

NREL Building Energy Research Overview of LDRDs and Technology Partnership Agreements



Chuck Kutscher

NREL Buildings and Thermal Systems Center

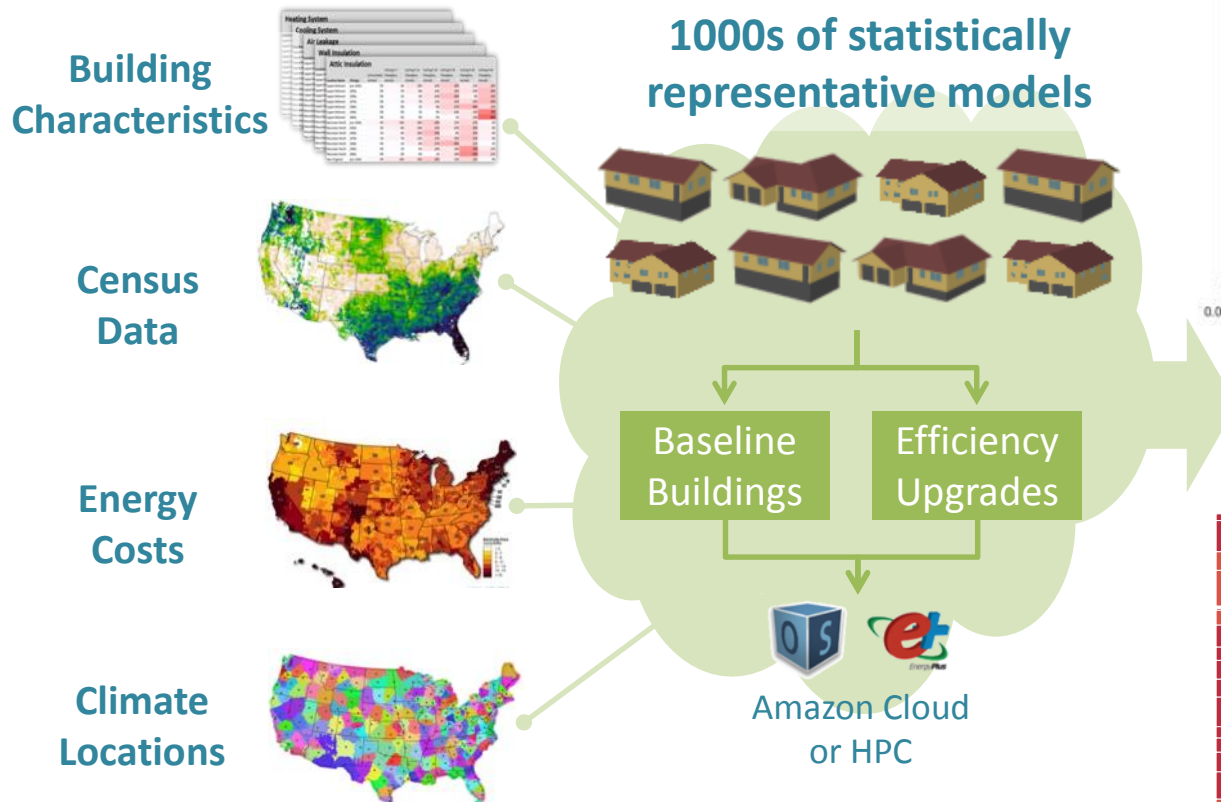
A. Lab-Directed R&D (LDRD) Projects

ResStock:

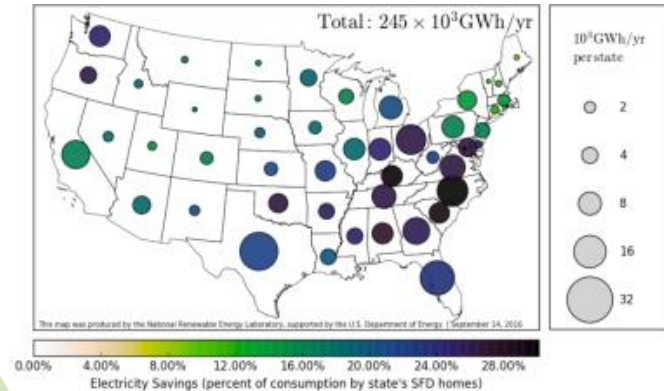
Residential Building Stock Potential Tool

ResStock

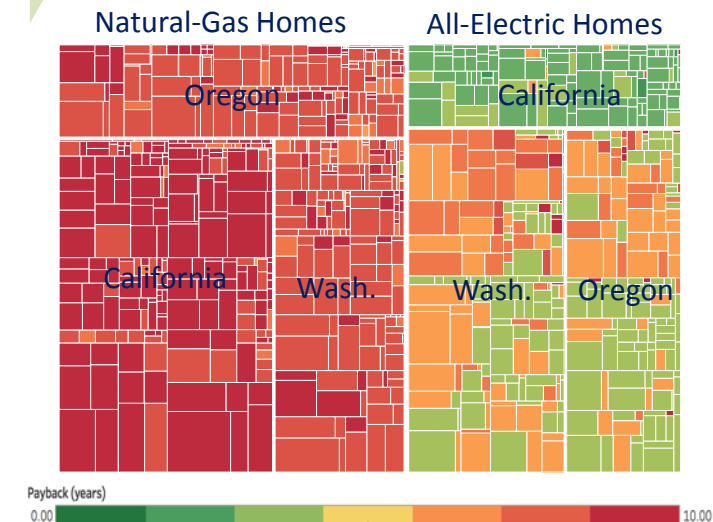
Residential Building Stock Potential Tool



National Potential

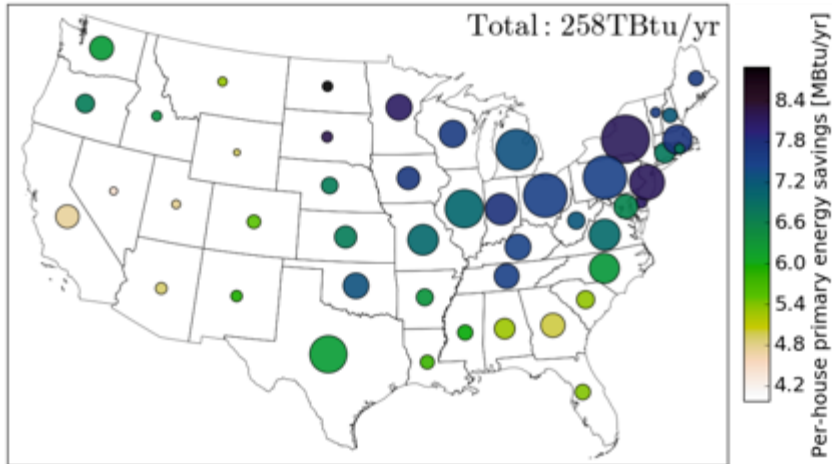


Regional Potential

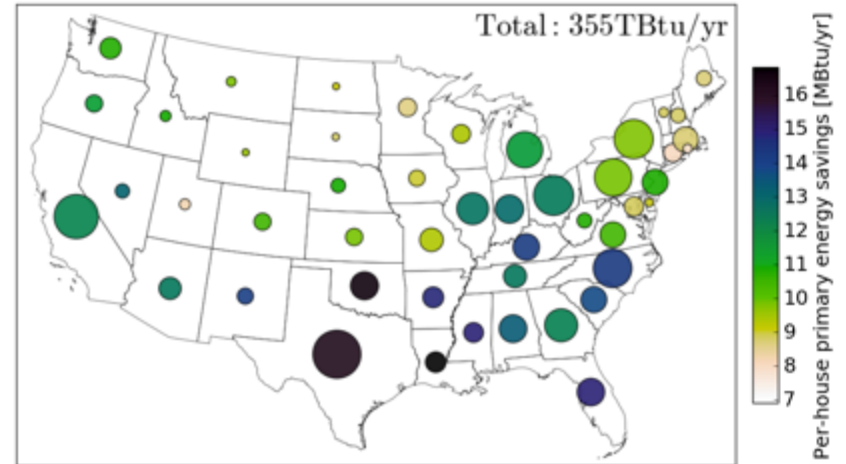


Preliminary Results – Economic Potential (NPV > 0)

