

Net-Zero Energy Schools: Lessons for Alexandria?

February 29, 2024 — 7:00-8:00pm ET



John Chadwick, AIA
Arlington Public Schools,
2011-2021



Wyck Knox, AIA
VMDO Architects,
2017-present

TECHNICAL REPORT

American Academy
of Pediatrics



DEDICATED TO THE HEALTH OF ALL CHILDREN™

Climate Change and Children's Health: Building a Healthy Future for Every Child

Samantha Ahdoot, MD, FAAP;^a Carl R. Baum, MD, FACMT, FAAP;^b Mary Bono Cataletto, MD, FAAP, FCCP;^c Patrick Hogan, MD,^d Christina B. Wu, MD, MPH, FAAP;^e Aaron Bernstein, MD, MPH, FAAP;^f COUNCIL ON ENVIRONMENTAL HEALTH AND CLIMATE CHANGE; COUNCIL ON CHILDREN AND DISASTERS; SECTION ON PEDIATRIC PULMONOLOGY AND SLEEP MEDICINE; SECTION ON MINORITY HEALTH, EQUITY, AND INCLUSION

Observed changes in temperature, precipitation patterns, sea level, and extreme weather are destabilizing major determinants of human health. Children are at higher risk of climate-related health burdens than adults because of their unique behavior patterns, developing organ systems,

abstract

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FUTURE**

<https://publications.aap.org/pediatrics/article/doi/10.1542/peds.2023-065504/196647/Climate-Change-and-Children-s-Health-Building-a>

TECHNICAL REPORT

American Academy
of Pediatrics



“The warming of our planet matters to every child. Driven by fossil fuel-generated greenhouse gas emissions, climate conditions stable since the founding of modern pediatrics in the mid-nineteenth century have shifted, and old certainties are falling away. Children’s physical and mental health are threatened by climate change through its effects on temperature, precipitation, and extreme weather; ecological disruption; and community disruption. These impacts expose and amplify existing inequities and create unprecedented intergenerational injustice. Fossil fuel extraction and combustion cause harm today and reach centuries into the future, jeopardizing the health, safety, and prosperity of today’s children and future generations.”

Children are at higher risk of climate-related health burdens than adults
because of their unique behavior patterns, developing organ systems,

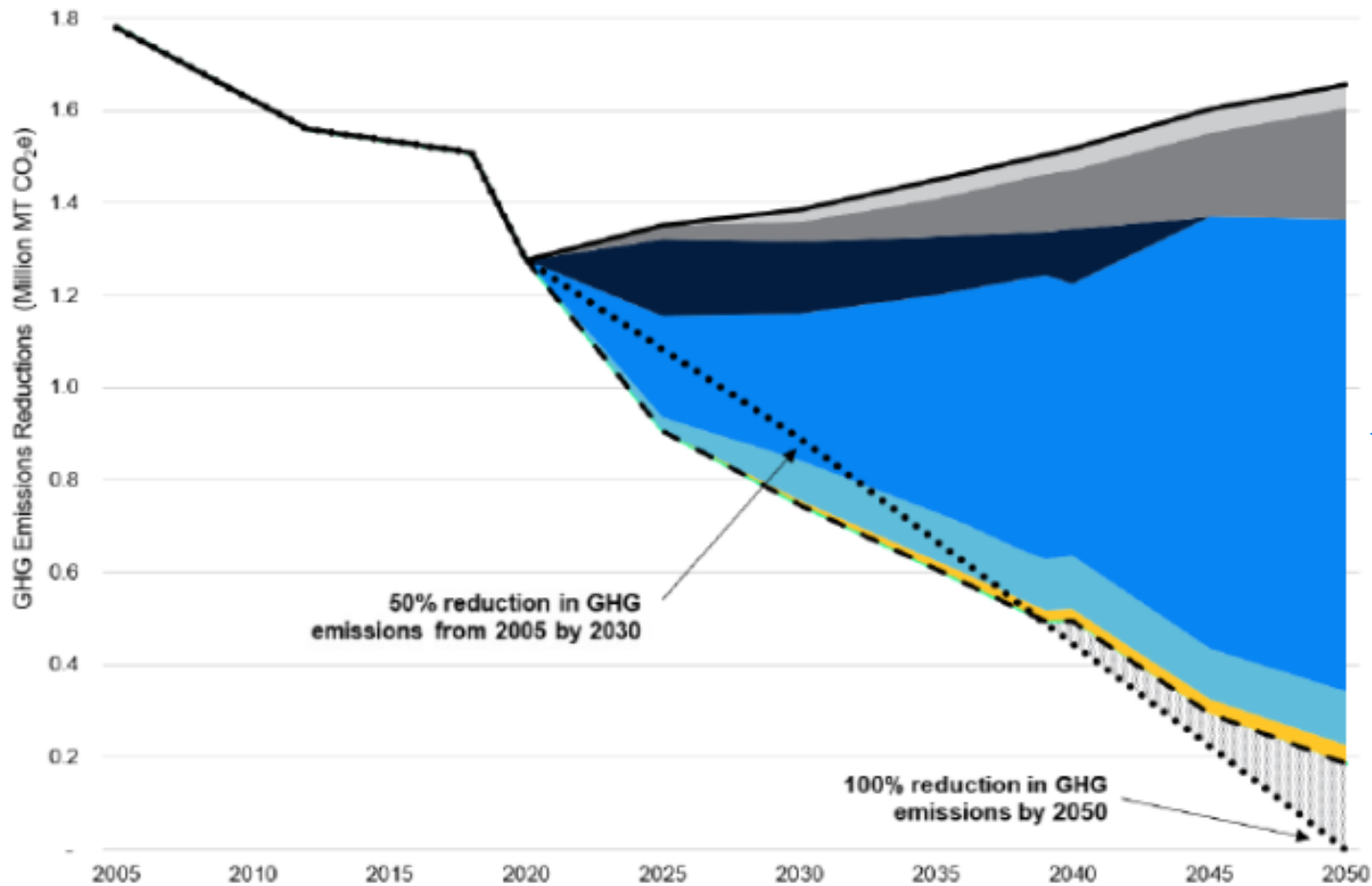
writing on climate change in pediatrics, environmental health, journal
of Pediatric Emergency Medicine, Yale School of Medicine, New Haven,
Connecticut; Division of Pediatric Pulmonology and Sleep Medicine.

