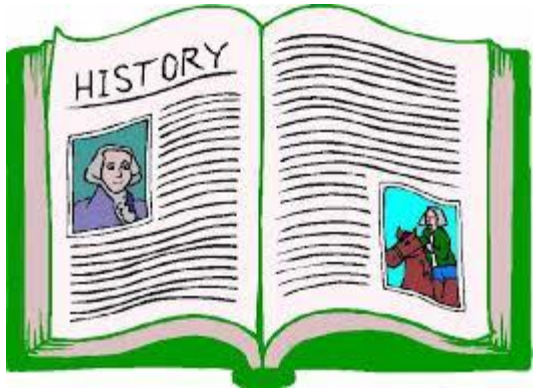
Staff Subcommittee on Gas



History of U.S. Natural Gas R&D

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> November 12, 2017

> NARUC Gas Staff Subcommittee
> Baltimore, MD

Overview

- Objective: Present a history of collaborative natural gas R&D in the U.S. with a view toward benefits (and costs) to gas consumers and the gas industry
- Review the historical events that precipitated the need for this R&D
- Provide a view of the trials and tribulations of collaborative funding over the decades
- Look at the alternative solutions developed for such funding
- Discuss the need for continued funding and cost sharing

Early Years

- 1925 - AGA Labs established in Cleveland and later Los Angeles, focusing on gas appliances
- 1941 – IGT founded in Chicago, focusing on coal gasification and combustion
- 1952 – PRCI established, focusing on transmission pipeline R&D
- Some action toward collaborative R&D, but not coordinated with each other and not “wellhead to burner tip”

Critical Events

- November 1965, Great Northeastern Blackout left 30 million people without electricity
- Oil Embargo of 1973 led to gasoline shortages and long lines at gasoline stations
- In 1970's, alarm at the apparently dwindling supplies of U.S. natural gas, reacting to gas curtailments in some states

Government Actions

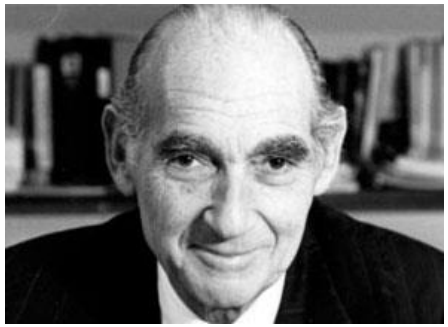
- Energy Reorganization Act of 1974 led to the formation of ERDA, which brought together for the first time the major R&D programs for all forms of energy
- Department of Energy Organization Act of 1977 led to DOE taking responsibility for long-term, high-risk energy R&D, replacing ERDA.
- SERI was established in 1977 to address challenges related to renewable energy

Private Sector Actions

- EPRI established by the electric utility industry in 1972
- IN 1973, an ad hoc committee of AGA and INGAA Board members proposed the creation of a gas research organization for comprehensive R&D for the advancement of gas-related technology

Founding of GTI

- In June 1976, the FPC issued a NOPR, FPC 566, to provide procedures and guidelines for advance assurance of rate treatment for R&D expenditures by jurisdictional companies (i.e., pipelines)
- There were 45 intervenors, including NARUC, gas LDCs, pipelines, producers, EEI, state PUCs, electric LDCs, and research organizations
- FPC Order 566 was approved, leading to the formation of GRI in 1976, with the first R&D program submitted to the FPC in 1977 and approved for 1978



Early History of GRI R&D

- Mission of GRI: To achieve mutual benefits for the gas industry and gas consumer by planning, managing, and developing financing for an R&D program subject to review by the FERC (formerly FPC) and, where appropriate, state regulatory commissions
- GRI was an R&D program management organization, like EPRI or DOE, not an R&D performer
- Objectives:
  - To develop cost-competitive sources of natural gas; highly efficient gas appliances, equipment and industrial processes offering least-cost energy service options; and cost-effective means for safer and more environmentally benign production, transport, storage, and utilization of gaseous fuels
  - Advance gas science and technology though long-range planning and basic research
  - Support these R&D activities with the development and analysis of technical, scientific and economic data
  - Facilitate the use of results through vigorous information dissemination and technology application efforts

