General Electric | HOMER Microgrid and Hybrid Power International | October 2021

AC vs. DC Coupled: an Old Debate Renewed

Presented by: Neha Sinha – GE Energy Storage Product Management Lead

HOMER MICROGRID AND HYBRID POWER | 9TH ANNUAL INTERNATIONAL

THE BUILDING BLOCKS OF AC AND DC COUPLED SYSTEMS

AC Energy

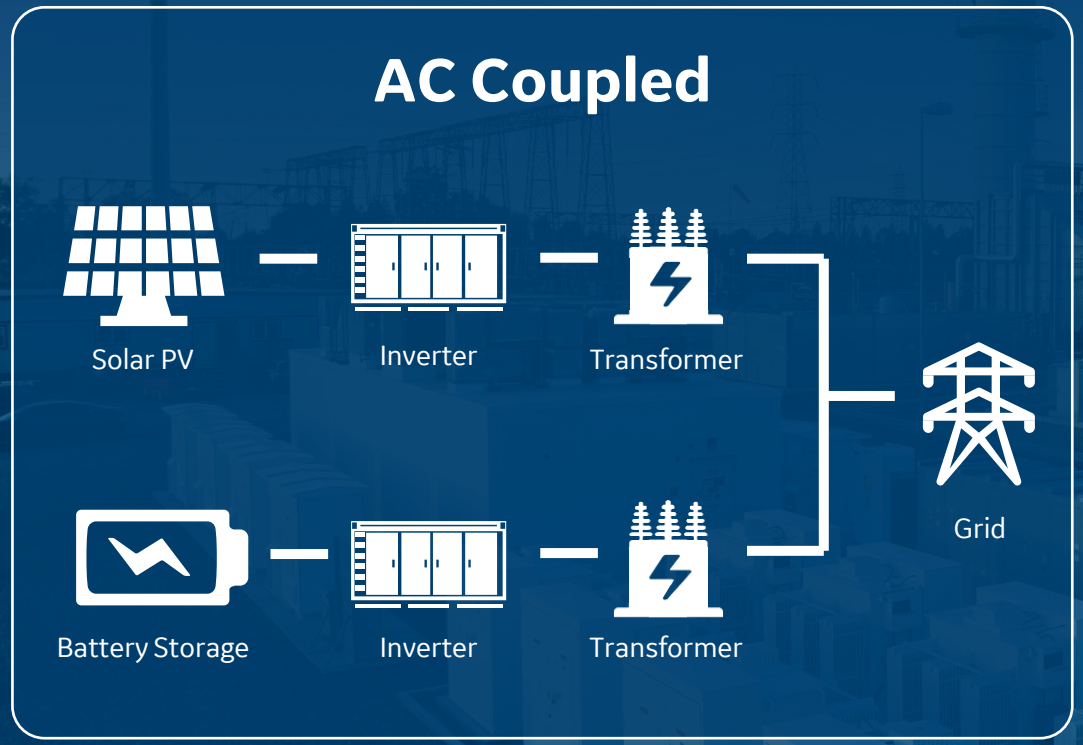
Grid

DC Energy

Solar PV

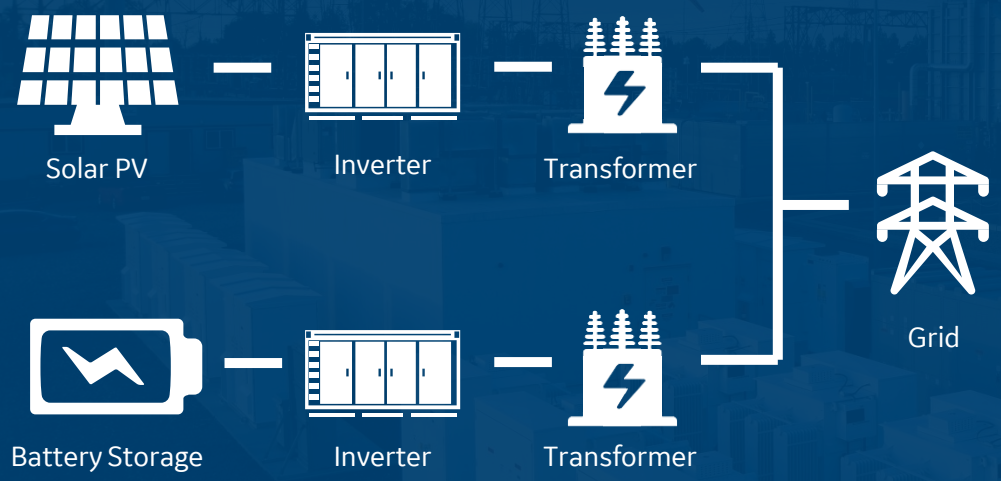
Battery Storage

THE BUILDING BLOCKS OF AC AND DC COUPLED SYSTEMS

