EPRI

Customer-Centric Approaches to Transforming MFAH to GEB

A Practitioner's Perspective Based on Scaled Field Trials

ENERGY DELIVERY AND CUSTOMER SOLUTIONS

Siva Sankaranarayanan
Principal Technical Leader, EPRI

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Outline of lecture

What is customer-centricity?

Grid-Interactive and Efficient Buildings (GEB) – What is our definition?

Motivation for customer-centricity

- Why is Multifamily Affordable Housing retrofit so hard?
- Understanding the requirements for MFAH
- Learning from the past…

Use cases for customer-centric approaches

- Necessary conditions – efficiency and electrification
- Sufficient conditions – smart-grid integration

Takeaways

The definitions & basics

Elements of a customer-centric approach

- A solution approach that keeps the “customer” needs front-and-center of the solution design
- Is fundamentally an approach that derives from empathy for the customer
- At its core, it is a “market-driven” approach

WHAT

WHY

- Customers are served by service providers within their community/societal context
- Customers are the ultimate beneficiaries of the solution while we attempt to stack value for other stakeholders
- While positive customer behaviors can help, negative behavior will certainly hurt the overall solution

GEB – What is our definition?

Building

Efficiency

- Must meet some efficiency standard or code, e.g., ASHRAE 90.1-2019 or IECC-2019

Flexible loads

MUST HAVE

Control System

Employ "Good Design Principles"

- Ability to provide positive outcomes for customer, service provider, and community/societal context

Electrification

On-site Renewables

NICE TO HAVE

Compensation

- Employs appropriate tradeoffs and "compensates" customers for the inconvenience to achieve win-win

Avoids "Bad Design Principles"

- A design that inherently disadvantages the customer in the process to achieve lose-win

Why is MFAH a hard-to-reach segment?

Motivation

Energy is not front-and-center of people's minds

MFAH operators often face difficulty navigating the landscape of options

MFAH is typically occupied by renters who cannot make change

Economics

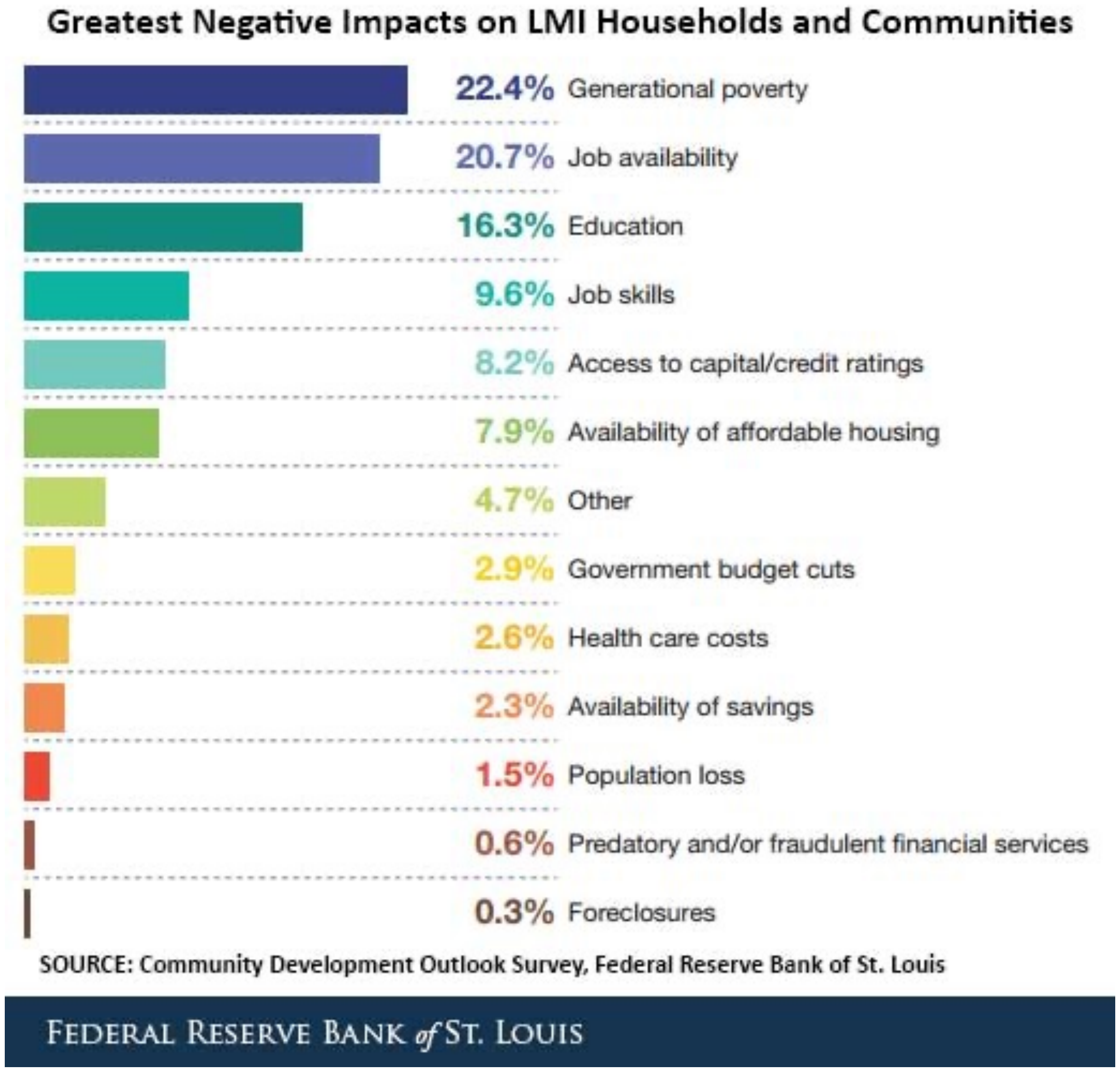
The first cost of any GEB retrofit is more expensive than standard products

Inability to recover the first cost through operating cost savings

Mismatched incentives

Customers face a lack of agency to make the right decisions

Let's dig a little deeper on the factors - Motivation



Energy Burden meets Choice Burden…

Source: https://cadmusgroup.com/wp-content/uploads/2023/05/equityimage1.jpg

Efficiency/Envelope
- Attic and Wall Insulation
- Air Sealing
- Fenestration/Windows
- Cool/Warm Roof

HVAC and WH
- Heat Pumps – VRF, Mini-splits, Unitary systems
- Heat Pump Water Heater – Centralized, Unitary

Renewables
- Solar PV
- Energy Storage

A heavy choice burden confronts MFAH operators trying to address energy burden

Understanding the economics – First Cost v. Op Costs

Community	First Cost ($)	Operating Cost Savings ($)	Incremental Peak Load (%)
Oleta	$322,740	-$4,217	+363%
Seneca	$465,047	-$16,424	+1%
Helen V	$513,453	-$13,166	+12%
Eliz. James	$945,593	-$34,285	-12%
12th Ave Arts	$649,440	-$34,389	0%
Total	$2,896,273	-$102,481	To be determined

- Most communities get Air Sealing Improvements, unitary heat pumps, Centralized Heat Pump Water Heaters, solar PV, and GEB Controls.
- Approx. 28 year cost recovery period for retrofits that have a lifespan of 18-20 years at best

First cost of GEB retrofits is too high for op cost savings to help break even

Requirements for a customer-centric solution for MFAH GEB Retrofits

Bill protection is key… the energy burden after retrofit cannot be higher than before!

