Celebrating Five Years of Collaboration with

# The City of Pittsburgh


NATIONAL ENERGY TECHNOLOGY LABORATORY


NETL and The City of Pittsburgh initiated a partnership on July 17, 2015, to transform the city's energy system and aging infrastructure by implementing a "grid of microgrids" concept that spanned nine energy districts. For five years, the City of Pittsburgh has provided an opportunity for NETL to demonstrate how advanced fossil energy technologies invented at NETL can support the safe, efficient use of energy and shape Pittsburgh into a "Clean Energy City of the Future."

To commemorate five years of collaboration, take a look inside the informative research studies, strong partnerships, innovative technologies, and a community of regional organizations that leverage each other's strengths to bring about positive change and transform Pittsburgh into a "Clean Energy City of the Future."

A Shared History

# A Shared History

## 1910
### Pittsburgh Experiment Station

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.



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

## Signatories:

- U.S. Department of Energy (DOE)
- 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 that can be replicated regionally or nationally.
- Establish guidance documents for evaluating regional energy needs and solutions.

## 1970s
### 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 early work paved the way for Marcellus Shale drilling in Western Pennslyvania that led to the nation's resurgence as an energy producer.

## 1977
### Pittsburgh Energy Technology Center

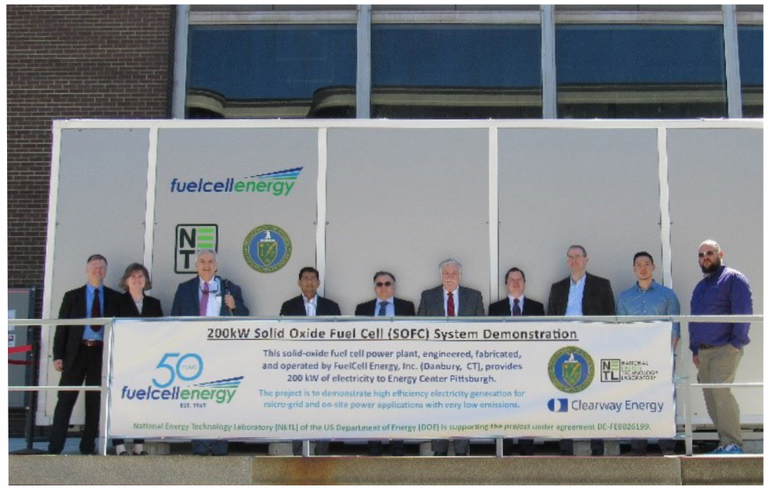
By 1977, the Department of Energy (DOE) was formed. The Pittsburgh research facilities became known as the Pittsburgh Energy Technology Center (PETC).

## Today
### Present Day & Commitment to Outreach

NETL includes facilities in Pittsburgh; Morgantown, West Virginia; and Albany, Oregon. Modern research includes supercomputers, lasers, data systems, sensors, and sophisticated information sharing processes. NETL conducts on-site school visits, hosts tours and regional Science Bowls, and conducts programs to actively encourage young people to pursue education and careers in STEM.

# Fuel Cell Energy
# **Solid Oxide Fuel Cell (SOFC)**
# at Clearway Energy Center

- A prototype 200 kW solid oxide fuel cell (SOFC) system from Fuel Cell Energy (FCE), funded by DOE/NETL, was Installed at Clearway Energy Center in July 2018 and operated over 2,500 hours between April 2019 – October 2019, using pipeline natural gas as a fuel. After the expiration of permit to operate at the Clearway Energy site in October 2019, the system was relocated to FCE's facility in Danbury, CT where it ran for an additional 2,500 hours, completing the targeted run of 5,000 hours.
- The performance of the SOFC system domenstrated the potential of the technology to deliver low-cost and efficient power generation with ultra-low emissions of pollutants.




*DOE Office of Fossil Energy (FE) officials joined NETL representatives to tour the prototype 200kW (SOFC) system in Pittsburgh's Central Business District on April 9, 2019.*

## Pittsburgh 2013 Energy Baseline

- This study focused on 2013 consumption data for the City of Pittsburgh and surrounding regions for natural gas and electricity in the residential, commercial, and industrial sectors.
- This consumption data is valuable to foster the development of systems that meet the unique needs of a metropolitan area at the lowest cost, and with the greatest impact.
- Opportunities for energy usage and emissions reductions were identified, which include home heating energy savings and improving vehicle efficiency through the electrification of light-duty municipal vehicles and city buses.

