Bringing Local Community Benefits to Prince Georges County, Maryland Through Demand Response Modeling for Electricity Usage in Buildings

UMD Presenters: Andy Fellows (iSchool), Qingbin Cui (Civil & Env. Eng.), Steve Gabriel (Mech. Eng.), Jelena Srebric (Mech. Eng.)

CPower Presenters: Bill Oosterom, Dave Resler

Other Proposal Team Members: Anna Alberini (Agri. & Res. Econ.-UMD), Ming Hu (Arch., Planning, & Preservation-UMD), Mark Matties (JHU-APL), Tony Shu (UMD), Dave Shaughnessy (UMD)

UNIVERSITY OF MARYLAND

Smart Cities Roundtable

February 28, 2020

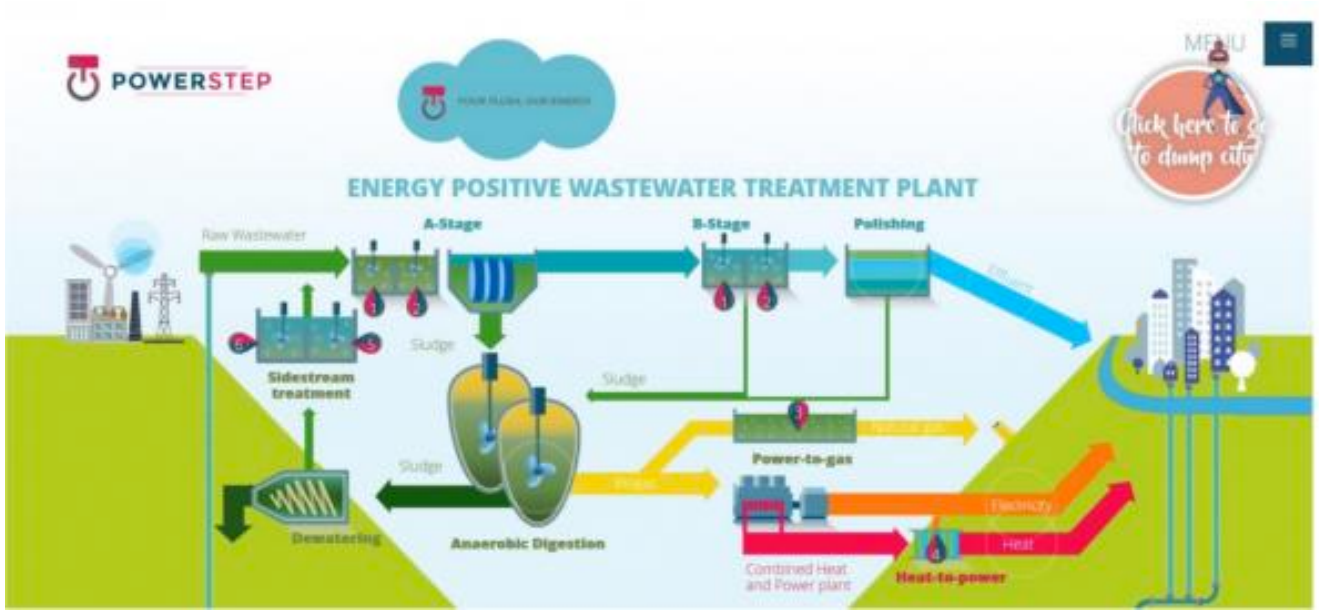
Outline

- Overview of proposal efforts (S. Gabriel)~ 10 min
- Sample benefits using UMD buildings (Q. Cui) ~10 min
- Building energy usage on campus & College Park (J. Srebric) ~10 min
- Benefits to Prince Georges County communities (A. Fellows) ~10 min
- Discussion of curtailment markets for PJM (Cpower) ~15 min
- Wrap-up and next steps (S. Gabriel) ~5 min
- Open discussion

Overview of Proposal Efforts
(S. Gabriel)

Sustainability & Demand Response: Supply Side

- How can we mitigate intermittency for renewable energy without using fossil fuel back-up?
- Can use the supply or the demand sides of energy (or both)
- **Supply side**
  - One way is to use more biofuels– renewables but these compete with food for land
  - Another way is to use waste and convert to energy (e.g., from wastewater treatment plants)



https://www.smart2zero.com/news/wastewater-power-plant-electrical-energy-sewage-treatment-plant

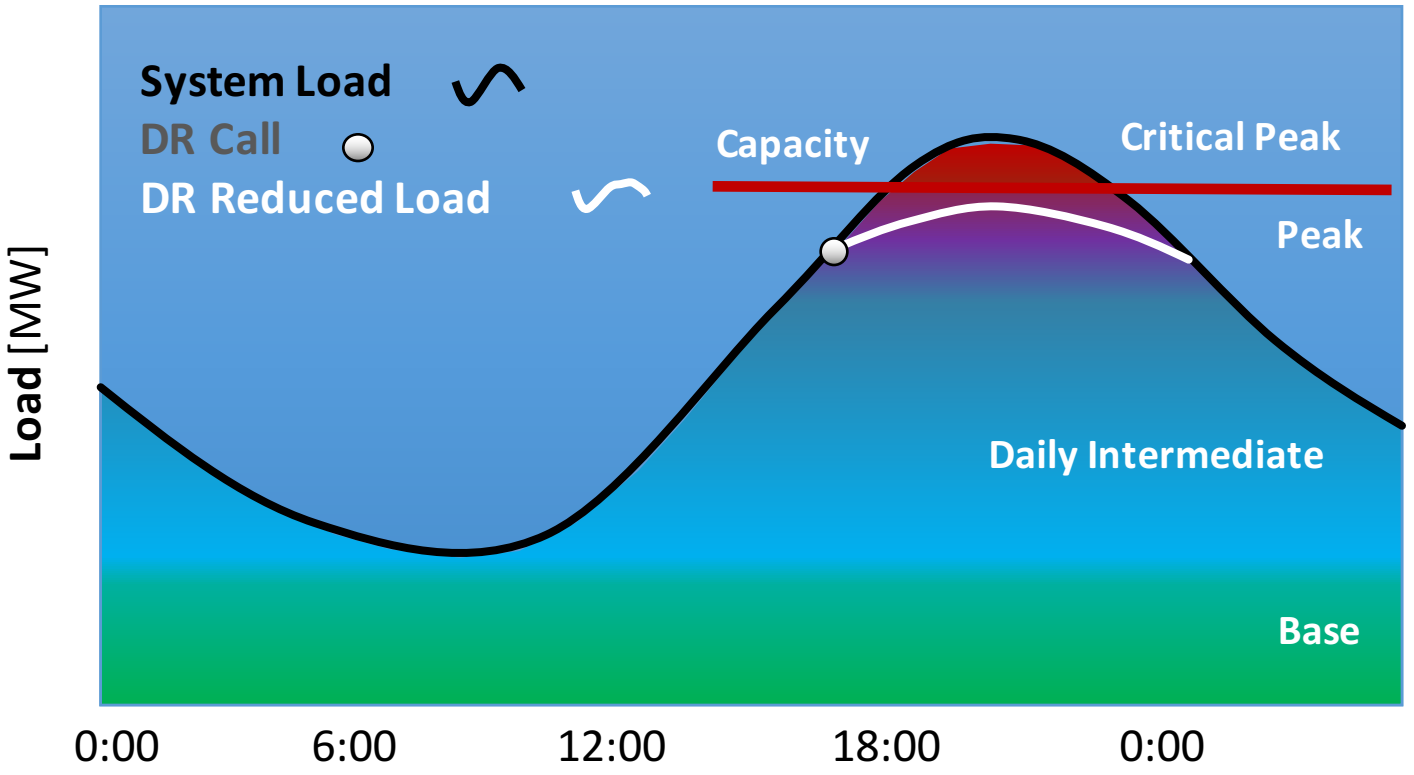
Sustainability & Demand Response: Demand Side

