AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

Making Resiliency Reality Through Electrification, Renewable Energy, and Electric School Buses

Module 2 in the Energy CLASS Prize "Resilience" Course
February 20, 2024

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STATE & COMMUNITY ENERGY PROGRAMS

Welcome

Let's get to know each other!	10 mins
Lesson Plan • Review Session #1 • Electrification Readiness in Schools • Renewable Energy Options • Electric School Buses • Case Study	1 hour 20 mins
Discussion	30 mins

Course Objective

Establish a baseline understanding of resistance and resilience, demonstrate how resilience can mitigate climate risk, and highlight tools and resources available to support districts in decision making.

1. Participants will understand the climate emergencies that can impact schools and communities in different geographical areas.

2. Participants will understand the importance of climate resiliency in schools.

3. Participants will understand what pathways districts have to make their schools more resilient over time.

4. Participants will be able to plan for upgrades over time to work towards healthier, safer, and more resilient buildings that protect occupants from indoor and outdoor hazards.

Today's Presenters

Reilly Loveland

New Buildings Institute

Paul Torcellini

NREL

Robert Stafford

WRI

Tim Farquer

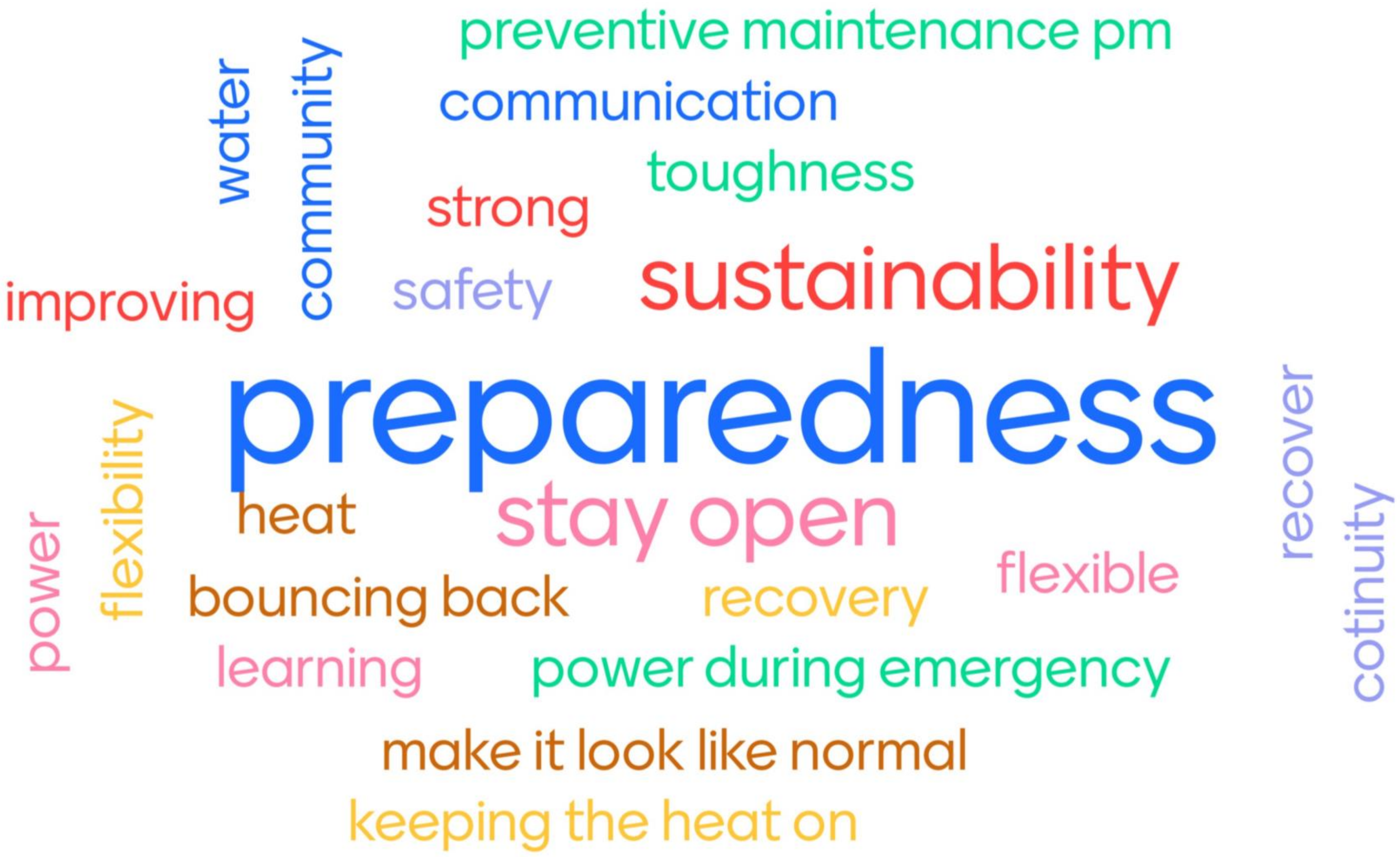
Williamsfield Schools

Forest Tanier-Gesner

PAE Engineers

Session #1 Review

Recap: What Resiliency Means to You



Resiliency needs can change and grow

Based on experiences, priorities, or new challenges.

Portland Public Schools suffer damage during historic ice storm
Credit: OPB

Revisiting basic terms and principles

- All schools are vulnerable to hazards and disasters. Districts should assess the risk of such events and plan accordingly, starting with safety measures that offer resistance.
- Increasing the resilience of a building will help it to "bounce back" more quickly and efficiently when hazards and disasters do occur. This can be accomplished through mitigation and adaptation actions.
- Resilient buildings will use the principles of robustness, resourcefulness, rapid recovery, and redundancy.

Revisiting basic terms and principles

- Resiliency can be addressed in all phases of the building lifecycle.
- A variety of tools are available to understand vulnerability and risk, investigate resiliency actions, and create climate action plans that align with state and local plans.
- Plans should incorporate campus, community, and curriculum-based actions

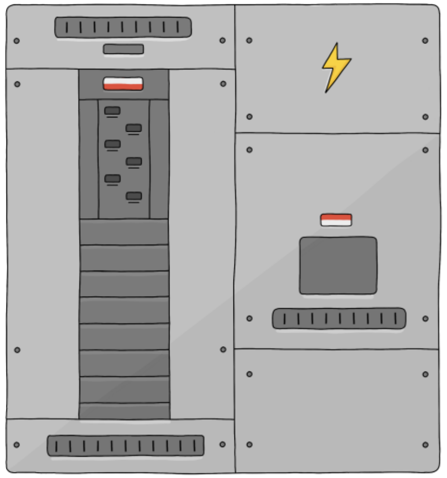
Why resilience in schools is important

Resilient schools can offer a variety of benefits:

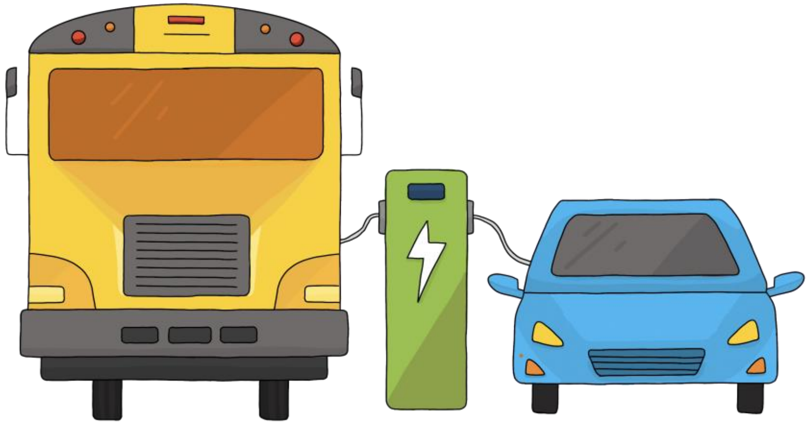
- ✓ Act as community resource center
- ✓ Ensure continuity in operations
- ✓ Stabilize future energy costs
- ✓ Reduce operating and maintenance costs
- ✓ Educate tomorrow's responsible citizens
- ✓ Set the example of what resilience can look like for your community

Technology deep-dive

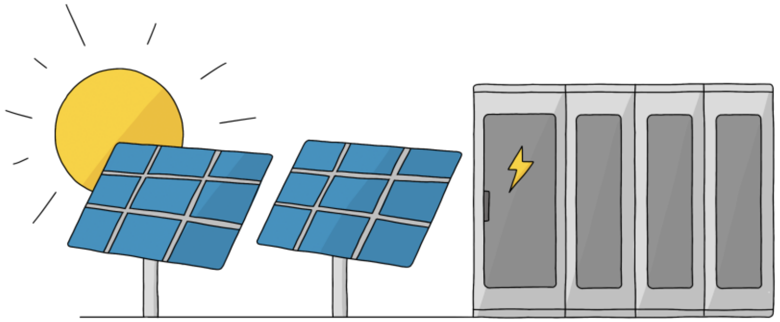
ELECTRICAL TRANSFORMER



ELECTRIC VEHICLE SUPPLY EQUIPMENT



SOLAR PANELS AND STORAGE



Source: Artwork by Nicole Kelner

Mentimeter Time

Do you have any specific issues in your buildings that drive your resiliency considerations (ex. what causes you to close school)?

