Resilience Gaps & Clean Energy Solutions at State-Owned Medical & Residential Care Facilities

IDEA Pittsburgh – June 26th 2019

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ARUP

Agenda

Resilience and Sustainability in MA

Study overview

Results

Example

Summary

Why do we need to be resilient?

The New York Times

Nursing Home Deaths in Florida Heighten Scrutiny of Disaster Planning

Tampa Bay Times

Following deaths from Irma, Florida looks to new rules for keeping nursing homes cool after outages

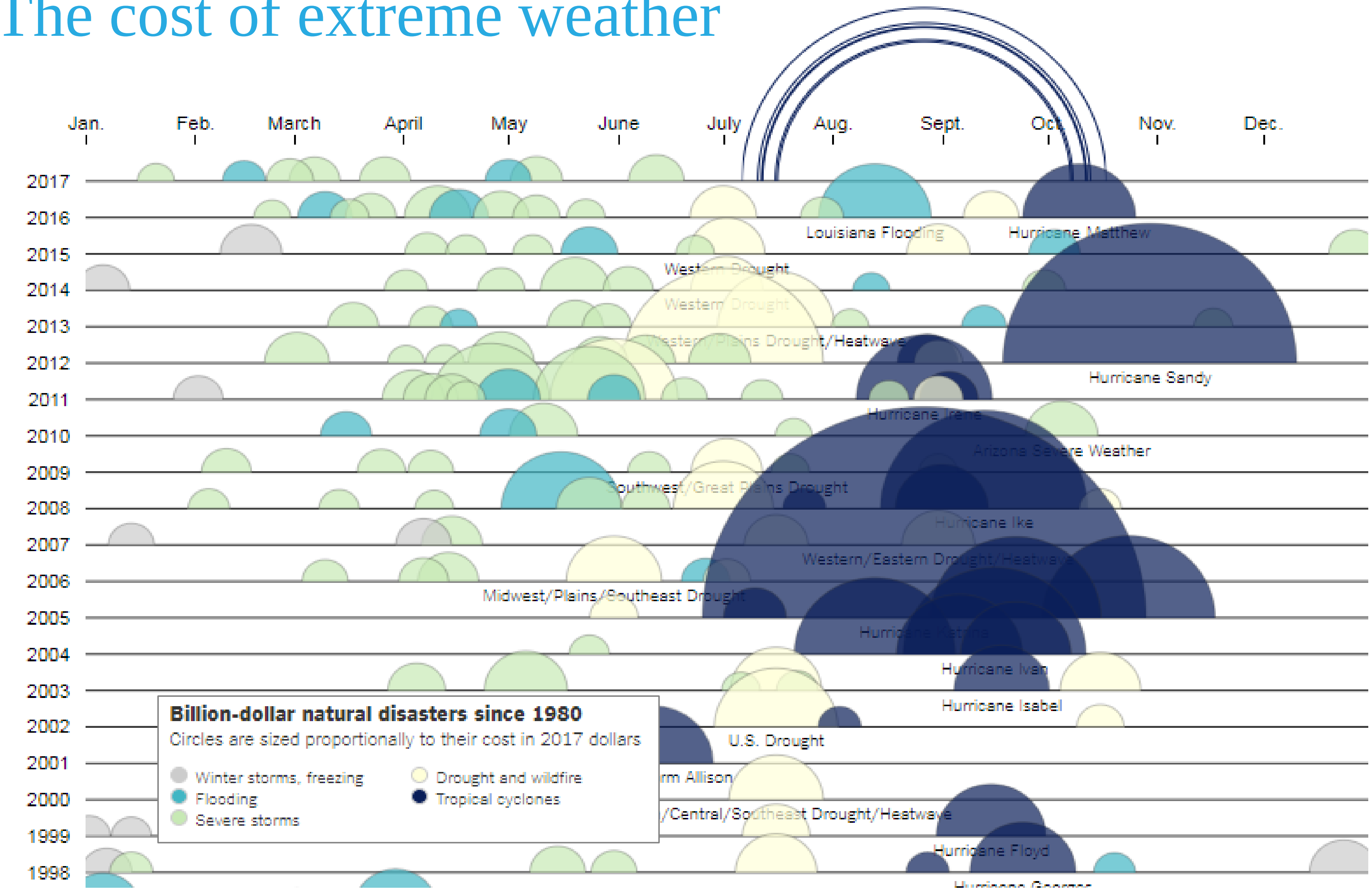
Some hospitals hang on as others close amid Harvey's floods

By Jen Christensen, CNN

Updated 12:29 AM ET, Thu August 31, 2017

CNN

The cost of extreme weather



https://www.nytimes.com/interactive/2017/09/01/upshot/cost-of-hurricane-harvey-only-one-storm-comes-close.html

Cost to US GDP

$3.9

trillion by 2025

Lost Business Sales

$7

trillion by 20205

Lost Jobs

2.5

million jobs in 2025

Cost to Families

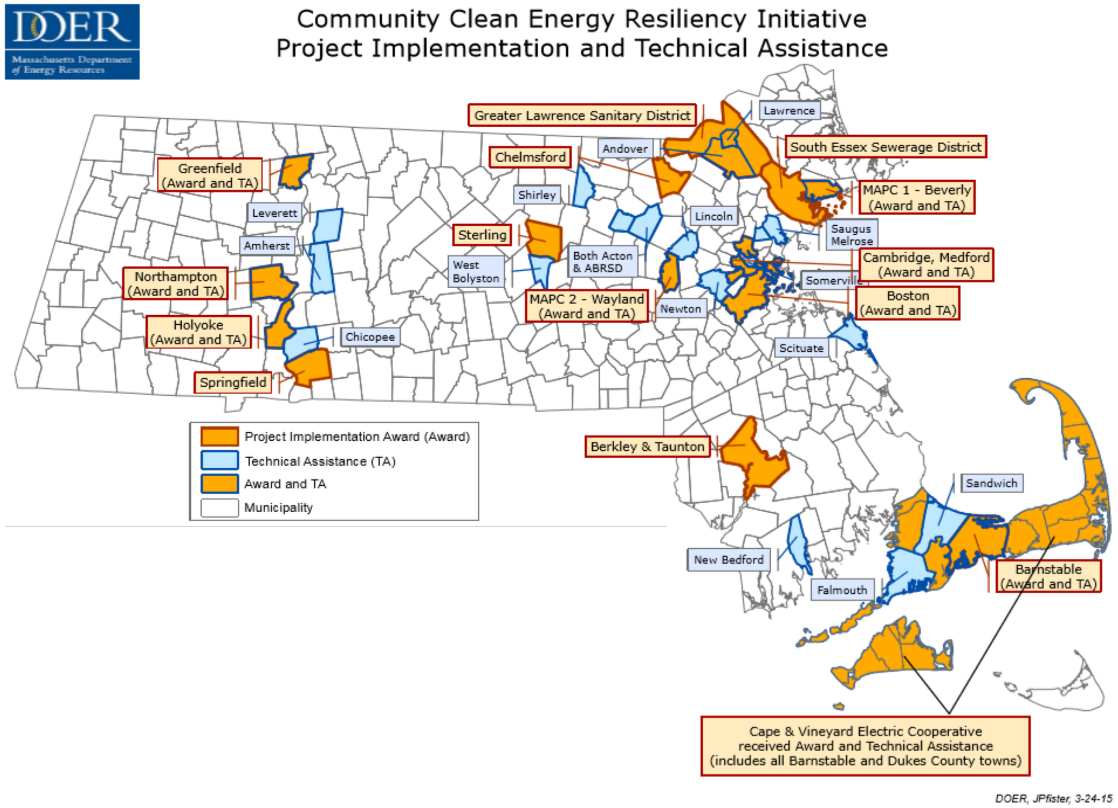
$3,400

per year

http://www.asce.org/failuretoact/

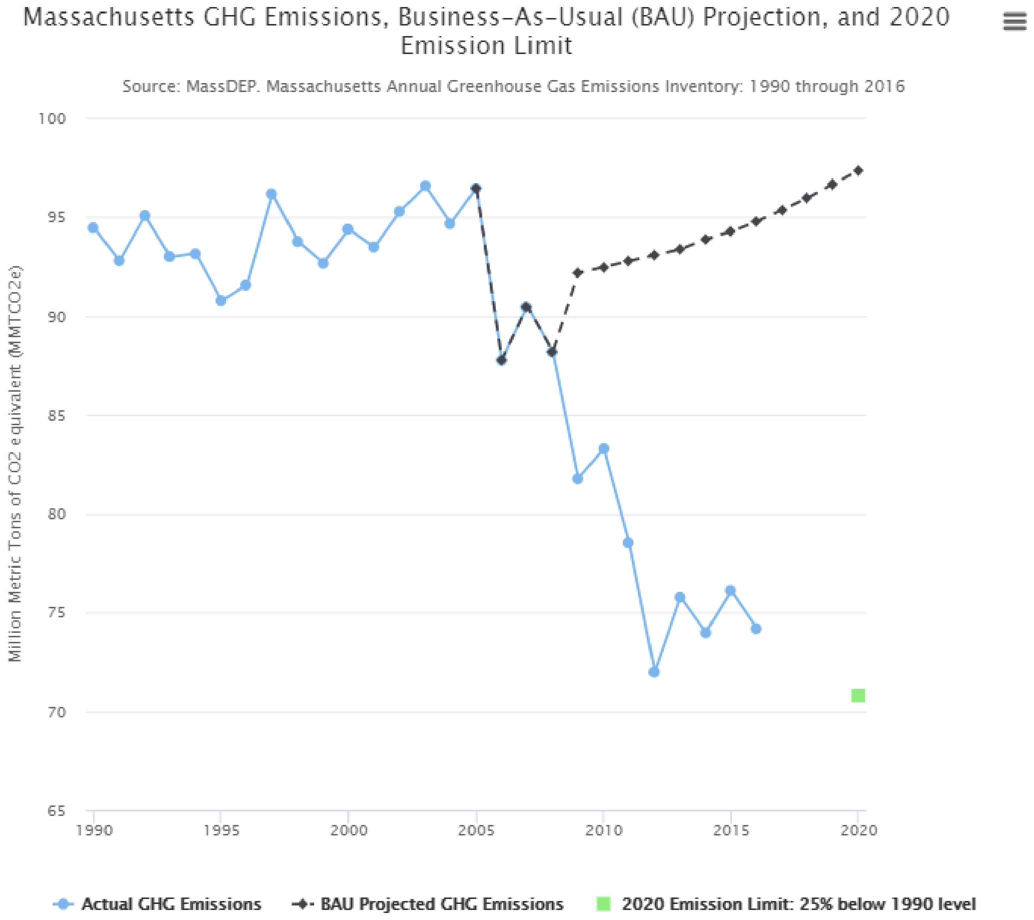
Massachusetts Context

Resilience



$2.4 Billion in Proposed Governor and Legislative Resilience Initiatives

Sustainability

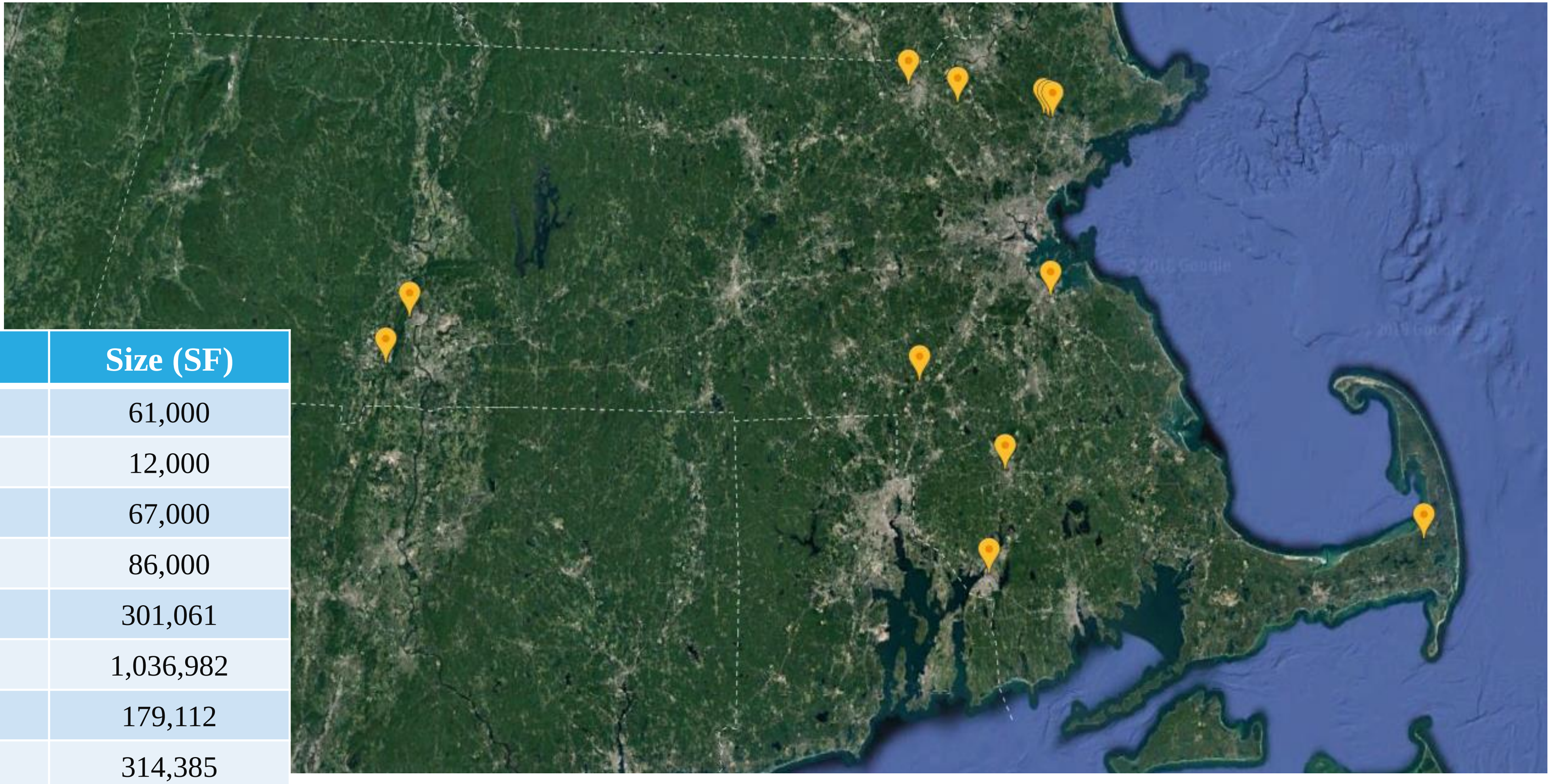


Robust clean energy and sustainability policies

Overview: Resiliency Study Goals

Purpose of Study	**“Identify opportunities to utilize clean energy technologies to increase the energy resiliency of each facility, thereby reducing the likelihood of prolonged outages during extreme weather events”**
Resilience Goals	• Increase length of time the site is able to maintain facility-wide or critical load operations during grid outage
	• Increase number of ancillary services or facility square footage with backup generation in the event of grid outage
	• Increase the redundancy of the existing backup generation
Clean Energy Objectives	• Replace or supplement fossil fuel back up power to increase facility operational capabilities during power outage
	• Provide diversity of fuel sources to increase reliability by removing reliance on a single fuel and on fuel transport
	• Reduce GHG emissions, reliance on fossil fuels

Project Overview: Background on Site Selection



Primary Purpose	Size (SF)
Community Mental Health Center	61,000
Community Mental Health Center	12,000
Community Mental Health Center	67,000
Community Mental Health Center	86,000
Hospital	301,061
Hospital	1,036,982
Hospital	179,112
Intermediate Care Facility	314,385
Long-term Care Facility	233,000
Long-term Care Facility	609,427
Youth Services Center	70,000
Youth Services Center	23,390

What is resilience?

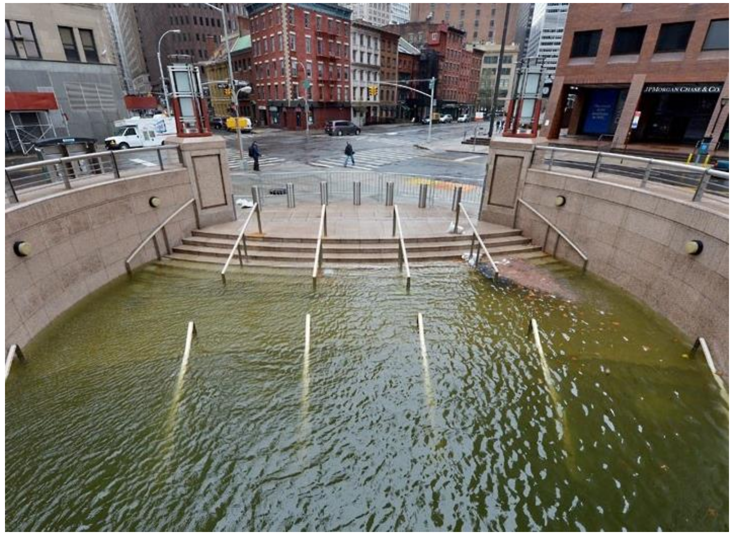
Resilience is the capacity to maintain services, increase flexibility, and continue to thrive despite shocks and stressors.

Key is to focus on the **CRITICAL FUNCTIONALITY** of systems, not simply restoring the system itself

Why do we need to be resilient?

