A POSITIVE CONTRIBUTION:

ENSURING OUR NEWER ENERGY TECHNOLOGIES FULFILL THEIR POTENTIAL

REBUILD CONFERENCE

OCTOBER 2024

Overview

Chris Edward, PE

Principal with IMEG's Sustainability and Energy Team

- Review of newer energy technologies from concept to operation.
- Case studies on building and campus level implementation, with recommendations on keeping projects successful throughout the operational lifespan of these systems.
    - **Campus Solar Array**
    - **Industrial Rooftop Solar**
    - **Net Zero Microgrid**
    - **Industrial Microgrid**
    - **Industrial Cogeneration**
    - **Campus Energy Plan**
    - **Off-Grid Station**

Key Learnings

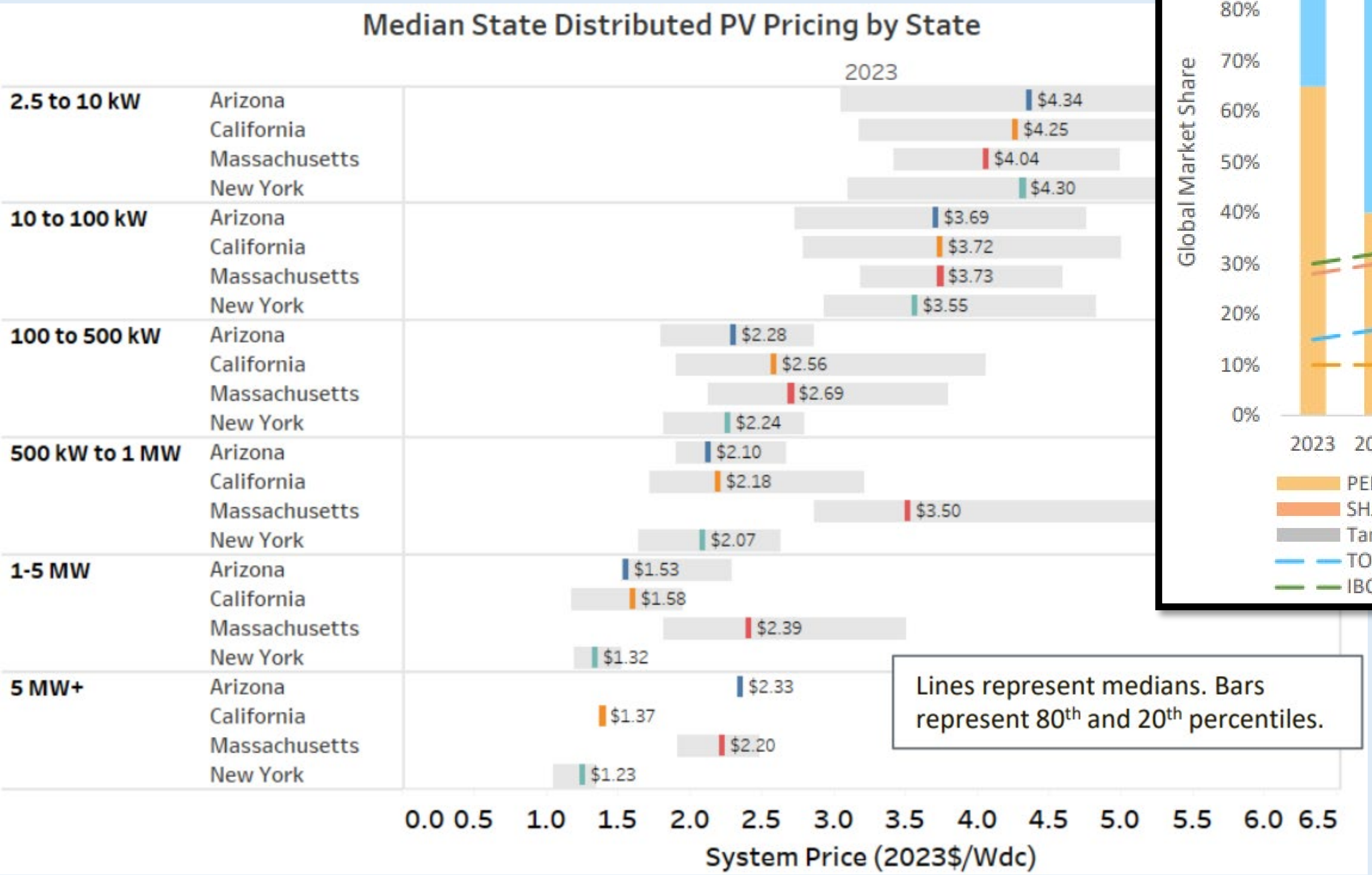
- The system types becoming most common in the industry.
- Frequent issues in system setup and commissioning.
- Potential operational pitfalls and how to avoid them.
- Optimizing the capability of newer energy technologies.

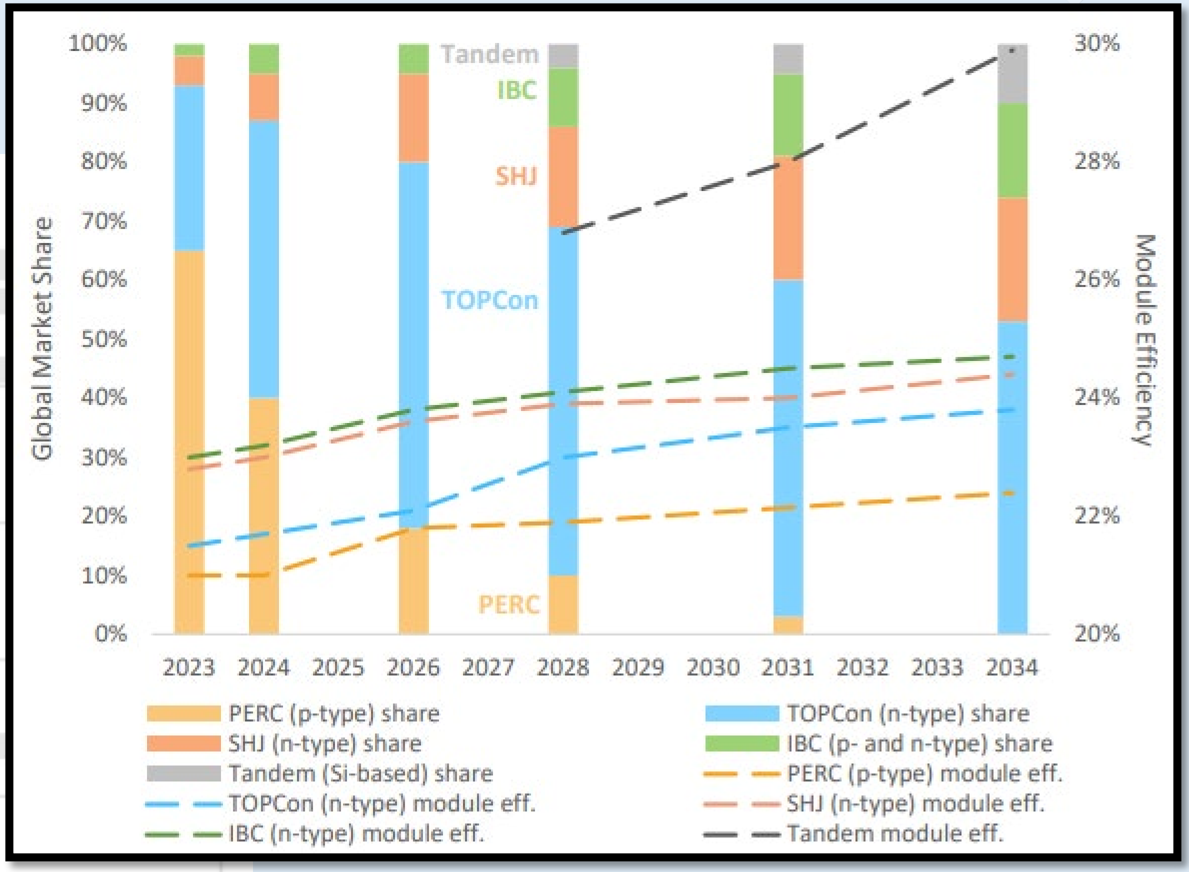
On-Site Energy Technologies

- SOLAR PV
- BATTERY ENERGY STORAGE
- MICROGRID
- COGENERATION
- 5TH GEN DISTRICT HEATING AND COOLING / GEOTHERMAL
- CARBON-NEUTRAL FUELS