Electrification Readiness

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What is electrification readiness?

Limiting barriers that impede you from replacing fossil fuel-based systems with electric alternatives.

For example: additional costs to upgrade electrical panels from increase in electrical needs.

Source: PreFast

Why do we need electrification anyway?

- Protect against fossil fuel cost volatility
- Improve air quality (especially buses)
- Save energy (higher efficiency systems)
- Reduce greenhouse gas emissions
- Enhance resiliency by enabling renewables and storage
- Prepare for future codes and policy requirements (e.g., building performance standards)

Electrical systems: key components

Grid

- Power plant
- Transmission lines
- Substation
- Electrical supply – transformers and feeder lines

School

- Main distribution panel
- Subpanels
- Main switchgear and Meters
- Branch circuits and outlets
- Safety and emergency systems
- Network and communication systems

Electrical systems: key components

Grid

- Power plant
- Transmission lines
- Substation
- Electrical supply – transformers ★

School

- Main distribution panel ★
- Subpanels ★
- Meters
- Branch circuits and outlets ★
- Safety and emergency systems
- Network and communication systems

★ Frequent barriers to electrification projects

Electrification Barriers and Solutions

Barrier	Solutions
Underpowered electrical service in older buildings	Measure what the load really is. Apply energy efficiency strategies. Design to the limits. Add storage. Upgrade your service
Costly labor to run new electrical lines	Plan ahead by installing conduit, raceways, cabling, and other infrastructure during construction or major renovations
Risk aversion	Educate stakeholders across all levels (students, faculty, staff, admin, etc.)

Scenario: Kitchen Remodel

Without Electrification Readiness	**With Electrification Readiness**
1. Kitchen designed for gas appliances with limited 240V circuits. 2. No upgrade to electrical panels 3. Gas appliances installed 4. Redo electrical panels back to main switchgear 5. Add 240V outlets and install equipment	1. When the new wing and cafeteria were built, the school designed the electrical infrastructure to accommodate all-electric kitchen. 2. 240V outlets strategically placed where major appliances are located 3. During the remodel, new induction ranges plug into 240V outlets easily

Scenario: Fleet Electrification

Without Electrification Readiness	With Electrification Readiness
1. After winning an electric school bus grant, an electrician assesses the electrical capacity to determine how much charging capacity is available 2. Contractor trenches in parking lot to install electrical raceways to eventual EV charger locations 3. Given the cost of site work, the budget allows for two Level 2 EV chargers	1. Through previous bond work to upgrade the main switchgear and repave the parking lot, additional raceways and electrical capacity were installed 2. After winning an electric school bus grant, the school can install two Level 3 chargers and two Level 2 chargers without the added infrastructure costs

Scenario: Heat Pump Installation

Without Electrification Readiness	With Electrification Readiness
1. Facilities manager pushes back on plan to install heat pumps due to concerns about performance in cold climate	1. District organizes a site visit of existing cold climate heat pumps in the region, where maintenance staff can talk with maintenance staff
2. Engineering firm meets regularly with facilities team and other stakeholder to discuss sizing and performance of heat pumps down to 0°F	2. Facilities manager becomes a champion for new heat pump installation and looks forward to reduced maintenance.
3. On equipment failure, a like-for-like replacement of a gas-fired rooftop unit replacement is installed	3. District allocates energy cost savings to high-priority budget items

Electrification Readiness Summary

System	How to be electrification ready
Kitchen	• Have 240V service in the kitchen and electrical capacity at the panel. • Demonstrate to kitchen staff the benefits of electric cooking equipment to generate buy-in
HVAC	• Verify the building's electrical capacity. Upgrade if needed to accommodate an eventual HVAC load from heat pumps, heat pump chillers, and other equipment • Demonstrate to facilities staff the cold-climate heat pump options and performance (if applicable)

Electrification Readiness Summary

System	How to be electrification ready
Water Heating	• Ensure you have electrical service where there are existing water heaters • For high-demand water heating, ensure you have 240V service and electrical capacity
EV Charging	• When installing new parking or renovating existing lots, install raceways for future electrical wiring to spaces for future EV charger installation • Review electrical capacity for eventual chargers and upgrade service if needed

Electrification Readiness Summary

System	How to be electrification ready
Solar PV and Storage	• Discuss options with your utility regarding interconnection rules and rate options. Ask about maximum size of systems • Allocate space for energy storage systems • Ensure roofs have sufficient structural capacity • Phase solar installation with roof replacement projects. (Design roof replacements to accommodate solar; assess roof penetrations) • If upgrading main panels, design for twice service entrance size. Add conduits to roof. • Review electrical systems with an electrician to assess the solar and storage potential

Electrification Readiness: Existing Buildings

- Create an action plan

Step 4. Prioritize CO_2e Emission Reduction Strategies and Report Data Example

CATEGORIES IN PRIORITY ORDER	SOURCE OF CARBON/ENERGY REDUCTION	STRATEGY	CARBON/ENERGY REDUCTION GOAL (%)
Avoid or use less fossil energy	**Energy efficiency improvements**	**See Step 6.1. Energy Efficiency Example**	**30%**
	Beneficial electrification[a]	Heat pumps replace chillers/boilers	10%
	On-site renewables (owned)	50 kW of photovoltaics (PV) covering 50% of roof	1%
	Off-site renewables	3.1 million kWh	39%

Broad categories for reducing carbon/energy

The percentage of carbon/energy reduction attributable to adopting low carbon/energy solutions in the example building

Better Climate CHALLENGE
U.S. DEPARTMENT OF ENERGY

Action Plan
BETTER BUILDINGS TOOLKIT

A Guide for Creating a Building-Level Action Plan to Improve Energy Efficiency and Reduce Carbon Emissions

Prairie Trails School is the first zero energy renovated school in the United States that also meets the PHIUS+ Source Zero standard for using 40%–60% less energy than conventional buildings.[1] Photo from FGMArchitects @PeterMcCulloughPhotography

Click to download the
Action Plan worksheet
https://www.nrel.gov/docs/fy23osti/85708ActionPlanWorksheet.doc

[1] https://www.fgmarchitects.com/post/prairie-trails-school-first-in-nation-on-key-sustainability-benchmark

https://www.nrel.gov/docs/fy23osti/85708.pdf

Electrification Next Steps!

- Next time you renovate, think of electrification readiness
  - Doing electrical work? Install raceways, branch circuits, and outlets for future installations
  - Trenching? Ask what else can you do to avoid that cost for future projects
- When considering electrification projects:
  - Talk to your utility representative, qualified electricians
  - Educate staff and bring them into the discussion to generate buy-in
- Review the Building Electrification Technology Roadmap for Schools

Increasing Resilience by Generating and Storing Energy

What is Resiliency in Schools?

When extreme weather forces local utilities to cut power, schools remain online, powered by renewable energy that is generated and stored on-site.

When wildfire smoke fouls the air, school ventilation and filtration systems maintain clean cool air, providing respite for students and their families.

When temperatures soar, children play on tree-sheltered schoolyards with pervious, heat-deflecting surfaces and drought-tolerant landscaping.

When students struggle to make sense and find balance in the face of uncertainty, their schools offer connection, competence, and hope in the future.

Resiliency is about strengthening the weakest link and providing multiple pathways.

