City of Pittsburgh & NETL

Award-Winning Regional Partnerships Driving Innovation

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U.S. DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

City of Pittsburgh & NETL

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Memorandum of Understanding (MOU)
Signed on July 17, 2015

Signatories:

- U.S. Department of Energy
- National Energy Technology Laboratory (NETL)
- City of Pittsburgh

Overarching Goals:
Leverage NETL and the DOE technical expertise and convening powers to facilitate the City's progress on resiliency and environmental goals.

- Identify solutions which can be replicated regionally or nationally.
- Establish guidance documents for evaluating regional energy needs and solutions.

NETL & City of Pittsburgh: A Shared History

1910 - 1950

1910

Pittsburgh Experiment Station

NETL, then called the Pittsburgh Experiment Station, opened in 1910 and investigated electricity, its applications in mining, safer use of explosives, and improved equipment and procedures for mine rescue work.

1920s & 30s

Investigating & Preventing Explosions

In the 1920s and 1930s, researchers focused on making everyday use of coal, petroleum, and natural gas safer, which led to the expertise needed for investigating and preventing explosions.

1950s

Space Innovation

During the space race of the 1950s, Bureau of Mines personnel conducted research on solid rocket propellants, safe handling of liquid-hydrogen fuel, the behavior of explosives in conditions resembling the lunar atmosphere, and shielding to protect space vehicles against meteor impacts.

NETL & City of Pittsburgh: A Shared History

1977 - Today

1970

Hydraulic Fracturing

In the mid-1970s, work began on directionally deviated well-drilling techniques to enhance petroleum and natural gas recovery followed by a concentrated research project on a technique that became known as massive hydraulic fracturing. This has to do with the Marcellus Shale drilling work in Western Pennsylvania that led to the nation's resurgence as an energy producer.

1977

Pittsburgh Energy Technology Center

By 1977, the Department of Energy (DOE) was formed. The Pittsburgh research facilities became known as the Pittsburgh Energy Technology Center (PETC).

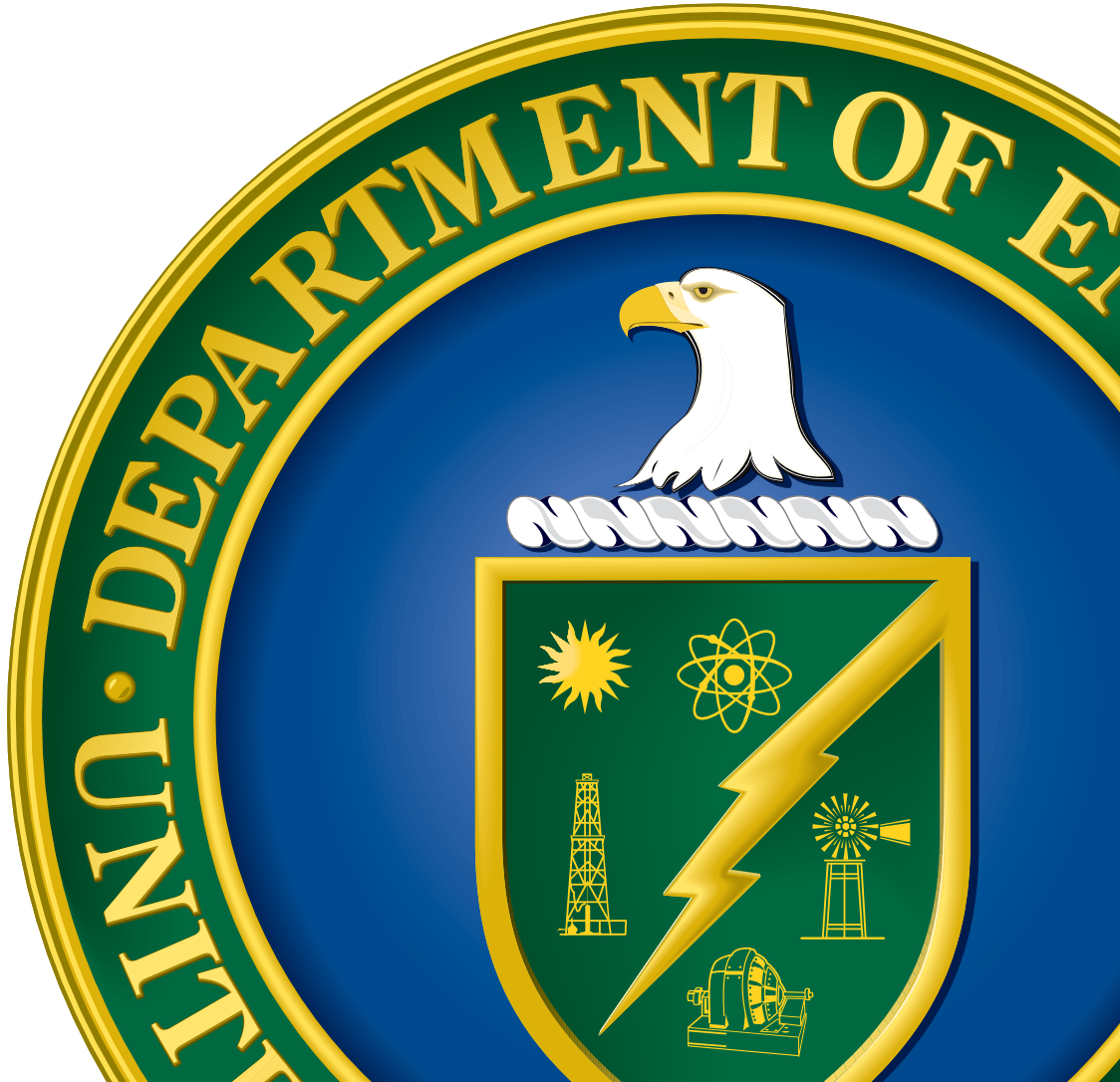
Today

Present Day & Commitment to Outreach

Today, the Pittsburgh facilities are joined with the DOE laboratories in Morgantown, WV and Albany, OR. Modern research focuses on topics such as supercomputers, lasers, data systems, sensors, and sophisticated information sharing processes. NETL conducts onsite school visits, hosts tours, conduct programs to actively encourage young people of the region to pursue education and careers in STEM, and hosts science bowls.

Supporting the Fossil Energy Mission

- NETL is developing smaller scale energy and other next-generation systems, and the MOU offers a chance to showcase these technologies along with other novel inventions.
- The MOU provides a platform to assist in the creation of on-site test-beds for new technologies, promoting Pittsburgh's leadership in energy and providing a location where NETL technologies can be tested and demonstrated.
- The City of Pittsburgh MOU also grants an opportunity to lead the next generation of energy district/microgrid research (beyond what's being done nationally).
- Energy district projects in Pittsburgh represent an area of new research and development by intelligently integrating generation with the isolated energy district. This plays to NETL's unique strengths and allows us to drive the dialogue on the value of FE.



NETL & City of Pittsburgh Partnership

Craft strategic plan supporting distributed energy strategies.

Identify financial opportunities to catalyze investment in distributed energy systems and supporting activities.

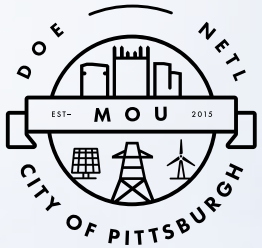
Address policy and regulatory needs for distributed energy and infrastructure modernization.

