U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Zero Energy Schools

K-12 Schools by the Numbers

- **1 in 6** Americans sets foot in a school each day
- **100,000** public K-12 schools in U.S.
- **7.5 billion** square feet
- **$6 billion** annually on K-12 energy bills, more than is spent on textbooks and computers combined
- **$49** billion annually for new construction and capital projects
- **2nd** largest public infrastructure investment after transportation

Why Schools Focus for ZE/ZER?

- Energy costs are significant share of school operational expenses
  - Energy expenses are second only to salaries
  - Deplete funding that could be allocated to resources for students
- Owner-occupied, design and construction investments are made for durability and low operating costs
- Good replication potential, strong stakeholder involvement, prominence in their communities
- Strengthens resiliency of critical community assets
- Unique opportunity to educate and shape the views of a new generation
- Important equity impacts
- Currently more ZE schools than any other building type

Accelerator Vision and Goals

Vision

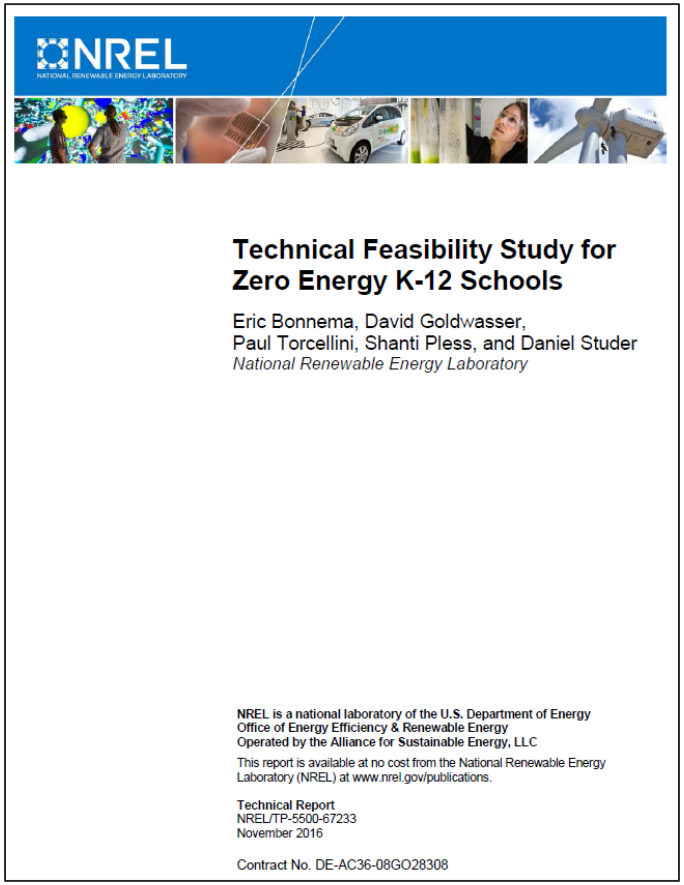
K-12 school buildings provide healthy, dynamic learning environments and resilient community assets that have minimal energy costs

Accelerator Goals

- **Identify** strategies to overcome barriers to building ZE K-12 schools and realizing the associated health, savings, and resiliency benefits
- **Share** solutions, resources, and technologies that help schools achieve ZE goals
- **Develop** replicable road maps to build ZE schools and achieve associated benefits
- **Increase** visibility and replication of best practice approaches and successful models

Accelerator Will Demonstrate ZE/ZER Pathway

- Establish EUI targets to drive energy efficiency (approximately 50-70% savings) such that ZE/ZER is possible for schools through Technical Feasibility Study for Zero Energy K-12 Schools
- Show that ZE/ZER schools are possible within conventional construction budgets
- Work with school districts and states to identify barriers to ZE/ZER schools creating solutions to overcome these barriers
- Identify and create resources to accelerate the construction of ZE/ZER schools


NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Technical Feasibility Study for Zero Energy K-12 Schools

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Technical Report
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Feasibility Study Prototype Characteristics

Building Characteristic	Feasibility Study Prototype	
Building type	Primary school	Secondary school
Size (ft^2)	82,500	227,700
Number of floors	2	3
Number of students	650	1,200
Space types	Art classroom, cafeteria, classroom, corridor, multipurpose room, kitchen, lobby, mechanical room, media center, office, restrooms	Art classroom, auditorium, cafeteria, classroom, corridor, gyms, kitchen, library, lobby, mechanical room, office, restrooms
Wall construction	Steel-framed	Steel-framed
Roof construction	Insulation entirely above deck	Insulation entirely above deck
Window area	35% window to gross wall area	35% window to gross wall area
Percent conditioned	Fully heated and cooled	Fully heated and cooled
HVAC system types	Zone-level ground source heat pump (GSHP) in classroom wings and common areas; packaged single zone GSHPs in gym, kitchen, cafeteria; dedicated outside air system with CO_2 based flow for ventilation air.	Zone-level ground source heat pump (GSHP) in classroom wings and common areas; packaged single zone GSHPs in gyms, kitchen, cafeteria, auditorium; dedicated outside air system with CO_2 based flow for ventilation air.