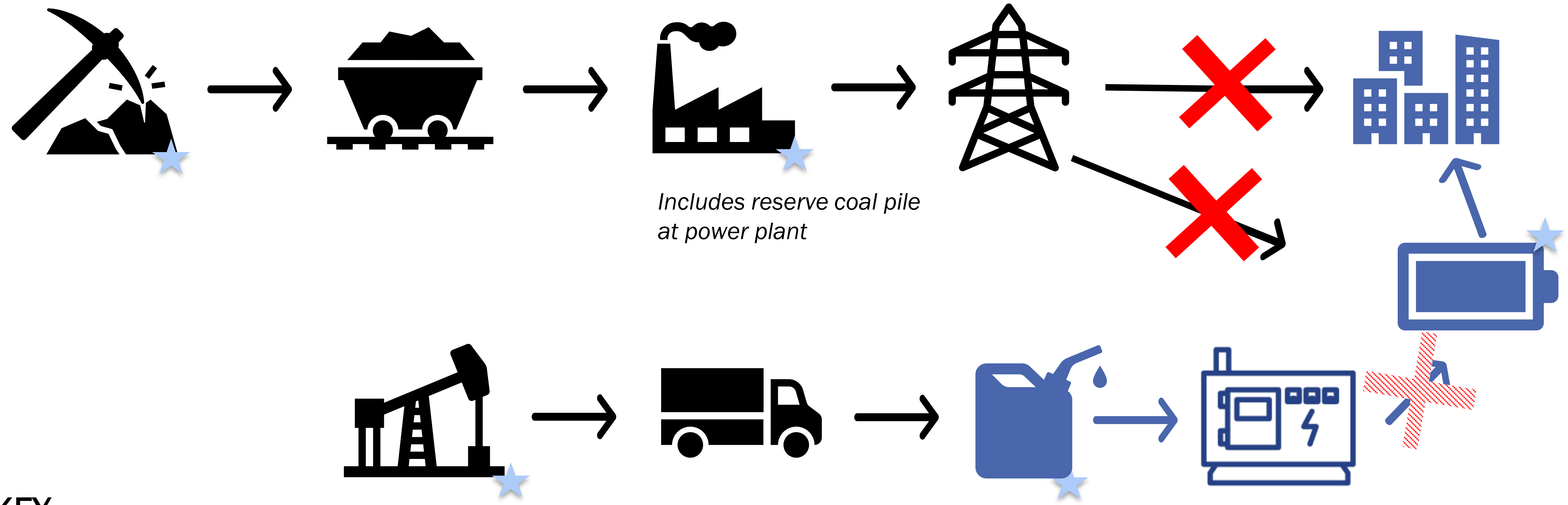


Image Credit: Torcellini, Goetsch, Schott/NREL

KEY
- ★ Indicates potential energy storage
- ✗ Indicates weakest link along the pathway
- Indicates intermittent weakness along pathway
- → Within site boundary

Generator with onsite battery

Presumably less risk when weak links are within the site boundary

Onsite Generation and Energy Storage

Onsite Generation – Electricity produced locally and delivered straight to the building. Includes solar PV and generators

Electrical storage – Energy storage that can directly output electricity to power building systems. Includes Lithium-Ion batteries, electric vehicles, and other battery types

Thermal storage – Hot or cold energy that can be stored and used to support or temporarily replace certain HVAC systems. Includes ice and hot water

Fuel storage – Most commonly refers to fossil fuels that can be burned. Includes diesel, propane, etc.

Where does energy generation and storage fit in?

Onsite generation and storage

- Reduces reliance on electricity grid
- Offers backup power in case of outage

Building systems

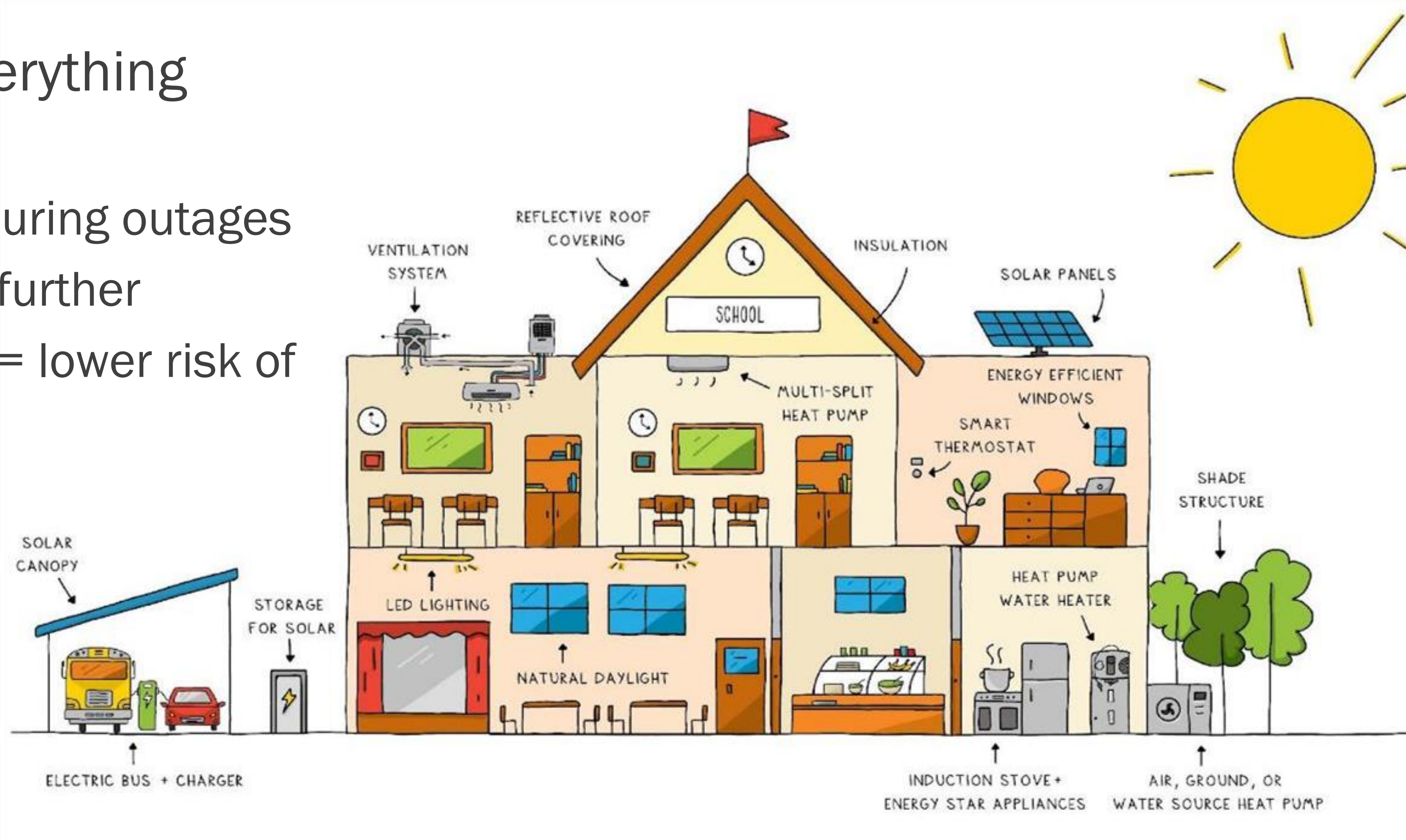
- Defines the magnitude of total energy consumption and power required to run the building

Building Envelope

- Passively impacts building system energy consumption and how quickly the building gains or loses heat to the outdoors

Don't forget energy efficiency

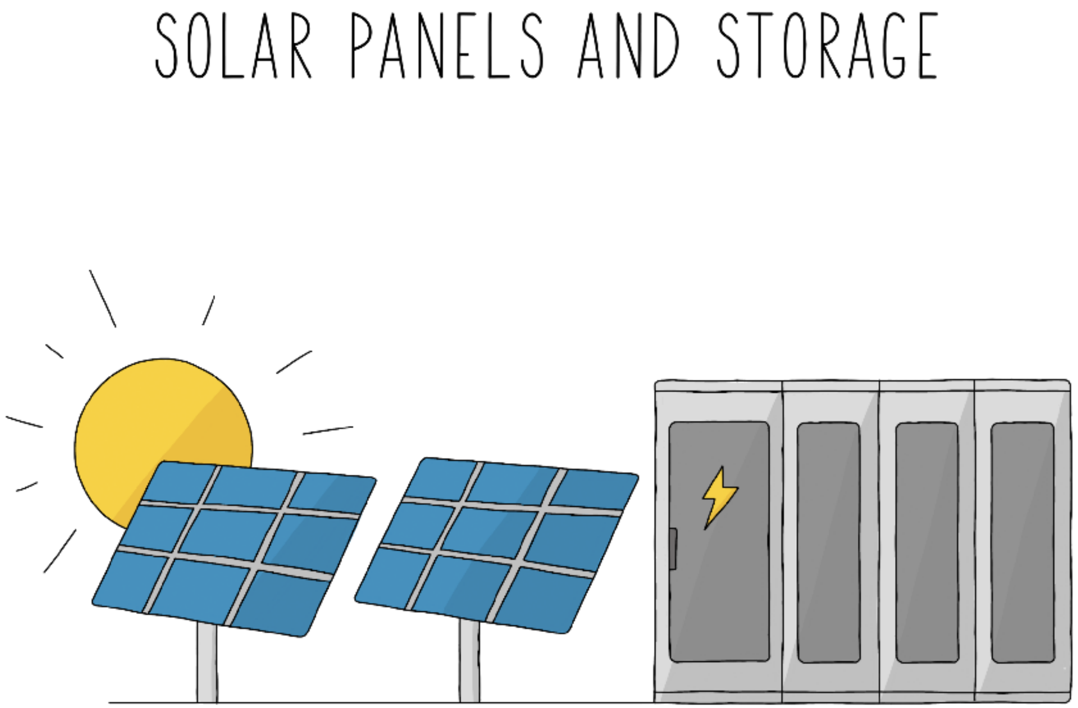
- Efficiency makes everything easier.
  - Increased comfort during outages
  - Stored energy goes further
  - Lower grid demand = lower risk of outage