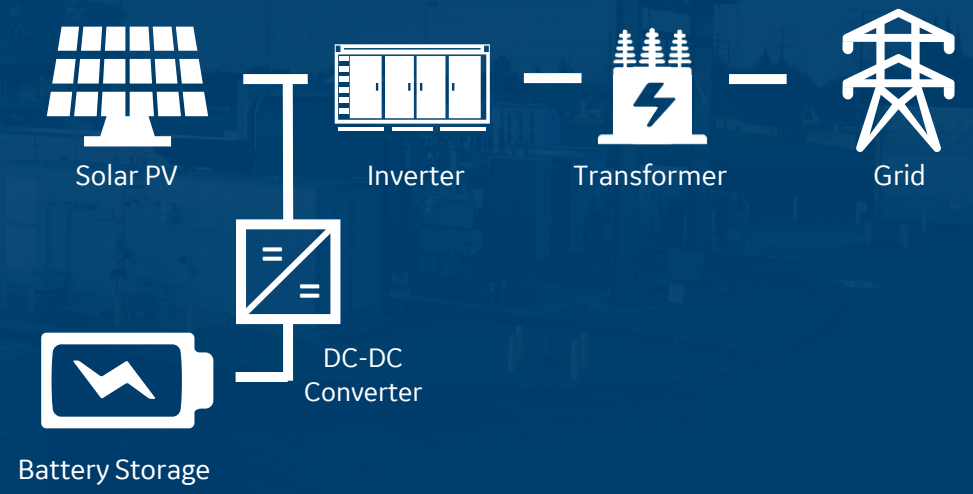


THE BUILDING BLOCKS OF AC AND DC COUPLED SYSTEMS

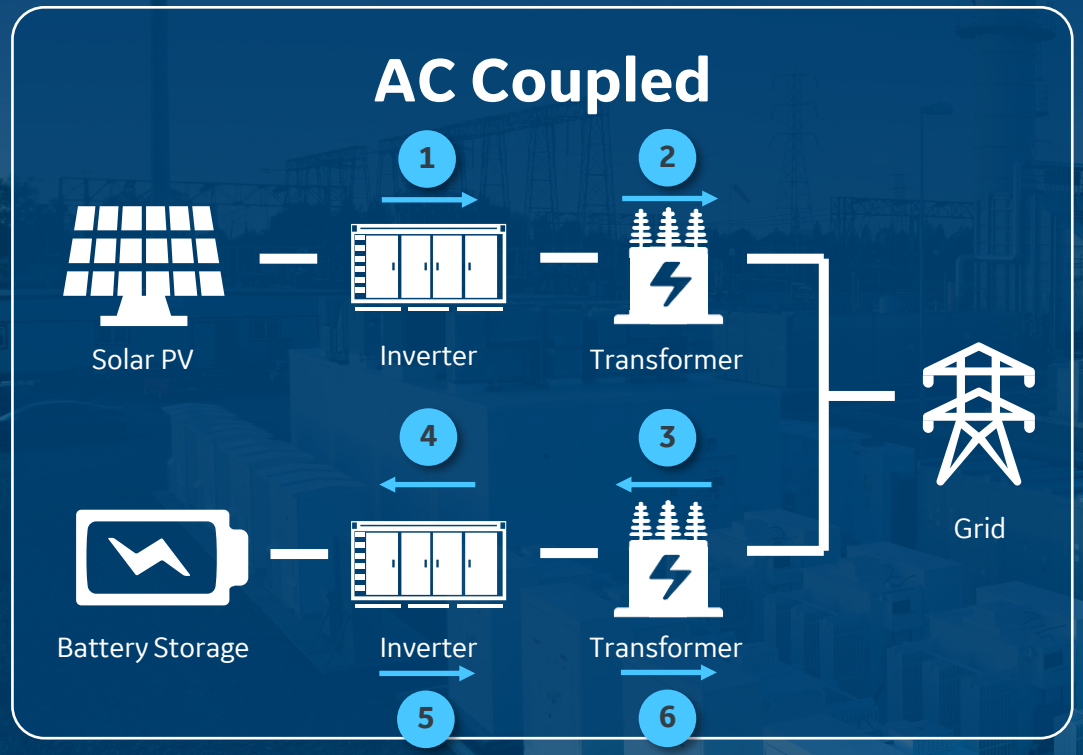
AC Coupled

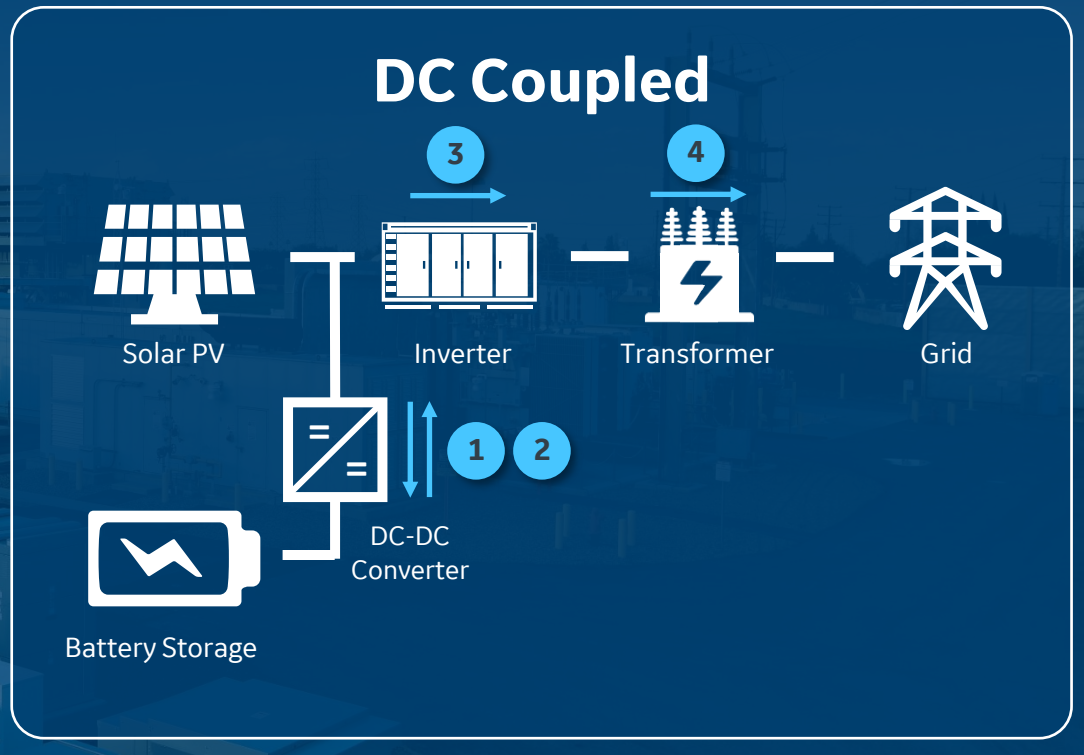


DC Coupled



COMPARING AC AND DC COUPLED SYSTEMS



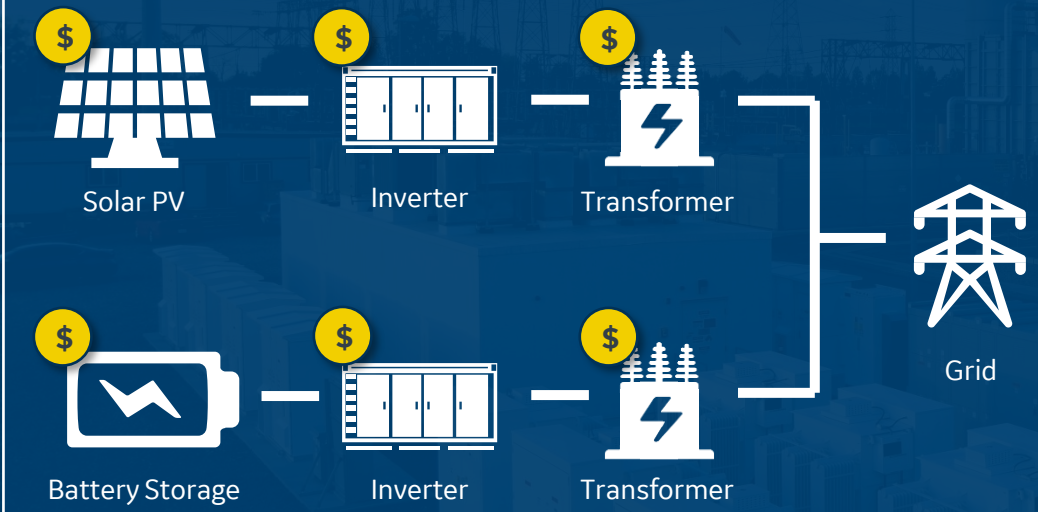


Efficiency loss over more conversions

Efficiency advantage of fewer conversions

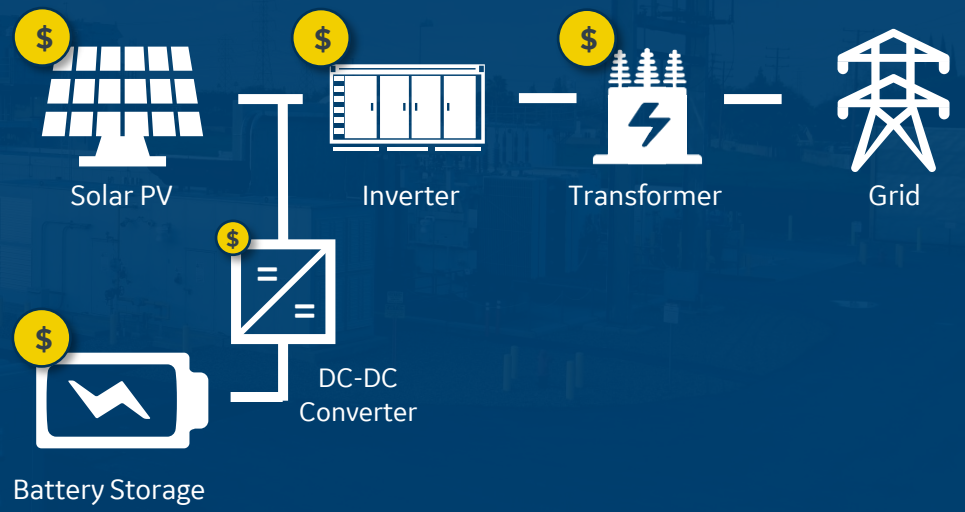
COMPARING AC AND DC COUPLED SYSTEMS

AC Coupled



