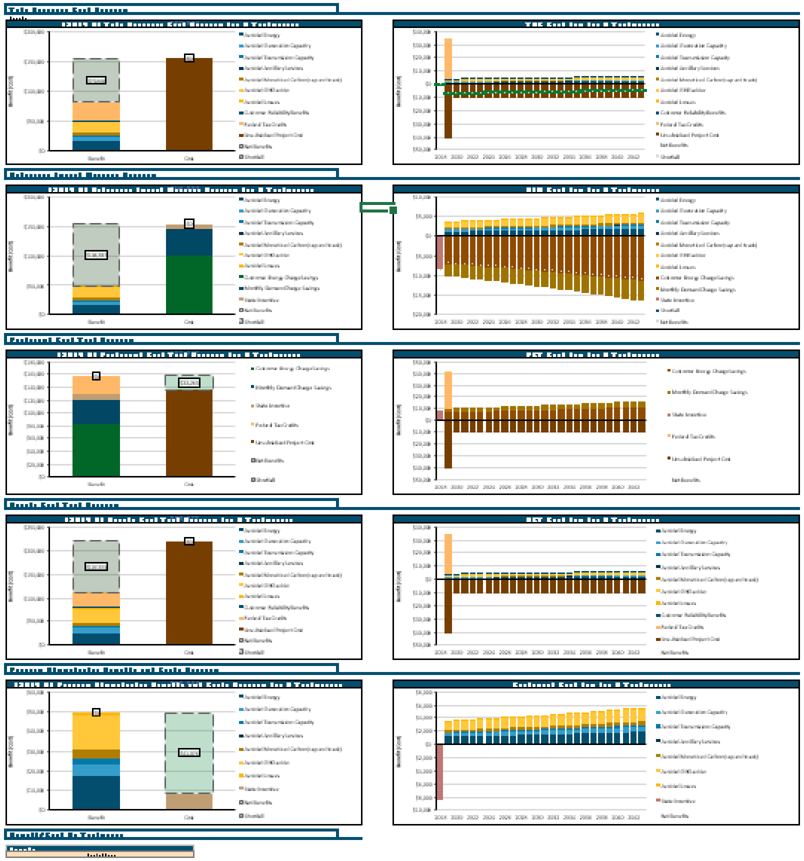
2. Save Case Settings | 3. Select Cases to Run

Load Saved Case Settings | Refresh Dropdowns

Runs

Input	Current Rate	Real Time Rate
System Scenario Name	SCE	SCE
Enable Ancillary Services	FALSE	FALSE
Customer Name	SCE_Commercial_default	SCE_Commercial_default
Enable Customer Load Modifier	FALSE	FALSE
Rate Scenario	SCE Com_TOU-8	real_time_rate_scenario
Customer DGPV (fixed kW or % of Customer Load)	fixed_by_customer_names	fixed_by_customer_names
Dispatchable Technology Installation Year	2019	2019
Technology Control Arrangement	customer control	customer control
Storage Technology	california_base-BTM_10kW_4hour	california_base-BTM_10kW_4hour
Managed EV Technology	NA	NA
Distributed CT Technology	NA	NA
Smart HVAC Technology	NA	NA
Smart Water Heater Technology	NA	NA
Distribution Location Name	DPA1	DPA1
Distribution Avoided Cost Level	default	default
Financial Scenario	california_base-BTM	california_base-BTM
RA / DR / Custom Signal Programs Scenario	NA	NA

Cost Test Results



Solar + Storage Simplified UI

+ **Provide quick case setup and standard results viewing for popular solar + storage use cases**
  - Case configuration and results in the same tab
  - Minimum inputs required for users to start the first PV + Storage project evaluation