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<https://publications.aap.org/pediatrics/article/doi/10.1542/peds.2023-065504/196647/Climate-Change-and-Children-s-Health-Building-a>

Meeting Green Building Policy Requirements is Essential for Addressing the Climate Emergency

Figure ES-3. A pathway to meet Alexandria's GHG reduction goals



“Support decarbonizing buildings through financial opportunities (existing buildings) & educate and drive implementation of the City Green Building Policy (new buildings)”



John Chadwick, AIA
Arlington Public Schools,
2011-2021



Wyck Knox, AIA
VMDO Architects, 2007 -
present

verified net zero



Discovery ES

Opened 2015

\$333 / sf final hard cost*

*under original budget
returned \$900K to school board*

** includes solar array and two artificial turf fields.
\$300 / sf without those items*

verified net zero



Alice West Fleet ES

Opened 2019

\$335 / sf final hard cost*

under original budget

** excludes underground garage, which
would reduce \$/sf. Garage was \$12M*

emerging net zero



Cardinal ES

Opened 2021

\$393 / sf final hard cost

under original budget

Three NZE projects from 2012 to 2023



RFP issued in May of 2012

Not budgeted for Net Zero,
just basic level of LEED

Budget never increased for
Net Zero

*“are you open to net-zero as
a goal?”*

*“if we submit with an
engineer from Kentucky that
we’ve never worked with,
will you score us low?”*



Focus was elsewhere: strong neighborhood resistance, extensive community engagement, & complicated permitting approval.

Attitude about sustainability: “that would be nice”

Didn't talk about it too much, didn't ask anyone's permission – just did it because it made sense - and slowly brought the superintendent and school board along.

Solar panels as bid alternate



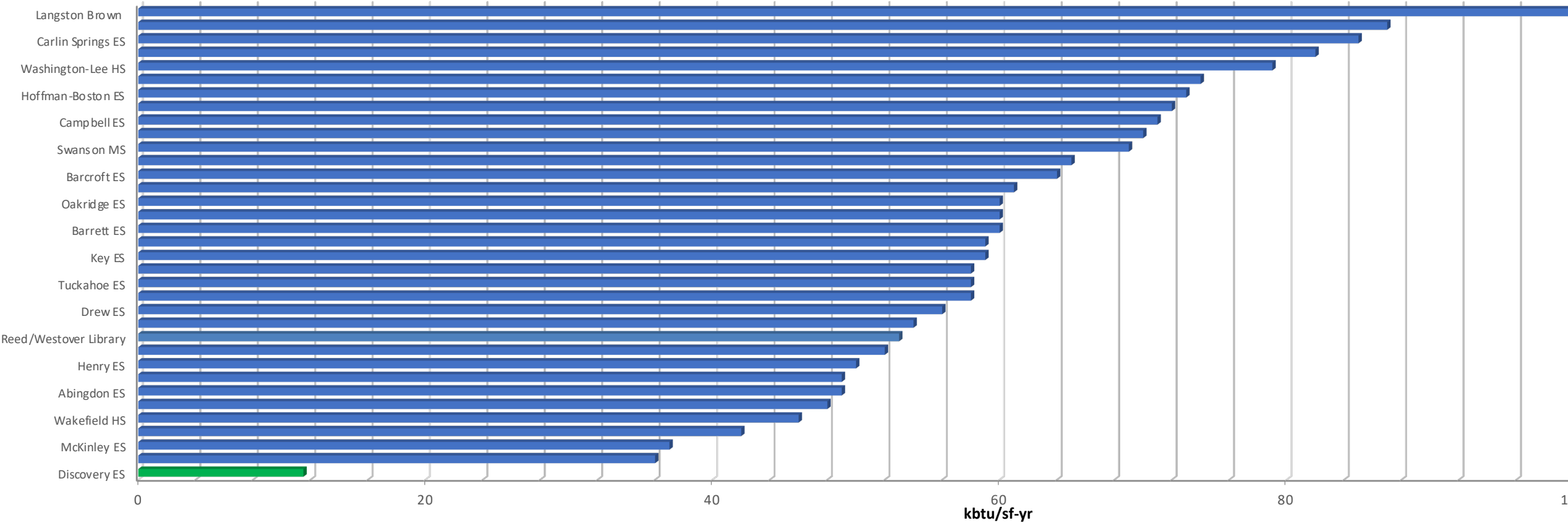


Discovery ES – first net-zero-energy building in Mid-Atlantic



Tiered design produced as much PV real estate as possible

Arlington Public Schools - 2017 Energy Consumption (EUI)



Performance: Year 3 – Improved to 14.7 EUI

Reduction: Cut 83% of the Energy compared to typical school

Net EUI of -4

Energy use and Net Zero are tangible, measurable goals



\$0.11 / SF

versus \$1.32 / SF for the average APS elementary

Discovery cost 11 cents / sf to operate, a \$118K annual utility savings

VMDO



You could operate 12 Discoverys at the same price as a non NZE school



RFP issued in June of 2014

Not budgeted for Net Zero,
LEED optional.

Budget never increased for
Net Zero

VERY constrained site and
strong opposition to adding
a school here

Used this project to get
approval for Arlington's first
solar Power Purchase
Agreement