- Efficiency loss over more conversions
- CAPEX increased by multiple inverters & transformers

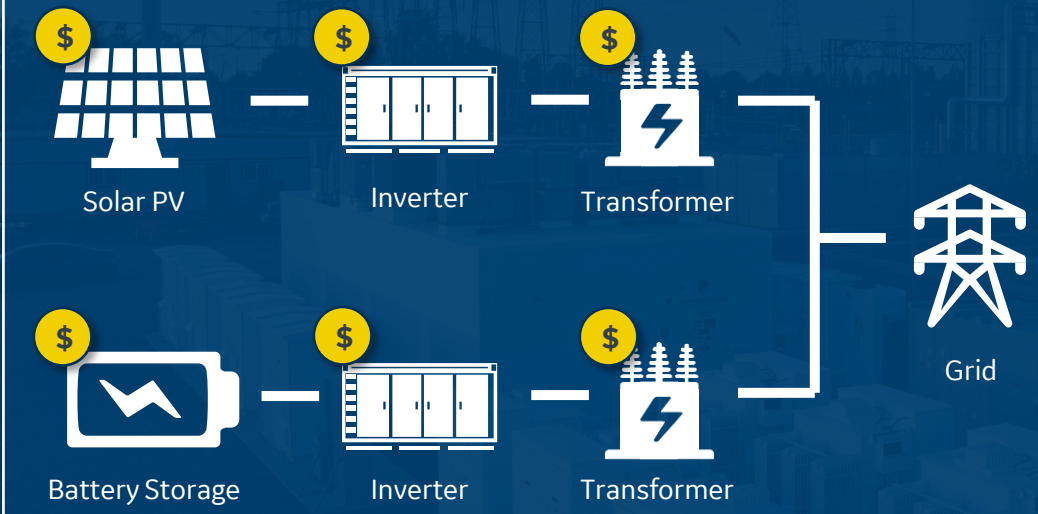
DC Coupled



- Efficiency advantage of fewer conversions
- CAPEX advantage of fewer inverters & transformers; lower cost addition of DC-DC

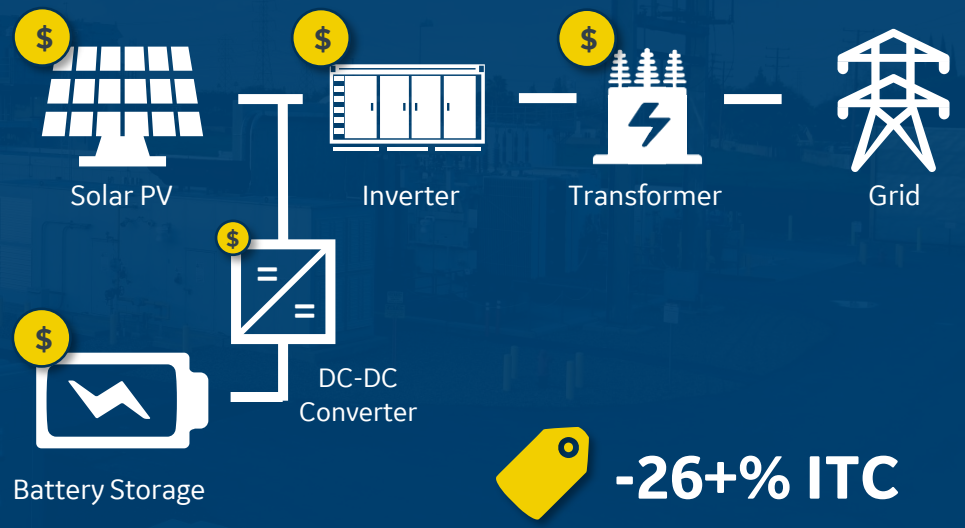
COMPARING AC AND DC COUPLED SYSTEMS

AC Coupled



- Efficiency loss over more conversions
- CAPEX increased by multiple inverters & transformers
- Potentially not qualified for ITC

