SUSTAINABILITY

conservation

health + wellness

stewardship
Place

compelling

engaging

visceral
What is net-zero energy?
39 Total
Net Zero Buildings
in the United States

152+ in planning stages

7 K-12 School Projects

Lumber Bridge NC  74,000 sf
Lexington KY  70,000 sf
Bowling Green KY  72,285 sf
Hood River OR  5,331 sf
Kamuela HI  5,902 sf
Seattle WA  1,425 sf
Putney VT  16,800 sf
Energy Use Intensity (EUI) =

Energy use per square foot over one year

$kBTU / s.f. / yr.$
Energy Use Index (kBtu/SF)

- FY2003: APS 84, Elementary Schools 78
- FY2013: APS 70, Elementary Schools 68

ASHRAE HS – 74 EUI
ASHRAE ES – 72 EUI

FY2003 – 3,985,768 sf
FY2013 – 4,474,542 sf
Are you willing to question…

How your power is purchased?

How food is cooked in the cafeteria?

How you procure and use information technology?

How testing is administered?

How you schedule your building systems? (including IT and kitchen)

How you clean your buildings?

Can’t expect 21st century results from 20th century process
Energy Modeling + PV Offset Costs

SITE AND MASSING OPTIONS

Baseline: Closest to selected orientation

$92,000 PV SAVINGS

$73,000 PV SAVINGS

$110,000 PV SAVINGS

$202,000 PV SAVINGS

Closest to final massing

$110,000 PV SAVINGS

$110,000 PV SAVINGS
Aerial view of existing conditions before project
School tied into south facing slope  |  preserved programmable space
No view of solar panels by neighbors
Good energy design + good neighborhood design
496 kW array, 1706 panels | Harvesting & celebrating light
Proper shading techniques + covered outdoor play space
ICF Thermal Envelope
Air tight building
Geothermal HVAC
Demand Control Ventilation
LED Lighting
Daylighting
Green Kitchen
Right Sizing Equipment
Real-Time Power Monitoring
Renewable Solar PV Energy
Performance to Date

Bid $4 Million under budget and completed under budget (with array and 2 turf fields)

$331/sf (typical range inside the Beltway)

2015-2016 School Year (actual)
APS Elementary School Energy cost average: $1.10/sf
Discovery: $0.32/sf (with PV array not online until Jan)

2016-2017 School Year (anticipated)
Discovery: $0.14/sf
$94,000 annual savings in operating costs
**Discovery Elementary School**

**Net Zero Energy**

**What is a Net Zero Energy Building?**
A net zero energy building generates more energy in a year than it uses. Our school will use energy from the local electric power grid, but also sells the clean, renewable energy produced by our solar panels back to the same power grid. Our school will be "net zero" over the course of 12 months; it will have cleaner produced as much energy as consumed, if not more.

**Why Have a Net Zero Energy Building?**
Using design strategies that conserve energy, our school consumes less energy than most buildings its size. However, our school can also produce clean, renewable energy and return it back to the local electric power grid. This energy is then used by local neighborhood buildings during peak electricity usage times throughout the year. Our school is a model of how clean, renewable energy can be produced to meet our local energy needs and also reduce the carbon impact a building can have on the natural environment.

**Production**
- Geothermal energy
- Solar panels
- Building materials
- Solar net meter

**Conservation**
- Solar orientation
- Building envelope
- Thermal mass
- Sensors
- Lighting
- All-electric kitchen
- Roof slope
Using Wayfinding to Teach about “Your Expanding World”
The Forest
The Ocean
The Atmosphere
The Solar System

OUR SOLAR SYSTEM

SUN

MERCURY  VENUS  EARTH  MARS  JUPITER  SATURN  URANUS  NEPTUNE  PLUTO
The Journey of Discovery: Earth

**Backyard Pre-K & K**
- Local fauna & their habitats
  - SOL: colors, shapes, sizes, weights, water phases, magnets, plant/animal growth, shadows, recycling, water/energy use at home

**Forest 1st Grade**
- Sustainable materials
  - SOL: motion, interactions with water, plants/animals basic life needs, sun as energy/light/position, weather/seasons, natural resources

**Ocean 2nd Grade**
- Water conservation
  - SOL: magnets/poles, phases/measurement of matter, life cycles, habitats, types/effects of weather, plants as source oxygen

Your Expanding World
There are 26 square miles that make up our backyard of Arlington
There are 23,400 square miles that make up our Virginia Forests.
The Forest Trailblazer Classrooms: Virginia Forest Species

White Tailed Deer
Odocoileus virginianus

Coyote
Canis latrans

Yellow Warbler
Setophaga petechia

Five Lined Skink
Eumeces fasciatus

Northern Mockingbird
Mimus polyglottos

Woodland Deer Mouse
Peromyscus maniculatus

Praying Mantis
Mantis religiosa

Spotted Salamander
Ambystoma maculatum

The White Tailed Deer is one of 50 different species of deer in the United States and is the state mammal of Virginia. Like other deer, they love to eat grass, but they also browse shrubs and flowers. They are known for their speed, being able to run up to 36 miles per hour. Their populations are monitored by the Virginia Department of Conservation and Recreation.