2014 to 2019: Alice West Fleet Elementary School

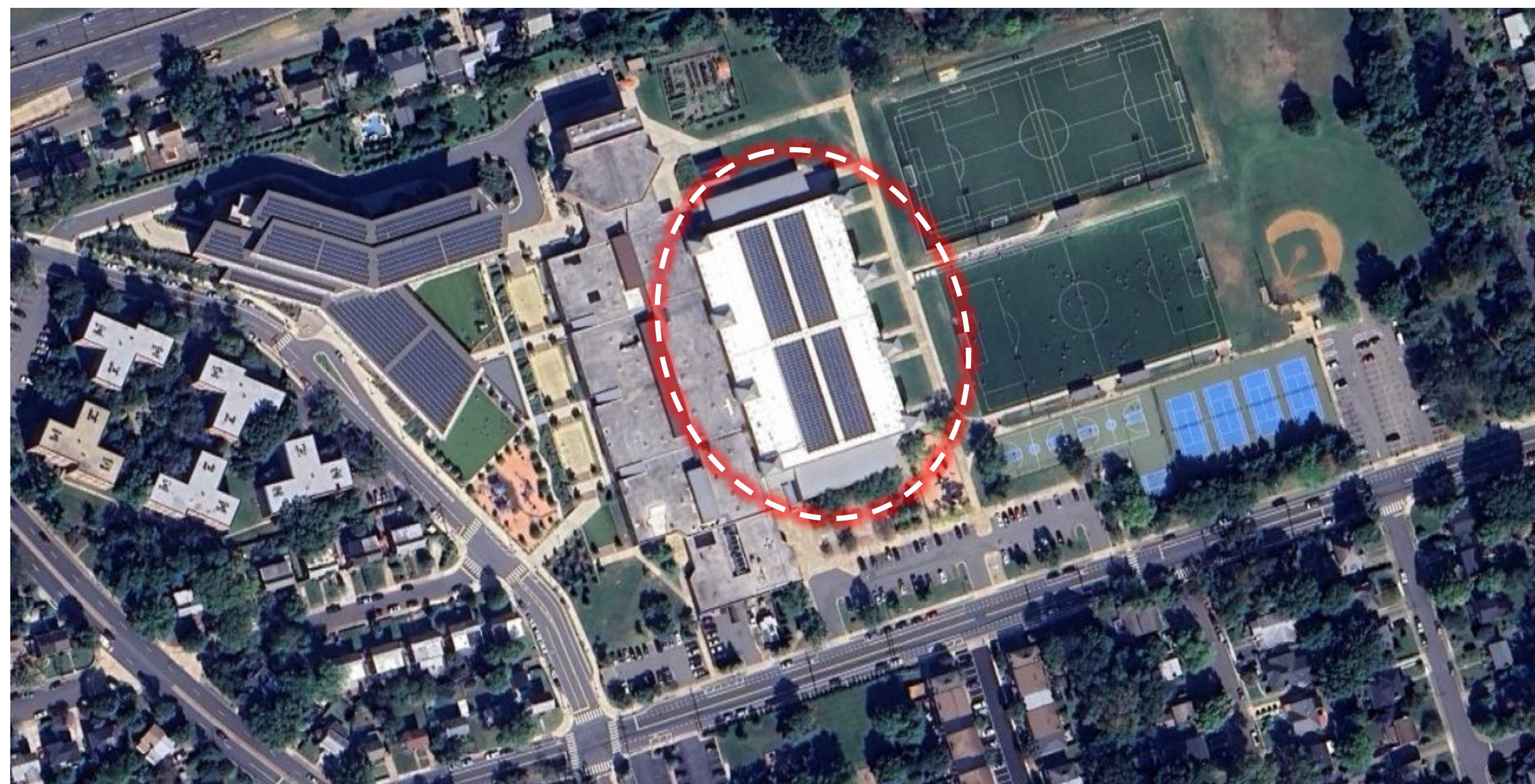
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Previous



New



2023: Power Purchase Agreement expanded to include community center



RFP issued in June of 2017

Requested Net-Zero in the RFP

Addition and renovation co-located with a historic structure

Also used a Power Purchase Agreement for the solar panels – and paying less per unit than APS was paying the utility company

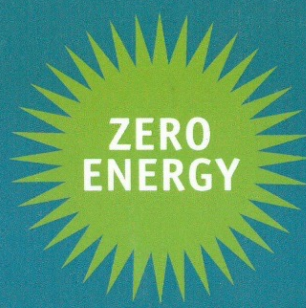


The following list of performance criteria shall be considered APS's project requirements, though the list is by no means to be considered exhaustive. The performance criteria listed are APS standards for new construction facilities. Since a portion of the Project includes an existing structure certain performance compromises may be necessary and shall be investigated and resolved during the initial design phases. The design shall:

- Integrate learning, design, sustainable design, and environmental stewardship so that it supports and enhances student learning and student success
- Deliver a balanced design that achieves **Zero Energy** status as defined by the United States Department of Energy
- Meet these measurable high performance criteria
 - Maximum Energy Use Intensity (EUI): 21
 - On-site renewable energy generation that exceeds the EUI via a solar photovoltaic array
 - Overall minimum insulation R-values: 30-roof, 25-wall, 10-under-slab
 - Thermally broken windows with insulated glass
 - Glazing percentage: 35-40%
 - Airtightness: 0.15 cfm/sf
 - HVAC System: ground source heat pump with dedicated outdoor air system
 - Lighting System: all LED
- Provide building systems that are durable, straightforward to operate/control, and are easily maintained
- Consider Indoor Air Quality, Thermal/Acoustic/Visual Comfort, and Universal Design standards beyond the minimums required by building code

ACHIEVING ZERO ENERGY

Advanced Energy Design Guide for K–12 School Buildings



Developed by:
ASHRAE
The American Institute of Architects
Illuminating Engineering Society
U.S. Green Building Council
U.S. Department of Energy

How Do You Deliver a Net Zero Energy School?

- Find good partners
- Set aggressive goals for your architect and contractor and maintain them
- Don't let the first cost of the solar panels be the excuse
- Integrate everything with the ZE goal
- Monitor energy use
- Don't forget the learning

VMDO



Alice West Fleet Elementary School

47

Years in practice



Lubber Run Community Center



Cardinal Elementary School

Mid-Sized Firm with
75 Employees
32 Licensed Architects
34 LEED APs
6 WELL Aps
2 Offices
1 CBE