- **Demand side**
  - A perhaps easier way is to shift some of the load over time to avoid expensive and polluting peaking plants– this is demand response (DR)
  - DR in commercial and industrial sectors more common than in the residential one
  - Residential load is harder to predict, dependent on weather, harder to monitor
  - Smart thermostats (smart homes) allow for new residential power load-shifting via internet-based thermostats and adjustments of setpoints (e.g., for A/C) for participating customers
  - DR provides a less-polluting, more cost-effective solution given sustainability goals
  - Expanded capability with Internet-of-Things (IoT) growth, real-time aspects with IoT connection

What is Demand Response (DR)?

Responding to system inability to cover peak demands by reducing typical consumption

- The utility or grid operator (ISO) forecasts or observes a short in capacity to meet the demand.
- Calls on resources to reduce consumption (or provide new capacity
- System load reduced so less need for peaking power plants (e.g., gas turbines)
- **This curtailment in load can also be proposed by the users (e.g., buildings)– get a "flexibility payment"– this is the main idea for the proposal efforts**



Direct Metering vs. Master Metering for Buildings

- **Direct metering**: 1 meter per utility type or residential unit, after reading the meter, the utility charges the resident(s) directly
- **Master metering**: measure the electricity (or natural gas or water) of multiple tenants with the same meter, the owner/landlord gets the bill. Master metering gives wholesale rates which are less costly.
  - The building management assesses costs for each tenant based on sub-meters
  - Utility sub-metering allows the landlord to bill the tenants separately since the metering is done separately

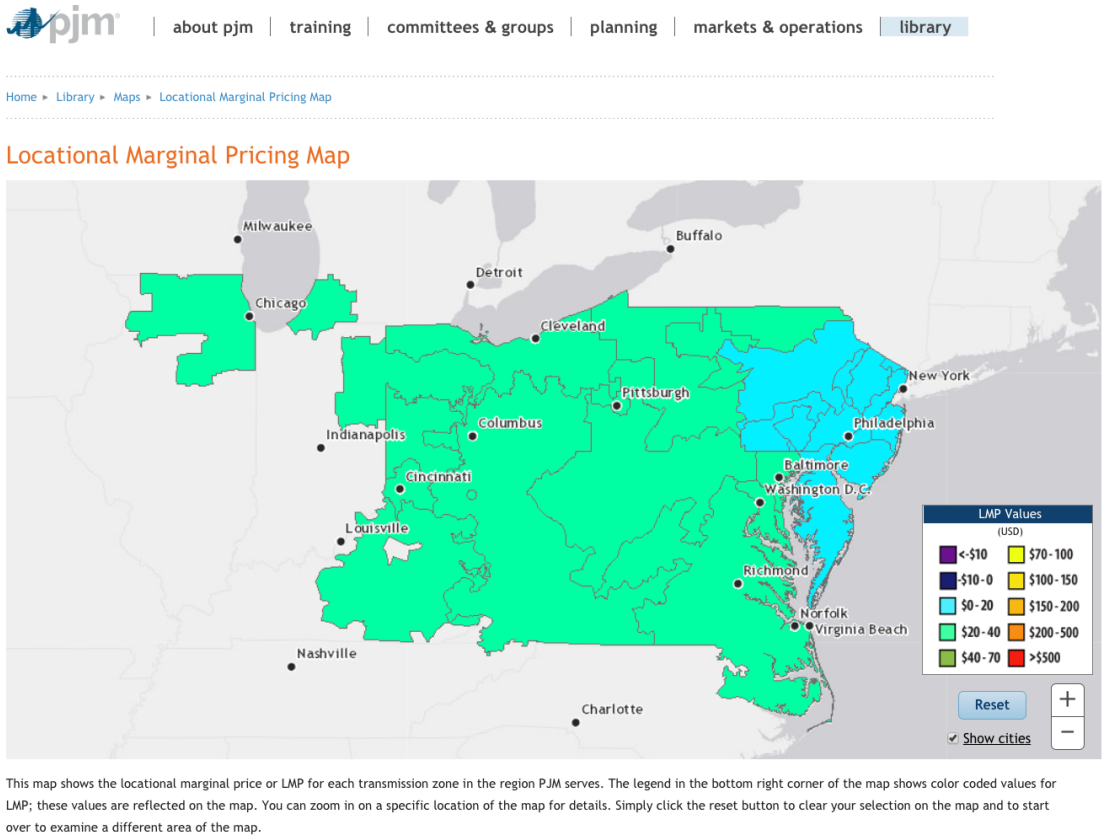
https://greencoast.org/master-metering/

Master Metering for Buildings and Demand Response Flexibility Payments

- Use the day-ahead market prices for power and commit to and deliver a reduction in power consumption and receive a payment.
- Currently University of Maryland does this and in effect gets a "check every month" that they do this for being "flexible" and committing to load reduction (i.e., decrease lighting, raise thermostat setpoints, change air flow for short periods of time)
- Illustrative example: day-ahead price is $40/MWh, master-metered building(s) commit to and deliver on 1 MW of reduction for 1 hour, get $40
- More about this in the other presentations that follow

Master Metering for Buildings and Demand Response Flexibility Payments

- PJM power market has curtail service providers so that this demand response can be done
- According to Dave Shaughnessy (FM) at UMD, these are sizeable payments.
- A master-metered building then could use these ”flexibility payments” to defray things like HOA or other building costs.
- Collective benefit, stronger incentive



pjm.com (June 5, 2019)