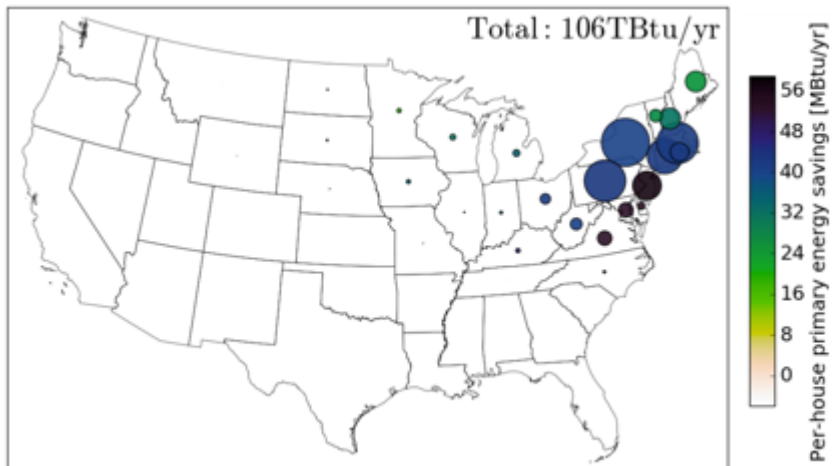
Air Sealing



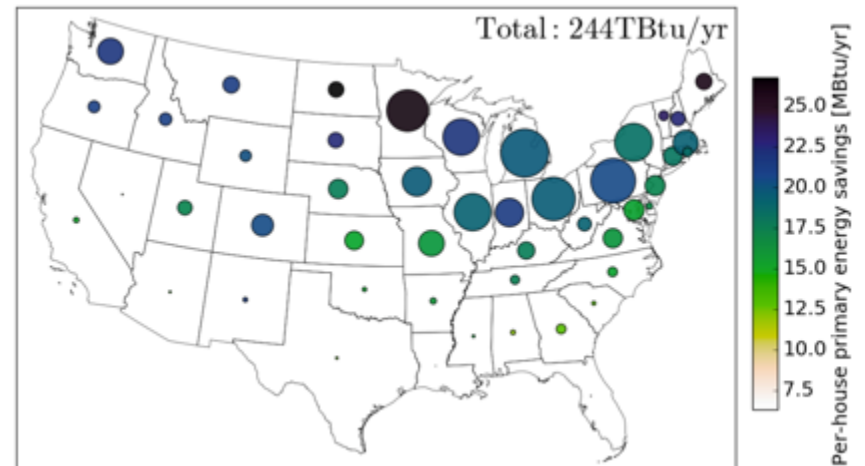
Attic Insulation (R-49)



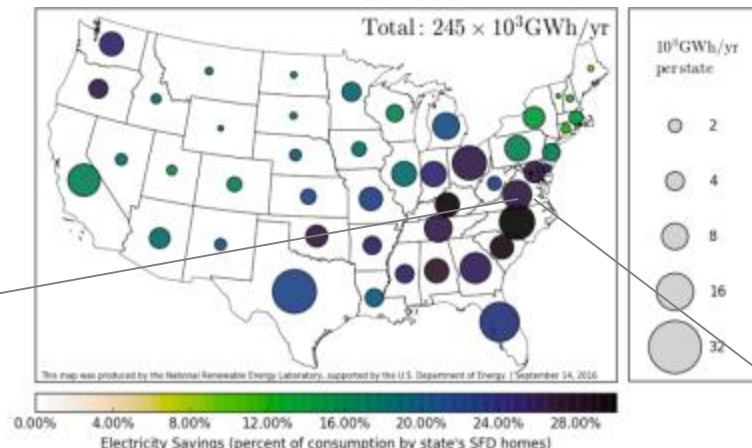
Replacing Oil Boilers with Ductless Heat Pumps



Basement Wall Insulation (R-10)



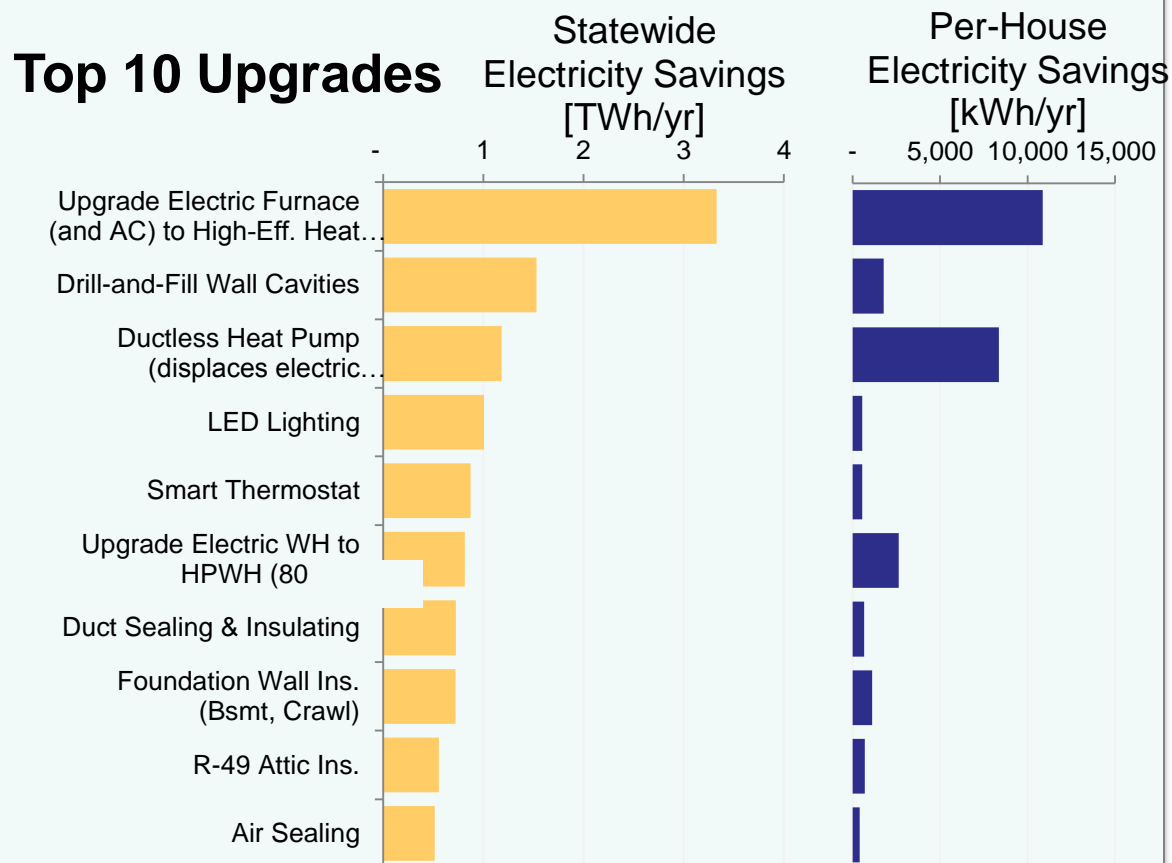
ResStock provides actionable results for states and cities