Source: Artwork by Nicole Kelner

Electrical storage

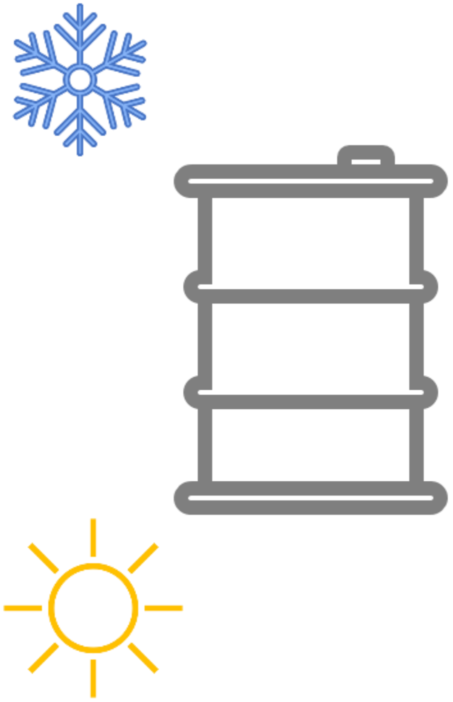
- Batteries are charged from the grid, onsite generation, or both
- Energy stored in the batteries can then be deployed to minimize energy costs, earn incentives from utility programs, and provide backup power to building systems



Source: Artwork by Nicole Kelner

Thermal storage

- Ice Systems
  - Special chillers make ice that is stored in highly-insulated tanks at night or when electricity is inexpensive
  - When electricity costs are high, the HVAC system uses the stored ice to provide cooling to the building, using a fraction of the normal energy use
- Hot Water Systems
  - Similar concept as ice systems – heat and store water in insulated tanks (just like tank water heaters) to deploy when electricity is expensive, or have on hand for resiliency in case of an outage



Key energy storage considerations

- Consider the size of the storage system – how much load do you want to backup, and for how long?
- Are you in a hot climate? That may point to an ice system
- Do you have physical space for storage?
- Do you have someone who understands and can maintain the system?
- What utility rebates and tax credits are available to you?

Mentimeter Time

What resilient design and operations practices does your organization currently utilize?

Instructions

Go to

www.menti.com

Enter the code

6179 5897

Or use QR code

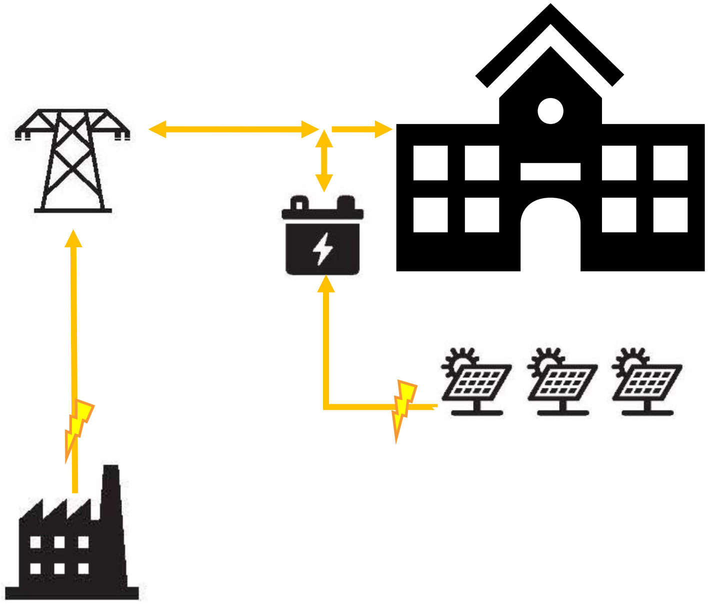
Microgrids as Resiliency

What is a microgrid and how does it work?

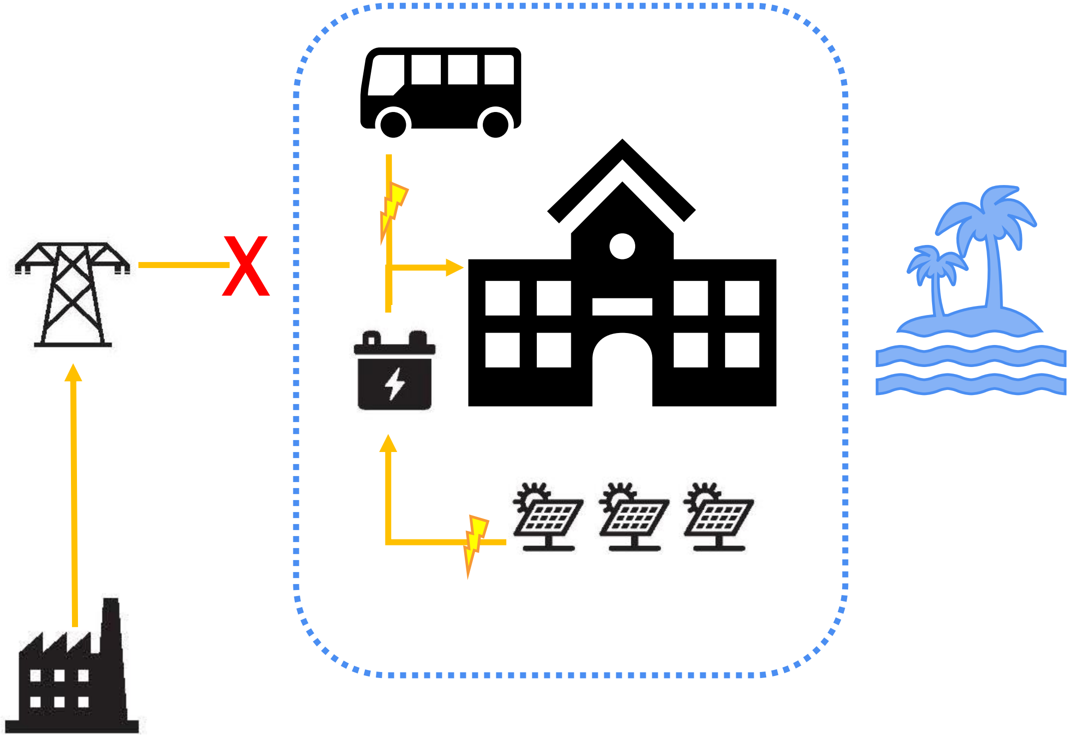
- A microgrid is a small-scale, fully contained energy system that can operate independently of the broader electricity grid
- When the grid connection goes out, electrical equipment automatically switches the building, room, or designated shelter to "island mode"
- In "island mode", specific electrical circuits are powered from local energy sources (e.g., heating, ventilation, a few electrical outlets)
- How long can the building last in "island mode"? That all depends on how much energy storage, how much load it's powering (energy efficiency!), and how much power is generated on site from solar.

Microgrid Operation

Normal Operation



Island Mode



Microgrids are the gold standard for resiliency

- It's the dead of winter and a storm knocks out some power lines, cutting power to the neighborhood. What can you do?

	No energy storage	Onsite energy storage	Onsite energy storage + Solar PV
Poor energy efficiency, leaky doors and windows	School quickly gets too cold for comfort – health hazard	Storage can provide heating for safety but quickly runs out	Storage can provide heating for safety but risks quickly running out when generation is low
High energy efficiency and good air sealing	School slowly gets too cold for comfort – you have time to arrange transport	Storage can provide heating for safety for longer until it runs out	Storage can provide heating for safety, potentially indefinitely

Key microgrid considerations

- Do you have physical space for batteries and structural capacity for solar panels?
- What are your utility's interconnection rules? (may limit the size)
- Which building systems do you want to power with the microgrid?
- Is your building a designated shelter? How long do you need to operate without the grid?

https://simpliphipower.com/deployments/commercial/schools/hawaii-schools-deploy-solar-simpliphi-microgrids-to-affordably-power-hvac/

Mentimeter Time

Think about potential barriers to implementing storage and renewable energy installations in your district. Please enter a few words to highlight those barriers.

Join at menti.com | use code 6179 5897

Mentimeter

Instructions

Go to

www.menti.com

Enter the code

6179 5897

Or use QR code

Technology Spotlight: Electric School Buses

Why electric school buses?

Improved Air Quality and Health	✓	Electric school buses (ESB) are the only school bus option with no tailpipe emissions. This decreases exposure to harmful pollutants like nitrogen oxides, which contribute to respiratory and heart disease and lung inflammation.
Reduced Greenhouse Gas Emissions[5]	✓	ESBs have less than half of the greenhouse gas emissions of any other school bus type, even when accounting for emissions from the generation of electric power.
	✓	ESB greenhouse gas emissions will only improve as the grid continues to decarbonize.
Cost Savings[6]	✓	Compared to diesel, a new electric school bus can save an average of $6,000 every year on operational expenditures and over $100,000 over the lifetime of the bus, depending on circumstances.
	✓	Charging costs are 40-75% lower than diesel fuel costs.
	✓	Maintenance savings of up to 60% over diesel school buses.
Increased Resiliency[7]	✓	Potential to serve as a backup generator during electricity outages.
	✓	Provides benefits to the local electric grid.