Residents in MFAH communities may not be tech-savvy, however, tech access & enablement are important for the community

Broadband access is still a major issue for MFAH both in terms of costs as well as the availability of Wi-Fi Connectivity

Customer education and engagement are key to improving awareness, participation, and outcomes

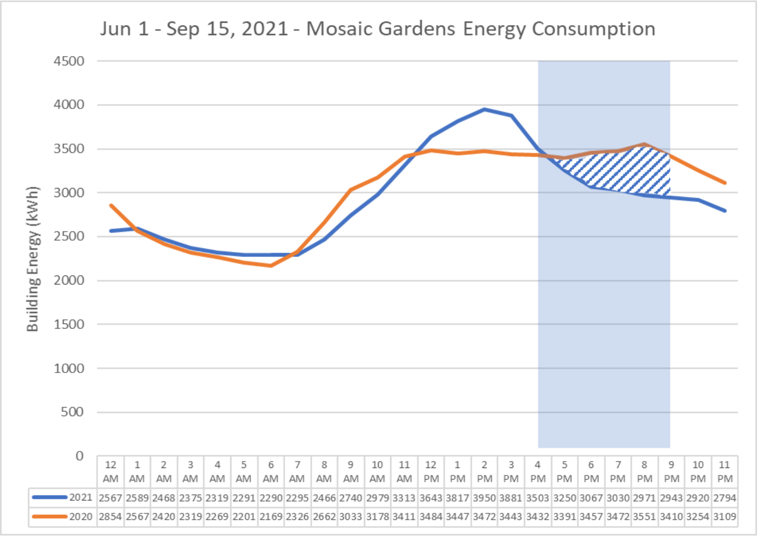
As a corollary to the above, taking customer input in designing engagement programs is crucial for participation

Requirements based on research into MFAH and other LMI communities

Lessons from the past

Lessons from our past…

- Bill protection is of primary importance
  - This includes the common area loads and master-metered facilities
  - A big difference between programs that actively include customer engagement vs those that are more passive.



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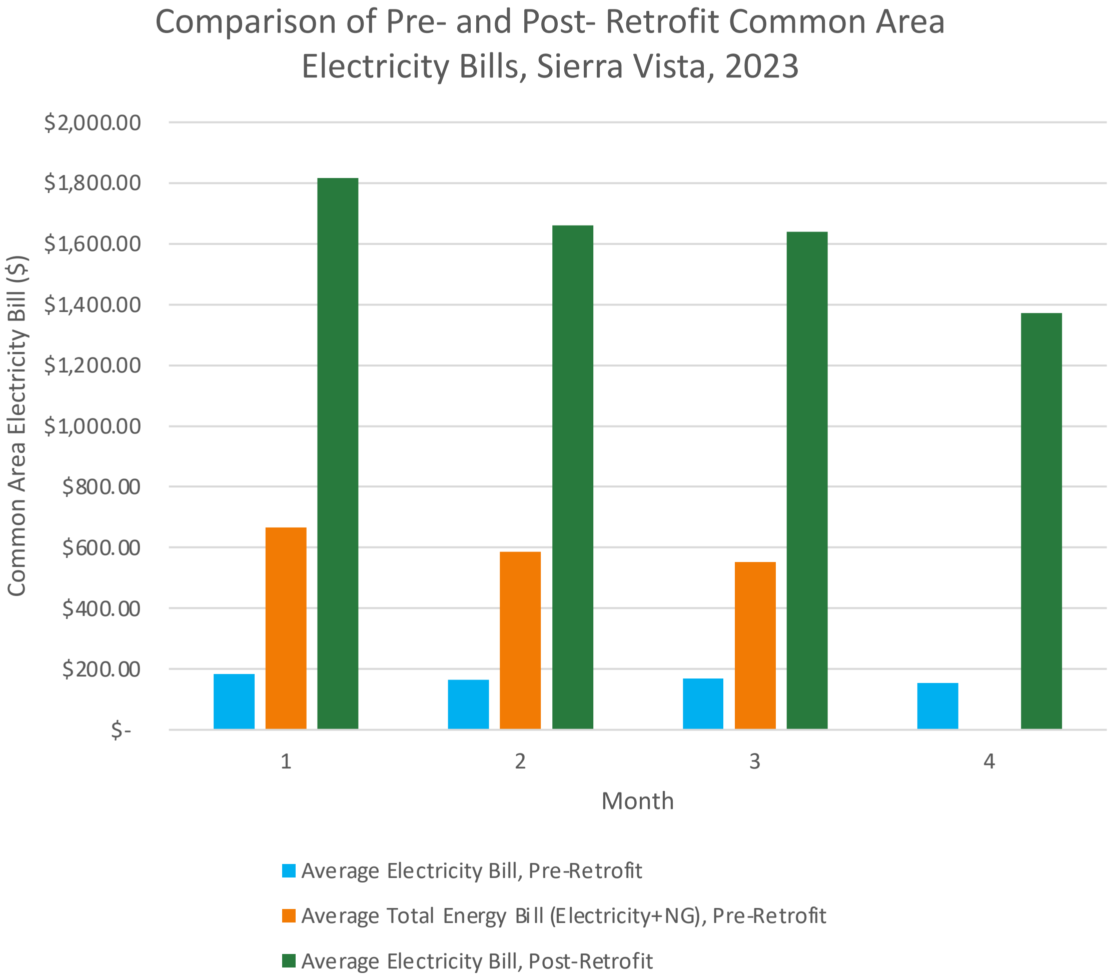
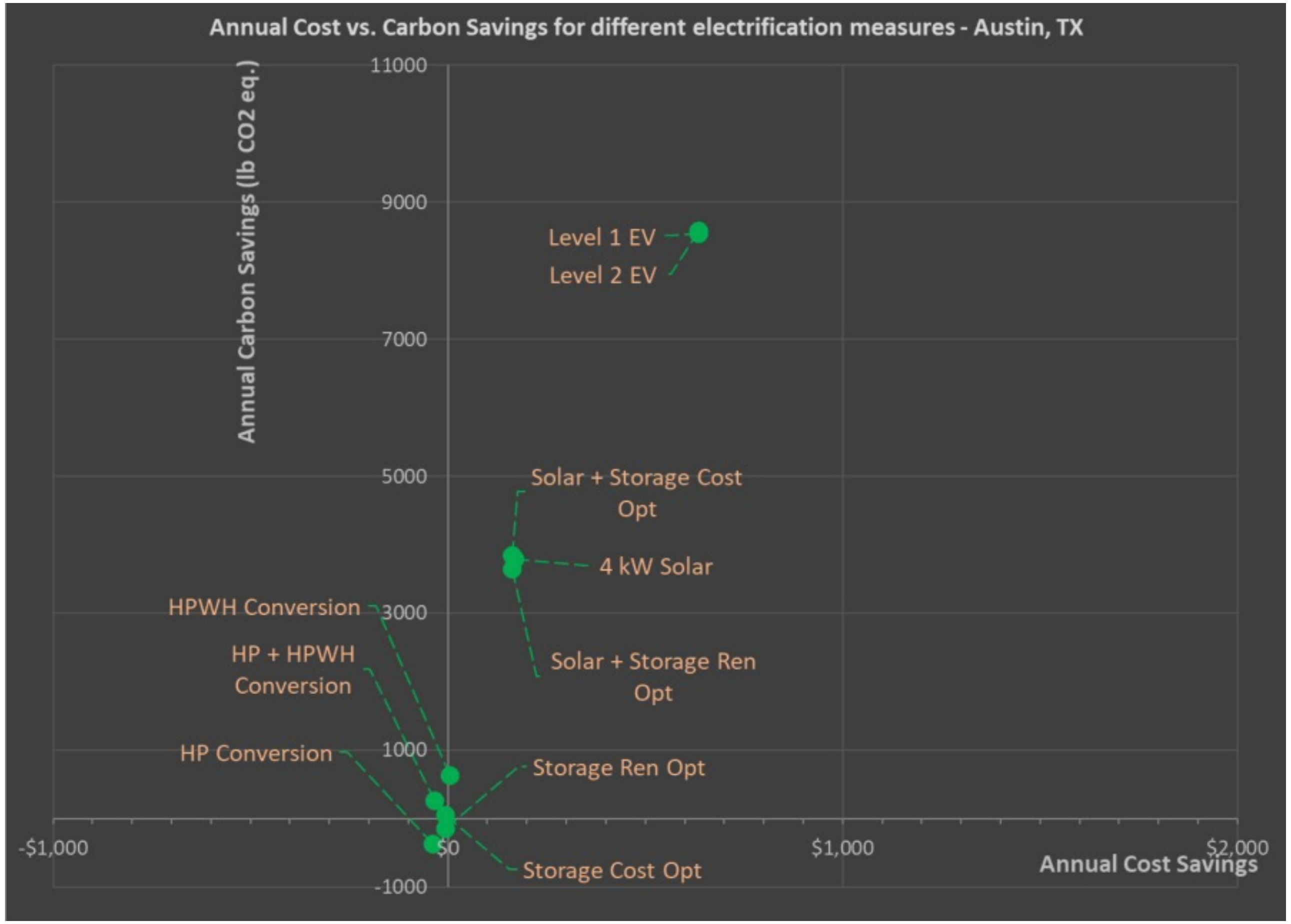
2021	2567	2589	2468	2375	2319	2291	2290	2295	2466	2740	2979	3313	3643	3817	3950	3881	3503	3250	3067	3030	2971	2943	2920	2794
2020	2854	2567	2420	2319	2269	2201	2169	2326	2662	3033	3178	3411	3484	3447	3472	3443	3432	3391	3457	3472	3551	3410	3254	3109