Conduct economic analysis of cost/benefits of distributed energy with microgrid integration and building performance policies.

Accelerate growth and access to energy jobs.

Form technical team to explore efforts of the City and within the City.

Prepare technology R&D roadmap for rapid demo and deployment.



A Grid of Microgrids

- Provide resiliency by ensuring localized energy generation.
- Higher utilization rates due to broader customer base: when one customer isn't using any energy, other customers may be.
- Single point of maintenance (compared to having to go into each commercial and residential building served by the system), streamlining maintenance, requiring only one system to be monitored for optimal operation.
- Increased upgrade and expansion options, as there is a reduced overhead of upgrading a single system, compared to many systems deployed in many buildings. An example is Duquesne University, which has continued to upgrade its combined heat and power (CHP) system, integrating cooling systems and thermal storage.
- Reduced costs due to economies of scale (compared to individual building-sized).
- Potentially broader range of systems available at larger scale.

Northside Energy District

Established in 1999, Clearway Energy Center Pittsburgh provides both district heating and cooling services to a total of 6.3 million square feet of building space, which serves more than 30 buildings on the north side of Pittsburgh. This includes PNC Park, Carnegie Science Center, and Allegheny General Hospital.

Uptown Energy District

Clearway Energy is designing a new heat and power plant in the Lower Hill/Uptown District to deliver heat to surrounding buildings including PPG Paints Arena and UPMC Mercy. This energy district could also integrate Duquesne University's cogeneration plant.

Oakland Energy District

Built in 1907, Bellefield Boiler Plant, serves most of Oakland's major institutions, including Carnegie Mellon University and Carnegie Museums of Pittsburgh. Carrillo Steam Plant in Oakland was established in 2009 and serves the UPMC. The two sites have interconnecting steam distribution lines.

Downtown Energy District

Established in 1983, (PACT) serves 59 buildings downtown including many local government buildings.

Second Avenue Microgrid

A project that will link grid and transportation modernization though garage/rooftop solar and electric vehicle charging stations.

Brunot Island Microgrid

This existing electric substation is a possible site for a biogas and waste-to-energy plant.

Larimer Energy District

A community-based microgrid that would be part of the redevelopment of a 285-acre neighborhood in the east end of Pittsburgh.

Hazelwood Green Energy District

This property is a mixed-use development in Hazelwood on a 178-acre former steel mill riverfront that would be operated almost exclusively on renewable-based distributed energy.

Woods Run Microgrid

A long-term priority for Duquesne Light Company is to install a nominal 10 MWe microgrid at their Woods Run operations center on Pittsburgh's North Side. The facility will be used to investigate challenges and solutions to integrating distributed energy technologies such as PVs, wind, and energy storage. This project is on hold for the foreseeable future.

Denmark/Pittsburgh Energy Exchange

- NETL is participating in the Partnership Agreement between the University of Pittsburgh and the Danish Ministry of Energy, Utilities, and Climate Change.
- Collaborators discuss new research and approaches for helping Pittsburgh and Denmark to become global leaders in energy innovation and urban development.
  - Specific focus on providing sustainable resources to underprivileged communities.
- Signed an agreement in Pittsburgh in March 2018.

Funding Opportunity Announcements (FOA)

- NETL identifies financial opportunities for the partnership by keeping a list of active, applicable funding opportunities on the NETL website.
- NETL keeps an archive of both present and past funding opportunities complete with descriptions about each opportunity. Avenues of opportunities listed include:
  - Funding Opportunity Announcement (FOA)
  - DOE Collaboration Opportunities
  - Request for Application (RFA)
  - Request for Information (RFI)
  - Request for Proposal (RFP)
  - Notice of Intent (NOI)

Smart City Challenge

- NETL was an active participant in the pursuit of a $50 million Smart City Challenge grant from the U.S. Department of Transportation (DOT) to improve regional transportation.
- Pittsburgh was awarded a $10.9 million grant under the Fixing America's Surface Transportation (FAST Act) to create "smart spines" that use sensors to help balance and move traffic through the city.

The Smart PGH plan

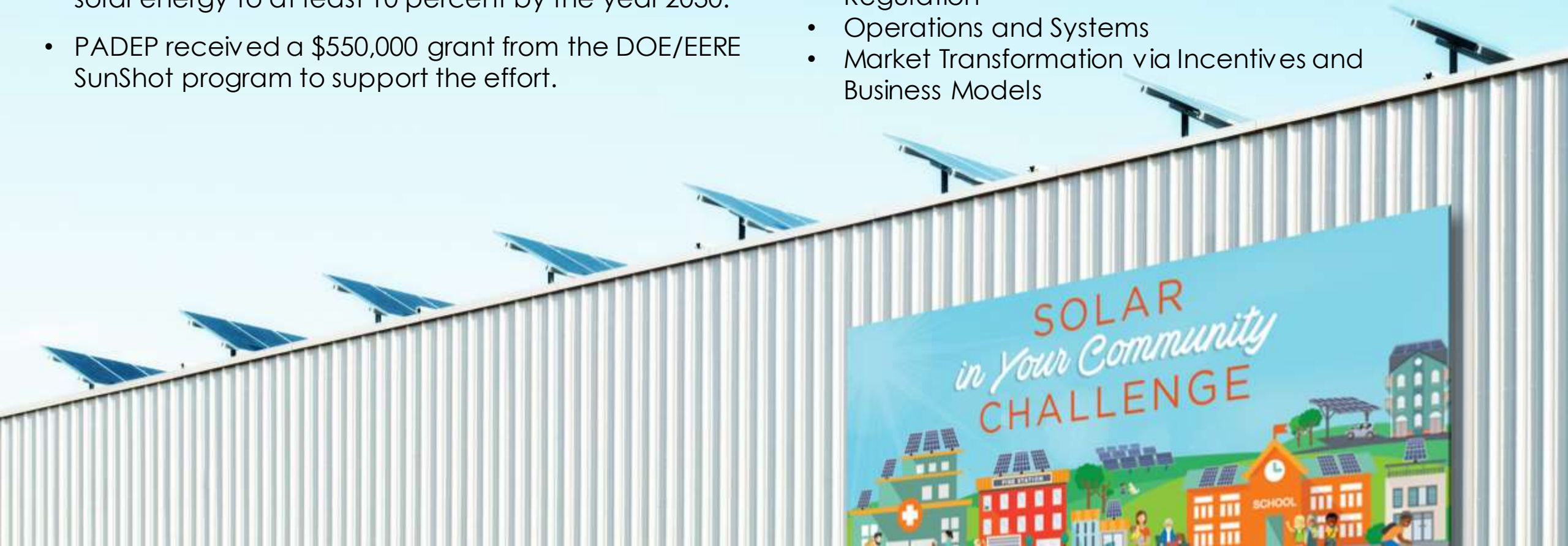
- The Challenge – Pittsburgh has one of the highest air pollution levels in the country, and poor air quality is well known to cause serious health and social impacts.
- The Goal – Jump-start electric conversion to reduce transportation emissions by 50% by 2030. Through demonstration projects in street lighting, electric vehicles, and power generation.
- The Strategy –
    - Convert up to 40,000 streetlights to LEDs to reduce energy use
    - Establish smart street lights with sensors to monitor local air quality
    - Install electric vehicle charging stations
    - Convert the City's public fleet to electric vehicles

Finding Pennsylvania's Solar Future

- NETL participates in Finding Pennsylvania's Solar Future led by the Pennsylvania Department of Environmental Protection (PADEP).
- The goal is to develop a detailed plan to increase the Commonwealth's electricity generation from solar energy to at least 10 percent by the year 2030.
- PADEP received a $550,000 grant from the DOE/EERE SunShot program to support the effort.