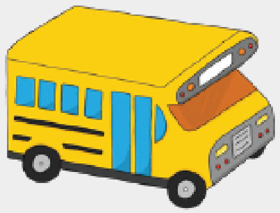
Source: https://newbuildings.org/resource/decarbonization-roadmap-guide-for-school-building-decision-makers/

Resilience features of ESBs

- ✓ Peak electricity load reduction through managed charging
- ✓ Integrate with onsite renewables
- ✓ Help stabilize the local electric grid
- ✓ Act as backup power in emergency situations
- ✓ Stabilize fuel costs and potentially fuel sourcing (for rural locations)

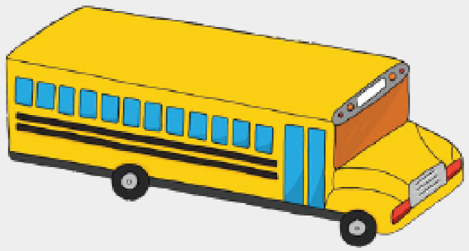
Technology overview: buses

TYPE A



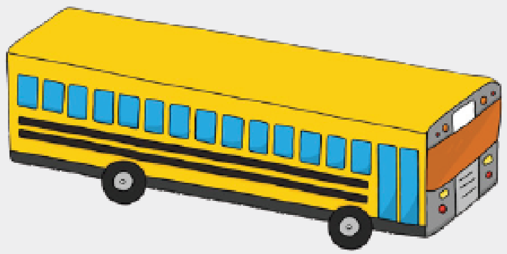
A small conversion bus using a cutaway front section with a left-side vehicle driver's door.

TYPE C



A large school but with the entrance door being behind the front wheels. It is also known as a conventional-style school bus.

TYPE D



A large bus with the entrance door located ahead of the front wheels and is also known as a rear engine or front engine transit style school bus.

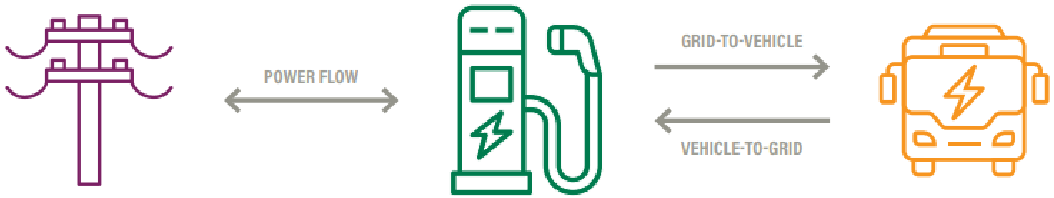
Source: GAO presentation of 2015 National School Transportation Specifications and Procedures.
Artwork by Nicole Kelner

Technology overview: charging

- Electric vehicle supply equipment (EVSE) is required
- Different charging levels are available; bidirectional charging is needed to reap resilience benefits
- Software is also a key consideration:
    - Charging Management Software for automation and timing
    - Managing charger use across multiple vehicles
    - Enable communication with utility

Suggested Resource: [All About Managed Charging and "Vehicle-to-Everything" or V2X]

BASIC V2G POWER FLOW DIAGRAM



Charging types and metrics

Characteristics	Level 2 (L2) Single Port	Level 3 / DCFC Single Port
Type of current	Alternating Current	Direct Current
Voltage (volts)	208/240	200-600
Power level (kW)	~7-20	~24-150
ESB recharge time	5.5-13 hours	1-4.5 hours
Charger cost	$400-$6,500	$10,000-$40,000
Installation cost	$600-$12,700	$4,000-$51,000
Electrical infrastructure upgrades	Typically minimal	May require new transformers, panel capacity, and meters
Use case	Buses able to charge afternoon and overnight; in rural areas, can be installed at drivers' homes	Overlapping routes; frequent afternoon and nighttime use

Notes: Costs are largely dependent on the power output (kilowatts) of the charger, the degree of control over charging, and other advanced features. Installation costs will be site and geography dependent. Estimates do not include potential grid upgrade costs.

Source: https://newbuildings.org/resource/decarbonization-roadmap-guide-for-school-building-decision-makers/

Managed charging

- Set time windows when charging will or will not happen:
  - Reduce cost by charging when electricity is cheaper (typically overnight)
  - Reduce emissions by charging when renewables are available
- Stagger charging start times to avoid large electricity demand costs due to charging all at once
- Notifications for when charging is complete, to reduce high-demand DCFC equipment use

Suggested Resource: Fundamentals of Managed Charging

Bidirectional charging

- Additional benefits to the building ("V2B"):
  - Draw power from bus batteries in case of grid disruptions or emergencies
  - Provide storage for onsite renewable energy at the time of generation
  - Reduce peak demand charges, sending energy from the ESB batteries to the building

https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Electrification_Workshop_Master_FINAL.pdf

Grid stabilization ("V2G")

- During high demand periods or when renewables are unavailable, behind-the-meter sources like energy stored in ESBs can stabilize the grid and prevent the use of dirty "peaker plants"
- Excess energy can be "sold" back to the utility, generating revenue for the district!
- Offers data insights to utilities on charging practices
- Utilities may offer shared ownership that will bring down upfront costs to the district

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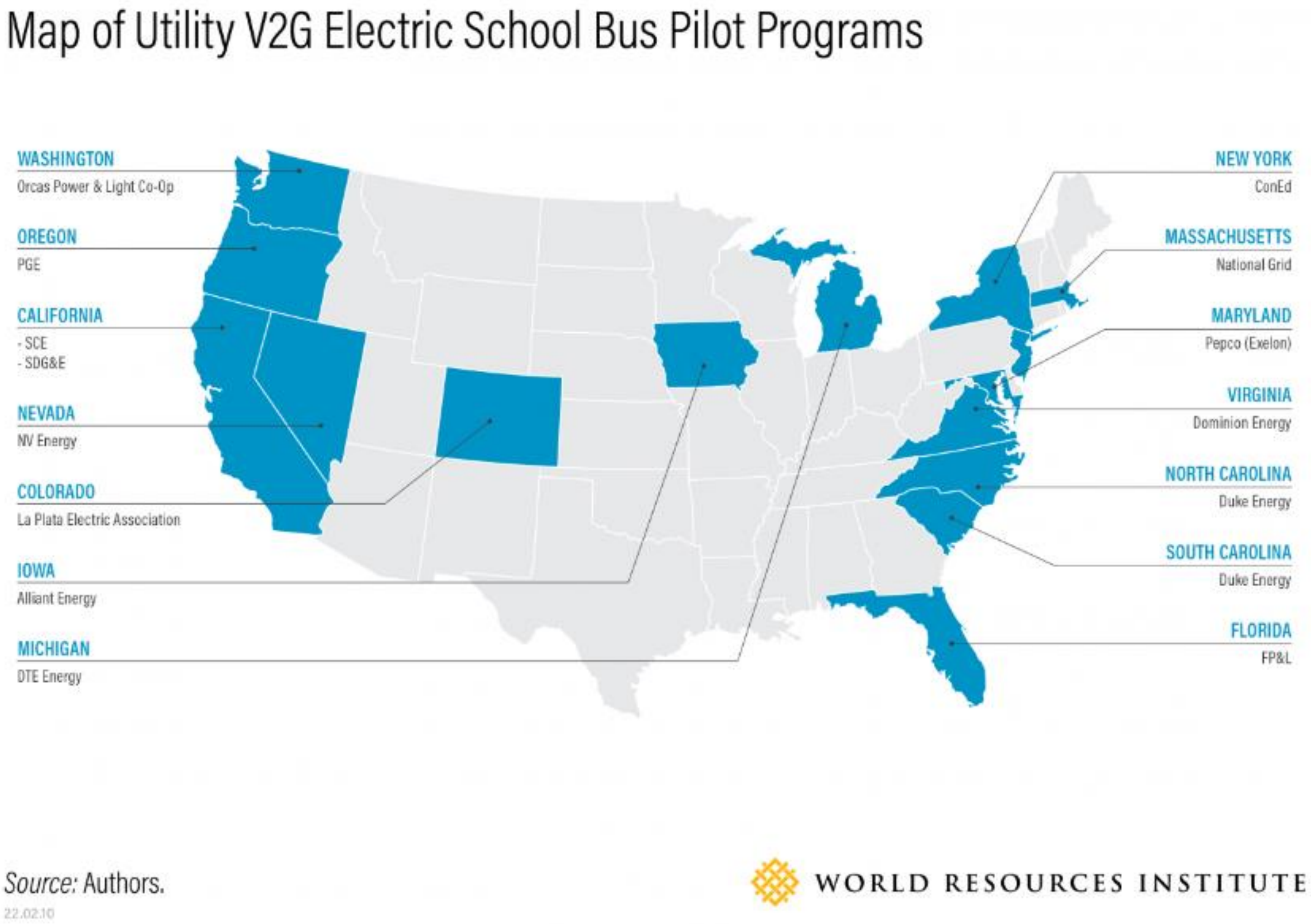
Grid stabilization

- A variety of pilot programs are coming online, with varying requirements – talk to your utility about options!



