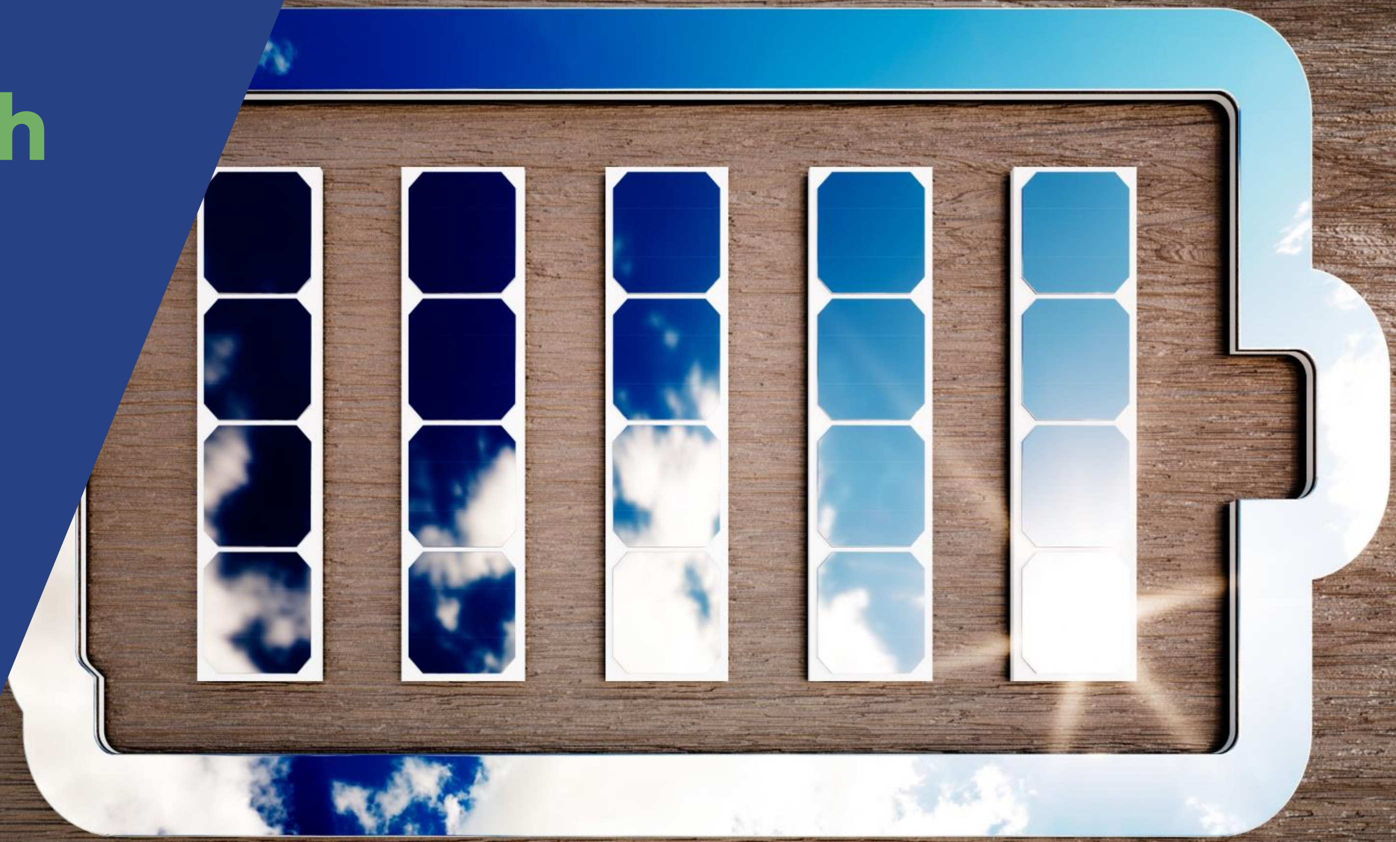
CESA Spotlight Webinar

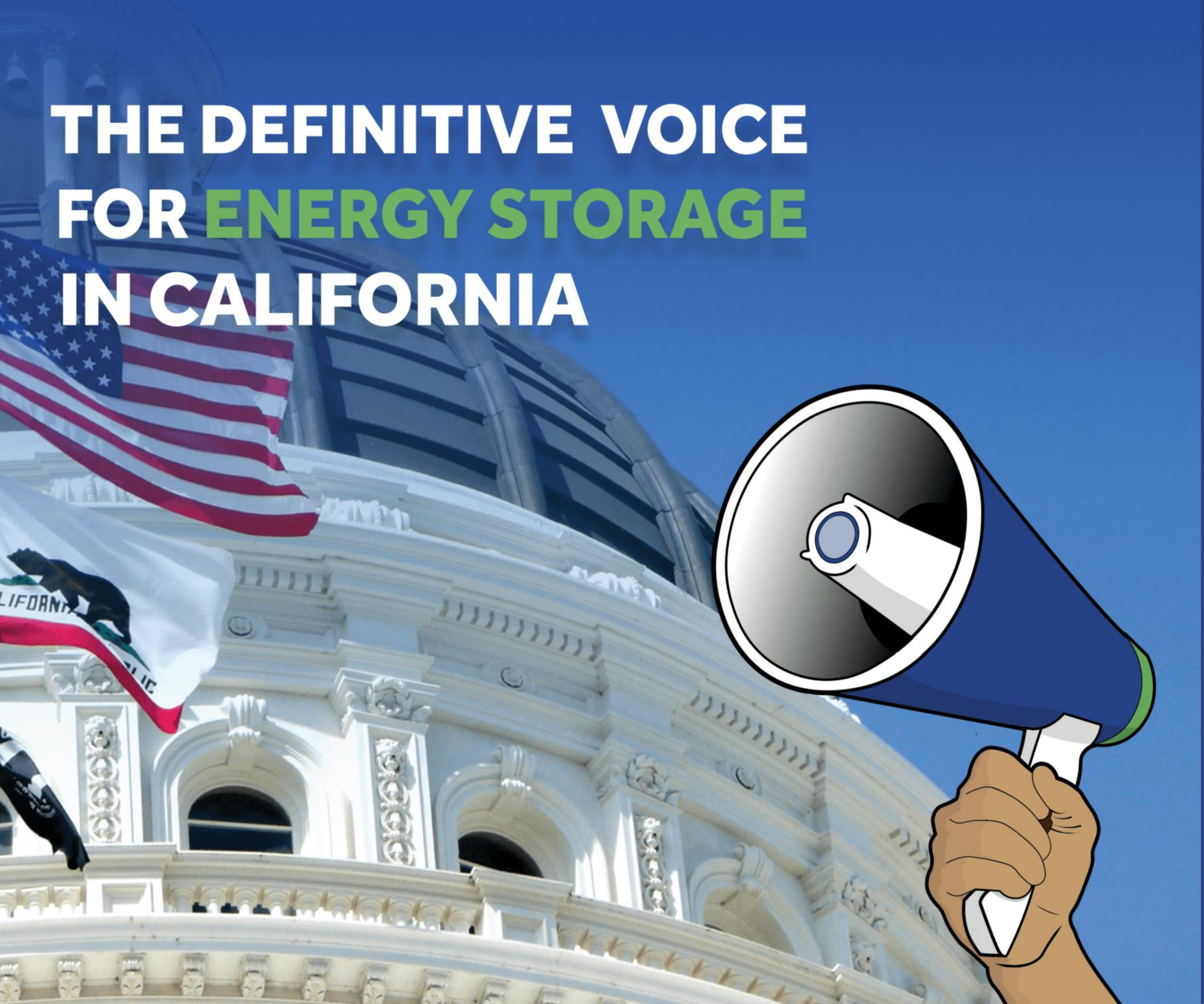
Enhancing the Value of Solar with Storage with Multiple Revenue Streams

Hosted by UL Renewables



CESA
CALIFORNIA ENERGY STORAGE ALLIANCE

THE DEFINITIVE VOICE FOR ENERGY STORAGE IN CALIFORNIA



CESA creates and builds energy storage markets and networks to support the grid in CA. CESA members help drive our advocacy, build relationships with our 100+ members, gain insight, and connect with energy storage policy-makers and buyers such as IOUs, CCAs, Munis, and more.

CESA 100+ MEMBERS

CALIFORNIA ENERGY STORAGE ALLIANCE

2022 CESA Strategic Priorities

Approved at 12/20/21 Board Meeting

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Strategic Priority	Objective(s)
Continue to create and expand storage markets and opportunities	• Connect planning models with timely procurement orders • Ensure planning models highlight storage needs in tech-neutral way
Ensure healthy markets for all types of storage	• Ensure appropriate storage valuation in RA reforms • Advance funding for emerging tech • Ensure valuation of BTM storage export QC • Recognize value of LDES capabilities
Reduce barriers and resistance at local levels of permitting and execution	• Streamline ad hoc permitting and approval processes • Address county concerns over revenue • Address battery safety concerns
Reduce storage interconnection delays and/or costs and improve interconnection processes	• Enable faster, cheaper, and better storage interconnection • Ensure timely storage deployment with timely upgrades construction • Advance plug-and-play system
Enhance and further develop wholesale market participation and products	• Fix and improve market participation and bidding models for energy storage and hybrid resources • Develop new market products

Our CESA Members

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8minute Solar Energy · aes · Burns McDonnell · ESS Inc · Fluence (A Siemens and AES Company) · Hydrostor · LG Energy Solution · Lockheed Martin · NextEra Energy Resources · OnwardEnergy · Ormat · Quidnet Energy · Recurrent Energy (A subsidiary of Canadian Solar) · REV Renewables · RWE · Southern Power · sunrun · Tenaska · Terra-Gen · Tesla · Trane · Vistra · Wellhead

Ameresco (Green • Clean • Sustainable) · American Fire Technologies · Antora Energy · Arevon · aypa · B2U · Borrego Solar · Boston Energy Trading and Marketing (A Subsidiary of Mitsubishi Corporation) · Broad Reach Power · Carrier · conEdison · Cupertino Electric Inc. · Customized Energy Solutions · Convergent · EDF renewable energy · Elsys · endurant · enel · Energport · Energydome (Ground-Breaking Energy Storage) · ESRG (Energy Storage Response Group) · Energy Vault (Enabling a Renewable World) · engie · Enlighten · esVolta · e-zinc · Forefront Power · Form Energy · Generate · Gridwiz · Gore · GSR Energy · Hecate Energy · Highview Power · H2 · Innergex · Jupiter Power · Largo Clean Energy · Li-ion Tamer · Malta · nexamp · Nuvation Energy · NGK · Nostromo · Peak Power · PolyJoule · PXiSE Energy Solutions · Qcells · redflow (sustainable energy storage) · Reimagine Power · Samsung · Samsung C&T · Sempra Infrastructure · Solas Energy Consulting · stem · Stoel Rives LLP · Storworks Power · Strata Clean Energy · Sumitomo Electric · sunnova · swell · TRC · UBS · UL · Vesper Energy · VRB Energy (Vanadium Redox Battery Solutions) · Vopak · Wärtsilä · Zēlos · Zitara

Clean Power Alliance (CPA) – Locally powered energy innovation. · MCE – My community. My choice. · City of Glendale Water & Power (GWP) – Your Trusted Community Utility · San José Clean Energy – A Program of the City of San José · Silicon Valley Clean Energy · Peninsula Clean Energy

Shape & Scale Western Storage Markets

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WEST
WESTERN ENERGY STORAGE TASKFORCE

Western Energy Storage Taskforce (WEST) Launched this Month!