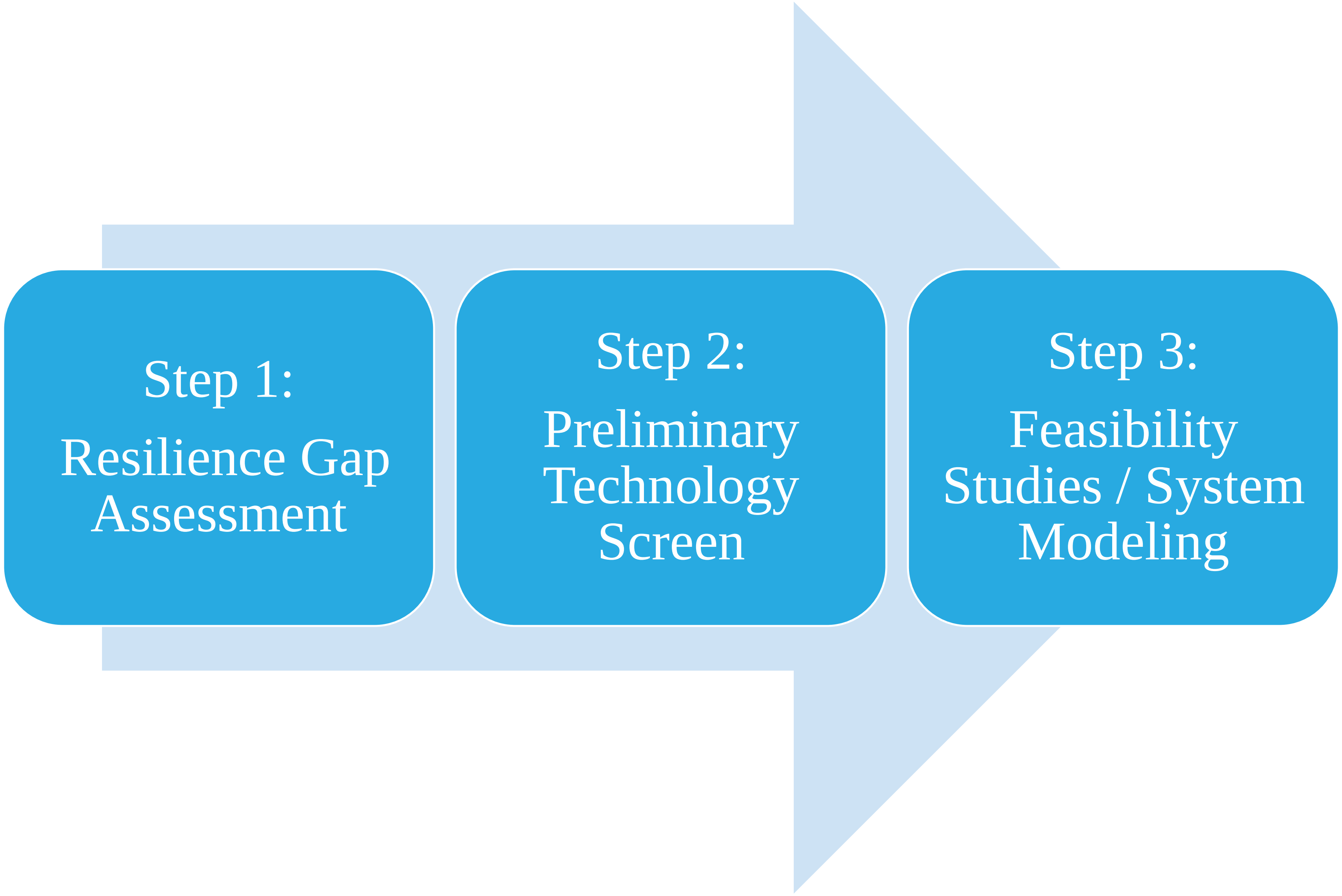
Enhanced resilience:

- Increases public and patient safety
- Avoids evacuations
- Protects vulnerable populations
- Reduces burden on emergency management personnel
- Reduces costs associated with crisis management



Study overview

3 Step Process



Step 1
Energy resilience gap assessment

Site investigation

Guided interview and site walk

- Are any sites particularly vulnerable to projected climate change impacts?
- Are any sites more susceptible to outages or operational failures?
- Are certain facility operations more vulnerable to outages than others?
- Are any of those operations critical?
- What types of resilience is needed for each site?
- How much would adding clean energy resiliency cost?

Shocks and stressors

- Flooding & Sea Level Rise
- Precipitation
- Temperature
  (Extreme heat and extreme cold)
- Wildfire
- Manmade Hazards
- Wind
- Earthquakes
- Winter Storms

Site score card

Score System

0	1	2	3
worst			best

Sufficient for current needs with significant redundancy

Sufficient for current needs with some redundancy

Sufficient for current needs, but lacks redundancy

Insufficient for current needs

Assessment Categories			
Systems Resilience			
Electrical			
Normal Power	Utility Service	2	1.5
	System Resilience	1	
	System Capacity	2	
	Equipment Age/ Condition	1	
Backup Power	System Resilience	1	1.5
	On-site Generation Capacity	2	
	On-site Fuel Storage Capacity	2	
	Equipment Age/ Condition	1	
HVAC			
Heating	System Resilience	2	2
	System Capacity	2	
	On-site Fuel Storage Capacity	2	
	System Backup Power/ Supply	2	
	Equipment Age/ Condition	2	
Cooling	System Resilience	2	0
	System Capacity	2	
	System Backup Power/ Supply	0	
	Equipment Age/ Condition	3	
Miscellaneous Systems			
	Medical Records	2	2.0
	Security/ Access Control System	2	
	Elevators/ Patient Transport	3	
	Domestic Water	2	
	Sanitary/ Wastewater	1	
	Telecom	2	
	Systems Resilience Average		1.4
Operational Resilience			
	Emergency Mgmt. Plan		0
	Staff Accessibility		2
	Staff Accommodations		1
	Operational Redundancy/ Access to Nearby Facilities		2
	Foodservice		0
	Pharmacy/ Drug Storage		2
	Flooding Risk		2
	Sensitivity to Extreme Heat or Cold		1
	Sensitivity to Extreme Wind		2
	Seismic Risk		2
	Operational Resilience Average		1.4

Energy resilience

Electrical

- Normal and emergency power system

HVAC

- Heating and cooling systems

Miscellaneous Systems

- Medical records
- Security/Access control
- Elevators/Patient Transport
- Domestic Water
- Sanitary/Wastewater
- Telecom/IT

Assessment Categories			
Systems Resilience			
Electrical			
Normal Power	Utility Service	2	1.5
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HVAC			
Heating	System Resilience	2	2
	System Capacity	2	
	On-site Fuel Storage Capacity	2	
	System Backup Power/ Supply	2	
	Equipment Age/ Condition	2	
Cooling	System Resilience	2	0
	System Capacity	2	
	System Backup Power/ Supply	0	
	Equipment Age/ Condition	3	
Miscellaneous Systems			
Medical Records		2	2.0
Security/ Access Control System		2	
Elevators/ Patient Transport		3	
Domestic Water		2	
Sanitary/ Wastewater		1	
Telecom		2	
		Systems Resilience Average	1.4

Operational resilience

Operational Resilience	
Emergency Mgmt. Plan	0
Staff Accessibility	2
Staff Accommodations	1
Operational Redundancy/ Access to Nearby Facilities	2
Foodservice	0
Pharmacy/ Drug Storage	2
Flooding Risk	2
Sensitivity to Extreme Heat or Cold	1
Sensitivity to Extreme Wind	2
Seismic Risk	2
Operational Resilience Average	1.4

Emergency Mgmt. Plan

Staff Accessibility

Staff Accommodations

Operational Redundancy/ Access to Nearby Facilities

Foodservice

Pharmacy/ Drug Storage

Flooding Risk

Sensitivity to Extreme Heat or Cold

Sensitivity to Extreme Wind

Seismic Risk

Portfolio score card

Systems Resilience Average
1.4
1.3
0.7
1.4
1.4
1.6
2.0
2.2
2.2
2.0
1.8
1.8
1.6

Systems Resilience Summary				
Electrical		HVAC		Misc. Systems
Normal Power	Backup Power	Heating	Cooling	
1.5	1.3	2.2	0	2.0
1.8	1	2	0	1.8
1.8	0	0	0	1.5
2	1.5	2	0	2.0
1.5	1.5	2.2	0	2.0
2	1.8	2	0	2.2
2	1.8	2.2	1.8	2.0
1.5	2.8	2.4	2.3	2.2
1.8	2.5	2.4	2	2.3
1.5	2.3	2	1.8	2.2
1.5	2	1.6	2	1.8
2.3	2.3	2.2	0	2.0
1.7	1.7	1.9	0.8	2.0

Score System

0	1	2	3
worst			best

Operational Resilience Average
1.8
2.1
1.7
1.4
1.8
1.6
1.7
2.1
2.1
1.8
2.1
1.8
1.8

Operational Resilience									
Emergency Mgmt. Plan	Staff Accessibility	Staff Accommodations	Operational Redundancy/ Access to Nearby Facilities	Foodservice	Pharmacy/ Drug Storage	Flooding Risk	Sensitivity to Extreme Heat or Cold	Sensitivity to Extreme Wind	Seismic Risk
2	2	1	2	3	2	2	1	2	1
3	1	2	3	3	2	2	1	2	2
2	2	3	2	0	2	2	1	1	2
0	2	1	2	0	2	2	1	2	2
2	2	1	2	2	2	2	1	2	2
2	2	1	2	2	2	2	1	1	1
2	2	1	2	1	2	2	1	2	2
2	3	2	3	3	2	2	2	1	1
2	3	2	2	3	3	2	2	1	1
2	2	1	2	2	2	2	1	2	2
2	3	2	2	3	2	2	2	1	2
2	2	1	2	2	2	2	1	2	2
1.9	2.2	1.5	2.2	2.0	2.1	2.0	1.3	1.6	1.7

Key portfolio Resilience Gaps

No backup power for cooling	Generator failure during power outage	No backup power for food service	Insufficient emergency preparedness planning
7 sites	4 sites	2 sites	1 Site

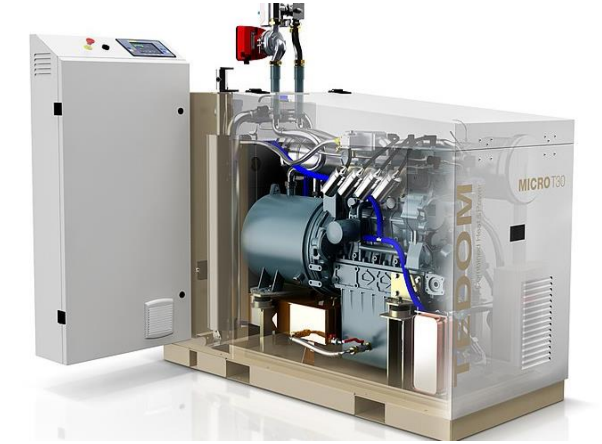
Identified several “Quick hits” which could immediately improve energy resilience

Step 2
Clean energy technology screening

Solar photovoltaics

Battery energy storage

Solar thermal

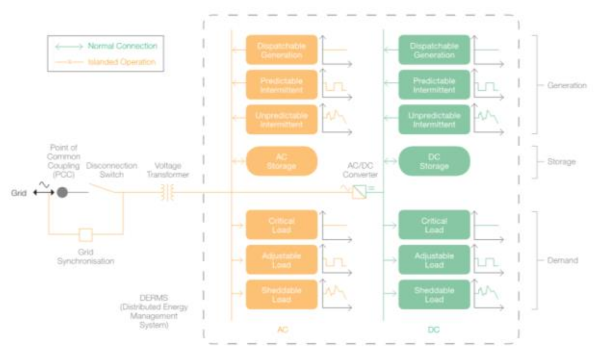


Combined heat and power

High efficiency fuel cells

Thermal energy storage

Wind power

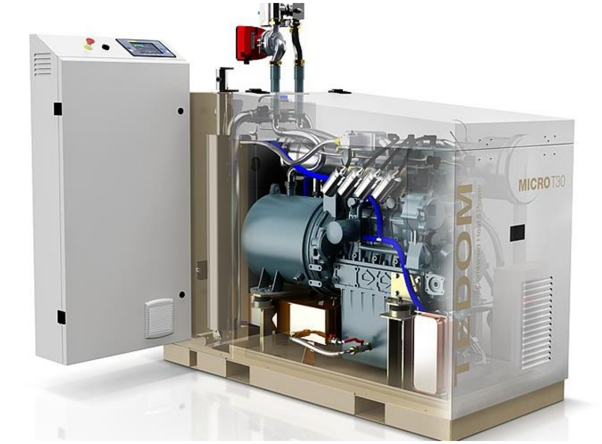


Microgrids

Solar photovoltaics

Battery energy storage

Solar thermal



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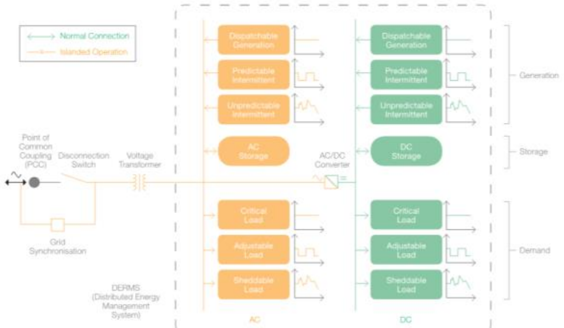
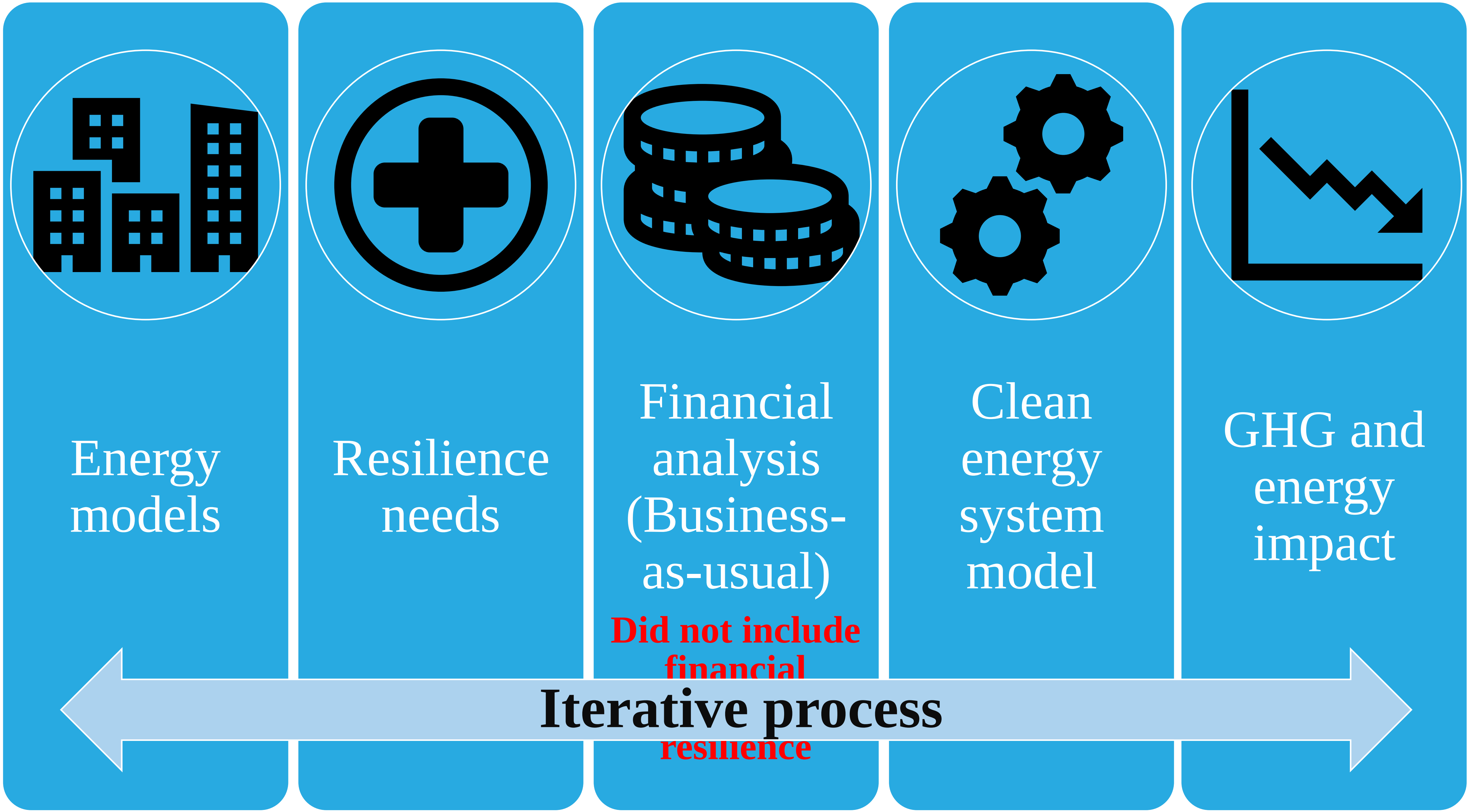


Microgrids

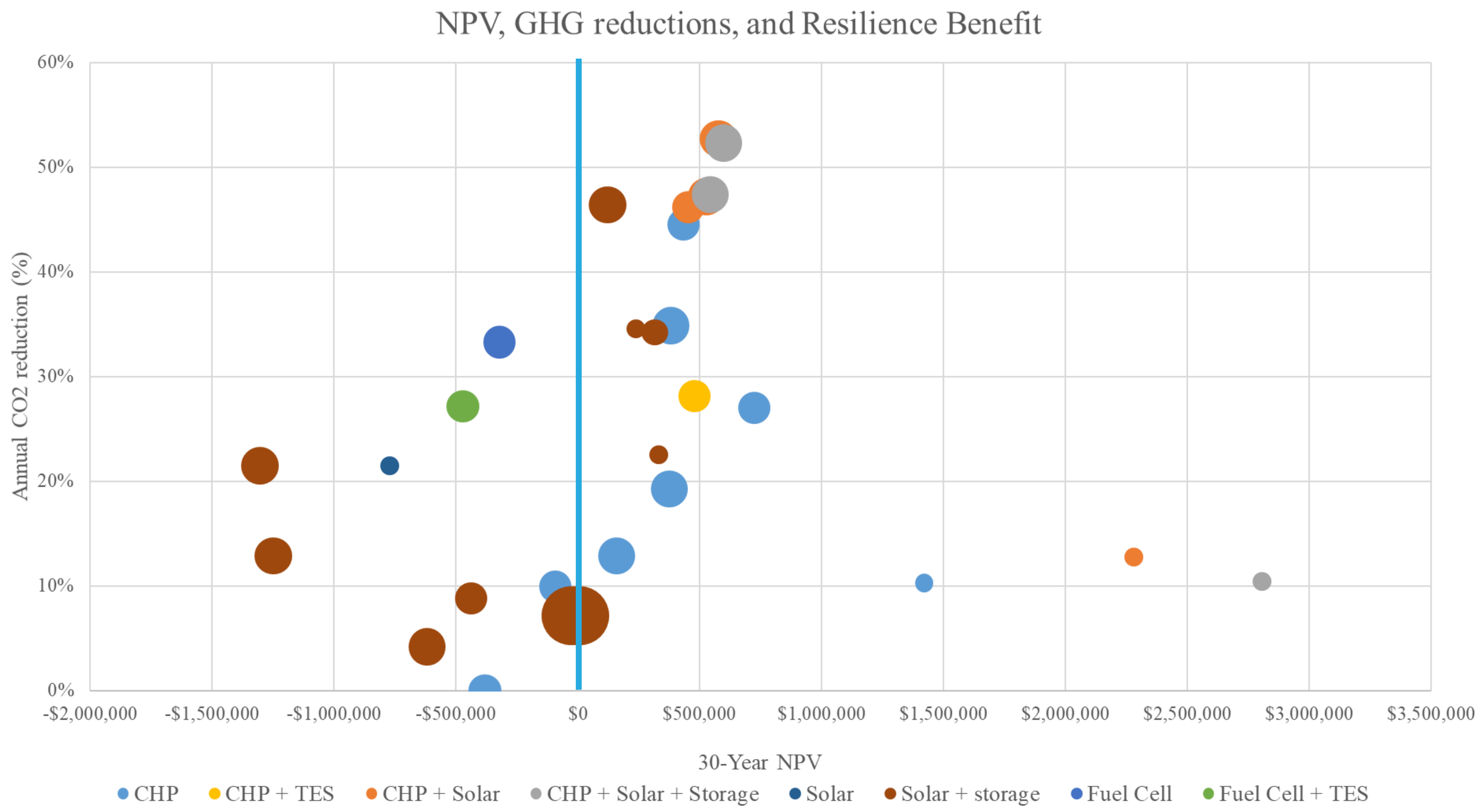
Step 3
Clean energy system modeling and feasibility study