Suggested Resource: [3 Design Considerations for Electric School Bus Vehicle-to-Grid Programs]

Planning considerations

- Talk to your utility early:
  - Get a site assessment
  - Understand electrical requirements and program opportunities
  - Determine how renewables can complement

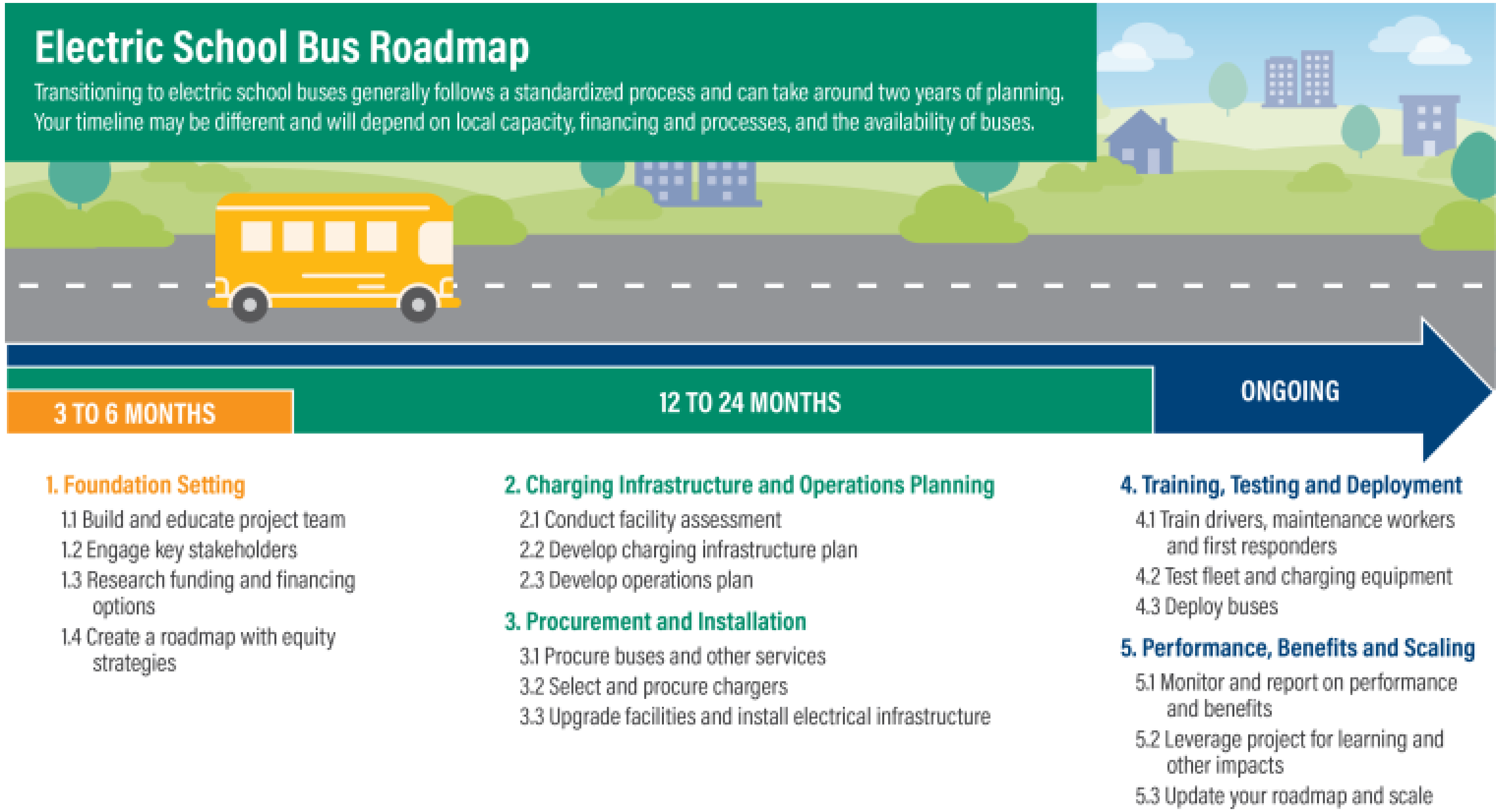
Suggested Resources:
Power Planner for Electric School Bus Deployment
Electric Vehicle (EV) Make-Ready Programs

Source: https://www.wri.org/insights/electric-school-bus-vehicle-grid-programs

Planning considerations

- Consider route efficiency first, do you need all the buses you currently have?
- Prepare for a multi-year timeline and incorporate into larger resilience plans and goals
- Consider maintenance costs in addition to fuel costs

Suggested Resources: Step-by-Step Guide for School Bus Electrification



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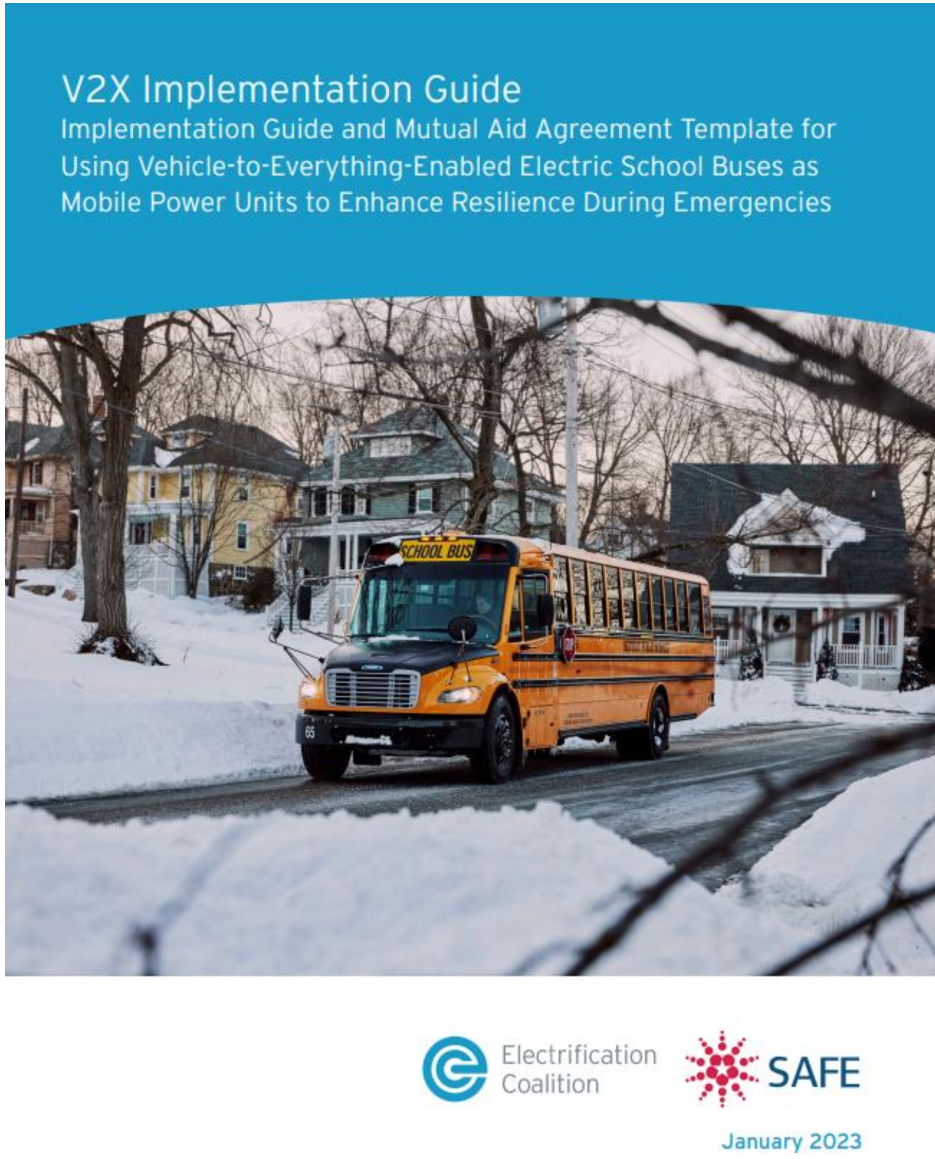
V2X Implementation

- Step-by-step guide for before, during, and after an emergency (outage).
- Focuses on powering a building being used as a shelter or certain essential loads such as heating, cooling, lighting, or refrigeration.
- Includes a template MAA or MOU.



