We have the energy to make things work... for you.
Getting to know PSE&G

- 6th Highest Gas Utility in US sales
- Serves 10 of the top 15 cities in NJ
- ~2,400 employees
- 12 District Headquarters
- 17,955 miles of gas distribution main
- 57 miles of gas transmission main
- 1.2 million gas services
- 1.8 million gas customers
- Sales volume growth: 1% per year
What is the Gas System Modernization Program (GSMP)?

- Accelerated cast iron and unprotected steel main and service replacement program
- Upgrades legacy low (utilization) pressure systems to medium pressure
- Relocates inside meter sets to outside
- Installs excess flow valve (EFV) safety devices
- Supports DOT focus on replacing the highest risk, most leak prone facilities

Continued replacement at these levels would replace/rehabilitate all the cast iron and unprotected steel by 2040
Gas System Modernization Program

- PSE&G currently operates and maintains over 3,900 miles of cast iron and unprotected steel gas distribution main.
- The program provides for investment and clause recovery of Utilization Pressure Cast Iron (UPCI) and Unprotected Steel replacement main, services, and associated uprating of plastic and protected steel in targeted areas
  - GSMP I started in 2016 (3 year term - $900M)
  - GSMP II started in 2019 (5 year term – $1.9B)
- Stipulated Base CapEx spend requirement associated with the program approval
  - Includes High Pressure Cast Iron (HPCI), UPCI, unprotected steel main and service replacement
  - Includes program and stipulated base inside meter set relocations
- Total ~170 miles of main replacement per year in Program and Stipulated Base
- The first two approvals are the beginning phases of a long-term 25 year replacement strategy for cast iron and unprotected steel mains
- Benefits:
  - Methane emission reduction is estimated at 30,000 metric tons of CO2 equivalent per year*
  - Medium pressure system allows usage of high efficiency appliances by customers
  - Includes installation of excess flow valve safety devices where applicable

* EPA SUBPART W METHODOLOGY.
The replacement of mains in the Program shall follow the prioritization based on the grid based Leak Hazard Indices developed by PSE&G using its Hazard Assessment model.

“...Recognizing that considering methane emission flow volume (i.e., emission size) as part of prioritization will reduce the amount of natural gas lost from emissions to the benefit of customers, and reduce the environmental impacts of such emissions, the Signatories agree that for grids with comparable Hazard Index/Mile, available methane emissions survey data estimating flow volumes, as prepared by the Environmental Defense Fund using Program plans, system information and maps provided by PSE&G, will be used, as appropriate, in sub-prioritizing replacement activities...”
Accelerated UP Cast Iron (UPCI) Replacement

• **Goal** - Replace priority areas most efficiently
  • Highest potential hazard
  • Contiguous area for construction efficiency

• **Map grid system utilized**
  • 1 square mile area
  • 1 – 20 miles of low pressure cast iron per grid
  • Similar environmental conditions
PSE&G Grid Mapping System
Prioritization of UPCI Replacement Main

- Hazard Index (HI) rankings used to express and compare relative hazard for main segments having a history of breaks.

- Factors used in the calculation
  - Hazard Index = Weighted Break History (WBH) x Environmental Index (E)
  - WBH = The sum of the factors multiplied by the number of annual break repairs for each period (factors higher for recent breaks)
  - Environmental Index evaluates the environmental conditions at the main segment location that may affect the relative hazard of a break and is based upon the following factors:
    - Building Density
    - Operating Pressure
    - Building Occupancy
    - Underground Utility
    - Building Set-back
    - Nominal Pipe Size

- Mileage is based upon total low pressure cast iron mileage in grid
Prioritization of UPCI Replacement Main (cont’d)

- Mains with break history - Hazard Index

- Individual segments within a grid are summed to obtain total hazard index for the grid

- Miles of UPCI main in grid are summed

- Hazard score divided by miles gives HI/Mi score

- Map Grids ranked by HI/Mi
Grid 2L-57 (Rank 2)
UP CI = 3.8 miles
HI/MI = 45.4
## Hazard Index – Grid 2L - 57