What is WEST? A new service offering exclusive to CESA Members:

- Results-driven, action-oriented advocacy aligned with member input
- Targets Western states outside California with emerging storage markets
- Creates tipping points in new markets

VISIT storagealliance.org/west

Contact Emily Yan to learn more:
eyan@storagealliance.org

California Storage Market Snapshot

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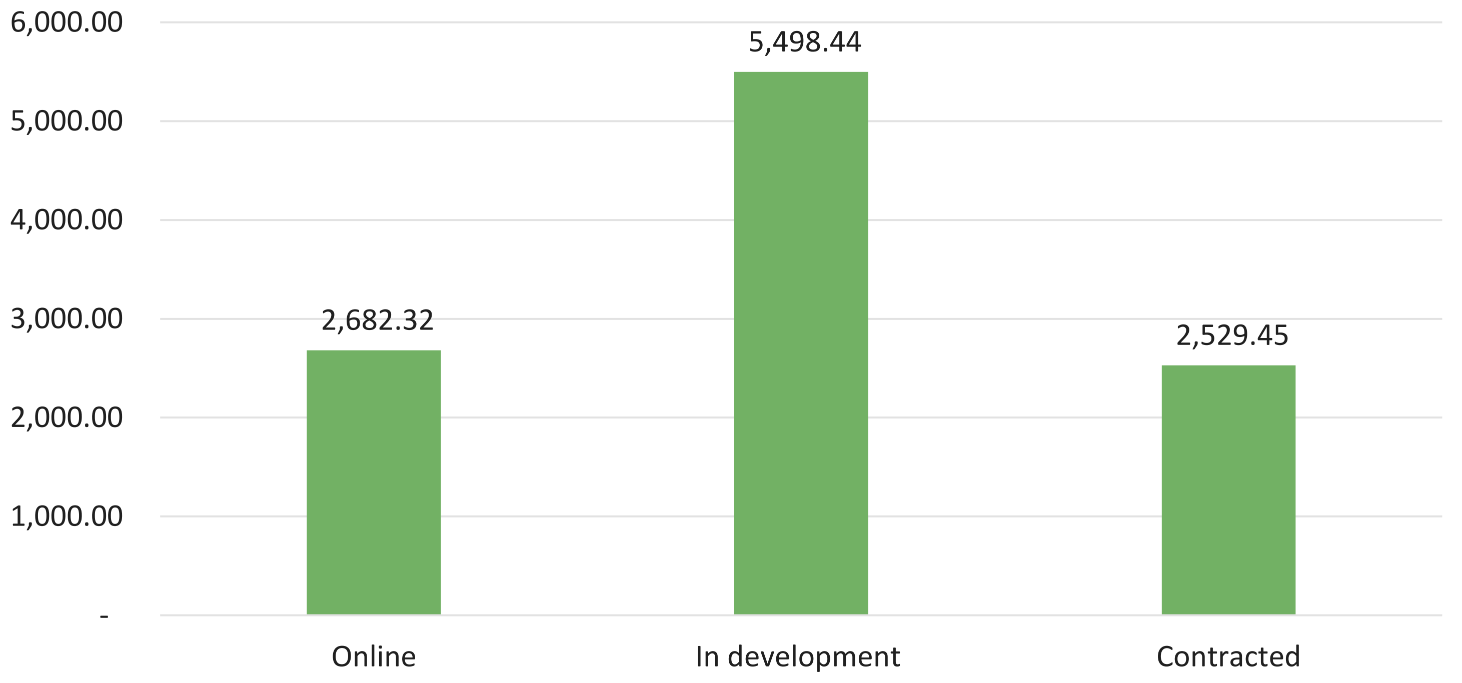
Table 1. Energy storage capacity procured by LSE since 2010 (MW)	
LSE	**MW**
Pacific Gas & Electric	3,321.7
Southern California Edison	3,165.3
Clean Power Alliance	1,195.5
San Diego Gas & Electric	752.2
Los Angeles Department of Water & Power	431.0
East Bay Community Energy	355.0
Central Coast Community Energy	229.1
San Diego Community Power	220.0
Clean Power SF	140.0
Valley Clean Energy Alliance & Redwood Coast Energy Authority	125.5
California Community Power	119.0
Silicon Valley Clean Energy & Monterey Bay Community Power	105.0
Silicon Valley Clean Energy	96.6
Sonoma Clean Power	80.0
Desert Community Energy	50.0
Redwood Coast Energy Authority	38.8
California Choice Energy Authority	15.0
San Jose Clean Energy	10.0
Riverside Public Utilities	7.9
Sacramento Municipal Utilities District	4.9
Redding Electric Utility	3.6
Glendale Water & Power	3.5
City of Santa Clara Utilities	3.3
City of Anaheim Public Utilities	3.2
Pasadena Water & Power	0.7
Moreno Valley Utilities	< 0.1
Lancaster Choice Energy	< 0.1
Colton Public Utilities	< 0.1
Alameda Municipal Power	< 0.1
Marin Clean Energy	< 0.1
Burbank Water & Power	< 0.1
Imperial Irrigation District	< 0.1

As of June 10, 2022, there are **10,710 MW** of active energy storage procurements since 2010

SGIP has enabled the installation of an additional **486 MW** of customer-sited electrochemical

Chart 1. Energy storage procurement since 2010 by status (MW)



Contact: Jin Noh (jnoh@storagealliance.org)

Webinar Overview

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Enhancing the Value of Solar with Storage with Multiple Revenue Streams

Hosted by UL Renewables

Alex Morris
Executive Director
CESA
Moderator

Gabriel Murtaugh
Storage Sector Manager
California ISO

Annamalai Muthu
Director, Energy Storage
Engie

Steffi Klawiter
Product Manager – Hybrids
UL Renewables

David Mintzer
Director, Energy Storage
Advisory Services
UL Renewables

POLL

Panelist

Gabriel Murtaugh
Storage Sector Manager
California ISO

- +10 years of electricity industry experience, and is currently the Storage Sector Manager at the California Independent System Operator
- Oversees storage related policy. Experience developing policy for market power mitigation, resource adequacy, and backstop procurement for the ISO.
- Serves as a liaison for storage related issues for parties outside of the ISO.
- Previously, Gabe held roles in the market monitoring group at the California ISO and as a market monitor for the Midcontinent ISO.
- Holds a master's degree in economics and an undergraduate degree in computer science and engineering.

Please enter any questions into Q&A section of GoToWebinar.

California ISO

CESA Spotlight Webinar

June 22, 2022

Gabe Murtaugh, Storage Sector Manager

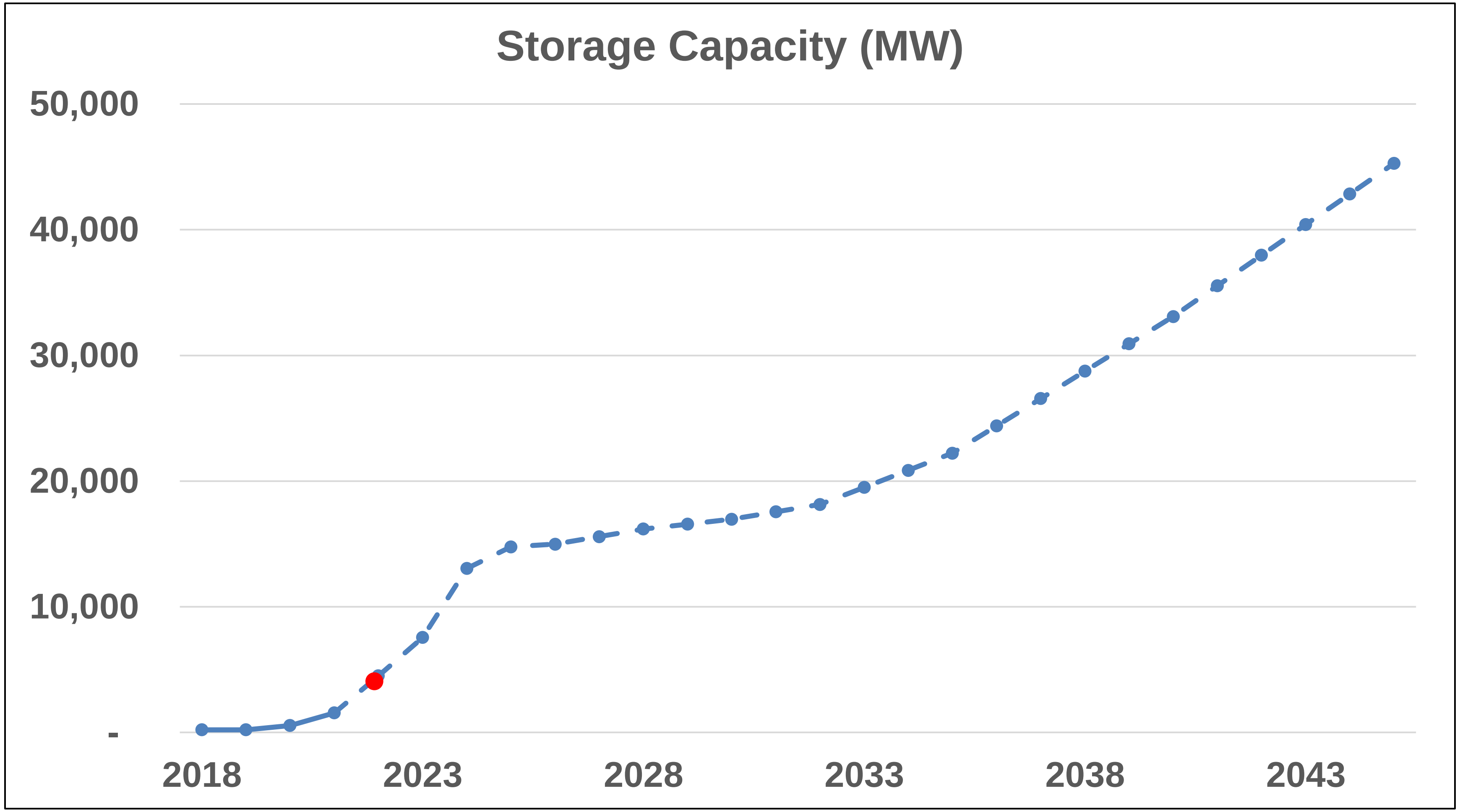
There is a huge influx of new storage resources onto the California ISO market

- Storage is rapidly growing because of state procurement mandates
  - Storage is effective at providing energy during the peak hour(s)
  - Storage can absorb energy during abundant periods

- The ISO currently has over 3,500 MW of installed storage
  - Last year there were only about 1,500 MW of storage

- Many storage resources are located at the same point of interconnection with existing or new solar resources
  - May use hybrid or co-located models to model these facilities

The state procurement plan calls for massive buildout of storage to reach 2045 greenhouse emission targets



Storage resources have a complex group of revenue streams to consider

- Resource adequacy payments
  - Resource adequacy payments for storage today are based on sustained energy possible over a four hour duration
  - Future resource adequacy markets will likely account for duration of a storage resources
- Federal investment tax credit programs
  - Available to storage resources located with renewables
  - Phases out if resource charges while on-site generation is not generating
- Market revenues
  - Energy awards in the day-ahead and real-time markets
  - Ancillary service payments
  - Other market products (imbalance reserves, flexi-ramp)

The California ISO is evolving already sophisticated modeling tools for storage

- The ISO developed a model for storage resources
  - Storage has a negative operating range (representing charging)
  - ISO tracks and ensures feasible levels of state of charge
- Hybrid models allows for a single resource ID
  - Allows for maximum capture of investment tax credits
- Co-located models allow for multiple resource IDs
  - Allows for all modeling features offered by the ISO
- We are thinking about ways to evolve modeling for storage resources
  - Cycling and state of charge drive costs for many storage resources, using these to inform bids may better align models with true costs
  - Additional tools for reliability are necessary for grid operators
  - Stakeholders requested more features to capture investment tax credits

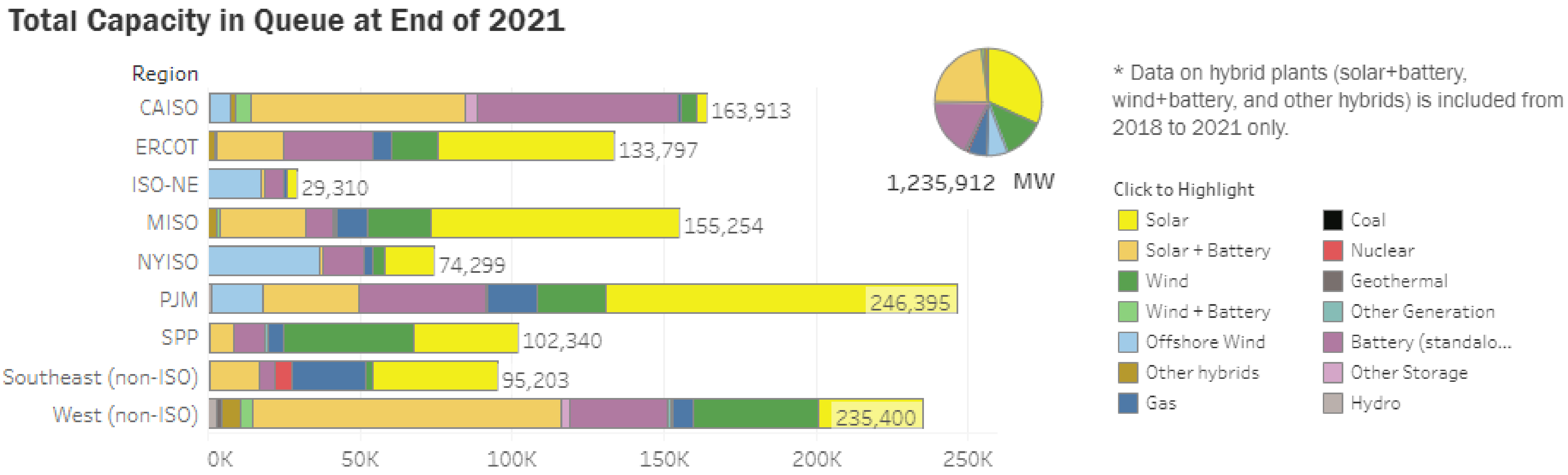
Panelist

Annamalai Muthu
Director, Energy Storage
Engie

- Leads Grid-Scale Energy Storage in North America. Joined ENGIE in April 2021 as part of the Renewables Business Unit.
- Previously, Annamalai was one of the first employees of a standalone battery storage company, Broad Reach Power (BRP), holding various roles ranging from finance to asset management. Before BRP, he worked in the banking industry for Royal Bank of Canada – Capital Markets. He started his career in transmission planning working for CenterPoint Energy, a regulated energy utility company.
- Has a Bachelor's degree in Electrical Engineering and a Master's degree in Business Administration from University of Texas at Austin.