GWU Thurston Hall Renovation

2 AIA COTE Awards
AIA 2030 Commitment
JUST Certified
Design Corps

3 Practice Areas
Serving Specific Client Needs:

K-12
Athletics + Community
Higher Education



Bluestone Elementary School

+500K SF

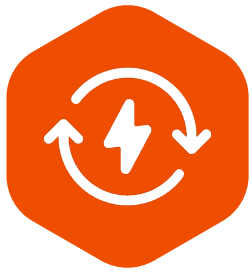
Net Zero Energy
Buildings



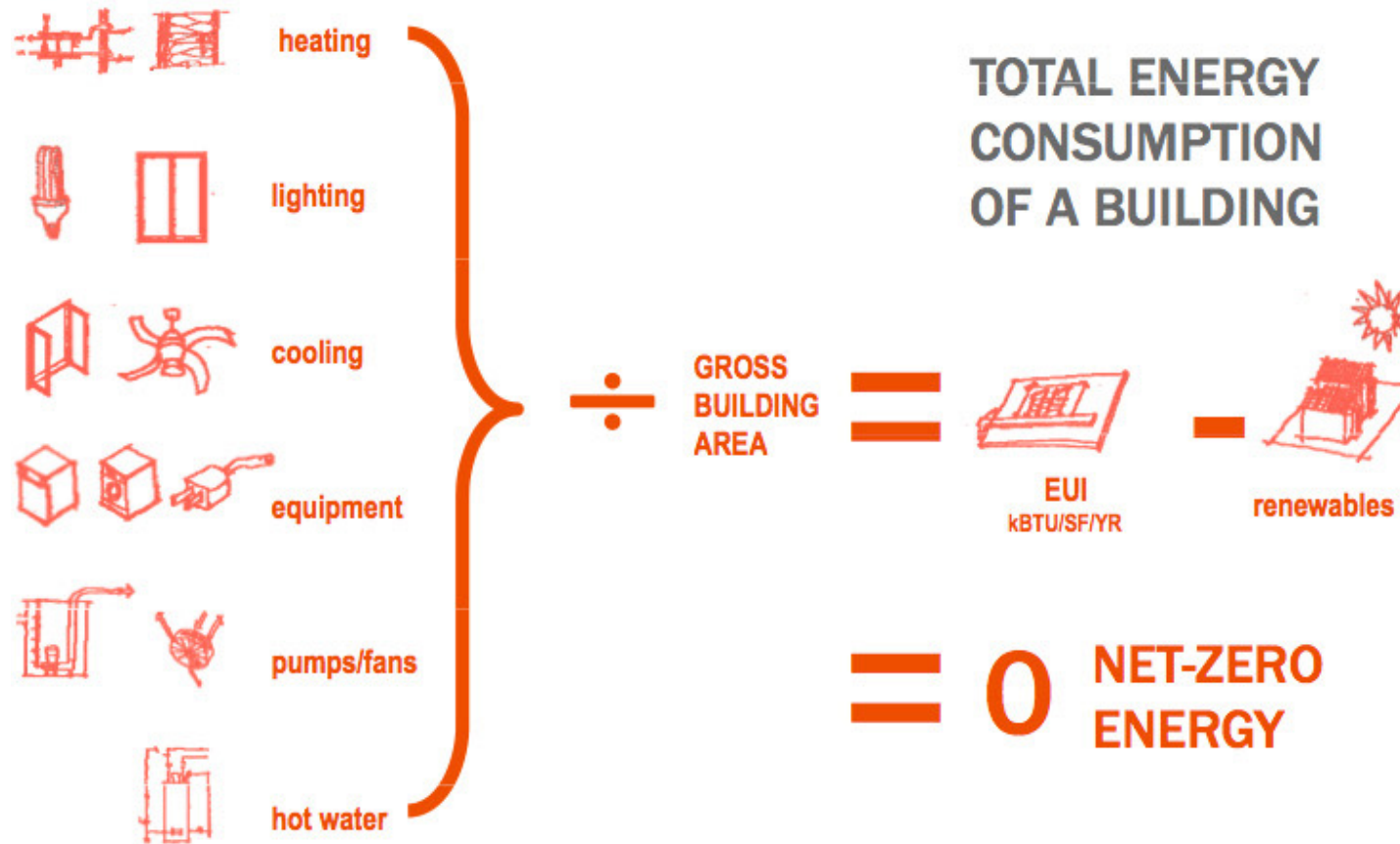
Virginia Wesleyan University Greer Center

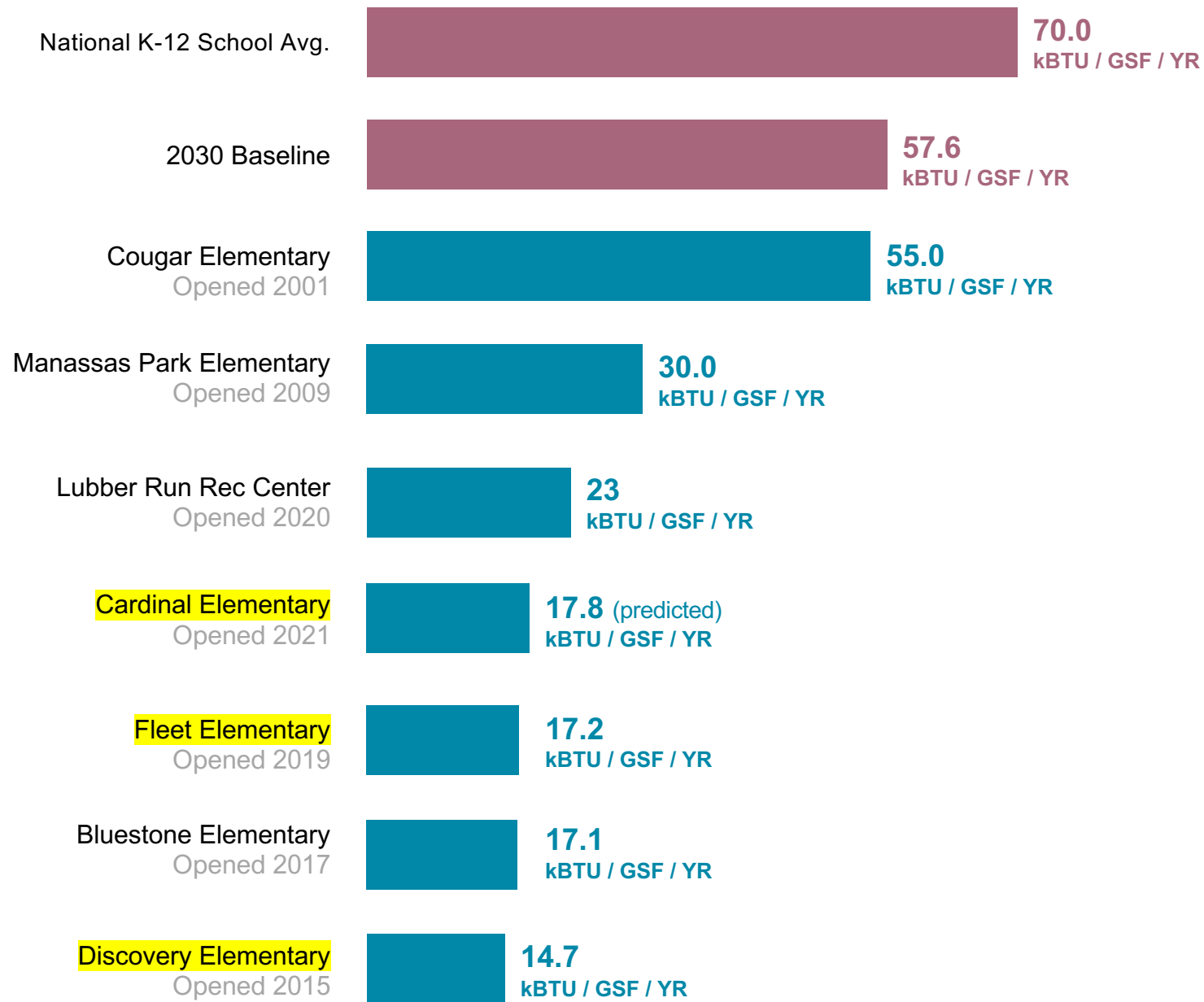


80 People all within 80 Miles



NZE (site) = Within a given site, a building that produces as much energy as it uses in the course of a year
...at the lowest possible cost





Building Performance in EUI (kBTU/sf/year)