Participants in the project are engaging in a modeling process to envision and predict the outcomes of possible approaches of solar energy deployment. The modeling process consists of 3 components:

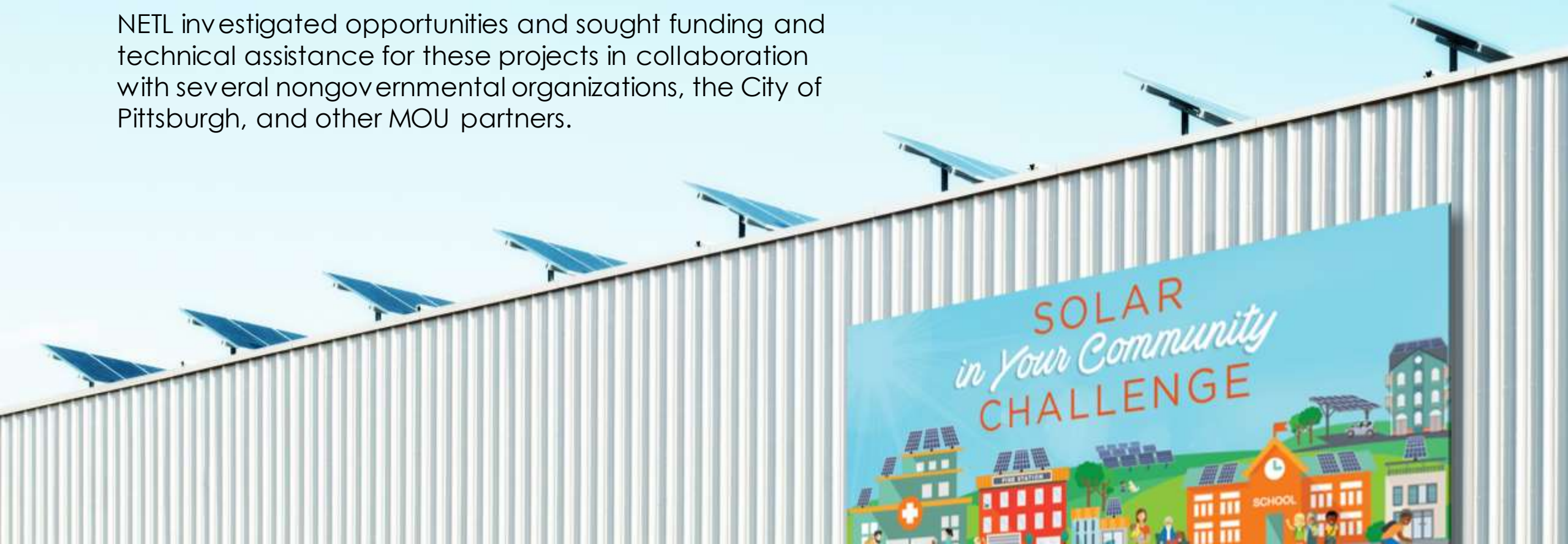
- Regulation
- Operations and Systems
- Market Transformation via Incentives and Business Models



DOE Sunshot: Solar in Your Community Challenge

The DOE Office of Energy Efficiency and Renewable Energy (EERE) provided prize money through the Solar in Your Community Challenge to low-to-moderate income communities for developing community-based solar projects that have high potential for replication.

NETL investigated opportunities and sought funding and technical assistance for these projects in collaboration with several nongovernmental organizations, the City of Pittsburgh, and other MOU partners.



2013 Energy Usage Analysis Overview

On March 28, 2017 the Pittsburgh 2013 Energy Baseline: Consumption, Trends & Opportunities report was published. The following is the scope of the report:

All Sectors in the City of Pittsburgh and Surrounding Areas

- Data was only available on a zip code-level, and some zip codes have non-City areas
- Accounts for approximately 578,000 residents compared to City population of 300,000

Focus on Natural Gas & Electricity Consumption

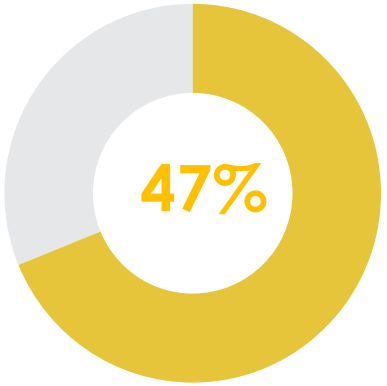
- Zip code-level 2013 consumption data provided by utilities
- Broken down by sector (residential, commercial, industrial)
- Monthly electricity usage available
- Equitable Gas provided monthly data, which was extrapolated for monthly gas consumption analysis

Transportation Fuel Consumption Estimate

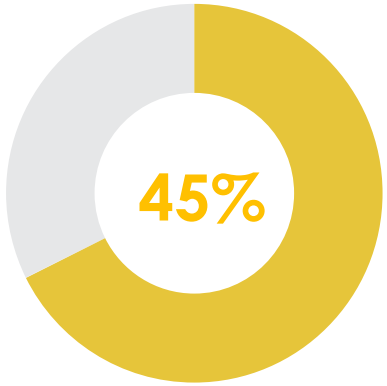
- Based on state-level data from EIA and the Commonwealth of Pennsylvania
- Used for an order of magnitude estimate only