On-Site Energy Technologies

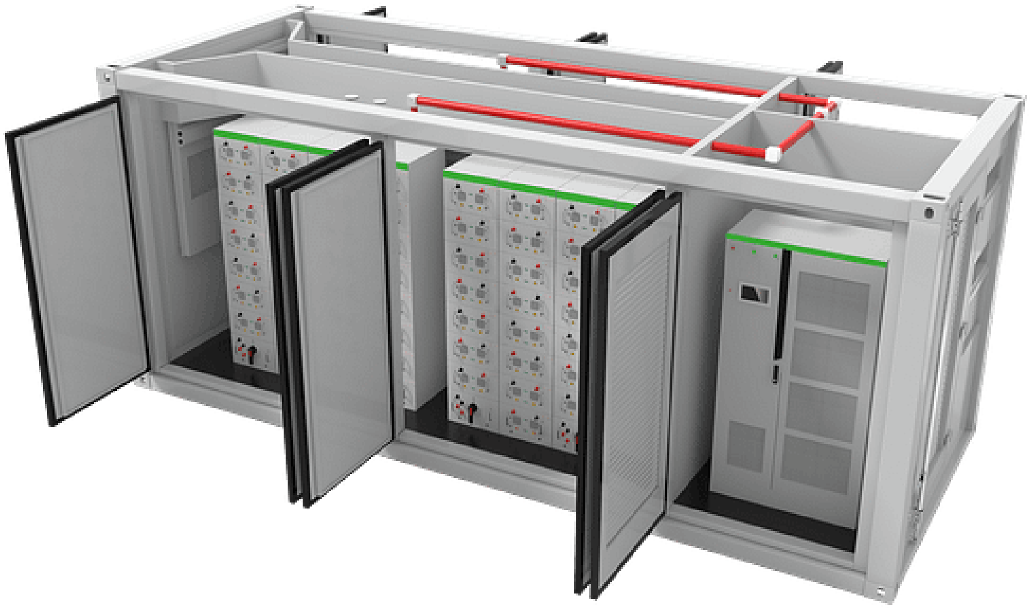
INDUSTRY STATUS – SOLAR PV

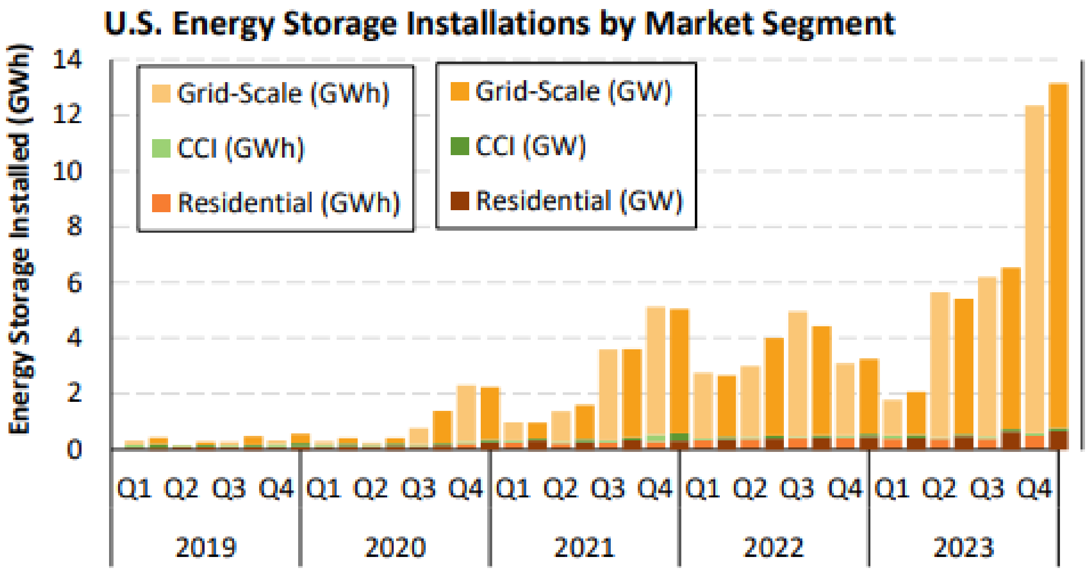


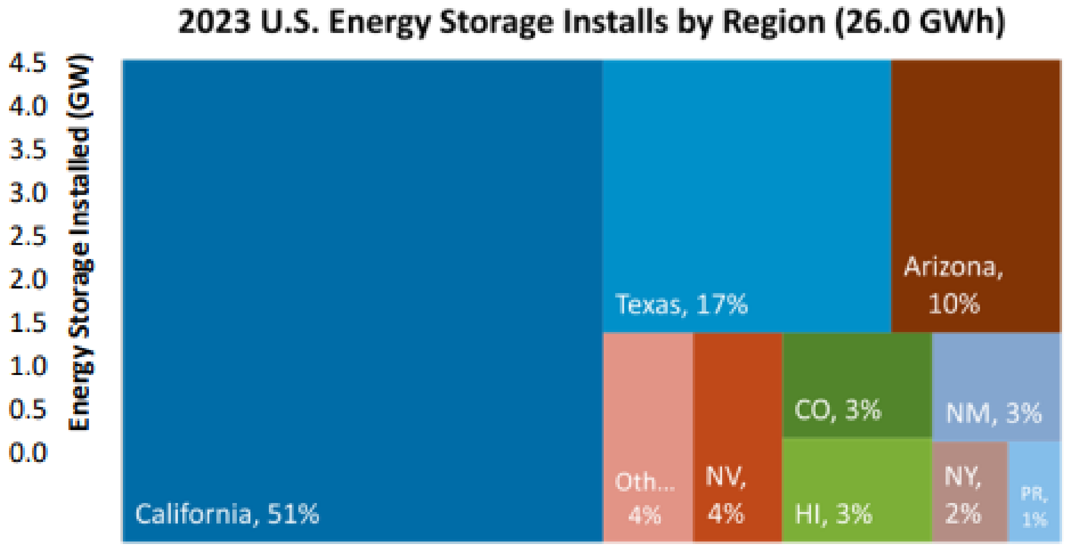


On-Site Energy Technologies

INDUSTRY STATUS - BESS





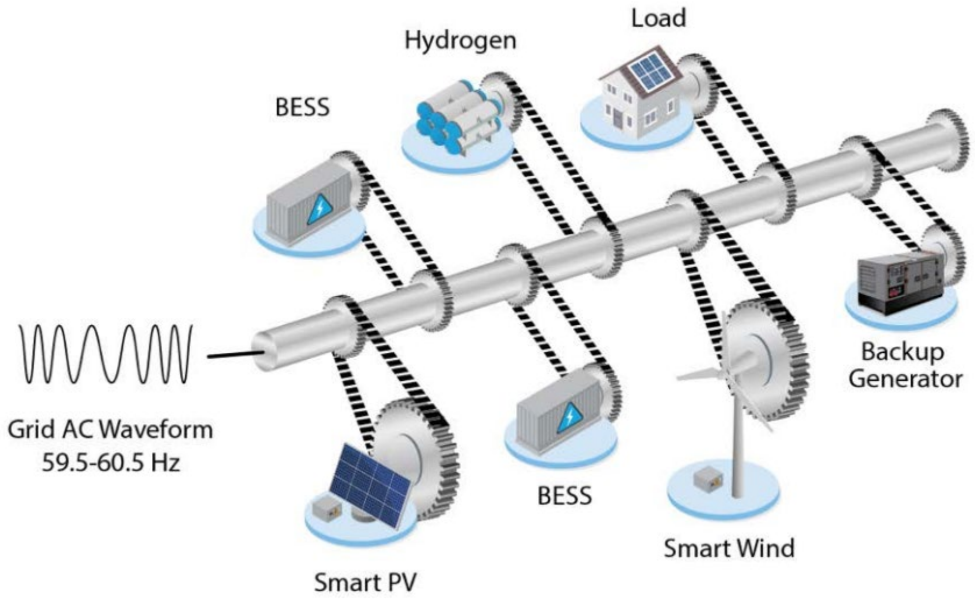


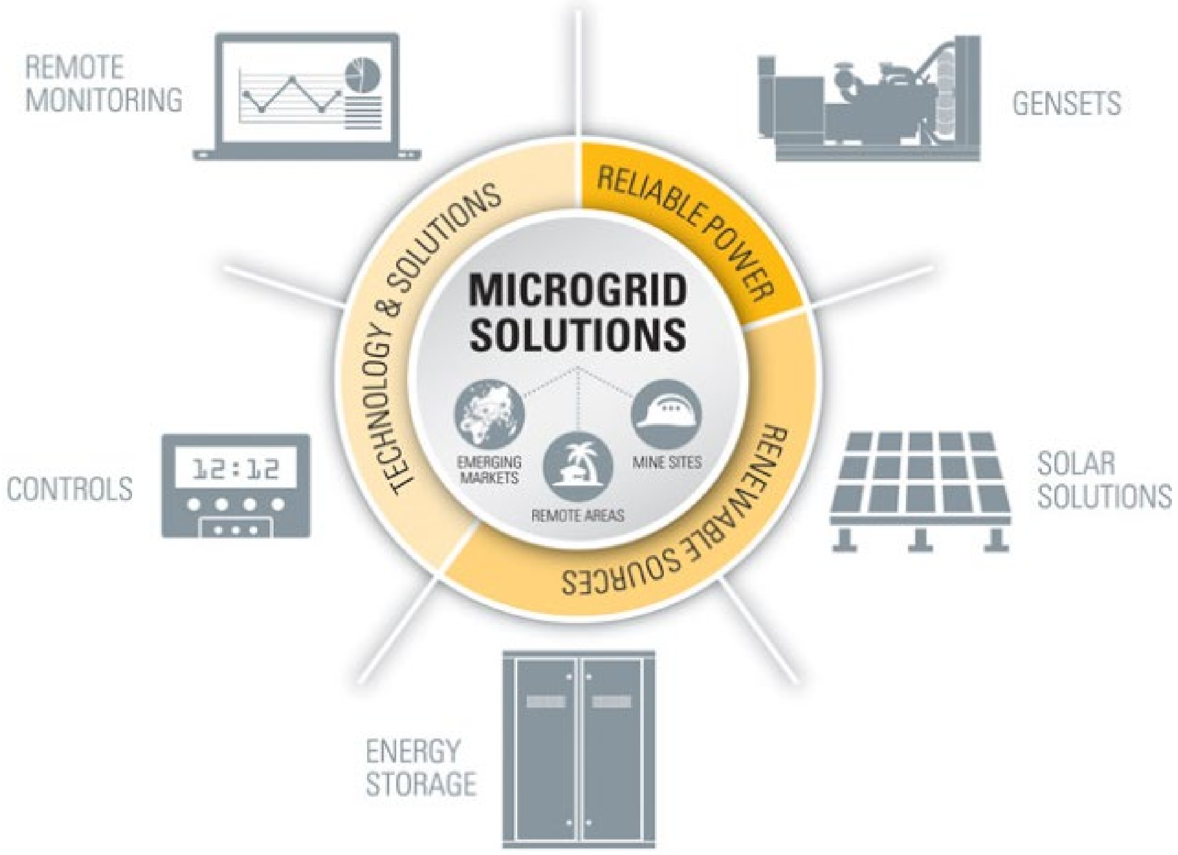
On-Site Energy Technologies

INDUSTRY STATUS - MICROGRID

U.S. DEPARTMENT OF ENERGY

By 2035, microgrids are envisioned to be essential building blocks of the future electricity delivery system to support resilience, decarbonization, and affordability.





On-Site Energy Technologies

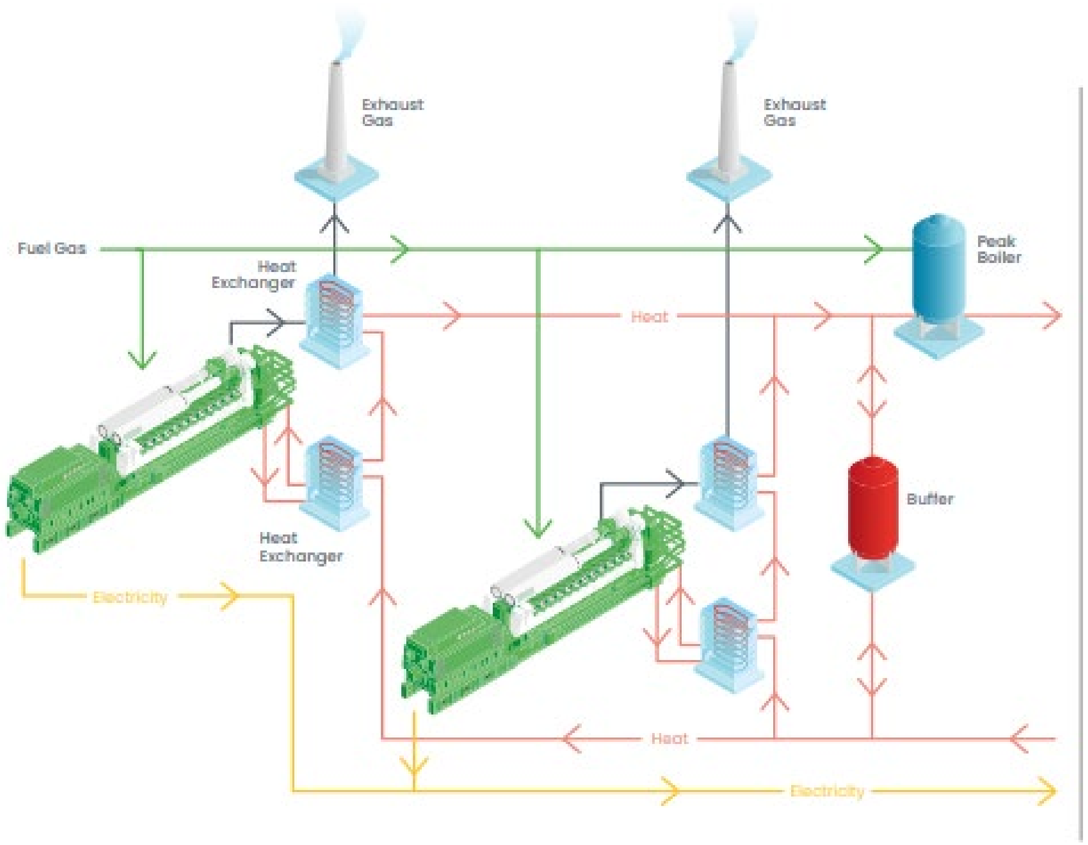
INDUSTRY STATUS - COGENERATION

30% Tax Credit for Natural Gas CHP Projects

The Energy Investment Tax Credit (ITC) applies to CHP systems fueled by natural gas, biogas, and other fuels. Technical eligibility requires overall efficiency over 60% LHV, including heat recovery.

Begin Construction Before January 2025

The 30% Tax Credit is available for projects that begin construction before January 1, 2025. After this date, the new law established a Clean Electricity Tax Credit for zero-carbon energy solutions, which will be available through 2032. CHP fueled by renewable fuels, including biogas and green hydrogen, are expected to be eligible for this credit.