NBI Getting to Zero Buildings Database

Use the filters on the left to filter projects in the map, and/or select a bubble on the map to filter the table below.
Use the tabs above or buttons in the top right to navigate to the analysis and graphics page

Reset Filters  Analysis Graphics 

ZE Status Count

- Emerging 10
- Verified 7

State or Province

- Alabama
- Alberta
- Arizona
- Arkansas
- British Columbia
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia

Building Type

- Education
- Food Sales
- Food Service
- Health Care (Inpatient)
- Health Care (Outpatient)
- Lodging
- Mercantile (Enclosed and Str..)
- Mercantile (Retail Other than..)
- Multifamily
- Not Available



ZE Status	State or Province	Name	Certifications	City	Building Type	Size (sf)	Total Site EU1	Net Site EU1
Verified	MD	Graceland K-8 School	LEED	Baltimore	Education	94,330	9	-5
Verified	MD	Holabird K-8 School	LEED	Baltimore	Education	94,330		-1
Verified	MD	Potomac Watershed Center	LEED, ILFI	Accokeek	Education	3,971	44	-1
Verified	MD	Wilde Lake Middle School		Ellicott City	Education	106,622	13	-11
Verified	VA	Alice West Fleet Elementary School		Arlington	Education	110,000		
Verified	VA	Brock Environmental Center	LEED, ILFI	Virginia Beach	Education	10,518	14	-14
Verified	VA	Discovery Elementary School	LEED, ILFI	Arlington	Education	97,588	8	-3
Emerging	DC	Banneker High School		Washington	Education	174,732		20
Emerging	DC	Grass Education Center		Washington	Education	3,800		
Emerging	DC	Stead Park Recreation Center		Washington	Public Assembly	15,863		
Emerging	DC	West Elementary School	LEED, ILFI	Washington	Education	88,585		17
Emerging	MD	Thomas Jefferson Elementary School		Baltimore	Education	105,000		
Emerging	VA	Bluestone Elementary School		Harrisonburg	Education	103,000		17
Emerging	VA	Cardinal Elementary		Arlington	Education	110,672		18
Emerging	VA	Center for Energy Efficient Design	LEED	Rocky Mount	Education	3,600		
Emerging	VA	Lubber Run Community Center	LEED	Arlington	Public Assembly	49,120		23
Emerging	VA	Piedmont VA Community College Advanced Technical ...		Charlottesville	Education	45,000		

To date, VMDO staff have been involved in 60% of NZE (verified or emerging) public buildings in the DMV – with many more on the way soon!

VMDO leadership in public NZE projects in the DMV





Design for ZE: giant arrays are a non-scalable approach

1

Net-Zero and Net-Zero-Ready
Schools don't cost more to build

Net-Zero and Net-Zero-Ready
Schools don't cost more to design



Proper orientation of the school: design choice that doesn't cost \$

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Proper orientation of the school: possible even in more urban settings



Fleet - south side shading with overhangs



Cardinal - south side shading with sunshades



Cardinal - north side



west

east



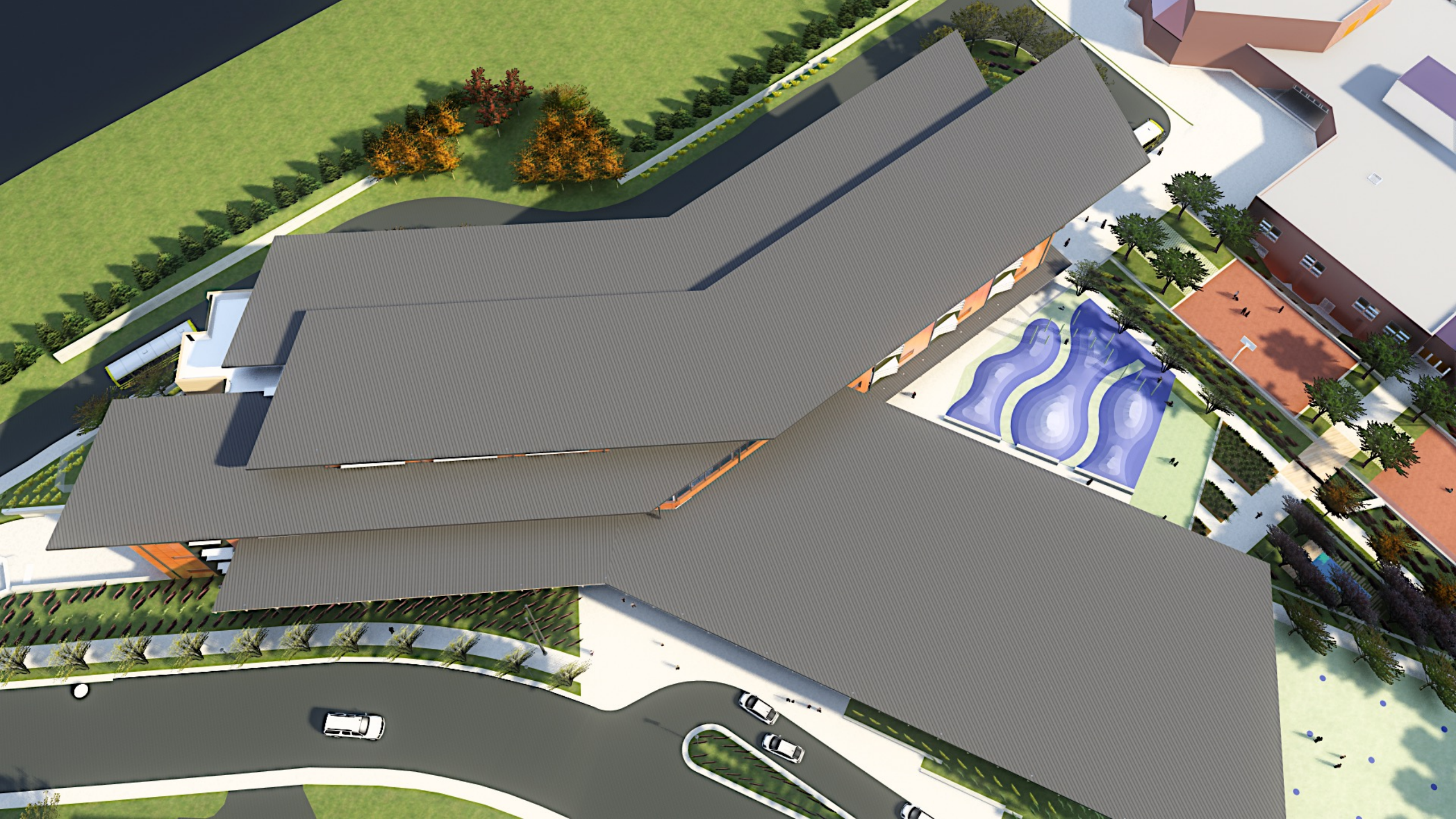


Stack the building from south to north to create PV space















Clean Roofs: no MEP equipment and stormwater on the ground

2

Geothermal systems are the undisputed kings of low energy use, and are probably the single best life-cycle cost decision.