Cost-effective savings for Virginia

Carbon Emissions
10.6
million tons per year

Utility bills
1.5
billion dollars per year



Applications



- Quadrennial Energy Review 1.2
- Home Improvement Catalyst
- Grid load modeling



- Regional Planning Tool
- Low-Income EE Potential



- Demand response potential



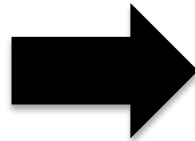
- City energy strategy

URBANopt: NREL's zero energy ready district modeling tool

Scaling Up to Zero Energy Ready Districts: The Next Step in NREL Buildings Leadership

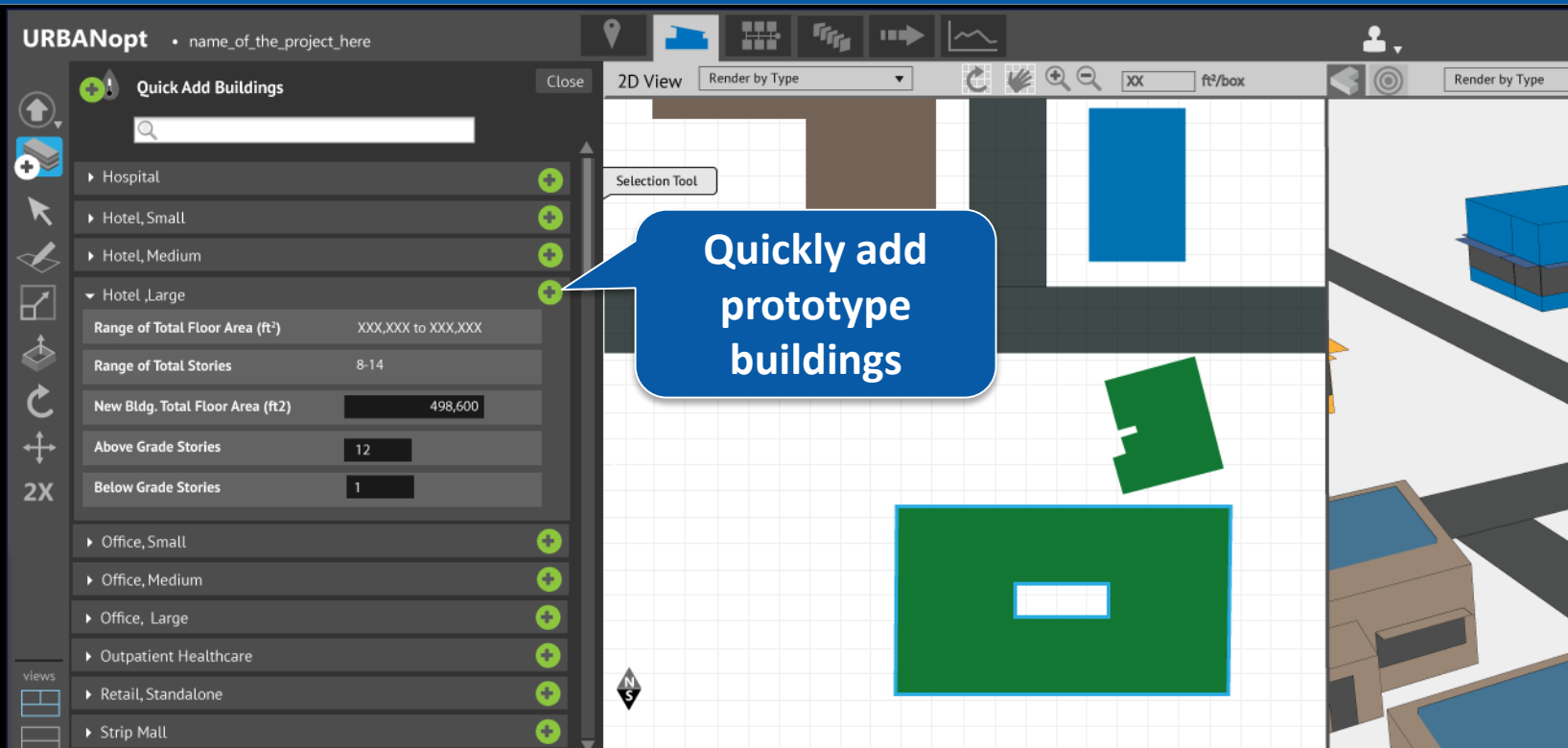


Zero Energy Ready Buildings



Zero Energy Ready Districts

URBANopt — Buildings



Quick Add Buildings

Search:

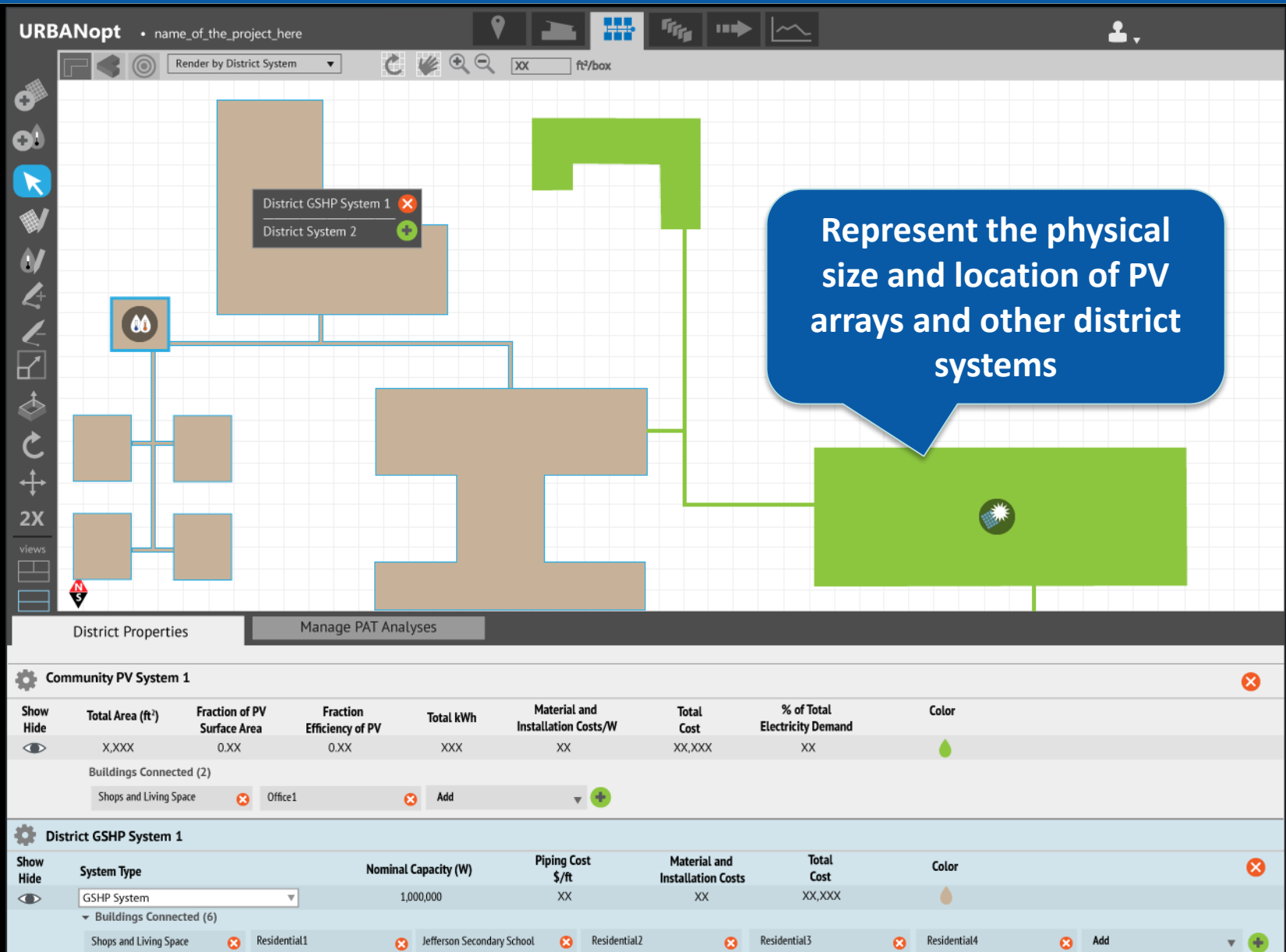
- Hospital
- Hotel, Small
- Hotel, Medium
- Hotel, Large
 - Range of Total Floor Area (ft²): XXX,XXX to XXX,XXX
 - Range of Total Stories: 8-14
 - New Bldg. Total Floor Area (ft²): 498,600
 - Above Grade Stories: 12
 - Below Grade Stories: 1
- Office, Small
- Office, Medium
- Office, Large
- Outpatient Healthcare
- Retail, Standalone
- Strip Mall