Changes in Strategic Emphasis

- In an era of gas curtailments, the first focus of GRI R&D was on gas supply: unconventional gas and synthetic natural gas (SNG), with 57% of funding going to supply R&D. Later supply R&D funding was reduced to 25% in 1988 and was subsequently restored to about one-third of GRI's budget. Emphasis shifted early away from SNG toward unconventional gas R&D (coalbed methane, tight gas sands, and Devonian shale)
- End-use R&D was initially 27% of GRI's budget, growing to 54% in 1983, and remaining at about half of GRI's budget thereafter.
- Gas operations R&D started out at 5% of GRI's budget, but grew to 9% by 1982, reaching 20% by 1994, and subsequently remaining at 15-25% of the overall budget
- Basic research was maintained at 10-13% (included in the above totals) of GRI's budget

GRI Funding History

Breaking of the Compact

- In 1985, FERC Order 436 required natural gas pipelines to provide open access to transportation services
- In 1992, FERC Order 636, pipelines were no longer permitted to act as merchants and sell bundled products, they could sell only the transportation component
- Results, in 1988, large industrials challenged the GRI funding approach, especially for end-use R&D. As a result of PGC v. FERC, 1988, FERC issued a ruling that end-use R&D in traditional markets for traditional applications was acceptable, but that R&D for new markets/new applications was not, and traditional markets/new applications needed to undergo a "net benefits test"

Breaking of the Compact (2)

- As a result of (1) increased competition between pipelines and (2) no longer owning the gas, the pipelines became less and less interested in supply, end-use, or distribution R&D
- Some pipelines asserted that with discounted gas sales, their shareholders were forced to pick up the GRI surcharge.
- Some producers worried that, with netback pricing, they would be forced to pick up the GRI surcharge
- Two pipelines resigned from GRI, effective January 1993 and others threatened to do so
- A proposed change in the funding mechanism, where GRI funds would no longer be collected on discounted gas sales, stabilized the situation temporarily

Settlement Conference and the Stipulation & Agreement (S&A)

- In 1993 the FERC approved the modified funding mechanism in an Interim Funding Order, and called for a settlement conference to develop a “more permanent system” of GRI funding
- The Settlement Conference was convened in 1997
- Represented there were NARUC, NASUCA, PGC (large industrials), 38 pipelines, many gas LDCs, GRI, and producers
- In 1998 an S&A was reached by all parties, calling for the phase out of the GRI FERC funding mechanism, with another $644 million allocated between 1998 and 2004, dropping to $60 million in 2002-2004 and zero thereafter. No “new load” R&D was to be conducted.
- The FERC funding mechanism was to be replaced by a “voluntary funding program” where the shippers (LDCs and others) could decided voluntarily whether or not to fund collaborative R&D.

What was Next?

- The GRI Board and the gas industry searched for alternative funding approaches. In agreement with the IGT Board, a merger between GRI and IGT was recommended
- In 2000, GTI was created by the merger of GRI and IGT. A major decision was that GTI would be for the most part a performing laboratory, not an R&D program management organization

Funding Approaches

- In 1998, a search for alternative funding approaches to the FERC mechanism was initiated
- The FERC had accepted a “check the box” approach, where LDCs (garnering approval *not* from the FERC), could ask their pipelines to continue to collect R&D funds
- GRI, then GTI, began the Delta Program in 1998, where gas LDCs could elect to *ask their PUCs* to shift the FERC surcharge (mostly in PGAs) into base rates. The initial charge would be the difference (delta) between the 1998 FERC surcharge and the reduced surcharge per the S&A. So the consumers would not be exposed to a rate increase

Funding Approaches (2)

- From 1998 to 2000, GRI was successful in bringing 8 states and about $5 million into R&D funding.
- Individual gas LDCs could choose specific R&D projects, called GTI Select, to fund collaboratively, with T&C negotiated on each. GTI Select proved unwieldy and unable to sustain major programs
- In 2003 OTD was formed for distribution R&D and in 2004 UTD was formed for end-use R&D. Standard T&C considerably speeded up project selection, funding, and initiation. Both programs were "customer choice." *UTD leverages gas industry funds 4.5/1*
- After 2004, the state-level R&D program would result in an increase in funding, at $1 per consumer per year
- GTI provided support to LDCs for rate case filings, established PIAC in 2000, and provided support to NARUC Gas and ERE Committees
- As of 2017, 30 states have approved R&D funding, GTI seeing about $15 million of that per year