Suggested Resources: V2X Implementation Guide and WRI Design Considerations for Bus V2G Programs

Case Study – Williamsfield Schools

Tim Farquer, Superintendent


WILLIAMSFIELD
W
SCHOOLS
LION
EMERGENCY EXIT
STOP
WILLIAMSFIELD SCHOOLS
LION C

FORTRESS POWER
Secure your energy

NUVVE

SIEMENS

Bus2Grid

LION ELECTRIC

BORGWARNER

WILLIAMSFIELD SCHOOLS
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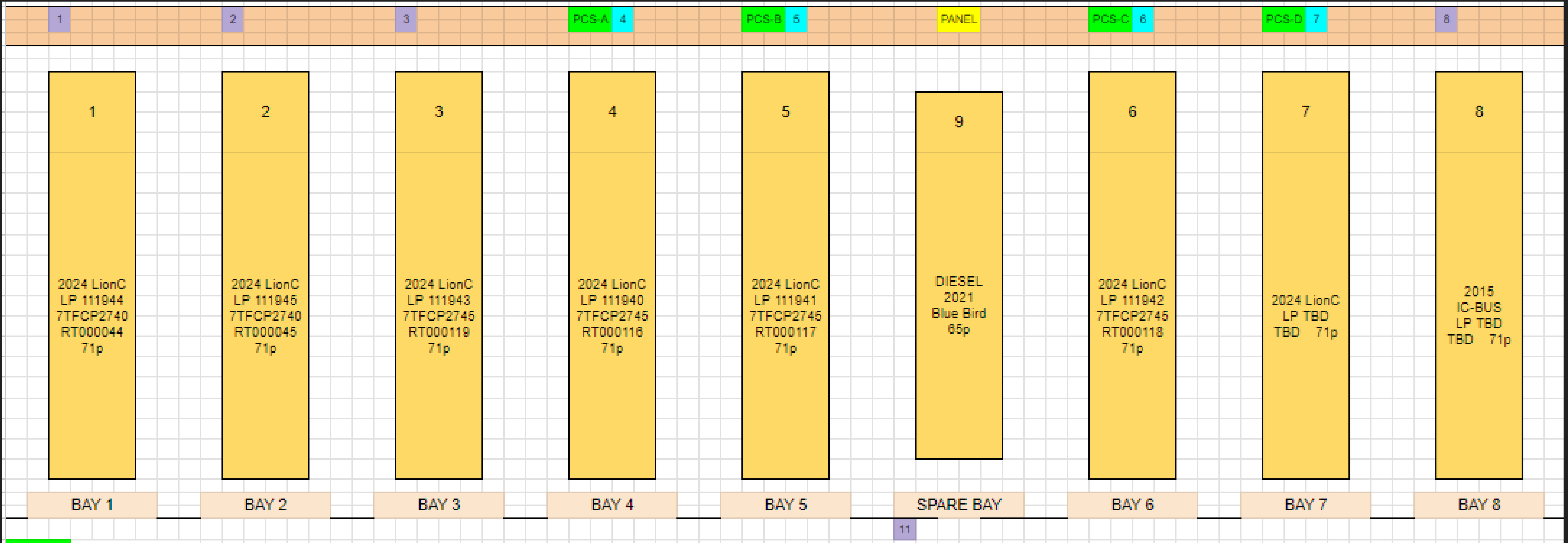
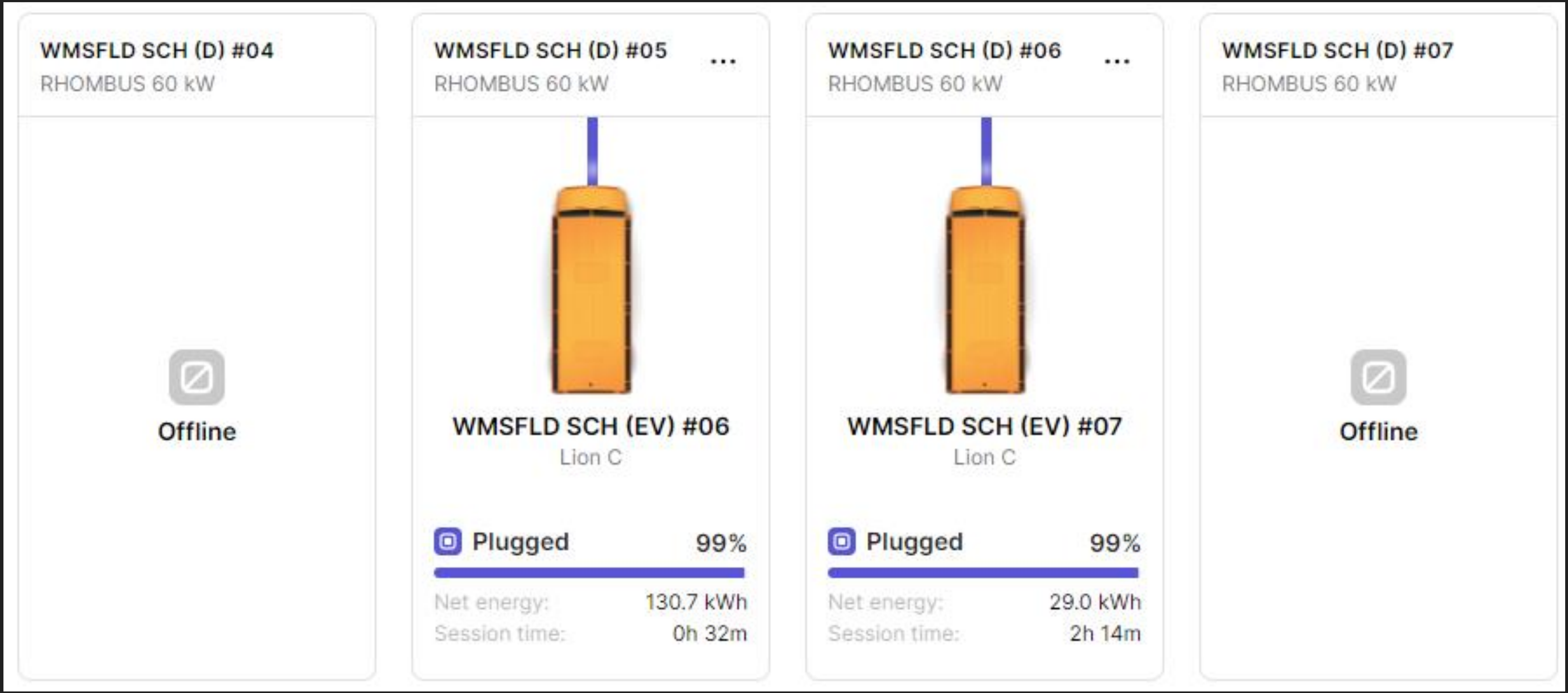
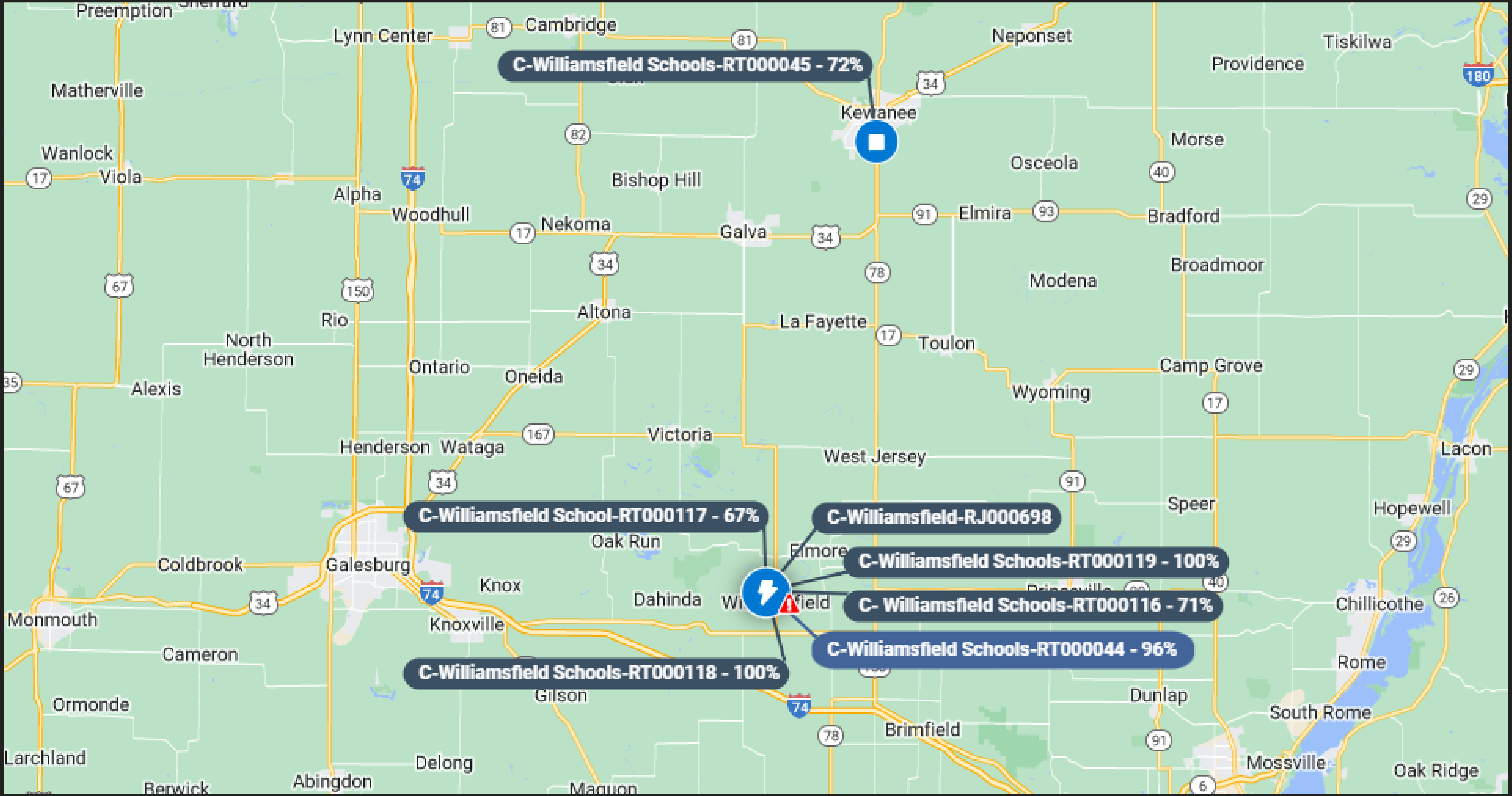