Three Potential Building Groups for Demand Response Benefits

- **Municipal buildings**: demand response payments get used for public benefit (e.g., fill budget gaps)
- **Master metered buildings**: building residents get collective benefit (e.g., less fees)
- **Single-family homes**: residents get individual benefits to use how they like
- Different incentive schemes/motivations for each of these groups
- **Main Idea: Add to existing UMD FM demand response program with reductions in power load from Prince Georges' County communities**

Sample Benefits Using UMD Buildings
(Q. Cui, T. Shu)

UMD Eppley Recreation Center Capacity Program Payments

Facilities:

- 230,000 sq. ft. building
- Includes multiple courts, pools, and weight lifting areas
- Open from 6am-12am weekdays and 8am-10pm weekends
- Electricity usage for large-scale heating/cooling, lighting, equipment, water pumps

Capacity DR Program:

- 850 kW average daily power consumption
- 10% in capacity program = $3000 in yearly revenue

UMD Knight Hall Capacity Program Payments

Facilities:

- 53,400 sq. ft. building
- LEED Gold Certified
- Consists of high-tech classrooms, labs, and journalism centers
- Open 7am – 10pm weekdays
- Electricity usage for heating/cooling, technology equipment and lighting

Capacity DR Program:

- 55 kW average daily power consumption
- 10% in capacity program = $200 in yearly revenue

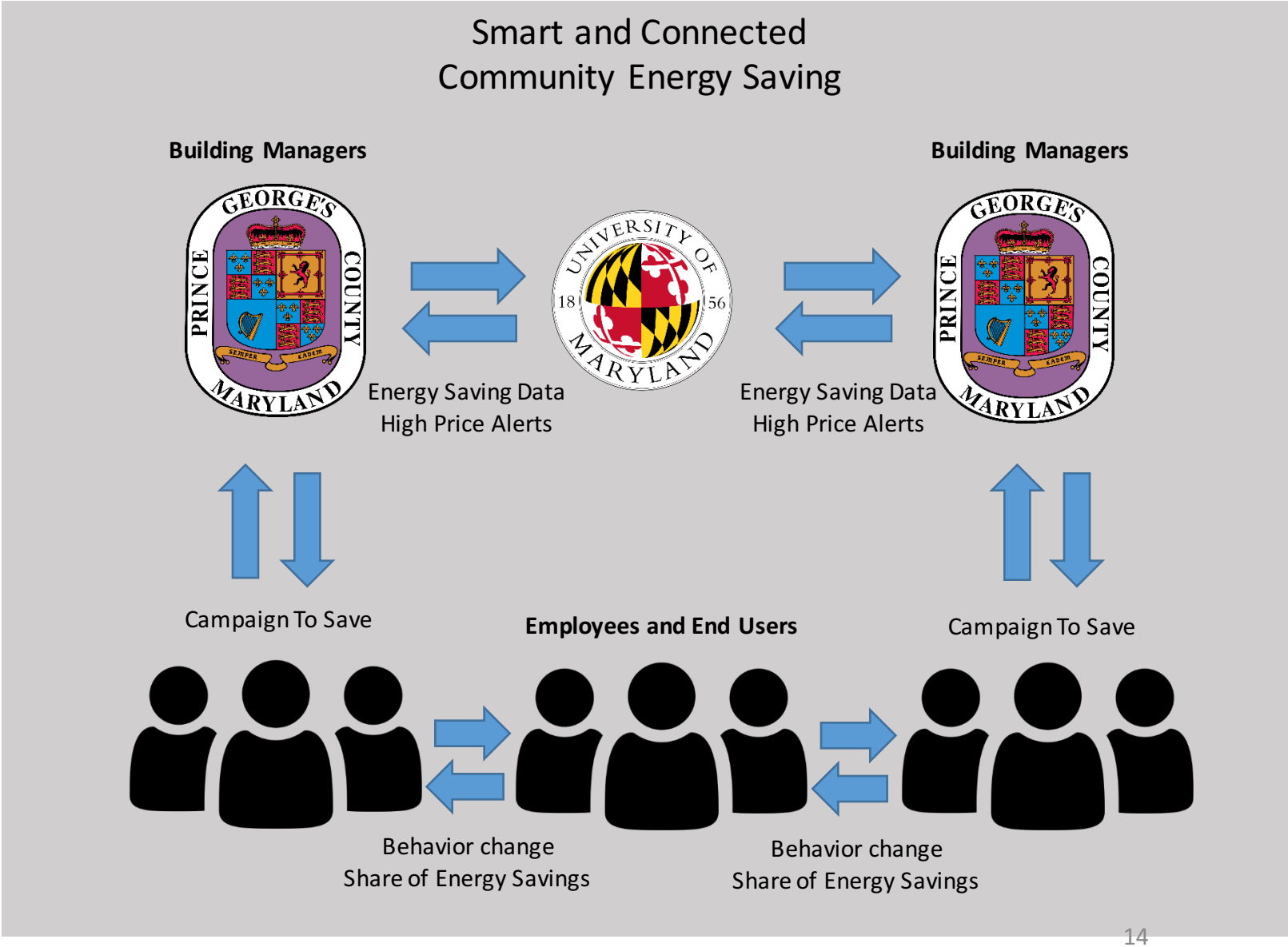
Capacity Markets vs Economic/Energy Savings Markets

Capacity:

- Generates greater source of revenue
- Emergency events are rare (none in past 7 years)
- Payments can be consistent and predetermined

Economic/Energy Saving:

- Encourages behavior and mindset change
- Creates a connected community
- Engages electricity end-users
- Revenue from curtailment requires daily registration and can be harder to predict



Economic and Energy Saving Costs Benefits

Economic:

- Requires bidding but generates revenue + cost savings
- Example – strike price $30 per MWh pays $30 per MWh for each MWh of reduction

Energy Saving:

- Only cost saving is factored
- Savings depends on price plan from distribution company
- Calculated savings from behaviors such as unplugging equipment, AC settings, turning devices and lighting off

Energy Efficiency Savings 2016 Study

Building	Maximum hourly electricity usage (kwh)		Average hourly Electricity usage (kwh)	Saving potential (Approximate)	
				Kwh/Mo	$/Mo
Cumberland Hall: • Student Dorm • 489 Residents 	Fall	280	141	10,144	$900
	Winter	276	90	6,488	$600
	Spring	232	111	7,975	$700
	Summer	240	107	7,669	$700

Building Energy Usage on Campus & College Park
(J. Srebric)

UMD's *C*enter for Sustainabil*ity* in the Built Environment (*City@UMD*)

The center's mission is to revolutionize the energy end-use systems in cities.