Best-in-Class ZE/ZER for Schools

- Classroom orientation on a long east-west axis
- Enhanced building opaque envelope insulation, window glazing, and overhangs
- Reduced lighting power density based on LED technology
- Use of vacancy sensors to minimize lighting
- Enhanced controls for common areas and exterior lighting
- Daylighting in classrooms, resource rooms, cafeterias, gyms, and multipurpose rooms
- Plug load reductions and improved controls for shedding loads during unoccupied periods
- High-performance commercial kitchen equipment and ventilation
- Demand-controlled ventilation and energy-recovery ventilators using dedicated outside air system
- HVAC equipment including system configurations
- High-efficiency service water heating equipment and distribution systems
- Exterior LPD reductions

EUI Targets to Meet or Exceed ZE

Climate Zone	Representative City	Primary School		Secondary School	
		Site Energy (kBtu/ft²·yr)	Source Energy (kBtu/ft²·yr)	Site Energy (kBtu/ft²·yr)	Source Energy (kBtu/ft²·yr)
1A	Miami, FL	25.9	76.4	23.1	68.5
2A	Houston, TX	24.3	71.1	21.7	63.5
2B	Phoenix, AZ	24.7	72.5	21.9	64.3
3A	Memphis, TN	23.8	69.0	21.2	61.6
3B	El Paso, TX	23.4	67.8	20.7	60.2
3C	San Francisco, CA	21.6	61.9	19.0	54.3
4A	Baltimore, MD	23.5	67.6	20.9	60.1
4B	Albuquerque, NM	23.1	66.6	20.4	58.8
4C	Salem, OR	22.4	64.2	19.7	56.4
5A	Chicago, IL	24.3	69.9	21.6	62.2
5B	Boise, ID	23.2	66.7	20.4	58.4
6A	Burlington, VT	24.5	70.1	21.6	61.9
6B	Helena, MT	23.5	66.9	20.5	58.4
7	Duluth, MN	25.9	74.1	22.8	65.1
8	Fairbanks, AL	28.7	82.5	25.0	71.5

Accelerator Partners

Current Accelerator Partners

- Implementing (Districts)
  - Hermosa Beach City School District
  - LA Unified School District
  - Arlington School District
  - Boulder Valley School District
  - Adams 12- Five star schools
  - Alexandria School District
- Implementing (States)
  - California, Minnesota
- National
  - NEED
  - NEEP
  - SoCalEd
  - TEC
  - NBI
  - NASEO
  - RMI
  - A4LE
  - U.S. Department of Education

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Zero Energy Districts

Why Districts Focus for ZE/ZER?

Cities are setting aggressive energy transformation and resiliency goals and ZED are a key strategy to reach these energy goals.

Source: Colorado State University

"The district is the optimal scale to accelerate sustainability — small enough to innovate quickly and big enough to have a meaningful impact." –EcoDistricts

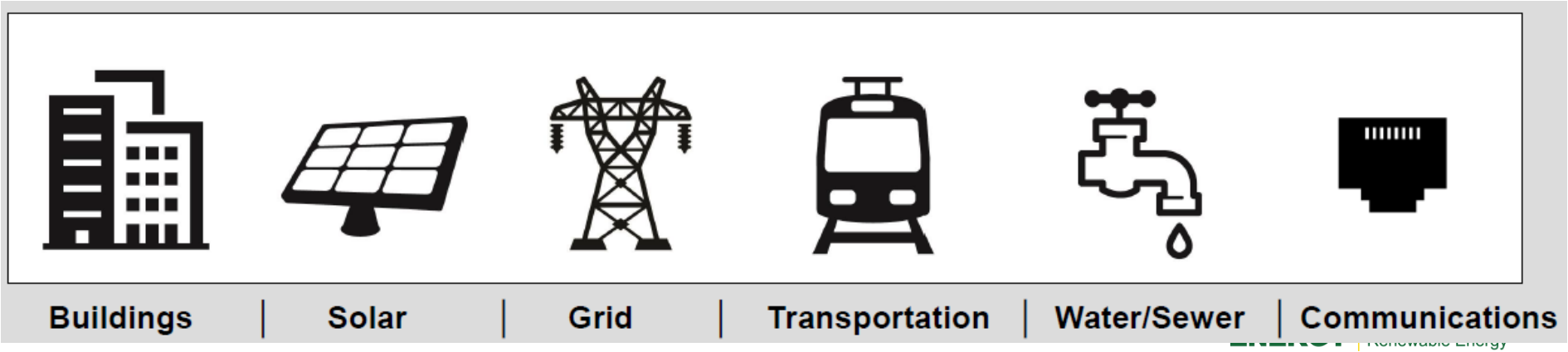
Districts are great testbeds to explore new technologies and business models. Economies of scale, shared energy infrastructure, and efficiently coordinated operations provide ZED cost-effective opportunities often not possible through individual buildings.