Please enter any questions into Q&A section of GoToWebinar.

Stand-alone & hybrid battery projects make up a significant portion of U.S. queue capacity



LBNL Interconnection Queue Study

- Several U.S. markets and utilities have explicitly identified a reliability need for energy storage resources
- Competitive markets have issued plans for FERC 841 compliance

Storage attractiveness depends on company's risk tolerance, financing strategy, and PPA demand

Hybrid Potential

- Enhance renewable participation in utility RFPs, capacity markets
- Improve project efficiency/reduce curtailment risk

Fixed Shapes, 24/7

- Incorporate fixed shape PPAs and similar contracts into portfolio
- Address commercial and industrial 24/7 clean energy targets

New Types of Load

- Industries like crypto mining drive concentrated load growth in rural areas
- Increased demand for data centers results in need for clean, reliable backup power

Merchant Potential

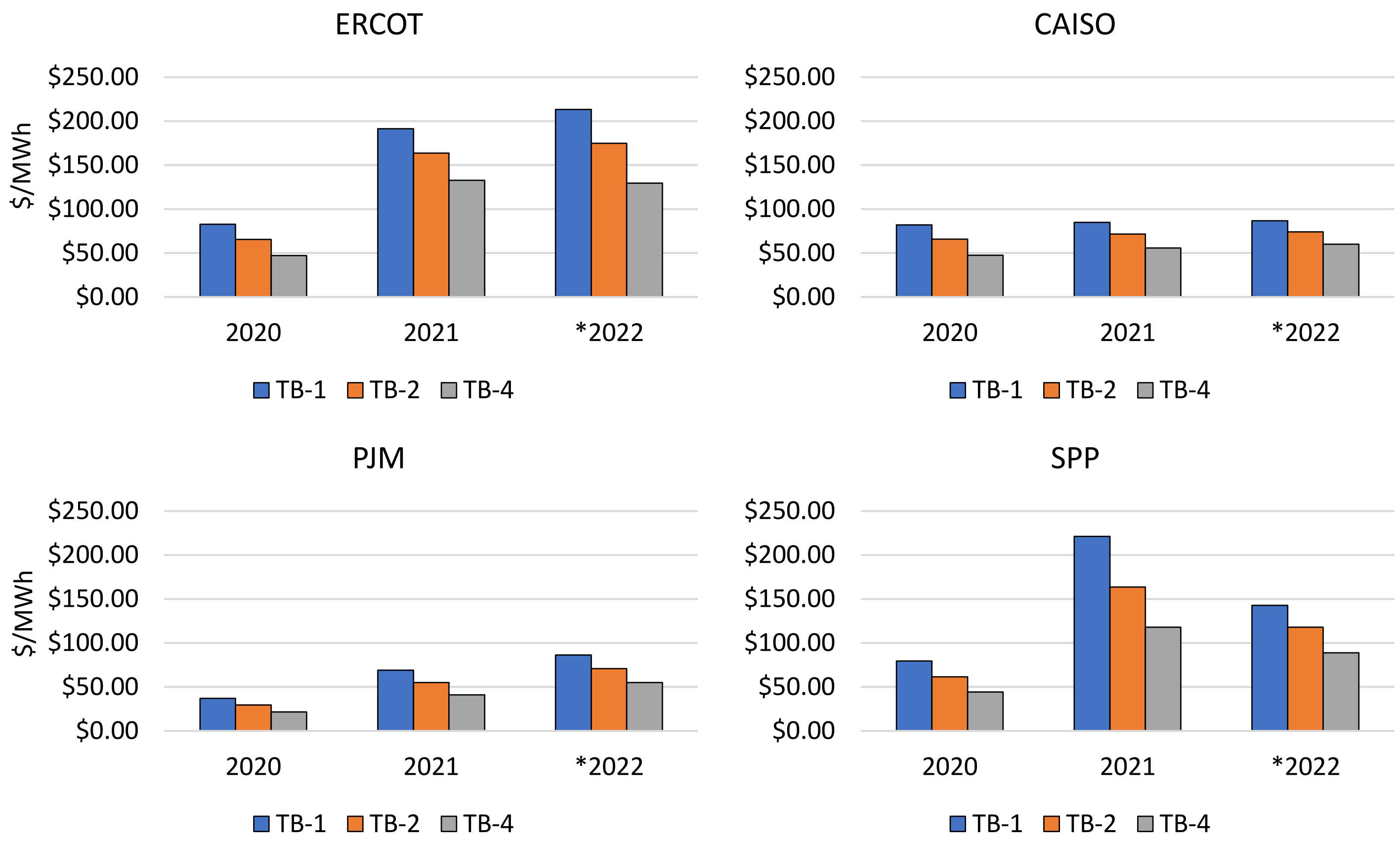
- Generator retirements and extreme weather conditions increase volatility
- Transmission congestion drives arbitrage opportunity at nodes with persistent volatility expected

Storage Opportunities

ENGIE

Distinct policy and market structures drive need for region-specific siting strategies

RT Top-Bottom Price Deltas in Several Wholesale Markets



- New York has released multiple storage roadmaps and recently doubled its 2030 storage target to 6 GW
- ERCOT has introduced storage-specific ancillary service products such as FFRS
- Several utilities within WECC have issued RFPs with specific provisions for storage
- CAISO recently incorporated capacity targets for both short and longer duration storage needs
- Regional distribution of volatility within a specific wholesale market further influences storage adoption

Data pulled from ERCOT, CAISO, PJM, and SPP RT settlements

Panelist

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Steffi Klawiter
Product Manager – Hybrids
UL Renewables

- Product Manager for the HOMER Software suite, which is used globally in three key markets: microgrids, distributed energy resources, and – now with HOMER Front – utility-scale renewable+storage projects.
- Masters in Renewable Energy Management, Steffi applies her experience with renewable energy systems to the HOMER software, and continues to be inspired by distributed energy, microgrids, and utility-scale hybrid projects around the world.

David Mintzer
Director, Energy Storage Advisory Services
UL Renewables

- Been with UL for two years and leads UL's North American energy storage advisory group.
- For the last 16 years he has served in the solar and storage industry in roles focused on product development, business development and project finance. During this time, he built approximately 750 MW of projects.

Please enter any questions into Q&A section of GoToWebinar.

Inputs for solar + storage time of delivery power purchase agreement (PPA)

Case study No. 1

Perform techno-economic analysis for hybrid systems

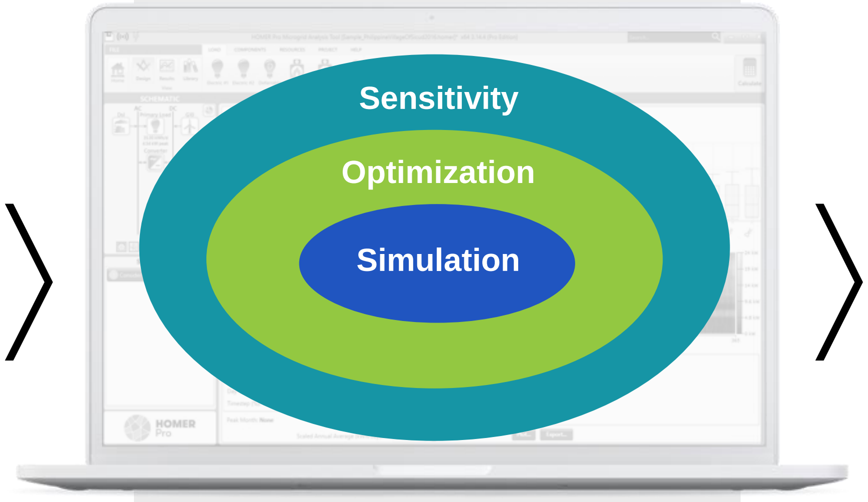
INPUT

ANALYSIS

RESULTS

Project specific details

- Economics
- Revenue stream, market prices
- Site-specific renewable resources
- System components
- Capital expenditures (CAPEX) and operating expenses (OPEX)