OTD Members


Operations Technology Development (OTD):
24 Members
WEC Energy Group
spire
ATMOS energy
Ameren
Oklahoma Natural Gas
CenterPoint Energy
Entergy
NiSource
AVISTA
PSNC ENERGY
A SCANA COMPANY
National Fuel
INTERMOUNTAIN GAS COMPANY
Washington Gas
conEdison
Piedmont Natural Gas
Pacific Gas and Electric Company
NYSEG
RG&E
ENBRIDGE
QUESTAR Gas
DUKE ENERGY
nationalgrid
NW Natural
Southern California Gas Company
A Sempra Energy utility
SOUTHWEST GAS
TECO
PEOPLES GAS
OTD
Operations Technology Development

UTD Members

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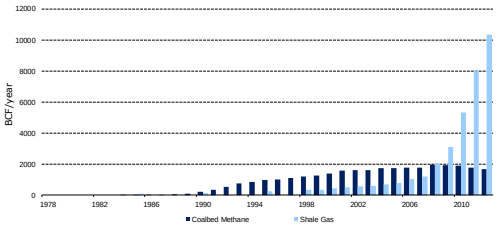
So What has Been Accomplished?

- World's first high-efficiency (90%+) furnace has transformed the furnace market, with capture of 25%-75% of the new and replacement furnace market in the northern half of the country. Annual savings to residential gas consumers of over $1 billion per year
- The Ultramizer 93% boiler has begun to transform the commercial and small industrial boiler market. Boilers are up to 30% of industrial load
- The shale gas revolution is saving (R, C, I) gas consumers $50 billion per year in gas costs, 48.4% of U.S. gas production in 2016
- The plastic pipe locator has enabled the accurate location of 645,000 miles of plastic distribution lines and 44 million plastic service lines
- **Benefit/cost ratios for gas consumers are 4/1 to 9/1**



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Remaining Challenges

- Getting the other 20 states and their gas LDCs on board R&D funding
- Supply: More cost-effective, environmentally benign recovery from gas shale wells
- Operations: Smarter gas systems, asset tracking, safer more environmentally benign operations, look ahead systems for horizontal boring, cyber security, better failure prediction models, how to get gas to underserved and unserved customers more cost effectively
- End-use: cost-effective high-efficiency GHPs, ultra low emission NOx burners, NGVs, high-efficiency gas cooling, GHP water heaters
- Cost sharing: strong support from DOE, CEC, NYSERDA, and PHMSA is of critical importance; manufacturers provide in-kind support, but the small and mid-size appliance and operations equipment manufacturers cannot afford to develop technologies on their own. *OTD and UTD are critical to providing cofunding for these government programs.*

Appendix

- History of GRI/IGT/GTI
- Shale Gas Benefits
- OTD Winners
- UTD Winners

GRI/IGT/GTI Company History

1940 | 1970 | 1990 | 2000 | 2010

1941
Institute for Gas Technology (IGT) formed at the Illinois Institute of Technology (IIT)

1947
IGT Laboratory
Chicago, Illinois

1970
Blue Flame natural gas powered rocket car sets world land speed record of 630 mph

Dr. Henry Linden
GRI President

1976
Federal Power Commission approved surcharge on pipeline transmission for research funding and Gas Research Institute (GRI) formed

1973
Oil Crisis

1992
FERC Order No. 636, Restructuring Rule mandated unbundling to separate sales from transportation services

1995
U-GAS® Plant
Shanghai, China

1991
GRI sponsored Mitchell Energy's first horizontal well in the Barnett shale

2000
GRI and IGT combined to form Gas Technology Institute (GTI)

2003
Operations Technology Development (OTD) launched to facilitate collaborative gas operations and infrastructure research

