

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
NEW YORK DIVISION**

RESEARCH, DEVELOPMENT & DEMONSTRATION (“RD&D”) PROGRAM

THREE-YEAR RD&D FORECAST

October 2021 – September 2024

April 1, 2022

Submitted to:

Kathleen H. Burgess, Secretary
State of New York Public Service Commission
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FOREWORD

The New York State Public Service Commission (“NYSPSC”), while streamlining the former annual reporting of five-year plans, ordered gas utilities to provide the Commission with a three-year research, development and demonstration (“RD&D”) forecast in Case 98-G-1304. The first report was filed on April 1, 2001, with the forecast to be updated every three years thereafter.

Accordingly, the material included in this document has been prepared by National Fuel Gas Distribution Corporation (“NFGDC” or the “Company”) to comply with the above order, and is to be considered as an update of the three-year forecast submitted to the Commission on March 31, 2022. This forecast covers the period October 1, 2021 through September 30, 2024.

I. Introduction

NFGDC, a wholly-owned subsidiary of National Fuel Gas Company, sells or transports natural gas to approximately 750,000 customers in western New York and northwest Pennsylvania. The Company's service territory includes the cities of Buffalo, Niagara Falls and Jamestown in New York, and Erie and Sharon in Pennsylvania.

The Company's Research, Development and Demonstration ("RD&D") Program detailed in this RD&D forecast is based on the goals and objectives of NFGDC. NFGDC continues to remain focused on customer service and the safe and efficient delivery of natural gas, while continuing to explore energy efficient and low emissions natural gas technologies. The RD&D Program funds the development, field testing, and demonstration of technologies, with the prospect of improving utility operations and increasing customers' choices of technologies. This may result in reduced costs, increased work management, greater reliability, reduced emissions, etc., for NFGDC's customers.

II. RD&D Program Overview

A. Goals and Objectives

The goals of the RD&D Program are to identify emerging technologies of benefit to NFGDC and its customers, fund developments through co-funded gas industry RD&D organizations and manufacturers, demonstrate appropriate technologies in the Company's service territory, and disseminate information to customers who could potentially benefit from the technologies. For technology demonstration projects, NFGDC seeks to have the technologies located at host sites with vested interests in the success of the technologies.

NFGDC does not internally conduct research and development. However, the Company does provide funding for external RD&D initiatives in concert with other gas industry, manufacturing, energy/environmental authorities, and other participants.

The primary purpose of the RD&D Program is the identification, development, introduction and demonstration of new technologies, equipment and processes which feature increased efficiency and improved performance (either in the residential, commercial and industrial end use market segments or in distribution operations). The main emphasis of the RD&D Program is on:

- Providing customers with a greater selection of energy-efficient, low-emissions technologies
- Remaining competitive with other energy technologies, while continuing to measure and advocate the positive environmental attributes of natural gas
- Reduction of fixed operating costs
- Improved gas load factors for greater seasonal utilization of gas facilities
- Increased safety and efficiency in delivering natural gas
- Increased customer benefits

B. Program Areas

NFGDC's RD&D Program in New York State consists of the ***Traditional RD&D Program*** funded through base rates and the ***Millennium Funds RD&D Program*** which is funded by a surcharge included in the Delivery Adjustment Charge, and is collected from New York ratepayers.

1. TRADITIONAL RD&D PROGRAM

The expenses of the Traditional RD&D Program are shared between New York and Pennsylvania to encompass NFGDC's service territory in both jurisdictions. The costs are allocated based upon Section D of this report. The Traditional RD&D Program addresses technology segments for residential, commercial and industrial end-use markets, and for Company operations technologies.

Internal RD&D – Internal RD&D Program addresses technologies nearing commercialization and consists of conducting technology demonstration projects, technology assessments, and technology transfer. Demonstration projects are initiated, implemented, and managed by NFGDC personnel. Technologies

demonstrated include new/emerging natural gas equipment, or other technologies not in significant use in the Company's service territory. These internal activities are supplemented by external research. External contract research is selectively funded under the Traditional RD&D Program, generally through leveraged Northeast Gas Association Research Committee ("NYSEARCH") activities.

a. Project Types

The Internal RD&D Program is divided into the following 3 areas:

- **End Use** – Projects in the residential, commercial and industrial market segments, featuring new and emerging technologies.
- **Operations** – Projects pertaining to NFGDC's gas infrastructure, including: reliability, work management, safety and the environment. Since the advent of Millennium Funds, that program has been funding the bulk of the qualified Operations projects.
- **Other** – Funding set aside to cover technology assessment, technology transfer and general administrative expenses of the RD&D Program.

As part of the Internal RD&D technology transfer function, support is provided to the:

- **Energy Solutions Center ("ESC")** – This organization consists of gas industry technical/marketing professionals and energy equipment manufacturers. The ESC gathers information on new efficient gas equipment performance and benefits and works with manufacturers to make the market aware of offerings. The ESC coordinates a number of equipment and industry consortia on behalf of the gas industry.

b. Project Management

The RD&D Program is managed through the Energy Services Department. The designated project manager, who may possess specific skills or interests in the technology, manages traditional internal projects.

Projects may originate from various internal and external sources and may consist of domestic or international technologies. Upon identifying a technology worthy of supporting, its potential benefits are evaluated. The impact of technologies can vary widely depending upon differing regional needs. Information is gathered and presented for approvals. Before funds and other resources are committed, approvals are received with permission to charge expenses. An example of the RD&D project approval form used for this purpose is provided in Appendix A. Each approved project is planned to include scope, budget, schedule and goals. At the completion of the project, the results are gathered and reported.

External RD&D – The internal activities are supplemented by external research. This consists of projects and programs funded under the Traditional RD&D Program. These external projects are managed by professional organizations experienced in RD&D and in the commercialization of natural gas and/or energy technologies.

The External RD&D Program supports funding for the following organizations:

- **New York State Energy Research and Development Authority (“NYSERDA”)** - NFGDC is a source of funding to NYSERDA through a mandatory assessment. The NYSERDA assessment is the largest single component of the Company’s Traditional RD&D Program
- **NYSEARCH** – NFGDC funds end-use and/or operations projects, on a voluntary basis, by participating in NYSEARCH. NFGDC selectively initiates or contributes to technology development projects managed by NYSEARCH, and receives project reports and other information. NYSEARCH leverages the resources of its membership, by contracting for applied research to be performed by qualified organizations.

Descriptions of projects in the Traditional RD&D Program are contained in the Project Summaries section of this report (Appendix B).

2. MILLENNIUM FUNDS RD&D PROGRAM

- a. **Background** - The Millennium Funds RD&D Program at NFGDC was established during the transition from the mandatory Gas Research Institute (“GRI”) Program under Federal Energy Regulatory Commission (“FERC”) jurisdiction, which began in 2000.⁽¹⁾ As GRI funding was reduced over a five-year period to zero, the NYSPSC allowed for collections (up to the difference of the previous New York State share of federal assessments) to fund RD&D in New York State. The initial NYSPSC Order essentially limited expenditures to Company operations technologies, with opportunities to petition for special consideration of natural gas appliance and/or supply and storage research. A subsequent NYSPSC Order allowed funding for natural gas appliance application research and approved end-use energy efficiency programs.⁽²⁾

Footnotes:

1. PSC Order establishing the Millennium Funds Program, Case 99-G-1369.
2. PSC Order allowing end-use energy efficiency programs, Case No. 04-G-1047, and Joint Proposal dated July 22, 2005.

- b. **Supported Programs** - Millennium funding is provided to NYSEARCH on a project-by-project basis, to arrange for research on behalf of the New York State gas industry. NYSEARCH efforts allow for funding to be leveraged with other participants, which further allows the industry to undertake new technology developments that could not be individually undertaken alone.
- c. **North American Heat Pump Collaborative** – Millennium funding is provided to a membership-based collaborative to accelerate the commercialization and market acceptance of gas heat pumps in North America. The goal of the collaborative is to enhance market share of gas heat pump technologies and energy efficient gas technologies.