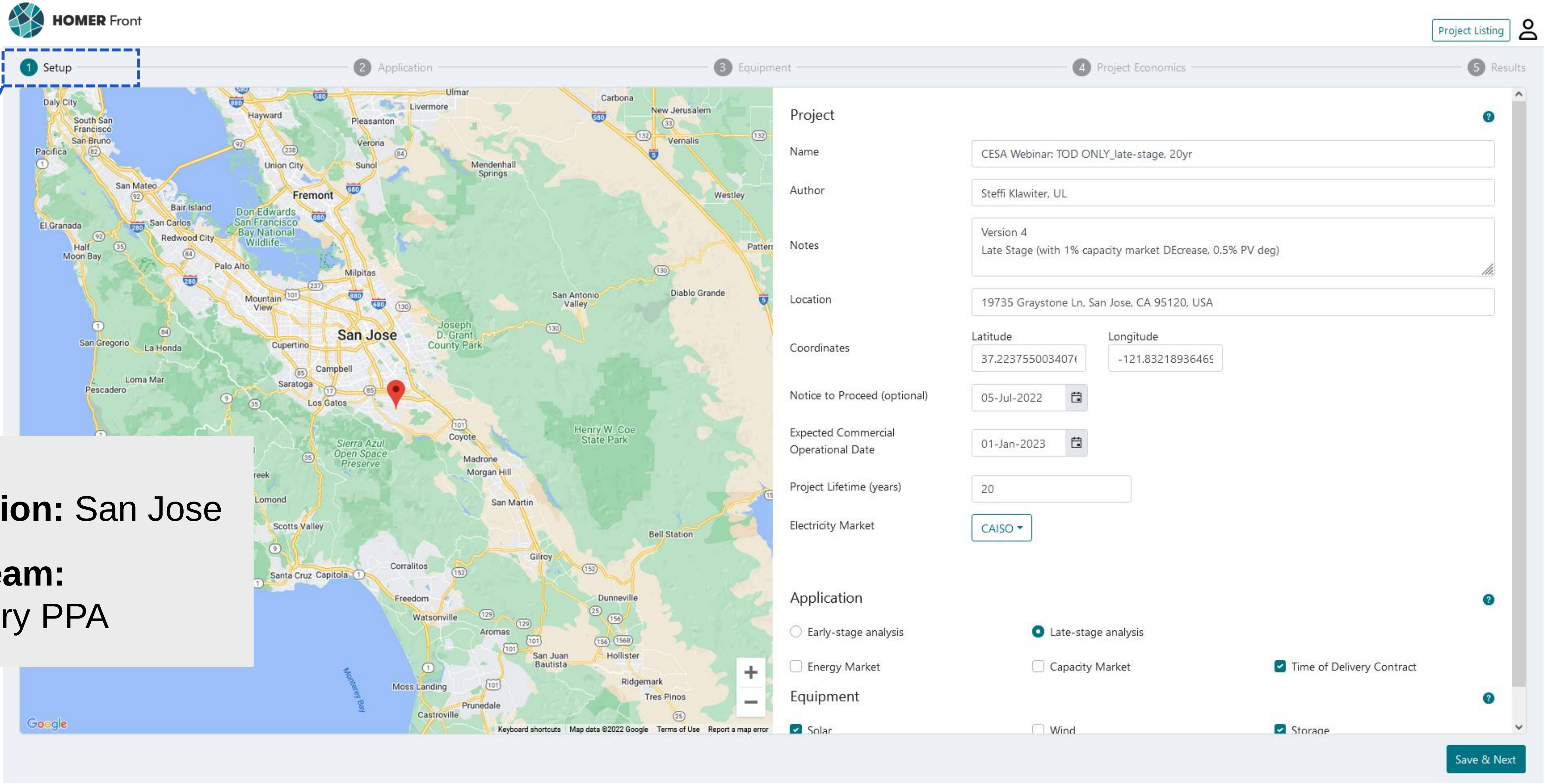


Complex analytics, easily user controlled

Data-driven insights Informed decisions

- Financials
- System sizing
- Performance details
- Emissions
- Various reports

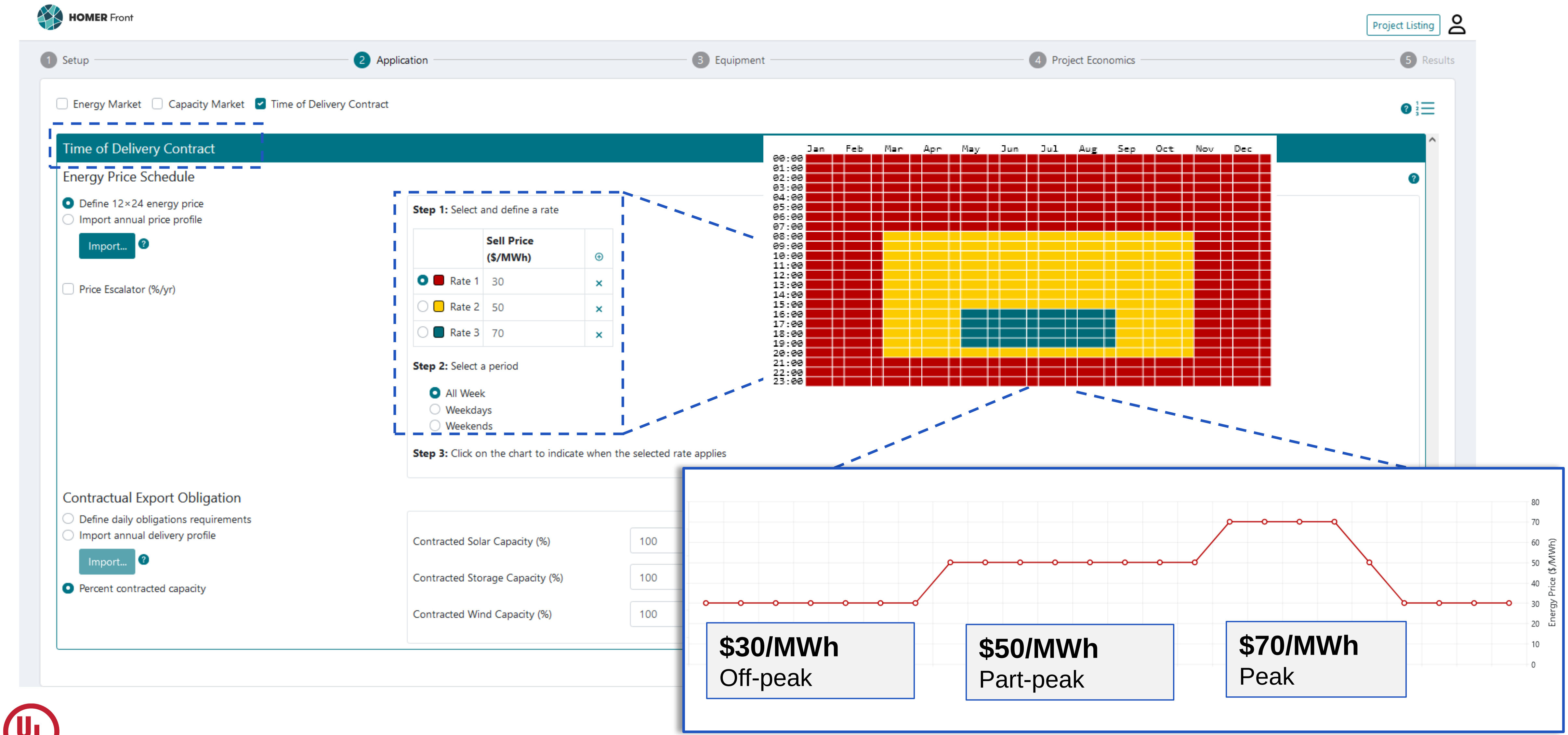
Assumptions for the case study



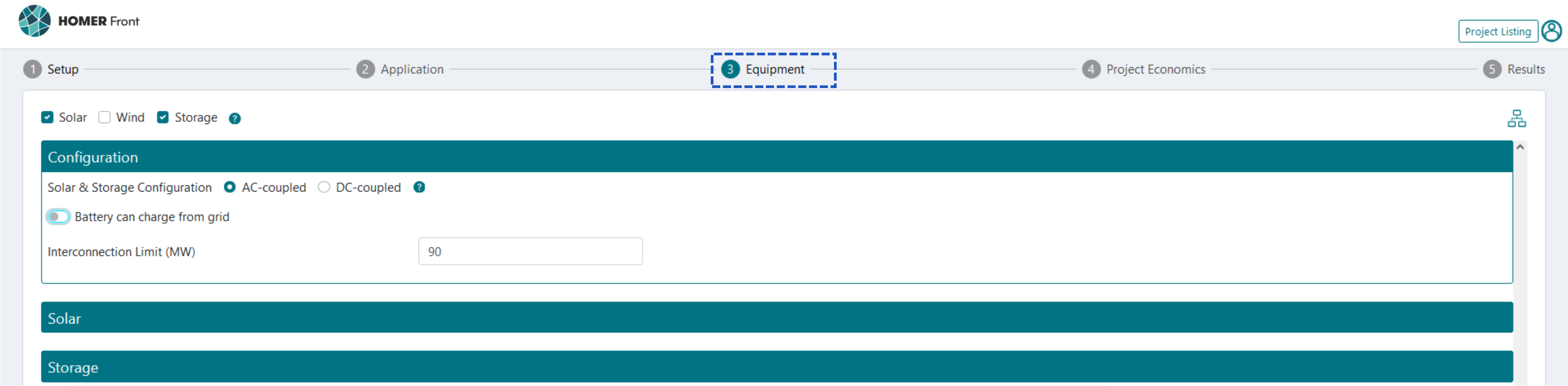
Project Location: San Jose

Revenue Stream:
Time of Delivery PPA

Time of delivery power purchase agreement

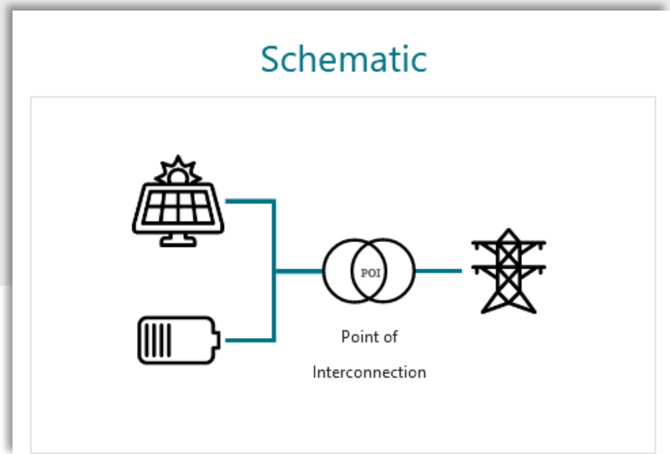


Equipment



AC-coupled configuration

90 MW interconnection



Solar

Solar

HOMER PV Calculator / PVsyst Import

Size

Size in MW

MW
100

Cost

Cost Sensitivity Analysis / Cost Breakdown

- Direct Capital
- Indirect Capital
- Annual Operations and Maintenance Costs (Operating Expenses)

O&M cost escalator (%/yr)

PV degradation (%/yr)

Solar DC/AC Inverter

Add another solar technology

GHI Data Selection:

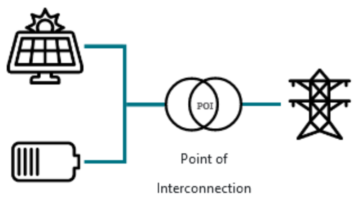
- Use NREL/NASA monthly GHI averages
- Upload annual GHI timeseries

Temperature Data Selection:

- Use NASA monthly temperature averages
- Upload annual temperature timeseries

100 MW-ac PV array size

Schematic



Item	Value	Unit
Direct Capital		
Module	0.355	$/Wdc
Power Conversion System	0.05	$/Wdc
Balance of System	0.15	$/Wdc
Installation Labor	0.07	$/Wdc
Contingency	1	% direct
Indirect Capital		
Permitting and Environmental	0.05	$/Wdc
Engineering and Developer Overhead	0.05	$/Wdc
Land Purchase, Preparation and Transmissi	0.005	$/Wdc
Sales Tax Rate	8	% direct
Annual Operations and Maintenance Costs (Operating Expenses)		
Fixed Annual Cost	1.05	$/kWdc-yr
Variable	0.98	$/kWdc-yr
Insurance	0.65	% direct/yr
Property Tax Rate	0.36	$/kWdc-yr
Station Power Cost	0.04	$/kWdc-yr
Interconnection Cost	0.05	$/kWdc-yr
Major Maintenance Cost	0.05	$/kWdc-yr

Storage

Storage

Storage Type: Energy Storage (1 MW / 4 MWh)

Parameters for Energy Storage (1 MW / 4 MWh)
Nominal Capacity per unit: 4,000 kWh
Nominal Power per unit: 1,000 kW
Roundtrip Efficiency: 94%
Allowable Range of Charge: 100%
Show More

Size

Size in Units

Units
100

Storage DC/AC Inverter

Cost

Cost Sensitivity Analysis | Cost Breakdown

- Direct Capital
- Indirect Capital
- Annual Operations and Maintenance Costs (Operating Expenses)

O&M cost escalator (%/yr)

Augmentation ($/kWh): 130

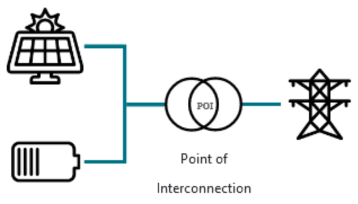
Augmentation price decline (%/yr)