District Scale Opportunities

District scale introduces opportunities for coupling strategies and benefits in buildings with infrastructure improvements in different sectors.

Examples include:

- Industrial/sewer waste heat recovery for use in buildings
- Building load aggregation/control for grid interactions
- Solar canopy electric vehicle charging stations
- Sensor/communications networks to support advanced data analytics for optimal district operations



Accelerator Vision and Goals

Vision

Communities with energy efficient, resilient, cost-effective buildings and infrastructure are common throughout the U.S.

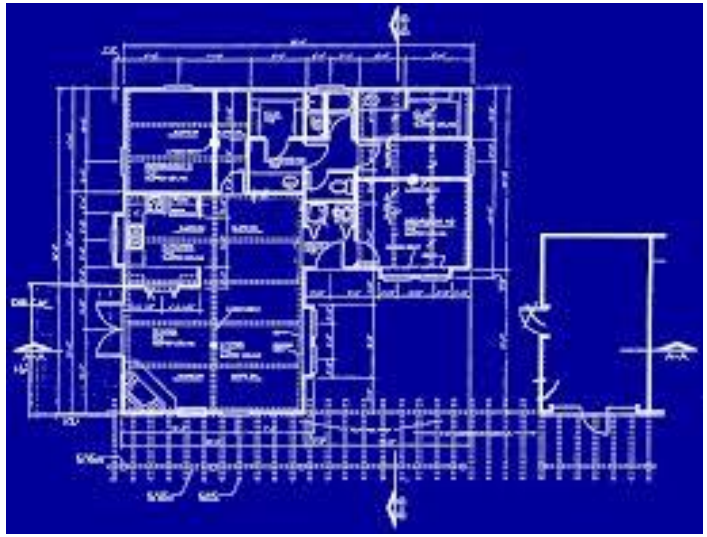
Goals

1. Support early adopters of ZE districts at two targeted and critical juncture points:
   - **Master planning** - including optimal district configurations and layout, building efficiency, renewable integration, utility partnerships, and district energy systems
   - **Financing and ownership structure** – including how to plan for, navigate and manage joint ownership structures, financing, and operations

2. Develop case studies, best practices, and pilot examples to support the replication of ZE districts

Accelerator Will Demonstrate ZE/ZER Pathway

- Provide aggressive EUI targets for new buildings that are integrated into the planning and procurement strategies
- Create methods to balance density, building level efficiency with synergies of district heating, cooling, and electrical systems (including building and community-scale renewables)
- Develop operations and ownership models to sustain efficient district operations
- Pilot customized incentives and policies that can be rolled out to broader scale



Accelerator Partners

6 Implementing Partners

- CA (2), CO (2), NY, and MN
- Cities, Developers, Housing Authorities and Core Stakeholders
- Commit to developing energy master plan
- Diversity of project types

5 National Partners

- RMI, EcoDdistricts, NLC, USGBC, Xcel Energy
- Commit to provide resources and support to districts

Partner	Location	Size	Parties	Phase	Unique Aspect
National Western Center	Denver, CO	250 acres, 2.8M Ft^2	City, University, Utility	$900M raised, Beginning development plan	City Convention Center development
Sun Valley Eco District	Denver, CO	~100 acres in study area, 750+ Mixed use/Housing Units on 45 acres owned by Housing Authority	Housing Authority, Non-profit Developer	Received $30M HUD Choice Neighborhoods Implementation Grant to begin development planning and implementation	Public/low income housing mixed with market rate housing and commercial development
Huntington Beach Advanced Energy Community	Huntington Beach, CA	TBD	City, University	Beginning master planning and site considerations	California Advanced Energy Communities Pro gram
Saint Paul Ford Site	Saint Paul, MN	135 acres, 3M Ft^2 Housing, mixed use, commercial	City, University	Early planning and ownership model development	Redeveloping old Ford manufacturing site
Fresno Advanced Energy Community	Fresno, CA	Downtown revitalization	City, Non-profit	Beginning master planning and site considerations	Revitalize the downtown, reinvest in older neighborhoods
Erie County Industrial Development Agency, NY	Erie County, NY	140 acres, Manufacturing and Commercial campus	County	First building in design, greater district master plan in development	Revitalization of old steel mill industrial site

Three Focus Areas

Zero Energy Master Plan

- EUI targets, performance certification
- Addresses affordability, resiliency, economic development priorities
- Procurement model and design guidelines
- Leverages economies of scale
- Integrates energy efficiency, district energy, CHP, and renewable energy

Zero Energy Business Model

- Leveraging third-party financed opportunities
- Shifting capital cost from building level to district level systems
- Leveraging all available incentives
- Recapturing real estate values of high-performance buildings

Zero Energy Operations Plan

- Creating a dedicated and integrated zero energy services provider
- Establishing a district energy billing system
- Benchmarking to ensure EUI goals are met

Thank you

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