Energy models
Resilience needs
Financial analysis (Business-as-usual)
Did not include
financial
resilience
Clean energy system model
GHG and energy impact
Iterative process

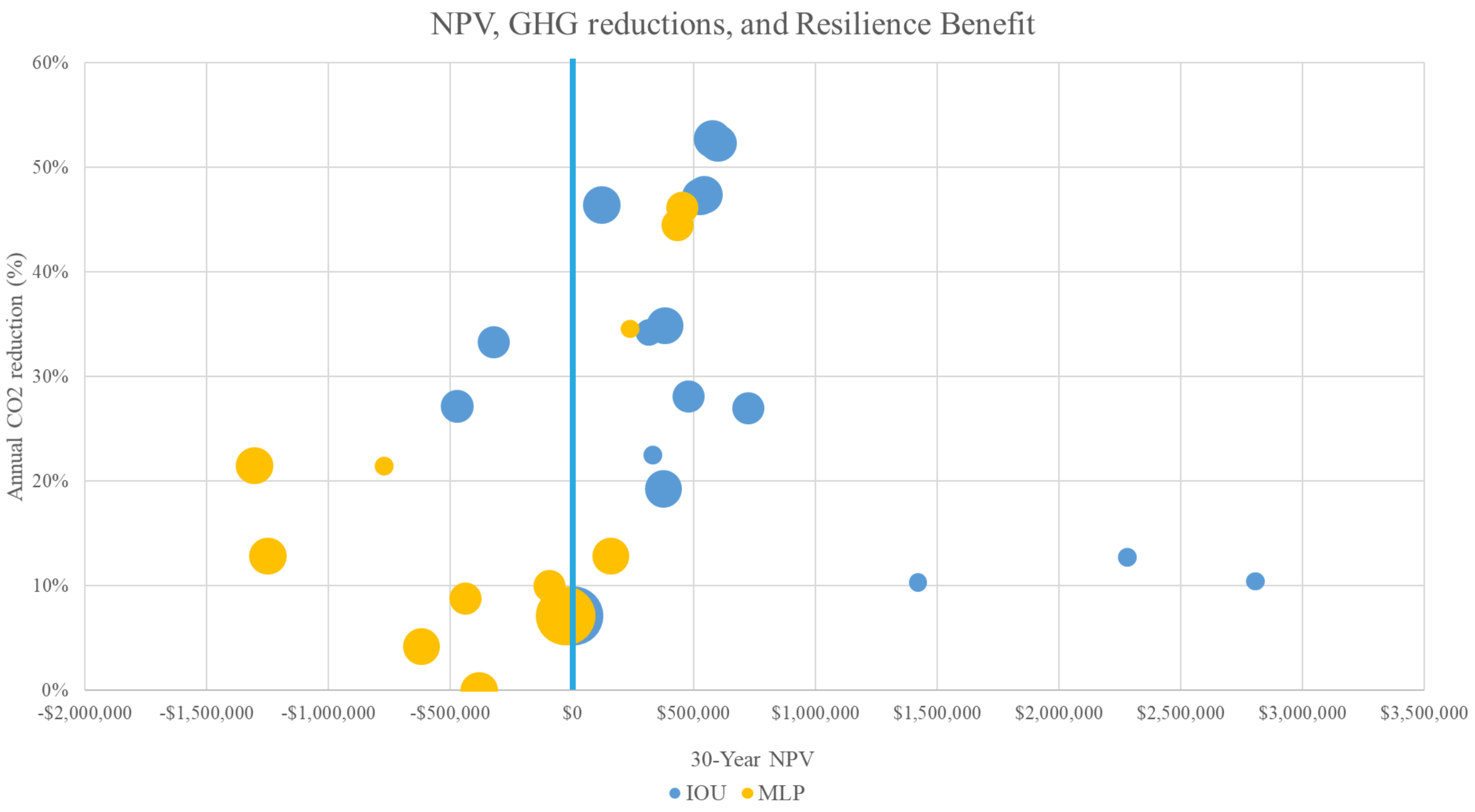
Results

	Utility	CHP	CHP + TES	CHP + PV	CHP + PV + BES	PV	PV + BESS	Fuel Cell	Fuel Cell + TES	Wind	uG
Site 1	IOU	✓	✓					✓	✓		
Site 2	MLP	✓					✓				
Site 3	IOU	✓		✓	✓		✓				
Site 4	IOU	✓		✓	✓		✓				✓
Site 5a	MLP						✓				
Site 5b	IOU						✓				
Site 6	MLP	✓					✓				
Site 7	MLP					✓	✓				
Site 8	IOU	✓		✓	✓		✓				
Site 9	MLP	✓				✓	✓			✓	
Site 10	MLP	✓		✓			✓				✓
Site 11	IOU										✓

	Utility	CHP	CHP + TES	CHP + PV	CHP + PV + BES	PV	PV + BESS	Fuel Cell	Fuel Cell + TES	Wind	uG
Site 1	IOU	✓	✓					✓	✓		
Site 2	MLP	✓					✓				
Site 3	IOU	✓		✓	✓		✓				
Site 4	IOU	✓		✓	✓		✓				✓
Site 5a	MLP						✓				
Site 5b	IOU						✓				
Site 6	MLP	✓					✓				
Site 7	MLP					✓	✓				
Site 8	IOU	✓		✓	✓		✓				
Site 9	MLP	✓				✓	✓			✓	
Site 10	MLP	✓		✓			✓				✓
Site 11	IOU										✓



NPV, GHG reductions, and Resilience Benefit
Annual CO2 reduction (%)
60%
50%
40%
30%
20%
10%
0%
-$2,000,000
-$1,500,000
-$1,000,000
-$500,000
$0
$500,000
$1,000,000
$1,500,000
$2,000,000
$2,500,000
$3,000,000
$3,500,000
30-Year NPV
CHP
CHP + TES
CHP + Solar
CHP + Solar + Storage
Solar
Solar + storage
Fuel Cell
Fuel Cell + TES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$1,000,000
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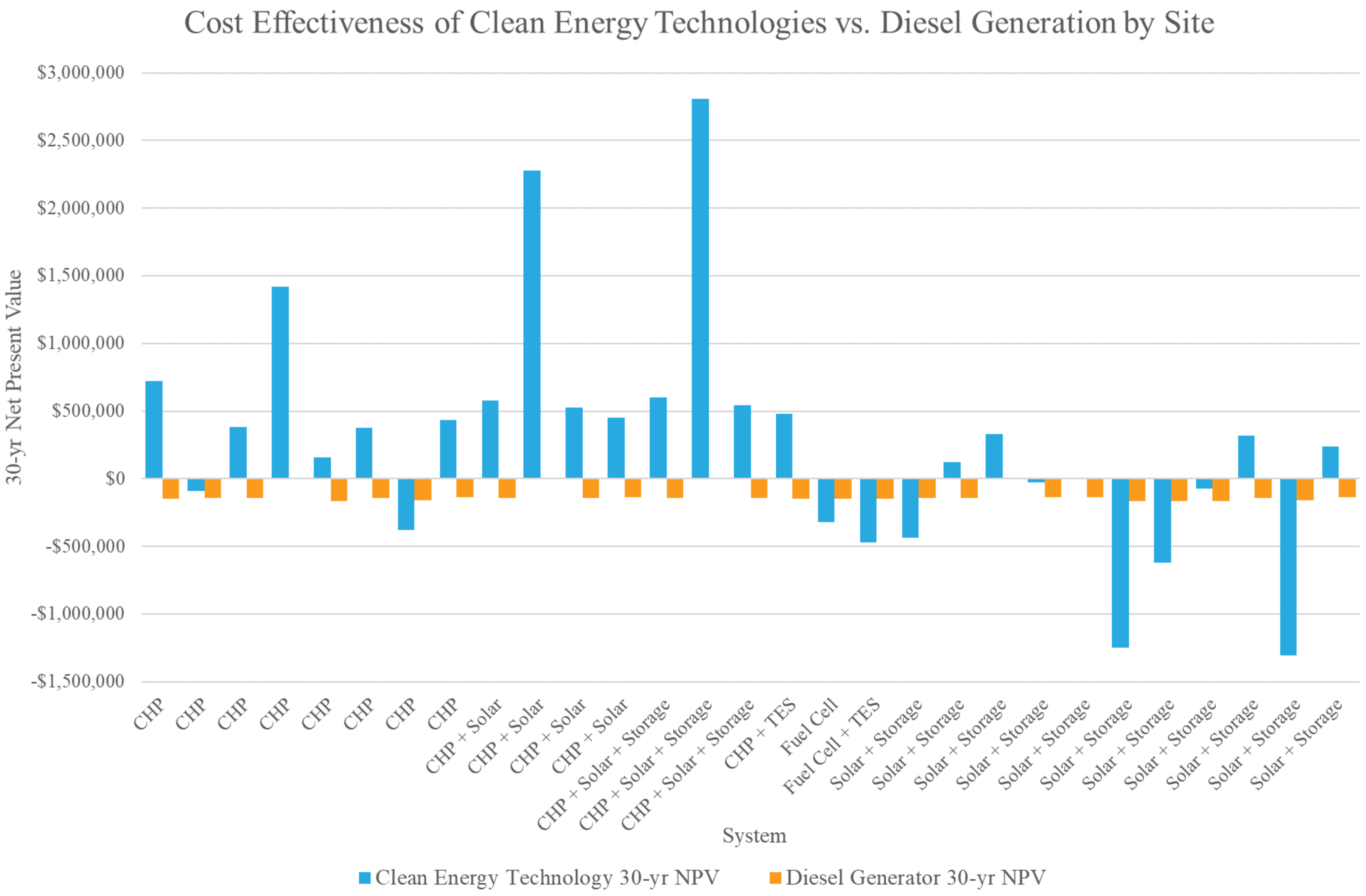
$2,000,000
$2,500,000
$3,000,000
$3,500,000
30-Year NPV
IOU
MLP


Cost Effectiveness of Clean Energy Technologies vs. Diesel Generation by Site
30-yr Net Present Value
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
-$500,000
-$1,000,000
-$1,500,000
CHP
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CHP
CHP + Solar
CHP + Solar
CHP + Solar
CHP + Solar
CHP + Solar + Storage
CHP + Solar + Storage
CHP + Solar + Storage
CHP + TES
Fuel Cell
Fuel Cell + TES
Solar + Storage
Solar + Storage
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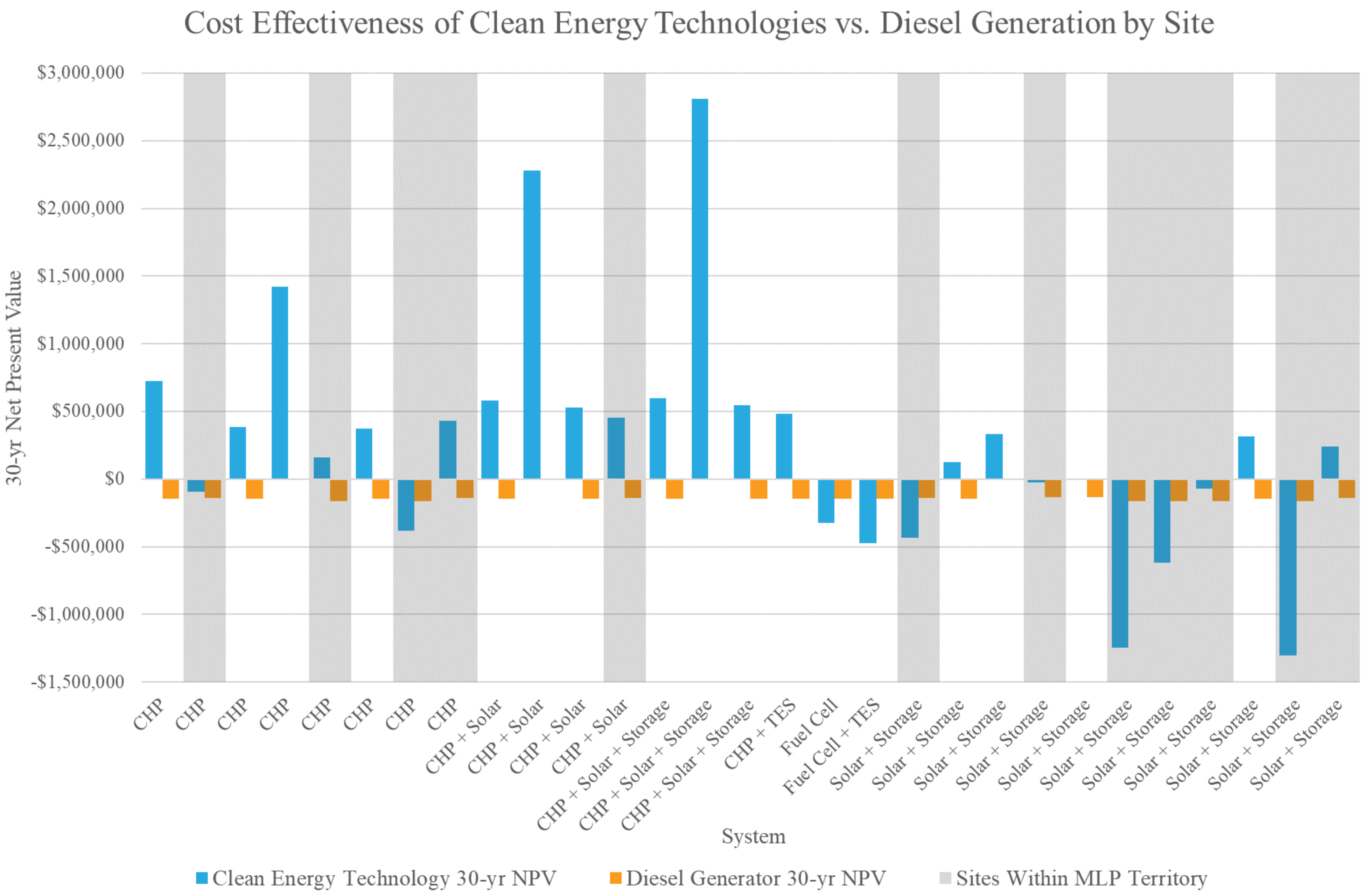
Solar + Storage
System
Clean Energy Technology 30-yr NPV
Diesel Generator 30-yr NPV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$1,000,000
$500,000
$0
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CHP + Solar
CHP + Solar
CHP + Solar
CHP + Solar
CHP + Solar + Storage
CHP + Solar + Storage
CHP + Solar + Storage
CHP + TES
Fuel Cell
Fuel Cell + TES
Solar + Storage
Solar + Storage
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Solar + Storage
Solar + Storage
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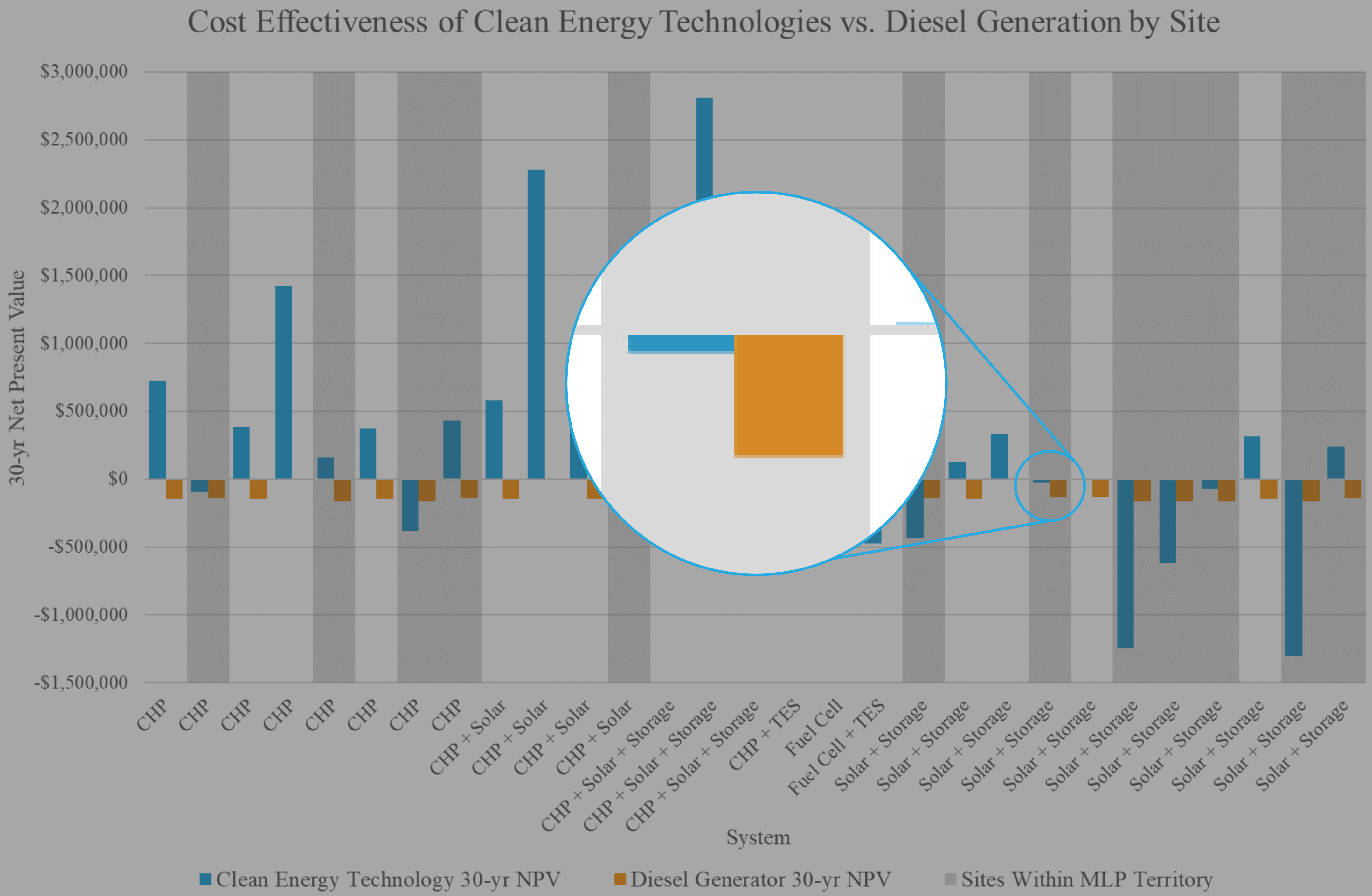
System
Clean Energy Technology 30-yr NPV
Diesel Generator 30-yr NPV
Sites Within MLP Territory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$500,000
$0
-$500,000
-$1,000,000
-$1,500,000
CHP
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CHP + Solar
CHP + Solar
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CHP + Solar
CHP + Solar + Storage
CHP + Solar + Storage
CHP + Solar + Storage
CHP + TES
Fuel Cell
Fuel Cell + TES
Solar + Storage
Solar + Storage
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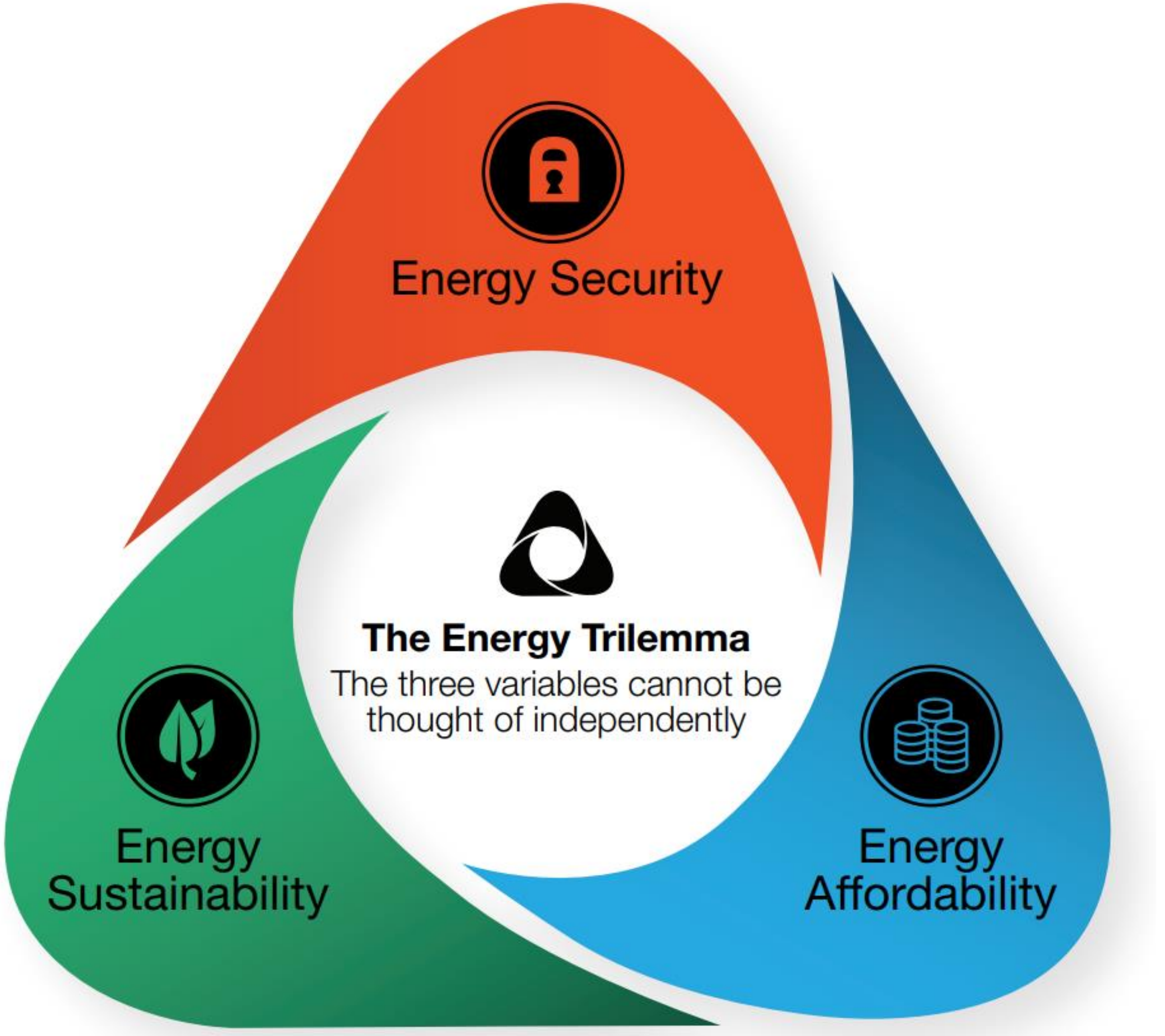
Solar + Storage
Solar + Storage
Solar + Storage
Solar + Storage
Solar + Storage
Solar + Storage
System
Clean Energy Technology 30-yr NPV
Diesel Generator 30-yr NPV
Sites Within MLP Territory