PCS	60kW V2G DCFC
A/B/C	Dispensers connected to respective 60kW V2G DCFC PCSs
L	Level 2 charging pedestals (19.3kW)


WMSFLD SCH (D) #04
RHOMBUS 60 kW
Offline
WMSFLD SCH (D) #05
RHOMBUS 60 kW
WMSFLD SCH (EV) #06
Lion C
Plugged
99%
Net energy:
130.7 kWh
Session time:
0h 32m
WMSFLD SCH (D) #06
RHOMBUS 60 kW
WMSFLD SCH (EV) #07
Lion C
Plugged
99%
Net energy:
29.0 kWh
Session time:
2h 14m
WMSFLD SCH (D) #07
RHOMBUS 60 kW
Offline



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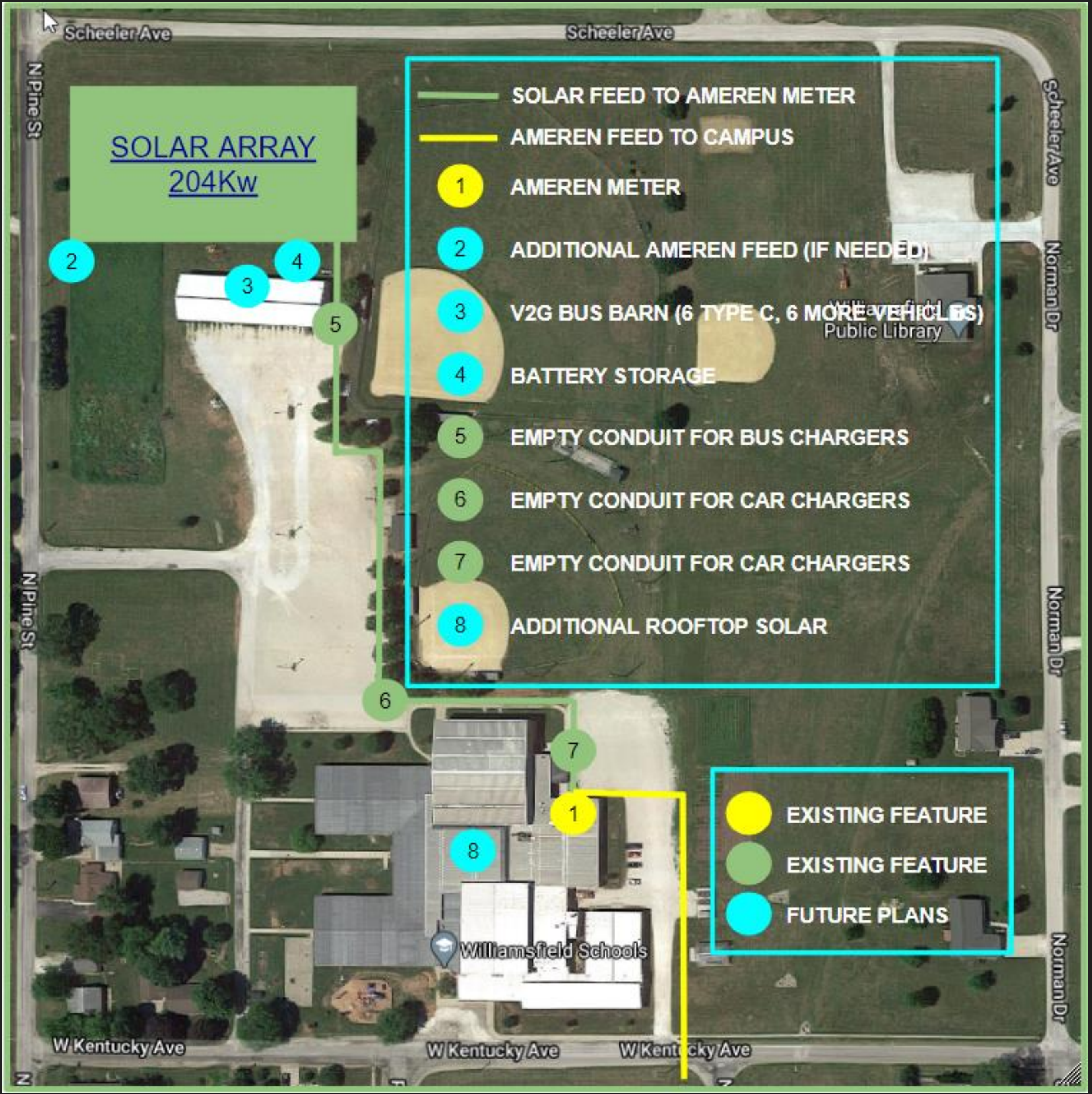
C-Williamsfield School-RT000117 - 67%
C-Williamsfield-RJ000698
C-Williamsfield Schools-RT000119 - 100%
C- Williamsfield Schools-RT000116 - 71%
C-Williamsfield Schools-RT000044 - 96%
C-Williamsfield Schools-RT000118 - 100%
Preemption
Lynn Center
Cambridge
Neponset
Tiskilwa
Providence
Matherville
Kewanee
Morse
Wanlock
Viola
Bishop Hill
Osceola
Alpha
Woodhull
Nekoma
Galva
Elmira
Bradford
Broadmoor
Modena
Rio
Altona
La Fayette
Toulon
North Henderson
Camp Grove
Ontario
Oneida
Alexis
Wyoming
Victoria
Henderson
Wataga
West Jersey
Lacon
Speer
Hopewell
Oak Run
Elmore
Coldbrook
Galesburg
Knox
Dahinda
Chillicothe
Monmouth
Knoxville
Cameron
Rome
Gilson
Ormonde
Dunlap
South Rome
Brimfield
Larchland
Delong
Mossville
Oak Ridge
Abingdon



Scheeler Ave
Scheeler Ave
N Pine St
SOLAR ARRAY
204Kw
SOLAR FEED TO AMEREN METER
AMEREN FEED TO CAMPUS
1 AMEREN METER
2 ADDITIONAL AMEREN FEED (IF NEEDED)
3 V2G BUS BARN (6 TYPE C, 6 MORE VEHICLES)
4 BATTERY STORAGE
5 EMPTY CONDUIT FOR BUS CHARGERS
6 EMPTY CONDUIT FOR CAR CHARGERS
7 EMPTY CONDUIT FOR CAR CHARGERS
8 ADDITIONAL ROOFTOP SOLAR
Public Library
Scheeler Ave
Norman Dr
EXISTING FEATURE
EXISTING FEATURE
FUTURE PLANS
Williamsfield Schools
W Kentucky Ave
W Kentucky Ave
W Kentucky Ave

Data

- Year 4 of ground mount solar array (20% electricity cost savings estimate)
- 23,000 electric bus miles traveled (96% fuel cost savings estimate)
  - $507 solar energy via PPA
  - $14,307 diesel fuel
- 40% overall energy savings in FY24
- V2G trials this summer
- FY25 projected microgrid activation

FORTRESS POWER
Secure your energy

NUVVE

SIEMENS

Bus2Grid

LION ELECTRIC

BORGWARNER


WILLIAMSFIELD
W
SCHOOLS
LION
EMERGENCY EXIT
STOP
WILLIAMSFIELD SCHOOLS
LION C

Discussion

Taking action

1. What questions do you still have about addressing resiliency? Are there any aspects of resiliency we didn't cover?
2. What topics covered this week do you want to/need to learn more about?

SCEP
STATE & COMMUNITY ENERGY PROGRAMS

Questions?

We look forward to working with you!