Life Cycle Greenhouse Gas Emissions from Energy Usage

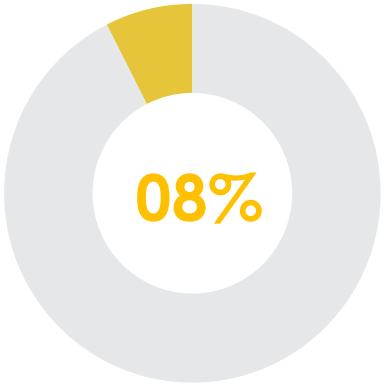
Energy Usage Breakdown



Residential



Commercial



Industrial

Pittsburgh 2013 Energy Baseline

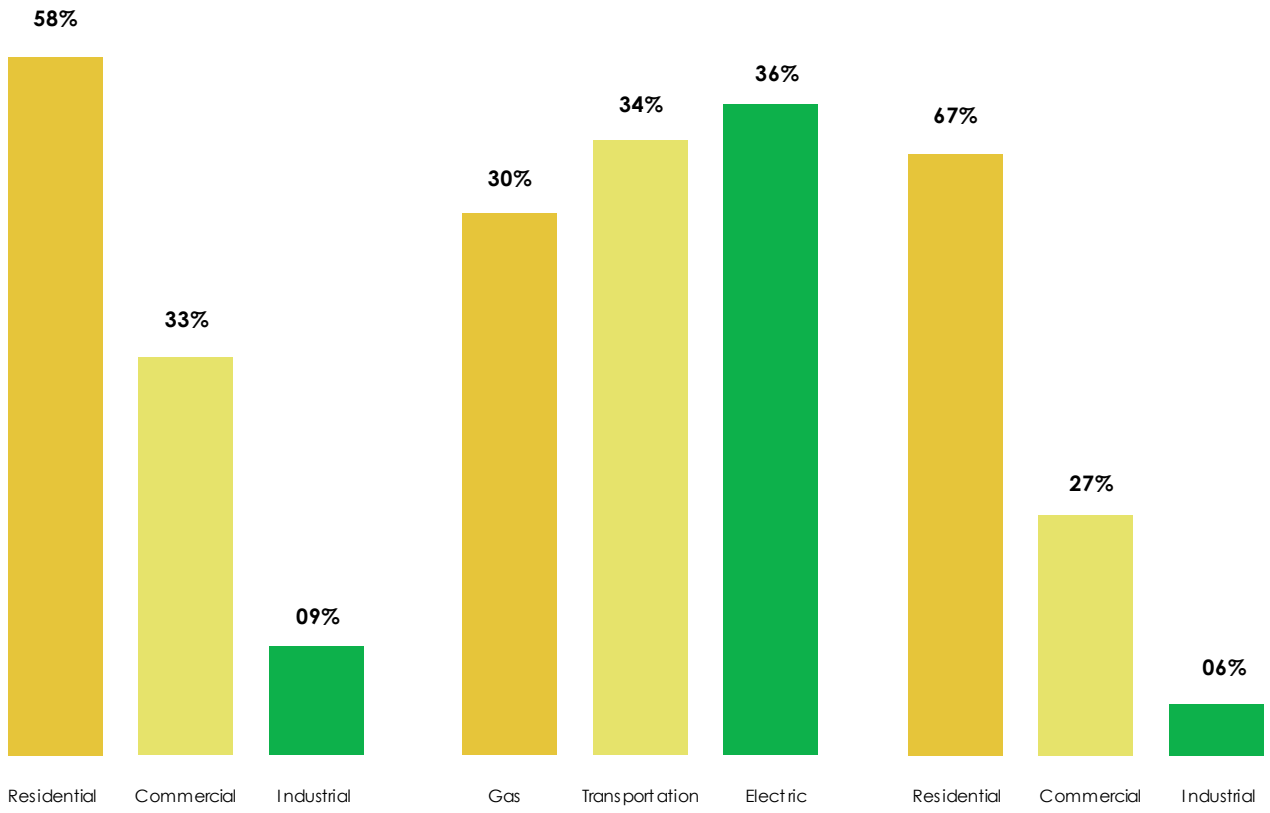
Greenhouse Gas (GHG) Emissions from Energy Consumption

- Life cycle emissions from natural gas and electricity usage totaled 6.7 million tons of carbon dioxide equivalents (CO_2e) in 2013.
- Electricity usage was the largest source of emissions at 55%, particularly in the commercial sector totaling 37% of Pittsburgh's overall GHG emissions.
- Natural gas usage in the residential sector was the second largest source of emissions, accounting for 26% of total emissions in the city.
- Emissions associated with space heating are likely to constitute between 17% and 25% of total emissions when both the residential and commercial sectors are considered.
- The impact of electricity usage is high despite regional GHG emissions profile for electricity that is slightly lower than national average.

Distributed Energy Resources

- Distributed Energy Resources (DERs) are smaller-scale, modular, electric and thermal energy generation and storage devices like combined heat and power, gas turbines, microturbines, wind turbines, PV solar, batteries, fuel cells, and geothermal.
- Coupling DERs with local customers or loads creates a localized grid called an energy district.
- Energy districts are connected to the larger, centralized power grid, but can run independently from it, leading to improved power reliability and quality, increased system efficiency, enhanced environmental performance, and grid-independence for individual end users.

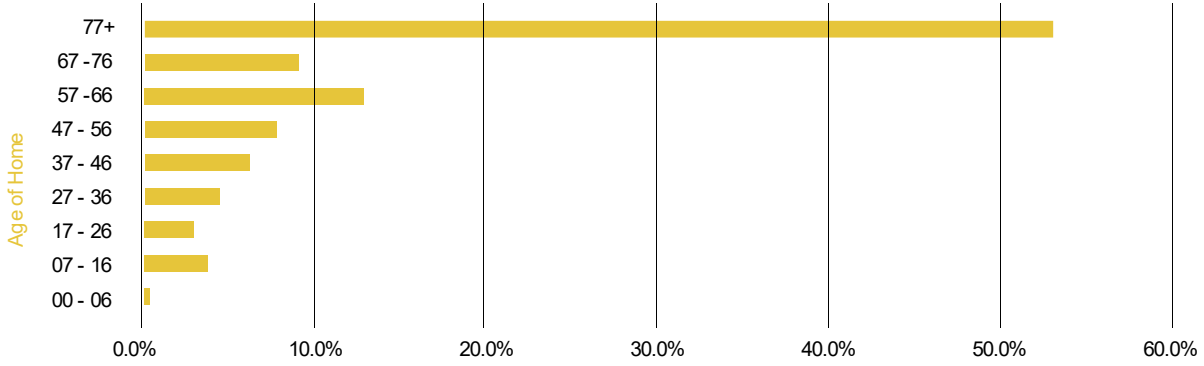
2013 Greenhouse Gas Emission Breakdown



Pittsburgh Snapshot

Population[1]	305,704
Total Housing Units[2]	154,942
Occupied Housing Units[2]	132,379 (85.4%)
Own / Rent[2]	49%/51%
Median Home Value[2]	$91,500
Mean/Median Household Income[3]	$40,009 - $60, 922
Occupied Homes Using Gas as Primary Heat Fuel[3]	81.5%
Estimated CO_2 Emissions from Residential Gas Usage[4]	1,341,830 Tons