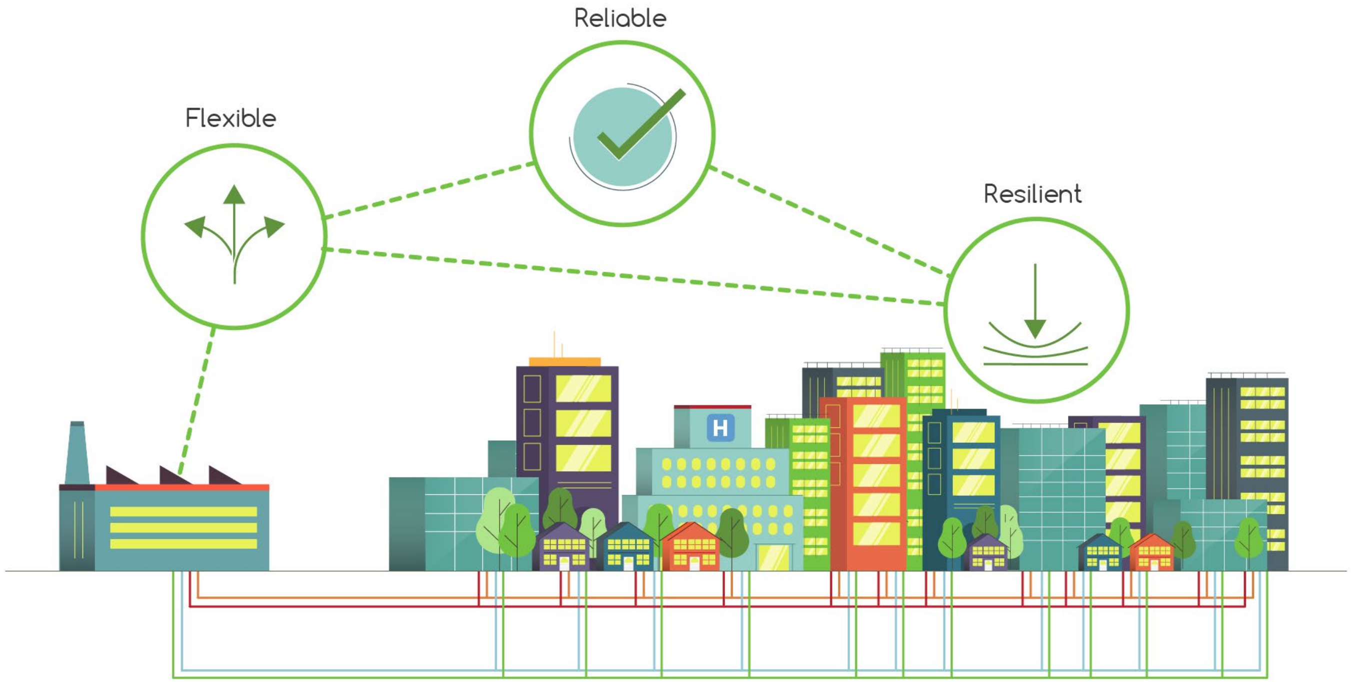


INDUSTRY STATUS – DISTRICT HEATING AND COOLING

5th Generation Substations – Ambient Loops

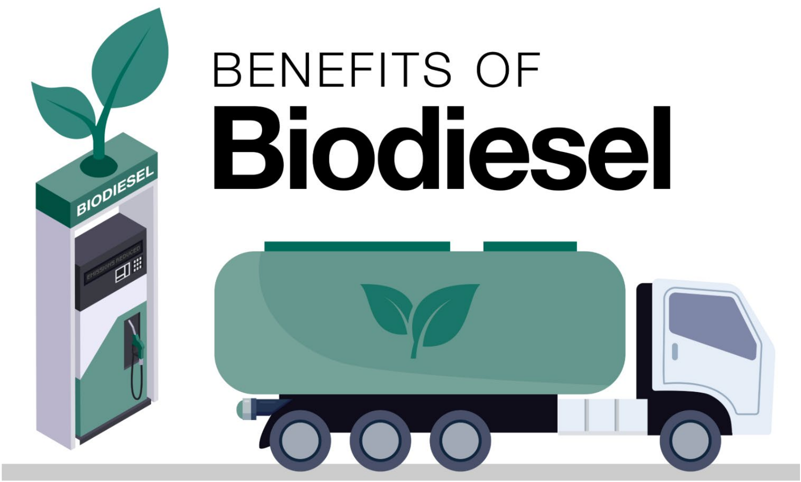
Integration of geothermal wellfields

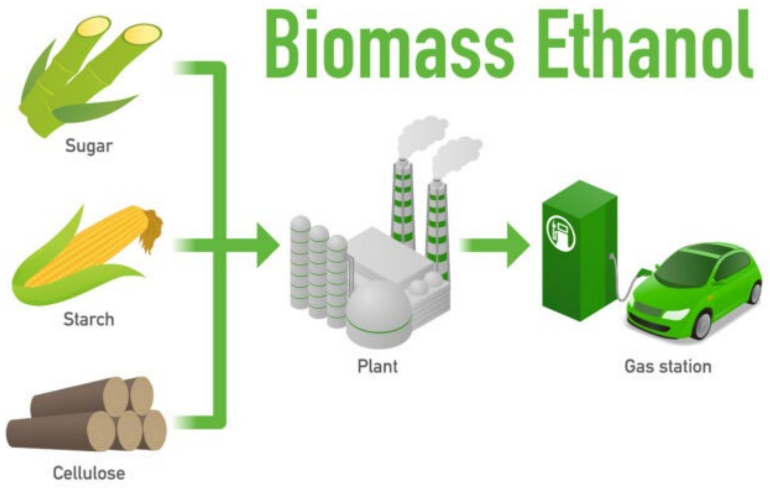
Diversity of equipment location and type



On-Site Energy Technologies

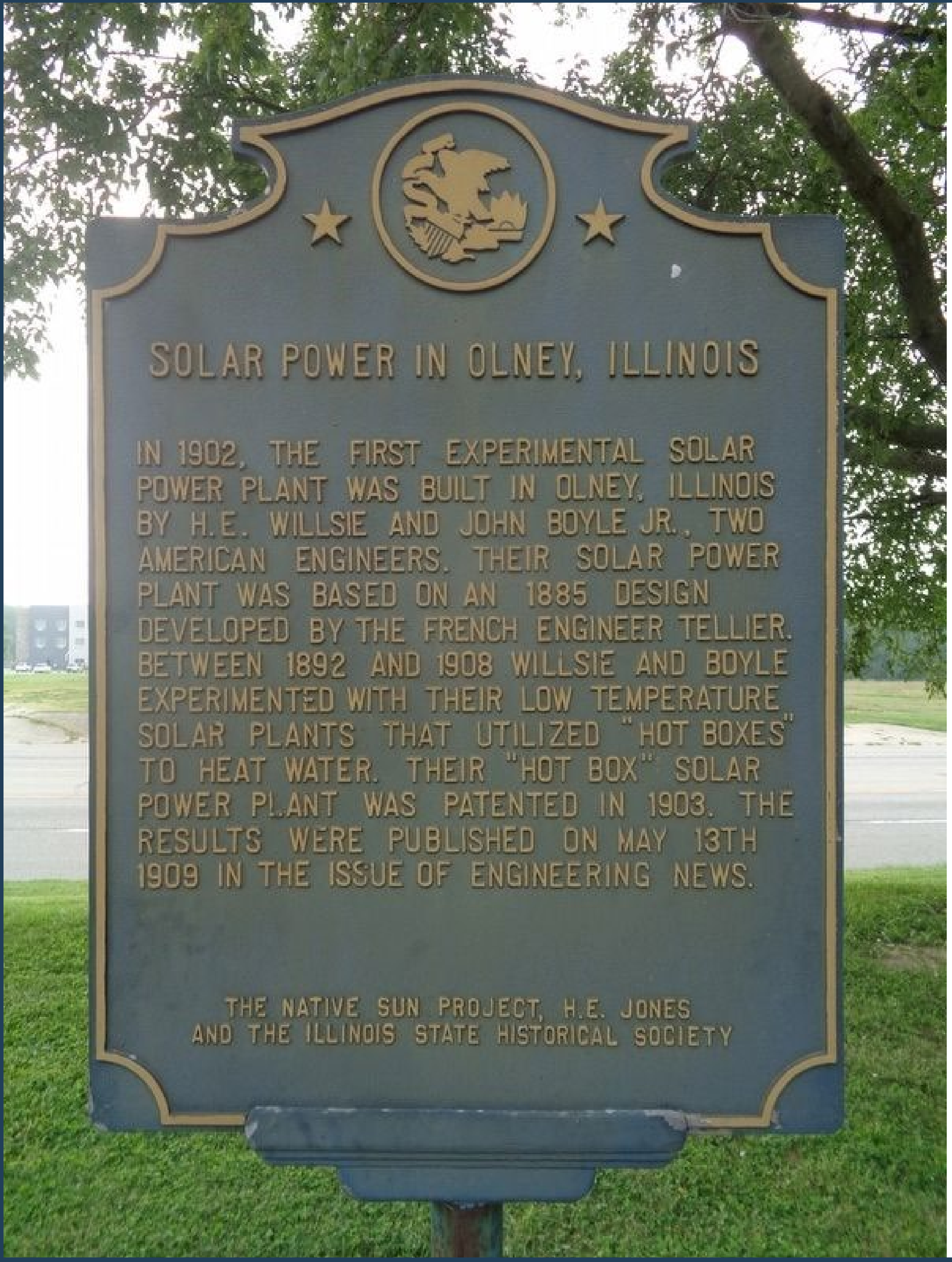
INDUSTRY STATUS – LOW-CARBON FUELS





Case Studies

- **Campus Solar Array**
  - Eastern Illinois
- **Industrial Rooftop Solar**
  - Upstate New York
- **Net Zero Microgrid**
  - Chicago Area
- **Industrial Microgrid**
  - West / South Africa
- **Industrial Cogeneration**
  - Central Illinois
- **Campus Energy Plan**
  - Colorado
- **Off-Grid Station**
  - Greenland



Campus Solar Array

Eastern Illinois

Introduction:

- The college campus sought a renewable energy source, aligning with local enthusiasm for the project.
- Desire to take advantage of federal and state funding opportunities.

Project Requirements:

- Maximize Solar PV generation within a $1.25 million budget.
- Provide enough detail on generation analysis and cost estimating to receive approval for full design-bid-build process.
- Gain board approval of final costs.

	Size of the PV System (kW DC)	Maximum Energy Savings Using PV ($/yr) *	First Cost for PV System ($)	First Cost for PV System, Civil, and Electrical Work ($)	Payback Period without incentives (yr)	First Cost w/ incentives ($)**	Payback Period with incentives (yr)**
1	2,800	$ 328,405	$ 9,800,000	$ 10,030,000	30.5	$ 5,015,000	15.3
2	1,400	$ 166,079	$ 4,900,000	$ 5,090,000	30.6	$ 2,545,000	15.3
3	1,000	$ 118,226	$ 3,500,000	$ 3,675,000	31.1	$ 1,837,500	15.5
4	400	$ 48,510	$ 1,400,000	$ 1,530,000	31.5	$ 765,000	15.8
5	350	$ 40,065	$ 1,225,000	$ 1,340,000	33.4	$ 670,000	16.7
6	250	$ 29,556	$ 875,000	$ 985,000	33.3	$ 297,500	10.1
7	125	$ 14,544	$ 437,500	$ 527,500	36.3	$ 263,750	18.1
8	75	$ 8,492	$ 262,500	$ 344,500	40.6	$ 110,250	13.0
9	50	$ 5,442	$ 175,000	$ 250,000	45.9	$ 85,000	15.6
6+9		$ 34,999	$ 1,050,000	$ 1,235,000	35.3	$ 382,500	10.9

Table 2. Solar PV Payback Analysis

Incentives:

1. Federal Tax Solar Credit – Inflation Reduction Act (IRA)

- Energy Communities Bonus of 10%.

- Domestic Content Bonus of 10%

A total of 50% incentive has been incorporated into the incentive calculations.