The Coyote is a member of the dog family, Canidae. They are known for their keen senses and are capable of hunting small animals such as rodents and birds. Coyotes are social animals and are known to howl at the moon.

The Yellow Warbler is one of the most common warblers in North America. They are known for their bright yellow plumage and their melodious song. They are often found in wooded areas and feed on insects.

The Five Lined Skink is a common reptile found in Virginia. They are known for their colorful pattern and ability to change colors. They are often found in grasslands and woodlands.

The Northern Mockingbird is a common bird found in North America. They are known for their mimicry, ability to imitate the songs of other birds. They are also known for their loud calls and are often heard in wooded areas.

The Woodland Deer Mouse is a common small mammal found in Virginia. They are known for their small size and are often found in grasslands, woodlands, and forests. They feed on seeds, leaves, and roots.

The Praying Mantis is a common insect found in Virginia. They are known for their distinct appearance and are often found on flowers and leaves. They are known for their ability to kill and eat other insects.

The Spotted Salamander is a common amphibian found in Virginia. They are known for their spotted skin and are often found in wooded areas and near streams. They are also known for their vocalizations.

The Forest Trailblazer Classrooms: Virginia Forest Species

The Forest Trailblazer Classrooms: Virginia Forest Species
The Forest Trailblazer Factoids: Forest, Materials, & Conservation

DISCOVER VIRGINIA’S FRIENDLY FORESTS
62% of Virginia is made up of forests! These forests provide homes to a range of different species including over 70 amphibian and reptile species, 200 bird species, and 55 mammal species. 27 of the plant and animal species found in Virginia forests are threatened or endangered and need their habitat protected.

How many different animals can you spot living in the trees in your neighborhood?

A WALK THROUGH OUR OWN FOREST AT DISCOVERY
The wood found in our school is certified by the FSC (Forest Stewardship Council), which means it was grown and harvested sustainably. The interior wood is white maple and the exterior wood is western red cedar. Can you identify the 6 local wood species that line this hallway by the shapes of their leaves?

To learn more about the FSC and forest stewardship, visit: https://us.fsc.org/

WHAT MATERIALS DO FORESTS PROVIDE US?
Trees are among the largest and oldest organisms on earth! Over 5,000 different products come from trees including hundreds of food items such as fruit, coffee, and nuts. They also help produce the oxygen that we breathe every day. One tree produces nearly 260 pounds of oxygen each year.

How many different products around your home and our school come from trees?

HOW OUR SCHOOL USED SUSTAINABLE MATERIALS
22% of the materials used to build our school were harvested and manufactured within 500 miles of here. During construction, our school recycled 95% of all waste produced during the project! Recycling reduces the need to use new raw materials from the earth.

Can you find all of these different products around our school?

HOW ‘CAN’ YOU HELP?
There are over 80 billion aluminium cans used each year around the world. Recycling a single aluminum can saves enough energy to power a TV for three hours. Make sure you always recycle aluminum here and at home!

RECYCLE TO SAVE TREES
The average American uses up to 680 pounds of paper each year! If you recycle all of that paper, you could save up to 6 trees each year. Use the recycling bins around our school to recycle your unwanted paper.
The Forest Trailblazer Explorers

**JOHN MUIR**
John Muir was a Scottish-American naturalist, author, environmental philosopher, and advocate of preserving and protecting nature. As a wilderness explorer, he is known for his exciting adventures in search of nature's beauty. As a preservationist, he taught people the importance of experiencing and caring for our natural heritage. He has been called "The Father of our National Parks" and helped form the Sierra Club.

**SACAGAWEA**
Sacagawea was a bilingual Lemhi Shoshone woman who accompanied Lewis and Clark's Corps of Discovery in exploring the Louisiana Purchase in 1805. She traveled thousands of miles with the expedition from the northern plains through the Rocky Mountains to the Pacific Ocean and back. Besides serving as the group's translator, Sacagawea established cultural contacts with Native American populations and researched natural history.