## Southpointe Business Park & City of Pittsburgh's Almono District – Case Studies in Deep Direct Use of Geothermal Energy

- NETL conducted a techno-economic study of geothermal energy extraction and use opportunities in the City of Pittsburgh's Almono District – now renamed Hazelwood Green.
- The study exclusively focused on deep direct-use (DDU) geothermal energy, which employs lower temperature geothermal resources found at depths exceeding 1,000 meters and assesses these resources for space heating.
- This study found that DDU for space heating is more expensive than heating with natural gas at today's low prices. However, DDU demonstration projects should be considered to help further mature DDU technology, which would make DDU technology an economically viable and a worthy option to consider over much of the eastern united States.

## Pittsburgh-Danish Energy Exchange

- In March 2018, the University of Pittsburgh and the Danish energy ministry signed an agreement to develop plans for implementing district energy infrastructure and smart city technologies in Pittsburgh.
- The partnership will leverage the Danish expertise in providing affordable, sustainable energy using integrated district energy systems with a focus on providing sustainable resources to underprivileged communities.
- NETL representatives helped discuss new research and approaches for helping Pittsburgh and Denmark in efforts to become global leaders in energy innovation and urban development.

# 2013 Energy Usage Analysis Overview

## Pittsburgh 2013 Energy Baseline: Consumption, Trends & Opportunities was published March 28, 2017. 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 include non-City areas
- Accounts for approximately 578,000 residents compared to City population of 300,000

**Focus on Natural Gas & Electricity Consumption**

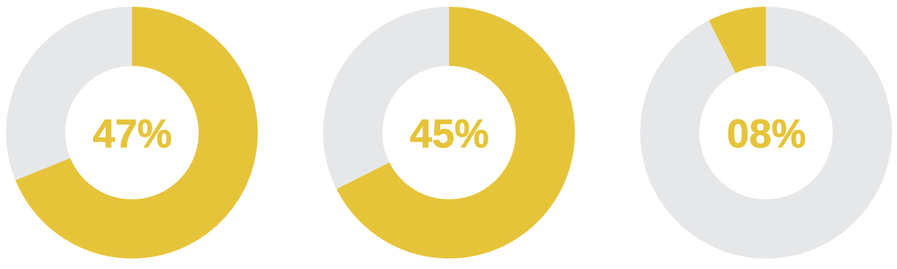
- Utilities provided zip code-level 2013 consumption data
- Broken down by sector (residential, commercial, industrial)
- Monthly electricity usage available
- Equitable Gas provided monthly data, which was extrapolated for monthly gas consumption analysis

**Transportation Fuel Consumption Estimate**

- Based on state-level data from EIA and the Commonwealth of Pennsylvania
- Used for an order of magnitude estimate only1