2D View | Render by Type | Selection Tool

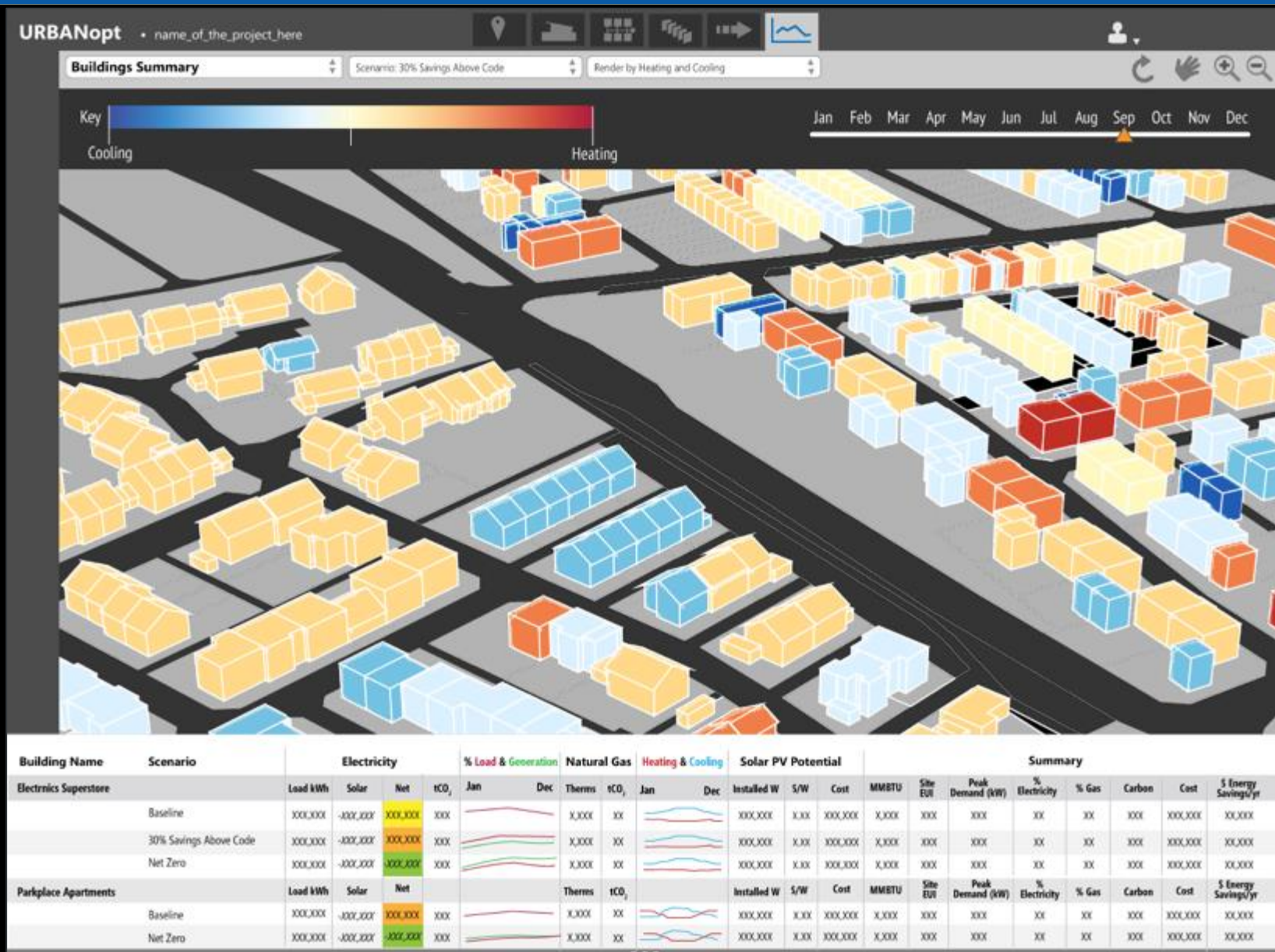
Building Properties | Total Buildings: 35

Show Hide	ID	Address	Track	Type	Name of Building	Total Floor Area (ft²)	Units/Tenants	Stories	Orientation(°)	Delete
	1	111 Elm	121.01	Office	Elm Office Park 111	X,XXX	XX	1	0	
	2	115 Elm	121.01	Mixed Use Commercial	Elm Office Park Shops/Apts	X,XXX	XX	3	0	
				Types of Use/Bldg	Floor Area (ft²)	# of Units	% of Total Floor Area	Delete Type		
				Retail	XXX	X	30%			
				Multifamily	XXX	X	70%			
	3	32 Maple	121.01	Residential	Maple Grove Homes Small	X,XXX	XX	1	180	
	4	201 Maple	121.01	Residential	Maple Grove Homes Med	X,XXX	XX	4	35	
	5	65 Elm	121.01	Fast Food	Quicks Subs	X,XXX	XX	2	45	
	6	33 Maple	121.01	Residential	Maple Grove Homes Med2	X,XXX	XX	3	270	
	7	701 Elm	121.01	General Hospital	General Hospital	X,XXX		2	0	

URBANopt — District Systems



URBANopt — Results



URBANopt — Buildings

The image displays the URBANopt software interface. The top section features a 2D View on the left and a 3D View on the right. The 2D View shows a top-down layout of buildings on a grid, with a selection tool highlighted. The 3D View shows a perspective view of the same buildings, with a sun path diagram indicating the sun's position for November Day Average. A blue callout box points to the 3D view with the text: "Adjust building height, orientation and location to maximize solar potential".