Millennium funding is also used to support the following programs offered through the Gas Technology Institute (“GTI”):

- **Utilization Technology Development (“UTD”)** – UTD is involved in the research and development of natural gas utilization, including: residential and commercial appliances, industrial process, distributed generation, and natural gas vehicles. The program strives to meet critical energy demands in the United States by providing efficient, safe, economical and environmentally acceptable uses of natural gas to the benefit of the public.
- **Emerging Technology Program (“ETP”)** – NFGDC funding for this program is included within UTD. ETP is a new initiative by GTI, created in 2012, to address issues related to better moving technologies from development to commercialization. In spite of many attractive technology developments after gas industry RD&D restructuring, much of the former effective infrastructure and staffing (in moving those technologies to market) no longer exist. ETP is an effort to attempt to re-establish that necessary function.
- **Operations Technology Development (“OTD”)** - OTD develops, tests, and implements new technologies, to provide solutions relating to gas operations and its infrastructure. It is designed to provide new tools, equipment, software, processes, or procedures that will enhance safety, increase operating efficiency, reduce operating costs, and help maintain system reliability and integrity. The scope of the program includes near-term to mid-term developments.
- **Sustaining Membership Program (“SMP”)** – NFGDC funding for this program is included within OTD. The SMP strives to develop new and innovative technology concepts, which aim to address current needs, and may potentially reduce the cost of transmission, distribution and environmental operations for member companies. The SMP addresses mid-term to long-term developments.

- **Low-Carbon Resources Initiative** (“LCRI”) – LCRI is an effort lead by the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) to collaborate on addressing the need to accelerate development and demonstration of low carbon energy technologies.

In addition, funding is provided by the RD&D Program to GTI, for Special Projects. NFGDC also reimburses for field support, testing and demonstration of new Company operations technologies, provided as “in-kind” services to NYSEARCH.

Working with these organizations gives the Company access to newly emerging technologies, which may be incorporated into the technology assessment and/or the technology demonstration elements of the Traditional RD&D Program.

Funding levels for the above programs, including funding levels by project, appear in Appendices D, E, F and G of this report.

C. Program Management

The Energy Services Department is responsible for the overall administration of NFGDC’s RD&D Program, managing the end-use demonstration projects of the Traditional RD&D Program, and managing the end-use RD&D activities within the Millennium Funds RD&D Program. The Mechanical Department is responsible for managing the Company’s operations projects within the Traditional RD&D Program, and within the Millennium Funds RD&D Program.

The Energy Services Department and the Mechanical Department use existing department personnel to manage RD&D projects, but occasionally use personnel “on loan” from other departments as project managers, as needed. From time to time, NFGDC may also assign personnel to an external project of NYSEARCH or GTI, where some special interest and expertise exists within the Company.

The following individuals are assigned to managing Internal RD&D projects on a part-time basis:

- Erik M. Solomon Area Manager, Energy Services Department
- Dale J. Halvarson Superintendent, Operations Department
- Robert D. Plewa Jr. Superintendent, Mechanical Department

The following personnel also serve on the indicated gas industry External RD&D committees and boards:

- Erik M. Solomon Utilization Technology Development (UTD);

Program Technical Project Committee (TPC);
Emerging Technology Program (ETP); and
Energy Solutions Center Board of Directors.

- Dale J. Halvarson Operations Technology Development (OTD) Program, including the Sustaining Membership Program.
- Robert D. Plewa Jr. NYSEARCH Research Committee.
- Robert D. Eck Utilization Technology Development (UTD) Board of Directors.
- Kevin D. House Operations Technology Development (OTD) Board of Directors

Involvement in these committees and boards provides input on direction, and forums to make suggestions on the development of beneficial new technologies. It further allows for early assessments of the impact of emerging technologies on the Company's market.

D. Program Cost Allocations and Expenditures

Total RD&D expenditures for both the Traditional RD&D Program and the Millennium Funds RD&D Program are collected in undistributed ledger accounts. NFGDC functionally treats the Traditional RD&D Program as a company-wide program, without regard to state. However, expenses are shared through the allocation percentages shown below. The allocations between New York and Pennsylvania are calculated based upon the relative percentages of throughput (measured in Mcf) for each category. The allocations are determined using the forecasted throughput information for fiscal year 2022. These allocations may change slightly from year to year, as throughput proportions change.

Accounts are in place, as shown below, to track costs for Traditional RD&D Program internal costs, Traditional RD&D Program external costs, and for Millennium Funds RD&D Programs. Expenditures for fiscal year 2022 will be allocated as follows:

I. Traditional RD&D Programs

A Internal

<u>Account</u>	<u>Program</u>	<u>% NY</u>	<u>% PA</u>
188001	Residential	73	27
188002	Commercial	72	28
188006	Industrial	47	53
188005	Operations	72	28
188007	Technology Transfer	70	30
188008	Technology Assessment	72	28
188009	General Administration	70	30

B External

<u>Account</u>	<u>Program</u>	<u>% NY</u>	<u>% PA</u>
188003	NYSERDA	100	0
188004	NYSEARCH	100	0

II. Millennium Funds

<u>Account</u>	<u>Program</u>	<u>% NY</u>	<u>% PA</u>
188050	Millennium Funds	100	0

Appendix C contains budgetary information and actual expenses for fiscal year 2021. Appendix D contains a forecast for fiscal years 2022-2024, for the Traditional RD&D Program.

Appendix A

TRADITIONAL RD&D PROGRAM

Example Project Approval Form

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM**

REQUEST FOR PROJECT APPROVAL

Project Name: _____

I. Program Area

Program Administration
 Research/Development

Field Test/Demonstration

II. Project Type

Residential End Use
 Commercial End Use
 Industrial End Use
 Company Operations

Technology Transfer
 Technology Assessment
 General Administration

III. Project Objective

IV. Project Description

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM**

REQUEST FOR PROJECT APPROVAL

V. Expected Project Benefits

A. General Benefits

NFGDC & RATEPAYERS

- ___ New Incremental Load
- ___ Retained Load
- ___ Load Factor Improvement
- ___ Cost Reduction
- ___ Firmed Load
- ___ Improved Productivity
- ___ Risk Reduction
(Health, Safety, Environ-
ment, Etc.)
- ___ Royalties/Equity
- ___ Other, Specify:

PARTICIPANTS

- ___ Cost Reduction
- ___ Improved Productivity
- ___ Risk Reduction
(Health, Safety Environ-
ment, Energy, Etc.)
- ___ Increased Quality
- ___ Increased Control
- ___ Other, Specify:

SOCIETY

- ___ Environment
- ___ Energy Security
- ___ Employment/Retainment
- ___ Risk Reduction
(Health, Safety, Etc.)
- ___ Other, Specify:

B. Expected Quantifiable Benefits to Company

Annual Load Gain (Loss) : _____ Mcf

Annual Cost Savings to Company : \$ _____

Annual Revenues:

	___ Gas Sales Margin	\$ _____
	___ Equity in a company	\$ _____
	___ Equity in a product	\$ _____
	___ Commissions	\$ _____
	___ Royalties	\$ _____
	___ Other	\$ _____

Total Revenues: \$ _____

Total Project Costs : \$ _____

Simple Payback Period : _____ Years

Future Market Potential

- Market segment (SIC) : _____
- # of Customers : _____
- Annual Volume : _____ Mcf
- Annual Margin : \$ _____

C. Expected Non-Quantifiable Benefits to Company

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM**

REQUEST FOR PROJECT APPROVAL

VI. Project Schedule

START : _____ / _____ / _____

COMPLETION : _____ / _____ / _____

VII. Project Budget

Activity	FY 2022	FY 2023	FY 2024	TOTAL
Total				

VIII. Project Administration

Project Request Originator : _____

Department : _____

Project Manager : _____

Department : _____

IX. Project Approval

Recommended: _____ Date _____

Reviewed : _____ Date _____

Approved : _____ Date _____
Executive

Appendix B

TRADITIONAL RD&D PROGRAM

Project Summaries

A. End Use

1. Residential

- Zero Net Energy (“ZNE”) Home Demonstration Project
- MyHEAT Pilot
- Hybrid Heating System Demonstrations
- GTI Hybrid Heating Systems Controls Pilot
- BlocPower Hybrid Heating Pilot

2. Commercial

- Compressed Natural Gas (“CNG”) Demonstration Vehicle
- Botanical Gardens Geothermal Study

3. Industrial

- Hydrogen Blending Demo

B. Operations

- Renewable Natural Gas (“RNG”)
- Mobile Vacuum Trailer Demonstration

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Zero Net Energy (“ZNE”) Home Demonstration Project

Project Type: Residential End Use

Objective: This project is designed to demonstrate the benefits of using high-efficiency natural gas equipment (heating, water heating, etc.) in conjunction with solar photovoltaic (“PV”) panels to reach a ZNE or “near-ZNE” rating, yield lower equipment first costs, and lower operating costs vs. similar all-electric options. A ZNE rating would be achieved by generating more electric power from the PV panels than the combined use of natural gas and electricity in the home over the course of 12 months.