**DANIEL BOONE**
Daniel Boone was a pioneer, explorer, woodsman, and one of the most widely known American frontiersmen. Boone was born near Reading, Pennsylvania but later blazing a trail to the west through the Cumberland Gap, thereby providing access to the frontier. Boone played a key role in the exploration and settlement of Kentucky, including carving out the Wilderness Road and building the settlement station of Boonesboro.

**THEODORE ROOSEVELT**
Theodore Roosevelt was an American statesman, author, explorer, soldier, and naturalist who served as the 26th President of the United States. While President, he set aside hundreds of millions of acres of wilderness, actively pursued soil and water conservation, and created over 200 national forests, parks, monuments, and wildlife refuges.
There are 85,100,000 cubic miles of water in our Atlantic Ocean.
The Journey of Discovery: Sky

Atmosphere

3rd Grade

Air Quality +
Greenhouse Gas

SOL: simple machines, material properties, adaptations, land/water ecosystems, soil, moon phases, water cycles, natural events, energy sources

Solar System

4th Grade

Light

SOL: motion/force/mass, electricity, plant anatomy, ecosystem connections, weather phenomena, solar system, sun/earth/moon relationships

Galaxy

5th Grade

Energy

SOL: sound, visible light, phases/atoms of matter, cells, organisms, ocean environment, earth’s surface

Your Expanding World

Solar System

3rd Grade

Galaxy

4th Grade

Air Quality +
Greenhouse Gas

Light

Energy

5th Grade

The Journey of Discovery: Sky
There are 196,900,000 square miles of Earth’s surface that our Atmosphere surrounds.
Rain

An important part of the water cycle, rain falls from the sky as a result of the earth's atmosphere. It is essential for sustaining life on earth.

Northern Lights

Also referred to as aurora borealis, the northern lights are phenomenon that occurs when charged particles from the sun enter the earth’s atmosphere and react with the gases therein. This creates a beautiful display in the night sky.

Lightning

Lightning is a sudden electric discharge that occurs when a large amount of energy is released in a short time. It is a natural phenomenon that is vital for the earth's ecosystem.

Tornado

Tornadoes are formed from rotating updrafts of air. They are accompanied by strong winds, rain, and lightning. Tornadoes can cause significant damage, but they are relatively rare.

Thunder

Thunder is caused by the rapid expansion of air as lightning strikes the ground. It produces a loud, rumbling sound.

Mist

Mist is made up of tiny water droplets suspended in air. It is common in areas with high humidity and can create a misty or foggy atmosphere.

Wind

Wind is the movement of air across the earth's surface. It is driven by differences in temperature and pressure, and it plays a crucial role in weather patterns.

Hurricane

A hurricane is a tropical cyclone with sustained winds of at least 74 mph. It is a powerful storm that can cause significant damage and loss of life.
The Atmosphere Aviators: Atmosphere, Air, & Conservation

WHAT DOES OUR ATMOSPHERE DO?
Earth's five-layered atmosphere provides more than just the air we breathe. It also serves as a buffer that keeps us safe from meteorites and harmful radiation. The lowest layer is the troposphere and although it only extends 11 miles high, it provides most of our weather and contains four-fifths of the earth's air. The atmosphere is 78% nitrogen, 21% oxygen, and a small mix of argon, carbon dioxide, helium, and neon.

HOW DOES OUR SCHOOL GET CLEAN, FRESH AIR?
There are 58 sensors in our school that measure carbon dioxide, a gas released by breathing. When too much carbon dioxide builds up in any one room, the sensors call for outdoor air to be provided. This air is first filtered and dehumidified. A classroom of 20 people can exhale enough carbon dioxide to require fresh air after 30 minutes.

187 solar panels are needed to offset the total energy usage of our school's outdoor air system.

WHAT IS THE GREENHOUSE EFFECT?
Greenhouse gases in the atmosphere absorb heat radiated by the earth. This prevents heat from disappearing into space and keeps the earth warm enough to sustain life. Greenhouse gases include carbon dioxide, methane, and nitrous oxide. Too much of these gases can intensify the warming effect on the planet. Earth is sometimes called the Greenhouse Planet because its climate is "just right."

KEEP THE AIR CLEAN
You breathe about 2 gallons of air every minute or 3,400 gallons of air each day! Taking the bus, carpooling, walking, or riding a bike to school can reduce air pollution from cars and help keep the air clean.