Case Configuration

	E3 Recommended Value	Overwrite	Final Value
Use case	BTM Bill Saving Evaluation		BTM Bill Saving Evaluation
Location	PGE_CZ12		PGE_CZ12
Installation year	2019		2019
Technology	☑ PV	☑ Storage	☑ Energy Efficiency (EE)
Utility rates	E19_scenario		E19_scenario
Use default customer load shape?	TRUE	FALSE	FALSE
Link for customized customer load shape			
PV			
PV size (kW)	101.1		101.1
PV all-in costs* ($/kW)	2736		2736
PV Lifetime	10		10
Use default PV shape?	TRUE	FALSE	FALSE
Link for customized pv shape			
Storage			
Storage Charge/Discharge Capacity (kW)	139.71		139.71
Duration (hours)	4		4
Round-trip Efficiency	0.85		0.85
Min SOC (%)	0		0
Battery all-in costs** ($/kWh)	364.8		364.8
Energy Efficiency (EE)			
EE load reduction (% of total energy use)	1%		1%
EE cost ($/annual kWh reduction)	500		500
Use default EE shape?	TRUE	FALSE	FALSE
Link for customized EE shape			
Demand Response (DR)			
Participate in default DR/RA program	FALSE		FALSE
Frequency of Events (#)	0.871		0.871
Duration (min)	96		96
Revenue ($/month/kW)	5		5
kW contribution (kW)	30		30

* pv all-in cost includes both the hard and soft costs of PV systems, including modules, permit, interconnection, installation, etc
** storage cost is total battery energy storage system cost, including modules, balance of system, and PCS; costs should be included in here are costs for Engineering, Procurement, Construction, Permitting, Site Preparation, Sales Tax, Shipping, SCADA, Metering, Interconnection, Land, and Development Fee if applicable

Distribution Values Screening UI

+ Provide screening for distribution hot spots and suitable technology to alleviate distribution system and bulk system needs

Quick Deferral Value Calculation

Quick Distribution Deferral Values Summary

Assumptions	
Name of the Summary	*Default*
Utility Discount Rate (%)	9%
Societal Discount Rate (%	3%
DER Installation Year	2017
Years for levelization	10

1. Calculate T&D Summary

Load T&D Summary Results

# of projects	3
# of DER Locations	3

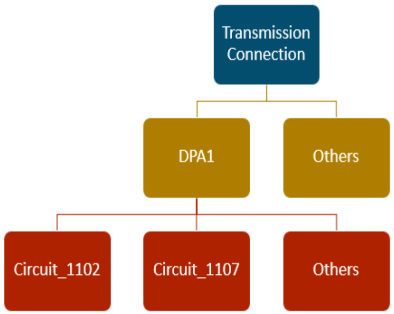
Assumptions

Results

Show results in	$/kW-yr
Results Discount Rate	Societal Discount Rat

Distribution Map

Refresh Chart



$/kW-yr deferral values

Deferral Avoided Costs Summary

$/kW-yr

DER Location -->	Maximum	Wires Project --> DPA1	Circuit1107	Circuit1102
		example_feeder_upg	example_poles_upgr	example_substation_
DPA1	218.96	218.96	-	-
Circuit1107	262.14	221.15	40.99	-
Circuit1102	227.50	221.15	-	6.35

DER Technology Value Screening

1 Select the Distribution Locations (DL)

System Scenario	SCE
Year of Analysis	2021
With Detailed T&D Deferral	TRUE
Enable Storage to Provide AS	FALSE
Include all DLs in database?	FALSE
Select one DL to model	Rector

2 Pick the DER Technologies

	Technology	Include in the Analysis?
	PV[1]	TRUE
	Storage[2]	TRUE
	Demand Response (DR)[3]	TRUE
	Electric Vehicle (EV)[4]	TRUE
	Energy Efficiency (EE)[5]	TRUE
0	*Res:Indoor_CFL_Ltg*	TRUE
0	*Res:RefgFrzr_HighEff*	TRUE
0	*Res:RefgFrzr_Recyc-Conditioned*	TRUE
0	*Res:RefgFrzr_Recyc-UnConditioned*	TRUE
0	*Res:HVAC_Eff_AC*	TRUE
0	*Res:HVAC_Eff_HP*	TRUE
0	*Res:HVAC_Duct_Sealing*	TRUE
0	*Res:HVAC_Refrig_Charge*	TRUE
0	*Res:Refg_Chrg_Duct_Seal*	TRUE
0	*Res:RefgFrzr_Recycling*	TRUE
0	*Non_Res:Indoor_CFL_Ltg*	TRUE
0	*Non_Res:Indoor_Non-CFL_Ltg*	TRUE
0	*Non_Res:HVAC_Chillers*	TRUE
0	*Non_Res:HVAC_Refrig_Charge*	TRUE
0	*Non_Res:HVAC_Split-Package_AC*	TRUE
0	*Non_Res:HVAC_Duct_Sealing*	TRUE
0	*Non_Res:HVAC_Split-Package_HP*	TRUE
0	*Res:ClothesDishWasher*	TRUE
0	*Res:BldgShell_Ins*	TRUE