Lessons from our past… misplaced incentives

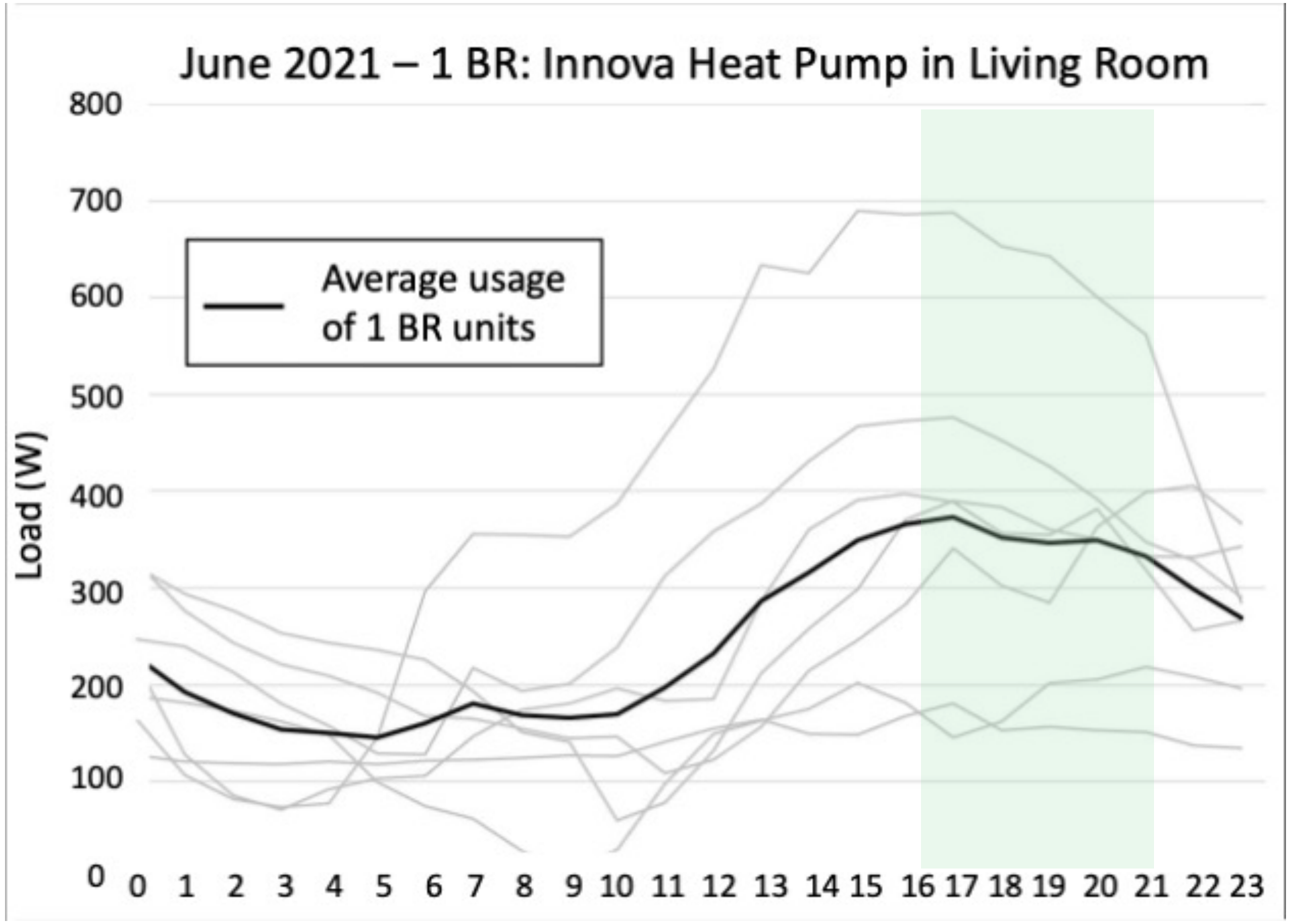
- The choice of GEB retrofit may not align with value-stacking
  - Solar PV + Battery, and Level 1/Level 2 EV charging are the most cost-effective whereas typical loads like HP, HPWH are not.
  - Most of the savings are from Solar PV which is not controllable. MFAH residents are not big EV users.
  - The utility rate structures have an outsized impact on the customer economic potential of GEB retrofits