Description: The demonstration project includes a partnership with Niagara Habitat for Humanity to cover the cost of energy analysis and optimizing building design, cover incremental building costs to meet ZNE or “near-ZNE” ratings, and provide for on-going monitoring of home performance (on a rehabilitation of an existing home and a new build in Niagara Falls, New York). A contract was executed with C.J. Brown Energy & Engineering, P.C. to administer the project, including energy analysis, optimizing the building design, and monitoring the performance of the homes with respect to a ZNE rating over a 5 year period.

Expected Benefits: This project hopes to demonstrate the ability to reach a ZNE rating, using energy efficient building practices along with high efficiency natural gas appliances, while identifying the incremental costs associated with designing and meeting ZNE ratings in an existing home.

Project Schedule: The demonstration projects are currently expected to be completed in 2020, at which point continuation of monitoring performance will continue for 5 years.

Project Expenses:

<u>FY 22</u> ■	<u>FY 23</u> ■	<u>FY 24</u> ■
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Project Status: On-going

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: MyHEAT Imagery Inc.

Project Type: Residential End Use

Objective: The objective of the project is to reduce energy demand among residential customers through behavioral and data-driven approaches. The project will collect aerial thermal data for the selected geographic area, processing thermal data and merging with ancillary datasets. Design of a personalized engagement campaign that will allow for robust evaluation. Lastly, provide project evaluations and verification of measured savings.

Description: A flyover of the specified geographic area(s) will be completed to collect the thermal data required to generate HEAT Maps and HEAT Ratings. Additional geospatial datasets, such as building shapes and customer address details, will also be compiled at this time. After combining relevant data from National Fuel and other external sources with the collected thermal data, MyHEAT will generate HEAT Maps and HEAT Ratings. Simultaneously, MyHEAT will work with National Fuel to design a unique customer-facing platform. Further, the project will identify target customers for engagement based on several factors including HEAT Ratings, consumption, and potentially stage of participation in efficiency programs.

Expected Benefits: MyHEAT will implement an engagement campaign that will periodically engage customers through the program by mail and email. Following the completion of the engagement campaign, the evaluation team will analyze consumption data pre- and post-intervention. The outcome will be a comparison of the reduction in consumption from customers receiving heat loss details to the control group.

Project Schedule: The project began in 2020, at which point continuation of future phases will be monitored.

Project Expenses:

<u>FY 22</u> ■	<u>FY 23</u> ■	<u>FY 24</u> ■
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Project Status: On-going

Project Manager: Ashley Butera

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Hybrid Heating System Demonstrations

Project Type: Residential End Use

Objective: The purpose of the hybrid gas and electric air source heat pump (ASHP) project is to analyze the performance data of installation packages that consist of a high efficiency electric ASHP in combination with a high efficiency gas furnace and tankless water heater. The ASHP supplies heat when the outside ambient temperature is above a set point temperature, and when the outside ambient temperature falls below the set point temperature the high efficiency natural gas furnace supplies heat.

Description: NFG is conducting a study to determine the monthly energy cost and usage changes, as well as the associated GHG emissions, associated with utilizing an ASHP in combination with a high efficiency furnace for heating (and cooling), as compared to a traditional furnace only and central A/C.

Expected Benefits: The result is to determine a cost-effective option to lower overall customer emissions. National Fuel will use this data to improve our existing enhanced rebate on a high efficiency furnace which is combined with an electric air source heat pump (ASHP) through our Conservation Incentive Program.

Project Schedule: The hybrid systems were installed throughout the 2020-2021 and 2021-2022 heating season, at which point continuation of monitoring performance will continue for 3 years.

Project Expenses:

FY 22	FY 23	FY 24
████████	████████	████████

Project Status: On-going

Project Manager: Ashley Butera

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: GTI Hybrid Heating System Controls Pilot

Project Type: Residential End Use

Objective: Demonstrate the Gas Technology Institutes' (GTI) Smart Hybrid Controller + Storage solution on several hybrid HVAC systems in National Fuel's service territory. The proposed demonstration may include a storage / backup technology for resilience.

Description: NFG and GTI will install the Smart Hybrid Controller & Storage solution on new customer hybrid heating demonstrations or leverage our existing demonstrations of hybrid heating systems deployed in NY. GTI will conduct a study to determine the monthly energy cost and usage changes, as well as the GHG emissions, associated with a utilizing the Smart Hybrid Controller & Storage, as compared to our existing hybrid heating installations.

Expected Benefits: The result is to determine a cost-effective option to lower overall customer emissions by installing a smart device to lower emissions associated with the source of energy utilized by the appliance.

Project Schedule: The demonstrations are planned to begin in the Fall/Winter of 2022.

Project Expenses:

FY 22	FY 23	FY 24
■	■	■

Project Status: Planning

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: BlocPower Hybrid Heating Pilot

Project Type: Residential End Use

Objective: The purpose of the BlocPower Hybrid Heating Pilot is to provide a low carbon solution prioritizing low and moderate-income communities. The focus is on natural gas and electric hybrid heat pump solutions that shift some heating to electric air source heat pumps while leveraging natural gas furnaces in very cold conditions.

Description: NFG and BlocPower are planning a 24-month program to provide hybrid heating solutions to low-rise multifamily and small commercial buildings in low to moderate income communities. The program includes sales, marketing, market research, incentives, and program management in our service territory. Along with the management and incentives, the program would support training for community-based contractors.

Expected Benefits: The result is to determine a cost-effective option to lower overall customer emissions within the low- and moderate-income communities. National Fuel and BlocPower will use this data to determine the appropriate incentives and financing necessary to increase hybrid heating installations.

Project Schedule: The program is planned to begin in the Fall of 2022 and run for 24 months.

Project Expenses:

<u>FY 22</u>	<u>FY 23</u>	<u>FY 24</u>
████████	████████	██

Project Status: Planning

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Compressed Natural Gas (“CNG”) Demonstration Vehicle

Project Type: Commercial End Use

Objective: The project provides first-hand experience with the day-to-day operation of a typical CNG bi-fuel passenger vehicle, the 2015 CNG Chevy Impala. Project objectives include tracking and documentation of vehicle performance, fuel costs, user fueling habits, and maintenance issues. Additionally, the vehicle will be made available for hands-on demonstration at trade shows and expos throughout the region, and to specific fleet managers interested in clean, alternative fuel options.

Description: The 2015 Chevy Impala is equipped with a bi-fuel CNG/gasoline system. The vehicle was purchased at the end of fiscal year 2015 and is currently being utilized by NFGDC personnel. The bi-fuel option allows the vehicle to run on either CNG or gasoline, while seamlessly switching between fuel types. This option helps to alleviate concerns over the relative scarcity of CNG fueling stations (a barrier to potential adoption), by allowing the vehicle to run on gasoline when CNG is not readily available. Custom graphics have been added to the vehicle to help promote CNG, as the vehicle itself is otherwise indistinguishable from a gasoline only Impala. Vehicle mileage, fuel use, and maintenance issues are being tracked via NFGDC’s fleet tracking system.

Expected Benefits: This project will gather real-world information and experiences related to owning and operating a bi-fuel CNG passenger vehicle. This information, along with the ability to provide hands-on demonstrations to fleet managers and other interested parties, should help increase market knowledge, and the potential adoption of CNG as a clean, cost-effective transportation fuel.

Project Schedule: The vehicle was purchased in September 2015 and has been used regularly since November 2015. The project is currently expected to continue through at least 2023.

Project Expenses:

<u>FY 22</u> ■	<u>FY 23</u> ■	<u>FY 24</u> ■
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Project Status: On-going

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Botanical Gardens Geothermal Study

Project Type: Commercial End Use

Objective: The objective of this project is to perform a feasibility study to evaluate the potential to deliver heating and colling energy utilizing a Geothermal Heat Pump (GHP) for the entire Buffalo Botanical Gardens facility.

Description: ARUP will evaluate the existing buildings heating and cooling load profile from existing building data. This data will be modeled along with the facility expansion data to facilitate a comprehensive geothermal analysis. After this is complete, a GHP concept design will be developed.

Expected Benefits: The study will develop the preliminary design parameters, assumptions and recommendations while identifying the key design interfaces and constraints.

Project Schedule: The study plans to be completed in 2022.