Right sized systems combined with well insulated, airtight buildings can reduce overall MEP costs



Ground Source Heat Exchange: you can make wells work on tight sights



Geothermal HVAC

no boilers, no chillers

Distributed system

only conditions occupied spaces

Demand Control Ventilation

Filters where they can be reached

Same size filter for the whole building



High performance systems are not highly complicated

VMD

Simplicity!

Want clear air and functioning units? Make them easy to get to and simple to service

Owner: *“By far the least problematic new building delivered in my ten years here. The building always in green lights”*

(red light is an alarm condition)



VS



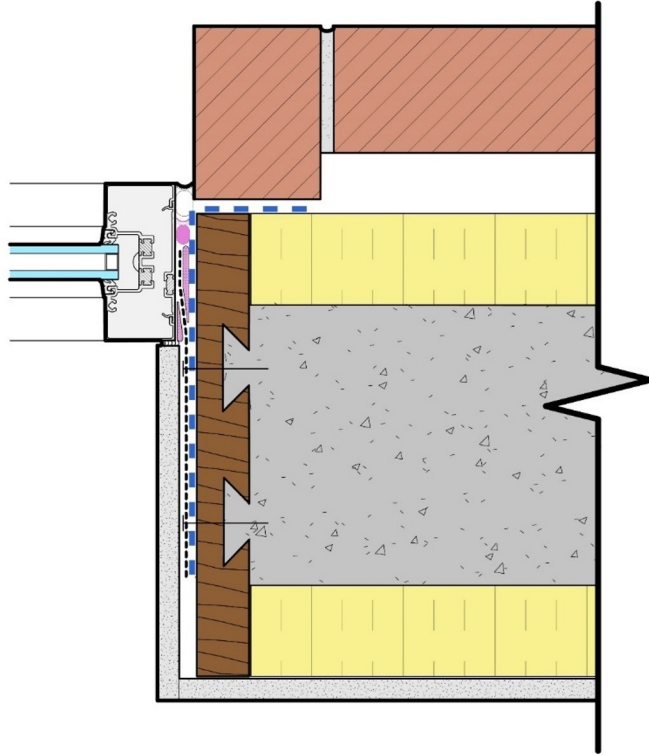
Design around effective R
value of total assembly
and model it

Use high performance
glass with low solar heat
gain coefficient

Be relentless about air
sealing and testing

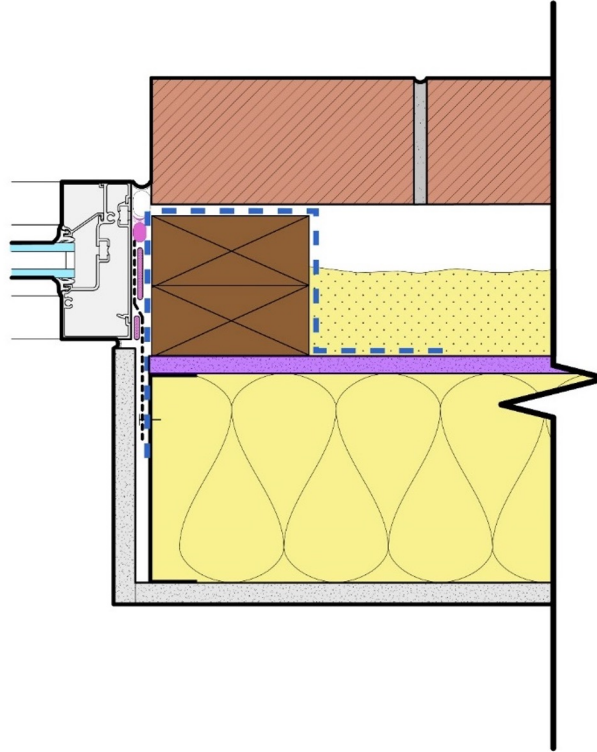


\$50 to \$59 / sf
Oct 2019 CM pricing for DMV



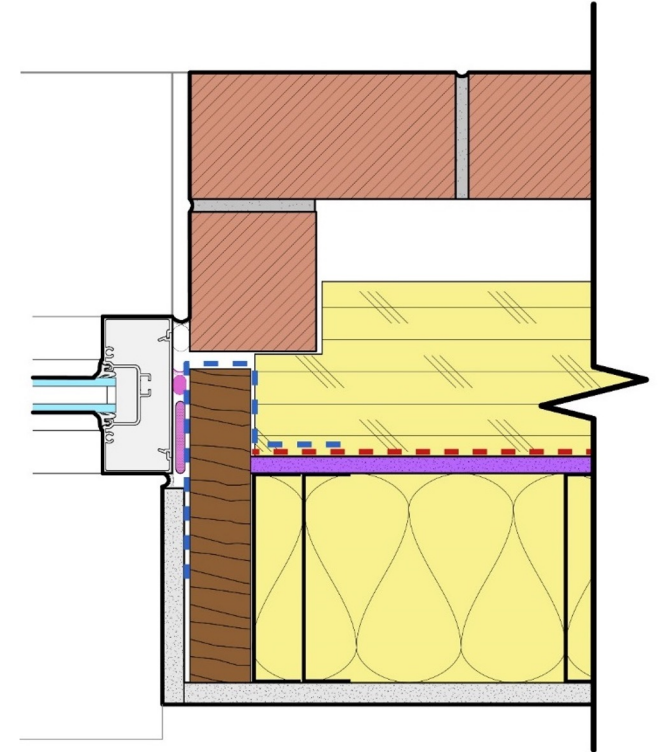
**Discovery
R-28**
designed in 2013

\$48 to \$57 / sf
Oct 2019 CM pricing for DMV



**Fleet
R-33**
designed in 2016

\$51 to \$61 / sf
Oct 2019 CM pricing for DMV



**Cardinal
R-30**
designed in 2019

There's lots of different ways to get there



Air Pressurization Testing – Measured Results

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	Code	Cardinal ES
Effective R-Value of wall assembly	15.6	30.7
U-Value of Glazing Assembly	0.42	0.33
Airtightness	0.40	0.10

\$170,000

Added investment in envelope

\$230,000

Savings from reduced HVAC sizing (incl. geothermal)

\$60,000

Net Savings (before PVs)