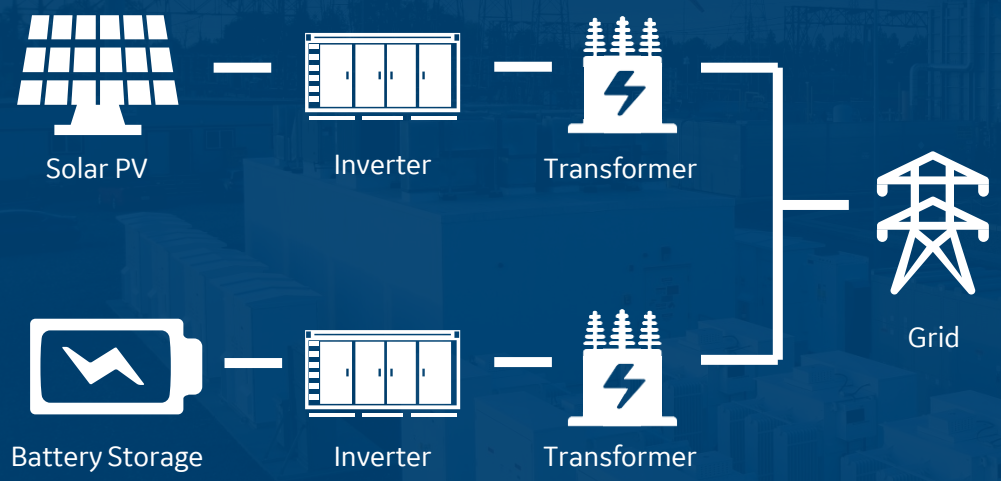
DC Coupled



- Efficiency advantage of fewer conversions
- CAPEX advantage of fewer inverters & transformers; lower cost addition of DC-DC
- ITC benefit to CAPEX investment