Project Expenses:

<u>FY 22</u>	<u>FY 23</u>	<u>FY 24</u>
████████	█	█

Project Status: Planning

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Hydrogen Blending Demo

Project Type: Industrial

Objective: Demonstrate the feasibility of using various levels of hydrogen blended with natural gas (HENG) downstream of NFG's meter while observing the impact on downstream natural gas equipment and emissions data.

Description: This demonstration will include the blending of hydrogen with natural gas with observations at the following percentages (by volume): 0%, 5%, 10%, 15%. The hydrogen provider is constructing a mixing skid that will perform the gas blending downstream of the NFGDC meter. The customer's boiler will burn the HENG that will be delivered through isolated house lines. The boiler burner will not be modified.

Expected Benefits: A final report summarizing the field observations at each HENG percentage. The report will also include the boiler efficiency and emissions impacts at each HENG percentage level.

Project Schedule: This project is currently expected to be completed between in the Fall of 2022.

Project Expenses:

<u>FY 22</u>	<u>FY 23</u>	<u>FY 24</u>
■	■	■

Project Status: On-going

Project Manager: Ken Lawton

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Renewable Natural Gas (“RNG”)

Project Type: Operations

Objective: Demonstrate the feasibility of using biogas sourced from farm waste (dairy farms), industrial process food waste, wastewater treatment facilities and/or municipal landfills to produce pipeline quality natural gas for system supply.

Description: These projects require partnerships with RNG developers at several potential RNG production locations. NFGDC plans to invest in the RNG testing equipment, to verify compliance with respect to the Company’s gas quality standards and currently effective tariff. NFGDC also intends to fund a portion of the RNG interconnection equipment costs.

Expected Benefits: Since RNG utilizes methane that otherwise would have been released into the atmosphere naturally, the greenhouse gas emissions (on a life cycle basis) should be at or near zero.

Project Schedule: These projects are currently expected to be completed between 2021 and 2023.

Project Expenses:

<u>FY 22</u>	<u>FY 23</u>	<u>FY 24</u>
■	■	■

Project Status: On-going

Project Manager: Erik M. Solomon

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD & D) PROGRAM**

PROJECT SUMMARY

Project Name: Mobile Vacuum Trailer Demonstration

Project Type: Operations

Objective: Investigate the most inexpensive, safe, ergonomic, and efficient way to perform a problem locates.

Description: NFG would like to explore use of a vacuum unit on wheels and an air wand to consider and evaluate this as a more efficient way to perform problem locates vs our current method of hand-digging, and more cost-effective than Vac-trucks currently employed at larger Service Centers. It is possible to house these units on trailers in a simple, compact, and efficient manner while still meeting the needs of smaller and more remote Service Centers.

Expected Benefits: Reduce the potential for third party damage by more quickly responding to problem locates and ultimately drive down the company damage rate. Make un-locatable facilities locatable by means of non-mechanical excavation which both reduces the risk of employee injury (less hand digging) and makes the process more efficient (one employee operation of unit rather than tie up two-person crew which are in high demand for other critical work).

Project Schedule: This project is expected to be completed in December 2023.

Project Expenses: FY 22 FY 23 FY 24
 ■ ■ ■

Project Status: On-going

Project Manager: William F. Snyder III

Appendix C

RD&D PROGRAM

Fiscal Year 2021 RD&D Budget and Actual Expenses Company Totals and New York Allocations

As mentioned previously, all expenditures for the Traditional RD&D Program are charged to undistributed accounts on the ledger. In this Appendix, the Company is reporting the total budget and total expenditures for the Total Company (i.e., both New York and Pennsylvania combined) as well as for New York only.

In the “End-Use” and “Operations” sections of the budget, project selections are based upon available opportunities and the potential of emerging technologies to address customer, market and company needs. The Traditional RD&D Program, for these two areas, is focused on the demonstration of new, or nearly commercialized products. These demonstrations aim to confirm performance, gauge manufacturer claims, and realize operation experience from a consumer perspective.

NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM

FY2021 Budget and Expenditures

October 1, 2020 - September 30, 2021

Project Type/Project Name	FY 2021 Budget		FY 2021 Expenses	
	Company Total	NY	Company Total	NY
I. Internal RD&D				
A. End Use				
1. Residential (188001)				
Demo Home - Zero Net Energy w/ Natural Gas				
Uncommitted (ASHP Hybrid & MyHeat)				
Residential Subtotal				
2. Commercial (188002)				
NY CNG Demonstration Vehicle				
Gas Heat Pump Demonstration(s)				
Uncommitted				
Commercial Subtotal				
3. Industrial (188006)				
Uncommitted				
Industrial Subtotal				
End Use Subtotal				
B. Operations (188005)				
Renewable Natural Gas (RNG) Demonstration				
Uncommitted				
Operations Subtotal				
C. Other				
1. Technology Transfer (188007)				
Energy Solutions Center (ESC) Dues				
ESC Consortiums (National Accounts, Residential Builder, IBS)				
ESC Gas Technology Magazine				
Uncommitted (Combined Heat & Power Magazine)				
Technology Transfer Subtotal				
2. Technology Assessment (188008)				
Hybrid Heat Pump Analysis (CJ Brown)				
Uncommitted (Wendel - NYSERDA PON & Hydrogen Consortium)				
Technology Assessment Subtotal				
3. General Administration (188009)				

Labor				
Employee Benefits				
Travel, Hotel, Meals Expenses				
General Administration Subtotal				
Other Subtotal				
INTERNAL RD&D TOTAL				

Project Type/Project Name	Company Total	NY	Company Total	NY
II. External RD&D				
1. NYSERDA (188003)				
2. NYSEARCH (188004)				
EXTERNAL RD&D TOTAL				
TRADITIONAL PROGRAM TOTAL				
III. NY Millennium Funds (188050)				
1. GTI				
Utilization Technology Development (UTD)				
Operations Technology Development (OTD)				
Emerging Technology Program (ETP)				
2. Northeast Gas Association				
NYSEARCH - Millennium Projects *(Refund of Operations Project)				
3. Other				
LCRI & Resource Innovations				
Uncommitted (INGAA)				
NY MILLENNIUM FUNDS TOTAL				
TOTAL RD&D PROGRAM				

Appendix D

RD&D PROGRAM

RD&D Forecasts 2022-2024 Company Totals and New York Allocations

NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM
Three-Year Plan Forecast
October 1, 2022 - September 30, 2024

Project Type/Project Name	Budget Forecast 2022-2024					
	Company Total			New York Allocations		
	FY 2022	FY 2023	FY 2024	FY 2022	FY 2023	FY 2024
I. Internal RD&D						
A. End Use						
1. Residential (188001) & (188010)						
Zero Net Energy (ZNE) Home Demo - New Build						
MyHEAT Pilot						
Hybrid Heating System Demos - NY (Incentives and M&V)						
GTI Hybrid Heating System Controls Pilot						
BlocPower Hybrid Heating Pilot						
Uncommitted						
Residential Subtotal						
2. Commercial (188002)						
NY CNG Demo Vehicle						
Botanical Gardens Geothermal Study						
Uncommitted						
Commercial Subtotal						
3. Industrial (188006)						
Hydrogen Blending Demo						
Uncommitted						
Industrial Subtotal						
End Use Subtotal						
B. Operations (188005)						
Renewable Natural Gas (RNG) Demonstration						
Mobile Vacuum						
INGAA JIP for EMAT						
INGAA Non-Traditional Pipe JIP						
Geohazard						
JIP In-Service Welding Proposal (Nathan Redgos)						
Uncommitted						
Operations Subtotal						
C. Other						
1. Technology Transfer (188007)						
Energy Solutions Center (ESC) Dues						
ESC Consortiums (Blue Flame Alliance, etc.)						
ESC Magazines (Gas Technology, CHP, Gas Heat Pump)						
Uncommitted						
Technology Transfer Subtotal						
2. Technology Assessment (188008)						
Hybrid Heating System Demo Analysis						
Uncommitted						
Technology Assessment Subtotal						
3. General Administration (188009)						
Labor						
Employee Benefits						
Travel, Hotel, Meals Expenses						
General Administration Subtotal						
Other Subtotal						
INTERNAL RD&D TOTAL						

Budget Forecast 2022-2024

Company Total	New York Allocations
----------------------	-----------------------------

FY 2022	FY 2023	FY 2024	FY 2022	FY 2023	FY 2024
----------------	----------------	----------------	----------------	----------------	----------------

Project Type/Project Name

II. External RD&D					
1. NYSERDA (188003)					
2. NYSEARCH (188004)					
EXTERNAL RD&D TOTAL					
TRADITIONAL PROGRAM TOTAL					
III. New York Millennium Funds (1951-188050)					
1. GTI					
Utilization Technology Development (UTD)					
Operations Technology Development (OTD)					
Emerging Technology Program (ETP)					
Low Carbon Resources Initiative (LCRI)					
2. Northeast Gas Association					
NYSEARCH					
3. Other					
North American Gas Heat Pump Collaborative					
ConEd Guidehouse Hydrogen Group					
Uncommitted					
NY MILLENNIUM FUNDS TOTAL					
TOTAL NY RD&D PROGRAM					

Appendix E

NEW YORK MILLENNIUM FUNDS RD&D PROGRAM

Project Commitments/Expenditures/Collections

The Millennium Funds RD&D Program is an umbrella program supporting other internal and external RD&D programs.