2004
Utilization Technology Development (UTD) initiated to address end use issues of interest to the gas industry

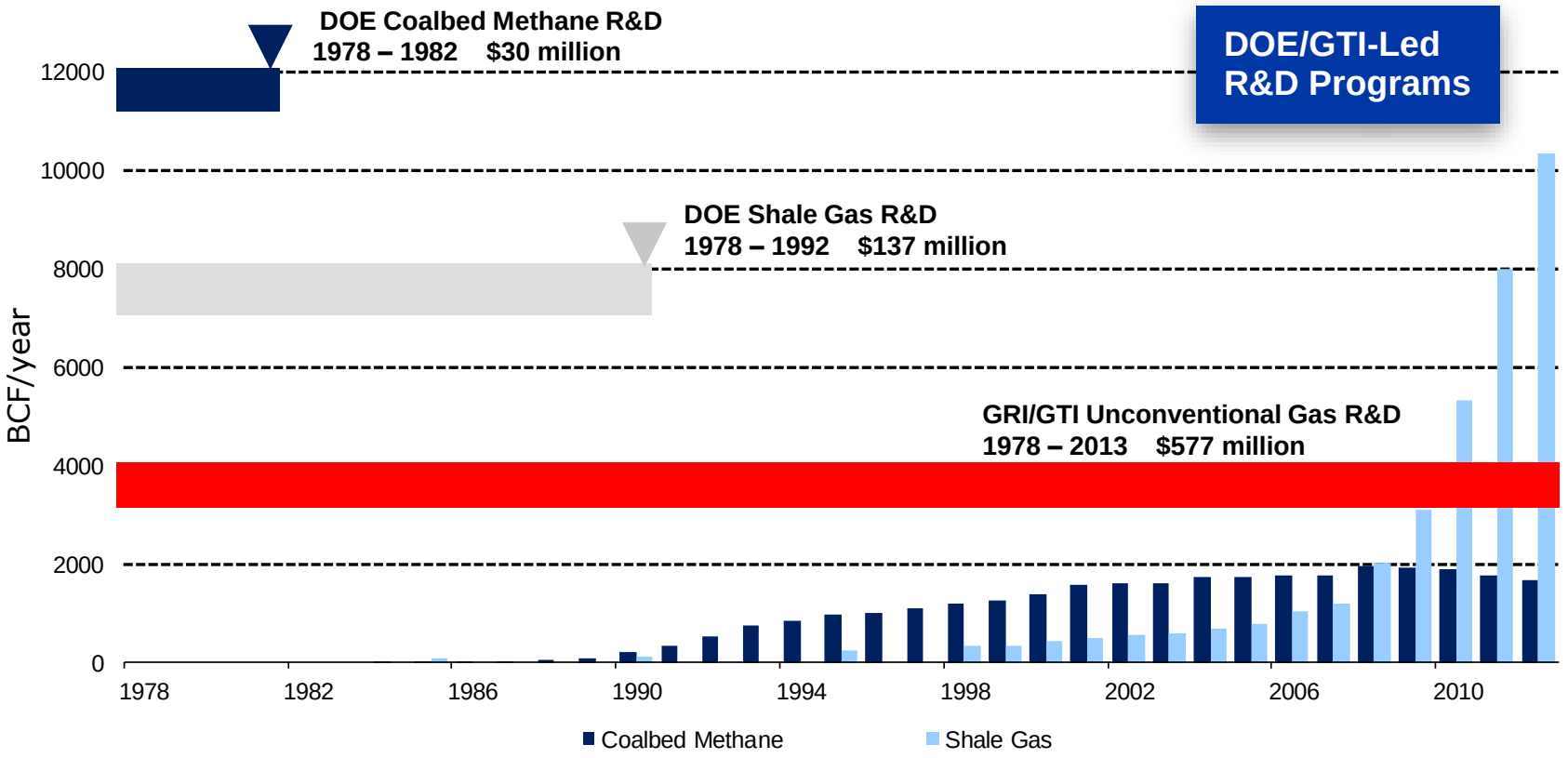
2009
GTI Pilot-Scale Gasification Campus
Des Plaines, Illinois