Below the 3D view is a table titled "Building Properties" with the following data:

Show Hide	ID	Address	Track	Type	Name of Building	Total Floor Area (ft²)	Floor Area (ft²)	# of Units	% of Total Floor Area	Delete Type
1	111 Elm	121.01	Office	Elm Office Park 111	X,XXX	XX	1	0		
2	115 Elm	121.01	Mixed Use Commercial	Elm Office Park Shops/Apts	X,XXX	XX	3	0		
Types of Use/Bldg						Floor Area (ft²)	# of Units	% of Total Floor Area	Delete Type	
				Retail		XXX	X	30%		
				Multifamily		XXX	X	70%		
3	32 Maple	121.01	Residential	Maple Grove Homes Small	X,XXX	XX	1	180		
4	201 Maple	121.01	Residential	Maple Grove Homes Med	X,XXX	XX	4	35		
5	65 Elm	121.01	Fast Food	Quicks Subs	X,XXX	XX	2	45		
6	33 Maple	121.01	Residential	Maple Grove Homes Med2	X,XXX	XX	5	270		
7	301 Elm	121.01	General Hospital	General Hospital	X,XXX	XX	2	0		

Denver National Western Center



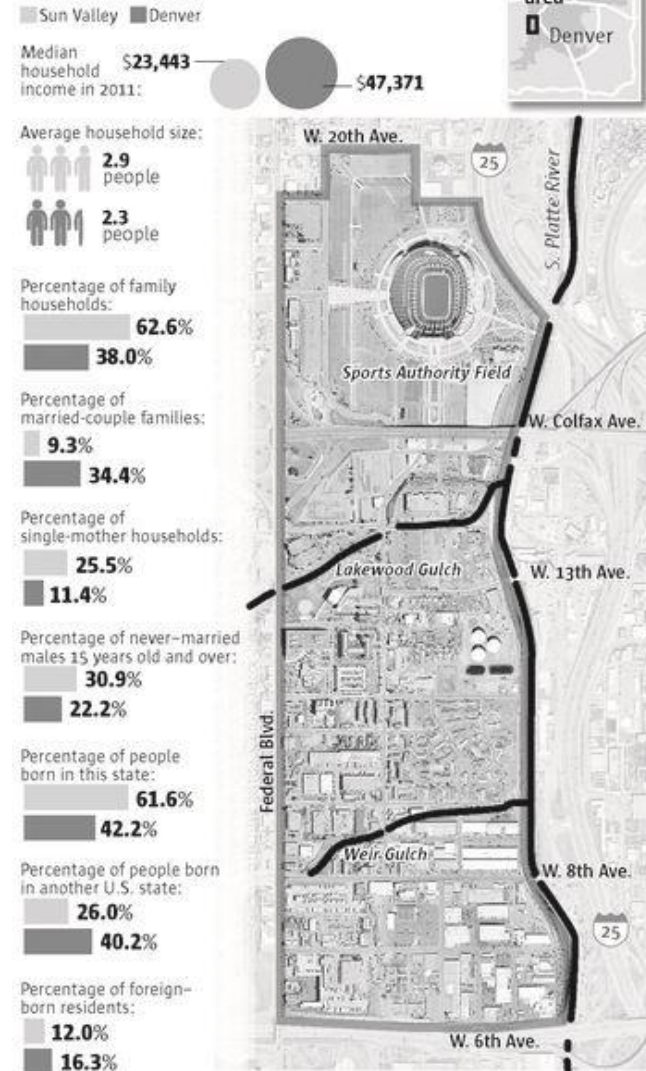
- Redevelop 130 acres
- Zero energy ready district
- Building EE, RE generation, waste heat capture



Denver Sun Valley Neighborhood

Sun Valley

Denver planners and EcoDistrict partners have launched a planning process to redevelop Sun Valley, Denver's lowest-income neighborhood, as an environment-friendly oasis.



Source: City and County of Denver

Severiano Galván, The Denver Post

- Rebuild public housing at 3 times density:
 - 1/3 public housing
 - 1/3 low-income
 - 1/3 market rate



Factory-Built Modular Housing

Energy-Efficient Manufactured Housing



iUnit Denver Delivery



Eliot Flats, Denver



iUnit Interior



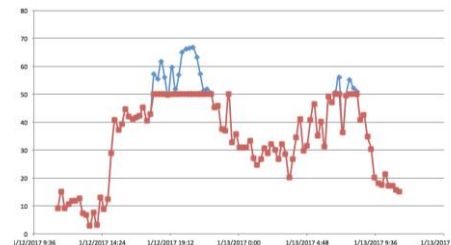
NREL iUnit in factory



NREL iUnit in Lab

Research Topics

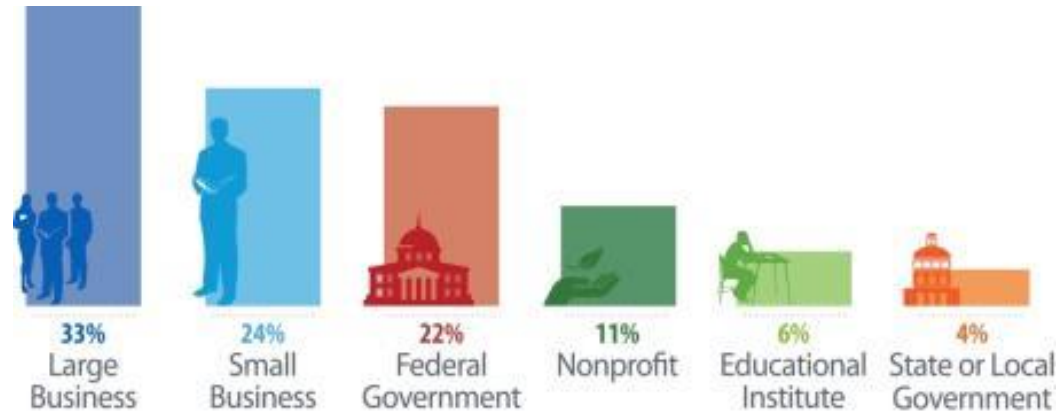
- Envelope improvements
- Waste heat recovery for DHW
- Integrate HRV/PTAC
- Advanced dryers
- Peak demand reduction



B. Technology Partnership Agreements

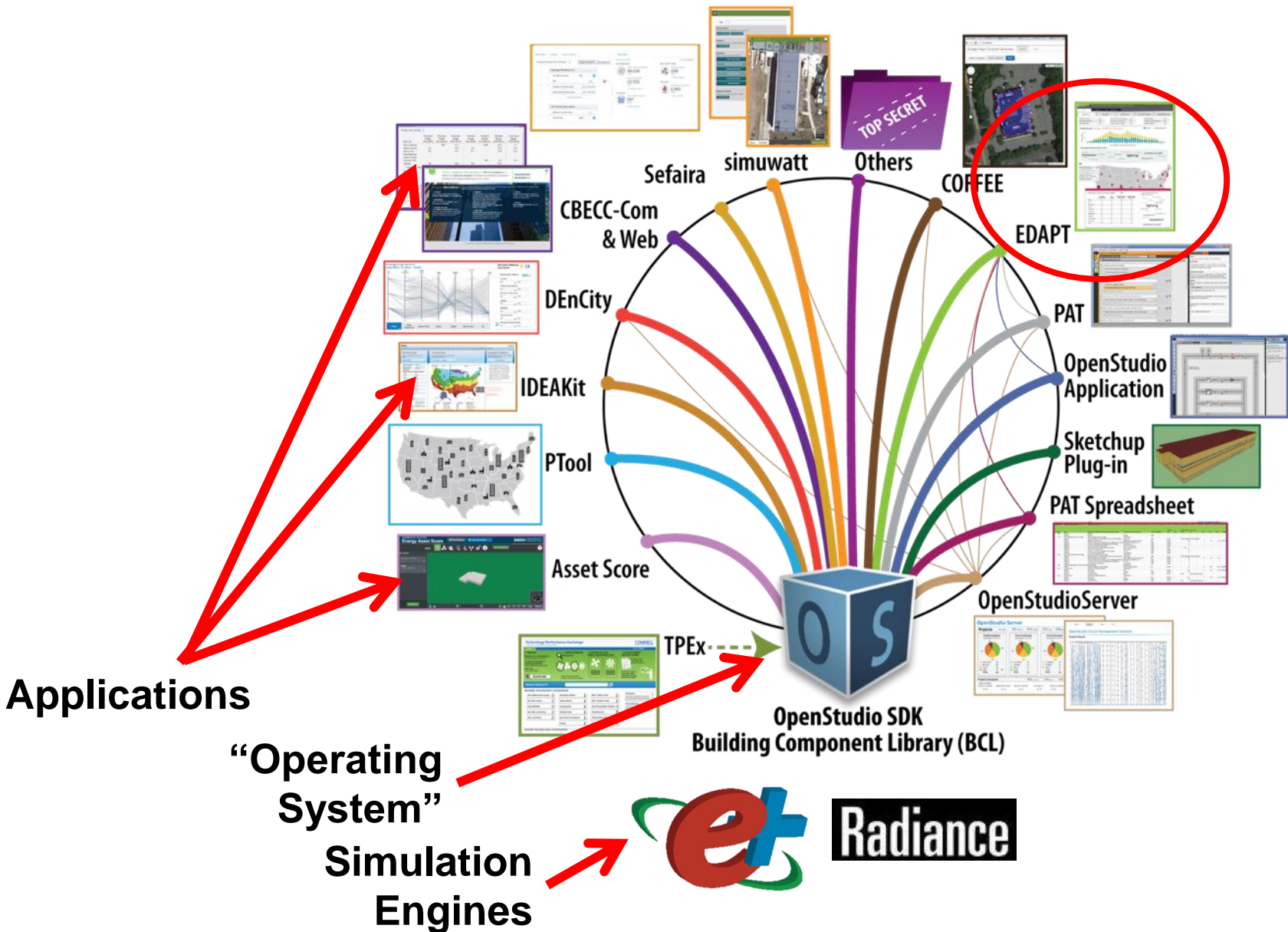
Partnering with Agencies, Institutions & Companies