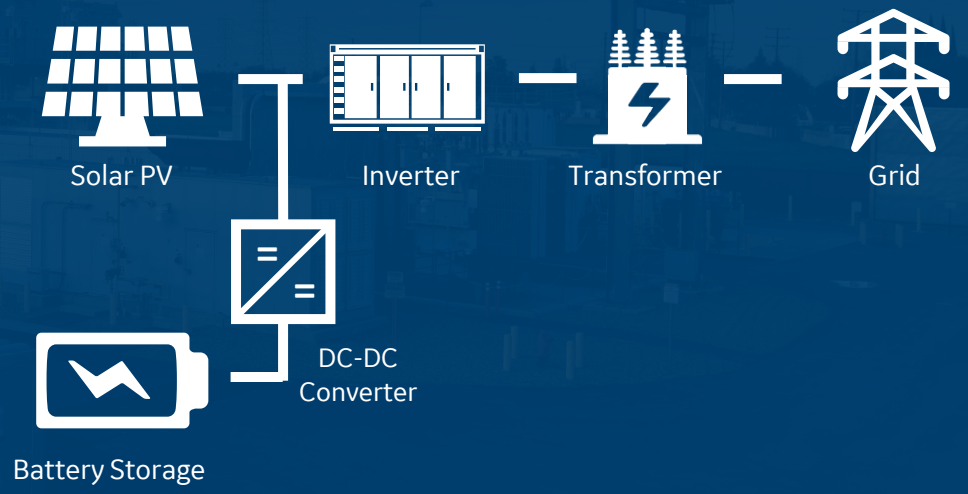
COMPARING AC AND DC COUPLED SYSTEMS

AC Coupled

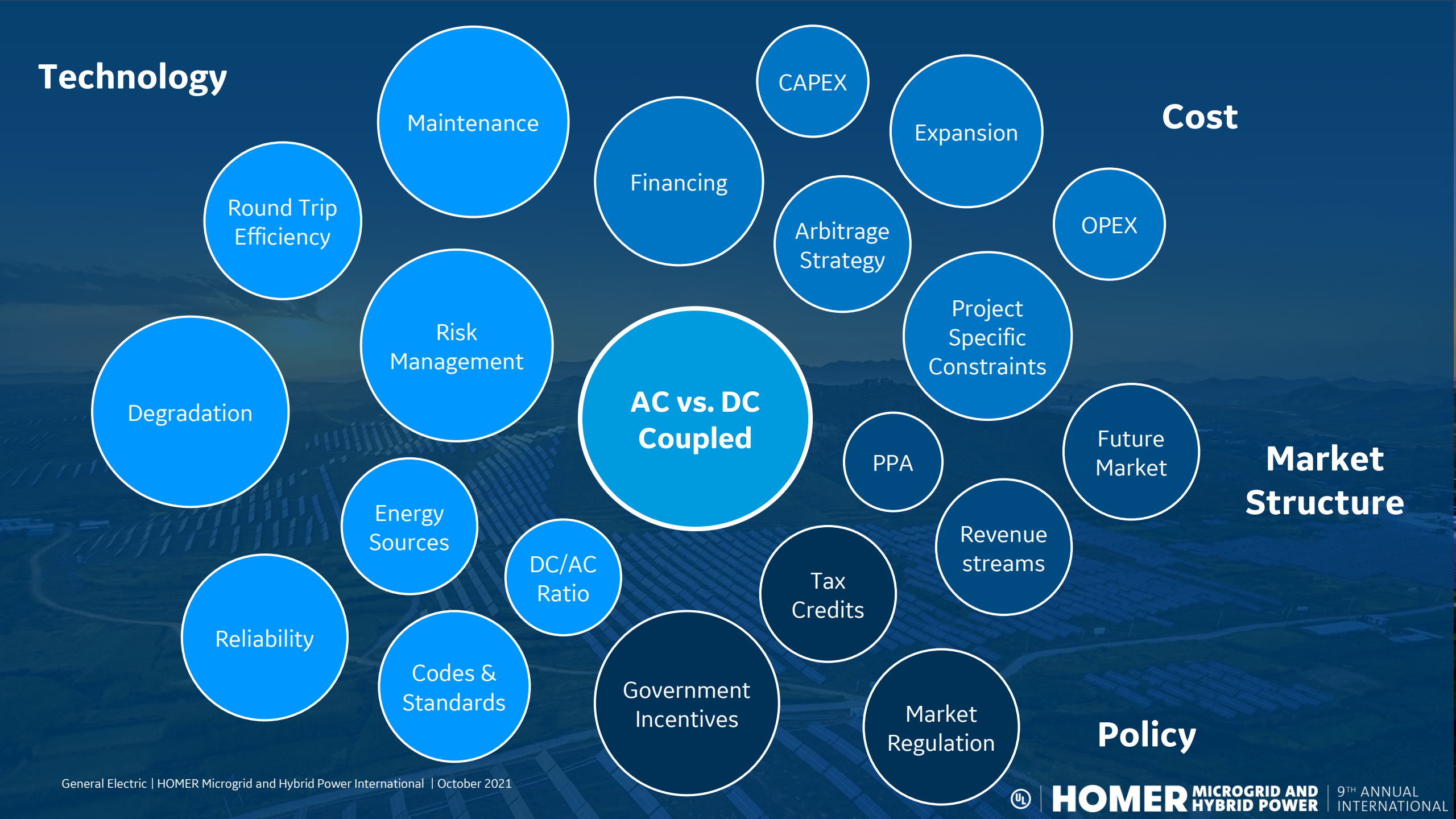


- Efficiency loss over more conversions
- CAPEX increased by multiple inverters & transformers
- Potentially not qualified for ITC
- More flexibility in expansion and application

DC Coupled



- Efficiency advantage of fewer conversions
- CAPEX advantage of fewer inverters & transformers; lower cost addition of DC-DC
- ITC benefit to CAPEX investment
- Difficult to expand or adapt to different applications


Technology
Maintenance
Round Trip Efficiency
Risk Management
Degradation
Energy Sources
DC/AC Ratio
Reliability
Codes & Standards
Cost
CAPEX
Expansion
Financing
Arbitrage Strategy
OPEX
Project Specific Constraints
AC vs. DC Coupled
Market Structure
PPA
Future Market
Revenue streams
Tax Credits
Government Incentives
Market Regulation
Policy

CASE STUDY: ARIZONA PUBLIC SERVICE (APS)

Project Information

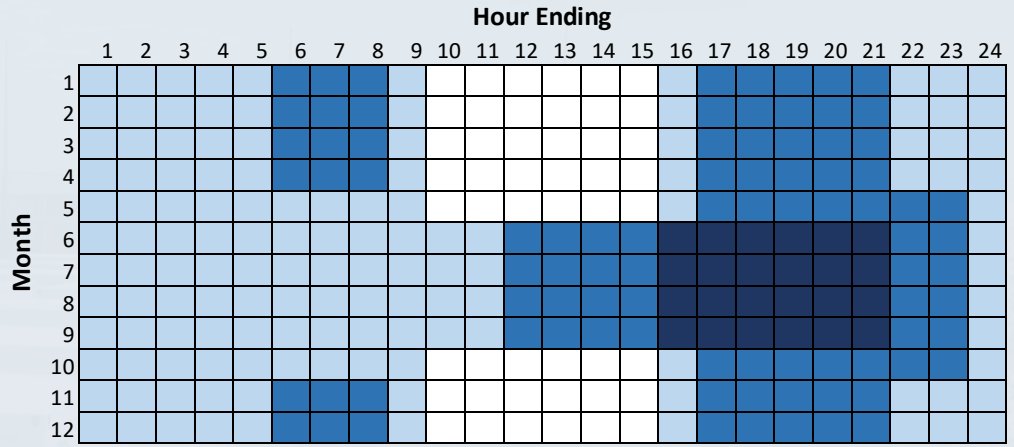
COD: 2024

Project life: 20 years

Design temperature: 122°F (50°C)

Plant size: 50 MW – 400 MW supply

Revenue: Tiered PPA rate



	Option 1	Option 2	Option 3	Option 4
Efficiency				
CAPEX				
Cost of Energy Source				
Sell to the Grid				
Financing & Tax Incentives				

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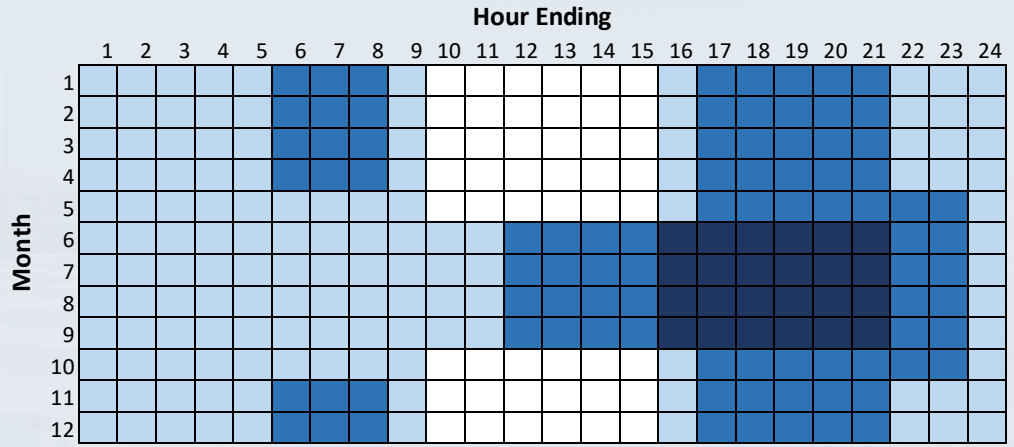

	Option 1: Solar Only	Option 2	Option 3	Option 4
Efficiency	●			
CAPEX	●			
Cost of Energy Source	●			
Sell to the Grid	●			
Financing & Tax Incentives	●			