2. IL Solar for All

3. IL Clean Energy Community Foundation

4. Illinois Shines - Solar Renewable Energy Credit (SREC)

Campus Solar Array

Eastern Illinois

Problem:

- Limited and inflexible funding.
- Inflationary pressures and material availability.
- Low interest from labor market for smaller systems.

Outcome:

- Fencing costs well exceeded the budget!
- Board approval difficult due to incentive details.
- Smaller array than desired.

Campus Solar Array

Eastern Illinois

Issues Involved:

- Federal and State incentives
- Budgeting and procurement process
- Knowing the target

Key
Takeaways:

- Up-front review cost structures with financial stakeholders
- Contractor involvement when budget is fixed
- Simplify and communicate the project goals

Industrial Rooftop Solar

Upstate New York

2.0-Megawatt roof-mounted system on ballasted aluminum racking.

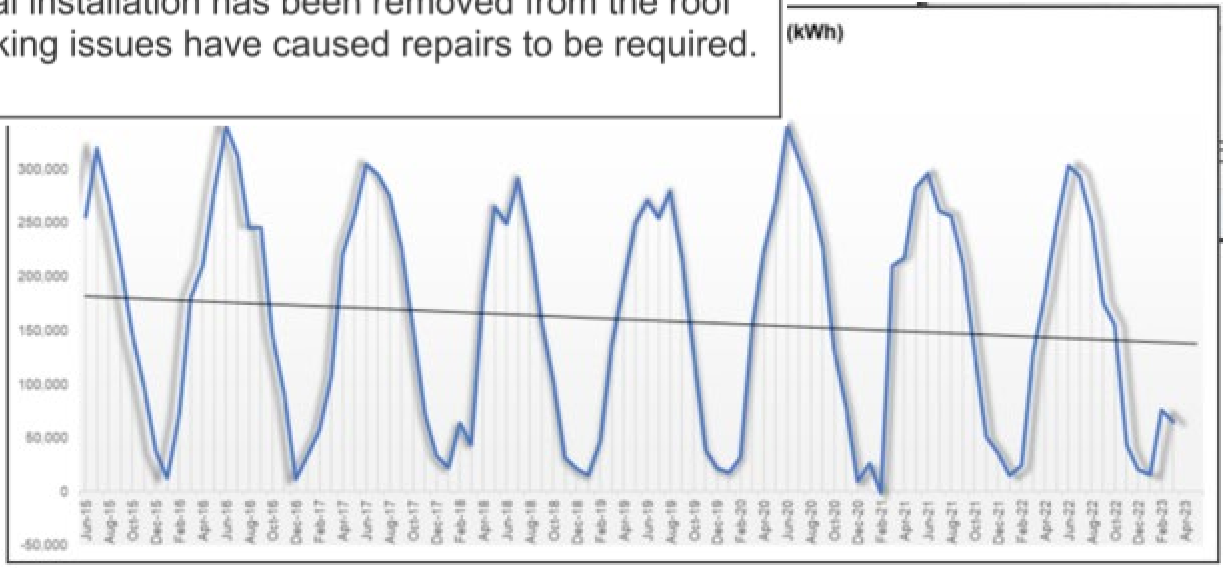
Installed in 2015 as part of a PPA contract where the vendor retains the renewable energy credits funded by the state of NY.

Contract length is 18 years, with an annual cost to Cummins for the system.

There is a buy-out option for the system, and [redacted] analysis shows an approximately $100K net added cost to end the PPA in 2024 vs. completing the contract.

The generation profile on an annualized basis has typically been within 10% of the projected output included in the PPA.

This original installation has been removed from the roof as roof leaking issues have caused repairs to be required.

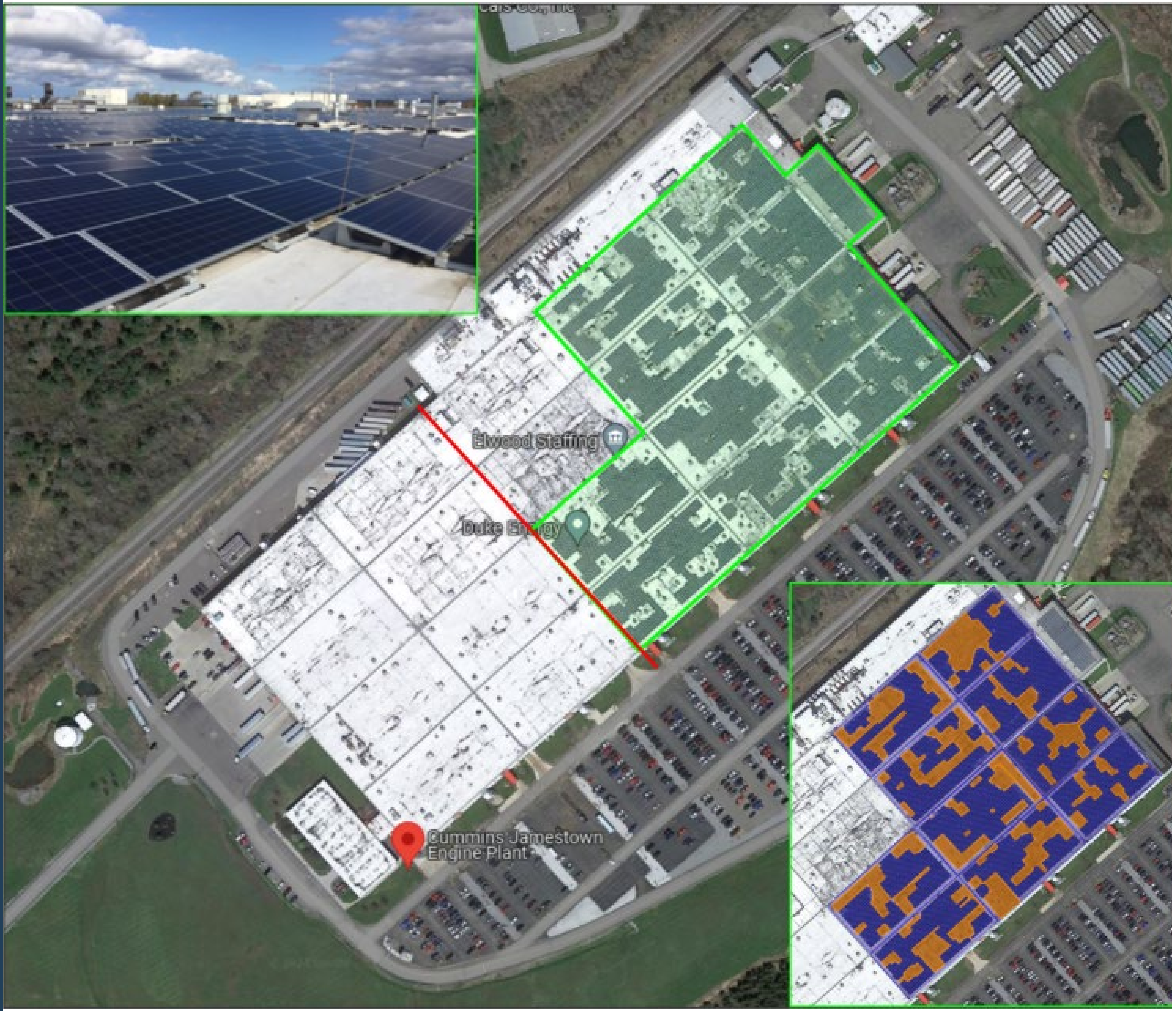


Introduction:

- An existing rooftop solar PV array had to be removed for roof repair and replacement.
- The warranty did not cover the cost of solar array removal. The roofing company blamed the array.

Project Requirements:

- Determine whether the solar PV array, owned by a 3rd party, should be re-installed on the roof.
- Determine viability of an alternate ground-mounted location.
- Review financial concerns of options, including selling / disposal.



Industrial Rooftop Solar

Upstate New York

Problem:

- Removal and replacement electrical costs were very high.
- Shipping and redeployment more expensive than buying new.
- Resale value of PV modules was minimal. Recycling costs high.

Outcome:

- Least costly option was to remove system from site, purchase RECs on the NY state market.
- Assisted owner in selecting removal methods.
- Wrote new standards for rooftop installations.

Industrial Rooftop Solar

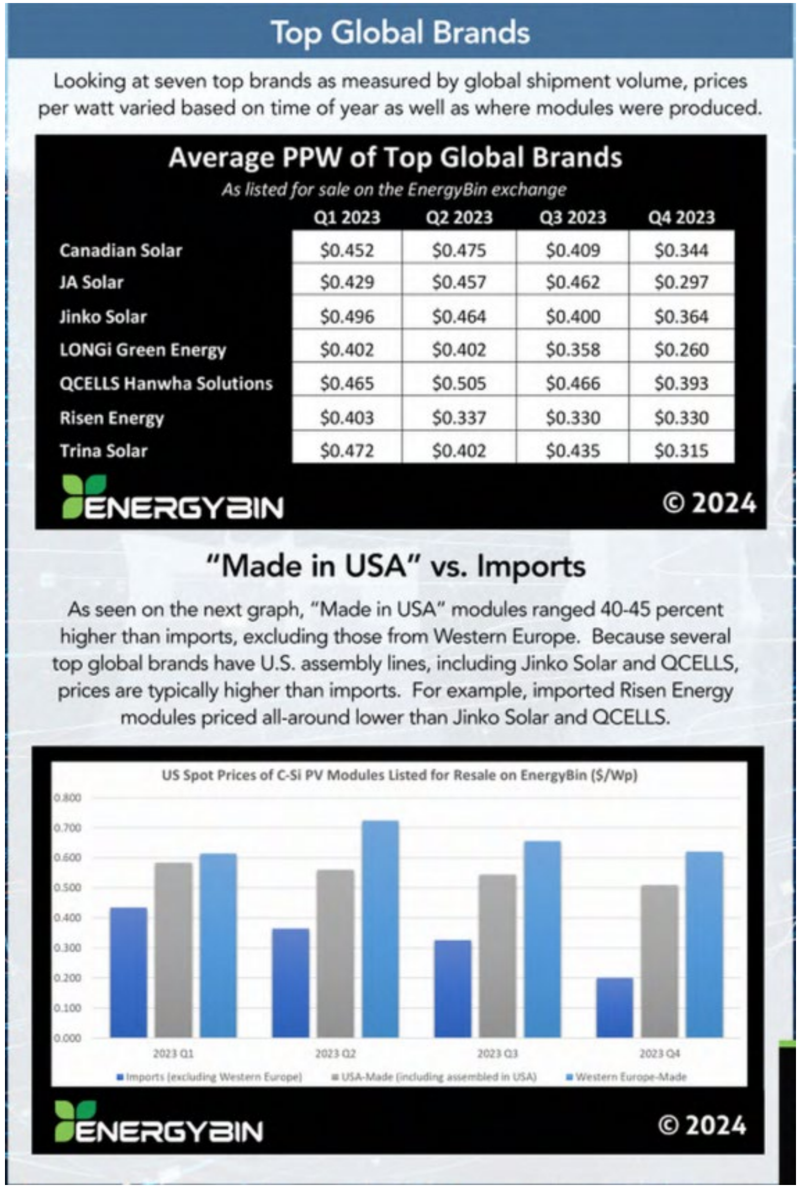
Upstate New York

Issues Involved:

- Solar PV operations agreements
- Roofing warranty coordination
- PV module depreciation

Key Takeaways:

- Rooftop installations must have involvement of the roofing installer and manufacturer.
- Have a long-term strategy for 3rd party agreements.
- Have a removal and recycling plan for year 20-30.



Top Global Brands

Looking at seven top brands as measured by global shipment volume, prices per watt varied based on time of year as well as where modules were produced.