1-5 see notes on the upper right corner

Model Folder Structure

+ Model Directory

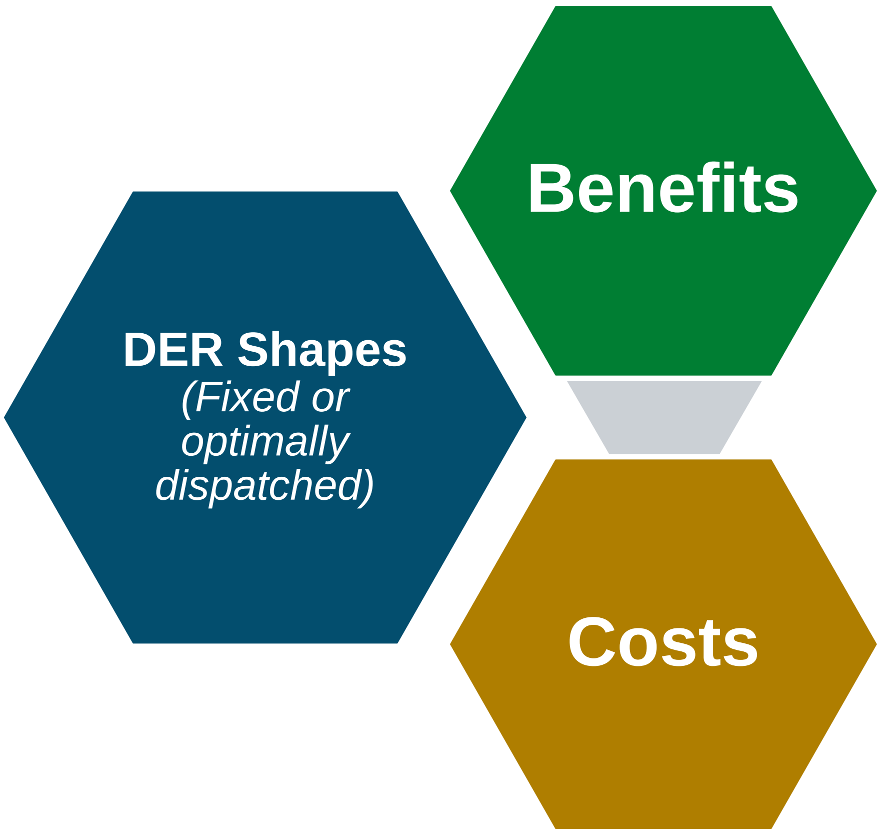
- cases
  - Case Names:
  - BTM Bill Savings
    - inputs
    - outputs
  - Deferral
  - FTM Wholesale
  - NWA
  - Rector Screening
  - Smart Home
  - Technology Screening
- code
- data
  - Data that is saved through Inputs Generator UI:
  - customer
  - distribution locations
  - financial scenario
  - generics
  - output settings
  - programs
  - rates
  - system scenario
  - technologies
  - cases_to_run.csv
  - README.md
  - td_summary_inputs.csv
- solvers
- Dashboard UI.xlsb
- Distribution Values Screening UI.xlsb
- Inputs Generator UI.xlsb
- PV + Storage Simplified UI.xlsb

Demonstration

- **How to use the tool to analyze a BTM PV + Storage system through the Simplified UI**
  - How to add a new rate to the database?
- **Walk through a standard case setup process: a FTM storage example**
  - Inputs Generator UI:
    - Set up battery parameters
    - Set up market prices and ancillary services prices
    - Set up financing assumptions
    - Configure the case
  - Dashboard UI
    - Load and review results

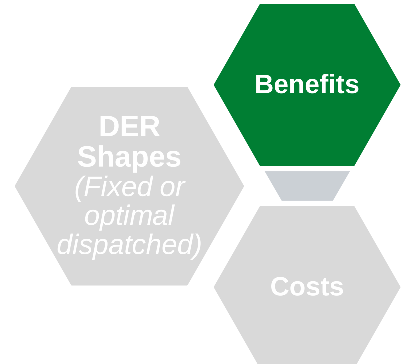
Appendix

Tool Overview



- **Benefits**
  - Revenues and savings
- **Costs**
  - Capital and O&M costs
  - Financing costs
  - Taxes and Incentives
- **DER Shapes**
  - Optimized dispatch shapes for dispatchable DERs
  - Fixed DER shapes based on region and customers (e.g. PV and EE)