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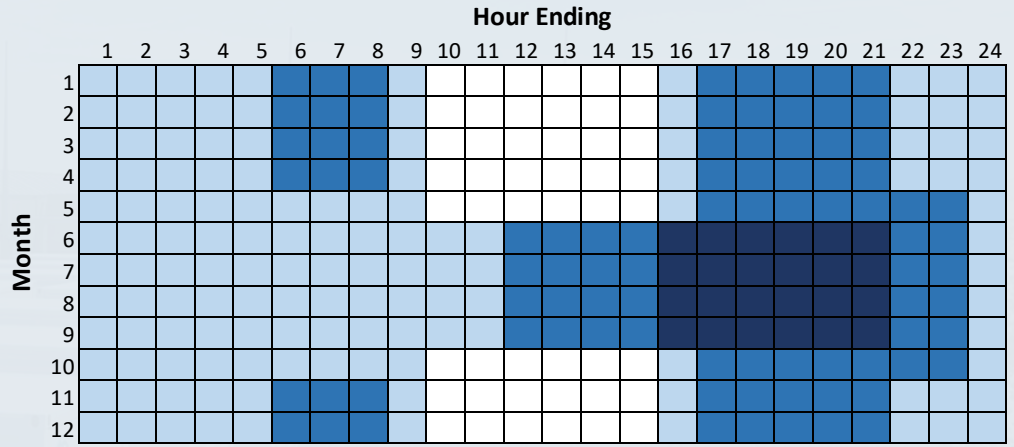

	Option 1: Solar Only	Option 2: PV + DC Coupled BESS	Option 3	Option 4
Efficiency	🟢	🟡		
CAPEX	🟢	🟡		
Cost of Energy Source	🟢	🟢		
Sell to the Grid	🔴	🟢		
Financing & Tax Incentives	🟢	🟢		

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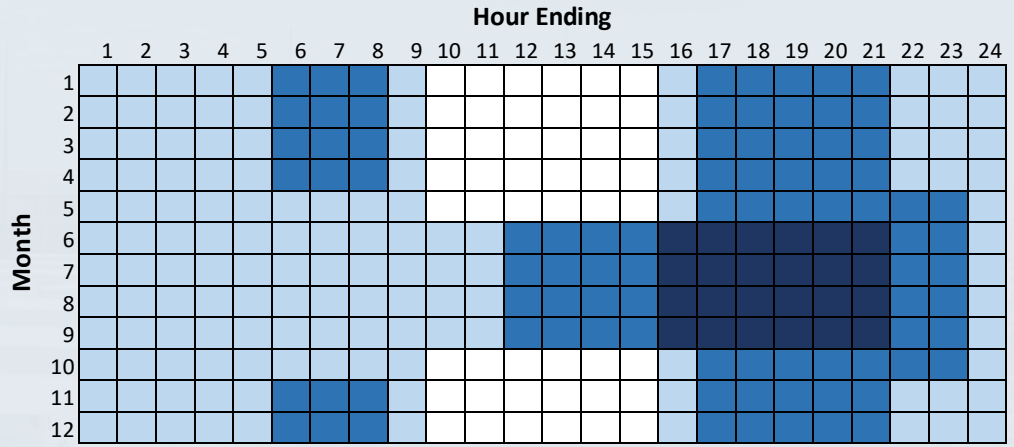

	Option 1: Solar Only	Option 2: PV + DC Coupled BESS	Option 3: PV + AC Coupled BESS	Option 4
Efficiency	🟢	🟡	🔴	
CAPEX	🟢	🟡	🔴	
Cost of Energy Source	🟢	🟢	🟢	
Sell to the Grid	🔴	🟢	🟢	
Financing & Tax Incentives	🟢	🟢	🟡	

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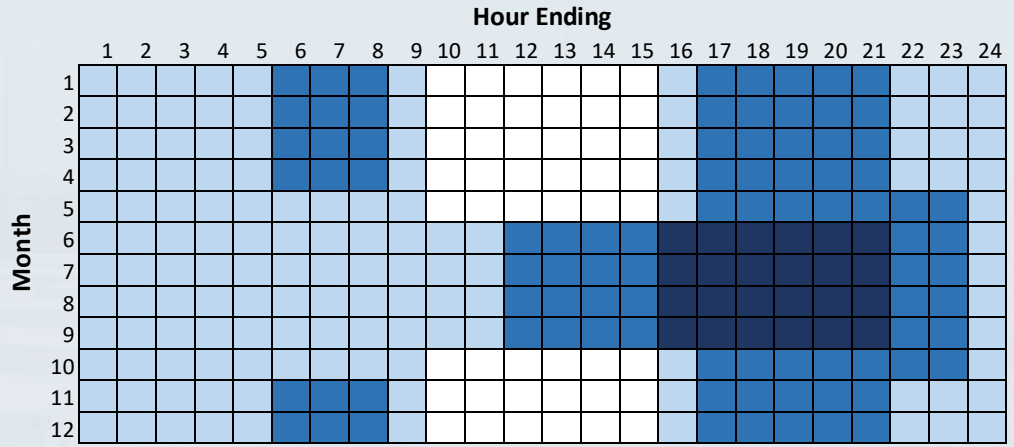

	Option 1: Solar Only	Option 2: PV + DC Coupled BESS	Option 3: PV + AC Coupled BESS	Option 4: BESS Only
Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

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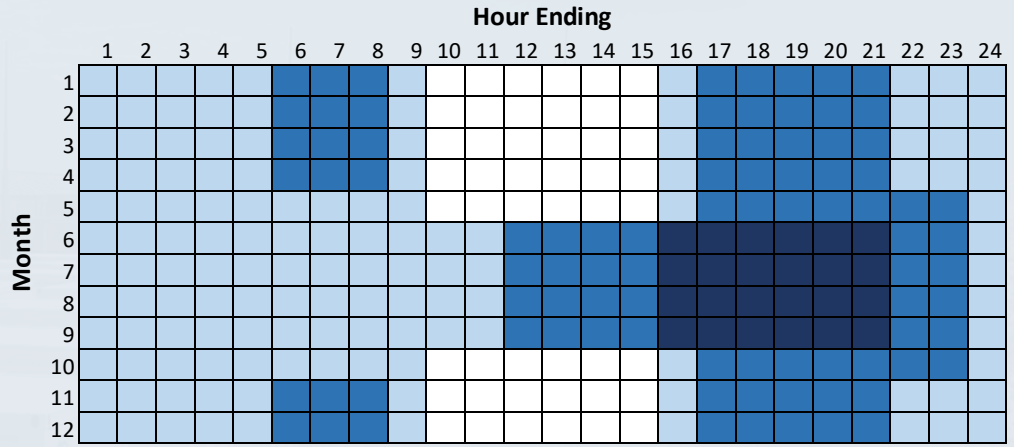

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Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