Energy Trilemma

Need to balance:

- Resilience
- Sustainability and
- Costs

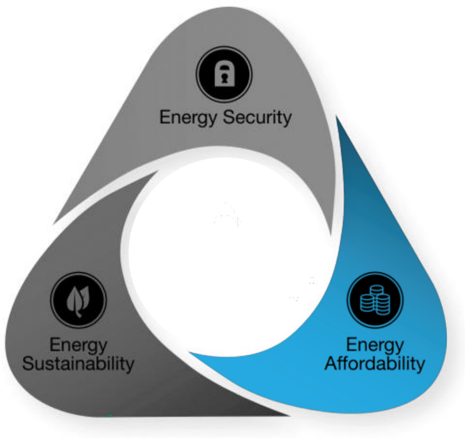
Traditional metrics to evaluate solution effectiveness are insufficient



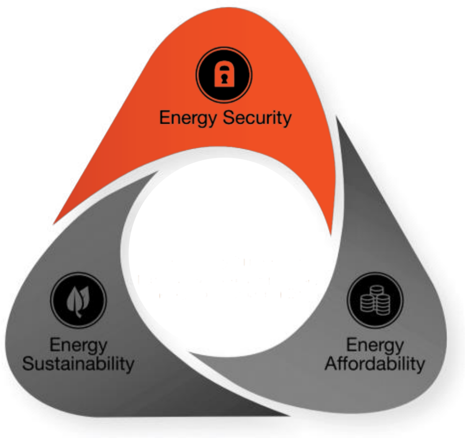
Solar + Storage example

Solar + storage basics

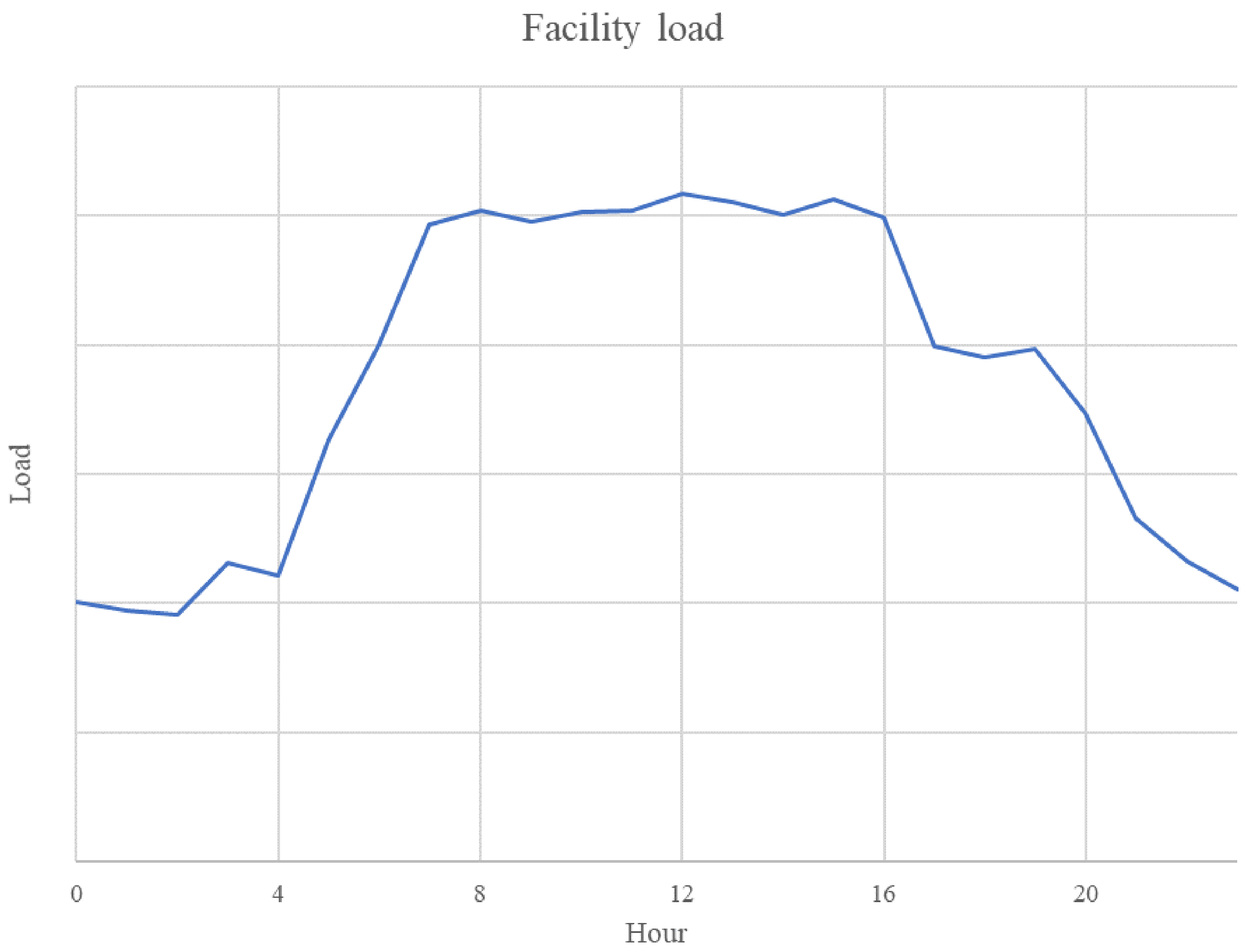
Maximize ROI (Business-as-usual):
Size solar to maximize ROI by minimizing export of PV energy
Size storage to reduce any remaining peak demand
Frequent charge/discharge cycles required to maximize revenue from energy storage



Maximize resilience:
Size solar to produce energy required for 24-hour operation of resilience loads
Size storage to power resilience loads once PV system is no longer generating energy