Benefits

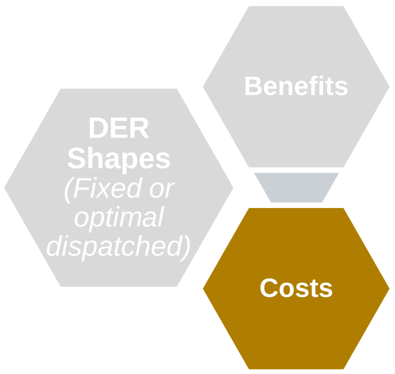


- **A wide range of benefit streams can be modeled**
  - The model is able to calculate and co-optimized against them – it is critical for value stacking
- **Benefit combinations**
  - Commonly used benefit combination for each use case is pre-defined
  - Users can also mix and match and pick their own benefit streams
- **Other highlights**
  - Flexible rate and utility program design
    - E.g. multi-tiered TOU demand charge, daily demand charge, real time rate, asymmetric energy charges, volumetric payment for demand response, etc.
  - Project-specific T&D Deferral Values (LNBA Style)

Customer sided	Distribution System	Bulk System
• Demand charge management • TOU energy charge management • Utility Program Revenue (e.g. DR program) • Back-up power	• Project specific T&D deferral • Interconnection costs reduction • Reliability • System avoided costs or Bulk system revenues	• Resource adequacy program • Wholesale energy market • Ancillary services revenue • Project specific transmission deferral • Renewable firming services

Costs

+ **A Pro Forma is integrated into the model to calculate the all-in project costs, including:**
  - Capital costs
  - Operating and maintenances costs
  - Financing costs
  - Incentives
    - Self-Generation Incentive Program (SGIP)
    - Investment Tax Credit (ITC)
  - Taxes
+ **Two financing options:**
  - Self-financing with the ability to specify a debt and equity ratio
  - Third-Party Leasing
+ **Users can also overwrite with their own cost estimate**



DER Shapes

+ Dispatchable

- Objective function: minimizing net costs
- Subject to technology, market, and incentive (e.g. ITC) constraints
- Co-optimization across multiple technologies with perfect foresight
- Price taker

+ Partial Dispatchable

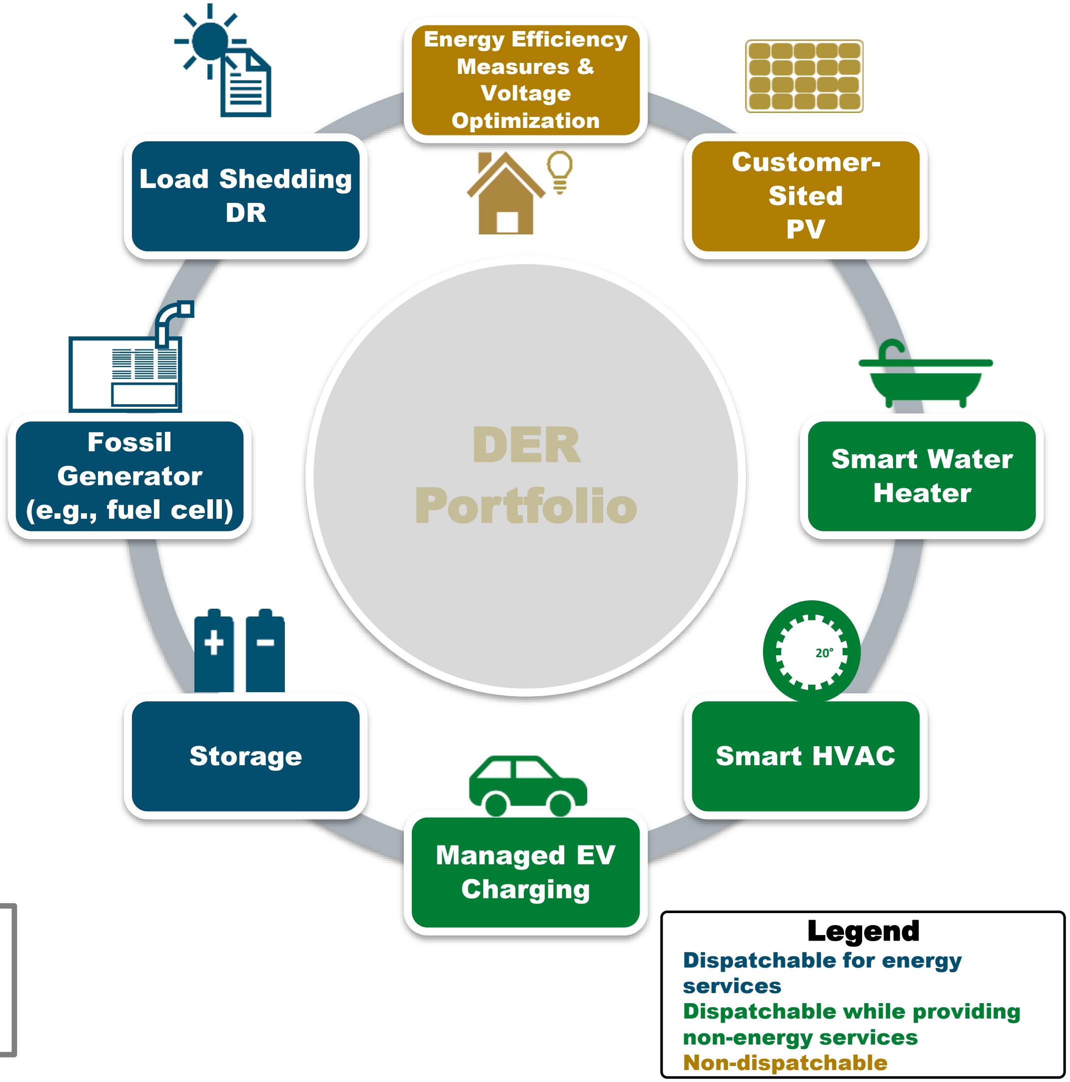
- Dispatch with the consideration of customer comfort level
- Co-optimize with both dispatchable and partial dispatchable technologies