Augmentation degradation limit (%): 10

Add another storage technology

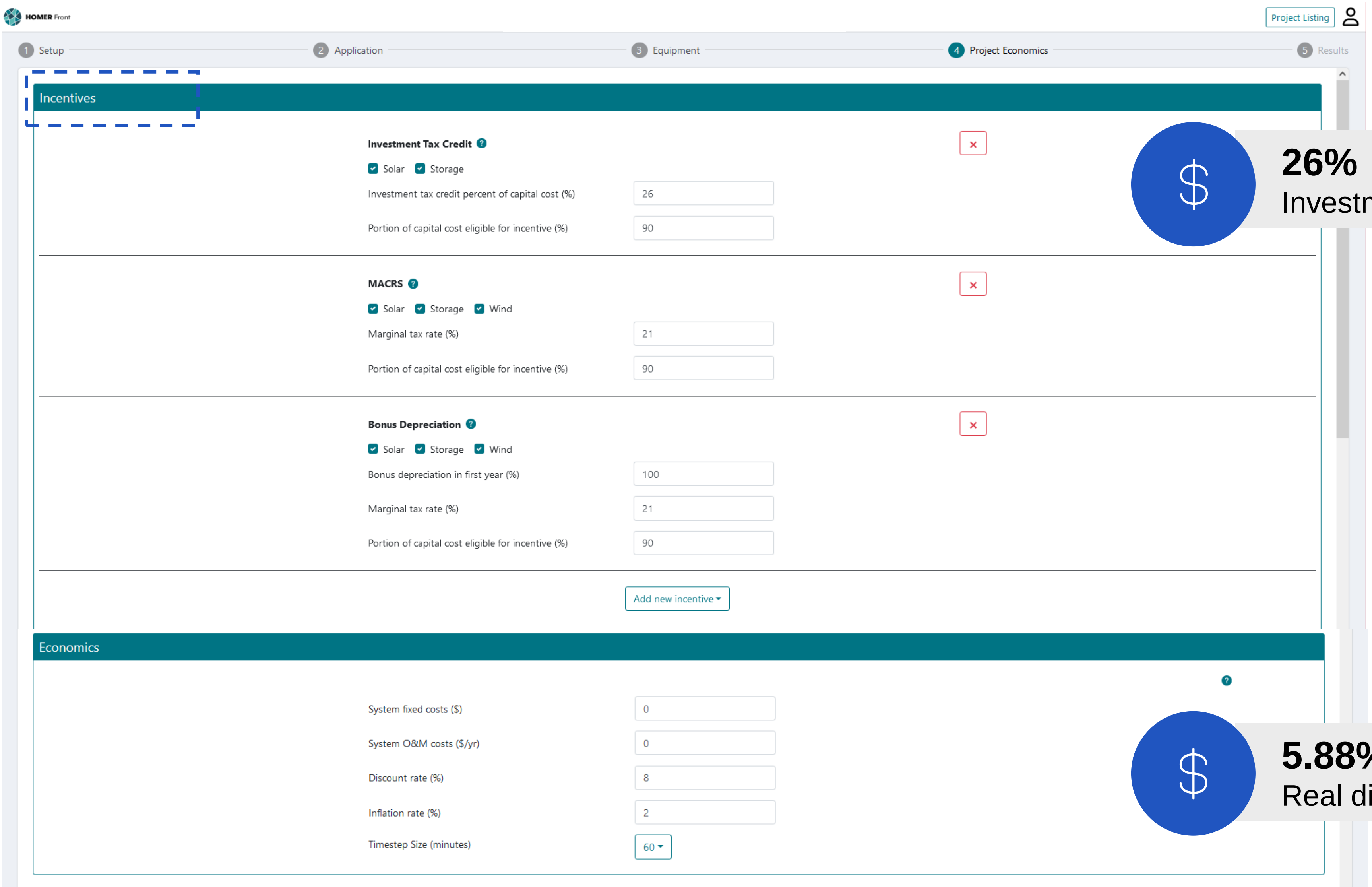
Item	Value	Unit
Direct Capital		
Module	200	$/kWh
Power Conversion System	27	$/kWh
Balance of System	12	$/kW
Installation Labor	12	$/kWh
Installer Overhead and Margin	12	$/kWh
Contingency	3	% direct
Indirect Capital		
Permitting and Environmental	1.9	$/kWh
Engineering and Developer Overhead	18.8	$/kWh
Land Purchase, Preparation and Transmissic	0.9	$/kWh
Working Capital Reserve Account	3	% direct
Sales Tax Rate	8	% direct
Annual Operations and Maintenance Costs (Operating Expenses)		
Fixed Annual Cost	2.63	$/kWh ca...
Variable Cost	0.1	$/MWh t...
Insurance	0.35	% direct/yr
Site Lease Cost	500	$/yr
Interest on All Reserves	2	% direct/yr
Storage Decommissioning Reserve	3	$/MWh t...

Schematic



100 MW / 400 MWh
AC storage size

Incentives



26%
Investment tax credit

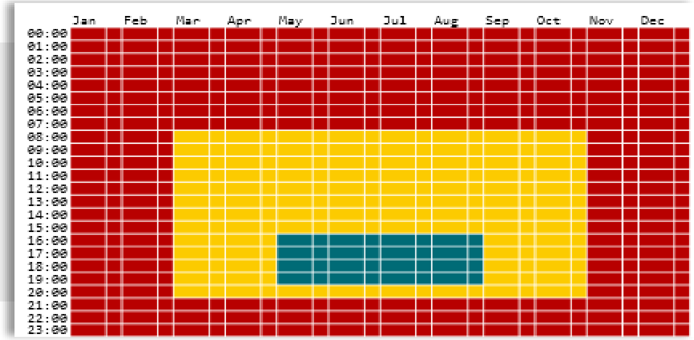
5.88%
Real discount rate

Summary of case study No. 1

Time of Delivery PPA

Revenue streams

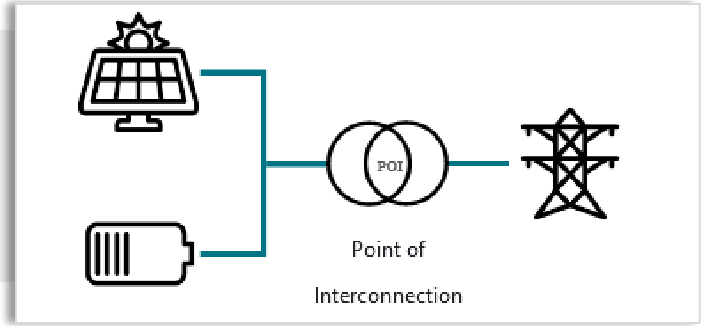
$30/MWh	$50/MWh	$70/MWh
Off-peak	Part-peak	Peak



Equipment

AC-coupled solar-plus-storage

90 MW	100 MWac	100 MW/400MWh
Interconnection	PV array size	AC storage size



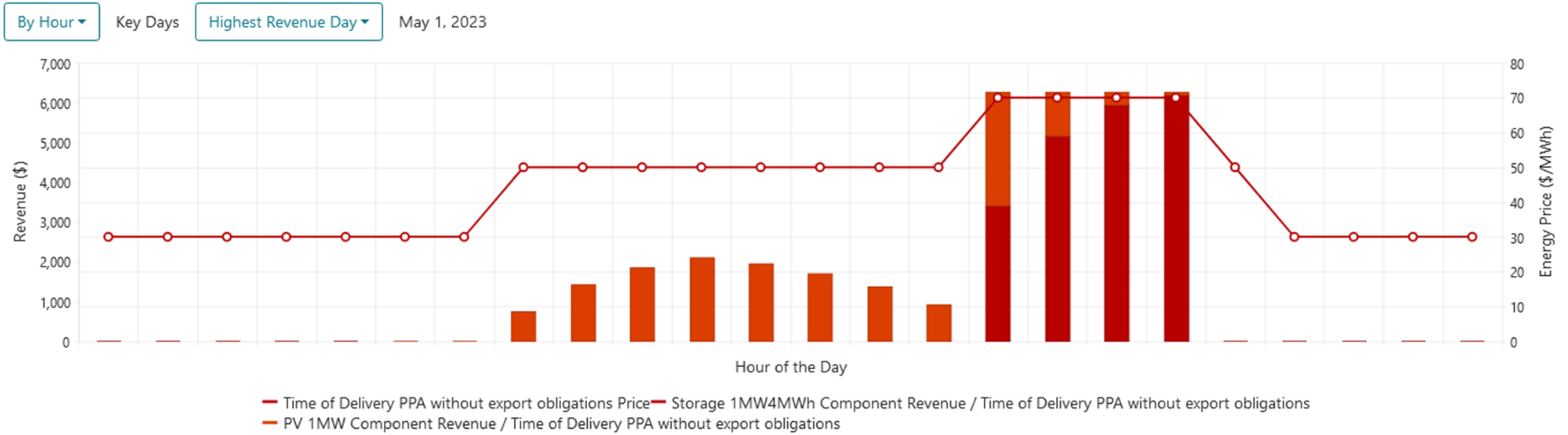
Incentives

26%	5.88%
Investment tax Credit	Real discount rate

Results for solar + storage time of delivery PPA

Case study No.1

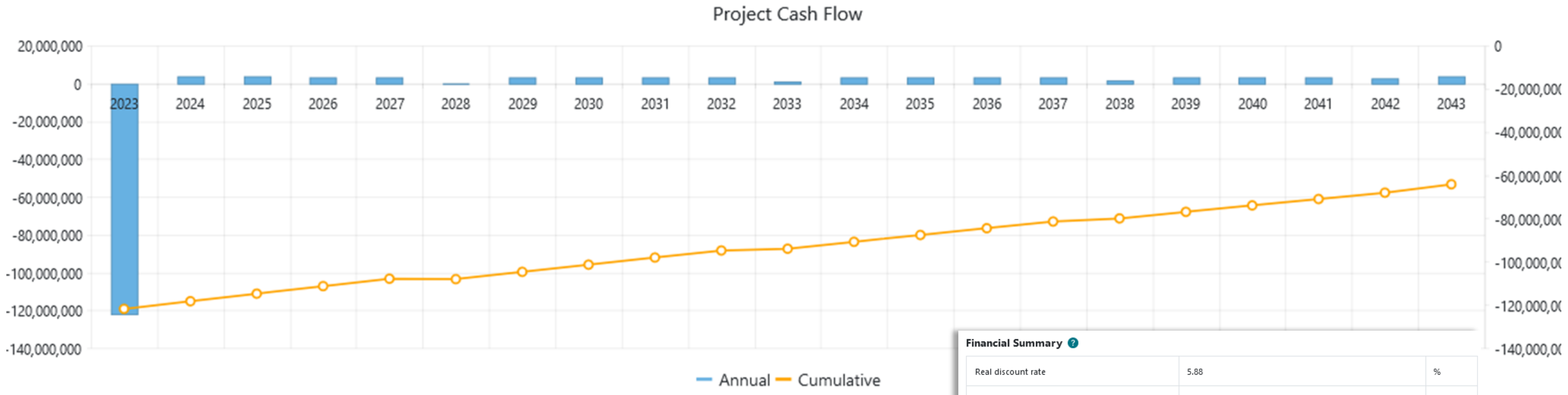
Storage allows a higher price for energy



Solar shifting

Value Driver

But the financials don’t deliver adequate return



Financial Summary

Real discount rate	5.88	%
Project life	20	yrs
Capital expenses	121,904,144	$
Operating expenses, excl. augmentation	4,285,959	$/yr
Augmentation expenses	408,860	$/yr
Contract participation	Time of Delivery PPA without export obligations	
Revenue	7,564,717	$/yr
IRR	—	%
NPV	-88,351,128	$
LCOE	0.051	$/kWh

$121.9M Capital expense

$4.69M/yr Operation and augmentation expense

$7.56M/yr Revenue

--% IRR

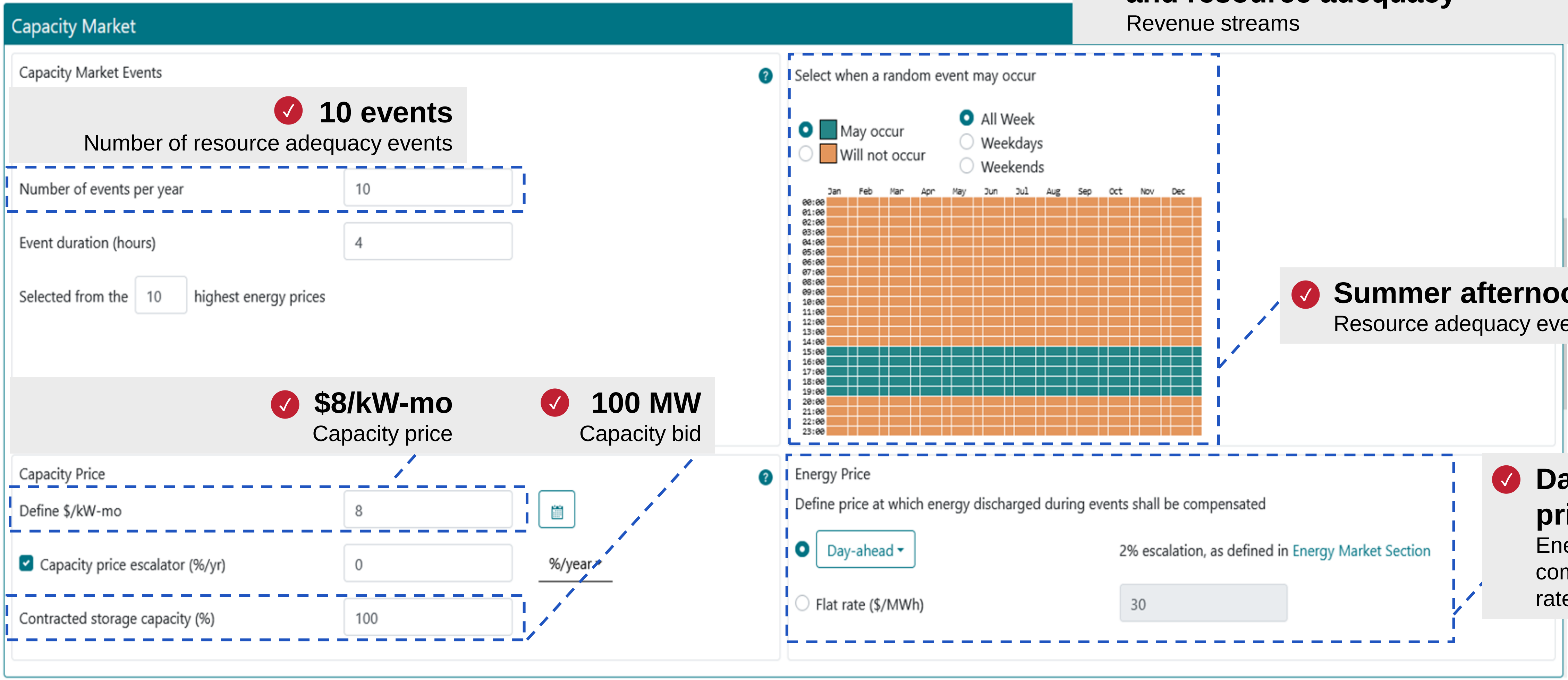
Solar + storage projects are challenged if they relying solely on PPAs for financial returns