Cost-effectiveness of GEB solutions are dependent upon a variety of market factors

Lessons from our past… impact of variability in user behavior

- Retrofitting swamp coolers with DC-inverter-driven Innova (Ephoca) units
  - Master-metered community shows wide variability in energy use after retrofits
  - Some apartments are aware of TOU peaks between 4 pm and 9 pm and reduce their energy use.
  - A few apartments indulge in overusing their new Heat Pump.

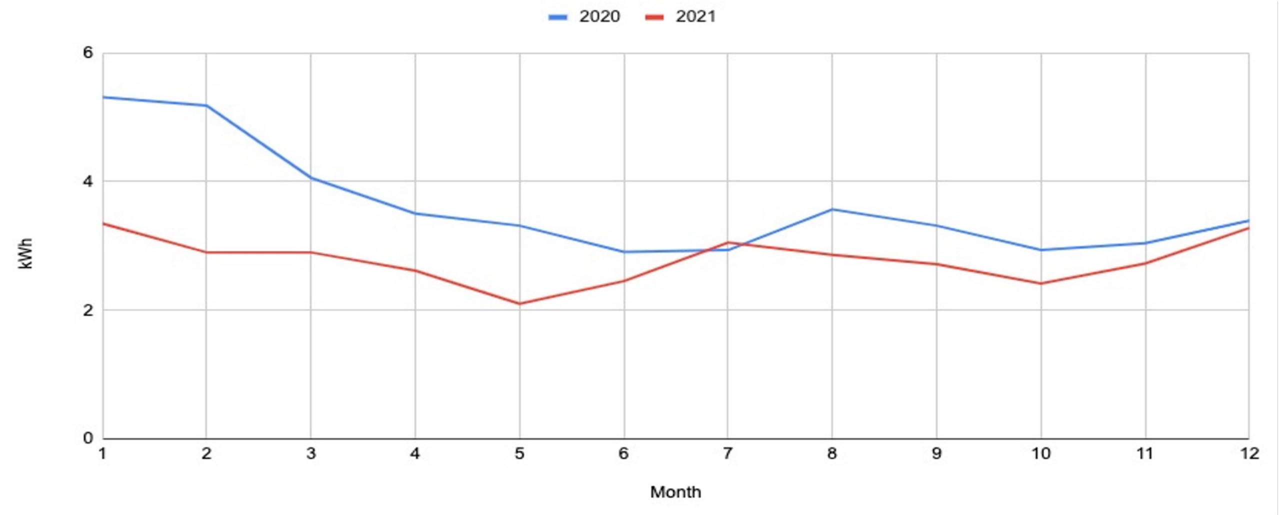


Consistent and conservative user behavior helps with value-stacking

Customer-centric GEB use cases

Customer-centric GEB use cases – DRAM participation

- Active customer engagement in DRAM participation
  - Community-driven events for customer education
  - Train-the-trainer enabled resident helper to improving resident participation
  - 53 unique events, with 765 resident opt-ins or an average of 16 opt-ins per event
  - 45% have achieved Gold or Platinum status, suggesting they are consistently saving between 15-80% compared to their historic baseline during DR events
  - Sampled participants participated in at least 50% of DR events and saved up to 50% compared to their historic baseline
  - Energy consumption in 2021 between the 4-9 TOU window fell compared to the previous year by an estimated ~15%
  - DRAM participation provides direct cash incentives to residents



Source: OhmConnect

Active Customer Engagement enables improved DR results

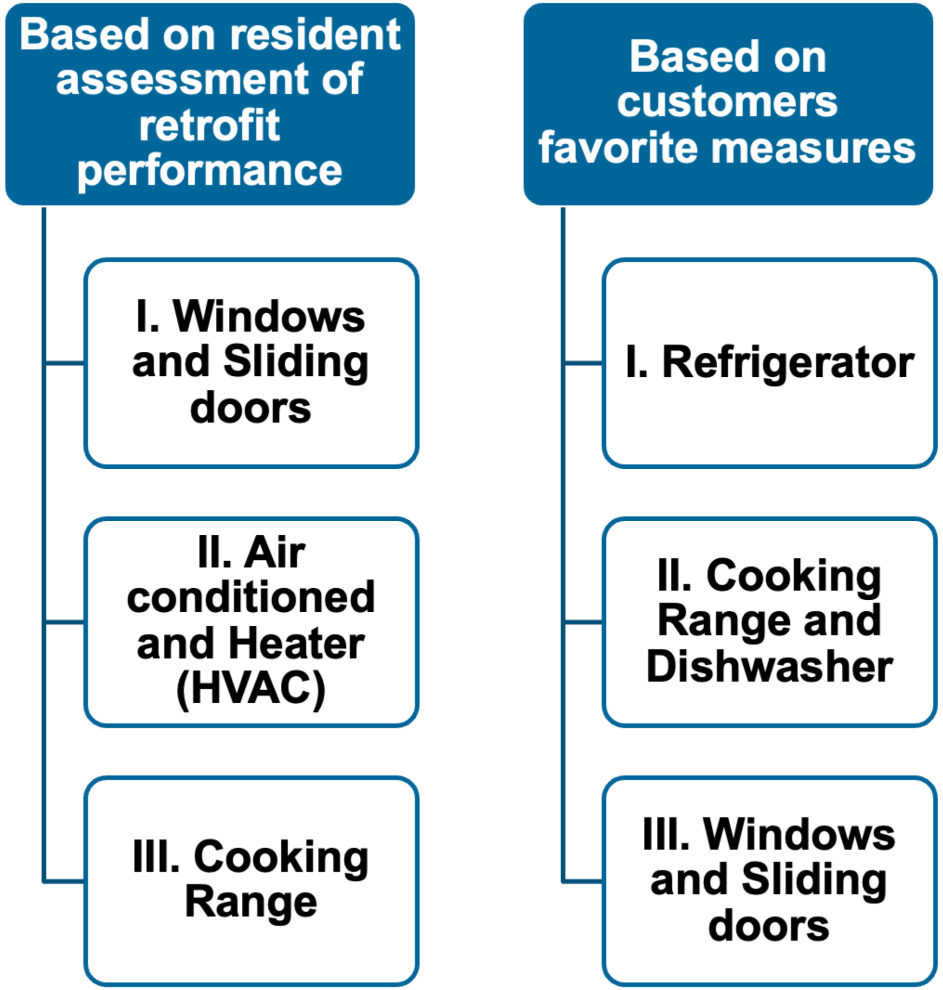
Customer-centric GEB use cases – Efficiency Upgrades (1)

- The pre-retrofit survey indicates the greatest pain points
  - Establish baseline on occupant experience (e.g. comfort, satisfaction, safety, health)
  - Lighting is the biggest challenge
  - Potential for dissatisfaction with "air quality"
- Completion by 47 out of 74 (64%) occupied households.