- 696 active partnerships with industry, academia, and government
- 236 new partnership agreements worth \$33M in 2015
- Every federal dollar invested → \$1.67 of TPA funding



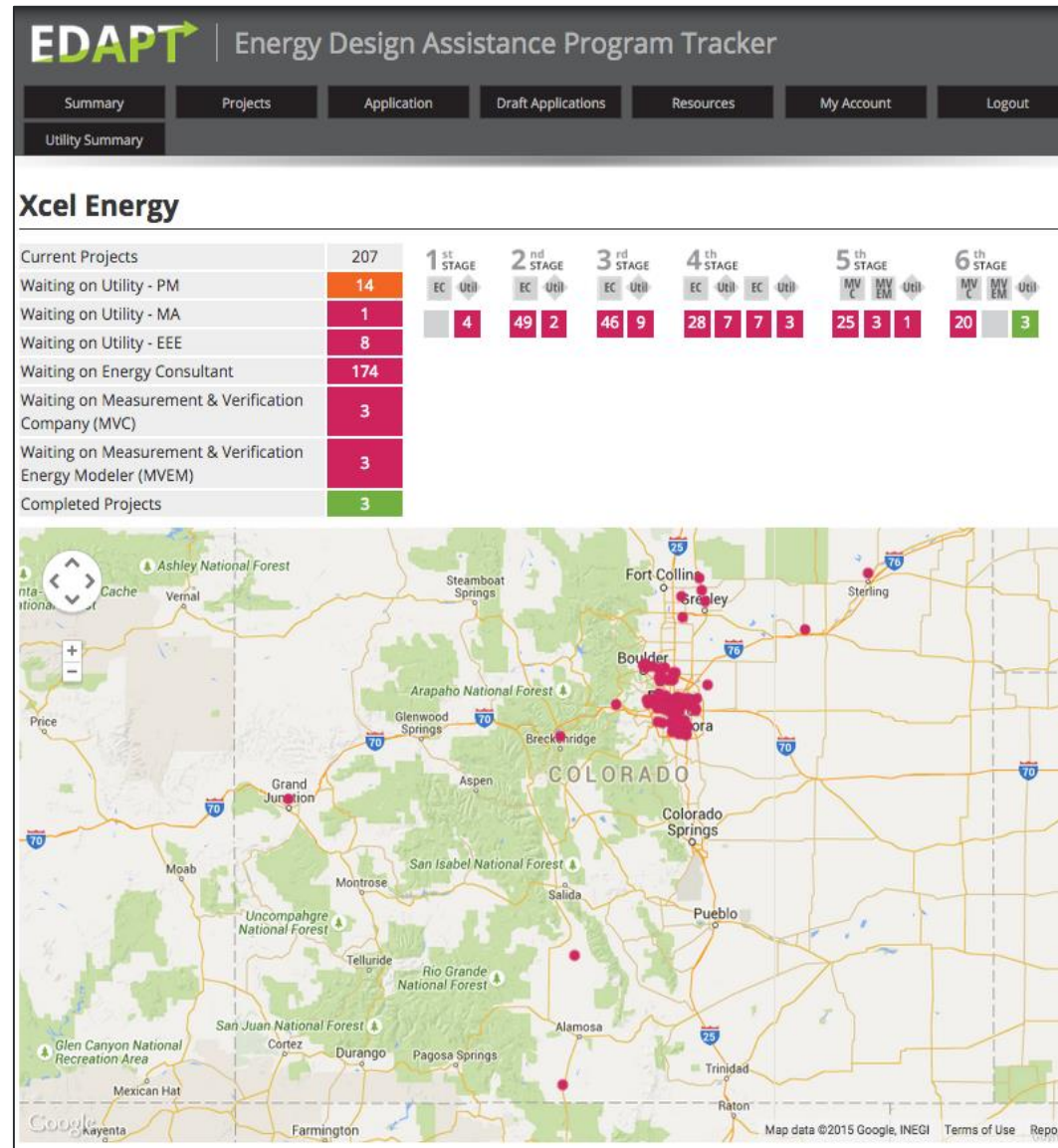
Energy Design Assistance Program Tracker (EDAPT)