+ Fixed shapes

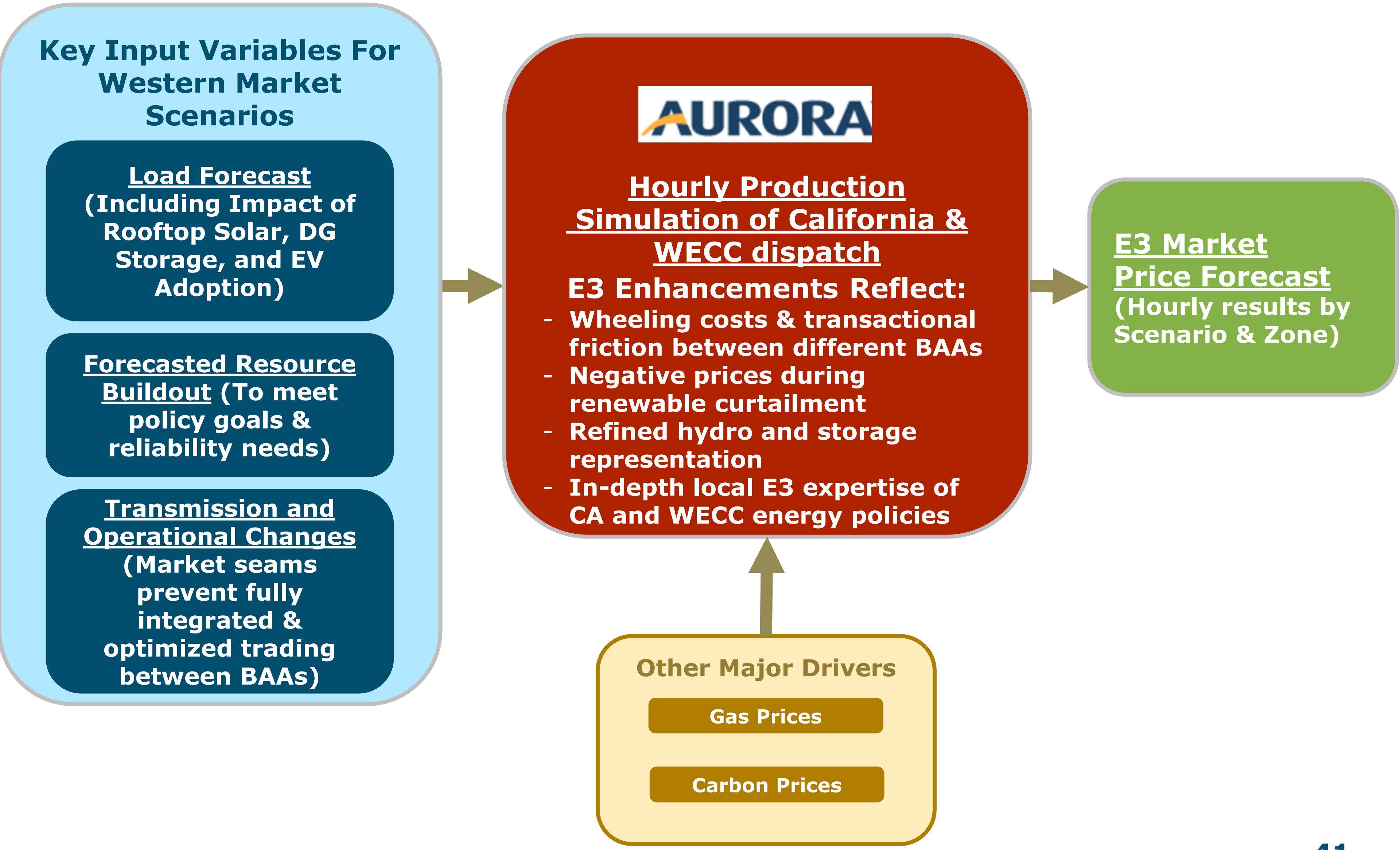
- User input based on the specific project or customer
- Default PV shapes pre-loaded for each climate zone