Complaint	% of Survey Participants
Dissatisfied with Cooling	21%
Dissatisfied with Heating	11%
Major Problem with Dirty Air	28%
Dissatisfied with Hot Water	15%
"Too Dark" in Apartment	30%
Inadequate Outdoor Lighting	59%

Customer-centric GEB use cases – Efficiency Upgrades (2)

- Post-retrofit survey indicates surprises
  - Positive customer response to Energy Efficiency upgrades.
  - More than 65% of respondents reported lower energy bills post-retrofits.
  - Tenant satisfaction has risen from 88% (pre-retrofit) to 97% (post-retrofit).
  - An increase in community satisfaction was seen post-retrofit from 37% (pre-retrofit) to 55% (post-retrofits)
  - A marked increase in tenant assessment of HVAC retrofit performance.
  - Higher tenant satisfaction in cooling and heating during summer and winter between pre and post-retrofit.



Windows, Sliding Doors, and Refrigerators are top measures

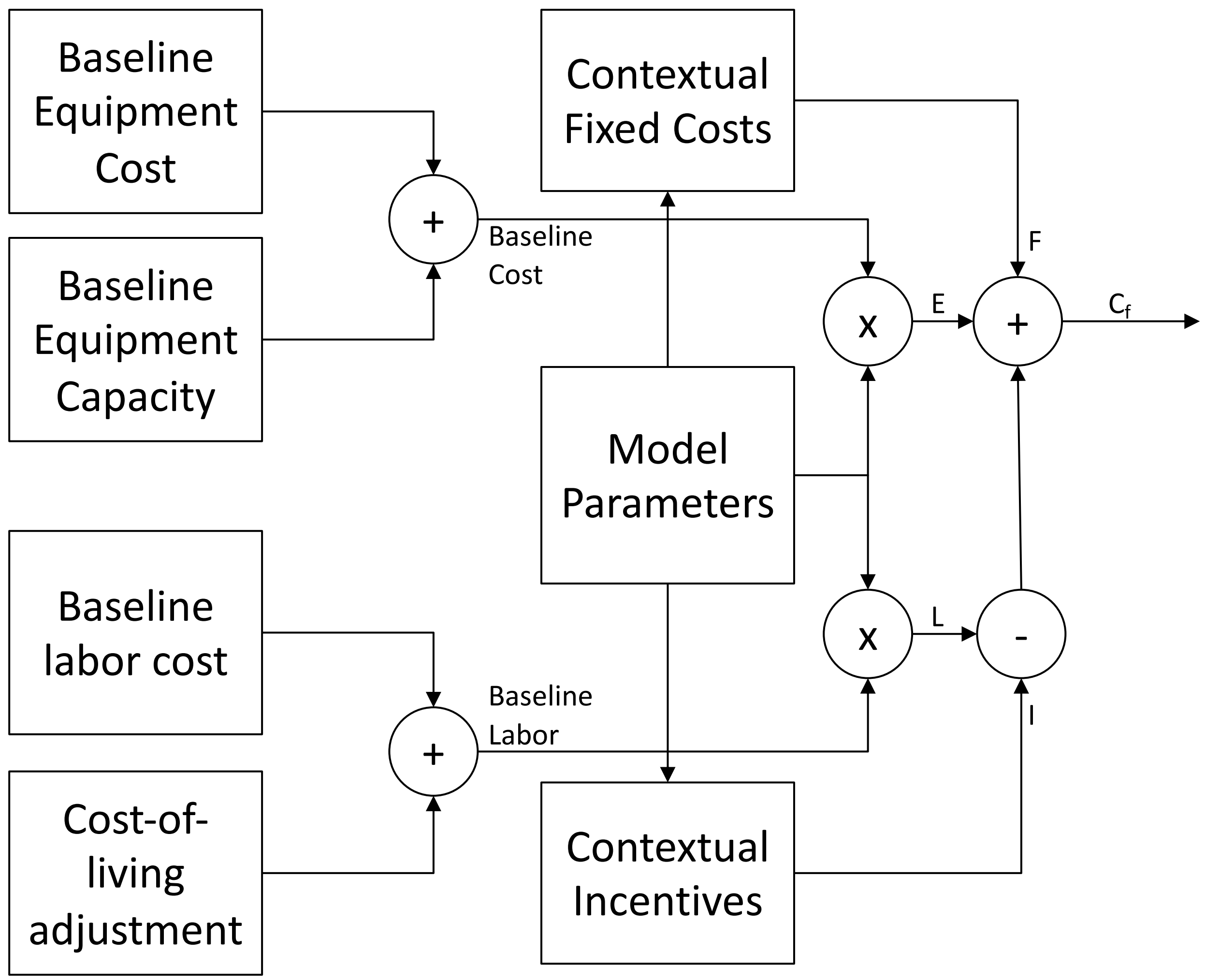
Systematic customer centricity – Cost-Benefit Analysis

	Utility	Customer	Society
First cost parameters (-)	✓ Distribution upgrades needed to accommodate electrification ✓ Customer acquisition (incremental administrative costs) *(not included in value model)*	✓ Equipment and labor cost of electrification measure ✓ Retrofit cost to enable electrification (wiring, panel upgrade, disposal of old equipment)	✓ Federal and state incentives *(not included in value model)*
Operating cost parameters (-/+)	✓ On-Bill Revenue	✓ Increase/decrease in bills	✓ Rates for electricity and natural gas ✓ Societal cost of carbon
Primary Value Dimension	Lifetime value of Infrastructure Upgrade Investment	Lifetime value of Electrified End-Use	Projected overall reduction in GHG emissions
Decision Tradeoff	Incremental peak demand, On-bill revenues	First cost, operating cost savings	Societal benefit, GHG reduction

EPRI's value framework for GEB retrofits

Systematic Customer-Centricity – Computational Approach

- Model the cost picture from a customer's perspective as well as utility perspective
  - Develop a parametric model for various electrification options
    - {Solar PV, Energy Storage, Level 1 & Level 2 EV chargers, HP, HPWH, HP+HPWH}
  - Adjust for relatively higher cost-of-living for Seattle
  - Explicitly account for equipment, labor, and maintenance costs as well as available federal, state, and utility incentives.
- Use the cost picture to establish strategies that provide win-win scenarios for customers and utility.