The Northeast Gas Association Research Committee (“NYSEARCH”) administers the Millennium Program on behalf of New York State. NYSEARCH provides continual offerings of gas industry research, development and demonstration projects, from which National Fuel may select to support through funding. If and when a project is chosen for co-funding, a signed Memorandum of Commitment (“MOC”) is executed between the Company and NYSEARCH. Payments are subsequently made to NYSEARCH, as projects progress.

Company support for Gas Technology Institute research continues, through the Utilization Technology Development, N.P. (UTD) and the Operations Technology Development, N.P. (OTD). Additionally, field operations support continues through the Millennium Funds RD&D Program.

Two additional sub-programs include the Emerging Technology Program (ETP) funded through UTD, and the Sustaining Membership Program (SMP) funded through OTD. Uses of funds external to NYSEARCH are reported back to them, for publishing in annual updates to their website. Additional detail is also included herein.

The table included in Appendix E includes information on total expenditures, and collections (refunds), since the inception of Millennium.

Appendices F and G provide details on project selections from 2021, for UTD and OTD, respectively.

NYSEARCH web address: <http://www.nysearch.org>

Notes:

1. **M-2005-013.** In 2005, NFGDC began participating in the new Utilization Technology Development (UTD) organization by sharing the annual costs with the Pennsylvania Delta Funds RD&D Program.
2. **M-2003-011.** In 2006, charges for participation in the Operations Technology Development (OTD) organization were reduced from [REDACTED] to [REDACTED] per year, as costs began to be shared with the Pennsylvania Delta Funds RD&D Program.

**NATIONAL FUEL GAS DISTRIBUTION CORPORATION
RESEARCH, DEVELOPMENT & DEMONSTRATION (RD&D) PROGRAM
Millennium Funds RD&D Program as of December 31, 2021**

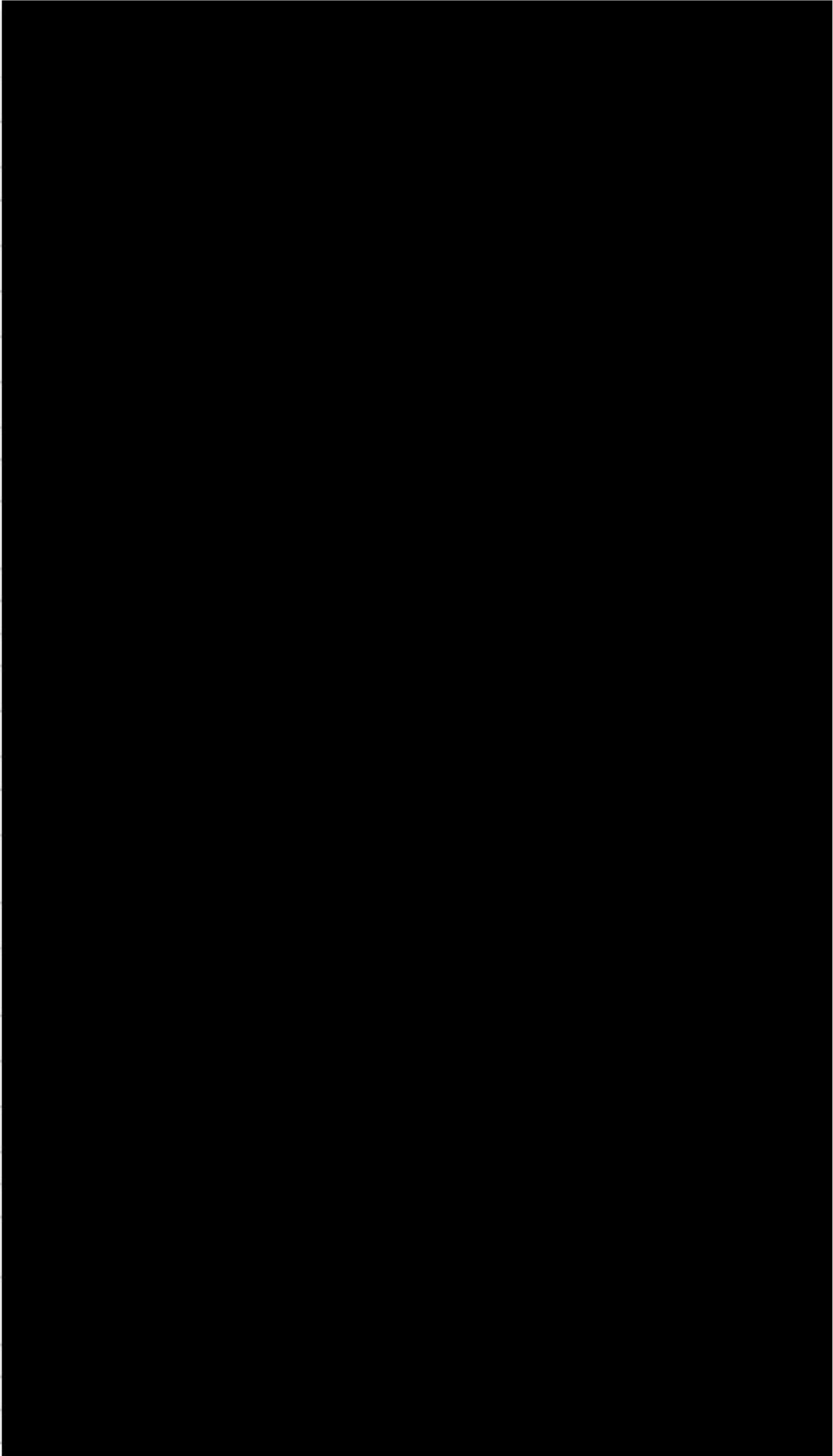
Proj. #	Title	Total	Expended	Forecast			Totals
		Committed	Past Years	2021	2022	2023	
M-2000-001	Variable Length Split Repair Sleeve						
M-2000-002	BNL Cast Iron Joint Detector						
M-2000-003	Purged Gas Recovery Device						
M-2000-004	CMU Robotic Camera						
M-2000-005	Development of Remote Leak Detection						
M-2000-006	Ecoseal Development						
M-2000-007	Emerging Technologies for Natural Gas (IGT)						
M-2000-008	Real Time Monitoring of Contact to pipelines						
M-2001-001	Global Technology Transfer Alliance						
M-2001-002	Impact of Sediments						
M-2001-003	Evaluation & Dev. Of Pipeline Inspection Tech. For High Pressure.						
M-2001-004	Development of Handheld Pipe Locator - Livemore						
M-2001-005	Development of Handheld Pipe Locator - Pipehawk PLC						
M-2001-006	Gasline Sensor Network System						
M-2001-007	Optical PCB Probe						
M-2001-008	Soil Stabilization						
M-2001-009	Urban Utility Center Technology Laboratory						
M-2001-010	Dev. Of Inspection Tool for Un-Piggable Transmission Mains						
M-2001-011	The Pavement Breaker Lift Assist						
M-2001-012	Phytoremediation of Cyanide at MGP Sites						
M-2001-013	Millennium Web Development						
M-2001-014	Dev. Of Inspection Tool for Un-Piggable Transmission Mains - Automatika						
M-2001-015	Flash Fire/Trench Rescue Study						
M-2002-001	Soil Compaction Measuring Device Study						
M-2002-002	Portable Methane Detector						
M-2002-003	GTI Sustaining Membership						
M-2002-004	Ground Probing Penetrating Imaging Radar						
M-2002-005	HDD Obstacle Detection- Acoustical						
M-2002-006	ULC Robotic Periscope						
M-2002-007	Weld Zone Butt Fusion						
M-2002-008	Oracle						
M-2002-009	CIP High Pressure Liners						
M-2002-010	Reduced Customer Outage for CIP liners						
M-2002-011	FFT Secure Pipe Optic Cable Monitoring System						
M-2002-012	PEX Pipe Project: Comparison of PEX and PE Pipe						
M-2002-013	InnerSeal						
M-2002-014	PFT Tracer						
M-2002-015	CISBOT						
M-2002-016	KeyHole Tech: Market Evaluation and Product Development						
M-2002-017	Robotic System for Live Gas Repairs						
M-2002-018	Infrasonic Sensor System for Remote Gas Pipeline Monitoring						
M-2002-019	PCB/PFT Explosives Real-Time Analyzer						
M-2002-020	GTI Research Collaboration Program						
M-2002-021	Millennium Field Ops Support						
M-2002-022	Bass/Trigon Risk Assessment Model						
M-2003-001	ViewGas Remote Leak Detector						
M-2003-002	Transtech Soil Compaction Meter						