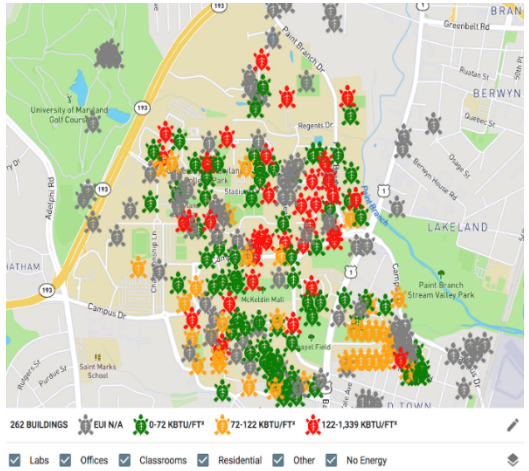
The center's projects explore emerging city properties from sub-scale processes through:

1) Multi-scale modeling of end-use energy in buildings
2) Technology for optimization of energy use and occupant comfort/health

City@UMD Example Projects Relevant for DR Effort

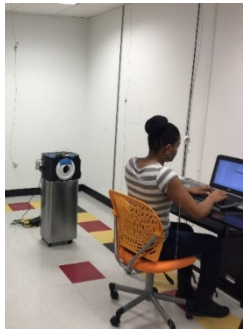
Project example (1) *TerpFootprints*

- Won 2019 Data Innovation Award by the Smart Energy Decisions
- Analyzed all campus buildings with 14.7 million sq. ft. in 262 buildings
- Processed data and applied machine learning for forecasting of utilities
- Provided reports to Facility Management, the Sustainability Council, and the President's Energy Task Force



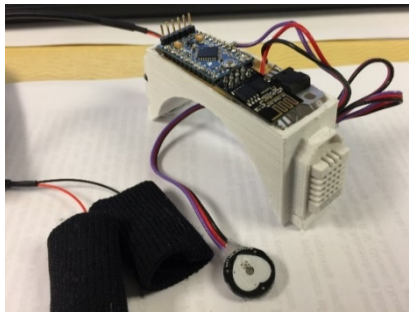
Campus Building Analyses

Project example (2) *Personal Comfort and Health*



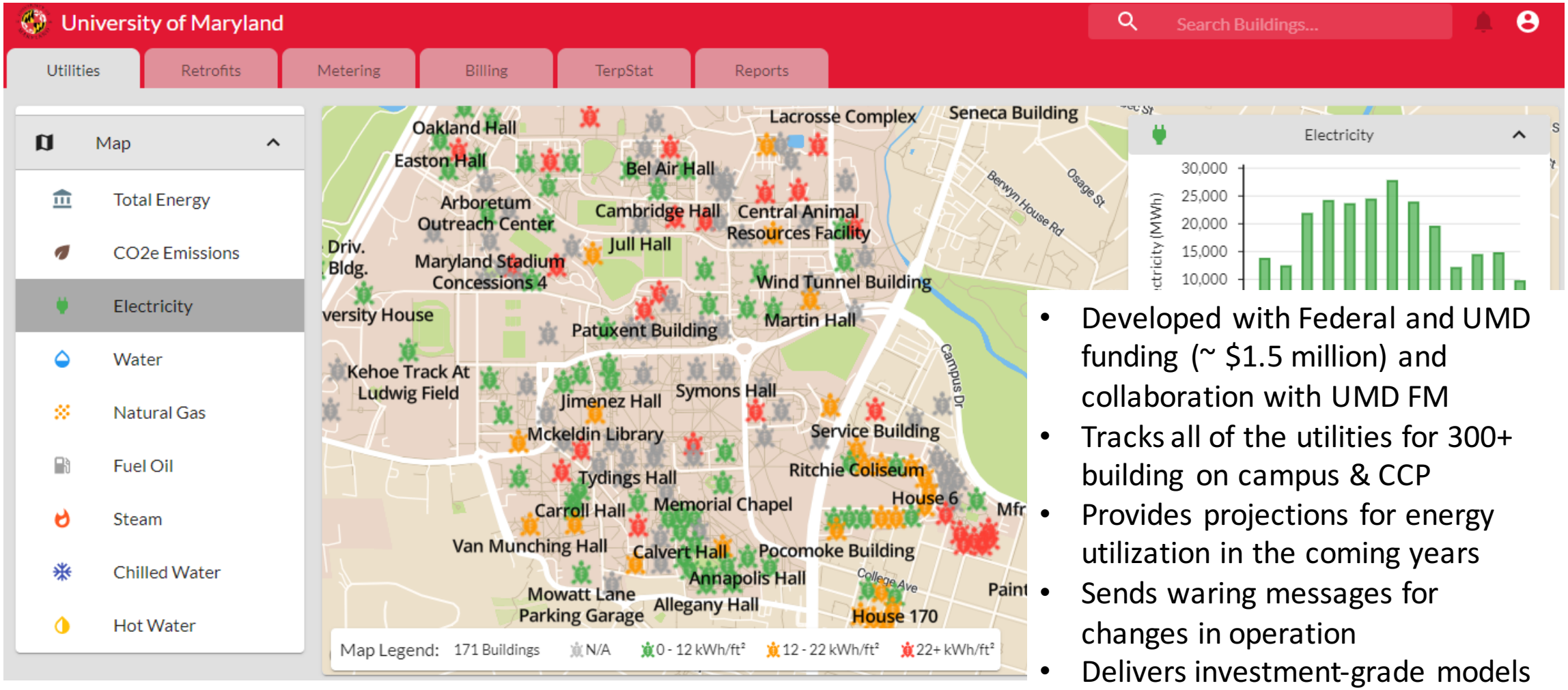
Environmental Lab

- Showed that 2-10 Watts of localized cooling satisfied comfort needs
- Defined a set of physiological data to monitor individual comfort
- Measured personal air quality in ten student dormitory buildings
- Identified 5 L/(s·person) of clean air to minimize risk of influenza
- Patented and licenses devices for delivery of personal microclimate