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Systematic customer-centricity – MFAH retrofit results

Choice	Customer First Costs ($)	Lifetime Customer Operating Cost Savings ($)	Incremental Peak Demand (%)	GHG Emissions Reduction (MTCO2e)	Lifetime Societal Benefits ($)
Heat Pump+ HPWH	**$14,743**	**-$146**	**48%**	**1.04 (100%)**	**$958**
50G/COP 3.0 HPWH	$6,144	$35	33%	0.53 (51%)	$351
3T/SEER 15/2-zone Mini-split Heat Pump	$9,798	-$193	39%	0.52 (49%)	$473
40G/COP 3.0/120V HPWH	$3,550	$35	33%	0.53 (51%)	$351
2x 1T 120V Heat Pump	$4,874	-$193	39%	0.52 (49%)	$473
120V HP+HPWH	**$8,425**	**-$146**	**48%**	**1.04 (100%)**	**$958**

- Economic value arising from heat pump-based water heating
- Space conditioning with heat pumps assumes gas furnace replacement with heat pumps which adds cooling loads in summer which causes savings to diminish.
- The use of 120V heat pumps reduces first cost for space conditioning and also reduces retrofit costs

MFAH can benefit from space and water heating retrofit with efficient, flexible HP and GEB controls

Customer-centric GEB use cases – Scale Up

DESIRED – Deep Efficiency & Smart-grid Integrated Retrofits in Disadvantaged Communities

- The project is conducted in 2 regions
  - Seattle – Seattle City Light and Community Roots Housing
  - NYC – NYPA, NYCHA.
- Demonstration includes 300+ units (6 communities) in Seattle and 300+ units (4 communities) in NYC
- Use of cutting-edge high-efficiency and connected technologies for enabling demand-side flexibility for grid services
- Use of an innovative buildings control platform that achieves flexible connectivity, standards-driven, and capable of signaling for grid services and collecting high-granularity data
- Exploring innovative business models to help scale the approach in addition to providing tech transfer to LMI communities and utilities.

Customer-centric GEB Retrofits at scale – 10 communities, 600+ living units, 2000+ residents

Research Innovation in DESIRED

- Centralized and Distributed Heat Pump technology for space and water heating
- Bifacial Solar PV and Bidirectional EV and Fleet Charging
- Grid marginal carbon emissions driven load and DER flexibility
- Enabling capacity market participation, temporal congestion avoidance
- End-to-end standards driven approach for scale
- Innovative customer engagement and education tools
- Multi-regional demonstration with varying utility business models

How to equitably transform Affordable Multifamily Buildings to GEB?

Major Customer Related Activities

CUSTOMER EDUCATION

CUSTOMER ENGAGEMENT

CUSTOMER CONSENT FOR PARTICIPATION & DATA SHARING

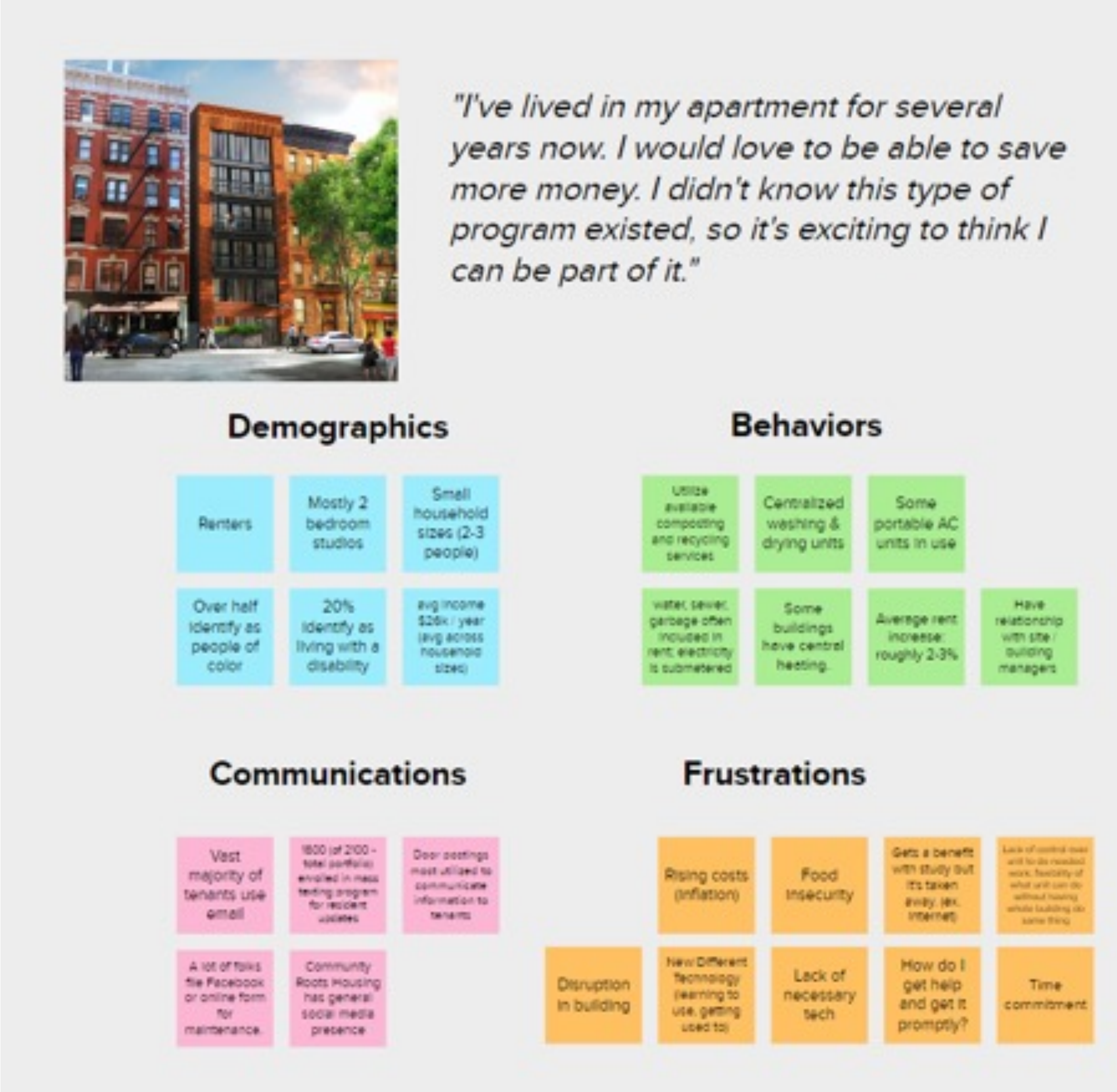
CUSTOMER SURVEYS

HUMAN SUBJECTS TESTING PROTOCOL & IRB APPROVAL

Broad Spectrum of Customer Impacting Activities

DESIRED Participant Persona

- Avg income < $26K
- >50% identify as POC
- Food Insecurity
- Utilize email, Facebook, Building Texts
- Utilize composting & recycling
- Electricity submetered
- Some portable AC units
- Relationship with bldg. manager