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<tr>
<th>District</th>
<th>Street</th>
<th>Municipality</th>
<th>Install Year</th>
<th>Main Size</th>
<th>Main Type</th>
<th>Pressure</th>
<th>Segment Length</th>
<th>B</th>
<th>P</th>
<th>O</th>
<th>U</th>
<th>S</th>
<th>Last Repair Date</th>
<th>Number of Breaks</th>
<th>WBH</th>
<th>BPOU/S</th>
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<td>1.3807</td>
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| Total Hazard Score | 170.1051 |
| Total CI Miles in Grid | 3.75    |
| Hazard Index Per Mile | 45.36   |
## Top 20 Hazard Index/Mile

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<th>HAZARD INDEX</th>
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</table>
Methane as a Greenhouse Gas

- Methane has 84 times the warming effect of carbon dioxide over a 20 year period.

- EDF estimates that about 25% of the manmade global warming we’re experiencing today is caused by methane emissions.

**Typical Composition of Natural Gas**

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<thead>
<tr>
<th>Component</th>
<th>Symbol</th>
<th>Percentage</th>
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<td>CH₄</td>
<td>70-90%</td>
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<tr>
<td>Ethane</td>
<td>C₂H₆</td>
<td>0-20%</td>
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<td>Propane</td>
<td>C₃H₈</td>
<td>0-5%</td>
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<td>Butane</td>
<td>C₄H₁₀</td>
<td>0-8%</td>
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<tr>
<td>Carbon Dioxide</td>
<td>CO₂</td>
<td>0-5%</td>
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<td>Oxygen</td>
<td>O₂</td>
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<td>Nitrogen</td>
<td>N₂</td>
<td>0-3%</td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>H₂S</td>
<td>0-5%</td>
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<tr>
<td>Rare gases</td>
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<td>trace</td>
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</table>

**GLOBAL MONTHLY MEAN CH₄**

![Graph showing global monthly mean CH₄ levels from 1980 to 2020](image)
Working with the EDF

- In advance of GSMP I, PSE&G engaged the Environmental Defense Fund (EDF) to quantify methane emissions in our service territory to consider in the prioritization of the work
- Mapping was performed over a six month period
- Study was done at no cost to PSE&G
- PSE&G followed the EDF equipment with its own optical methane leakmobile to compare data
The EDF partnered with Google and Colorado State University on a nationwide program to detect and map methane leaks from natural gas distribution systems.

A Google street-view car, equipped with state of the art methane and meteorological sensors, was driven repeatedly along streets with natural gas pipelines to map emissions.

Urban areas have been mapped across the country (Birmingham, Boston, Burlington, Chicago, Dallas, Indianapolis, Jacksonville, Los Angeles, Mesa, Pittsburgh, Staten Island, and Syracuse).

The same technology used to map these cities was also used for the PSE&G project.
What Technology Was Used?

• Advanced GPS technology and anemometer
• Open path, Cavity Ring-Down Spectroscopy (CRDS)
• LiCor analyzer

• High data collection rate
• No pumps (closed path CRDS)
• The longer the laser path, the better the sensitivity in detecting molecular signatures
• Equipment uses a series of mirrors within the sample cavity to reflect the laser path from a distance of 25 cm to over 20 km
Methane Quantification Data

- Different gases absorb light (laser) at specific rates
- Normal atmospheric air has a certain decay pattern as the laser fades inside the sample chamber (blue graph)
- When a gas like methane is in the sample, it absorbs light at a different decay rate than the control (green graph)
- The laser wavelength and difference in decay rates is used to quantify methane by analyzing the sample data stream through a series of algorithms
- Wind and precipitation are factors in sampling

Fig 1. Ring Down Graph. Adapted from Picarro. Retrieved from Picarro.com
Readings vs Indications

Overlap of UPCI Pipes and Observed Data from EDF Methane Mapping

New Jersey: Observed Readings
Clustering of readings that contribute to one verified leak of the following size:
- Yellow: 700 to 9,000 liters/day
- Orange: 9,000 to 60,000 liters/day
- Red: More than 60,000 liters/day