Comfort with Physiological Data

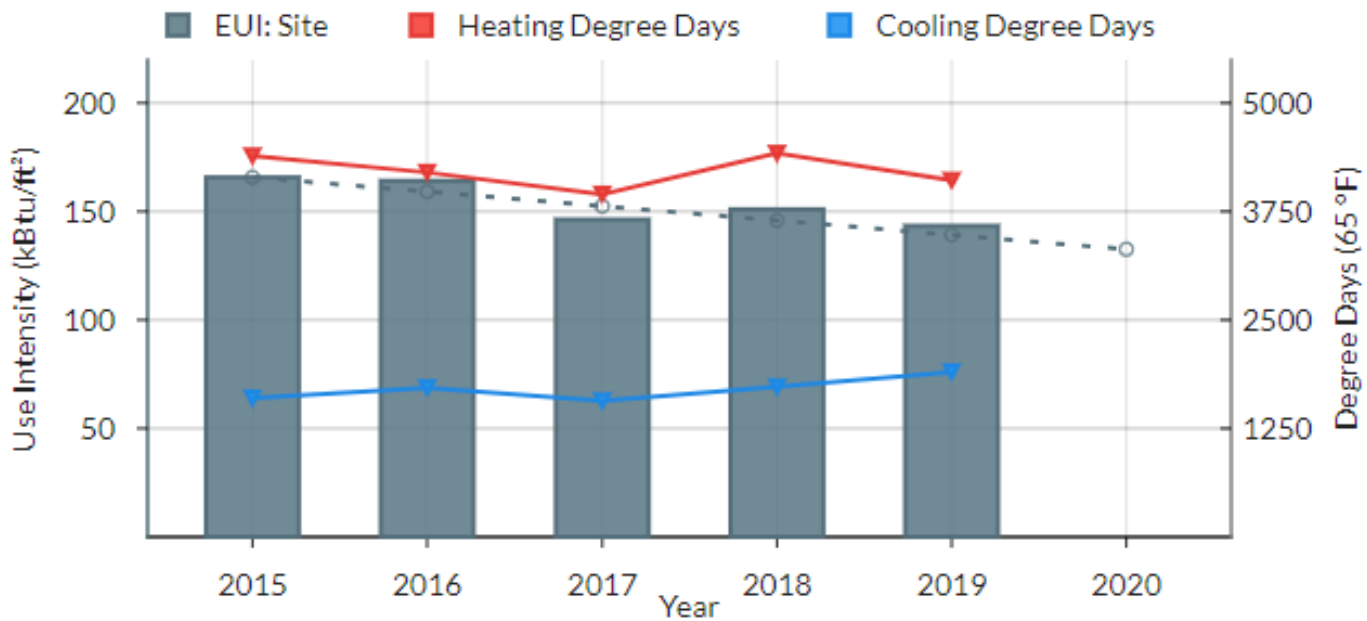
City@UMD's TerpFootprints



- Developed with Federal and UMD funding (~ $1.5 million) and collaboration with UMD FM
- Tracks all of the utilities for 300+ building on campus & CCP
- Provides projections for energy utilization in the coming years
- Sends waring messages for changes in operation
- Delivers investment-grade models and retrofit savings

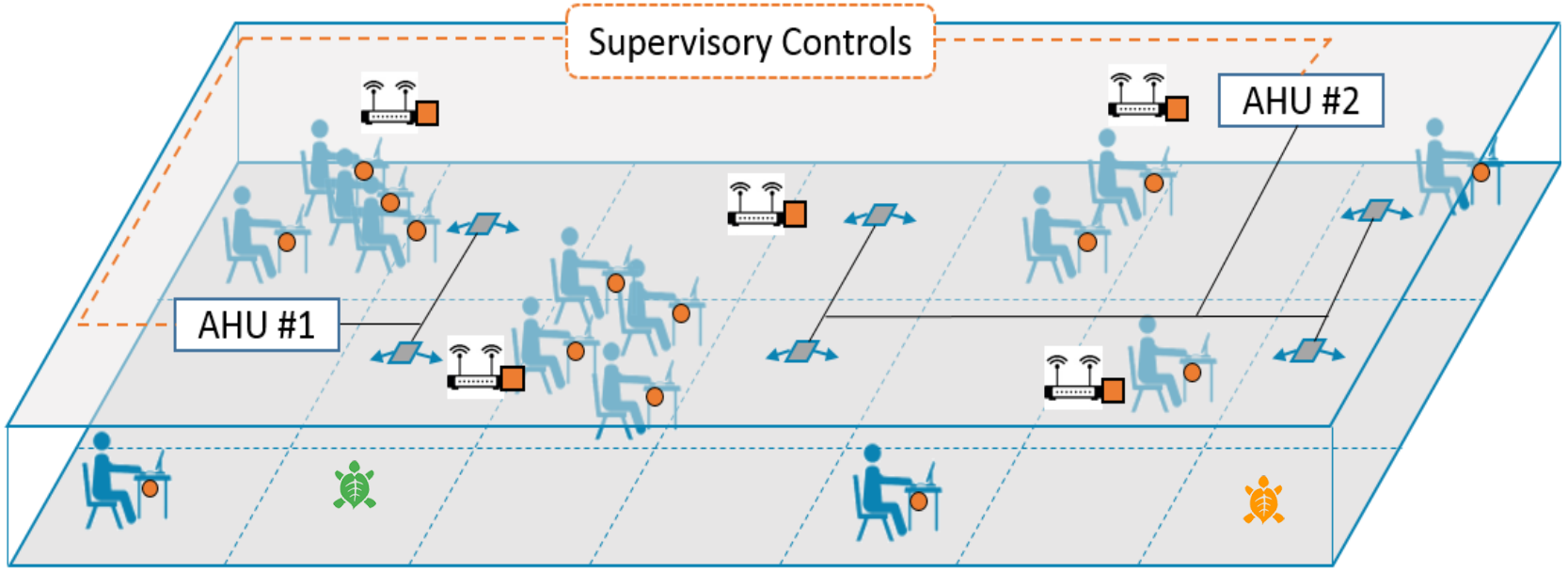
City@UMD's TerpFootprints

2019 sees the campus hit a 6% growth in building square footage as compared to the 2015 baseline. The latest addition is the Iribe Computer Science Building which opened in 2019.



	2015	2016	2017	2018	2019*
EUI: Source	216 kBtu/ft² → 0%	222 kBtu/ft² ↗ 2%	195 kBtu/ft² ↘ -10%	217 kBtu/ft² ↗ 1%	200 kBtu/ft² ↘ -8%

City@UMD's AI Thermostat Project



Next Generation of Building Controls Technology (*U.S. Patent Application 62/629,569, IS-2018-021*)

- An effective approach to curb electricity demand uses a relatively inexpensive infrastructure of thermostats
- Occupants want their environments to be comfortable and do not want to actively participate in the thermostat management
- Analyses of physiological data can replace interactions with analog, digital or api-based thermostats

Benefits to Prince Georges County Communities (A. Fellows)

Prince George's County
Town of Berwyn Heights
City of College Park
City of Greenbelt
City of Hyattsville
City of New Carrollton
Town of Riverdale Park
Town of University Park
Other jurisdictions

Benefits:

- Potential for modest revenue with limited effort
- Reduced need for use of peak demand polluting facilities
- Related to efforts to improve building efficiencies, reduced carbon footprint
- Part of strengthening Smart Cities collaboration with future benefits.

Discussion of Curtailment Markets for PJM
(CPower)

University of Maryland System
Smart Cities
Demand Response Discussion

Feb 28, 2020

Discussion Topics

- Introduction of CPower
- Curtailment Service Provider Description
- Demand Response Overview
- PJM Demand Response Programs
- Capacity Market Program
- Synchronized Reserve Program
- Economic Energy Program
- Energy Efficiency Program
- Questions?