EATING LOCAL HELPS
It is estimated that 13% of U.S. greenhouse gas emissions result from the production and transport of food. You can help reduce carbon emissions by choosing to eat locally grown foods.

OUR SCHOOL'S CARBON FOOTPRINT
Compared to a typical elementary school of the same size, Discovery prevents 1,397 metric tons of carbon from being released into the atmosphere annually. That's the same amount of carbon that is released by burning 1.5 million pounds of coal or 157,183 gallons of gas. It would require 1,145 acres of trees to absorb "Carbon Footprint" is the amount of carbon emissions by a country, organization, or individual person.
AMELIA EARHART
Amelia Earhart was an American aviation pioneer and author. Earhart’s public career lasted less than a decade, from 1928 to 1937, but she used her fame to promote two causes important to her: the advancement of commercial aviation and the advancement of women. She became the first woman to fly solo across the Atlantic Ocean in 1932 and set many other records throughout her career.

CHUCK YEAGER
Chuck Yeager is a retired brigadier general in the United States Air Force and record-setting test pilot. Yeager is a World War II fighter pilot ace and later commanded fighter squadrons. His flying career spans more than 60 years and has taken him to every corner of the globe. On October 14, 1947, he became the first human to officially break the sound barrier when he flew the experimental Bell X-1 rocket at 670 mph.

LUKE HOWARD
Luke Howard was a British manufacturing chemist and meteorologist. Howard was a pharmacist by profession, but meteorology was his hobby. His fascination with the weather led him to devise the classification of clouds that still remains in international use today. In December 1802, he proposed that every cloud belonged to one of three principal families, to which he gave the Latin names: cirrus, cumulus, and stratus.

WILBUR & ORVILLE WRIGHT
Wilbur and Orville Wright were American inventors and pioneers of flight. Considered the fathers of modern aviation, they developed innovative technology that changed the way we view our world. In 1903, the Wright brothers piloted the first powered airplane flight. Two years later, they built and flew the first fully practical airplane in Kitty Hawk, North Carolina. The same types of controls they devised then are still used today.
THE WOOD IN YOUR SCHOOL

There are Virginia species of trees used all throughout your school. This wood came from sustainably maintained forests because we need to protect our trees.

Can you identify the different wood patterns and the shapes of their leaves?
There are 4,700,000,000 miles from Earth to the edge of our Solar System - Pluto.
There are over 100,000,000,000 stars in our Milky Way Galaxy.
The Galaxy Voyager Classrooms: Milky Way Galaxy Elements
**WHAT IS SOLAR POWER?**

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available. Enough sunlight reaches the earth’s surface each hour to satisfy the world’s energy demands for an entire year! Plants use solar energy to create chemical food in the form of photosynthesis.

**OUR SCHOOL USES SOLAR PANELS TO PRODUCE ENERGY**

There are 1,710 solar panels on our roof, which produce 618,000 kilowatt-hours of electricity annually. As sunlight moves through a photovoltaic cell, the photons in light are absorbed by the bottom of the panel and push electrons to the topside. This movement of particles creates an electrical current similar to a battery. In full summer sunshine, the solar panels produce enough energy to power 62,000 LED light bulbs!

**EARTH’S NATURAL ENERGY SOURCE**

“Geo” means “from the earth” and “thermal” means “heat.” Geothermal refers to a type of energy found in the earth that can be captured to provide clean and renewable energy. Geothermal energy is very energy-efficient. Almost none of the energy used is wasted, so it helps keep energy bills very low! Have you ever seen a volcano or a geyser? If so, then you’ve seen geothermal energy in action!

**OUR SCHOOL EXCHANGES HEAT WITH THE EARTH**

A large system of 70 geothermal pipes circulates 12,500 gallons of water between our school and 500’ deep underground wells. Heat pumps move heat back and forth between this water and our school’s air. When cool air is needed, heat is taken from the air and transferred to the water. The heat pumps work in reverse when warm air is needed. 767 solar panels are needed to offset the total energy used to provide conditioned air to our school.

**FLICK THE SWITCH**

About 30% of energy used in buildings and homes is used inefficiently or unnecessarily! Make sure you turn off lights when you leave the room and unplug powered off electronics to save energy at home and school.

**SAVING ENERGY IS ‘COOL’**

Cooling and heating costs make up about 50% of an average U.S. home’s total energy bill. Lower the temperature on your thermostat in the winter and raise it in the summer when no one is home to save energy and money!