Inputs for solar + storage time of delivery PPA and resource adequacy

Case study No. 2

Resource adequacy

Time of delivery PPA and resource adequacy
Revenue streams



10 events
Number of resource adequacy events

$8/kW-mo
Capacity price

100 MW
Capacity bid

Summer afternoons
Resource adequacy events called

Day-ahead price signal
Energy compensation rate

Summary of case study No. 2

Resource adequacy

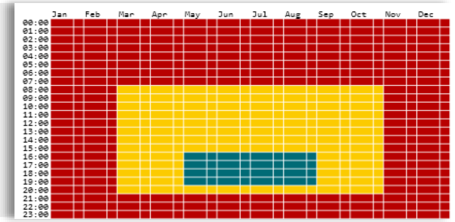
Revenue streams

100 MW Capacity bid	$8/kW-mo Capacity price	10 events Number of events	Day-ahead price signal Energy compensation rate

Time of Delivery PPA

Revenue streams

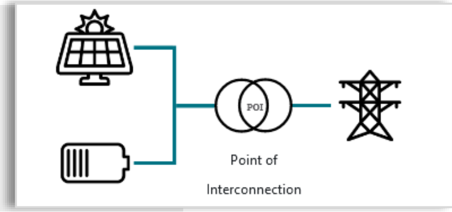
$30/MWh Off-peak	$50/MWh Part-peak	$70/MWh Peak



Equipment

AC-coupled solar-plus-storage

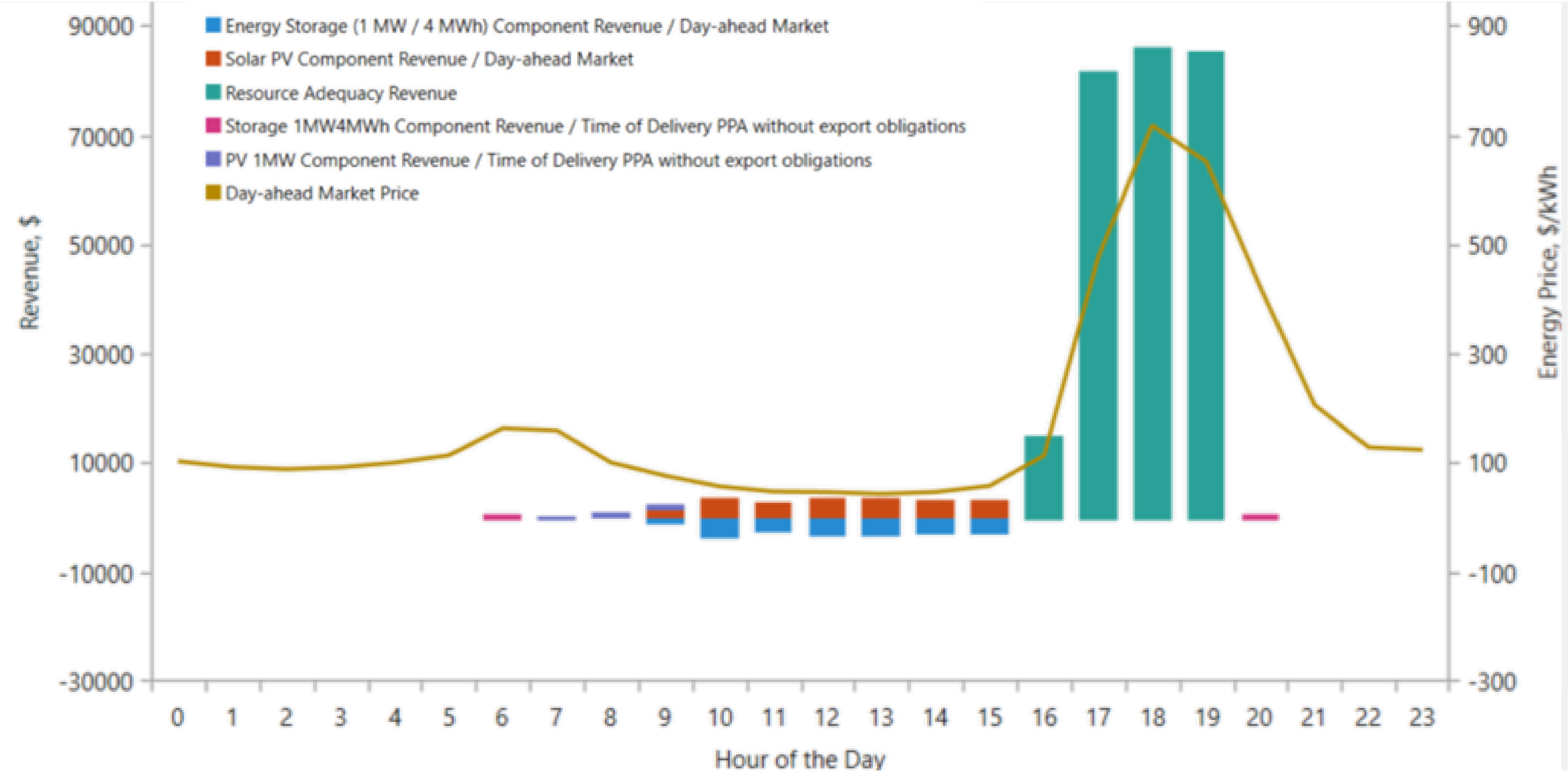
90 MW Interconnection	100 MWac PV array size	100 MW/400MWh AC storage size



Incentives

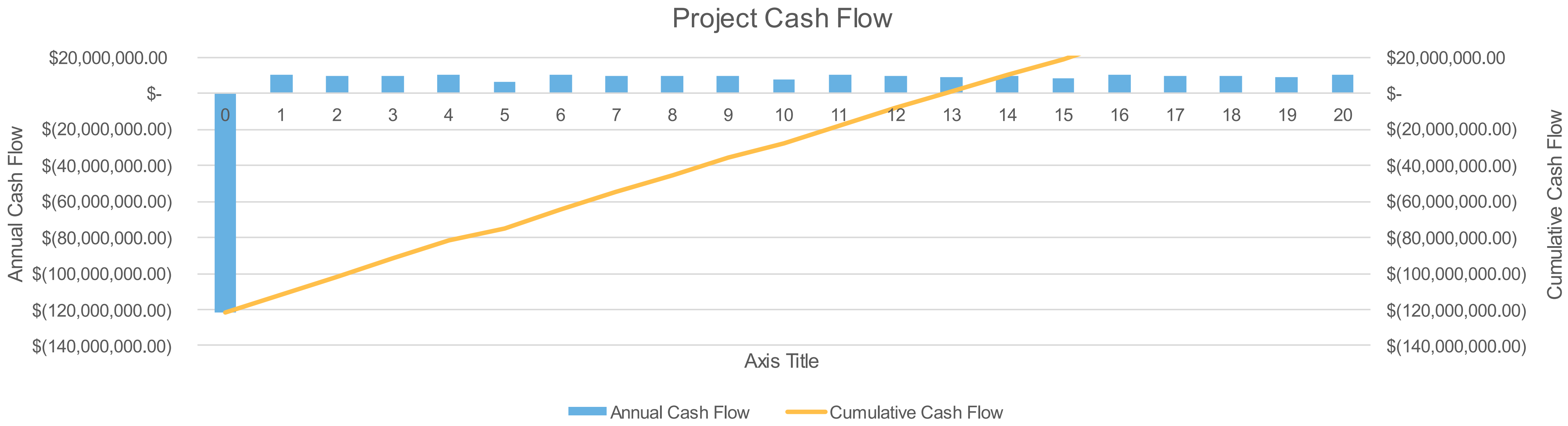
26% Investment tax Credit	5.88% Real discount rate

Capacity revenue can be significant



Capacity revenue
Value Driver

But still not enough



$

$121.9M Capital expense

$4.93M/yr Operation and augmentation expense

$7.10M/yr TOD revenue

$7.33M/yr Capacity market revenue

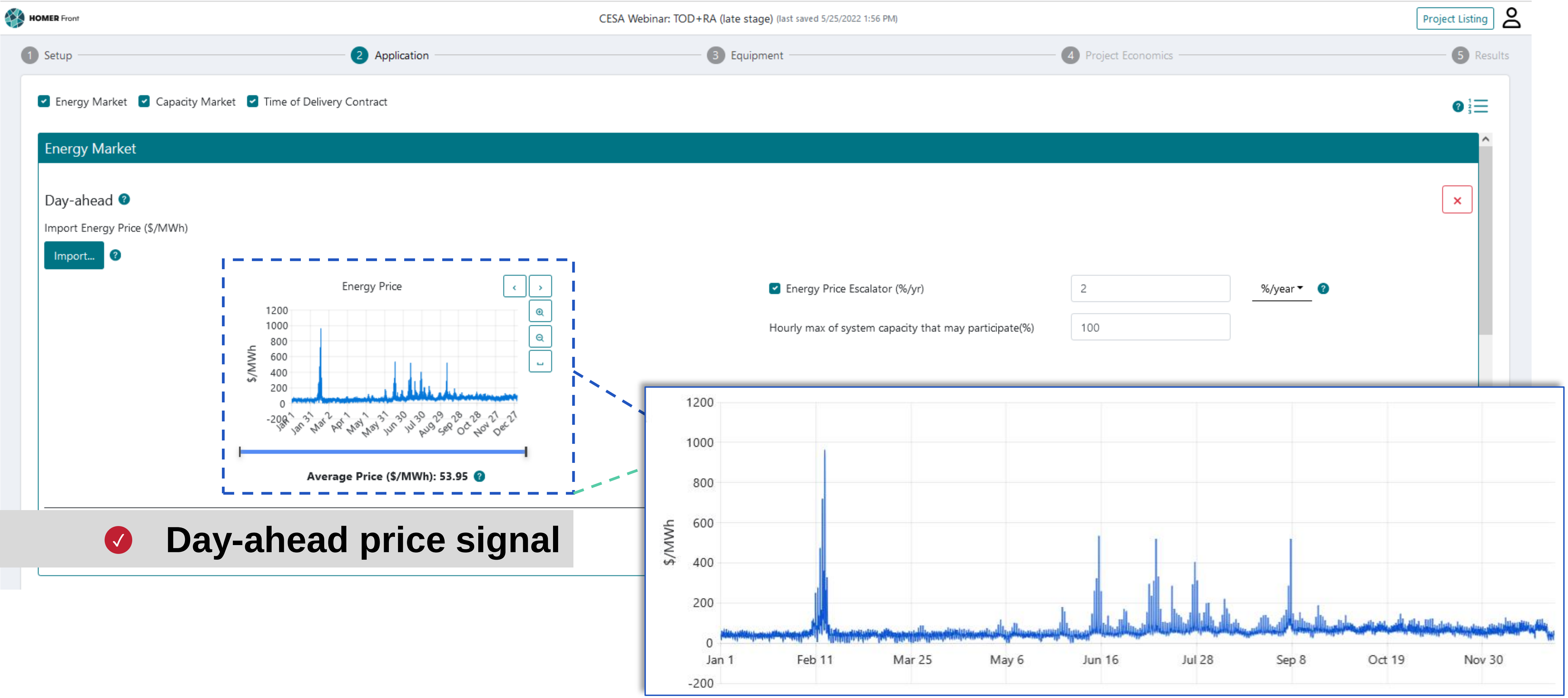
4.7% IRR

Solar + storage projects need to explore all revenue opportunities, including capacity and energy markets, in addition to contracts and PPAs.