Who is CPower?

- 120 dedicated resources – we are powered by our people!
- National experience. Local expertise.
- 50+ demand-side programs
- 4,200+ MWs enrolled
- 20+ utility programs
- 1,350+ customers, 10,000+ sites
- Demand-side solutions including:
  - Capacity
  - Economic
  - Synch Reserve
  - EE
  - PLC management
  - Generator assessment/permitting
- End-to-end, in-house, full-service operations, dispatch and fulfillment
- Trusted by several states and municipalities as their CSP for demand response
- Certified EE M&V provider

CPower

CPower
Curtailment Service Provider (CSP) Role

- PJM Membership
  - Required to participate in Demand Response programs
  - Carries membership obligations and risks
  - Represent customer interests in stakeholder settings
  - Secure MW position via Auction Process three (3) years in advance; Collateral Commitment
  - Compliance, Rules & Program Changes

- Enrollment/Registration
  - Assess/Qualify Potential Participant Capabilities
  - Energy Engineers to identify curtailment strategies and quantify potential program revenue
  - Assess optimal risk profile for customer based on operational needs
  - If applicable, create seasonal excess registration blocks, per PJM zone
  - Register load response assets with PJM

- Operational Procedures and Responsibilities
  - Initiation and termination of events (10 minute, 30 minute, 60 minute, 120 minute)
- Settlement
  - Measurement & verification, analysis, calculations, payment, and reporting

Demand Response Overview

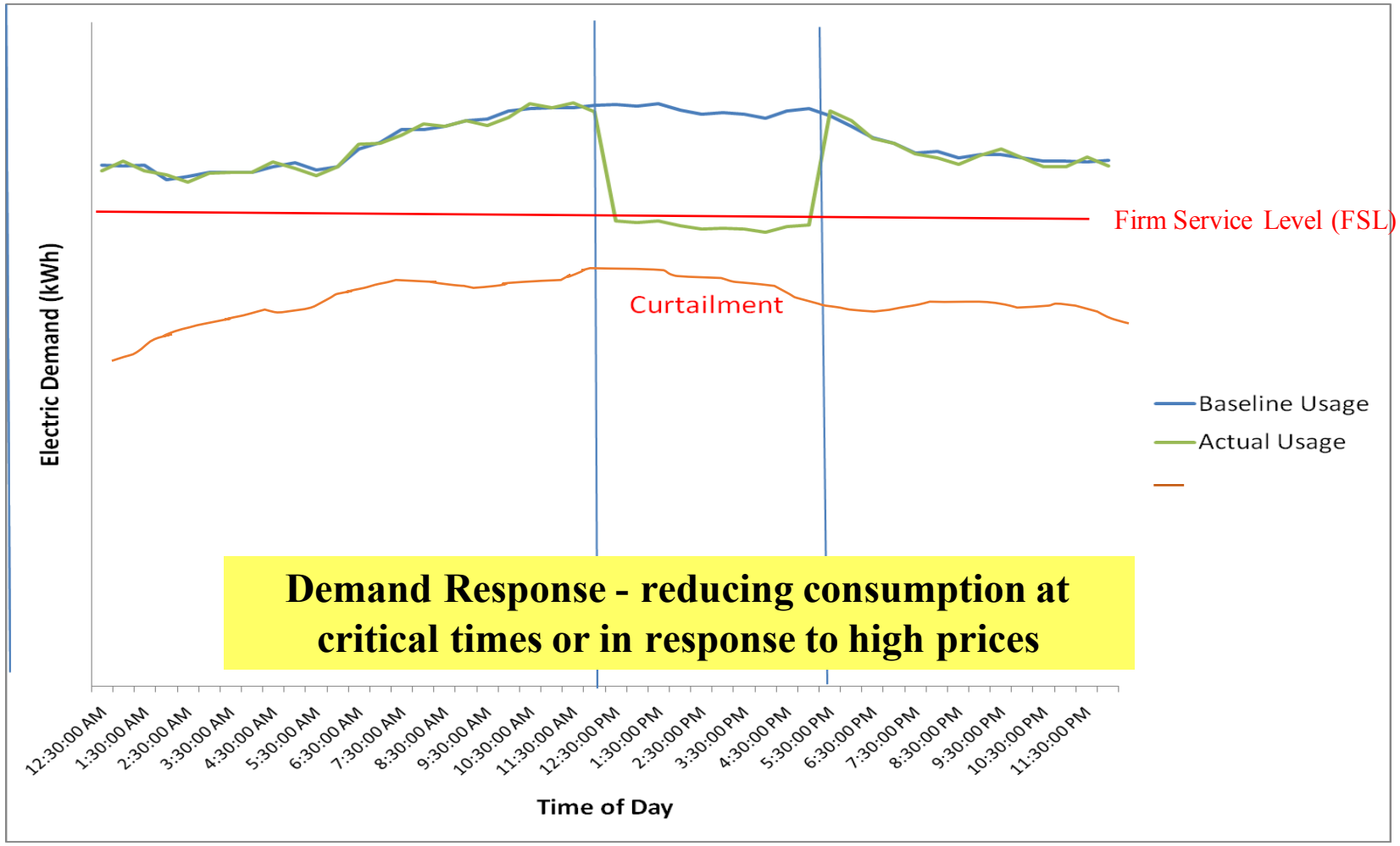
- Definition
  - Measurable reduction in electrical usage by customers in response to market conditions
  - Customers participate in a curtailment program that provides an incentive to reduce load during critical periods

- Benefits
  - Provides a significant source of new revenue
  - Helps ensure local electric grid reliability
  - Benefits environment by reducing the need for new peaking power plants

"Demand response is one of many resources needed to satisfy the increasing demand for electricity in North America."

- North American Electric Reliability Corp.