+

+

\$45,000

Value of Reduced PV Array

\$105,000



Integrated Design: good envelopes pay for themselves

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What if ice cost \$119,000? Annual energy use of average APS ES in 2015

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3

All electric buildings are possible



All electric buildings, including kitchens. No fossil fuels and no complaints

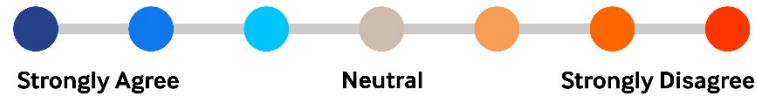


4

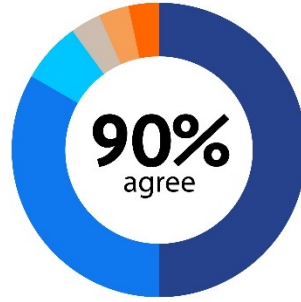
Building amenities and occupant comfort don't have to be sacrificed to achieve Net Zero

Bluestone Post Occupancy Evaluation:

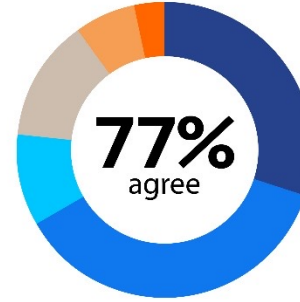
How much do you agree or disagree with the following statements?



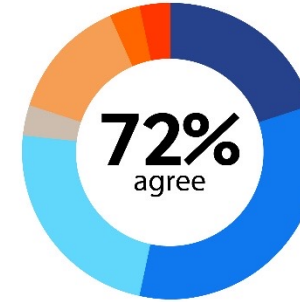
This building fits well with the surrounding environment



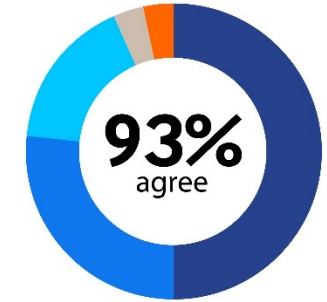
This building promotes a sense of safety



This building makes me feel happy



This building makes me feel connected to nature



 **CBE** | 2019 Livable Building Award
CENTER FOR THE BUILT ENVIRONMENT | 2021 Livable Building Award

We Design Facilities Where Teachers + Students Thrive

VMDO



FY 2018 / Absentee Rates per Teacher

Bluestone Elementary School + Surrounding Elementary Schools

School	Building Absences	# of Teachers	Avg. Absences
Bluestone ES	144	52	2.7
KES	115	38	3.02
SMES	225	48	4.6
SES	199	46	4.3
SSES	218	50	4.3
WES	259	49	5.2

>36%
fewer

5

A high-performance, low-impact mindset has unexpected benefits



Footprint of new construction + geothermal wellfield

84" storm pipe (that's huge!)

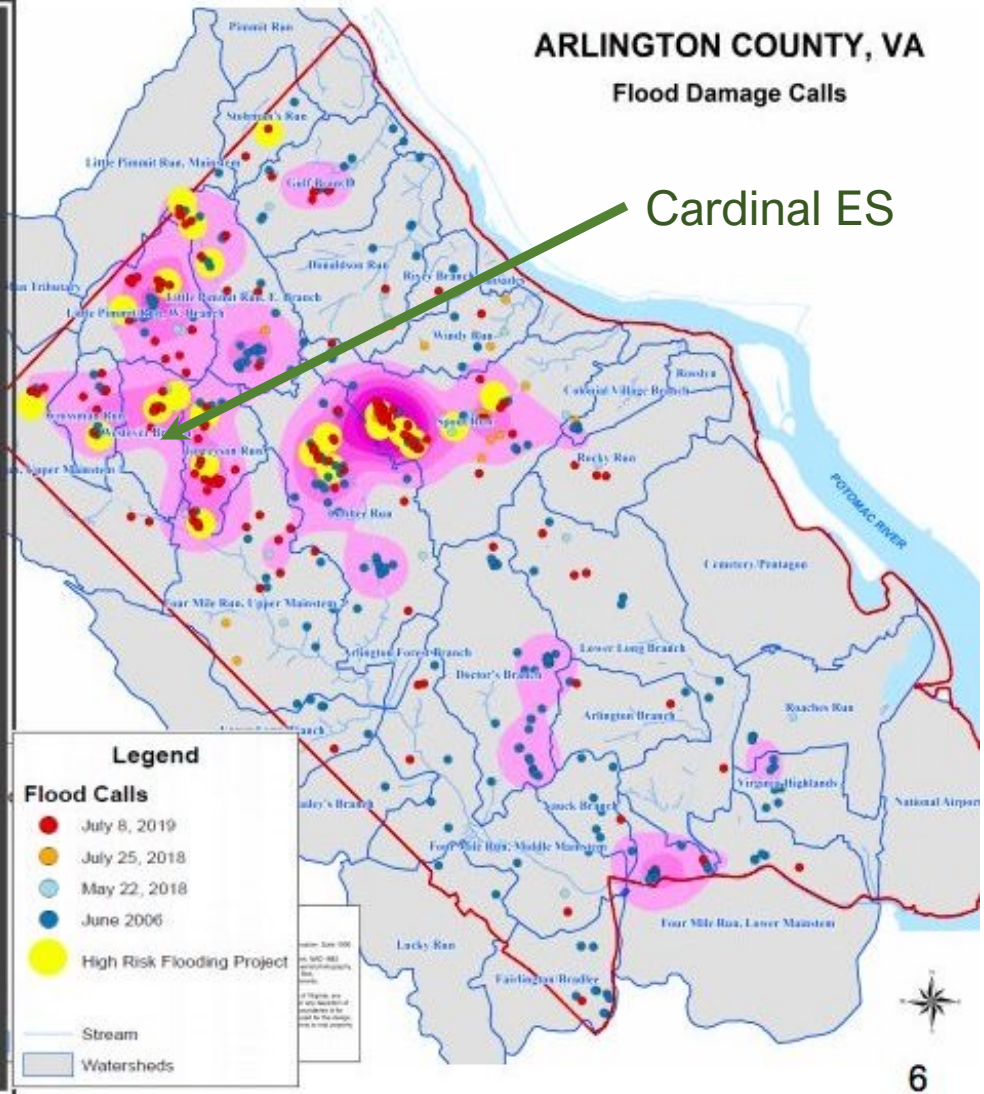
Cardinal: a 185-acre watershed flows through this 5.7 acre site



Flood Damage Calls

Map demonstrates flood calls from the following storms in relation to high risk flooding projects identified in Stormwater Master Plan:

- July 8, 2019
- July 25, 2018
- May 22, 2018
- June 2006



2019 – a month's worth of rain in one hour





Resiliency

VMDO



Holds and slowly releases 535,000 cubic feet of water – 90th percentile storm event **W&M**



Resiliency

VMDO



Because it was a low-impact design, the Cardinal project added 92,160 sf of new construction to the site but didn't have to upgrade the existing electrical service.