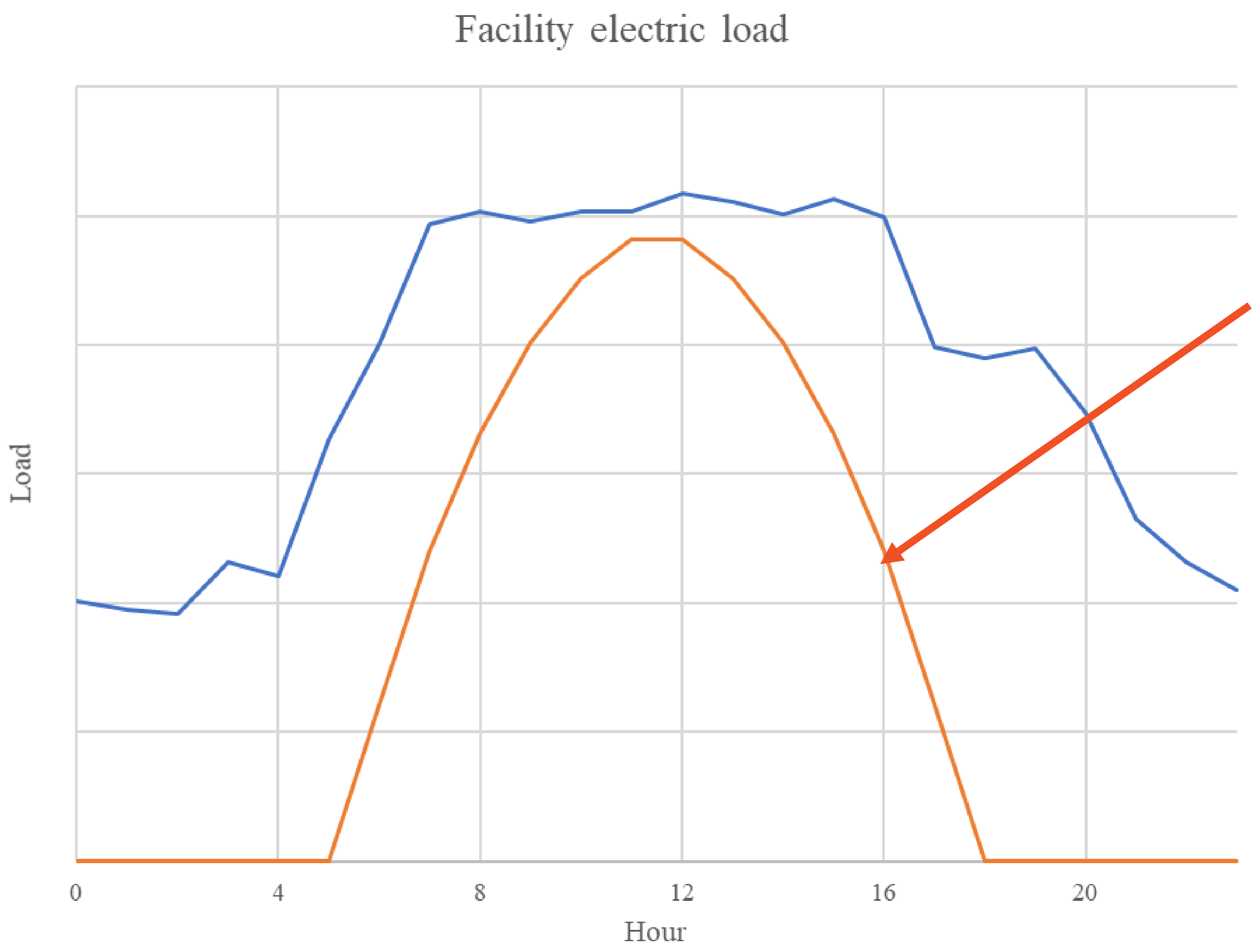


Solar + storage system sizing
Maximize ROI



Solar + storage system sizing

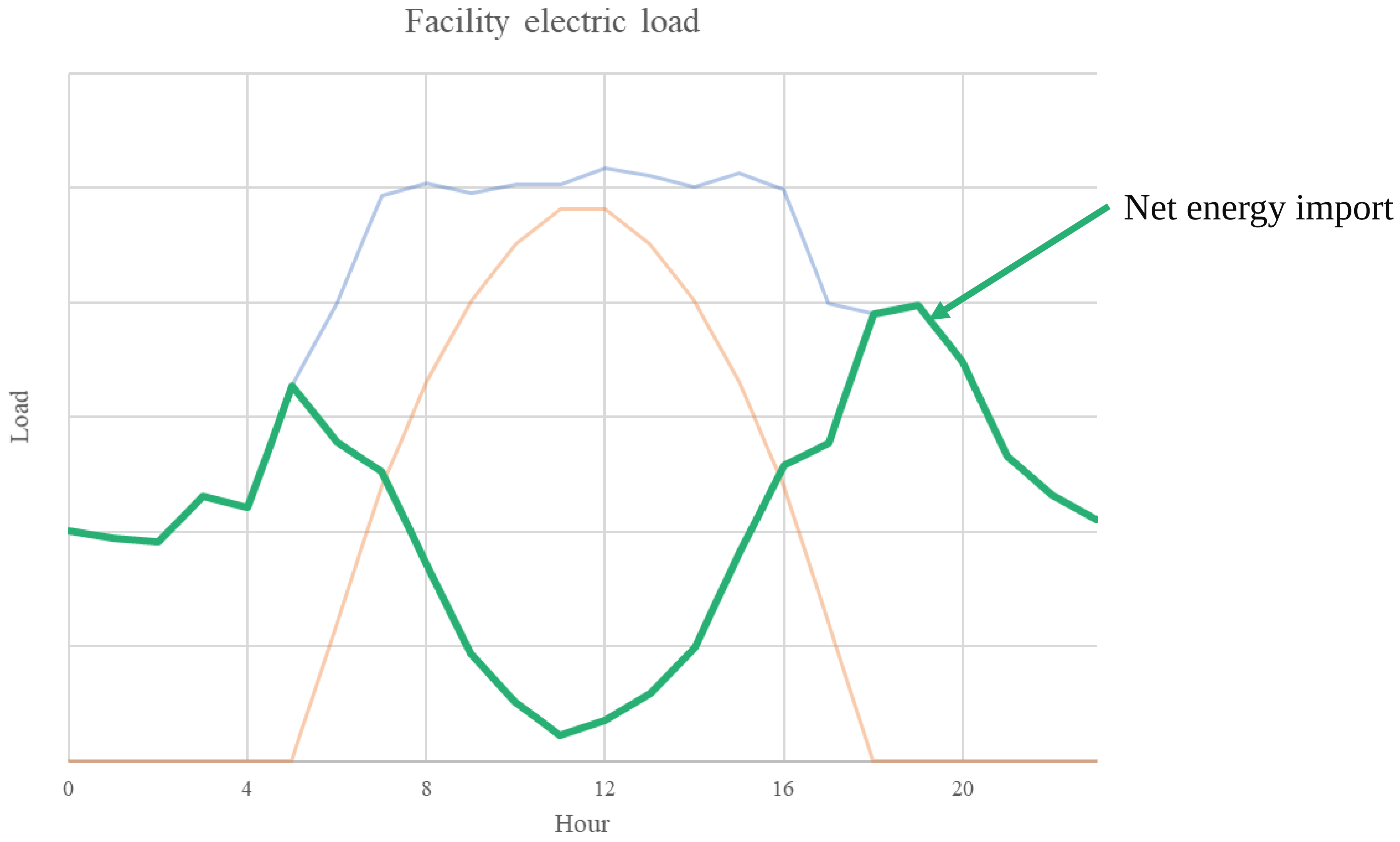
Maximize ROI



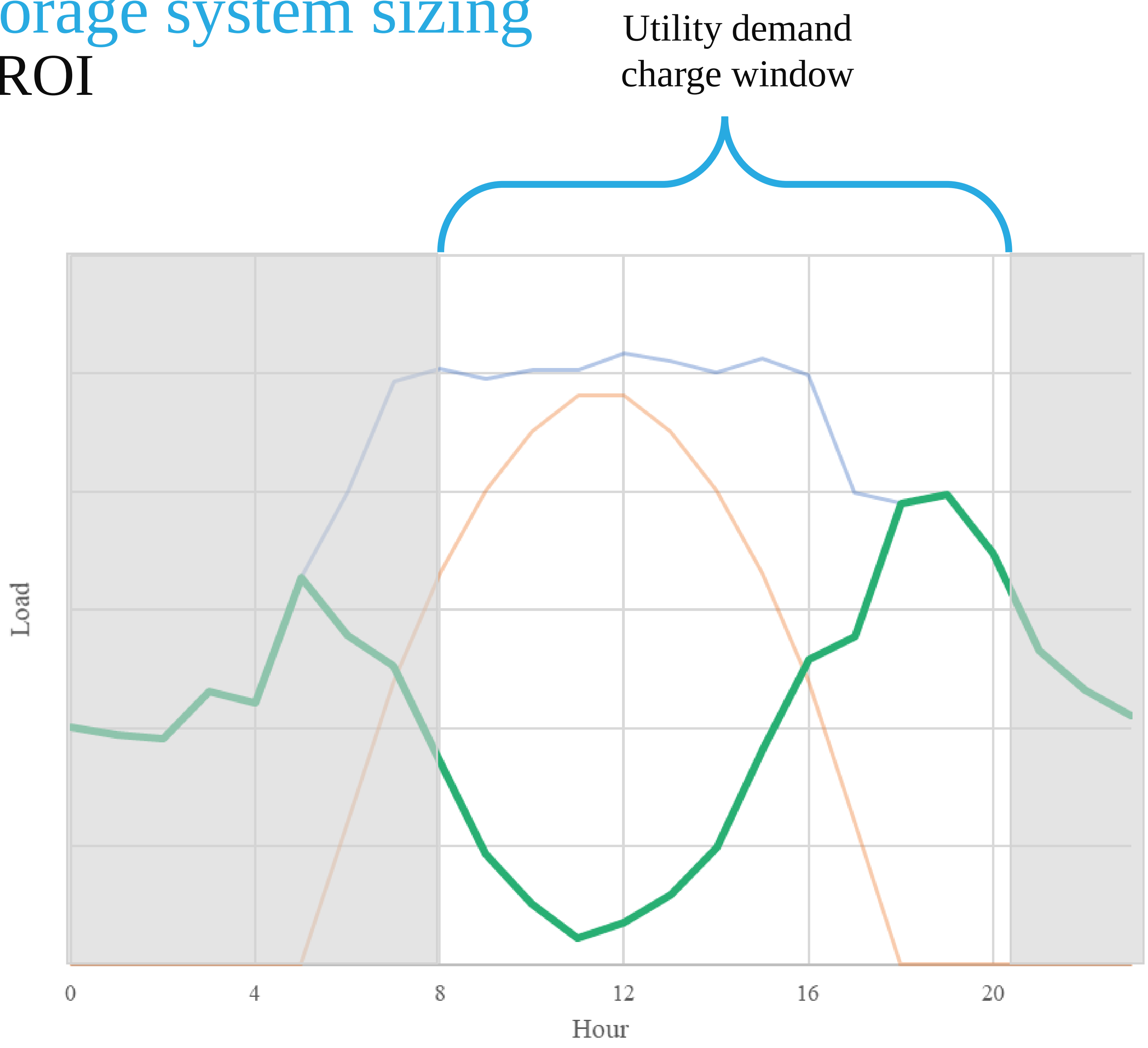
PV system sized to ensure all energy is used on-site