Mobile App – Business Requirements

01

Develop innovative approaches to customer engagement in disadvantaged communities

02

Provide a platform for customer engagement that can work in communities without ubiquitous broadband connectivity

03

Allow customers the ability to visualize their energy use and receive customized recommendations that can potentially induce energy conservation behaviors

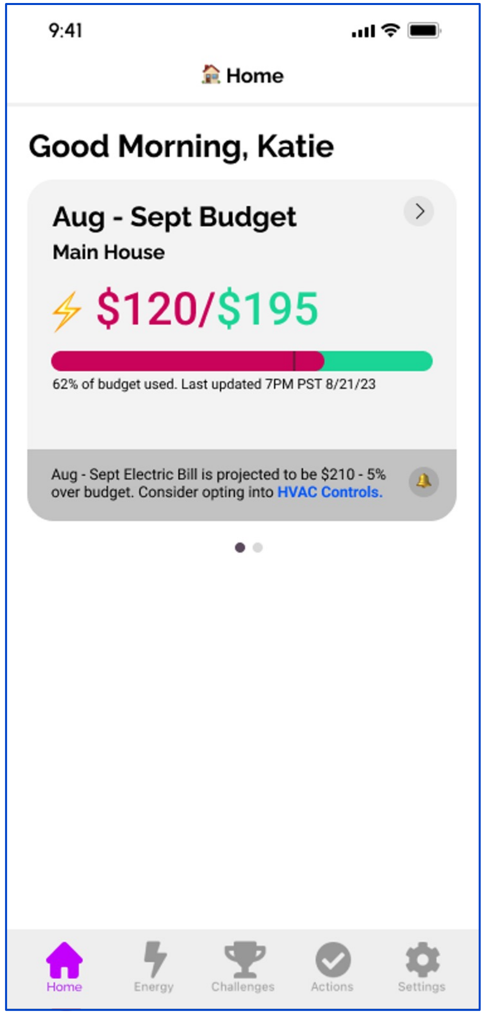
04

Offer customers the ability to define their own usage thresholds for effecting varying degrees of behind-the-meter load control

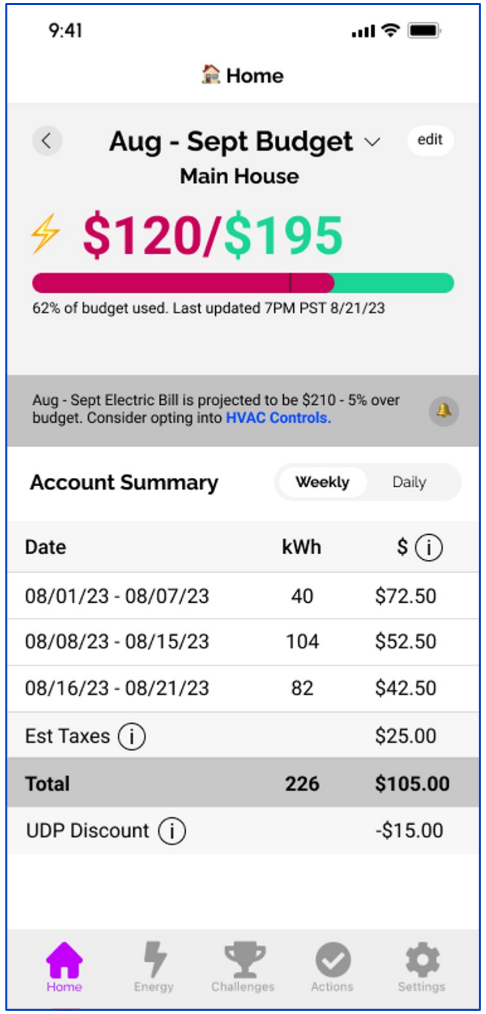
05

Reduce the energy-cost volatility for residents of disadvantaged communities relative to time-varying electricity rates