Distribution of Age of Homes in Pittsburgh

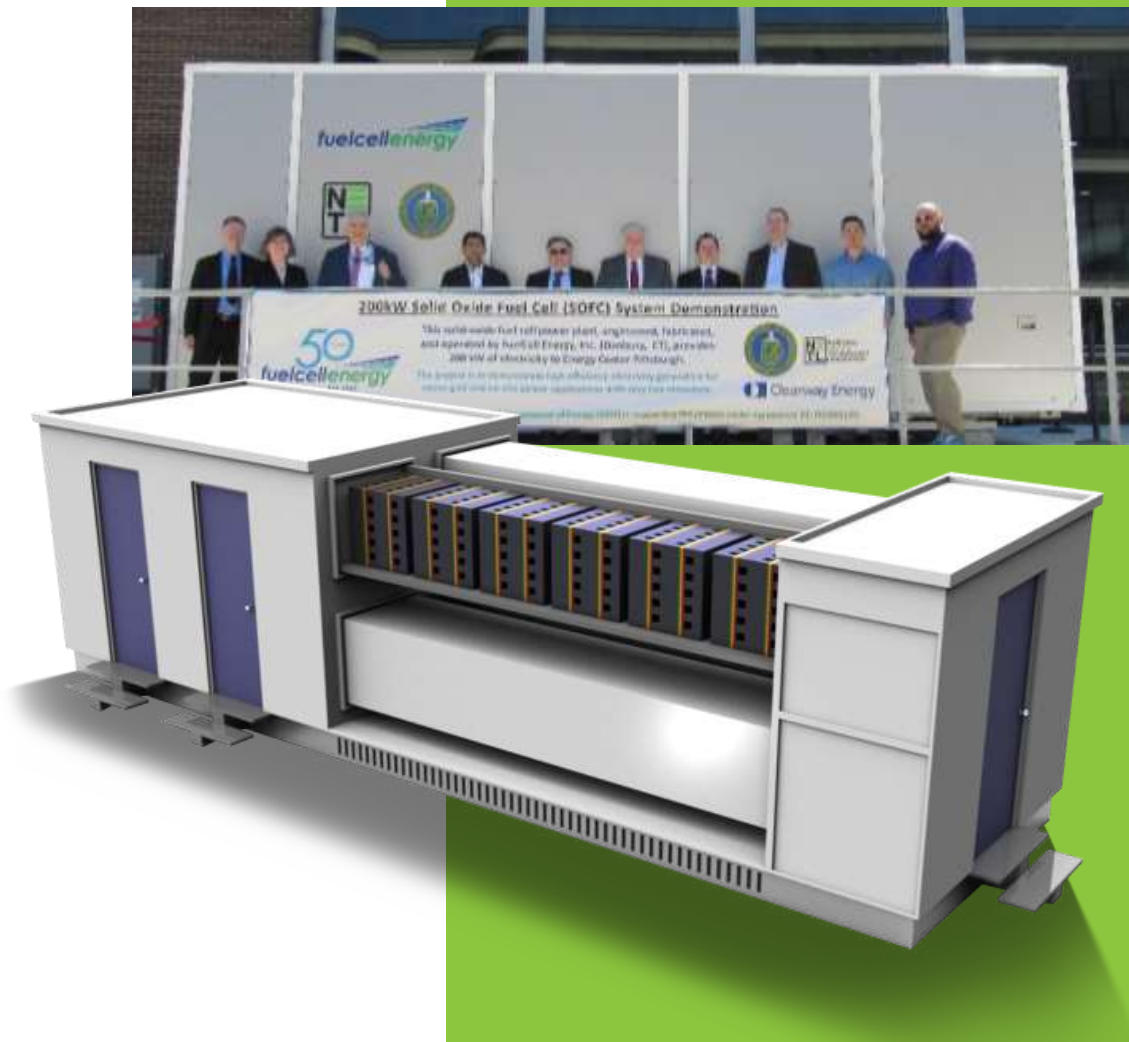


- Population data comes from US Census Data (DP01) "Profile of General Population and Housing Characteristics" report for Pittsburgh as of 2010
- Housing data comes from US Census Data (DP04 "Selected Housing Characteristics" report for Pittsburgh as of 2014
- Population and income data comes from US Census Data (DP03 "Selected Economic Characteristics" report for Pittsburgh as of 2014
- Gas CO_2 Emissions estimate based on LCA data from Tom Tarka (399.2 lb CO_2/MWh

Fuel Cell Energy Solid Oxide Fuel Cell (SOFC)

- The partially-NETL funded 200kW Solid Oxide Fuel Cell (SOFC) operated from April – October 2019.
- Uses clean natural gas and ran for a pre-determined 3,900 hours to quantify long-term degradation as well as systems availability and reliability.
- SOFCs convert chemical energy of a fuel and oxidant directly into electrical energy, generating power through an electrochemical reaction rather than a combustion process.
- The performance of the SOFC successfully demonstrated the potential of the technology to deliver low-cost and efficient power generation with ultra-low emissions of pollutants.

U.S. Department of Energy Office of Fossil Energy (FE) officials joined NETL representatives to tour the prototype 200kW Solid Oxide Fuel Cell (SOFC) system in Pittsburgh's central business district that is advancing technology to provide clean, high-efficiency power from fossil fuels on Tuesday, April 9, 2019.



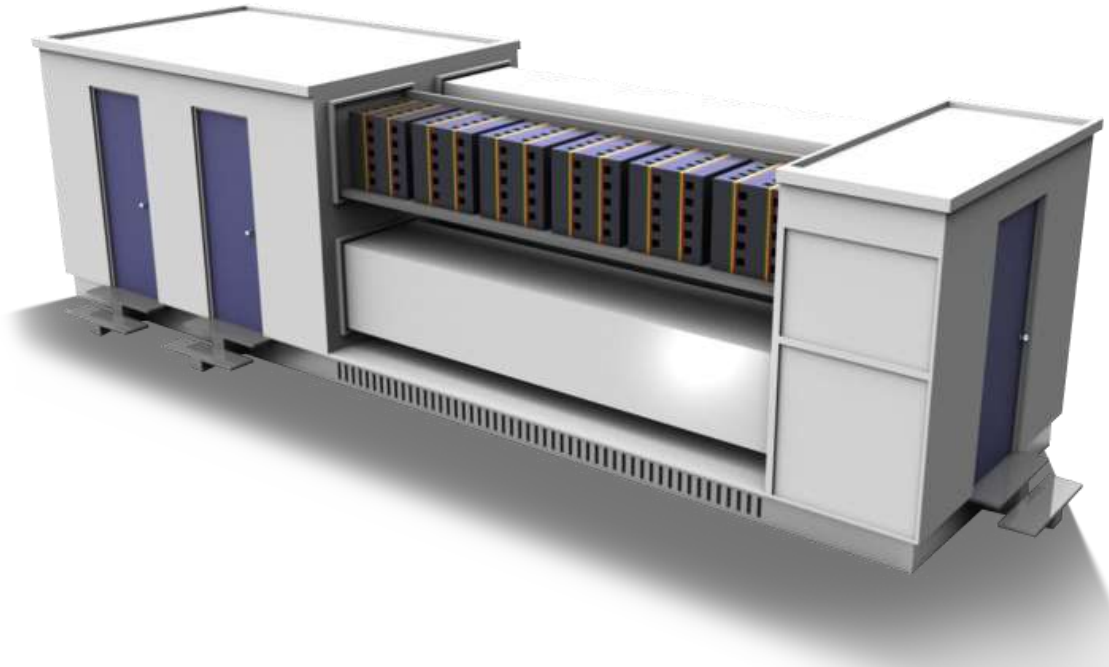
Solid Oxide Fuel Cell Research

The NETL Fuel Cell Program maintains a portfolio of RD&D projects that address the technical issues facing the commercialization of SOFC technology and a series of increasingly larger demonstration projects intended to validate the solutions to those issues.

The program's efforts are channeled through Systems Analysis and three key technologies:

- Cell Development
- Core Technology
- Systems Development

Within the Systems Development key technology, projects focus on innovative SOFC stack technologies that have potential to significantly decrease cost of SOFC power systems by leveraging advancements in lower-cost materials, advanced manufacturing methods, and/or alternative architectures.