Time of delivery PPA and resource adequacy and day-ahead market

Case study No. 3

Energy compensation rate



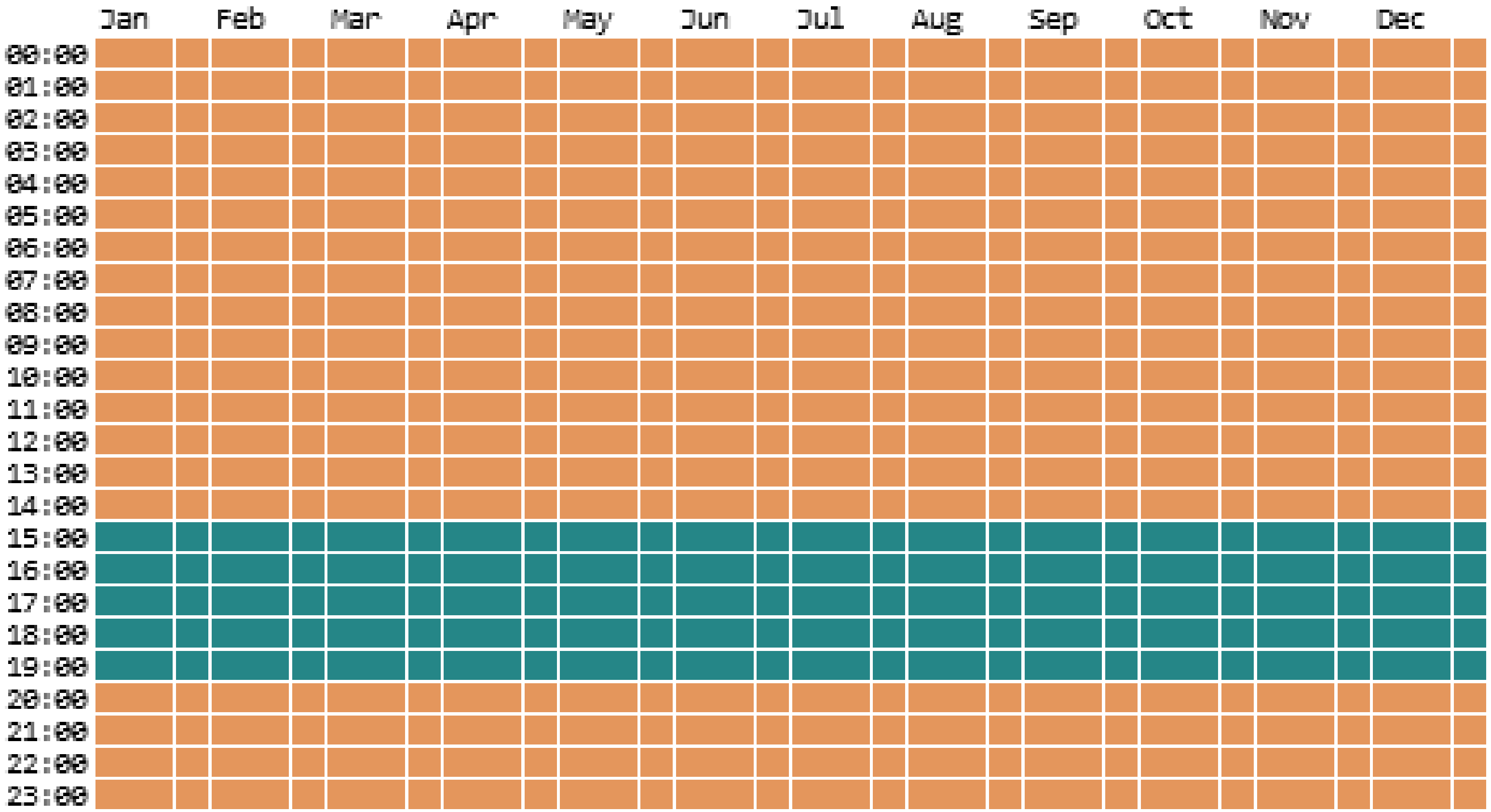
✓ **Day-ahead price signal**

Market allocation

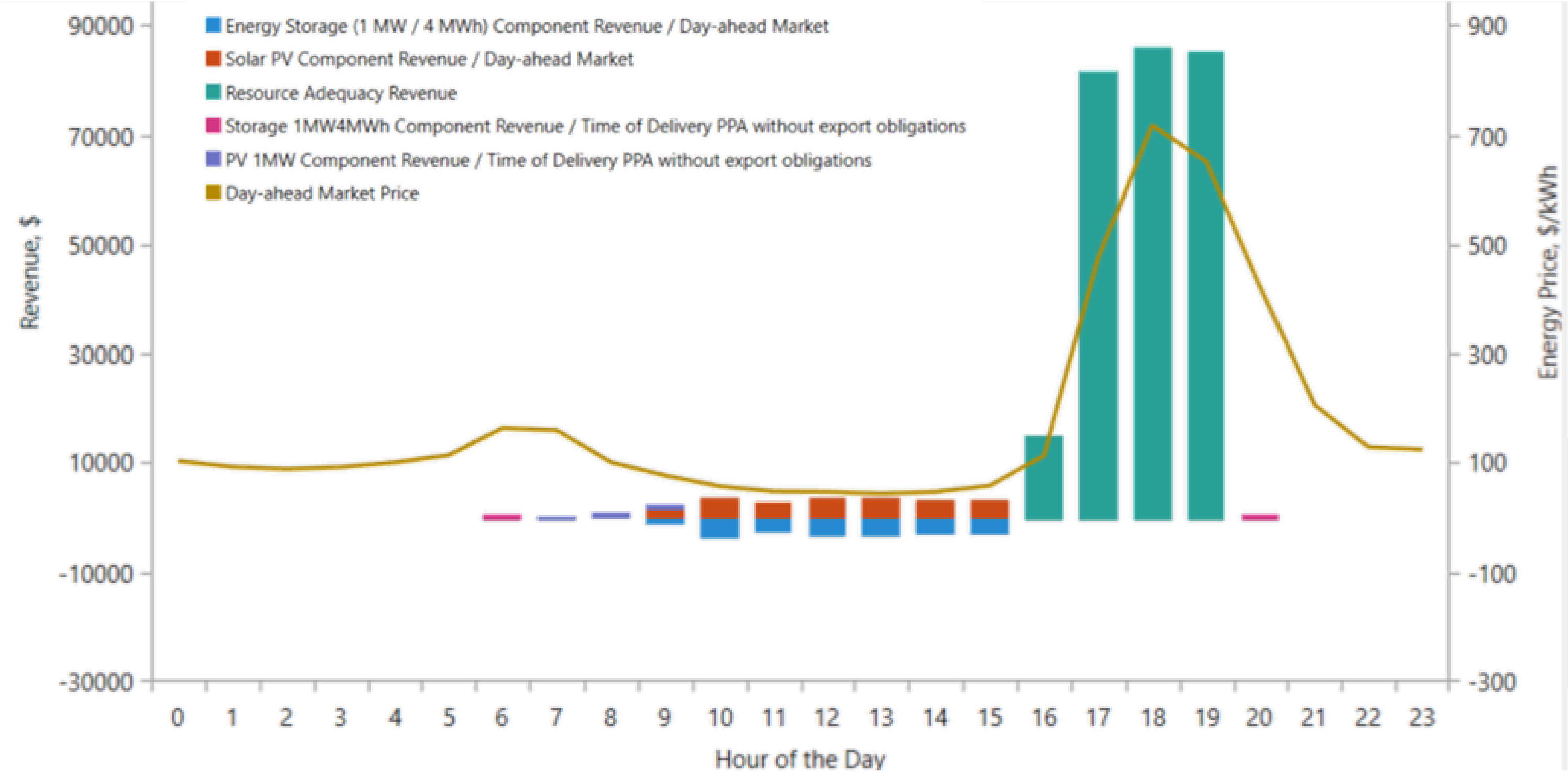
20%
of storage capacity will sell to the TOD outside capacity events

80%
of storage capacity will sell to the day-ahead market outside capacity events