Demand Response Proposition



Resources used for Demand Response


Lighting Reduction


AC Strategies


Backup Generation


Elevator Cycling

- Manual or Automatic Load Drop
- Energy Management Systems
- Load Shedding Schemes
- Lighting Control Schemes
- Backup Generation
- Ice Storage Systems

PJM Demand Response Programs

Emergency Capacity Market
Designed to prevent grid failure/interruptions during periods of high usage

Synchronized Reserve
Designed to stabilize grid for reliability issues

Economic Energy
Market price-based program to alleviate load

Energy Efficiency
Revenue recognition for permanent load reduction

PJM Emergency Capacity Market Demand Response Program

Capacity Performance (Annual)

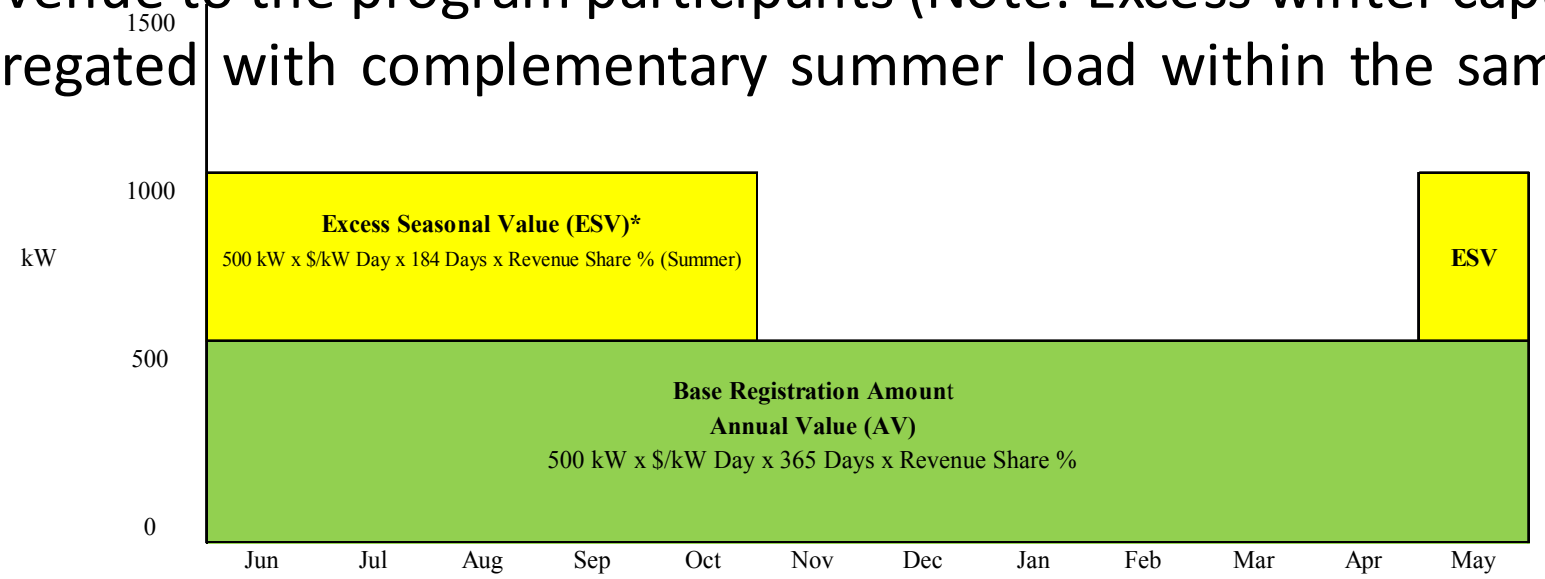
- June through October and the following May
  - 7 days/week between the hours of 10:00 am – 10:00 pm
- November through April
  - 7 days/week between the hours of 6:00 am – 9:00 pm
- Unlimited # of Events
- 12 hour maximum duration in the summer & 15 hour maximum duration in the winter
- Thirty (30) Minute Response (unless 1 or 2 hour Exemption is granted)
- 100 kW minimum commitment
- One (1) Hour Test Event minimum, if no actual PJM-initiated events are called
- Events outside of parameters above will be communicated, but are voluntary
- Revenue forfeiture for non-compliance capped at the annual projected revenue amount (i.e.; no “out of pocket” penalty)

Capacity Performance Details & Challenges

- In the Capacity Performance program, Participants and Curtailment Service Providers will need to evaluate Summer and Winter usage and curtailment capabilities.
- Analysis includes, but is not limited to, the calculation and acceptance of Winter Peak Load Contribution (PLC) values, the identification of winter curtailment strategies, and the calculation of the curtailment amounts associated with the identified strategies.
- **A single curtailment registration value is to be submitted (i.e.; Not one value for the summer and another for the winter), and it must represent the curtailment amount that can be provided year-round, which will be the lower value.**
- **This base registration amount is called the Annual Value or AV.**
- Example:
  - Participant can provide a 1 MW curtailment commitment in the Summer, but only a 500 kW (.5 MW) curtailment commitment in the winter.
  - The lower value of 500 kW must be registered as that is the amount that can be provided on a 365-day basis (Maximum Annual Value)

Capacity Performance, Registration with Seasonal Values

- While the base registration will represent the Maximum Annual Value, excess summer or winter curtailment capability can be registered via an aggregation block, *if a complementary load can be found in the same PJM utility zone.*
- For example, 500 kW excess summer capability shown in yellow. CPower can register the excess load if a complementary 500 kW winter load is identified in the same PJM utility zone.
- Such load would be identified as **Excess Seasonal Value (ESV)** and would represent additional revenue to the program participants (Note: Excess winter capability can be similarly aggregated with complementary summer load within the same PJM utility zone.)



* Winter Excess Seasonal Value (ESV) paid at kW x $/kW Day x 181 Days x Revenue Share %

Historical Emergency Events

Year	# of events	Event Durations	Yearly Totals
2007	1 event	5 hrs (SW & Eastern MAAC)	5 hours total
2008	0 events		0
2009	0 events	1 one-hour test event	1 hour total
2010	3 events	4 hours/4 hours/4 hours	12 hours total
2011	1 event	5 ½ hours	5 ½ hours total
2012	1 event	3 hours; Not all zones	3 hours total
2013	1 event	3.5 hours	3.5 hours total
2014	0 events	1 one-hour test event	1 hour total
2015	0 events	1 one-hour test event	1 hour total
2016	0 events	1 one-hour test event	1 hour total
2017	0 events	1 one-hour test event	1 hour total
2018	0 events	1 one-hour test event	1 hour total

- 2019 0 events 1 one-hour test event
  1 hour total

PJM Capacity Market Values
2019-2020 through 2021 – 2022

(Note: 2022-2023 values known in March 2020 ??)