Solar + storage system sizing

Maximize ROI

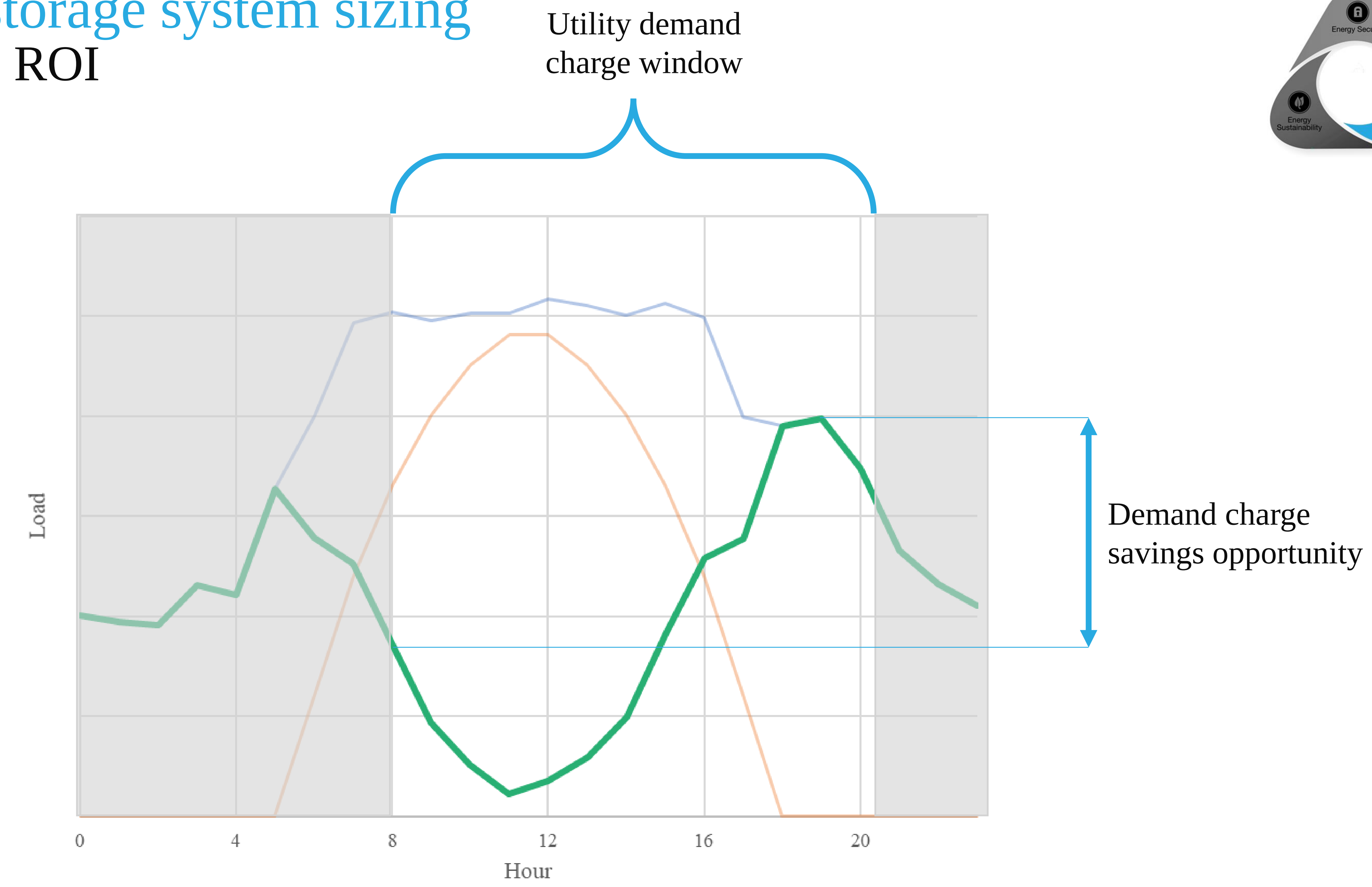


Solar + storage system sizing
Maximize ROI



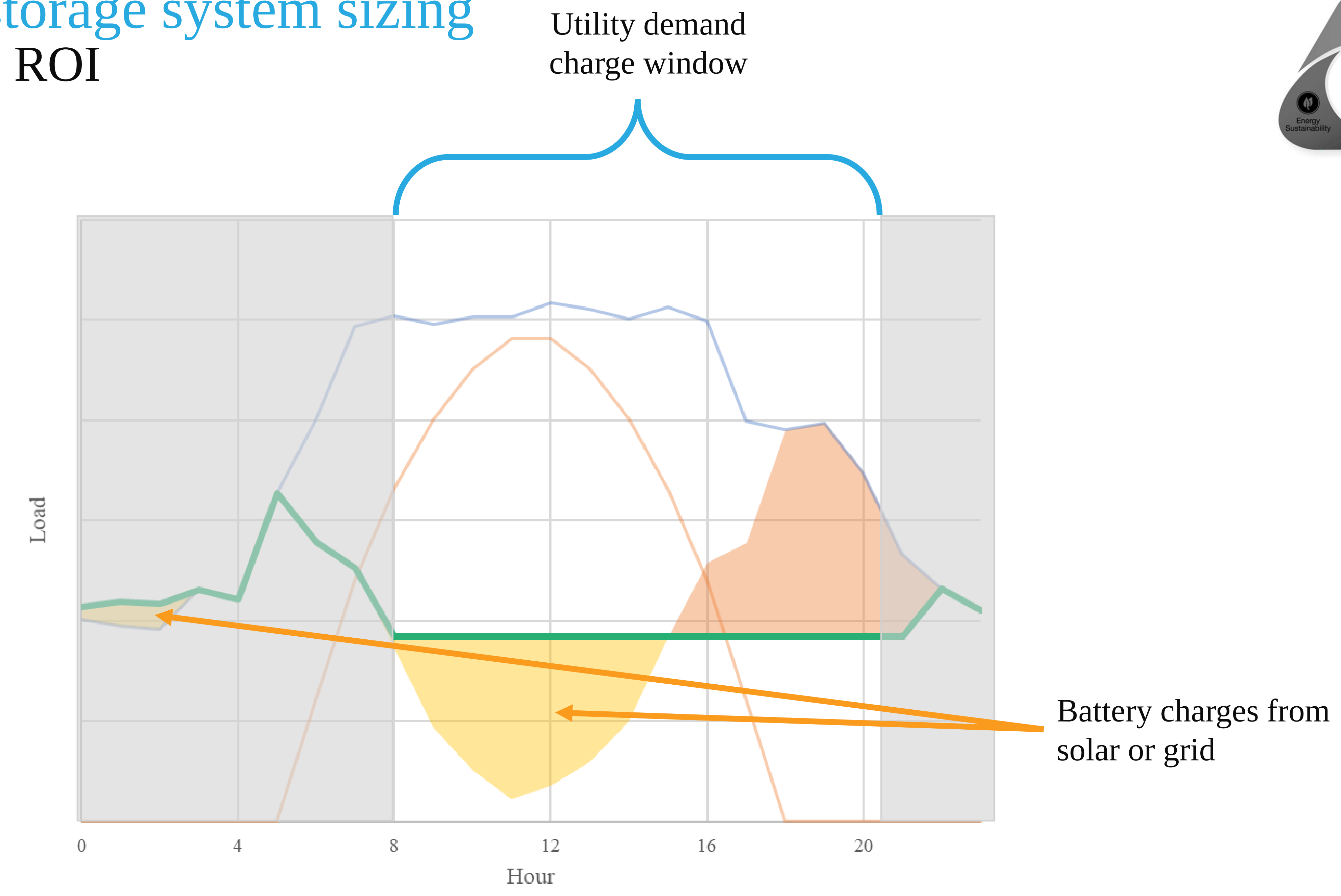
Solar + storage system sizing

Maximize ROI

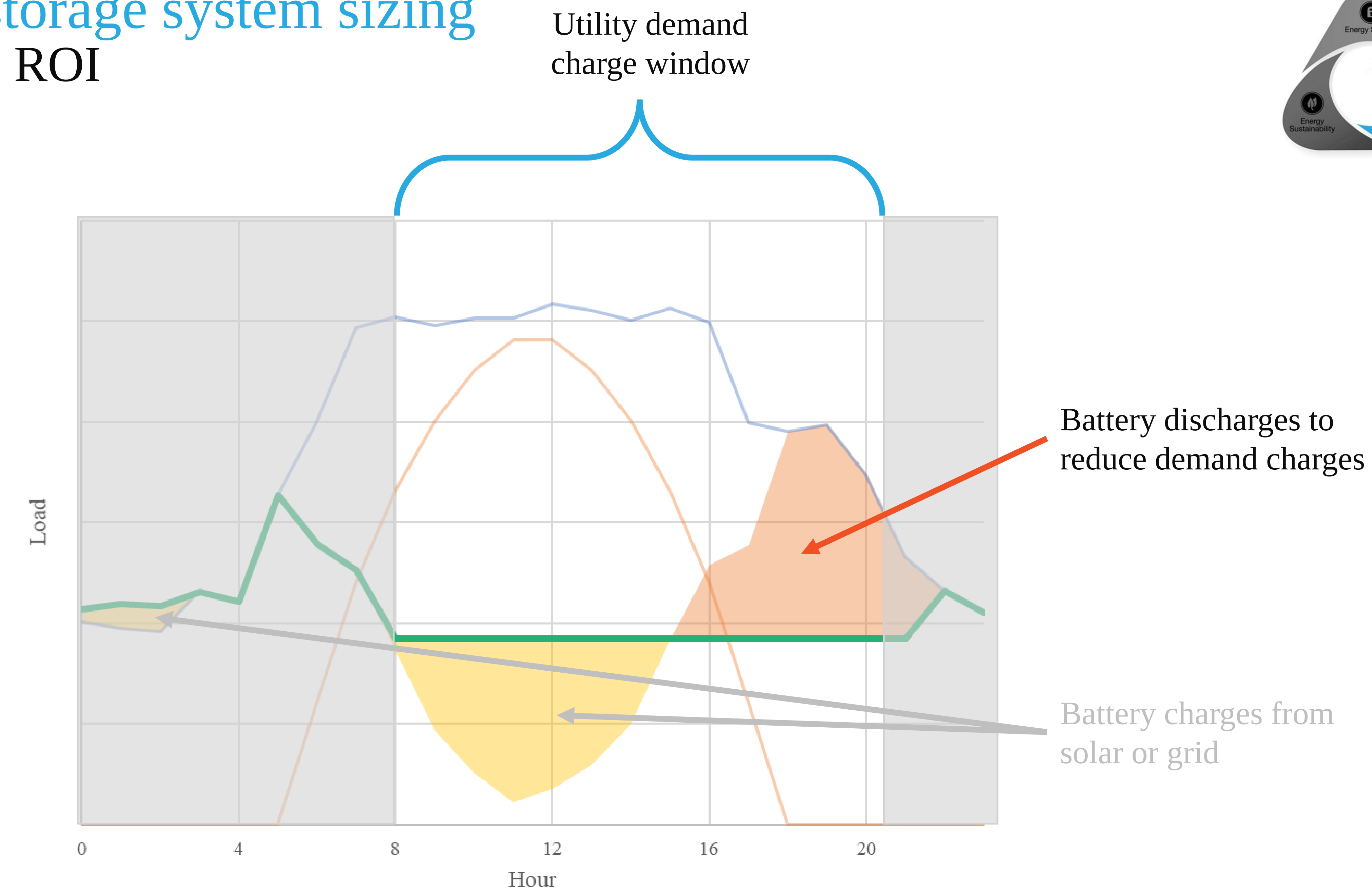


Solar + storage system sizing

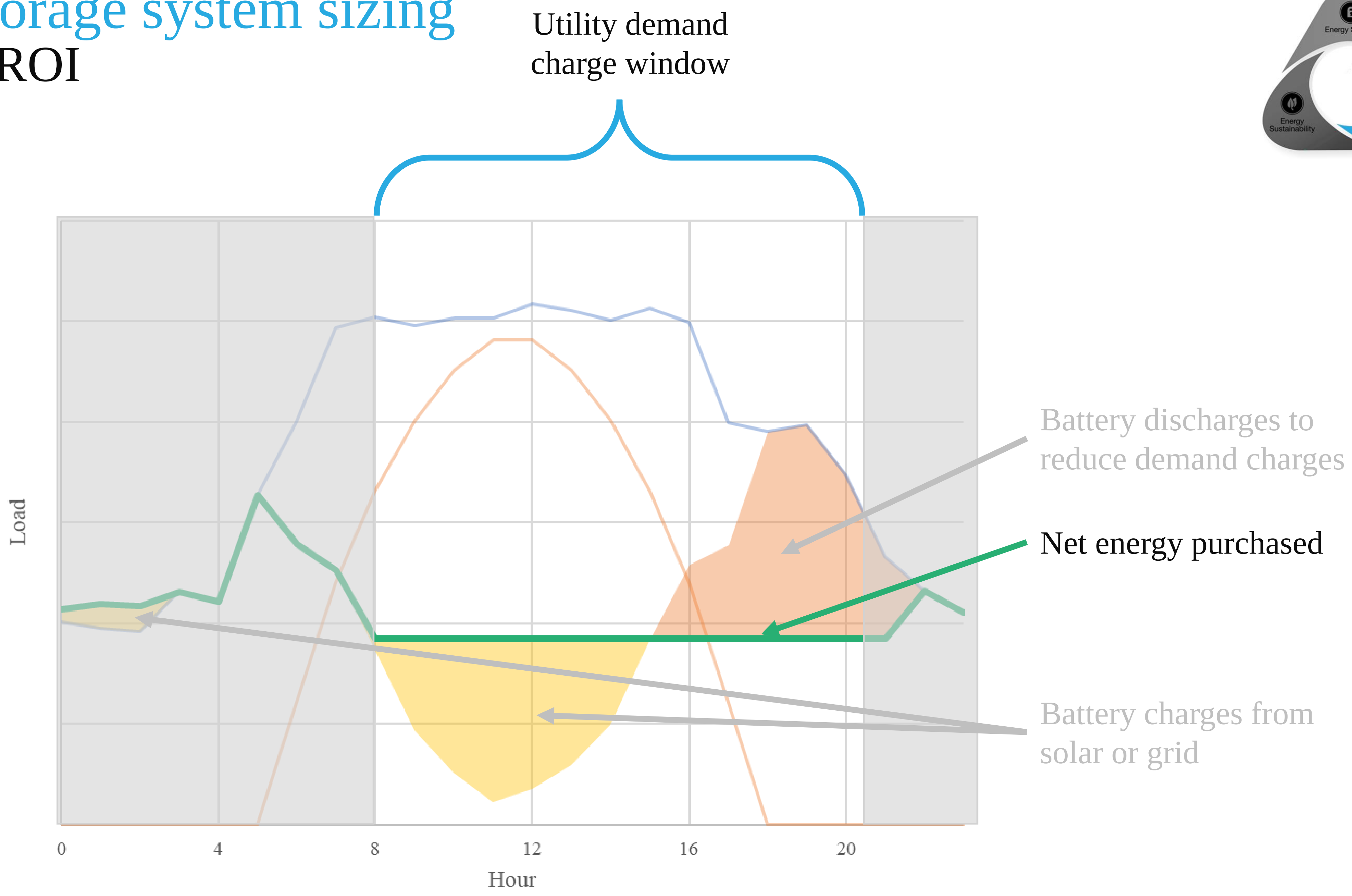
Maximize ROI



Solar + storage system sizing
Maximize ROI

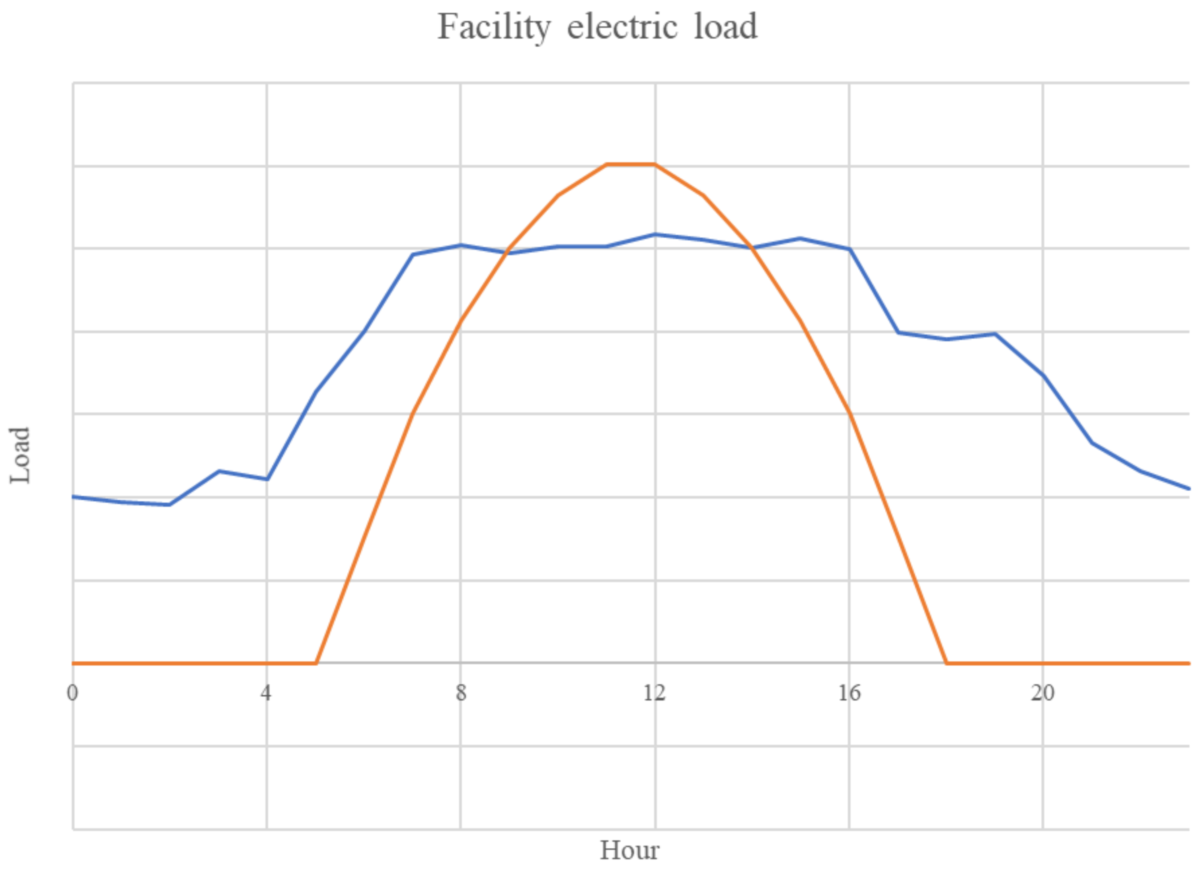


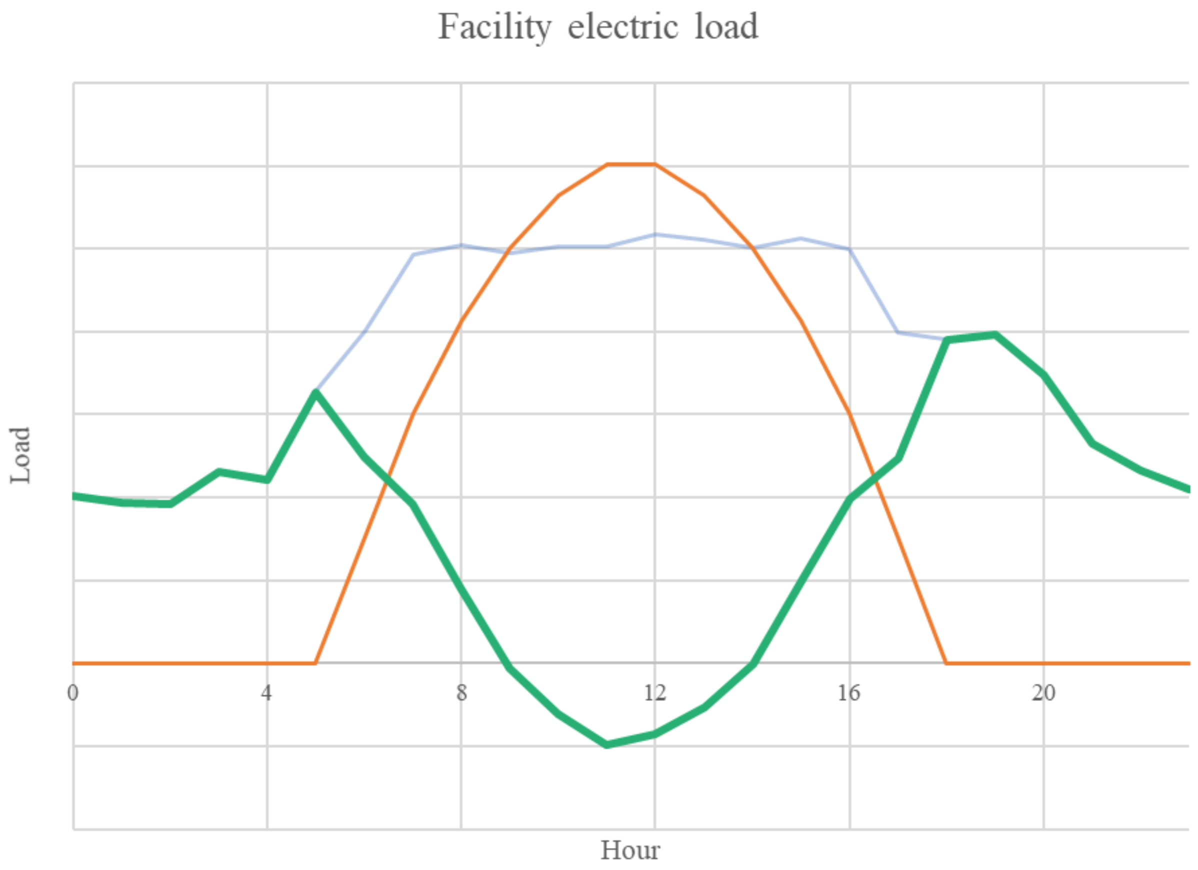
Solar + storage system sizing
Maximize ROI