Solid Oxide Fuel Cell Research

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200
kWe

50%
Will use natural gas as a fuel and produce electricity at efficiency greater than 50%

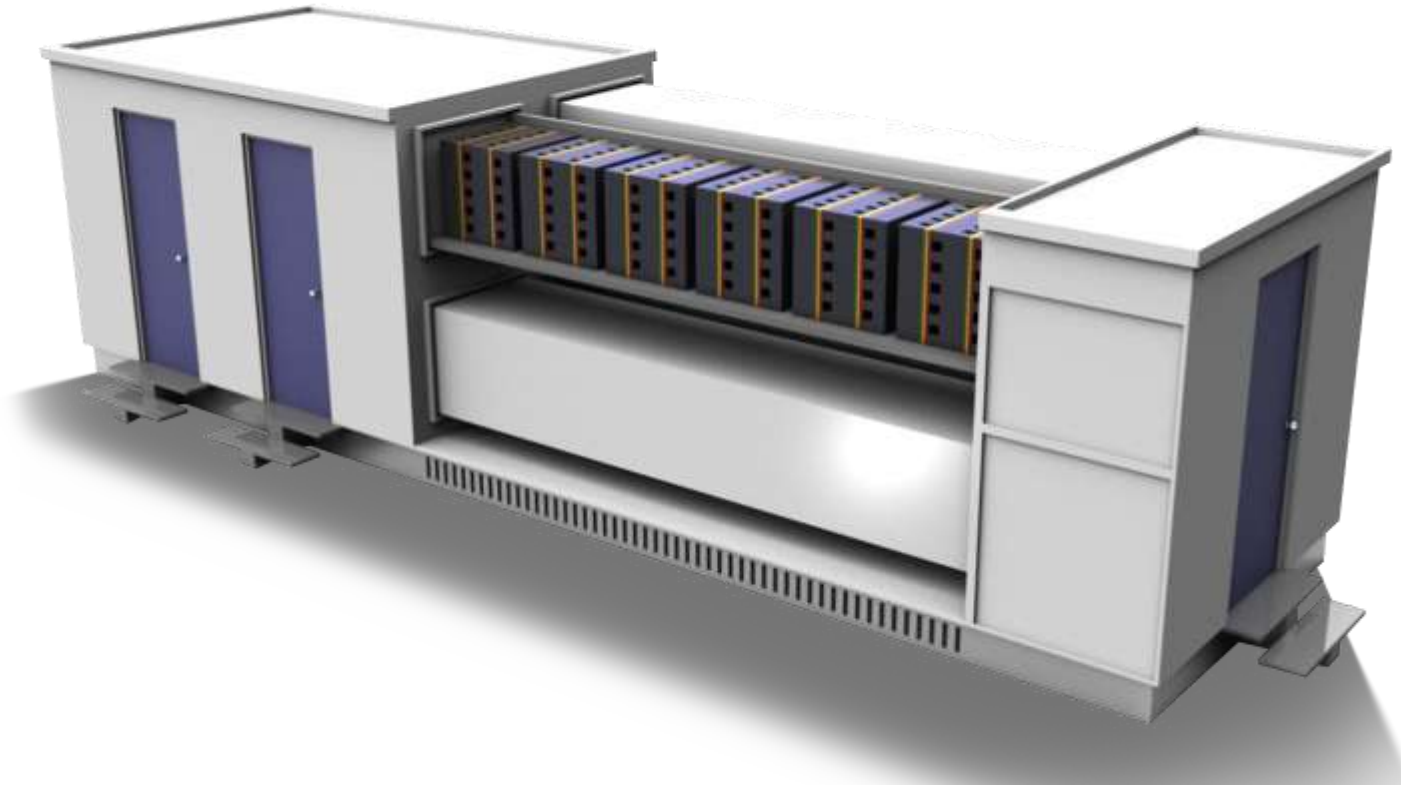
80%
Heat recovery capability for up to 80% overall efficiency (electric and thermal)

100
Can power approximately 100 homes

Distributed power generation source and con operate independently from the grid

Very clean
low emission technology

Unattended operation with remote monitoring



Goal

Identify specific strategies to increase in-state solar-powered electricity generation by 10 percent by the year 2030

15 Strategies to Get to 10 Percent of Electricity from Solar

The "Finding Pennsylvania's Solar Future" project group identified 15 strategies that, if implemented, will enable Pennsylvania to get 10 percent of its electricity from in-state solar energy.

Seven strategies incorporate development of both grid-scale and distributed systems. Eight strategies are specific to either distributed or grid-scale solar development. The list isn't meant

15 Strategies to Get to 10 Percent of Electricity from Solar

Cross-Cutting Strategies: Grid-scale and Distributed

Alternative Energy Portfolio Standards	1. Increase the AEPS solar photovoltaic (PV) carve-out to between 4 and 8 percent by 2030, and ensure creditable Solar Renewable Energy Credits are limited to those generated in Pennsylvania wherever possible.
Access to Capital	2. Increase access to capital by expanding availability of solar lending products to residential and commercial projects to enable solar ownership. 3. Provide loan guarantees to lower interest rates and incentivize deployment of solar generation.
Carbon Pricing	4. Implement a carbon pricing program and invest the proceeds in renewable energy and energy efficiency measures.
Siting & Land Use	5. Support the creation and adoption of uniform policies to streamline siting and land-use issues while encouraging conservation.
Tax Incentives	6. Evaluate the state tax policy and consider exemptions that encourage the development of solar PV systems. 7. Assist solar project sponsors in identifying investors and/or companies that have sufficient tax equity appetite to take full advantage of the federal solar Investment Tax Credit and Modified Accelerated Cost Recovery System depreciation, if sponsors can't do so themselves.

Cross-Cutting Strategies: Grid-scale and Distributed

Alternative Energy Portfolio Standards	8. Develop guidelines for limited use of long-term contracts (LTCs) for a period of 10 or more years to ensure Pennsylvania benefits from grid scale solar energy. 9. Evaluate and consider utility ownership of solar generation especially in cases where market-driven deployment may be insufficient to achieve public goals and/or reliability concerns. This may include solar for low income and Customer Assistance Programs in particular.

15 Strategies to Get to 10 Percent of Electricity from Solar

Distributed Generation Strategies

Virtual Net Metering	1.	Expand customers' ability to use net metering.
Community Solar	2.	Identify and remove the barriers to the deployment of community solar systems in Pennsylvania.
Alternative Rate Making	3.	Ensure alternative ratemaking is addressed in a manner that does not create a disincentive for solar deployment.
Property Assessed Clean Energy (PACE)	4.	Enable and encourage municipalities to offer PACE programs that include solar projects.
Addressing Interconnection Issues	5.	Accelerate use of smart inverters to manage over-voltage concerns on low voltage distribution lines and avoid unnecessarily adding costs.

Next Steps

Over the next few months, the "Finding Pennsylvania's Solar Future" project group will develop a Strategy Support Guide. Action items will be identified to facilitate implementation of the strategies presented in Pennsylvania's Solar Future and determine what additional information is needed to continue to deploy solar to meet the 10 percent target—and possibly beyond.

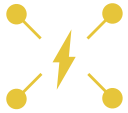
Learn more about development of the Strategy Support Guide at https://www.dep.pa.gov/PASolarFuture

Case Studies in Deep Direct Use of Geothermal Energy

Southpointe Business Park and City of Pittsburgh's Hazelwood Green

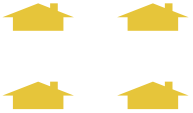
Residential Heating Solutions

- Identify scope of Natural Gas (NG) Usage for heating
- Examine technology solutions to reduce usage



Utilizing Microgrids for Peak Shaving

- Marginal power generation is coal- or gas-based
- Microgrid generation could displace these during peak periods
- Addresses high emission generation and potentially improves microgrid economics through increased utilization
- Limited and achievable scope (rather than having 100% renewables)



Energy Systems for Neighborhoods

- A neighborhood mini-grid would consist of an energy efficient or renewable power source (wind/solar + battery, SOFC, geothermal, etc.)
- Designed for islanding to provide backup power to the above critical secondary services.
- Addresses City's interest in Resiliency and "Grid of Microgrids" vision

Geothermal Takeaways

- NETL investigated the feasibility of using deep geothermal resources for space heating, a form of DDU geothermal energy.
- DDU geothermal energy is beneficial because it can heat buildings and other things by **drawing heat from the hot rock and water within deep subsurface formations.**
- The more commonly used shallow systems only produce usable geothermal energy after concentrating the heat through ground-sourced heat pumps (GSHP), which require more outside energy.
- Utilizing DDU energy instead of relying on GSHPs would **further reduce a site's carbon footprint and lower its electrical demands.**
- DDU could be a more competitive option if future analyses find: (1) the geothermal temperature gradient is higher, (2) true project costs and risks are lower, or (3) competing energy prices go up.