DOE Modeling Ecosystem



EDAPT

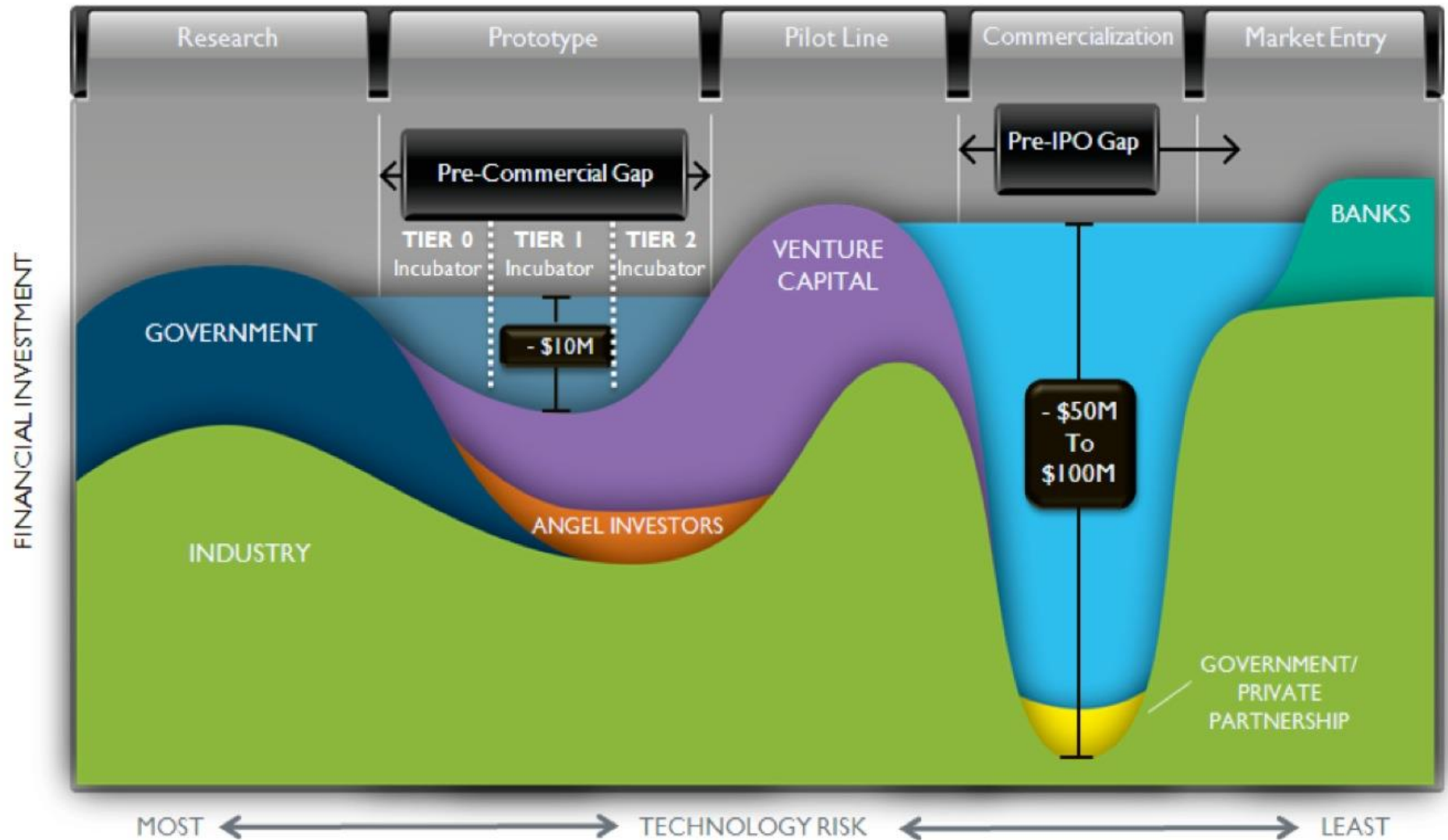
- **Supports \$8 billion/yr. utility incentive industry**
- **Automated:**
 - Notifications
 - Quality checking
 - Reporting
- **Developed for Xcel Energy**
 - Saves \$500K/yr in admin costs
 - Significant increase in number of projects processed annually
- **New users:**
 - Austin Energy
 - Energy Trust of Oregon
 - Planning RFP to transfer to private sector



Wells Fargo Innovation Incubator (IN²)



IN² addresses gaps:



3 Tiers



TRL 1-5

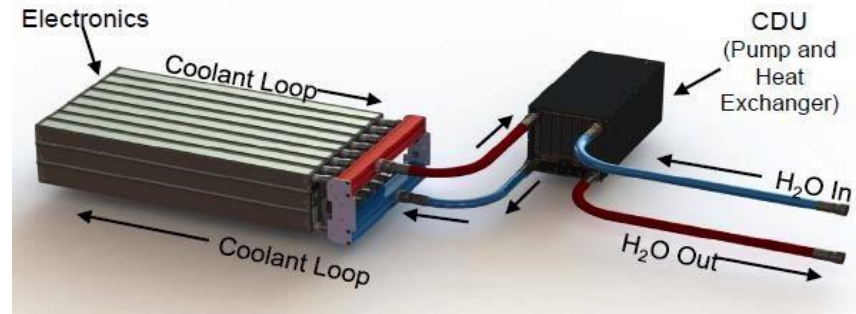
TRL 6-7

TRL 8-9

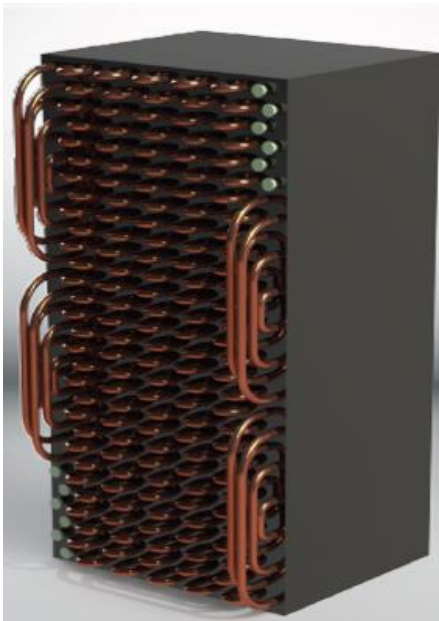
Example Projects



Whisker Labs
Stick-on submeters
Tier 2



LiquidCool Solutions
Direct CPU cooling
Tier 3



NETenergy
Thermal
battery for
HVAC system
Tier 2



Go Electric
UPS and microgrid
controller
Tier 3

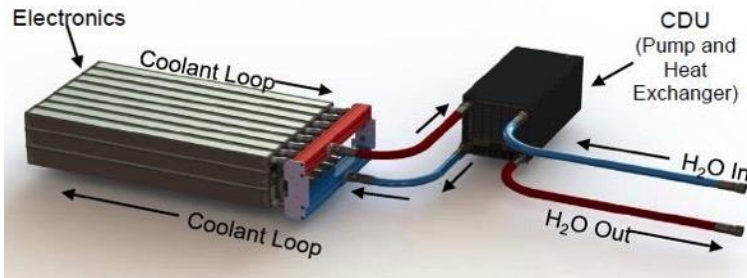
LiquidCool Solutions

The Problem

- ~15% of data center energy is used to move air for cooling
- Air cooling requires significant floor area and maintenance

A Solution

- No, compressors, fans, or other moving parts
- High-quality waste heat



NREL Activities:

- Provide 3rd party performance validation
- Energy Systems Integration Facility (ESIF), building-integration demonstration in real-world data center



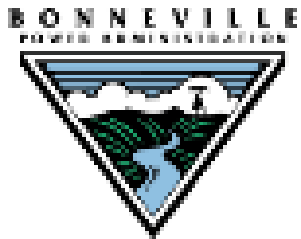
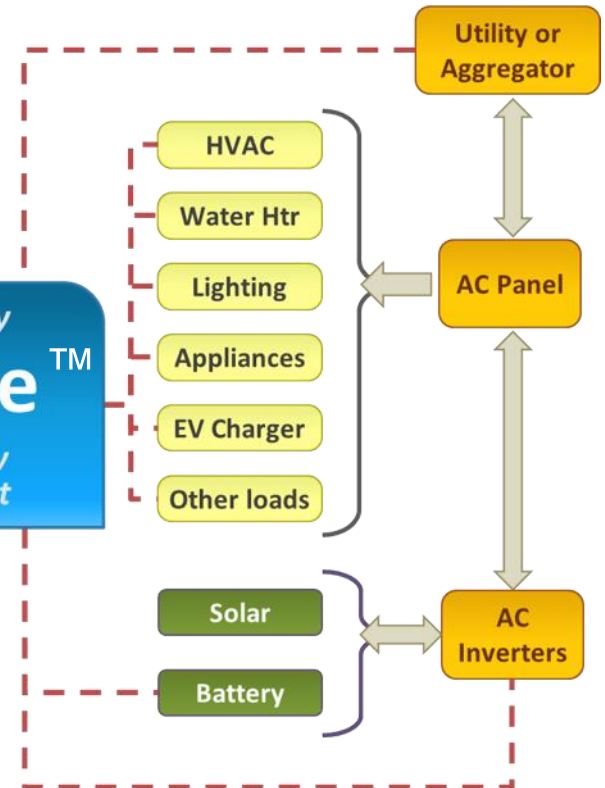
Home Battery Project