Average PPW of Top Global Brands

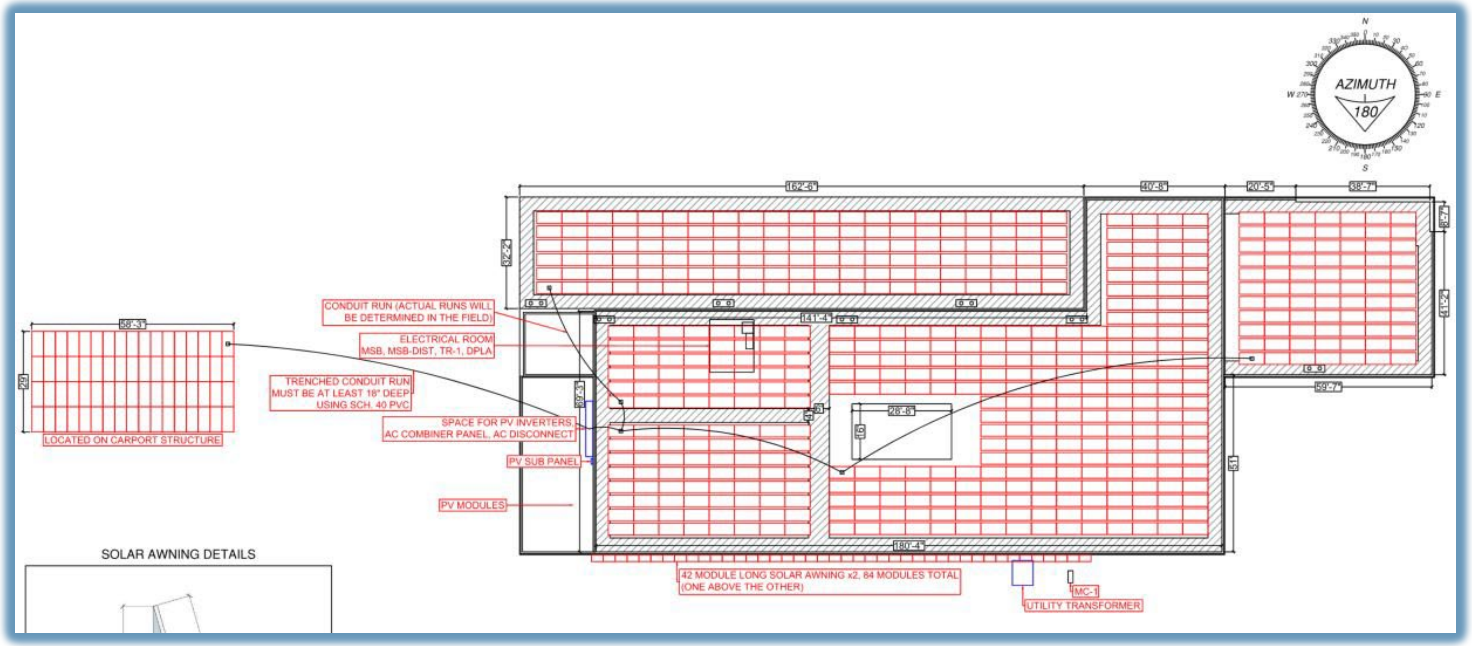
As listed for sale on the EnergyBin exchange

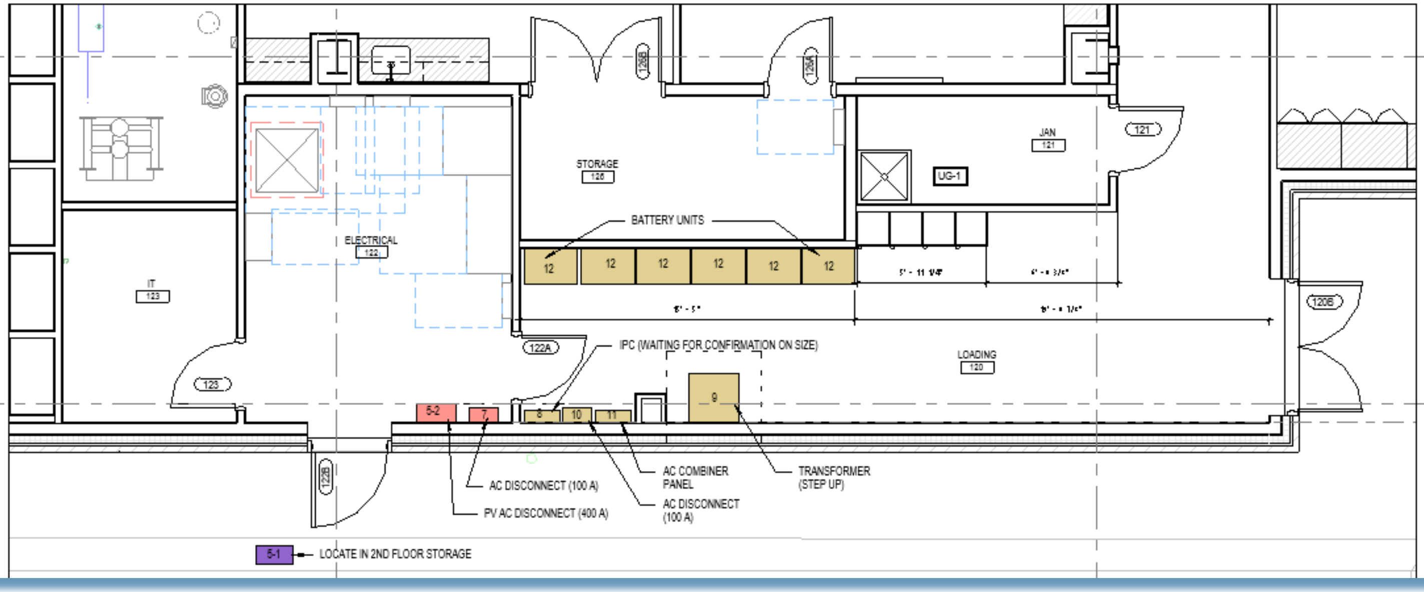
	Q1 2023	Q2 2023	Q3 2023	Q4 2023
Canadian Solar	$0.452	$0.475	$0.409	$0.344
JA Solar	$0.429	$0.457	$0.462	$0.297
Jinko Solar	$0.496	$0.464	$0.400	$0.364
LONGi Green Energy	$0.402	$0.402	$0.358	$0.260
QCELLS Hanwha Solutions	$0.465	$0.505	$0.466	$0.393
Risen Energy	$0.403	$0.337	$0.330	$0.330
Trina Solar	$0.472	$0.402	$0.435	$0.315

ENERGYBIN © 2024

"Made in USA" vs. Imports

As seen on the next graph, "Made in USA" modules ranged 40-45 percent higher than imports, excluding those from Western Europe. Because several top global brands have U.S. assembly lines, including Jinko Solar and QCELLS, prices are typically higher than imports. For example, imported Risen Energy modules priced all-around lower than Jinko Solar and QCELLS.





Net Zero Microgrid

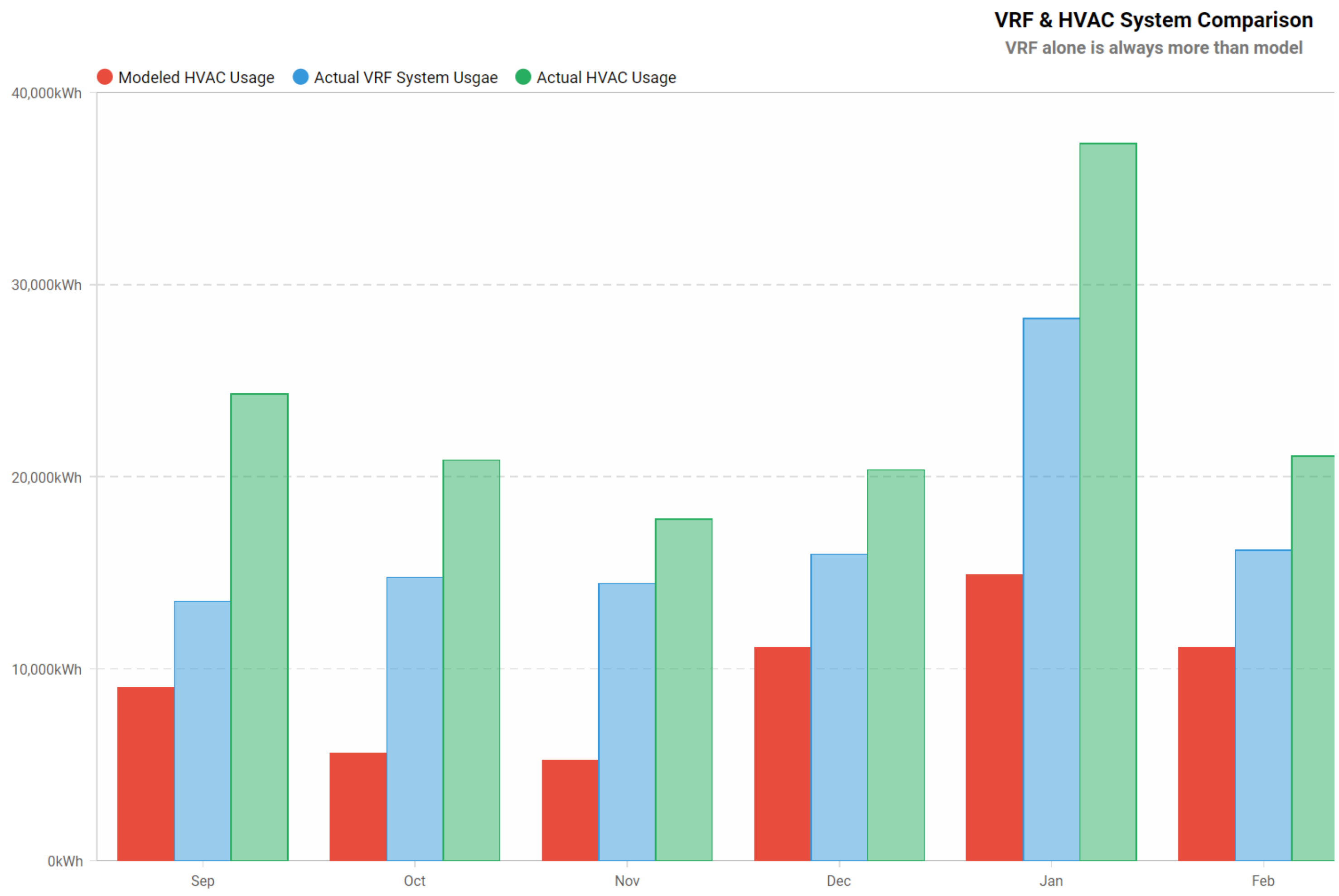
Chicago

Introduction:

- Recreation center project initiated with grants for net-zero operation, LEED platinum, microgrid technologies.
- Project financials did not work without the funding assistance.

Project Requirements:

- Show net-zero electrical use within the 1-year period after start of operations.
- Provide community shelter function using the BESS / Microgrid for backup power.
- Solar PV used for the site generation system.



Oak Park	January	February	March	April	May	June
Modeled Month / Annual Total	4.46%	5.68%	8.31%	10.11%	11.21%	12.33%
Modeled Energy Generation	17,087	21,762	31,802	38,695	42,901	47,198
Actual Energy Generation	3,727	20,716	28,375			
Difference	(13,361)	(1,046)	(3,427)			
% Difference	**-78%**	**-5%**	**-11%**			

Net Zero Microgrid

Chicago

Problem:

- No budget initially established for the BESS / microgrid components.
- PV production not meeting targets, 3rd party EPC difficulties.
- Minimal requirements for continued commissioning, verifications.

Outcome:

- Late corrections made to the PV arrays, additional modules required.
- Battery system too small (but is expandable).
- Heavy energy use reductions required.