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*The Galaxy Voyager Factoids: Galaxy, Energy, & Conservation*
The Voyager Spacecrafts are two American robotic probes, Voyager 1 and Voyager 2, launched in 1977 to study our outer Solar System. Since their launch they continue exploring where nothing from Earth has flown before. They have made it beyond Pluto into interstellar space, the region between stars. Both spacecrafts are still sending scientific information about their surroundings through the Deep Space Network, or DSN.

George Carruthers is an African American inventor, physicist, and space scientist who has lived most of his life in Washington, D.C. As a child, he enjoyed visiting museums and was a member in various science clubs. Carruthers invented the first moon-based observatory, an ultraviolet camera which was used in the Apollo 16 mission. Carruthers was inducted into the National Inventors Hall of Fame for his contributions.

Albert Einstein was a German-born theoretical physicist. He is considered the most influential physicist of the 20th century. He developed two theories of relativity: the first is Special Relativity, which establishes the relationship between space and time through objects in motion and the constant speed of light. The second is General Relativity, which redefined the laws of gravity by focusing on gravity with inertia and the correlation between gravity and time.

Galileo Galilei was an Italian Renaissance astronomer, physicist, engineer, philosopher, and mathematician. Galileo has been called the “father of observational astronomy,” the “father of modern physics,” and the “father of science.” He constructed a telescope which allowed him to confirm the phases of Venus, discover the four largest moons of Jupiter (named the Galilean moons), and observe sun spots.
Solar Lab outside the Galaxy corridor
Solar Calendar = Time of Day + Time of Year
WHAT DOES THIS DATA MEAN?
This shows the total amount of energy used to operate Discovery Elementary today. This means all energy required to heat, cool and light the building, store and prepare food, operate technology, and power everything plugged into outlets.

PERCENT CHANGE
(from previous period)
~ 2.8 %

EQUIVALENTS
- Typical Houses: 2.3 kWh
- Typical 60 watt LED Bulbs: 22 kWh
- Typical Smartphones charged: 112 kWh

ENERGY CONSUMPTION BREAKDOWN
- Plug: 20%
- Kitchen: 10%
- Lighting: 15%
- HVAC: 35%
WHAT DOES THIS DATA MEAN?
For business professionals caught between high OEM price and mediocre print and graphic output, there’s a solution: Business Express’s Eclipse line of compatible laser toner cartridges that meet or exceed OEM quality for 20% less than typical OEM price.

PERCENT CHANGE
(from previous period)

~~ 0.5% ~

EQUIVALENTS

<table>
<thead>
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<th>Item</th>
<th>Equivalent</th>
</tr>
</thead>
<tbody>
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<td>Typical Houses</td>
<td>1.3</td>
</tr>
<tr>
<td>Typical 60 watt LED Bulbs</td>
<td>8</td>
</tr>
<tr>
<td>Typical Smartphones charged</td>
<td>2</td>
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</tbody>
</table>
WHAT DOES THIS DATA MEAN?

This data represents all the energy that goes into powering Discovery! Everything from bringing fresh air to making sure the lights come on.

PERCENT CHANGE

(from previous period)

\[ \text{Percent Change} = 2.8\% \]

EQUIVALENTS

- Typical Houses: 2.3
- Typical 60 watt LED Bulbs: 22
- Typical Smartphones charged: 112

TOTAL ENERGY PRODUCTION

\[ +3 \text{ kW} \]

HOME

SCHOOL YEAR

D S A T U R D A Y , O C T O B E R 1 2 0 1 6

54°/66°
You feel the energy when you walk in, but what does it mean for learning?
When Collaboration Becomes The Norm
Expanding The Notion of Team
A walk down the hallway breaks down the idea of “my isolated room”
Not 5 third grade classrooms, but 5 third grade teachers teaching all
Collaboration becomes the norm because design has stripped us of isolation.
human graph on bike walk to school day - Ms Cs 2nd grade @DiscoveryESPTA @DiscoveryAPS @ATPcommutes @MissCoulouris

Natural light, atrium windows are Awesome to students @RussoErin @vmdoarchitects @PhilipDonovan
Authentic learning
Authentic learning
Powerful, purposeful learning
Axis, orbit, equator, math, science, history… and the Pantheon!
This is their school | Student ownership of their learning
Discovery

I am a bird
Who flew out of a wooden house
Who flew through the whispering leaves of the forest
Who soared over the depths of the ocean
Then I went into the atmosphere
Spinning through sparkling snow
And flew into the solar system
Dancing through twinkling stars
And flew into the galaxy
where I thought
I came from a backyard
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