M-2003-003	Alternative Repair Materials for Concrete Dyke on LNG Plant (BNL)
M-2003-004	Alternative Leak Repair with MW Polymer
M-2003-005	Comparison of Reinforced Thermoplastic to Steel
M-2003-006	Secure & Smart Utility
M-2003-007	GTI Direct Assessment
M-2003-008	EWI Ultrasonic NDE for Electrofusion Joints
M-2003-009	Explorer II - Metal Loss Module
M-2003-010	Alternate Solution to LL30 Requirement
M-2003-011	GTI Operations Technology Devt (OTD)
M-2003-012	Study LNG Issues in NY
M-2003-013	GTI/NFG Direct Assessment
M-2003-014	Starline Cured In Place Pipe Liner Testing
M-2004-001	No Pig Inspection Technology
M-2004-002	TWI/Petrochem Ultrasonic Inspection Technology
M-2004-003	Harris CI Joint/Pipe Locator
M-2004-004	ULC/AI Slimkit Inspection Access
M-2004-005	SwRI Magnetostrictive Sensor
M-2005-001	Leak Monitoring for Gas Pipelines Using Optical Fiber Spectroscopy
M-2005-002	Feasibility Study of Airborne RMLD
M-2005-003	Design, Construction and Operation of a Regional Test Bed Network
M-2005-004	Development of a Prototype Mobile RMLD
M-2005-005	Gas Interchangeability for LDC Infrastructure Integrity
M-2005-006	Explosion Proof Halogen Work Area Lighting
M-2005-007	Enbridge Pipeline to UltraClean Generation
M-2005-008	Starline Intermediate Pressure Liner
M-2005-009	GTI - Innovative Methods for Inspecting PE Pipe
M-2005-010	Study Effect of Islander East Gas on Keyspan Couplings
M-2005-011	Angled Electrofusion Fitting
M-2005-012	Development of a Corrosion Camera
M-2005-013	NFG - GTI Utilization Technology Devt (UTD)
M-2005-014	Evaluation/Validation of ICDA
M-2005-015	NMPC Feasibility Study of Mains Replacement Model
M-2005-016	EPRI Funding for MGP Site Remediation and Health Risk R&D
M-2006-001	LANL Acoustic Standoff Sensor for Pipeline Inspection
M-2006-002	Butt Fusion Joint Integrity Program
M-2006-003	Development of Combustible Gas Indicator with GPS
M-2006-004	Live Video for Pig Runs: KeySpan Project
M-2006-005	Failure Testing for Gas Transmission Couplings
M-2007-001	Mini-Camera for Inspection of Cased Crossings
M-2007-002	Feasibility Study of Fiber Optic Tether
M-2007-003	Multi-Technology Testing for Cased Pipe Applications
M-2007-004	Migma - Mobile Leak Detection, Proof of Concept
M-2007-005	TransKor Remote Inspection Testing
M-2007-006	Investigate Effects of PE Internal Scratching
M-2007-007	Technology Advancement in Damage Prevention Tools and Communications
M-2007-009	KSE Stonybrook Project - Proof of Concept, Self Powered Sensors
M-2007-010	Digital Leak Detector
M-2008-001	Magal Damage Prev Monitoring
M-2008-002	ALPIS - Helicopter Based Distribution Leak Survey

M-2008-003	Evaluation of Rapid Crack Propagation
M-2008-004	Testing Program for RFEC Sensor on CI Pipe
M-2008-005	Developing Platelet Tech for Distr & Transmission
M-2008-006	Expanding the Functions of No-Blow Tools
M-2008-007	Leak Detection System Using PFT Analysis
M-2008-008	Biomethane Tech Review
M-2008-009	BioFuels Devt Project
M-2008-010	PE Piping Standards
M-2009-001	DIMP - Risk Practices/Models
M-2009-002	Mecaptan Sensor Development
M-2009-003	Adaptation to Climate Change
M-2009-004	University of Binghamton Corrosion Sensor
M-2009-005	Supplemental Administrative Fees
M-2009-006	CIP Lining - Cornell Study for Bare Main
M-2009-007	Particulate Dispersion Study
M-2009-008	TWI NDE Ultrasonic Inspection System
M-2010-001	Service Tee Renewal
M-2010-002	Methane MR Sensor Development Program
M-2010-003	PCB Absorption in PE Pipe Testing
M-2010-004	Soil Vapor Intrusion
M-2010-005	Guided Wave Test Program with Impro
M-2010-006	Evaluation of CIPL Near High Temperature Steam Mains
M-2011-001	Self-Healing Pipe, Phase I Literature Search
M-2011-002	Storage Effects on Gas Quality
M-2011-003	Odor Masking
M-2011-004	NASTT Carbon Calculator Spreadsheet Tool
M-2011-005	Fiber SenSys Development and Testing of Fiber Optic System
M-2011-006	Robotics Supporting Technologies, Crack Detection Sensor
M-2011-007	Cased Pipe Inspection via Vents
M-2011-008	BioBall Test Program: Sewer Pipe
M-2011-009	30"-36" Robotic Platform - Accelerated Development
M-2012-001	Development of Corrosion Sensor Array for Monitoring Natural Gas
M-2012-002	Living Lab for Biogas/BioMethane Treatment
M-2012-003	Enterprise Level Assessment of Data Management Solutions
M-2013-001	Explorer 16/18 - Inspection of Unpiggable Pipelines
M-2013-002	RMD Crack Sensor using Eddy Current Technology
M-2013-003	WKU Advanced Chemical Sensor
M-2013-004	Devt and Comparison of Leak Detection Methodologies
M-2013-005	Devt of Acoustic Leak Detection System
M-2014-001	sUAS Technology - Regulatory & Technology Assessment
M-2014-002	Leak Pinpointing Inside Pipe
M-2014-003	Picarro Methane Emissions Analyzer System
M-2014-004	Technology Evaluation & Test Program for Quantifying Methane Emissions Related to Non-Hazardous Leaks
M-2014-005	Critical Valve Operability
M-2014-006	Feasibility Study on Innovative Visual Methods for Leak Detection
M-2014-007	Structural Wear Tests of Composite Covers Using Roadway Parameters
M-2014-008	Detection of Corrosion in Tunnel Riser Pipes
M-2015-001	Multi-Technology Test Program of Methane Detection from Small Unmanned Aerial Systems (sUAS)