**Life Cycle Greenhouse Gas Emissions from Energy Usage**

### Energy Usage Breakdown




Residential Sector | Commercial Sector | Industrial Sector

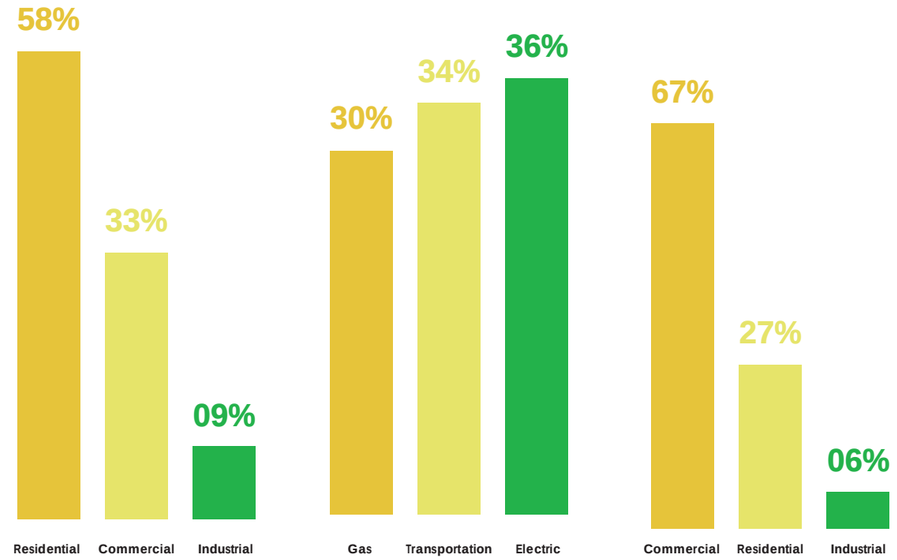


# 2013 Energy Usage Analysis Overview

## Greenhouse Gas 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 greenhouse gas (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 considering both the residential and commercial sectors.
- **The impact of electricity usage is high** despite a regional GHG emissions profile for electricity that is slightly lower than national average.

### 2013 Greenhouse Gas Emmission Breakdown




By Gas by Sector | By Fuel Type | By Electric by Sector

# Opportunities in Energy Savings

## Reduced Gas Consumption

- Clean Cities coalitions work to cut petroleum use in communities across the country.
- 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.

PITTSBURGH
REGION CLEAN CITIES

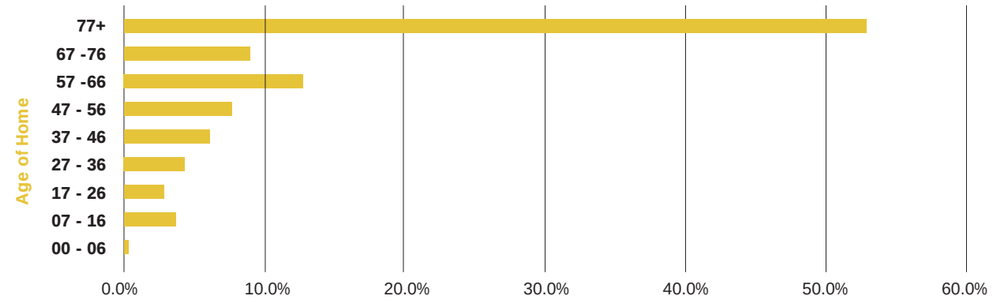


## Pittsburgh Snapshot

| | |
|---|---|
| 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/Meadian Household Income[3] | $40,009 - $60, 922 |
| Occupied Homes Using Gas as Primary Heat Fuel[3] | 81.5% |
| Estimated $CO_2$ Emmissions from Residential Gas Usage[4] | 1,341,830 Tons |

1. Population data comes from US Census Data (DP01) "Profile of General Population and Housing Characteristics" report for Pittsburgh as of 2010
2. Housing data comes from US Census Data (DP04) "Selected Housing Characteristics" report for Pittsburgh as of 2014
3. Population and income data comes from US Census Data (DP03) "Selected Economic Characteristics" report for Pittsburgh as of 2014
4. Gas $CO_2$ Emissions estimate based on life cycle analysis data from Tom Tarka (399.2 lb $CO_2$/MWh

### Distribution of Age of Homes in Pittsburgh



# Finding Pennsylvania's Solar Future

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

**Participants in the project engaged in a modeling process to envision and predict the outcomes of possible approaches of solar energy deployment.**

**The modeling process consists of three components:**

1. Regulation
2. Operations and Systems
3. 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. NETL, the City of Pittsburgh, and other local and regional partners are investigating opportunities for community solar projects.

# Goal

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

## 15 Strategies to Get to 10% of Electricity from Solar

The "Finding Pennsylvania's Solar Future" project group identified 15 strategies that, if implemented, will enable Pennsylvania to get 10% 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 to be exhaustive, and strategies can be combined to create many pathways to 10%.




### 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% 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.<br>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.<br>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. |

### Grid Scale Strategies

| | |
|---|---|
| **Long-Term Contracts** | 1. 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.<br>2. Evaluate and consider utility ownership of solar generation especially in cases where market-driven deployment may be iinsufficient to achieve public goals and/or reliability concerns. This may include solar for low income and customer assistance programs in particular. |
| **Grid Modernization** | 3. Investigate opportunities for grid modernization to enable increased solar generation. |

### 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 Ratemaking** | 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% 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 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 (compared to 100% renewables)

### Energy Systems for Neighborhoods

- A neighborhood minigrid 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 Key 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.