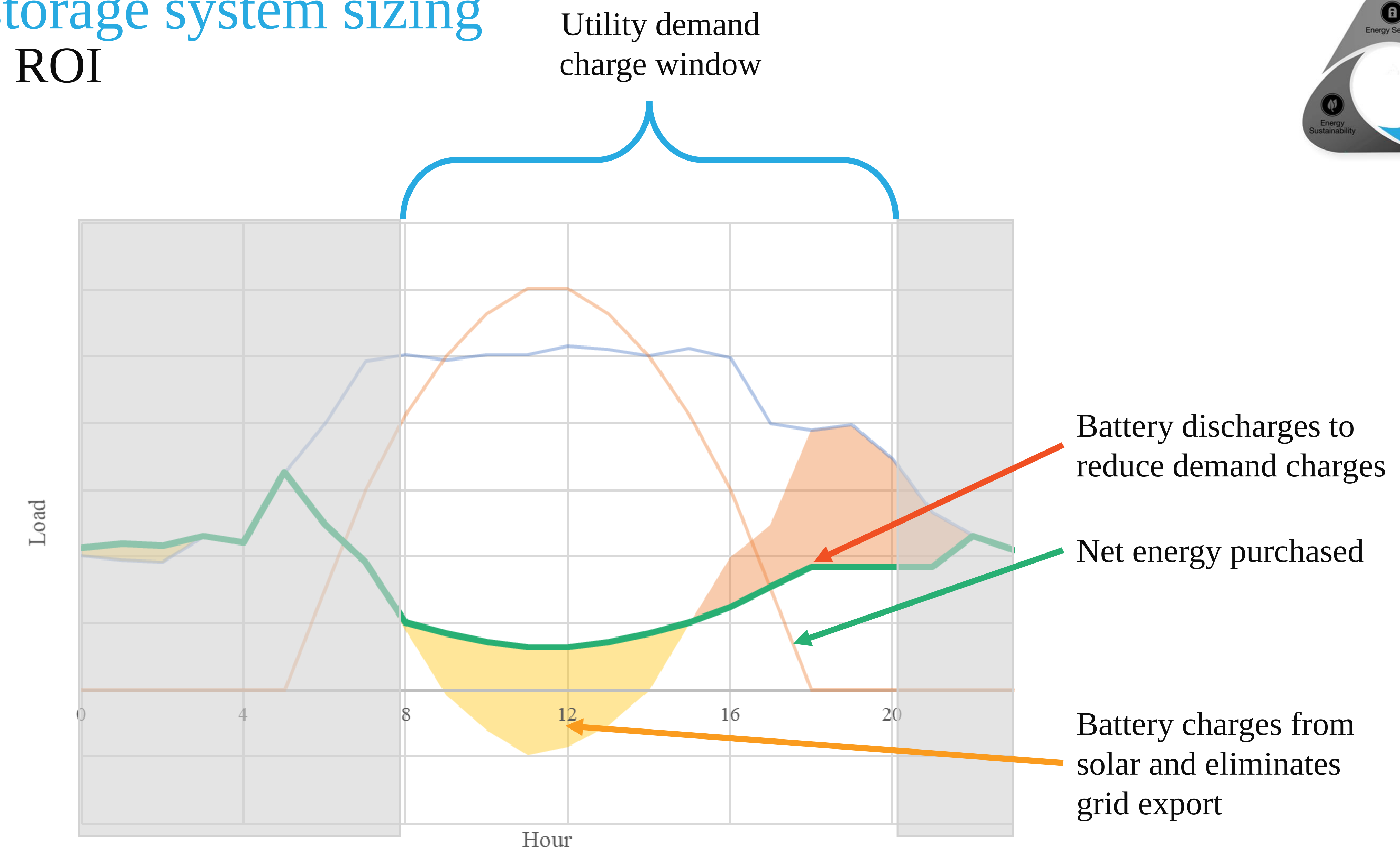
Solar + storage system sizing

Maximize ROI – Batteries allow larger PV system sizes



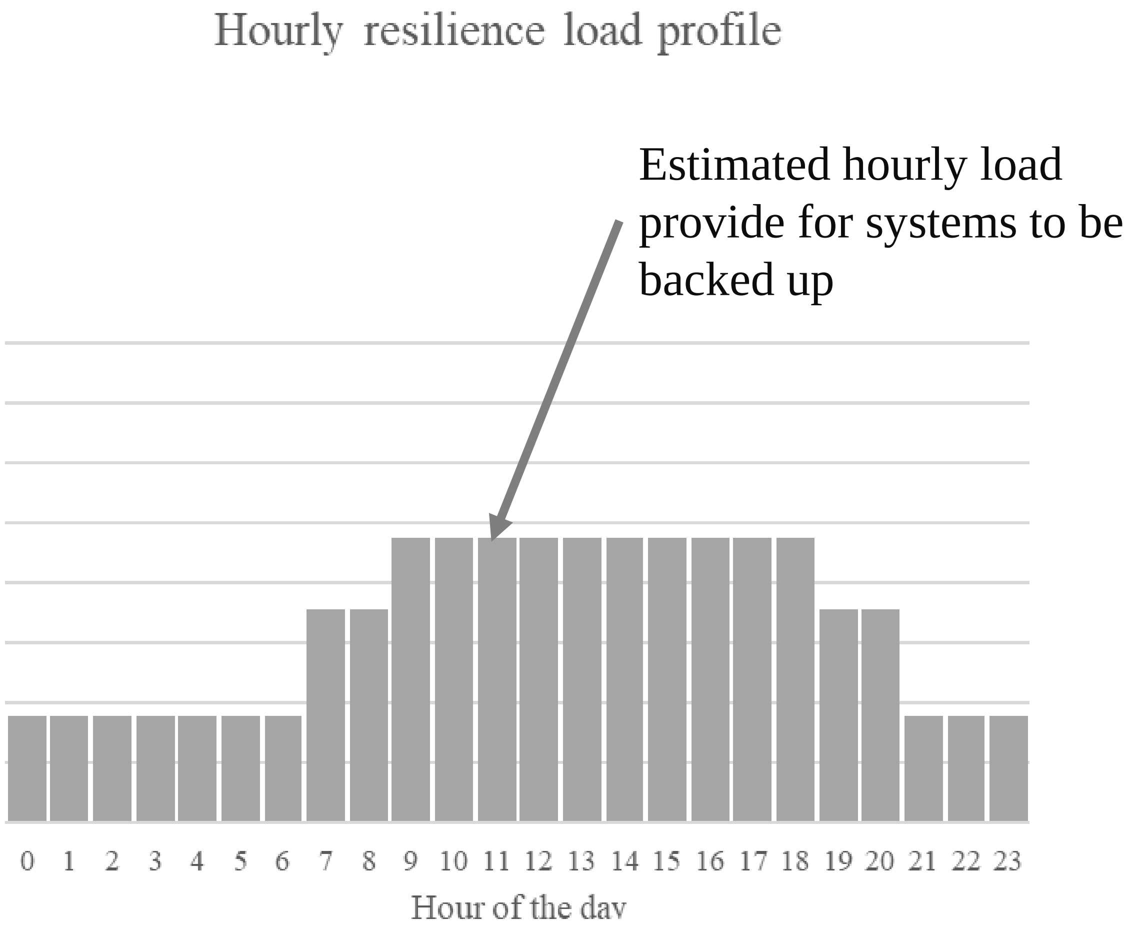


Solar + storage system sizing
Maximize ROI



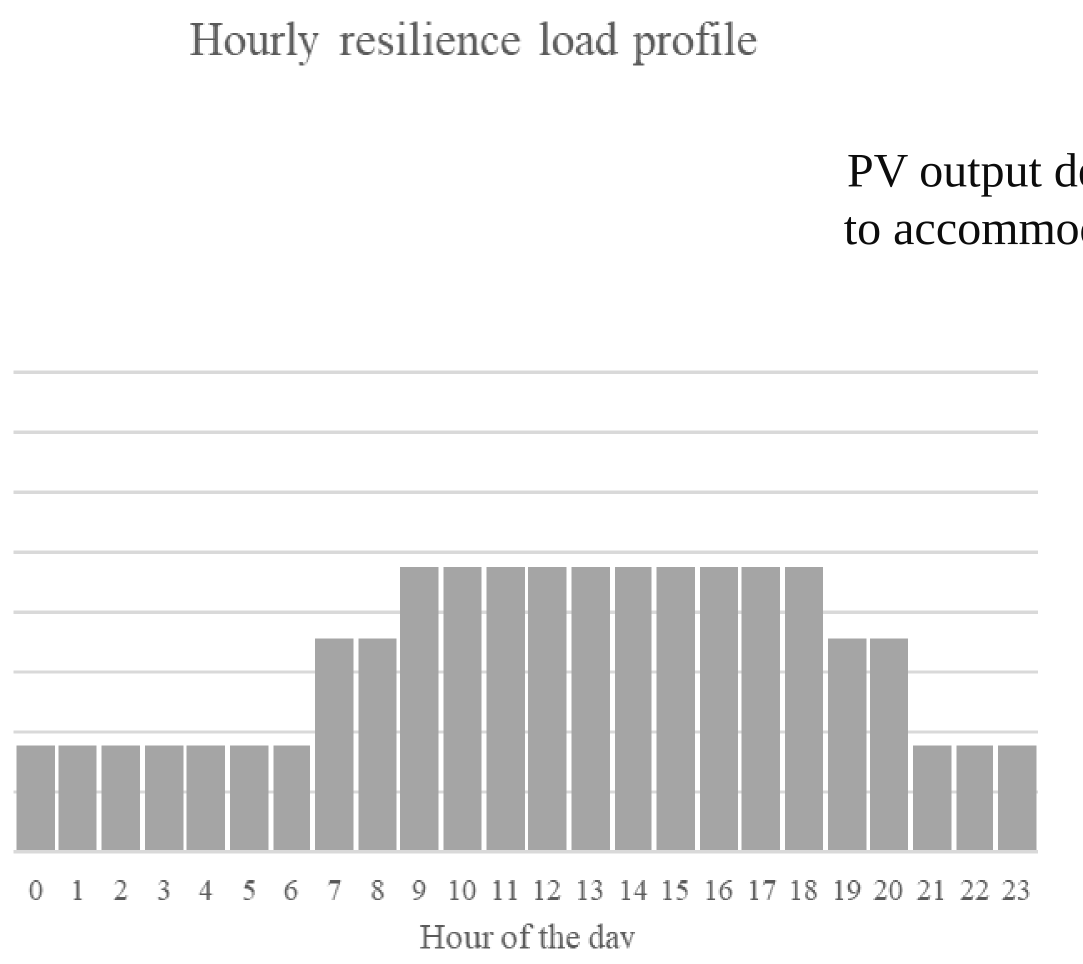
Solar + storage system sizing

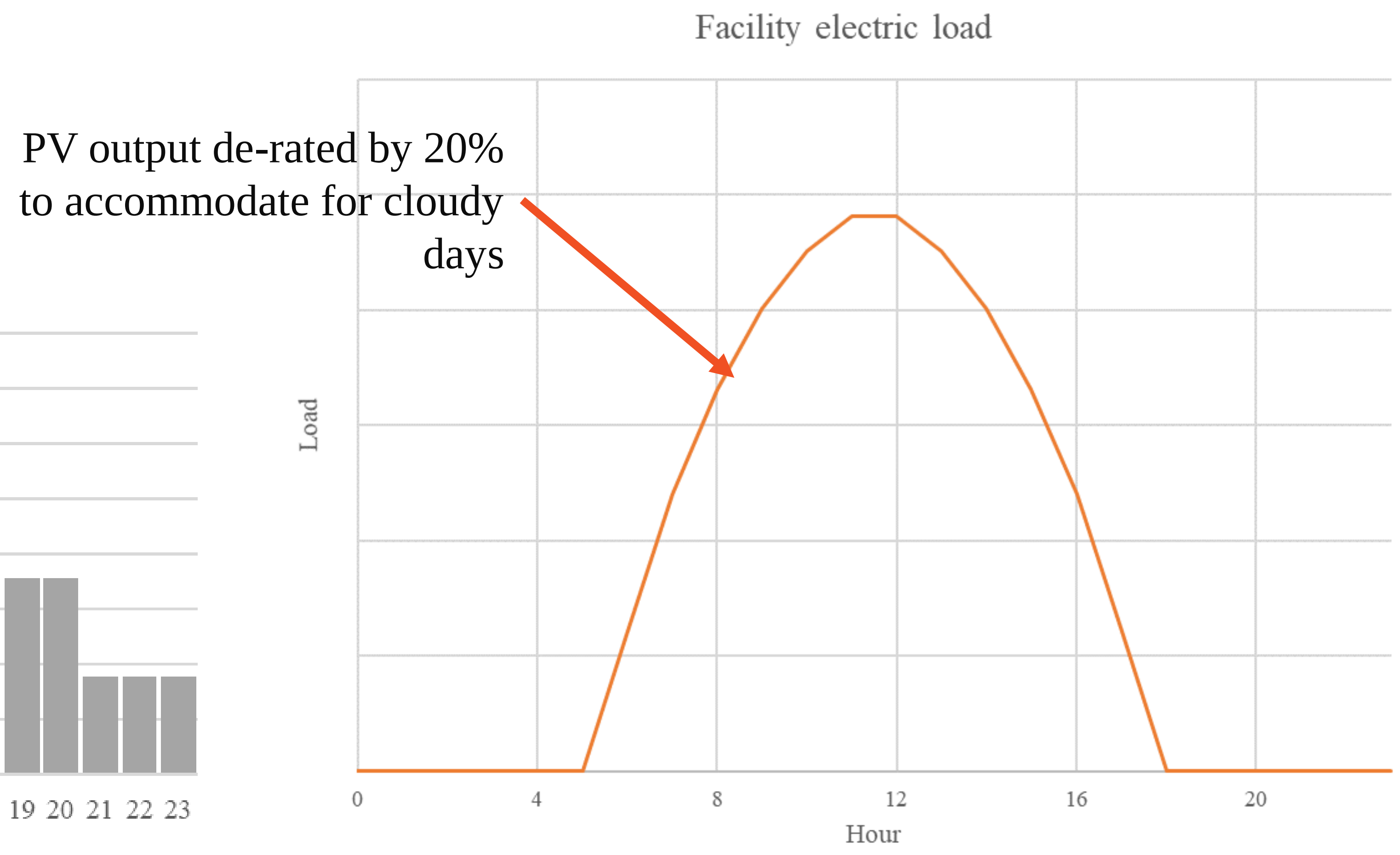
Resilience scenario - When utility power is not available



Solar + storage system sizing

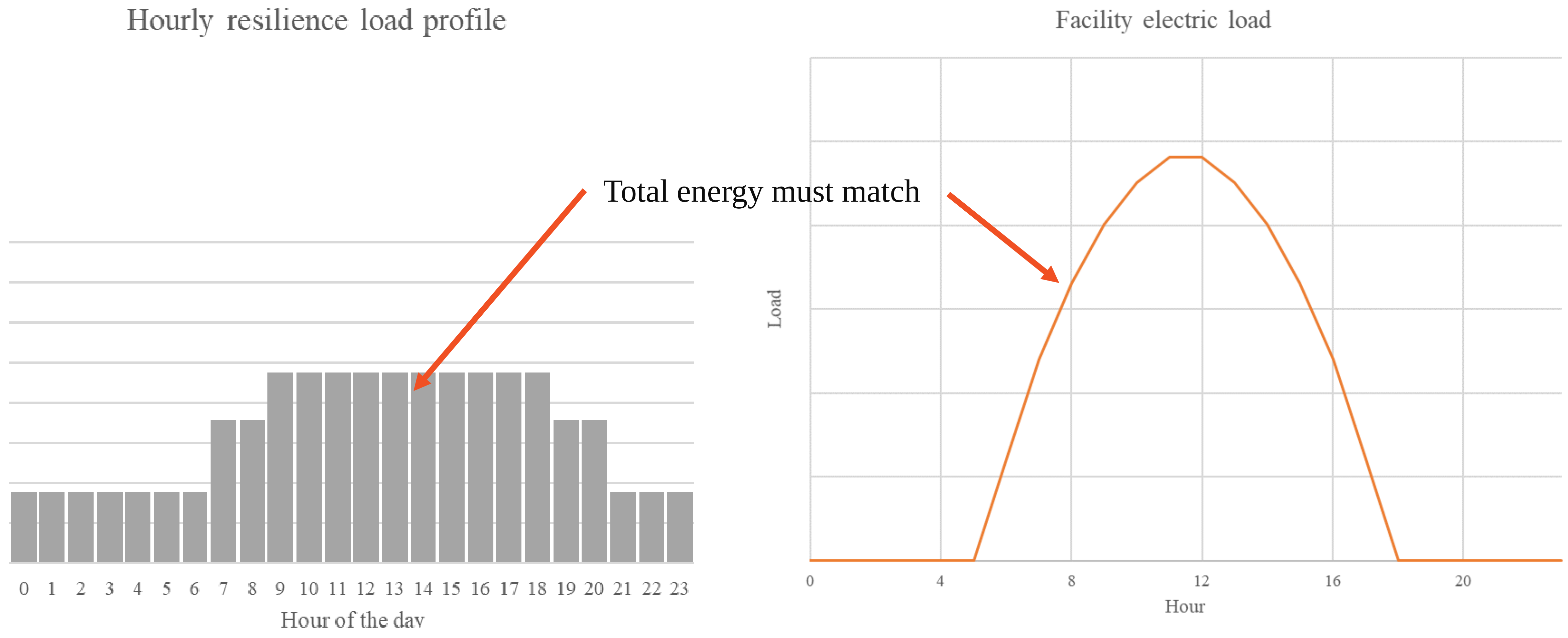
Resilience scenario - When utility power is not available





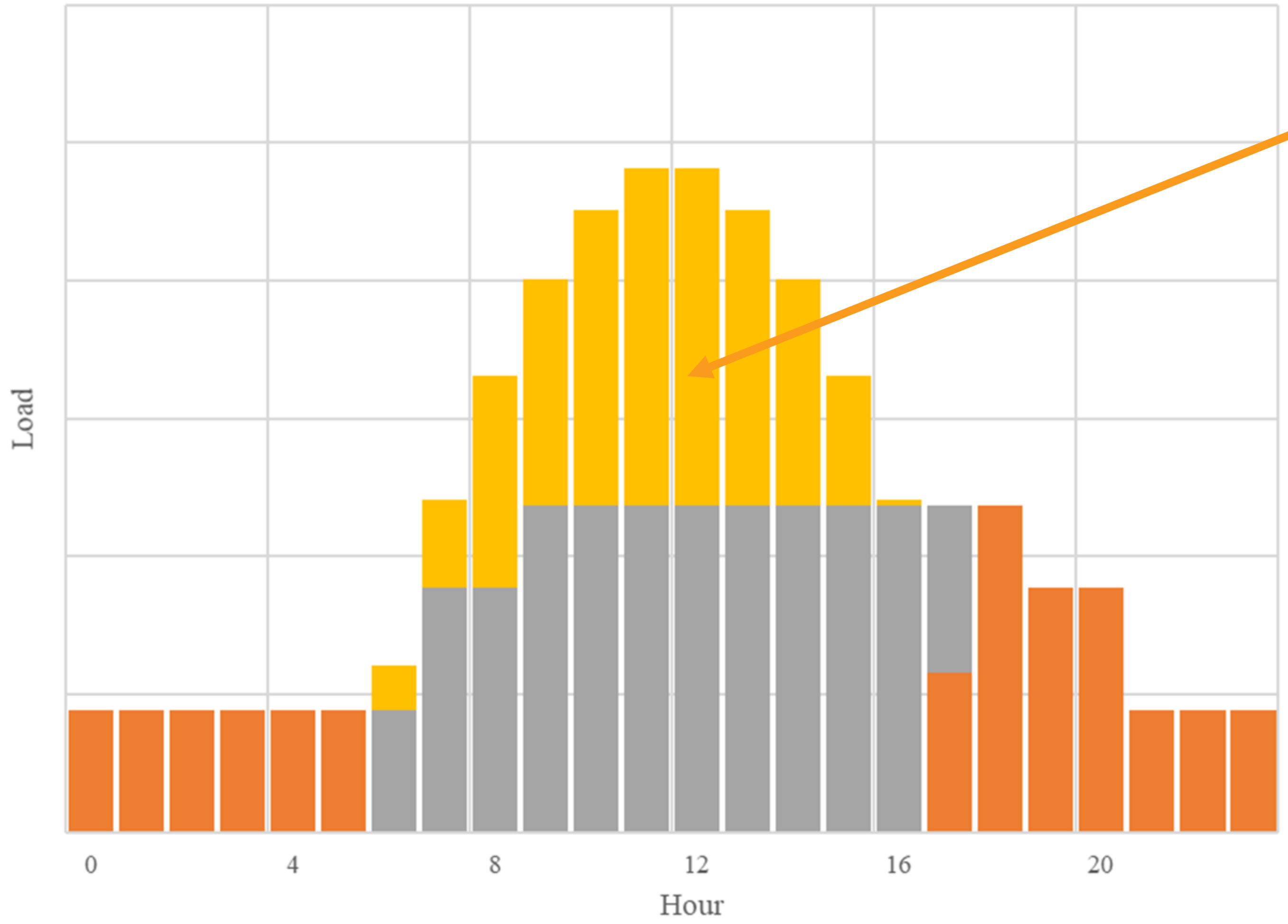
Solar + storage system sizing

Resilience scenario - When utility power is not available



Solar + storage system sizing

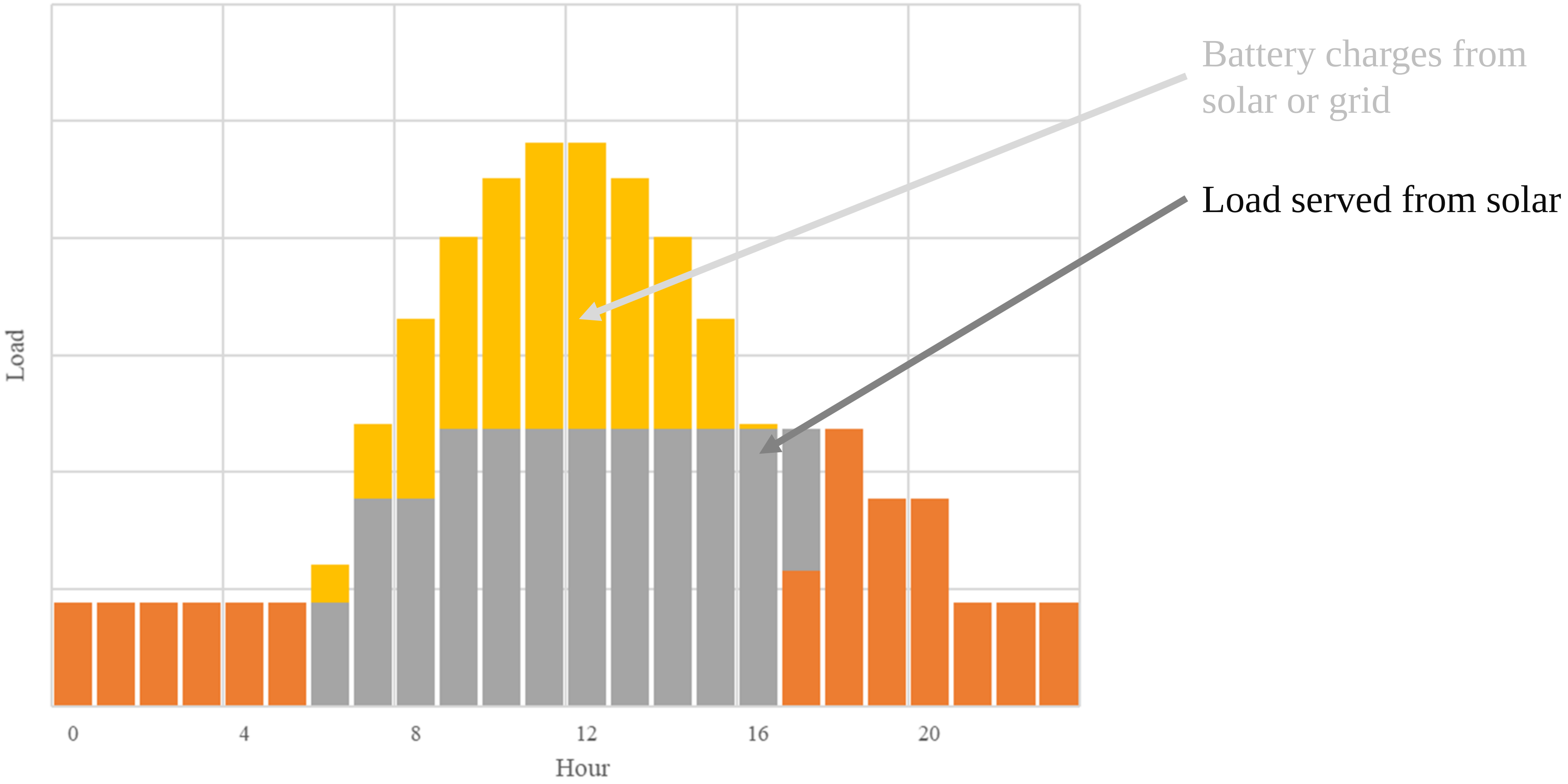
Resilience scenario - When utility power is not available