M-2015-002	Standoff Gas Flow Imaging and Analysis System Proof of Concept
M-2015-003	Development and Testing of an 8" Butt Fusion Repair Sleeve (BFRS) for PE
M-2015-004	Development of 12" PE Repair Sleeve for Butt Fusion Joints
M-2015-005	Development and Testing of an 2" Variable Length Repair Sleeve (VLRs) and Butt Fusion Repair Sleeve (BFRS) for PE Main and Service Pipe
M-2015-006	Field trial BEM Internal Inspection Technology
M-2016-001	Post Mortem Slow Thermal Cooling Testing of Field Aged Cured-In-Place Lined (CIPL) Cast Iron and Mechanically Joined Steel Pipe
M-2016-002	Odor Detection Threshold Study
M-2016-003	Development and Testing of RFID Embedded in PE Coil Pipes
M-2016-004	Alternate Crack Sensor Probe for Explorer
M-2016-005	Survey and Assessment of Technologies for the Inspection of PE Pipe
M-2016-006	Energy Harvesting for GasComm™ Real Time Sensing Network
M-2016-007	Spectral Imaging for sUAS Platforms
M-2016-008	Development & Testing of JANA NDE Ultrasonic Inspection Tool for Electro-fusion PE Joints
M-2016-009	Energy Harvesting for Onboard Re-Charging of EXP Robotic Platforms
M-2017-001	Methane Detector – Advanced R&D for Remote Communications
M-2017-002	Explorer Automation
M-2017-003	BioMethane Data Collection Project
M-2017-004	Methane Oxidation Catalysts for Reduction of Emissions in Flaring
M-2017-005	SwRI Pipe Locator using Enhanced Time Domain Reflectometry (ETDR)
M-2017-006	Pipeline Cleaning Tool for Liquids with Flow
M-2017-007	Gas Distribution Line Passive Flood Protection Device
M-2017-008	On the Mark (OTM) Damage Prevention Vehicle (DPV) Pilot Program
M-2017-009	Emergency Main Stop-off Station (EMSOS) Phase 3 - Field Installation, Testing and Commercialization - Con Ed Project
M-2017-010	Development of an Electrofusion Repair Sleeve- Con Ed Project
M-2017-011	PHASE I - DEVELOP ALGORITHM FOR IDENTIFYING CORROSION ON GAS SERVICES
M-2017-012	Residential Methane Detectors
M-2018-001	Reducing Methane Emissions at Threaded Connections – Sampling Program
M-2018-002	Evaluation of Non-Thermal Infrared Gas Imaging for LDC Applications
M-2018-003	Validation of Chemical Analysis Methods for Pipeline Steels
M-2018-004	Development and Testing of an 1 1/4" Butt Fusion Repair Sleeve (BFRS) and Variable Length Repair Sleeve (VLRs) PE Main and Service Pipe
M-2018-005	Natural Gas Dispersion in Residential Structures
M-2018-006	Augmented Reality/Hololens Application Development
M-2018-007	Development and Testing of MetGlas™ Amorphous Metal Tape for Pipe Location
M-2018-008	Expansion of NYSEARCH RANGE™ Model & Study of Siloxane Concentration Limits
M-2018-009	Terahertz Inspection of Plastic Pipe
M-2018-010	Identification and Development of an Analyzer for Siloxane Measurement
M-2018-011	Scaling of Microbial Power-to-Gas Conversion for Long-Term Operation
M-2018-012	Gas ICS Data Acquisition & Forensic Techniques
M-2018-013	Newtown Creek Renewable Gas Project
M-2019-001	GasComm™ Application for PE Pipe

M-2019-002	Standardization of Surface Expression Equipment and Protocol to Implement Emissions Validation Process
M-2019-003	Expanding sUAS Technology Assessment for Data Analytics and Advanced Sensing
M-2019-004	Development of Mercaptan Sensor Systems with Non-Radioactive Ionizer
M-2019-005	Meter Collar Methane Detector
M-2019-006	Robotic System for Above Ground Inspection of Natural Gas Infrastructure
M-2019-007	Study for Application of X-Rays in the Inspection of Plastic Pipe and Fittings
M-2019-008	Development/Testing/Commercialization of GasComm™ RTU/Control Module
M-2019-009	Standard Library of PE Joint Samples with Embedded Defects for NDE Tool Validation
M-2019-010	Eclipse Scientific Red/Green Light Tool for NDE of PE Pipe Butt Fusion Joints
M-2019-011	AMI Value Box Motion Sensor
M-2019-012	Gas ICS Data Acquisition & Forensic Techniques
M-2019-013	Phase 2 – Develop Laser Inspection and Acceptance Criteria For High Density Polyethylene Pipe Butt and Electrofusion Joints
M-2019-014	MMT HSD Evaluation JIP
M-2019-015	GoT - Integrated Safety Solution
M-2019-016	North American Gas Heat Pump Collaborative
M-2020-001	Millennium Website Support - NY Member Administrative Mechanism
M-2020-002	Impact of Hydrogen/Natural Gas Blends on LDC Infrastructure Integrity
M-2020-003	3D Subsurface Metal Pipe Characterization
M-2020-004	Multi-Technology Test Program of NDE Technologies for PE Pipe Joints
M-2020-005	Artificial Intelligence (AI) Proof-of-Concept Study(ies) for Predictive Maintenance in Gas Operations applications
M-2020-006	Standardization of NYSEARCH's Methane Emissions Validation
M-2020-007	Feasibility Study for a Robotic Platform and Suite of Sensors to Identify Degradation in Non-Conforming Driscopipe @ 8000
M-2020-008	Study Impact of Trace Constituents in RNG on Natural Gas Grids and Consumer Appliances
M-2020-009	Development of a Decision-making Algorithm for Detection and Quantification of Leaks
M-2020-010	BAH and Heath AMI Capable Natural Gas Detector
M-2020-011	Development of a Model to Forecast CECONY
M-2020-012	AMI Rectifier Monitoring Station
M-2020-013	Urbint(R) Machine Learning Modeling Applied to Predictive Analytics of Incoming Gas Leaks Total
M-2020-014	EPRI/GTI Low Carbon Resource Initiative - Accelerating Technologies that Enable Deep Carbon Reductions
M-2020-015	Impact of H2/CH4 Blends - DNV JIP
M-2020-016	INGAA Geohazard JIP Study
Totals	



Millennium Fund - Summary					
	Balance at <u>12/31/2017</u>	Balance at <u>12/31/2018</u>	Balance at <u>12/31/2019</u>	Balance at <u>12/31/2020</u>	Balance at <u>12/31/2021</u>
Beginning Balance					
Revenues					
Expenses					
Ending Balance					

Appendix F

UTILIZATION TECHNOLOGY DEVELOPMENT PROGRAM

Project Allocations - 2021

As part of the Millennium Funds RD&D Program (Project M-2005-013), NFGDC participates in the Gas Technology Institute not-for-profit Utilization Technology Development (“UTD”) Program. The UTD conducts applied research, development and technology demonstrations for customer end-use appliances and technologies. Annual payments have historically amounted to [REDACTED]. In 2015, UTD Board Members voted to approve a dues increase, which resulted in this figure increasing to [REDACTED], in 2016 and later. Proposed projects are presented at an annual allocation meeting of the membership, normally held in March/April of each year. NFGDC allocates dollar amounts to individual projects of the Company’s choosing. During this allocation process (if projects are fully subscribed by others), then amounts may be either allocated to other worthwhile projects or may not be allocated at all (contingent upon the availability of future projects beneficial to NFGDC, its customers and potential end-users of the technologies).

Final allocations to UTD, from 2021, illustrate the project selections and allocations by NFGDC. One benefit of the program is that all the members share in the results of all other member-supported projects, even if they did not allocate funds to those projects. There are projects of great interest to others, and to the Company, which may already have been fully subscribed.

GTI web address:

<https://www.gti.energy/>

UTD web address:

<http://www.utd-co.org>

ETP web address:

<https://www.gti.energy/emerging-technology-program>

UTD Payments, Fees, Credits, Carryover

Payments to UTD

Administration Fees

Carryover of Unallocated Funds from Prior Year

Funds Available for Allocation

Allocations to Projects

Residential and Light Commercial

1.14.K.2 Refund

1.14.K.3 Refund

1.15.C.3 Next Generation Residential Gas Clothes Dryers - Phase 3: Full Prototype

1.16.H.3 EnergyPlus Models and Market Analysis for Advanced Resid. Heating Systems - Phase 3

1.17.B.4 Thermoelectric Generator for Self-Powered Water Heater - Phase 4

1.17.C Refund

1.18.F.3 Mitigating Methane Emissions from ResCom End Use Equipment – Phase 3

1.19.C Integrated, Self-Powered, High-Efficiency Burner System

1.19.E.2 Sequestering Non-Condensable Gases for Enhanced Gas Abs. HP Reliability - Phase 2

1.19.I.2 Comparative Assessment of Space Heating Systems in Virtual Test Home - Phase 2

1.20.A Robur and SMTI Low-Capacity Gas Absorption Heat Pump Laboratory Evaluation

1.20.B Boostheat Thermal Compression-based Gas Heat Pump

1.20.E Gas-Fired Binary Fluid Ejector Heat Pump Water Heater

1.20.F Emerging Rescom Fuel Cells - Laboratory Evaluations

1.20.G High-Efficiency Combi System Integrating PV and Self-Power

1.20.G.2 High-Efficiency Combi System Integrating PV and Self-Power - Phase 2

1.20.H Hydrogen-Blended Gas in Residential/Commercial Combustion Equipment

1.20.H.2 Hydrogen-Blended Gas in Residential/Commercial Combustion Equipment - Phase 2