Other highlights

- Temperature-based day mapping
- Flexible Optimization Window (Daily, Monthly, Annual) and Intervals (Hourly, 15mins, 5mins)



Background on E3 future price scenario modeling



Proposed Scenarios
Reference Scenario

Key Assumptions	1) Reference Scenario	Narrative
California Loads	Reflect current policy trends using the latest CEC IEPR (2018)	Only existing trends in electrification will be captured. This would result in a price shape that may not be reflective of realistically expected future.
Loads for the rest of WECC	E3's US PATHWAYS model Reference Scenario that reflects current policy and legislation	Only existing trends in electrification will be captured. This would result in a price shape that may not be reflective of realistically expected future.
Technology Costs	E3 proforma modeling using publicly available costs data (NREL ATB, Lazard)	E3's proforma modeling incorporates current market trends to create realistic trajectories for technology costs.
Resources, CA	AURORA used for creating optimal portfolios to meet SB100; benchmarked to Reference RESOLVE cases	AURORA has a long-term capacity expansion feature that builds new resources based on a combination of technology costs, policy constraints, load growth, and expected resource retirements to meet the system's energy and capacity needs. AURORA's portfolio will be used to meet current legislation and policy (SB100).
Resources, rest of WECC	AURORA used for creating optimal portfolios to meet existing policies; benchmarked to Reference RESOLVE cases	AURORA's results will be benchmarked to E3's expectations of resource buildouts where applicable. Under existing policy, renewables in other regions are not expected to have a significant impact on market prices outside of California.

Proposed Scenarios
Higher Electrification Scenario

Key Assumptions	2) Higher Electrification	Narrative
California Loads	Custom developed load scenarios using E3's CA PATHWAYS model and internal knowledge on expected market trends	Loads will reflect E3's outlook on realistic levels of building electrification and electric vehicles adoption that incorporate current market trends and adoption economics. Changes to load shapes and their impact on prices will be captured.
Loads for the rest of WECC	Custom developed load scenarios using E3's US PATHWAYS model and internal knowledge on expected market trends	Similar to E3's outlook for California loads, loads for rest of WECC will also reflect market realities of adoption of different technologies, their impact on electric loads, and their consequent effects on prices.
Technology Costs	E3 proforma modeling using publicly available costs data (NREL ATB, Lazard)	E3's proforma modeling incorporates current market trends to create realistic trajectories for technology costs.
Resources, CA	AURORA used for creating optimal portfolios to meet SB100 but with higher loads than Reference scenario; benchmarked to applicable RESOLVE cases	CA resource buildout will be developed using AURORA and will meet SB100 legislation requirements to meet expected level of loads.
Resources, rest of WECC	AURORA used for creating optimal portfolios to meet most likely policies WECC-wide	Resource buildout for rest of WECC will be developed using AURORA to meet most likely policies (carbon taxes under consideration in WA, cap and trade in OR, higher RPS in AZ, etc) expected in the mid-long term.