Geothermal Takeaways

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Above Ground
- Estimate site energy needs
- Determine district piping network requirements
- Calculate operational costs

Below Ground
- Estimate potential geothermal reservoir thicknesses and depths
- Calculate local geothermal gradient and heat flow
- Predict depth to key temperature zones
- Calculate years to abandonment and heat capacity of reservoir
- Determine geothermal hardware requirements and give rough estimate on cost of well
- Calculate cost to operate below ground system

System
- Determine overall levelized cost of heat (LCOH)
- Assess surface LCOH and compare to other case studies

Hazelwood Green Goal:
- Attain net-positive building energy performance site-wide

DOE Pittsburgh Region Clean Cities Program

- The Pittsburgh Region Clean Cities works with vehicle fleets, fuel providers, community leaders, and other stakeholders to reduce petroleum use in transportation.
- The Pittsburgh Region Clean Cities supports the establishment of alternative fueling stations.
- The City of Pittsburgh MOU website lists the location of electric vehicle charging stations throughout the City of Pittsburgh and surrounding communities.
- NETL actively provides project management support to the Pittsburgh Region Clean Cities Program.

PITTSBURGH REGION CLEAN CITIES

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Better Building Initiative

The Better Buildings Initiative is a national leadership initiative that makes commitments to improve the energy efficiency of their buildings and plants, save money, and increase competitiveness.

Leaders involved in the Better Buildings Initiative include:

- State and Local Officials
- Corporate and Chief Executive Officers
- University Presidents
- Utilities

Work being done so far through the Better Buildings Initiative includes:

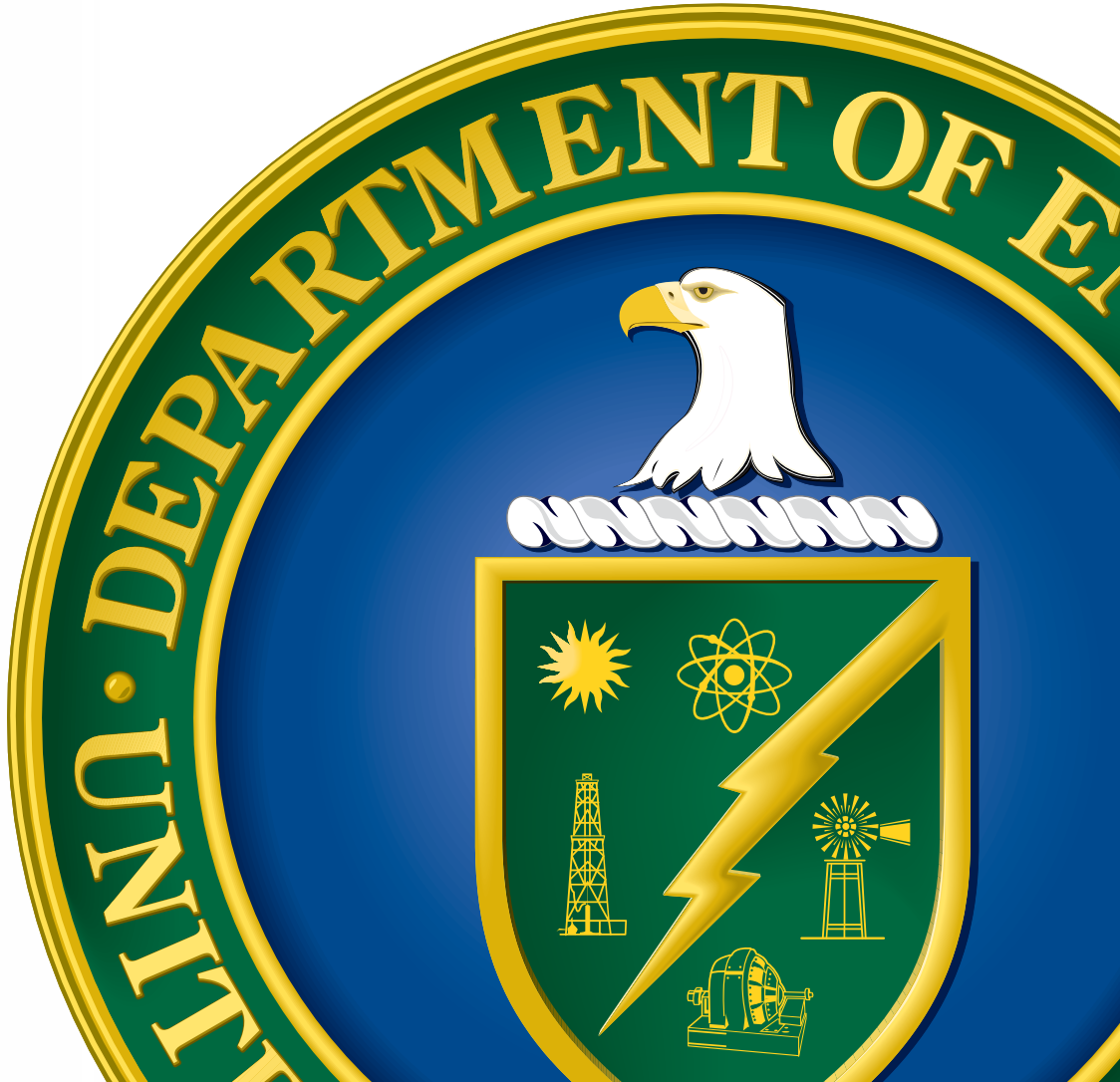
- Retrofit the City Council Building with energy efficiency HVAC and electrical equipment
- Replace 10% of the City's 40,000 streetlights with LEDs
- Install five solar thermal projects and one PV project
- Purchase 25% of all electricity needs through green sources

Better Building initiative

As of May 2021, the U.S. Department of Energy (DOE)'s Better Buildings Initiative, in collaboration with nearly 1,000 businesses, government, and other partners, saved $13.5 billion in energy costs and more than 130 million metric tons of carbon emissions in the past year—equivalent to the greenhouse gases emitted by 28.2 million vehicles in a single year. These building efficiency improvements are key to reaching President Biden's goal of net-zero carbon emissions by 2050.

- 950+ unique partners
- 2.2 QBtu energy saved
- $13.5 billion dollars saved
- 133 million avoided CO_2 Emissions (metric tons)
- 10.2 billion water savings (gallons)
- 12.5 billion square feet covered
- 3,200 industrial facilities
- $26 billion funding extended by allies

Pittsburgh, PA is a recognized partner of Better Buildings and has taken the Better Buildings Challenge.