Net Zero Microgrid

Chicago

Issues Involved:

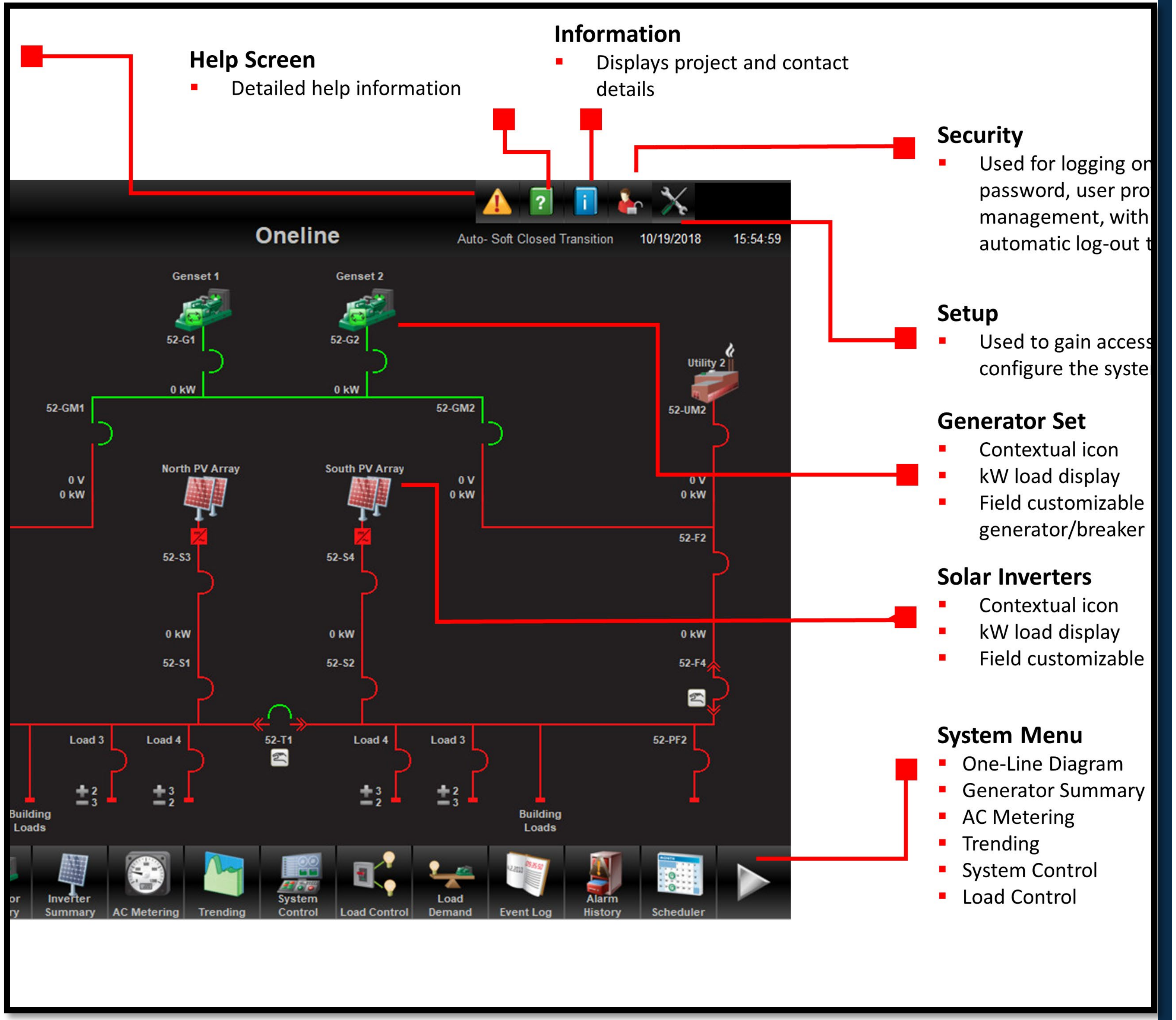
- Solar PV operations agreements
- Measurement and Verification
- Process and budget

Key Takeaways:

- Keep the project team involved post-occupancy, through warranty period.
- Include Cx, M&V activities in contract documents.
- Spend time in a pre-design phase to line out essential project requirements and budgets.

Industrial Microgrid

West / South Africa



Introduction:

- Locations require on-site power systems due to reliability issues.
- Full site operation needed at any time of day.
- Opportunity to implement advanced microgrid automation.

Project Requirements:

- Grid interconnection and islanding transitions needed to be seamless.
- Integration of Solar arrays, BESS, diesel RICE engines.

Industrial Microgrid

West / South Africa

Problem:

- New and untested equipment, software, protocols.
- Sites remote from technical staff.
- Limited project team.

Outcome:

- Project commission timeline went far past initial estimates.
- Solar array installation took 3 iterations to complete, major comms protocol issues.
- Maintenance not supported and difficult to keep systems fully operational.

Industrial Microgrid

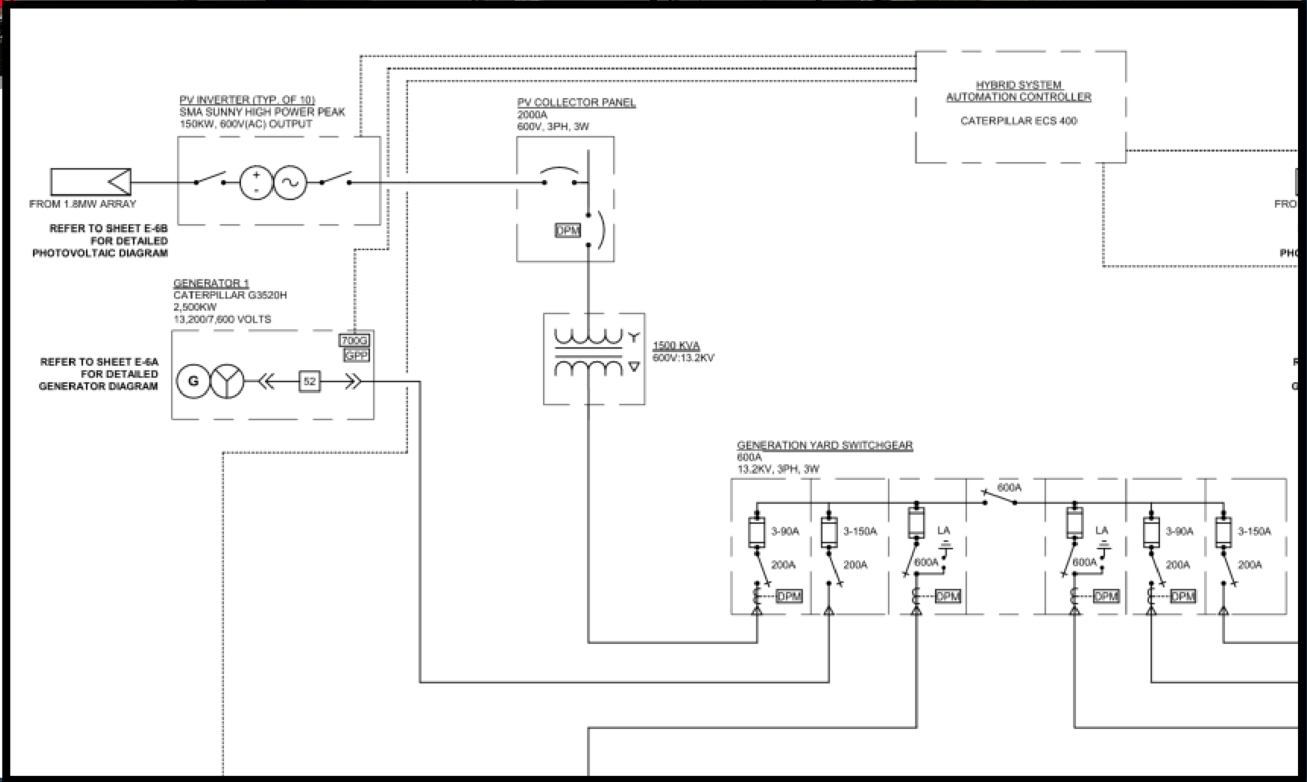
West / South Africa

Issues Involved:

- Component interoperability
- Commissioning
- Automation

Key
Takeaways:

- Test and verify equipment interoperability well in advance of deployment.
- Understand commissioning targets and requirements.
- Pre-plan levels of automation for a stepped 'ramp-up' of the system operations.



Industrial Cogeneration

Central Illinois

Introduction:

- Large site with dedicated utility substation.
- Near constant heating water needs.
- Plenty of available land for PV

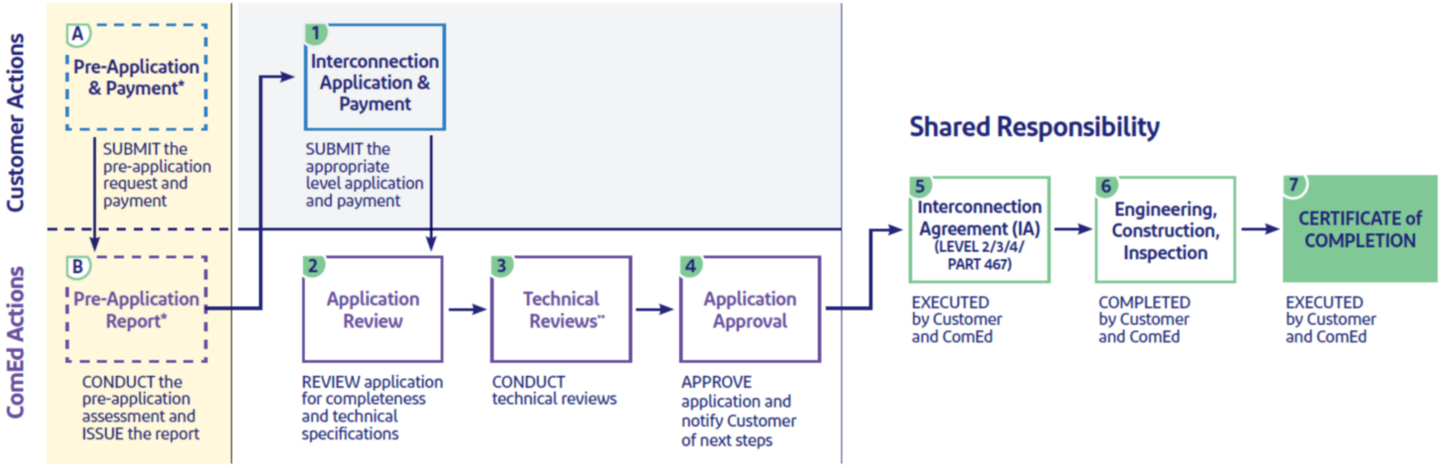
Project Requirements:

- 3.5MW Solar PV array
- 5MW natural gas-fired cogeneration plant
- Microgrid automation controls for peak-shaving, rate curtailment, optimization

Requirements for Interconnection

Interconnection Process Overview

Pursuant to the interconnection rules, DER interconnection requests must undergo the following before permission to operate may be granted:



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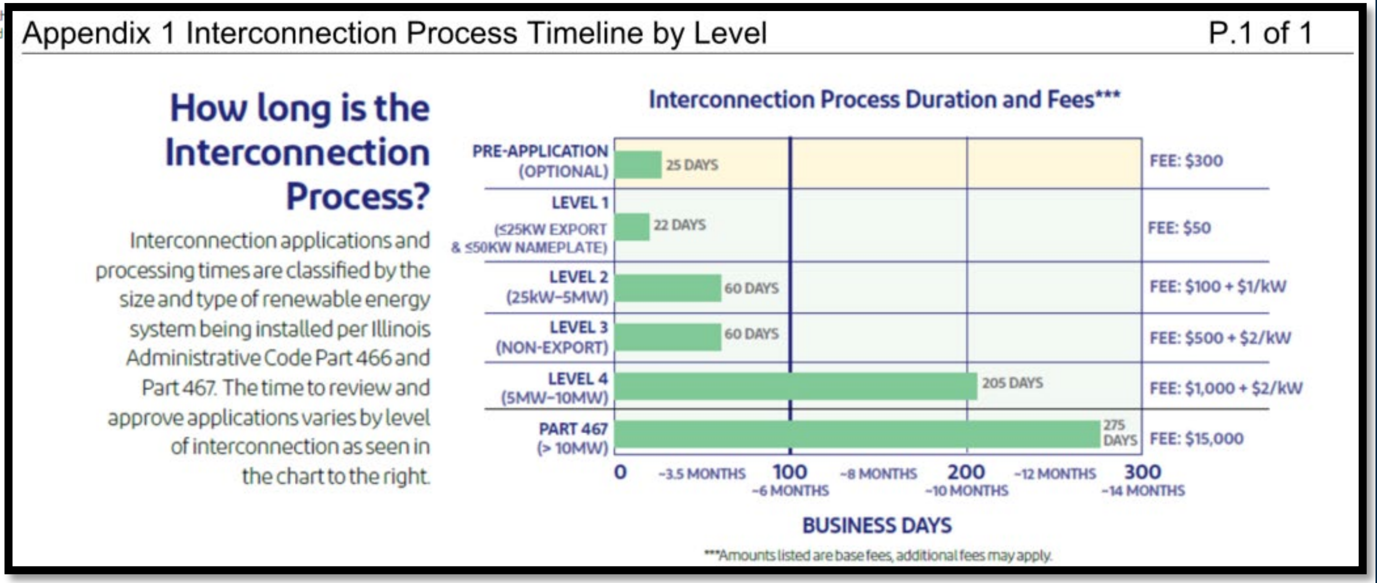


Industrial Cogeneration

Central Illinois

Problem:

- Construction must start in 2024, per IRA requirements
- Unfriendly interconnection process
- High costs to implement system

Outcome:

- System fully designed
- Construction has started meeting IRA minimums
- Interconnection applications finalized

Industrial Cogeneration

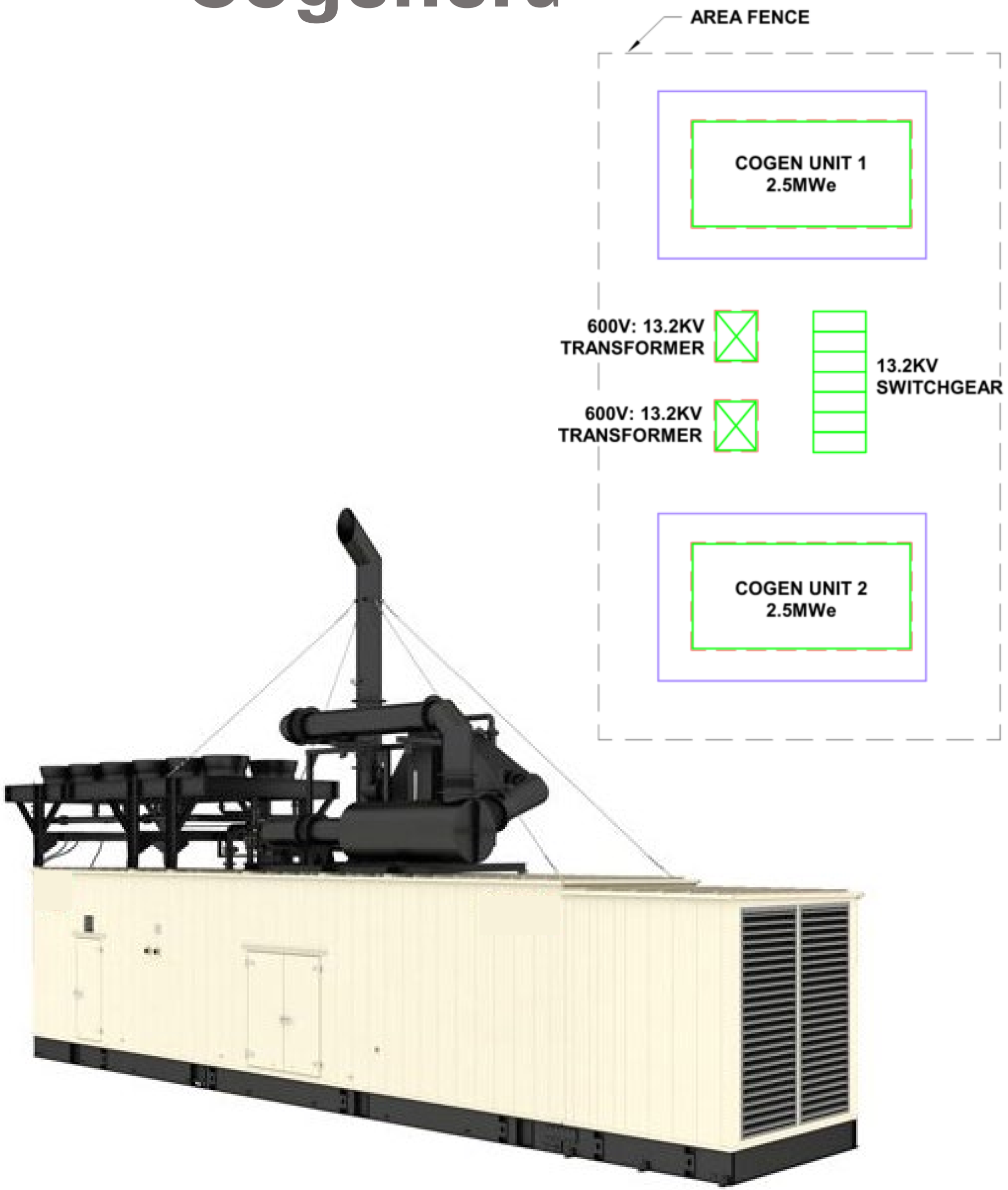
Central Illinois

Issues Involved:

- Utility interconnection agreements
- Inflation Reduction Act
- Process and budget

Key Takeaways:

- Start utility interconnection planning well in advance of implementation deadlines.
- Understand current IRA incentive requirements and timelines.
- When incentives and interconnection costs determine project viability, allow for proving out within project schedule.



Property Type	2026-2029 Site EUI (kBtu/square foot)	2030-2050 Site EUI (kBtu/square foot)	2026-2029 GHGI Intensity (kg CO2e/square foot)	2030-2050 GHG Intensity (kg CO2e/square foot)
Ambulatory Surgical Center	79.2	63.5	4.9	2.8
Hospital (General Medical & Surgical)	217.6	172	13.5	7.7
Laboratory	200.7	161	12.5	7.2
Medical Office	76.7	64.9	4.8	2.9
Other - Specialty Hospital	217.6	172	13.5	7.7
Outpatient Rehabilitation/Physical Therapy	79.2	63.5	4.9	2.8
Residential Care Facility	68	57.7	4.2	2.6
Urgent Care/Clinic/Other Outpatient	76.7	64.9	4.8	2.9

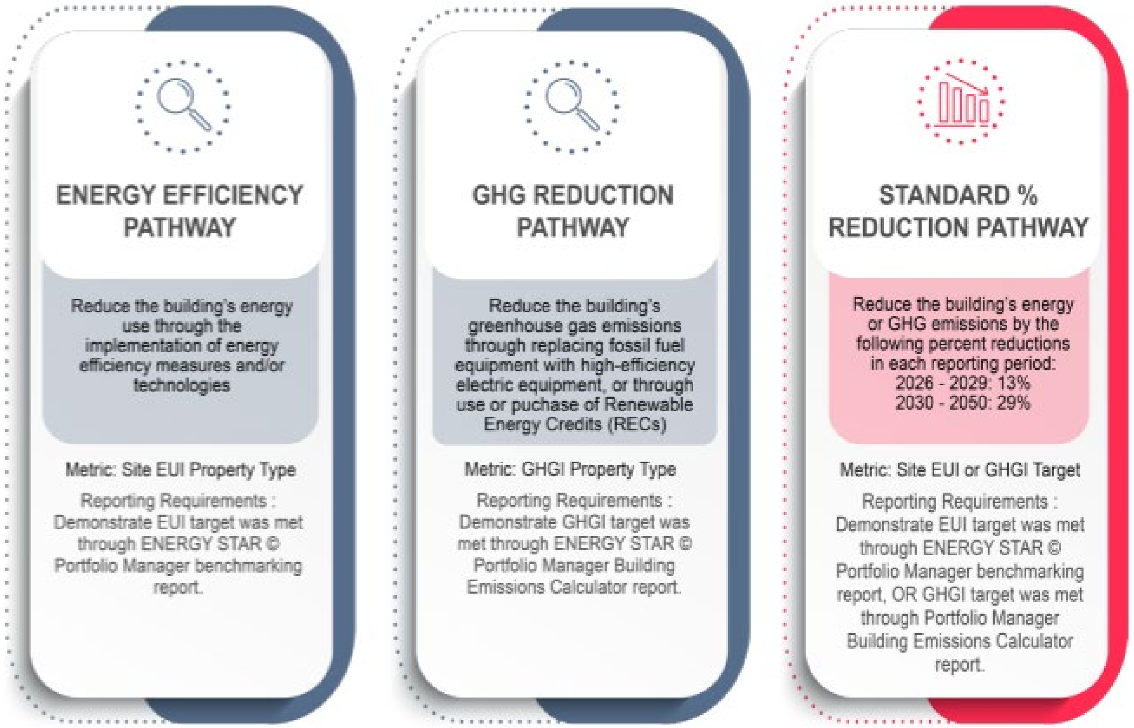


Image 2.2- The Colorado Building Benchmarking and Performance Standards (BPS) pathways to compliance.

Campus Energy Plan

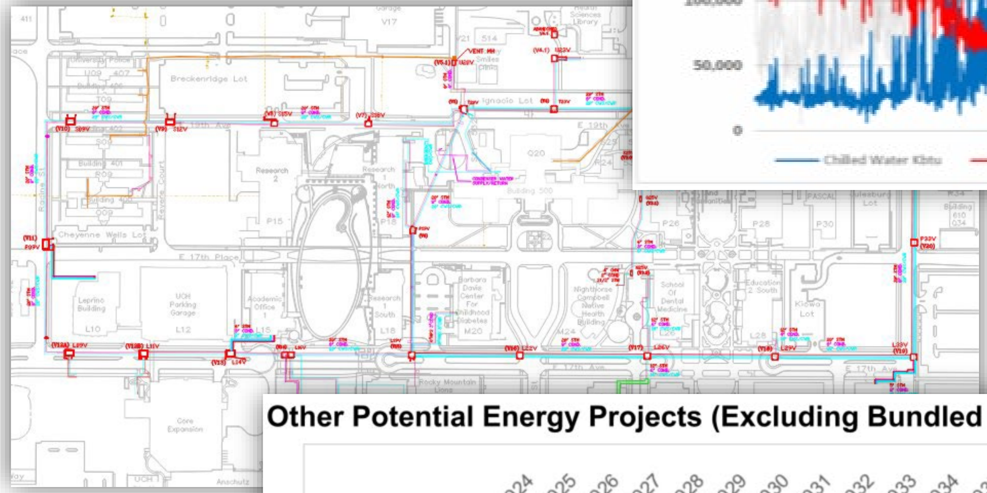
Colorado

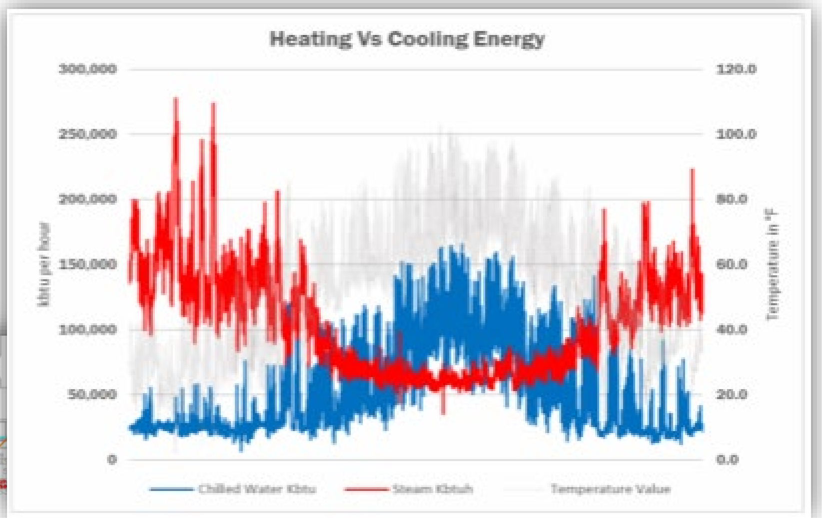
Introduction:

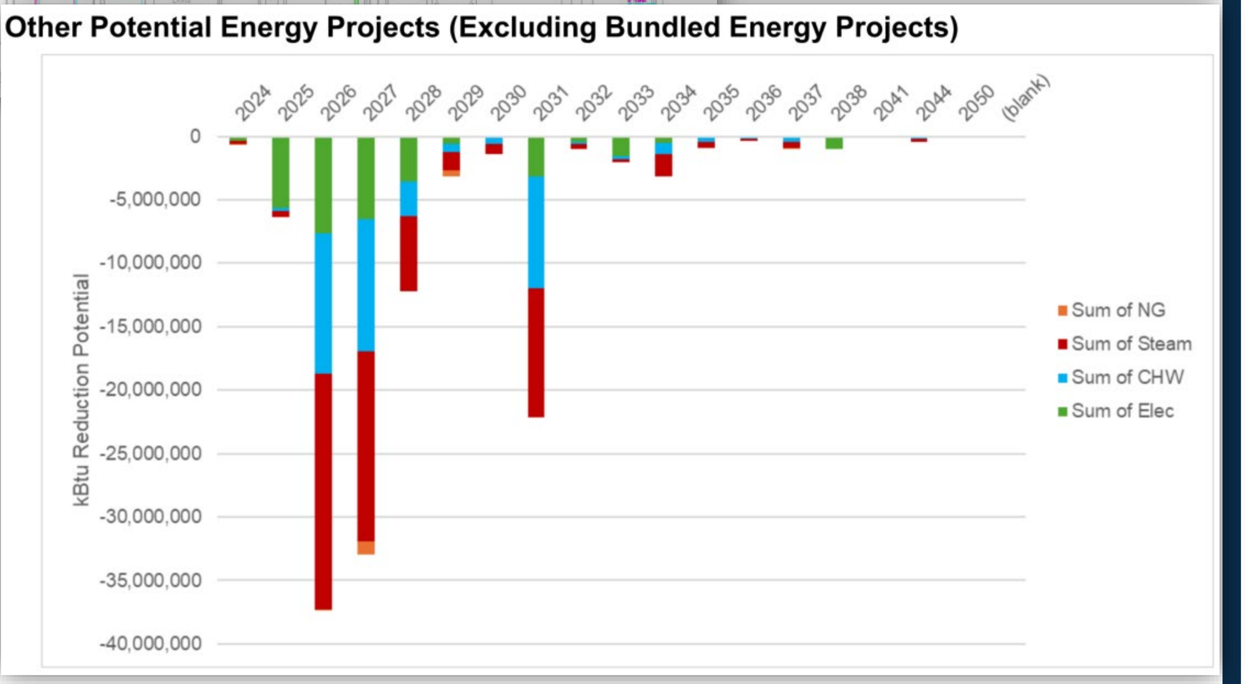
- State mandates newly require energy benchmarking and use reductions over time.
- Campus includes multiple stakeholders on a common central utilities system.

Project Requirements:

- Develop an energy master plan creating a roadmap for decarbonization and compliance.
- Help all stakeholders understand costs and incentives.







Campus Energy Plan

Colorado

Problem:

- Existing gas-fired boilers and electric chillers support most campus buildings.
- Multiple users on the campus present different decarbonization goals and financial incentives.
- Campus growth will require additional energy infrastructure.

Outcome:

- Focus is on energy efficiency measures first. This extends timeline for larger investments.
- HVAC equipment life cycle planning provided schedule of conversions to low-temperature heating.

Campus Energy Plan

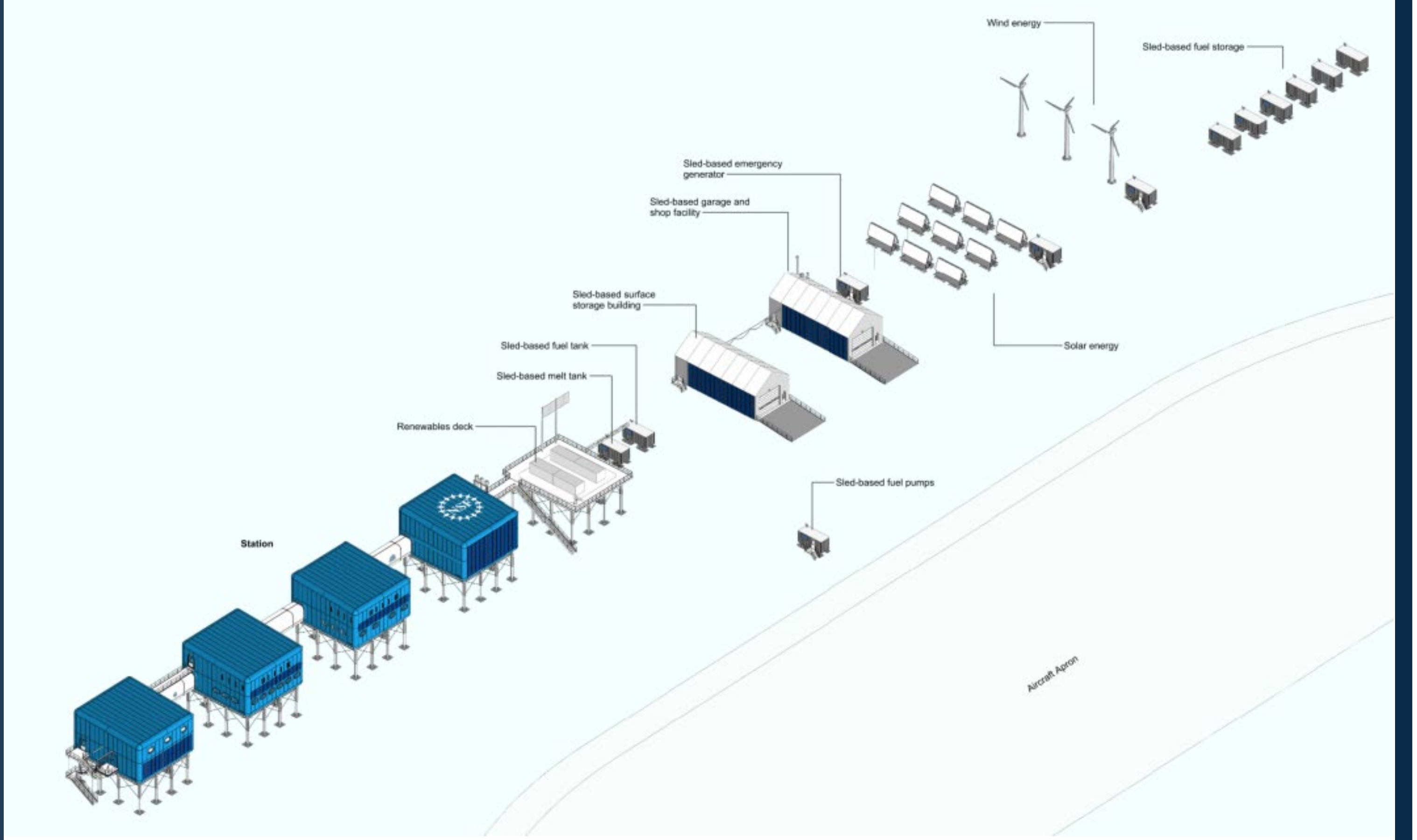
Colorado

Issues Involved:

- Benchmarking data requirements
- Incentive structures
- Planning for utility system changes

Key Takeaways:

- Large infrastructure changes require consistent and a long-term outlook.
- Incentives and mandates are constantly evolving.
- Iterative approaches can minimize cost and space-planning issues.



Off-Grid Station

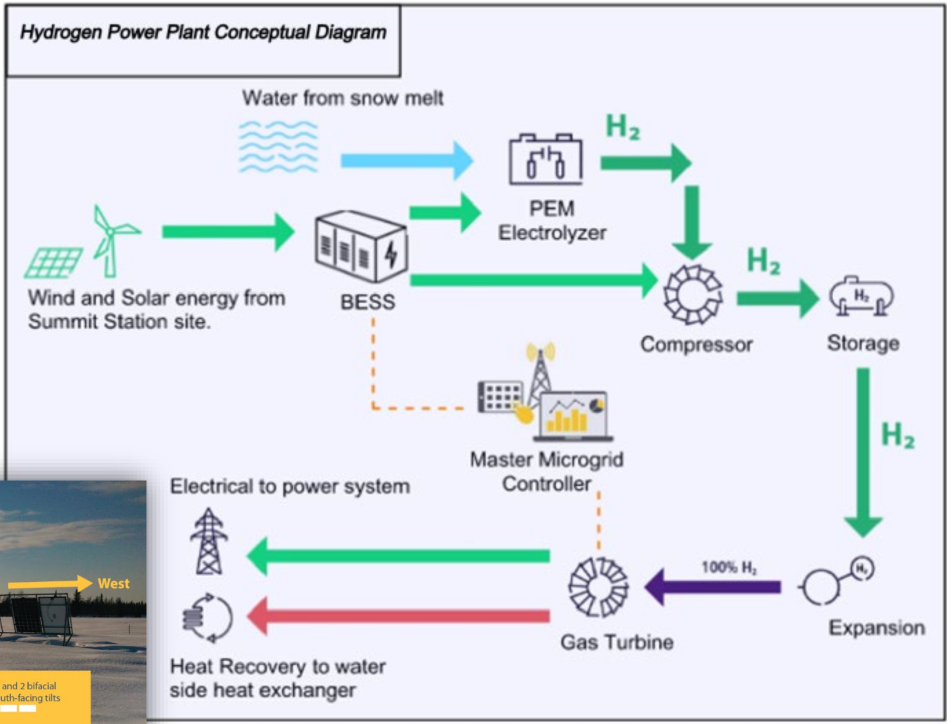
Greenland

Introduction:

- New science station located on top of the Greenland ice sheet
- Submitted for funding, construction complete by 2030

Project Requirements:

- Highly utilization of renewable energy sources
- Automation and remote management via microgrid control system.
- High level of power plant reliability.



Off-Grid Station

Greenland

Problem:

- Existing station runs entirely on Jet-A fuel.
- Complex systems are difficult to maintain in this remote location.

Outcome:

- Renewable generation includes Wind, Solar, BESS, Hydrogen.
- Planning for future Fuel Cell or Nuclear microreactor
- Redundancy through diversity of generation sources.

Issues Involved:

- Leading-edge energy technologies
- Off-grid operations
- Extreme conditions

Key Takeaways:

- Provide systems that can achieve specific project goals to ensure time and $$ is not wasted.
- Decarbonization goals are pushing designers to utilize long-term solutions.
- R&D efforts are progressing rapidly from benchtop to proving grounds.

Off-Grid Station

Greenland

LESSONS LEARNED AND KEY TAKEAWAYS

- Energy-focused projects are becoming more complicated.
- Incentive structures, costs, and regulations can change drastically from year to year.
- Take the time to understand the level of complication. Pull the right people together.
- Ensure the implementation team has the time and tools they needs to accomplish the project requirements.
- Build system operations into the project plan.
- Set the processes and timelines to match project needs.
- Provide flexibility for the future. The energy economy is moving quickly!

Thank you.

Chris Edward

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