Power for construction / pumps + 100% ventilation for Covid = EUI 21

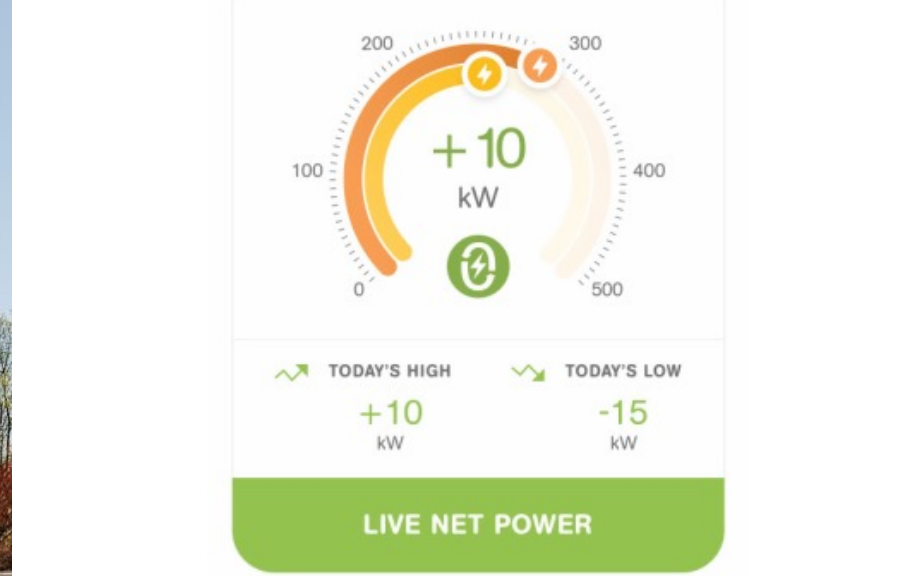
VMD O

6

Sustainable buildings enhance a school's mission and help teach



Solar Calendar: Tells time of day & time of year

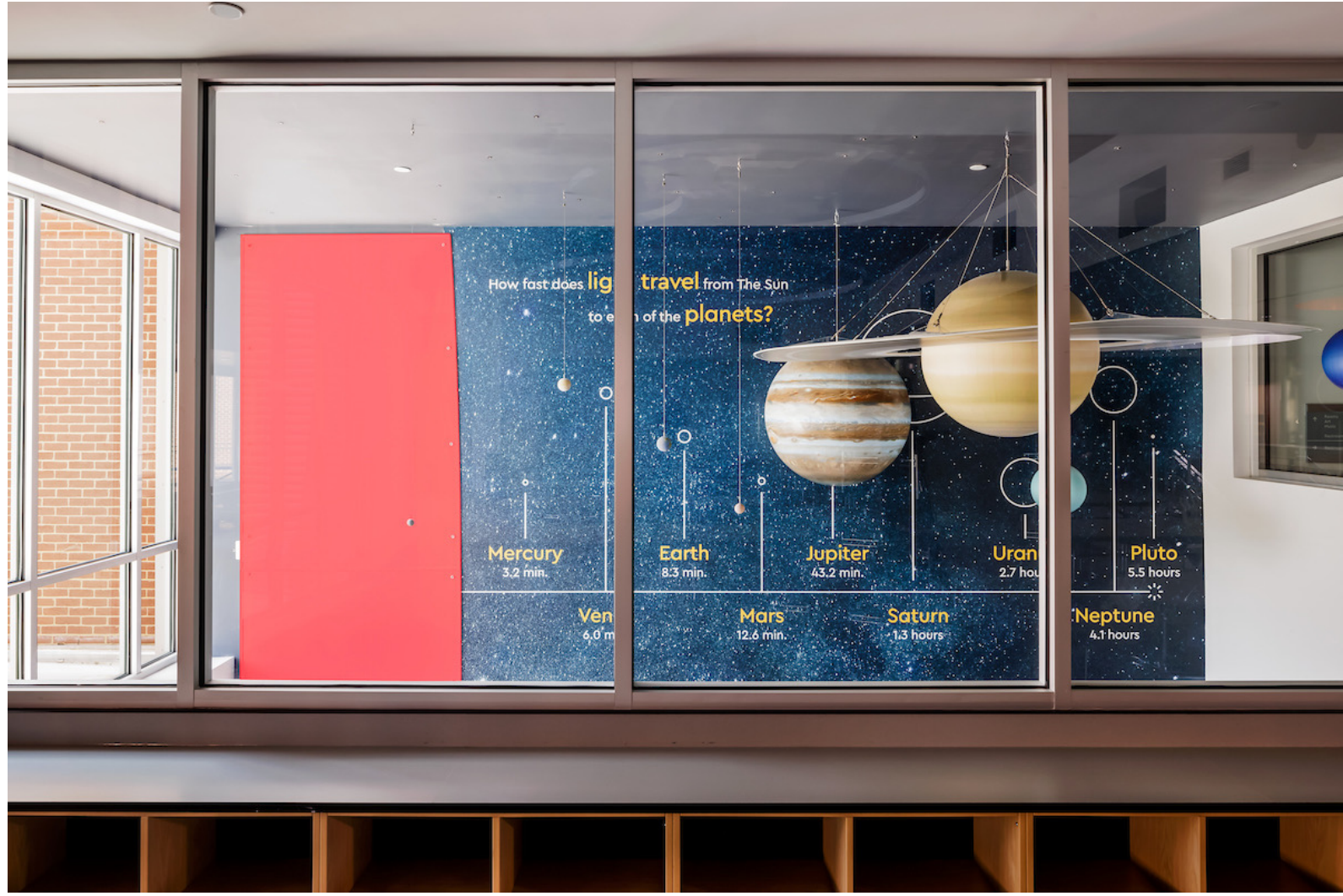


Interactive Solar Lab



Expressing Building Data: consumption & production, each node is 10kW

VMDO







John Re
@HeyJReDiscovery



Following

human graph on bike walk to school day - Ms
Cs 2nd grade @DiscoveryESPTA
@DiscoveryAPS @ATPcommutes
@MissCoulouris



Student led initiatives: Graphing data; Hydroponic garden

V M D O



Today's kindergartens will graduate from high school in 2036 – future is now **V M D O**