100%
of storage capacity will bid into capacity market during capacity events

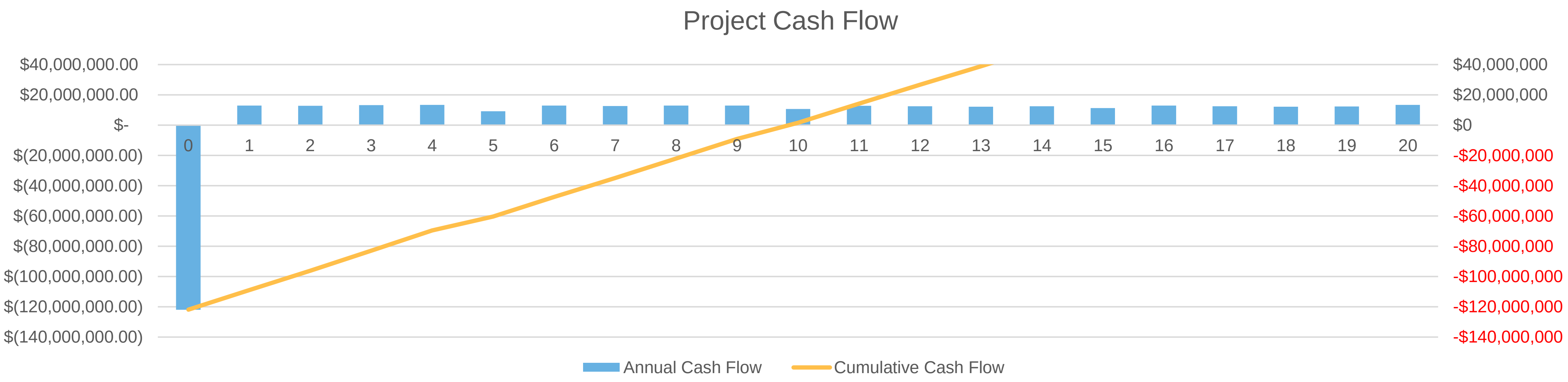


Value stacking enables financial viability



Day-ahead revenue
Value Driver

Results



$121.9M Capital expense

$4.93M/yr Operation and augmentation expense

$2.60M/yr TOD revenue

$7.33M/yr Capacity market revenue

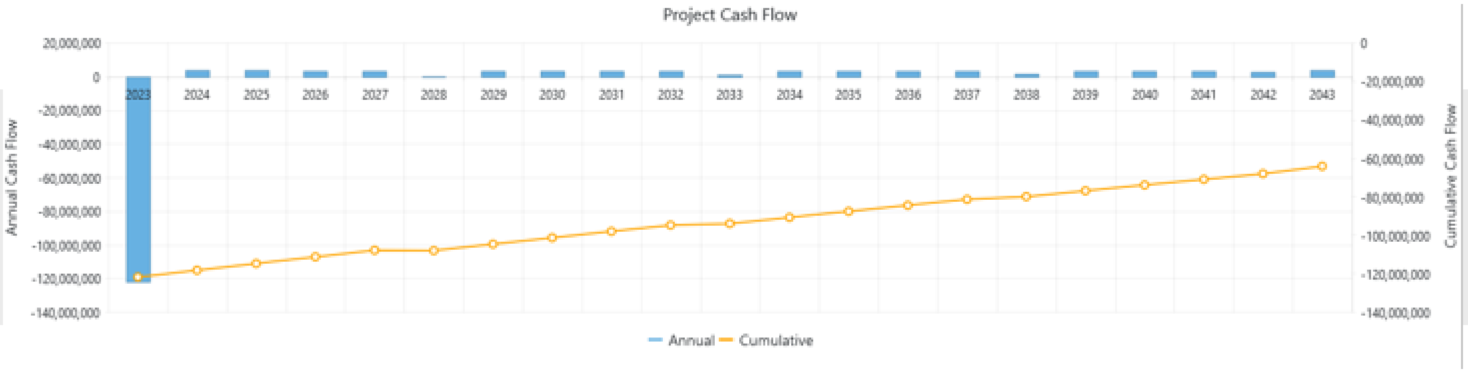
$7.40M/yr Day-ahead energy revenue

8.0% IRR

Compare

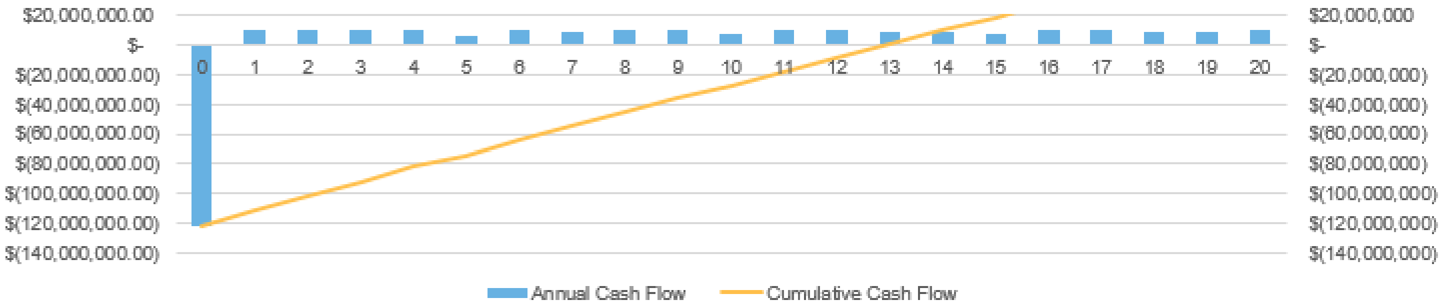
Time of Delivery (TOD) PPA

--% IRR



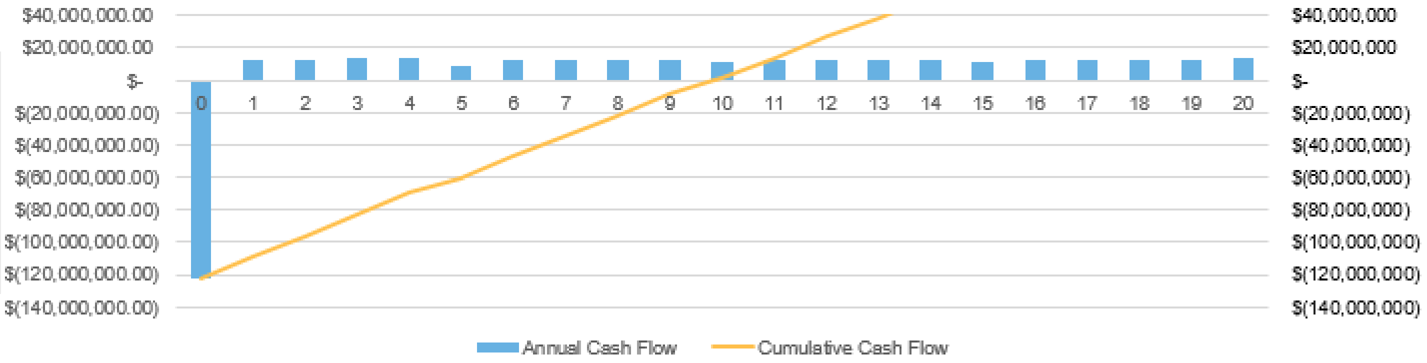
TOD PPA + Resource Adequacy (RA)

4.7% IRR



TOD PPA + RA + Day-ahead market

8.0% IRR



Sensitivities

Case study No. 3

Inputs

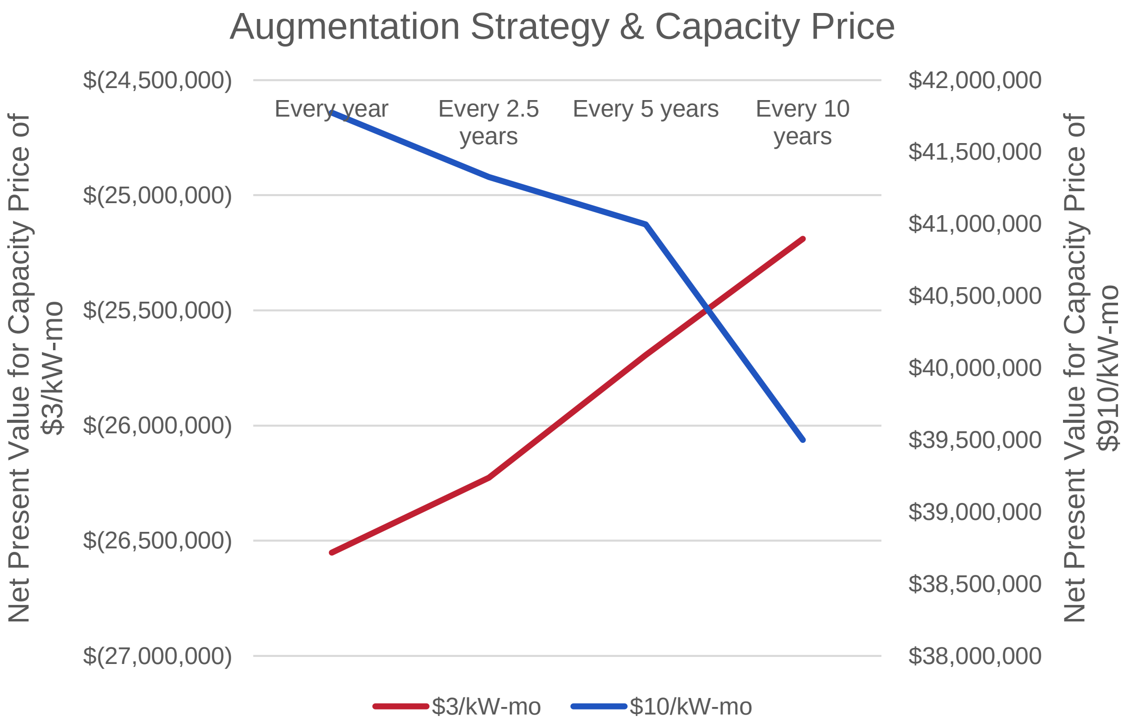
Capacity price

- $6/kW-mo
- $7/kW-mo
- $8/kW-mo
- $9/kW-mo

Augmentation every:

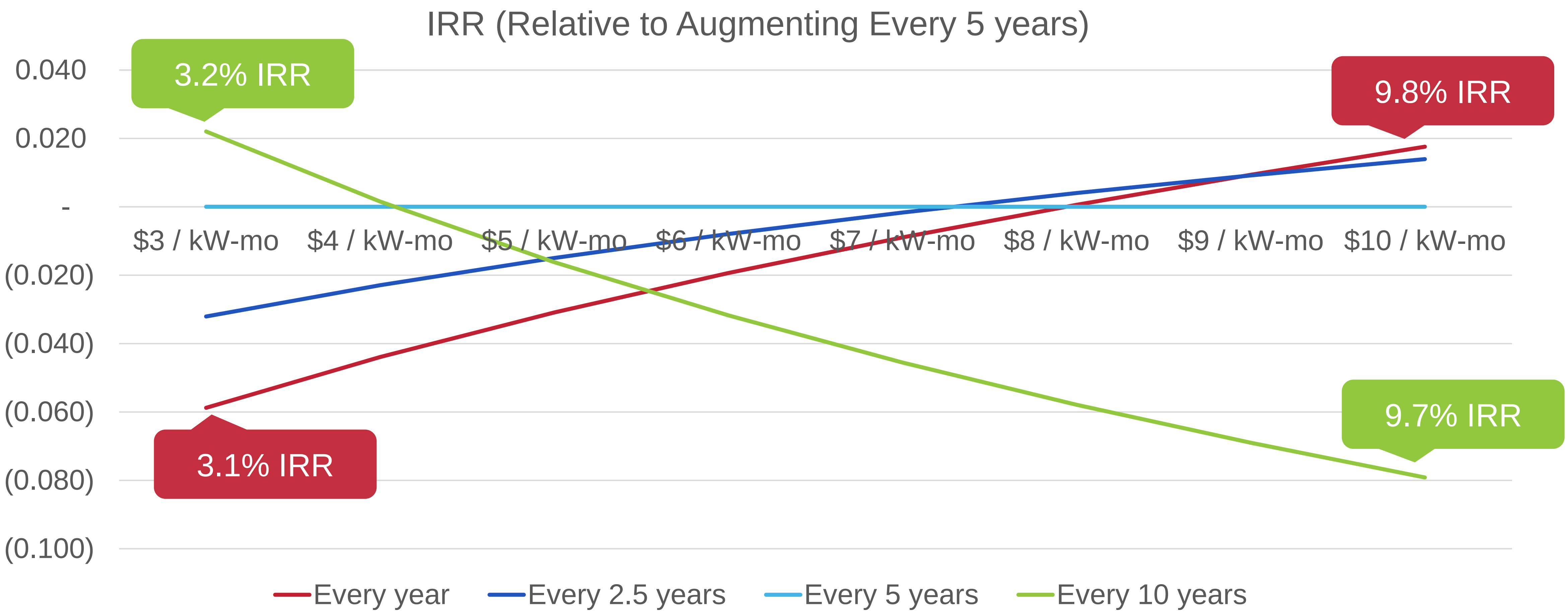
- 1 year (20 times)
- 2.5 years (8 times)
- 5 years (4 times)
- 10 years (2 times)

Quickly simulate each case to understand risk



Augmentation Cadence	Capacity Price ($/kW-mo)	IRR (%)	Net Present Value ($)
Every year	$ 3	3.1%	$ (26,551,720)
Every 2.5 years	$ 3	3.1%	$ (26,225,880)
Every 5 years	$ 3	3.1%	$ (25,694,030)
Every 10 years	$ 3	***3.2%***	***$ (25,189,130)***
Every year	$ 4	4.2%	$ (16,790,800)
Every 2.5 years	$ 4	4.2%	$ (16,575,520)
Every 5 years	$ 4	4.2%	$ (16,166,590)
Every 10 years	$ 4	***4.2%***	***$ (15,947,700)***
Every year	$ 5	5.2%	$ (7,029,878)
Every 2.5 years	$ 5	5.2%	$ (6,925,152)
Every 10 years	$ 5	5.2%	$ (6,706,256)
Every 5 years	$ 5	***5.2%***	***$ (6,639,138)***
Every 10 years	$ 6	6.1%	$ 2,535,181
Every 2.5 years	$ 6	6.2%	$ 2,725,216
Every year	$ 6	6.2%	$ 2,731,044
Every 5 years	$ 6	***6.2%***	***$ 2,888,312***
Every 10 years	$ 7	7.1%	$ 11,776,620
Every 2.5 years	$ 7	7.1%	$ 12,375,580
Every 5 years	$ 7	7.1%	$ 12,415,760
Every year	$ 7	***7.1%***	***$ 12,491,960***
Every 10 years	$ 8	8.0%	$ 21,018,060
Every 5 years	$ 8	8.0%	$ 21,943,210
Every 2.5 years	$ 8	8.0%	$ 22,025,950
Every year	$ 8	***8.0%***	***$ 22,252,880***
Every 10 years	$ 9	8.8%	$ 30,259,500
Every 5 years	$ 9	8.9%	$ 31,470,660
Every 2.5 years	$ 9	8.9%	$ 31,676,310
Every year	$ 9	***8.9%***	***$ 32,013,810***
Every 10 years	$ 10	9.7%	$ 39,500,940
Every 5 years	$ 10	9.8%	$ 40,998,100
Every 2.5 years	$ 10	9.8%	$ 41,326,680
Every year	$ 10	***9.8%***	***$ 41,774,720***

At higher capacity prices, augment more often



Summary

- Increasingly, project viability will require stacking multiple revenue streams.

Internal rate of return

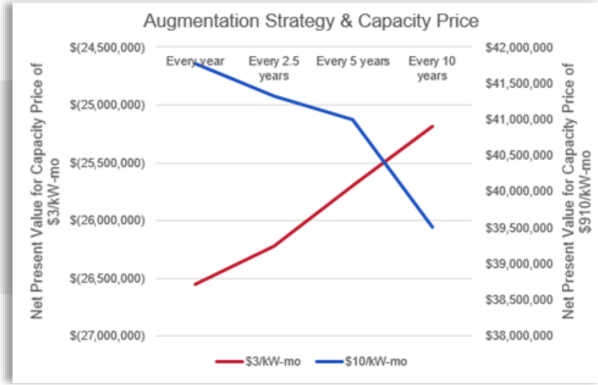
1. Time of delivery PPA	2. TOD PPA + resource adequacy	3. TOD PPA + RA + Day-ahead market
--% IRR	**4.7%** IRR	**8.0%** IRR

- Market conditions influence the operational strategy.

Sensitivity

Capacity price and augmentation strategy

0.1% Difference in IRR



Lessons

Steffi Klawiter

Q&A

Alex Morris
Executive Director
CESA
Moderator

Gabriel Murtaugh
Storage Sector Manager
California ISO

Annamalai Muthu
Director, Energy Storage
Engie

Steffi Klawiter
Product Manager – Hybrids
UL Renewables
Support@homerenergy.com

David Mintzer
Director, Energy Storage
Advisory Services
UL Renewables
David.Mintzer@UL.com

Please enter any questions into Q&A section of GoToWebinar.

THANK YOU

Please contact us at: info@storagealliance.org | www.storagealliance.org

CESA

CALIFORNIA ENERGY STORAGE ALLIANCE