- PSEG UPCI Pipes
- PSEG Map Grid

Overlap of UPCI Pipes and Verified Leaks from EDF Methane Mapping

New Jersey: Verified Leaks
- Yellow: 700 to 9,000 liters/day
- Orange: 9,000 to 60,000 liters/day
- Red: More than 60,000 liters/day

- Estimated Total Flow Rate: 119 (+/- 15%) L/min
- Number of Verified Leaks: 24
- Miles of UPCI: 3.4 miles
- Flow Rate/Mile UPCI: 34.8 (+/- 4.3) L/min/mile
- Rank: 4
  * Represents 95% confidence of true leak rate

These maps only show readings that potentially overlap with utility UPCI pipes. Other recorded EDF data is not represented.
Using the Results in GSMP I

- Hazard Index per Mile (HI/Mi) still primary risk ranking tool

- Any grid with HI/Mi > 25 is highest priority

- Where HI/Mi is comparable (< 25), EDF data used to help sub-prioritize by leak rate of liters per minute per mile of UPCI pipe in the grid (L/Min/Mi)
  - Grids with outlying leak rates of >10 L/Min/Mi take highest priority
  - Grids with leak rates of <10 L/Min/Mi as well as non-surveyed grids take secondary priority

- Grids are evaluated for construction efficiencies and logistics as well as permitting and municipality conflicts prior to setting the final prioritization

- Results reviewed with EDF and submitted to the NJ Board of Public Utilities
Reduction in Emissions

- Outlier grids (>10 L/min/mi) were looked to be moved up in schedule where possible.

- Mains retired earlier than originally planned stop emitting methane faster.

- By accelerating high emissions grids, PSE&G was able to reduce total grid emissions by 83% early in the program.

- To achieve the same emissions reductions, 35% less main abandonments were needed vs if PSE&G followed strictly by hazard ranking.

- The accelerated grids the company prioritized for upgrades accounted for more than 37% of the emissions but only 9% of the mileage on which leak rates were measured.
Continuing the Program into GSMP II

• GSMP II filed in 2017 and approved in Spring 2018 as a five year extension

• Hazard Index and methane mapping to be used again to prioritize grids

• Picarro was chosen to map 44 “B Grids” of similar HI/mi that covered the 280 miles agreed to in the stipulation
Reduction in Risk and Methane Mapping

Low Pressure Cast Iron Main Grids

- **PRIORITY A**
  - Mar-15
  - Miles 467, Grids 80
  - Feb-17 + GSMP Forecast
  - Miles 143, Grids 27

- **PRIORITY B**
  - Mar-15
  - Miles 625, Grids 98
  - Feb-17 + GSMP Forecast
  - Miles 466, Grids 66

- **PRIORITY C**
  - Mar-15
  - Miles 1324, Grids 160
  - Feb-17 + GSMP Forecast
  - Miles 1366, Grids 170

- **PRIORITY D**
  - Mar-15
  - Miles 1072, Grids 177
  - Feb 17+ GSMP Forecast
  - Miles 918, Grids 169

- Mar-15
  - Miles 3,487 Miles 515 Grids

- Feb-17 + GSMP Forecast
  - 2,897 Miles 434 Grids

Continuous to address the highest hazard main segments
Methane Quantification Survey

- Areas require 3 passes on each side of the street for proper sampling (95% statistical confidence interval)

- Indications are run through an algorithm with wind, vehicle speed, ethane content and other factors, leak rates are determined

- Heat maps can show areas of high emissions and calculated leak rates
Using GSMP II Results

- Discussion with EDF after data collected to set prioritization
- Threshold of 4.5 L/min/mi used for accelerating grids that were surveyed (down from 10 L/min/mi in GSMP I)
- 6 grids accelerated
- If retired sooner than “as is” plan, they account for 41% of the methane loss in only 16% of the grids surveyed
- Construction beginning in Spring of 2019
Key Takeaways

- Hazard Ranking and safety are highest priority
  - Hazard Rank and Leak Volume do not necessarily correlate

- Methane Emissions sub prioritization useful for areas of relatively equal hazard
  - Better for the environment
  - Less chance of non-hazardous leaks getting worse
  - Fewer potential customer calls/complaints

- Other LDC’s and PUC’s continue to discuss best applications for the technology's use
Questions?