2015
GTI President & CEO David Carroll assumed the Presidency of the International Gas Union (IGU)

2015
GTI acquired Aerojet Rocketdyne's fossil energy business

2017
GTI International subsidiaries combined to form energy efficiency and alternative transportation services firm Frontier Energy

GTI/DOE Research Investments Sowed the Seeds of Unconventional Natural Gas Production Into The Future



Shale gas was 48.4% of production in 2016 (15.8 Tcf)

Sources: GTI, EIA, DOE Department of Fossil Energy

Results from GTI's Utilization Technology Development (UTD) Program

Transport Membrane Condenser and Ultramizer

Low-Oil-Volume Fryer

NovelAire Dehumidifier

Equinox Solar-Assisted Heating System

RASERT Heating System

Cummins 8.9-L Ultra-Low-Emissions Engine

Venting Solutions Software

Source Emissions Calculator

Operations Technology Development (OTD) Market Impact (1)

Metallic Joint Locator (MJL)
SENSIT Technologies

The SENSIT Ultra-Trac® MJL accurately locates bell joints, valves, pressure control fittings, repair clamps, mechanical couplings and service connections on metallic piping systems, significantly reducing excavation areas and pavement restoration costs. In field tests, the MJL was also able to detect bell and spigot joints for an eight-inch-diameter water main buried at a depth of six feet.

Acoustic Pipe Locator (APL)
SENSIT Technologies

SENSIT's commercially available Ultra-Trac® APL provides the ability to locate plastic pipes before excavations and construction. In pre-commercial testing, the system was shown to be capable of detecting multiple buried plastic pipes at depths up to five feet.

Kleiss MCS Flow Stopping System
Mainline Control Systems

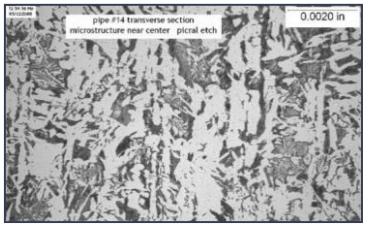
Marketed as the Kleiss MCS Flow Stopping System, this new system is used to stop the flow of gas in polyethylene, steel, cast-iron, and PVC pipes at diameters up to 18 inches and pressures up to 60 psig. The system, which is manufactured in Europe, was investigated through OTD to validate its operation and potential savings in the U.S. gas industry.

Gas Line Tracer and Directional Entry Tool
Jameson

The Gas Line Tracer was developed to address the issue of locating previously un-locatable plastic gas distribution lines. The Directional Tool enables vertical insertion of tracer rods and cameras into live gas mains, facilitating the difficult first bend at entry.

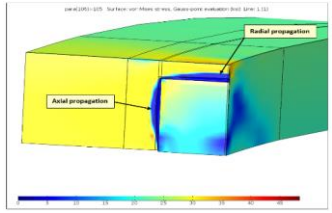
OTD Market Impact (2)

Surface-to-Bulk Material Verification for IVP



Validated models to characterize material properties including yield/ tensile strength and chemistry of in-service pipelines without taking the line out of service or removing samples. Will directly support the choice of non-destructive surface testing as part of the DOT/ PHMSA pending Integrity Verification Process (IVP).

MAOP Verification Alternatives to a Hydrotest for ECA



Developed and deployed a critical crack/wall-loss model that allows operators to determine if an inspection technology could detect a crack-like flaw and/or wall loss that would fail a pressure/hydro test at a particular pressure. Helps enable operators to use Engineering Critical Assessment (ECA) in lieu of a hydrotest which requires shutdown and water injection.

Asset Tracking – 16-digit alphanumeric code – ASTM F2897

Developed a series of algorithms to create a unique identifier for distribution asset tracking and traceability. Final efforts resulted in the creation of a 16-digit alphanumeric code. The overall format and syntax is summarized within a recently approved ASTM specification (F2897-11).

Keyhole Technology Transfer

GTI's Keyhole Consortium Program is enabling broader adoption of minimally invasive access to underground pipe and related assets. With keyhole suppliers, have developed a suite of tools and techniques for cost-effective underground natural gas infrastructure service and repair.

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