Pittsburgh 2030 District

- The 2030 Districts are 19 cities committed to reducing building energy use, water consumption, and transportation (GHG) emissions by 50% by 2030.
- The Pittsburgh 2030 District is the largest of the 2030 Districts, covering 81 million square feet.
- All new buildings built for the 2030 district must achieve carbon neutrality, defined as no net annual production of (GHG).
- The Pittsburgh Climate Action Plan 3.0 adopted the 2030 District goals as their own objectives, specifically calling for reductions in energy, water, and transportation emissions to achieve carbon neutrality.

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Pittsburgh 2030 District

74.3%

74.3% of the City of Pittsburgh Property

81.7

81.7 Million square feet

102

Property Partners

506

506 Building committed to project

21%

Pittsburgh committed 21% of the total square footage committed in North America for the 2030 Districts project

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Beyond Traffic: Smart City Challenge

While Columbus, Ohio, won the Smart City Challenge in July 2016, Pittsburgh was awarded $10.9 million under the Fixing America's Surface Transportation (FAST) Act to create "smart spines" that will collect data through a network of sensors to help balance traffic through the city, improving regional transportation.

Plans call for development of a full range of diverse transportation elements that improve air quality, develop new manufacturing related to smart traffic signals and traffic devices, and help to facilitate electric vehicle use. Powering of the city's electric vehicles would be accomplished through locally-sourced distributed energy that would be developed under the MOU.

Combined Heat and Power Technical Assistance Partnership

NETL connected the City of Pittsburgh to the DOE/EERE Combined Heat and Power (CHP) Technical Assistance Partnership (TAP).
TAP toured and assessed three of the City's existing CHP/district heating resources:

- Duquesne University's Cogeneration Plant
- NRG's North Shore Cogeneration Plant
- (PACT) plant that provides steam to downtown Pittsburgh.

The CHP TAP team's initial analysis from the spring of 2016 was that the **City of Pittsburgh had significant opportunity to utilize existing and planned CHP for increasing the resiliency of the City's power grid**, but that economic factors (such as the current low cost of electricity) could be a challenge to expanding CHP in the City.

Duquesne University's Cogeneration Power Plant

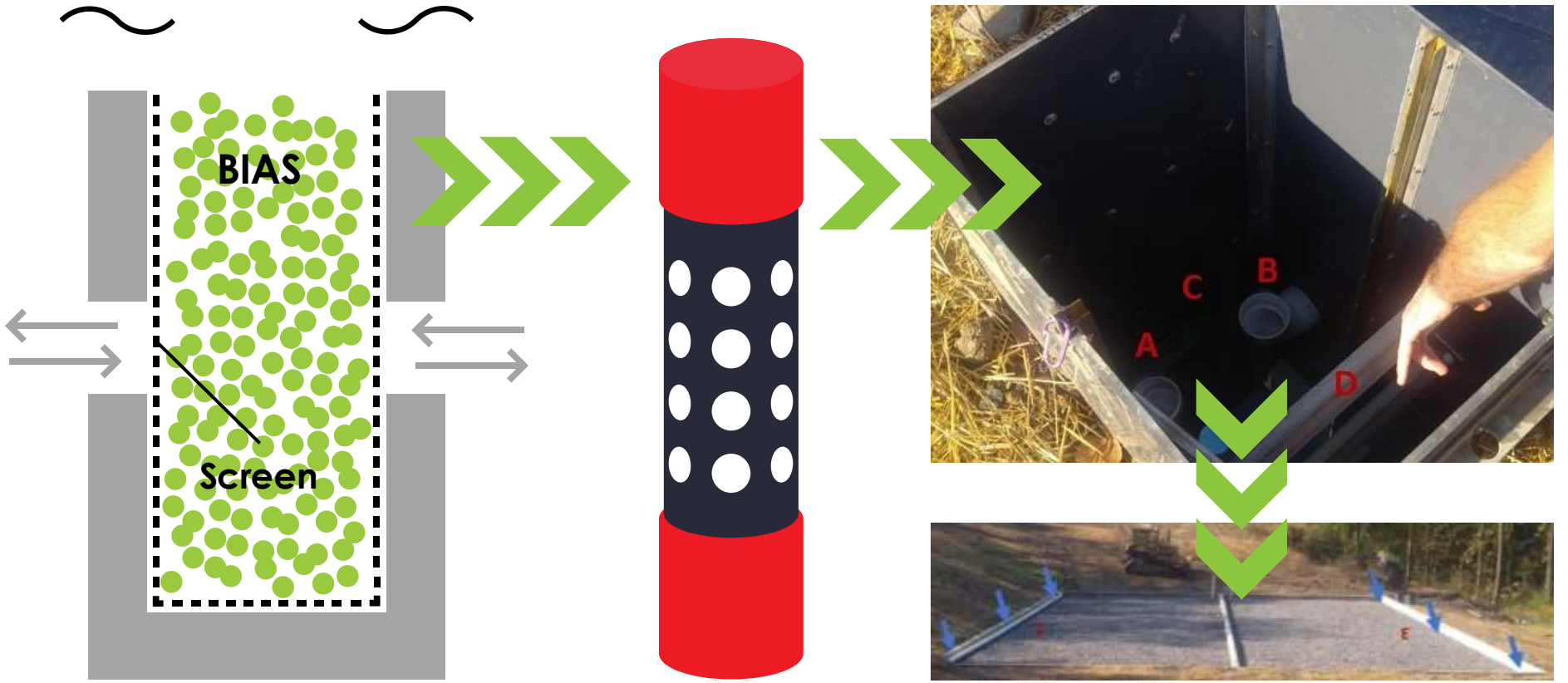
Pittsburgh Botanic Garden

Field Test at Pittsburgh Botanic Garden, formerly an Abandoned Mine

- In March 2020, NETL conducted a field test at Pittsburgh Botanic Garden that demonstrated the Lab's basic immobilized amine sorbent (BIAS) process could successfully extract rare earth elements (REEs) from acid mine drainage. The tests are expected to continue in the future.
- The research indicates BIAS could potentially provide a reliable domestic supply of critical materials needed to produce wind turbines, electric and hybrid vehicles, computer components, medical devices, smart phones, and other valuable products.
- BIAS will help create a healthier aquatic ecosystem at Pittsburgh Botanic Garden and clear the acidic water that kills aquatic life and restricts the use of these waterways as sources for public drinking water and recreation.

Pittsburgh Botanic Garden

Field Test at Pittsburgh Botanic Garden, formerly an Abandoned Mine



Reactors Placed in AMD Treatment System Inlet

AMD Enters Passive Treatment System (after REE removal)

NETL envisions that this collaboration can serve as a model for other collaborations between the Department of Energy (DOE) National Laboratories and cities.

This collaboration has received regional and national recognition for its successful collaboration between state and local economic development groups and federal laboratories for economic benefit.
Awards received by this collaboration include:

- 2018 Federal Laboratory Consortium (FLC) Mid-Atlantic Regional Award for State and Local Economic Development
- 2019 Federal Laboratory Consortium (FLC) National Award for State and Local Economic Development
- Honorable Mention in the 2019 Smart 50 Awards for Smart Cities

Local Universities

Duquesne University

University of Pittsburgh Center for Energy

Carnegie Mellon University

Government Organizations

National Energy Technology Laboratory

Hazelwood Green

Private Companies

fuelcellenergy

Clearway

DLC Duquesne Light Co.

Non-Profit Organizations

Pittsburgh 2030 District

Pittsburgh Regional Alliance

RAND Corporation


Thank You
For more information please visit
https://www.netl.doe.gov/mou