Customer-centric engagement – Mobile App Designs

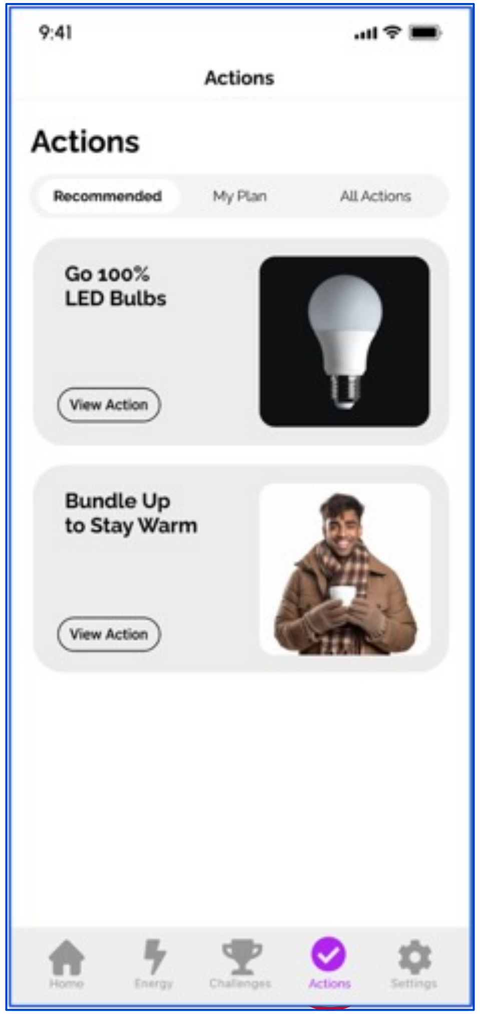


Estimated Bill Info

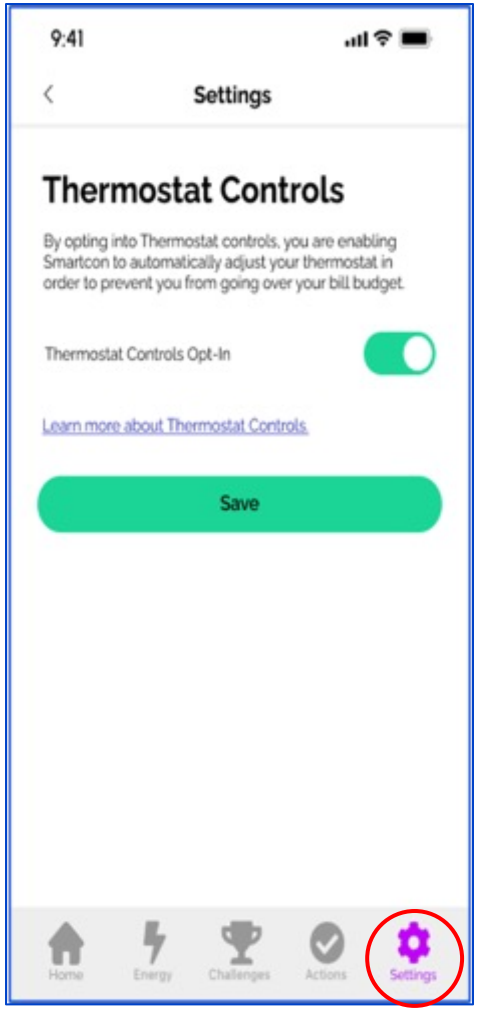


Estimated Bill Detail

Energy Use Detail



Energy Saving Tips



Load Control Opt-In

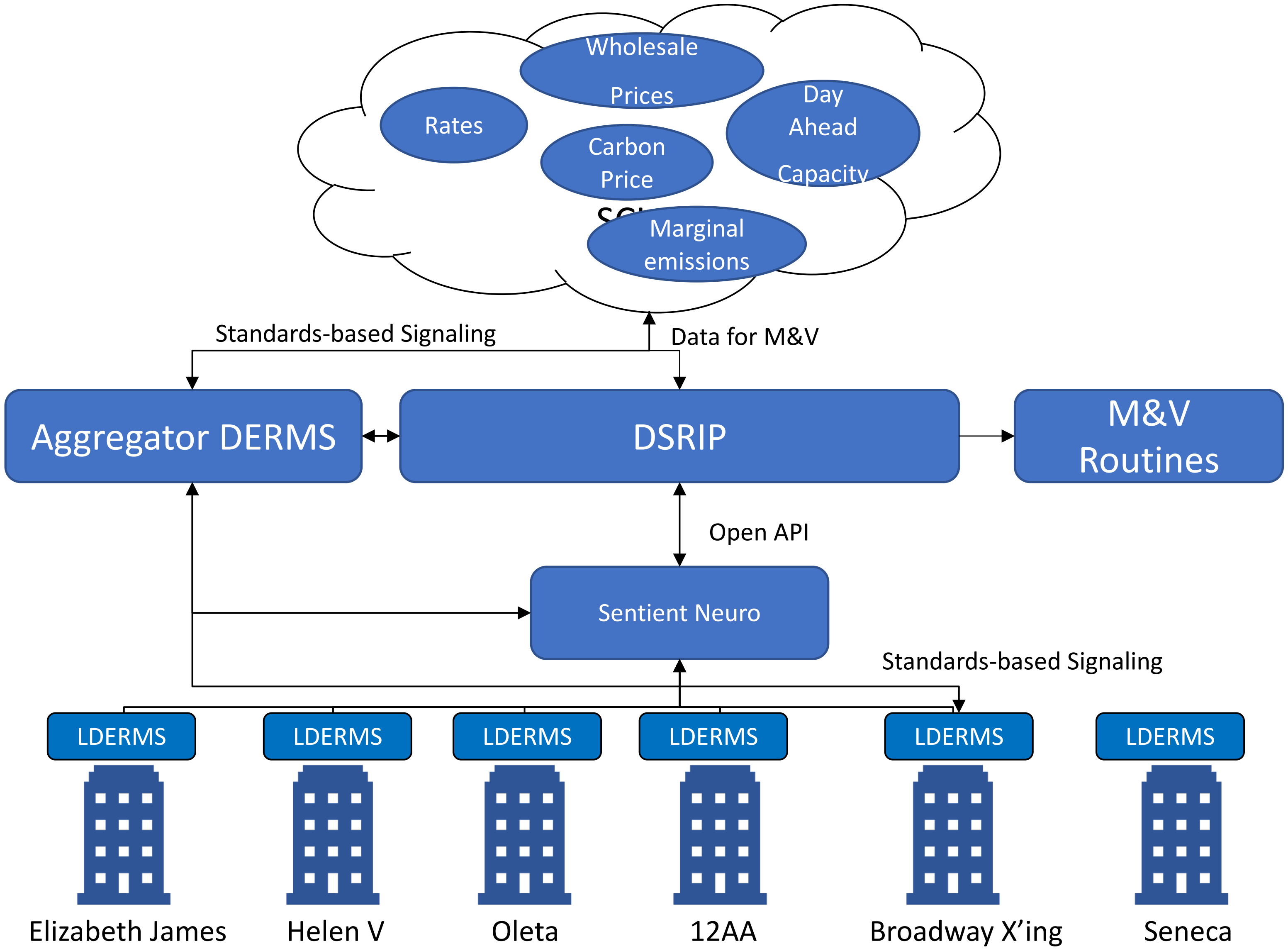
DESIRED Controls Architecture

Utility Layer provides grid-scale & utility-driven stimuli, use-cases, and evaluation of project benefits

ADERMS provides standards based signaling for Grid services; DSRIP provides data aggregation functions for M&V

Sentient Buildings provides fleet level aggregation and control of flexible loads

Community Layer is the built-environment, flexible loads, and customer-sited DERs; LDERMS provides DER control through standards-based signaling



Coordination of Control Strategies

Three levels of coordination in play

- Intra-Unit – Load prioritization,
- Intra-Building – Aggregated building loads + Community DER,
- Inter-Building – Grid-Services requiring multiple buildings + DER

Three levers for implementing coordination

- Intra-Unit – Mobile app (behavioral) + Sentient Neuro
- Intra-Building – Sentient Neuro + LDERMS
- Inter-Building – Aggregator DERMS + LDERMS + Sentient Neuro

Data needs for control actions

- Neuro – for unit-level control actions
- LDERMS + Sentient Neuro – for building level control actions
- Aggregator DERMS + DSRIP (Data Aggregation Middleware) for inter-building control actions

Control Strategies to be deployed

Mobile App

Use thresholds to drive towards a flat-bill control strategy

Employ unit-level controls first through behavioral messaging at 60% of the threshold

Secondarily employ messaging + load control based on reaching 80% of the threshold

Local-DERMS

Temporal congestion avoidance – use Building Loads + Solar PV + managed EV charging + Centralized Water Heaters

Employs MPC with constraints on common area monthly bills

Determine optimality between Solar curtailment vs. Solar self-consumption using centralized water heater storage tanks

Aggregator-DERMS

Marginal carbon emissions data for NYPA territory is available via the Singularity platform.

Use day-ahead marginal carbon emissions to load shift away from carbon-intensive times

Study the potential for using direct carbon signaling vs. rate-signaling for decarbonization

Conclusions & Takeaways

- Recognize that we are facing a complex problem – getting MFAH residents to care about their energy use.
- Understand the tradeoff between engagement and automation – preferable if it can be achieved through automation of loads that are outside the purview of the customer.
- Design algorithms, methods, and systems that actively engages customers to achieve success.