1.20.I Membrane Based Ionic Liquid Absorption Heat Pump for Commercial HVAC

1.20.J Integrated CHP System for Multi-Family Buildings

1.20.J.2 Integrated CHP System for Multi-Family Buildings - Phase 2

1.21.A HeatAmp Adsorption Thermal Heat Pump

1.21.B Technical Support for ResCom Gas Equipment Testing, Performance and Safety

1.21.C CleanO2 CARBiNX Carbon Capture

1.21.E Gas Engine Heat Pump Modeling, Testing and Implementation

1.21.F Commercial Heat Pump Water Heater Field Performance Comparison

1.21.I Ionic Liquid Absorption Heat Pump for Commercial Water Heating

2.19.F CYSORE 24kW mCHP and Chiller System - Lab Test

Large Commercial and Industrial

- 2.14.O.3 Gas Quality Sensor Validation - Phase 3
- 2.17.A.3 Water Recovery From Humid Exhaust Gas Field Demonstration – Phase 3
- 2.20.A Low Emission Efficient Burner for Ovens and Dryers - Field Demonstration
- 2.20.B Sub-Dew Point Cooling Technology
- 2.20.C High Efficiency Low Emission Commercial Baking Oven Field Demonstration
- 2.20.E Energy Source Options for Industrial Users
- 2.20.E.2 Energy Source Options for Industrial Users - Phase 2
- 2.21.A High Hydrogen Burner for Commercial and Industrial Applications
- 2.21.B Energy Recovery from Brewing/Distilling Operations: Field Demo
- 2.21.C Zero Emissions Processes with Carbon Recovery
- 2.21.D High Efficiency Crop Drying Process

Food Service

- 1.14.A.6 Next Generation of CFS Burners - Phase 6
- 1.16.B.4 Refund
- 1.17.H.2 Residential Cooking Pollutants and IAQ - Phase 2
- 1.17.H.3 Residential Cooking Pollutants and IAQ - Phase 3
- 1.19.A.2 High Efficiency Smart Convection Oven - Phase 2
- 1.19.B.2 Gas Fired Warewasher - Phase 2
- 1.19.B.3 Gas Fired Warewasher - Phase 3
- 1.20.K Field Evaluation of Indoor Air Quality in Residential Kitchens
- 1.21.G Technical Support to Address Gas Foodservice Technologies
- 1.21.H CFS Burner Technology Carbon Reduction Including Hydrogen Blending

Clean Transportation

- 2.19.G CNG Dispenser-Tank Communication
- 2.20.F Next Generation NGV Driver Information System
- 2.20.G Smart CNG Station - Field Demonstration
- 2.21.F CNG Locomotive Field Demonstration
- 2.21.G Distributed RNG Production and Cleanup
- 2.21.H Improved Hydrogen Fueling for Heavy-Duty Vehicles
- 2.21.I Technical Support for Clean Transportation Testing, Performance and Safety

Adjustments and Miscellaneous Refunds

- Board Designated Net Assets 2021
- G&A Refund 2021

Funds Allocated to Projects

Unallocated Funds

Funds Available for Allocation (check)

* UTD uses negatives numbers for allocations to projects and positives for refunds

Appendix G

OPERATIONS TECHNOLOGY DEVELOPMENT PROGRAM

Project Allocations - 2021

As part of the Millennium Funds RD&D Program (Project M-2003-011), NFGDC participates in the Gas Technology Institute not-for-profit Operations Technology Development (“OTD”) Program. The OTD conducts applied research, development and technology demonstrations for field operations, infrastructure and environmental technologies. Annual payments for the program amount to [REDACTED]. Proposed projects are presented at an annual allocation meeting of the membership, normally held in December of each year. NFGDC allocates dollar amounts to individual projects of the Company’s choosing. During this allocation process (if projects are fully subscribed by others), then amounts may be either allocated to other worthwhile projects or may not be allocated at all (contingent upon the availability of future projects beneficial to NFGDC, its customers and potential end-users of the technologies).

Final allocations to OTD, from 2021, illustrate the project selections and allocations by NFGDC. One benefit of the program is that all the members share in the results of all other member-supported projects, even if they did not allocate funds to those projects. There are projects of great interest to others, and to the Company, which may already have been fully subscribed.

GTI web address:

<https://www.gti.energy/>

OTD web address:

<http://www.otd-co.org>

SMP web address:

www.gastechnology.org/Expertise/Pages/Sustaining-Membership-Program.aspx

Payments to OTD, Fees, Carryover

Payments to OTD

Administration Fees

Carryover of Unallocated Funds from Prior Year

Funds Available for Allocation

Allocations to Projects

(1) Pipe and Leak Location

1.14.g.6 Residential Methane Detectors Program, Phase 6: Support for NFPA Standard Development

(2) Pipe Materials Repair and Rehabilitation

2.14.c.2 Assessment of Squeeze-off Location for Small Diameter Polyethylene (PE) Pipe and Tubing, Phase 2 - Refund

(5) Construction/ Infrastructure Techniques

5.07.p (GTI) GNSS (GPS) Consortium

5.15.a.3 Cyber Security Working Group

5.16.f - Improved Safe Excavation Productivity for Locating Buried Utilities - Refund

5.17.k - Protect Tracer Wires from Corrosion - Best Practices and New Methods - Refund

5.19.f - Purging Gas Pipes into Service without Venting Gas to Atmosphere - Refund

5.19.f.2 - Purging Gas Pipes into Service without Venting Gas to Atmosphere - PHASE 2

5.19.k.2 - Utonomy Smart Regulator - Phase 2

5.20.a - Subsurface Multi-Utility Asset Location Detection

5.20.e - Single-Path Ultrasonic Meter Long-Term Performance Testing and Monitoring

5.20.k - Smart Shutoff Technology for Commercial and Residential Buildings

5.21.a - Meter Removal Tool - Commercialization Phase

5.21.e - Evaluation of the CoSMiC Eye Satellite Based Pipeline Right-of-Way Monitoring System

5.21.g - Remote Monitoring of Pipe-To-Soil Utilizing AMI

5.21.j - Hydrogen Blending Impact on Aldyl-A nad HDPE Pipes

5.21.n - Advanced Training Technologies Consortium 2021

5.21.q - Development of a MDPE and HDPE Allowable Pull Load calculator

5.21.s - Gap Identificaion Between Hydrogen and Natural Gas Pipeline Standards and Practices

5.21.t - Effect of hydrogen blended natural gas on the performance of gas meters and diaphragm type service regulators- Phase 1

(6) Memberships/Other

- 6.08.a (GTI) Carbon Management Information Center
- 6.11.a PRCI Membership
- 6.a (GTI) SMP

(7) Methane Emissions/Detection and Gas Quality

- 7.10.b.3 - Odor Fade and Odor Masking from H2 Blends
- 7.16.e.3 - Biomethane On-Line Monitoring Phase III
- 7.18.h.2 - Gas Quality Resource Center (7.11.a and 7.18.h)
- 7.20.a - Develop Remote Sensing and Leak Detection Platform with Multiple Sensors
- 7.20.b - Validation of Remote Sensing Leak Detection Technologies under Realistic Conditions
- 7.21.f - Developing a Framework for Certifying Responsible Natural Gas
- 7.21.j - Assessing Performance Impacts and Leak Rates of System Components

(8) Intelligent Utilities

- 8.17.b.3 - Transmission Tracking and Traceability Marking Standard Pilot Projects
- 8.17.b.4 - T and T - GS1 barcode standardization, counterfeit protection, and two way communication.
- 8.17.c.3 - GNSS Smart Automations (GSA) Phase 3
- 8.20.a - B31Q Training Documentation Portal
- 8.20.j - Above Ground Service Tee Identification and 3D Mapping
- 8.20.l - Enhanced Locating Technologies for Underground Pipelines with Better Accuracy
- 8.20.m - 3D Visualization Software for Mapping Underground Pipelines and Improving Pipeline Asset Management
- 8.21.g - GNSS Testing in an Urban Environment
- 8.21.h - Tracking Software Development for Pipeline Safety Management Systems

Adjustments and Miscellaneous Refunds

- Board Designated Net Assets 2020
- G&A Refund

Funds Allocated to Projects

Unallocated Funds

Funds Available for Allocation (check)