2019/20 $/MW-YEAR		
LDA	ZONE	BASE
EMAAC	AECO	$36,516
	DPL	$36,516
	JCPL	$36,516
	PECO	$36,516
	RECO	$36,516
	PSEG	$36,516
MAAC	METED	$29,280
	PENELEC	$29,280
	PPL	$29,280
BGE	BGE	$29,390
PEPCO	PEPCO	$4
RTO	AEP	$29,280
	APS	$29,280
	DAY	$29,280
	DEOK	$29,280
	DOM	$29,280
	DUQ	$29,280
	EXPC	$29,280
	ATSI	$29,280
COMED	COMED	$66,894

2020/21 $/MW-YEAR		
LDA	ZONE	CP
EMAAC	AECO	$68,573
	DPL	$68,573
	JCPL	$68,573
	PECO	$68,573
	RECO	$68,573
	PSEG	$68,573
MAAC	METED	$31,405
	PENELEC	$31,405
	PPL	$31,405
	BGE	$31,405
	PEPCO	$31,405
RTO	AEP	$27,933
	APS	$27,933
	ATSI	$27,933
	DAY	$27,933
	DOM	$27,933
	DUQ	$27,933
	EXPC	$27,933
DEOK	DEOK	$47,450
COMED	COMED	$68,664

2021/22 $/MW-YEAR		
LDA	ZONE	CP
EMAAC	AECO	$60,491
	DPL	$60,491
	JCPL	$60,491
	PECO	$60,491
	RECO	$60,491
PSEG	PSEG	$74,566
MAAC	METED	$51,100
	PENELEC	$51,100
	PPL	$51,100
	PEPCO	$51,100
BGE	BGE	$73,110
RTO	AEP	$51,100
	APS	$51,100
	DAY	$51,100
	DEOK	$51,100
	DOM	$51,100
	DUQ	$51,100
	EXPC	$51,100
ATSI	ATSI	$62,535
COMED	COMED	$71,376

PJM Synchronized Reserve Demand Response Program

Payment from PJM for the ability to quickly shed load in response to short-term reliability needs

PJM Program: Synchronized Reserve

Program highlights	• Reserve market service is a year-round program whereby the PJM RTO occasionally needs immediate assistance with system reliability. • If the participant's nominated curtailment is accepted by PJM, payment is earned regardless of whether an event is called. • Event notification: 10 minutes prior to the event. • Number of events: Estimated 40 events per year. • Duration: Up to 30 minutes
Timing	• Program is available 24/7/365.
Requirements	• 100kW minimum load commitment. • 10-minute response time. • Load will be curtailed for a maximum of 30 minutes per event • One-minute interval metering is required
Payments	• Amount based on Synchronous Reserve Market Clearing Price (SRMCP).

PJM Economic Energy Demand Response Program

Payment from PJM for load curtailment during periods of high market price on the grid

PJM Economic Energy Program

- Economic Energy Program pays incentive to customers to reduce electricity consumption during high PJM market prices

  - 100KW Minimum Load Reduction
    - *Load Shedding or Generation Dispatch (if permitted)*
  - Payment based on Strike Price and Locational Marginal Price (LMP)
  - Participant/CPower agreed to Strike Price that identifies the LMP at which the curtailment effort makes economic sense for participant
  - CPower, via the CPower App, advises of hours of curtailment opportunity based on LMP and Strike Price, and commences participation process
    - *Notice of Opportunity Hours*
    - *Authorization to Register for Event*
    - *Registration of Curtailment Commitment and Duration*
    - *Compliance Confirmation/Settlement/Payment*

  - Day Ahead and Real Time (Balancing) Markets
    - Each require "day before" decisions and actions

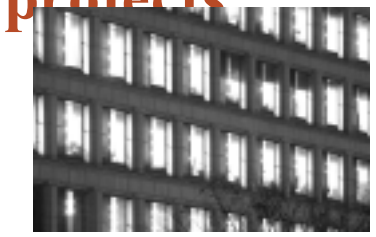
PJM Energy Efficiency Demand Response Program

Payment from PJM for permanent load reduction (kW) provided via energy-efficiency retrofits/projects

What is Energy Efficiency?

The permanent reduction of electrical demand through installing energy efficient systems, improvements or upgrades in equipment or devices.

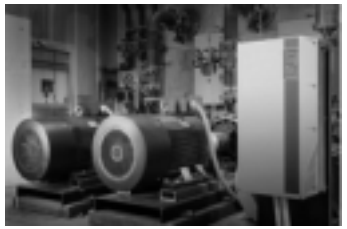
Qualifying EE projects:


Lighting


Chillers


Process Improvements


Green/LEED Building


VFDs

Qualifying Timelines

Installation Period	Project Fully Installed by June 1 of:	Remaining Eligible Years
June 2016 – May 2017	2017	2020/21
June 2017 – May 2018	2018	2020/21, 2021/22
June 2018 – May 2019	2019	2020/21, 2021/22, 2022/23
June 2019 – May 2020	2020	2020/21, 2021/22, 2022/23, 2023/24

Energy Efficiency Program Parameters

Minimum Size	**100 kW aggregation by zone**
Compensation	$/kW rates based on zone and enrollment years
Compliance Period	Project must be able to be measured to show demand reduction between the hours of 2 pm – 6 pm, Jun – Aug excluding weekends and NERC holidays. Starting Jun 2020 enrollments, projects will also require permanent load reductions during Jan – Feb, 7 am – 9 am and 6 pm and 8 pm
Enrollment Deadline	15 business days prior to Jun 1, (typically around May 10)
Measurement and Verification (M&V)	Verification of average load reduction during PJM peak

Qualifying projects include:

- Lighting
- Refrigeration
- HVAC
- Motors
- Variable-frequency Drives (VFDs)
- Weatherization/Building Envelope
- LEED/Green Building
- Industrial Process Improvements
- New construction projects exceeding industry standards

Non-Qualifying projects include:

- Dispatchable Resources
- Load-shifting
- Behavior change, programmable thermostats
- Solar, wind, cogeneration
- Fuel switch (conversion to natural gas)

Information Required

- Preliminary Information Required
    - Description of Measures Completed
- What type of project?
- When completed?
- Estimated kW reduction

    - Have rebates been received for this project?
- If yes, copy of rebate application
    - Client Name, Address, PJM Zone, Utility Account Number(s)

- After initial evaluation to ascertain whether the project is qualified and the potential revenue estimated, additional detail information may be required.

Thank you!

Dave Resler

Dave.Resler@CPowerEnergyManagement.com

Bill Oosterom Resler

Bill.Oosterom@CPowerEnergyManagement.com

1-844-CPOWER1

Wrap-Up and Next Steps
(S. Gabriel)

Summary

- **Summary**
  - Using demand response for Prince Georges' County buildings towns/cities can have real "flexibility" payments
  - University of Maryland has expertise in DR (via FM)
  - Use this knowledge to build smart communities in Maryland to adopt demand response for collective benefit to municipal, master-metered buildings as well as single-family homes
  - Demand response can also help with sustainability goals

Next Steps

- **Next Steps/Ongoing Steps**
  - Meeting with communities in MD to see about adopting such DR programs
    - Need information on potential buildings: energy usage, building aspects that can be adjusted for demand response)
    - **Need all this information by March, 2020**
  - Met with University of Maryland FM personnel to gain more knowledge on the practical aspects of how to optimize DR
    - Monthly brown bag to discuss proposed work
    - **We are writing up the current program details (should be ready by early March)**
  - Contact NSF program manager in early Spring (**March 2020**)
  - Write up and submit proposal to NSF (or other State/Federal agencies)- **Summer 2020**