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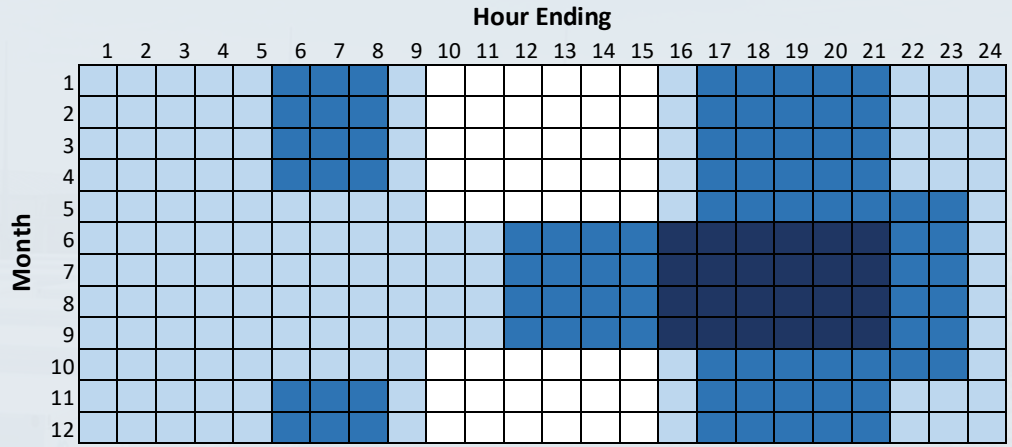

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Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

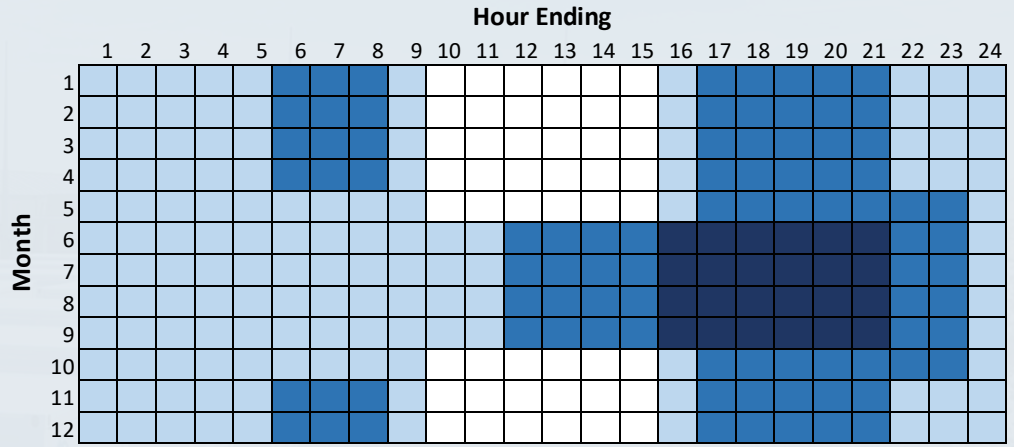
CASE STUDY: STACKED REVENUE

Project Information

COD: 2024

Project life: 20 years

Revenue: Tiered PPA rate
Merchant market
Ancillary services



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Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

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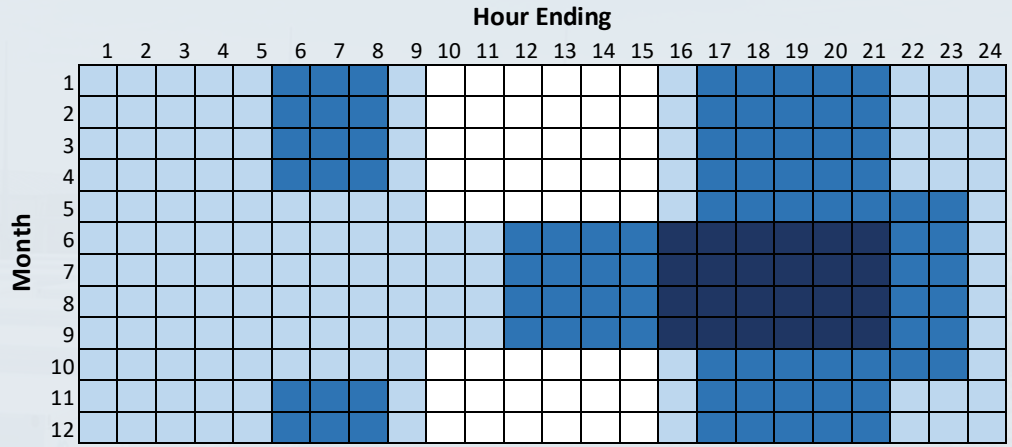

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Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

CASE STUDY: STACKED REVENUE

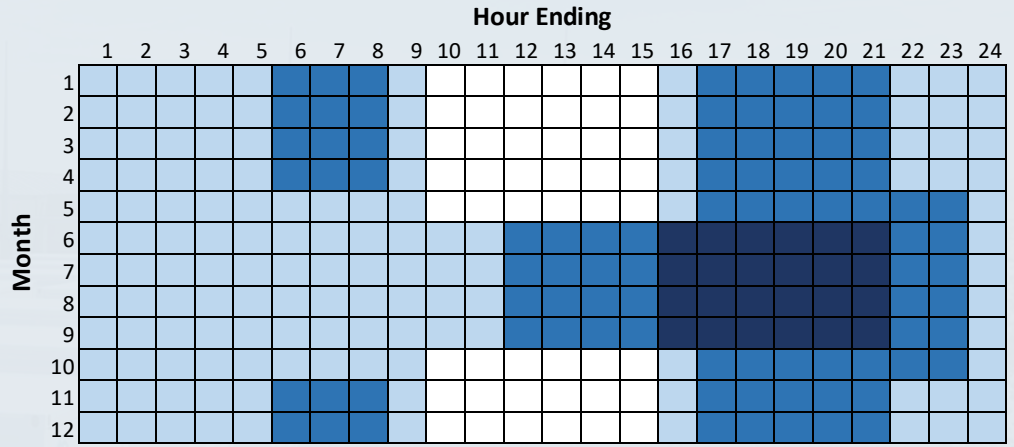
Project Information

COD: 2024

Project life: 20 years

Revenue: Tiered PPA rate
Merchant market
Ancillary services

Measurement: Metering
Resource Adequacy test



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Efficiency	🟢	🟡	🔴	🟡
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴

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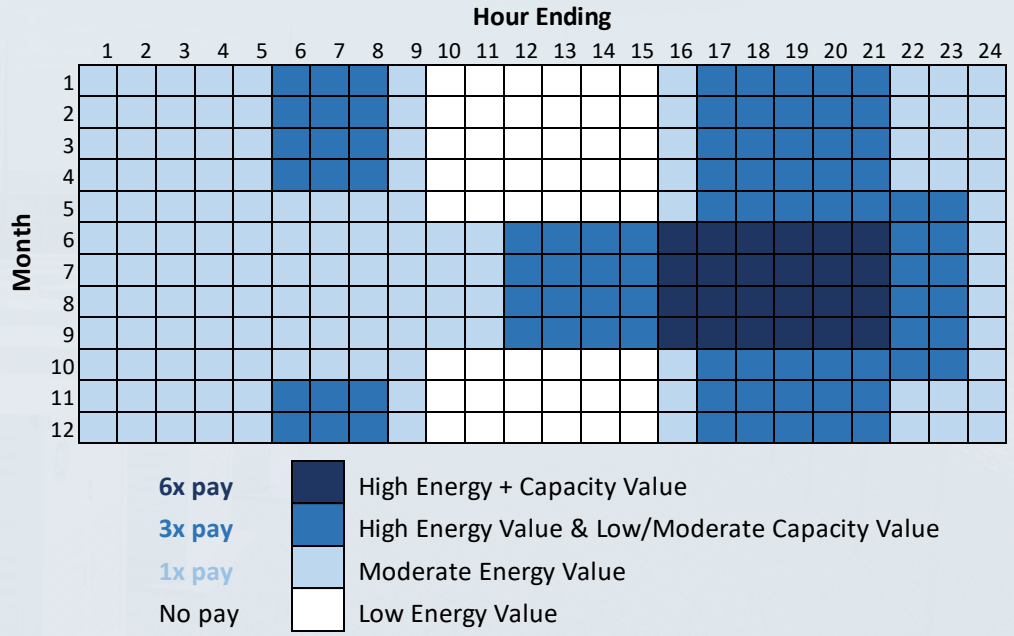

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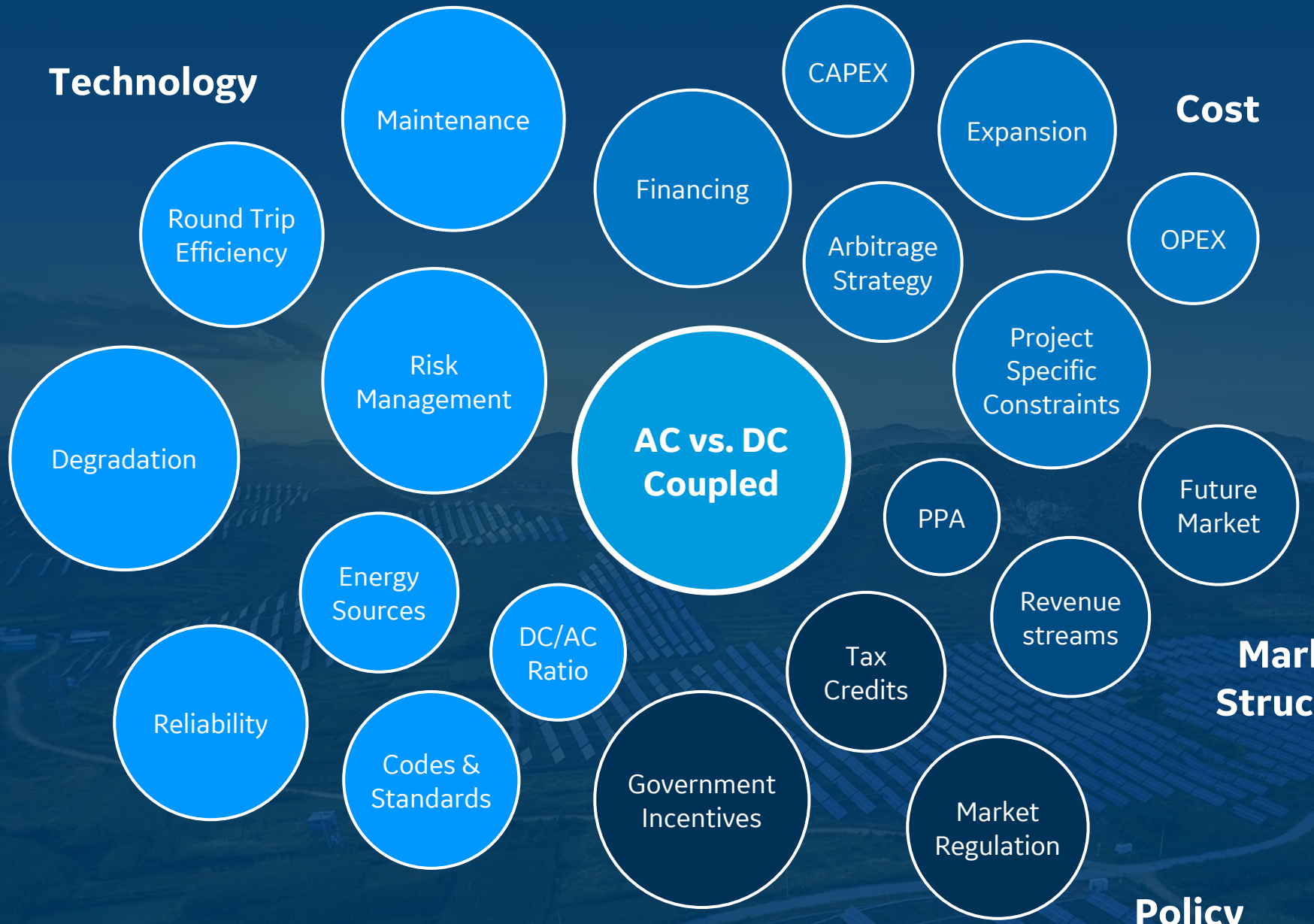
CAPEX	🟢	🟡	🔴	🔴
Cost of Energy Source	🟢	🟢	🟢	🔴
Sell to the Grid	🔴	🟢	🟢	🟢
Financing & Tax Incentives	🟢	🟢	🟡	🔴



Tools to evaluate unique factors of every project:

HOMER
GE Hybrid Architect

Learn more:

ADDING STORAGE TO YOUR PROJECT: IS IT AS EASY AS YOU THINK?

Sept. 9th, 2021 HOMER Webinar