# Summary of Geothermal Analysis Performed

## 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

# Better Buildings 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

# 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.

**74.3%**

74.3% of the City of Pittsburgh property

**81.7**

81.7 million square feet

**102**

102 property partners

**506**

506 buildings committed to the project

**21%**

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

# 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.

Capitalizing on five existing energy districts and the city's unique geographic features, NETL is working with Pittsburgh and regional partners to create a network of small-scale distributed energy systems that supply local residents with clean, reliable and cost-effective power. Rather than relying on a centralized grid supplied by distant facilities, these systems can operate independently or in conjunction with the main electrical grid and incorporate a diverse mix of energy sources, including advanced energy technologies pioneered by NETL and other national laboratories.

Pittsburgh's focus on energy districts is based on the increasing global recognition of the value that district-scale energy systems can bring. Designing systems around the energy needs of a neighborhood or city allows developers to take advantage of local resources, infrastructure, and other regional features. While these systems may require more up-front engineering, they are highly efficient and often more cost-effective than traditional technologies. NETL's vision is to have a system of interconnected energy districts that work together to provide the City with clean energy.

### 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

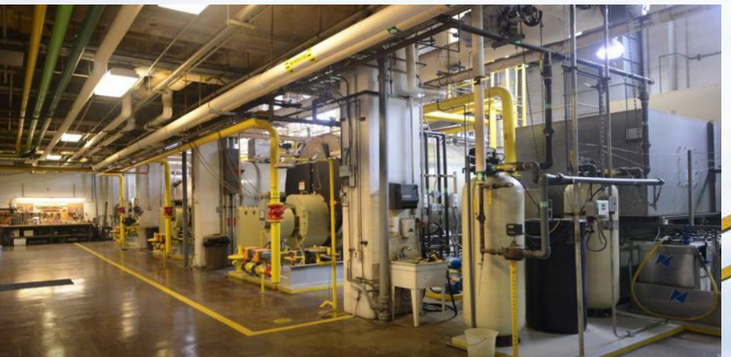
This property is a mixed-use development in Hazelwood on a 178-acre former steel mill riverfront that would be operated almost exclusively on renewable-based distributed energy.

### 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.

# 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



## Collaborators of NETL – City of Pittsburgh Partnership

**Local Universities**

- Duquesne University
- Carnegie Mellon University
- University of Pittsburgh Center for Energy

**Government Organizations**

- National Energy Technology Laboratory
- City of Pittsburgh
- Hazelwood Green

**Private Companies**

- FuelCell Energy
- Clearway
- Duquesne Light Co.

**Nonprofit Organizations**

- Pittsburgh 2030 District
- Pittsburgh Regional Alliance
- Green Building Alliance
- RAND Corporation

# 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

**Field Test at Pittsburgh Botanic Garden, formerly an Abandoned Mine**

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**Field Test at Pittsburgh Botanic Garden, formerly an Abandoned Mine**

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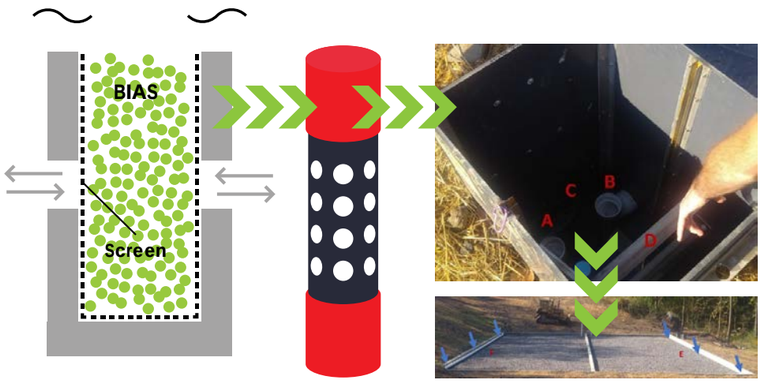


Reactors Placed in AMD Treatment System Inlet

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

FLC

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