Battery charges from solar

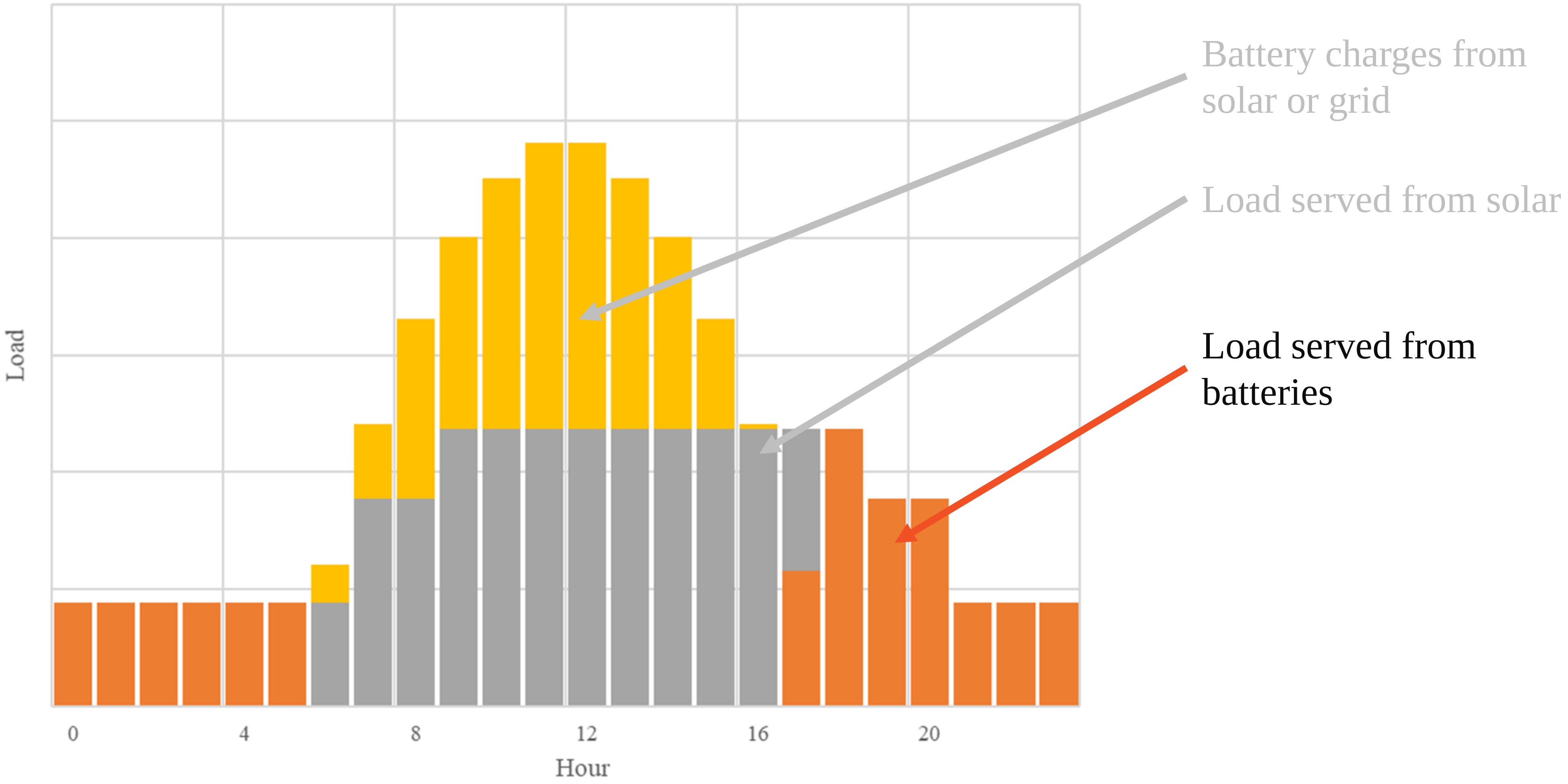
Solar + storage system sizing

Resilience scenario - When utility power is not available



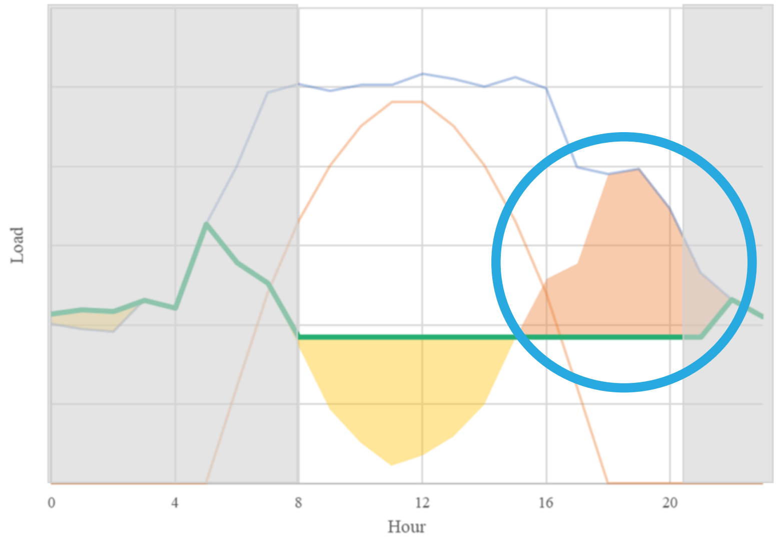
Solar + storage system sizing

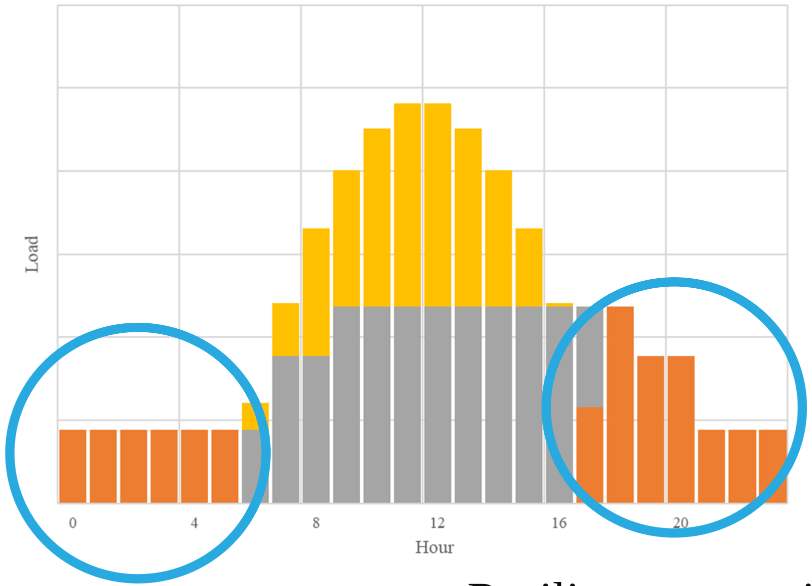
Resilience scenario - When utility power is not available



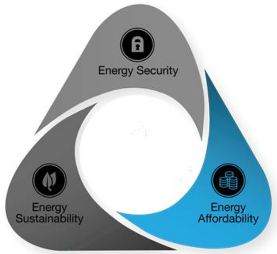
Solar + storage system sizing
Challenge

If energy required for resilience is higher than that required to maximize ROI, system will not fully monetize installed battery capacity

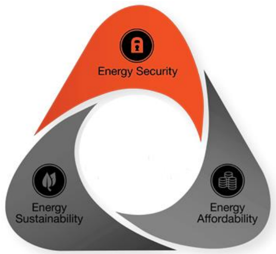




Maximize ROI



Resilience scenario



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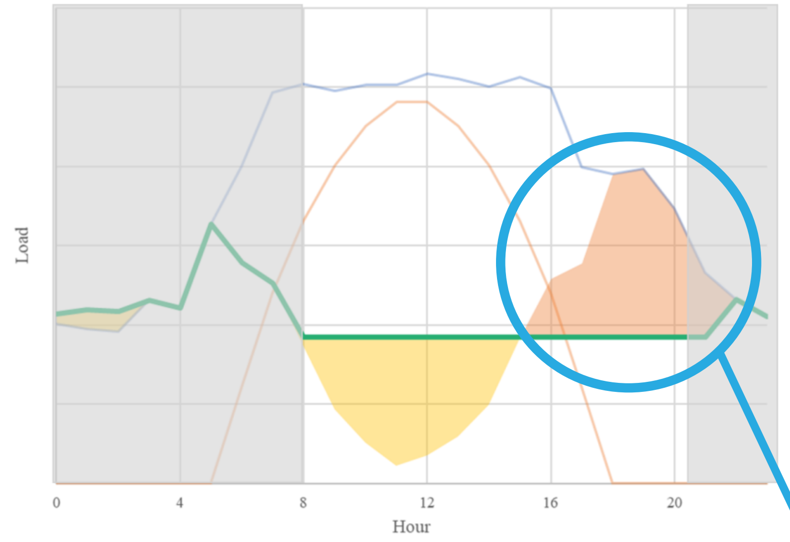
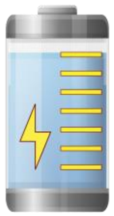
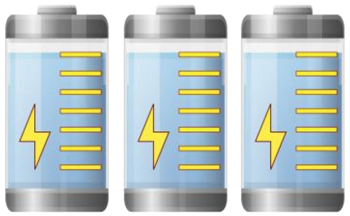
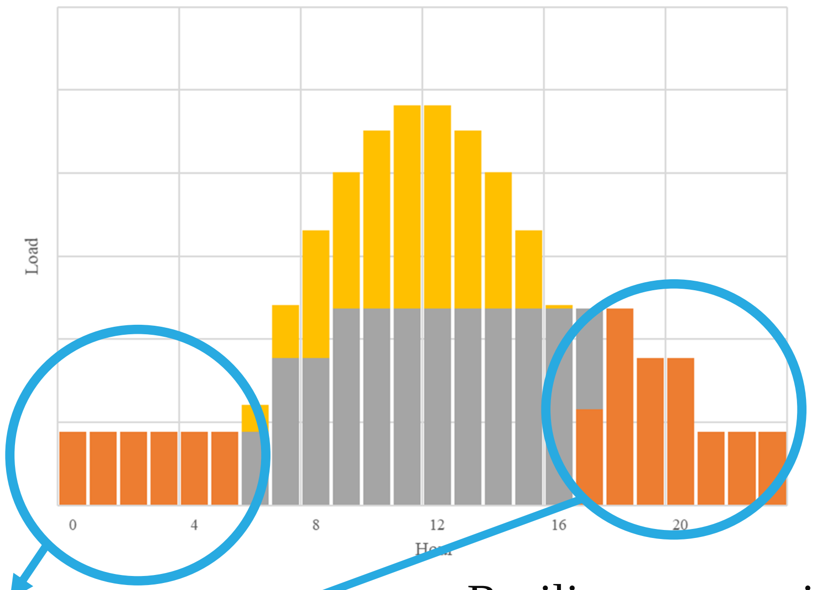
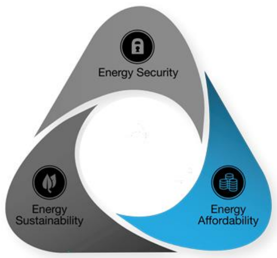




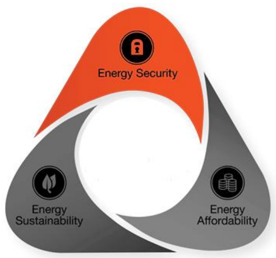




Maximize ROI



Resilience scenario



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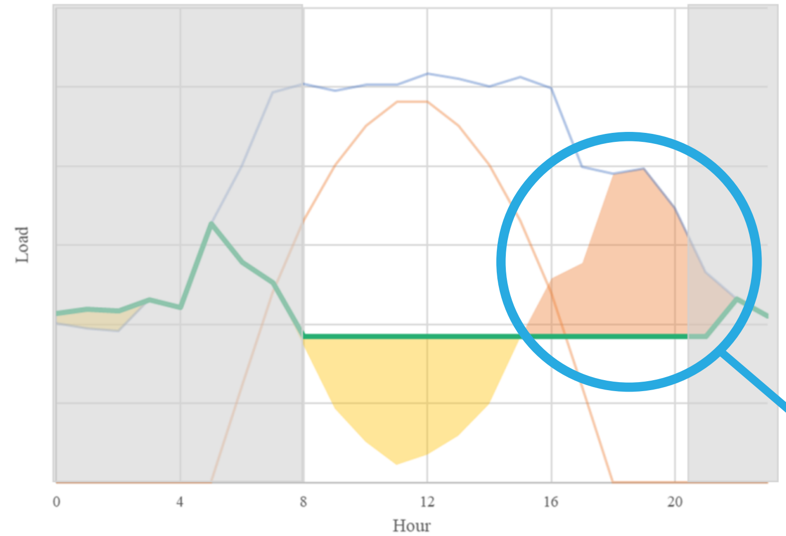
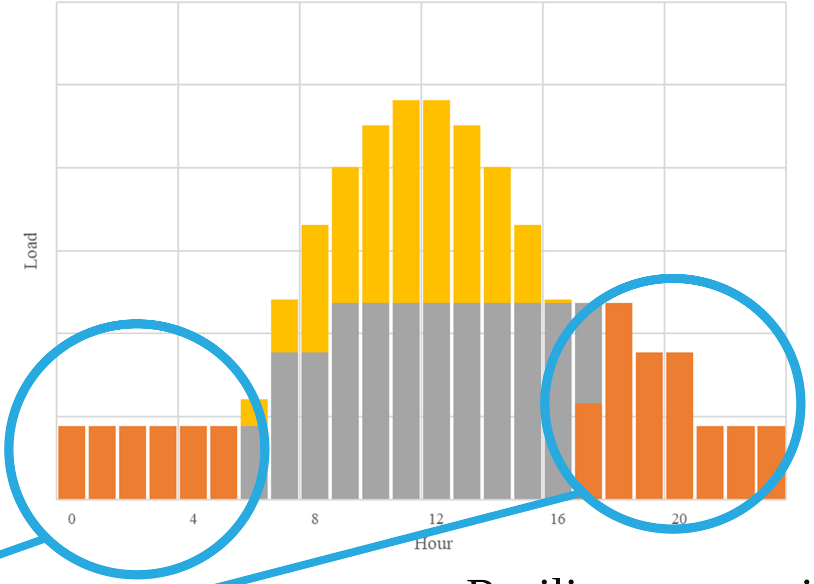
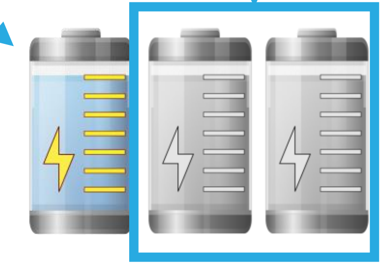
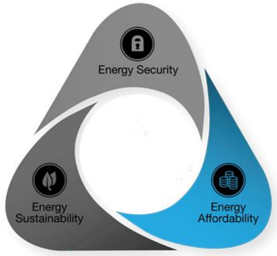


Batteries do not generate revenue

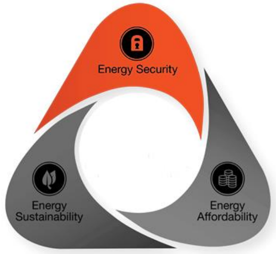




Maximize ROI



Resilience scenario



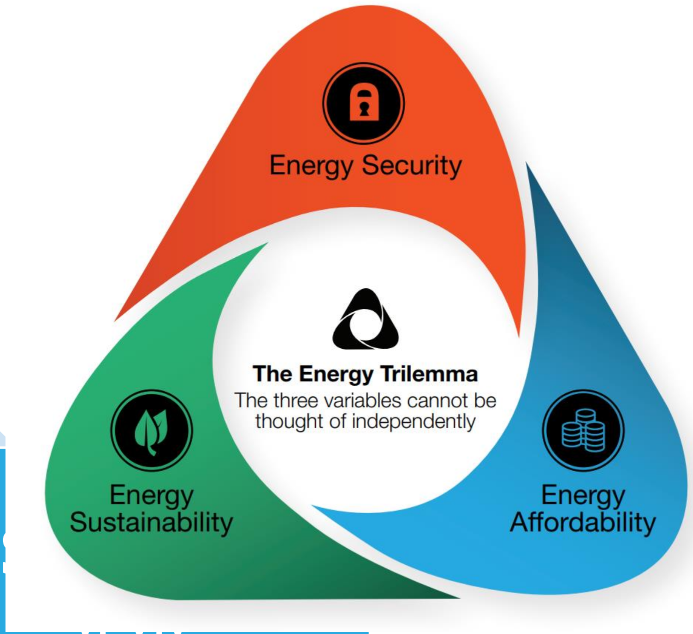
Summary

Process

Step 1:
Resilience Gap Assessment

Step 2:
Preliminary Technology Screen

Feasibility Studies / System Modeling



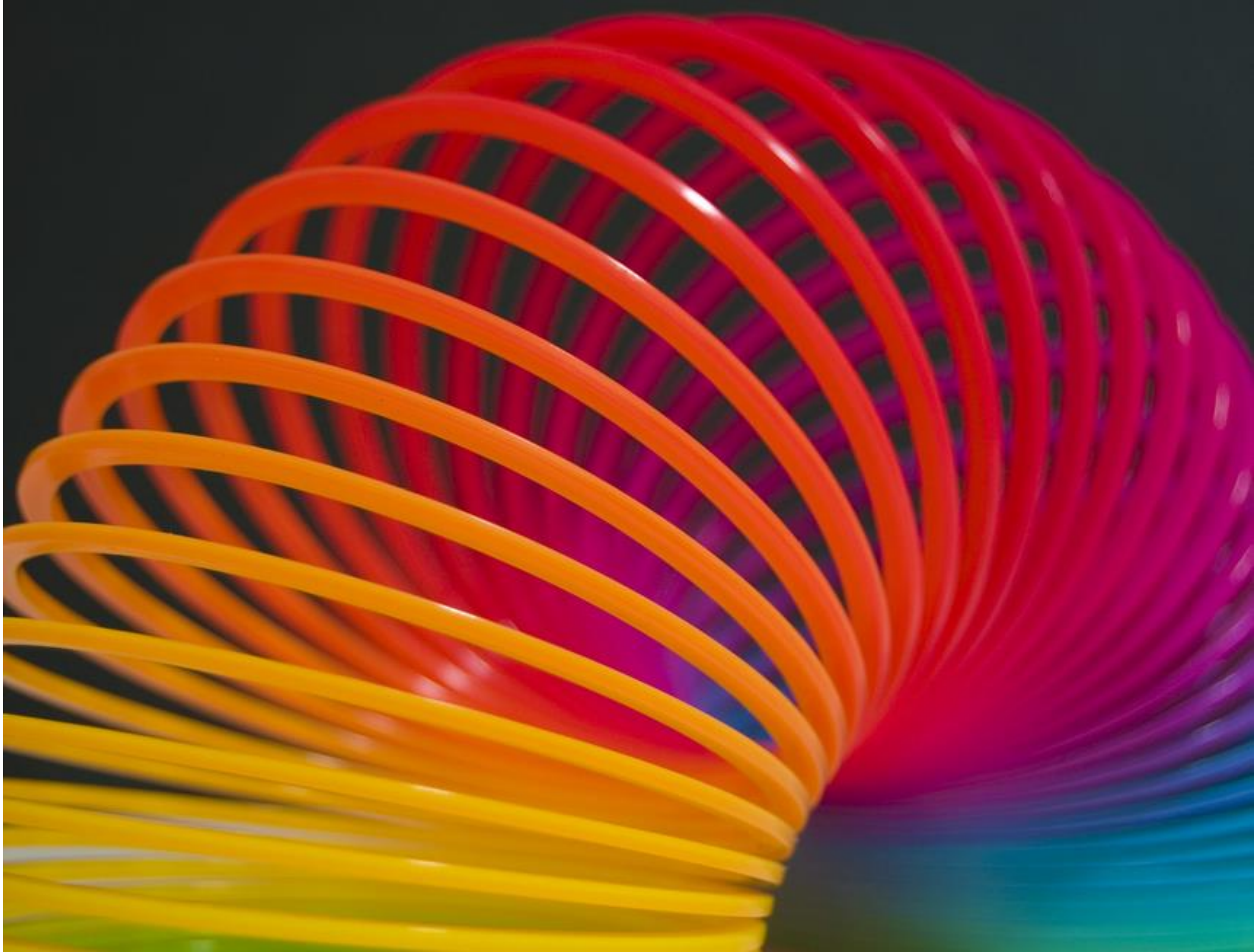
Modify expectations for ROI and NPV for clean energy systems in order to value resilience benefits.

Align resilience expectations with realistic system capabilities.

Be flexible

Some resilience is better than none.

Resilience can address a range of challenges leading to multiple strategies.



Questions

ARUP