HOME BATTERY SYSTEM SCHEMATIC

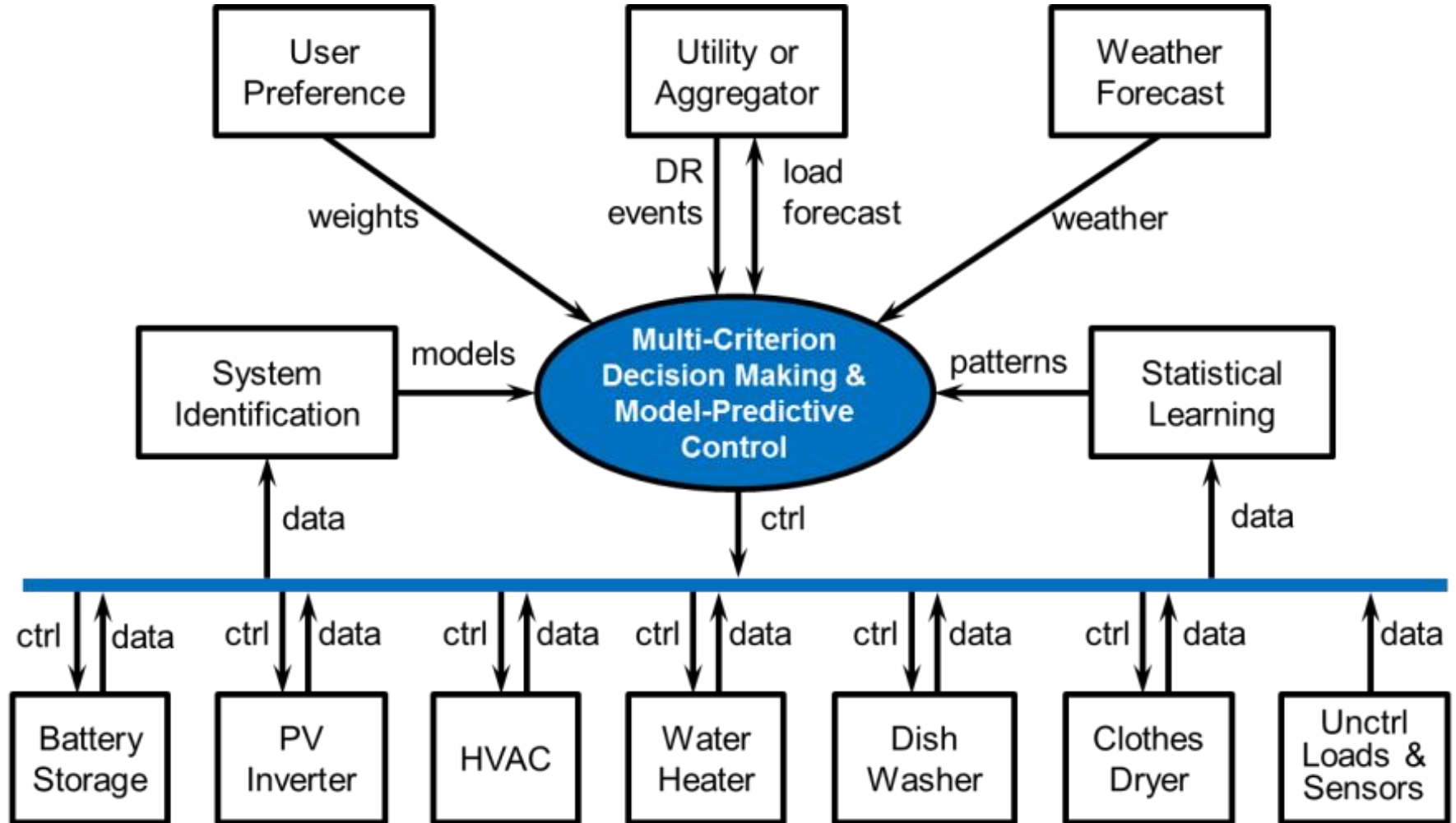
Cybersecurity
foreseeTM
Home Energy Management



BOSCH



Colorado
State
University



ESIF Systems Performance Lab



Battery Project Devices



Customized heat pump
water heater

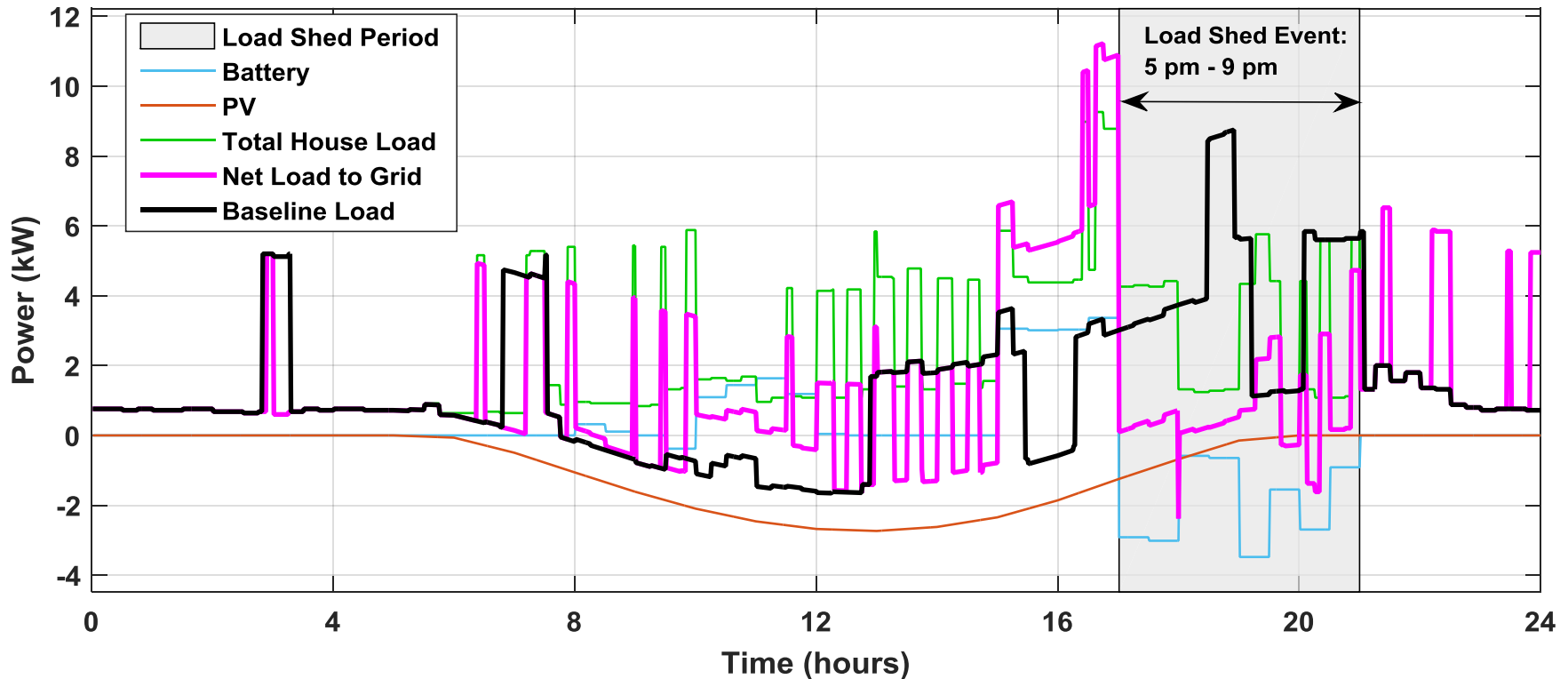


3-kW PV inverter



12 kWh Battery pack w/
5-kW inverter

Simulated Load Shed Event



Energy reduction during the 4-hour load shed event: 14.1 kWh

- 7.9 kWh reduction from the battery (fully discharged)
- 6.2 kWh reduction from building loads



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