the Energy to Lead

Codes, Standards, and Regulations Impacting New Product Development and Application

American Society of Gas Engineers Conference

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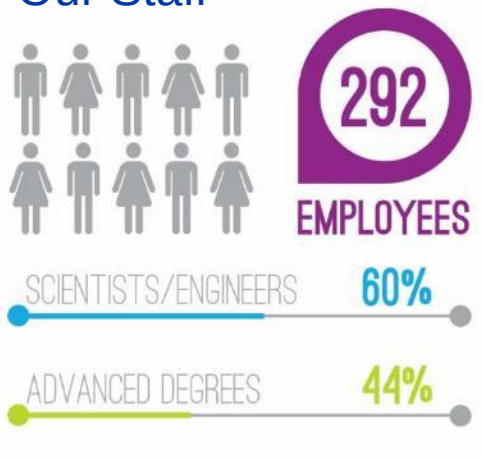
GTI Overview

ESTABLISHED 1941

- Independent, not-for-profit established by the natural gas industry
- Providing natural gas research, development and technology deployment services to industry and government clients
- Performing contract research, program management, consulting, and training
- Wellhead to the burner tip including energy conversion technologies



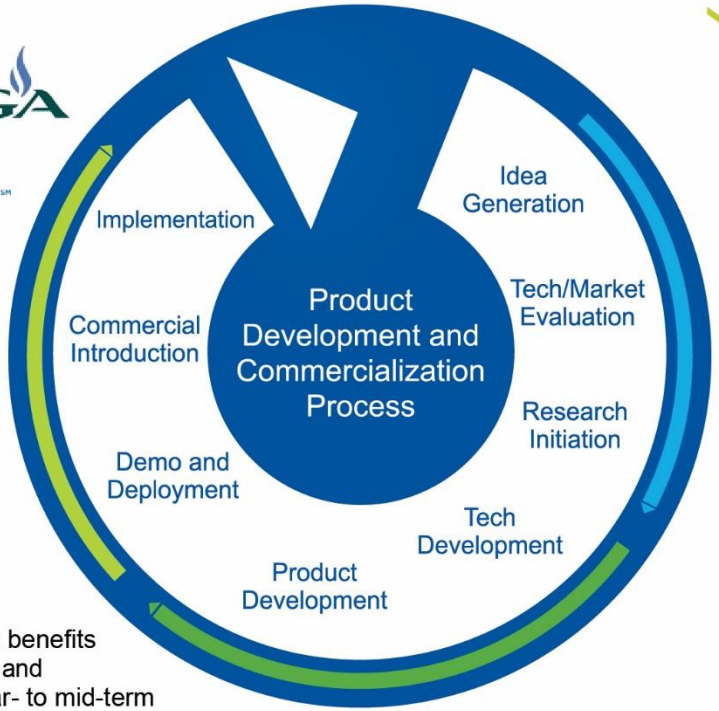
GTI End-Use Product Development & Commercialization Process

Utility Energy Efficiency Programs

AGA

CEE

ESC



The Flame of Innovation
SMP

SMP builds a strong technology base for new technologies, product concepts, and related solutions through the "proof of concept" stage for gas utility members and their customers

Established in 1985

ETP
Emerging Technology Program

ETP helps companies assess the benefits of new energy efficiency products and integrated solutions for use in near- to mid-term energy efficiency program implementation

ETP encompasses a variety of new manufacturer technology/ product offerings

Established in 2012

UTD
Utilization Technology Development

UTD and its 16 members serve over 24 million natural gas consumers in the U.S. and Canada. These companies work together on technology developments that meet their end-use customer energy efficiency and environmental needs

Established in 2004

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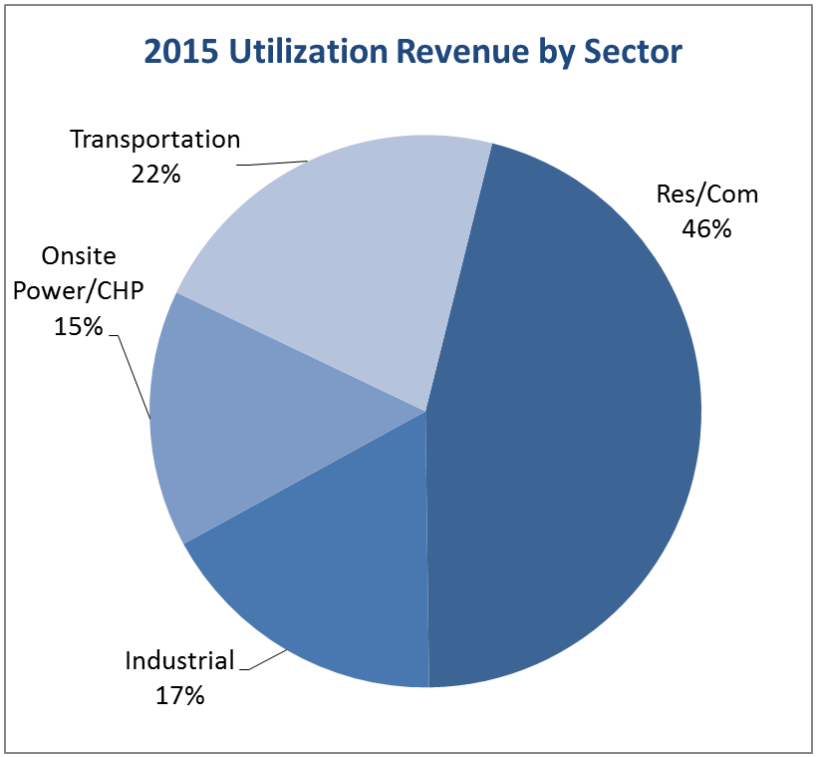
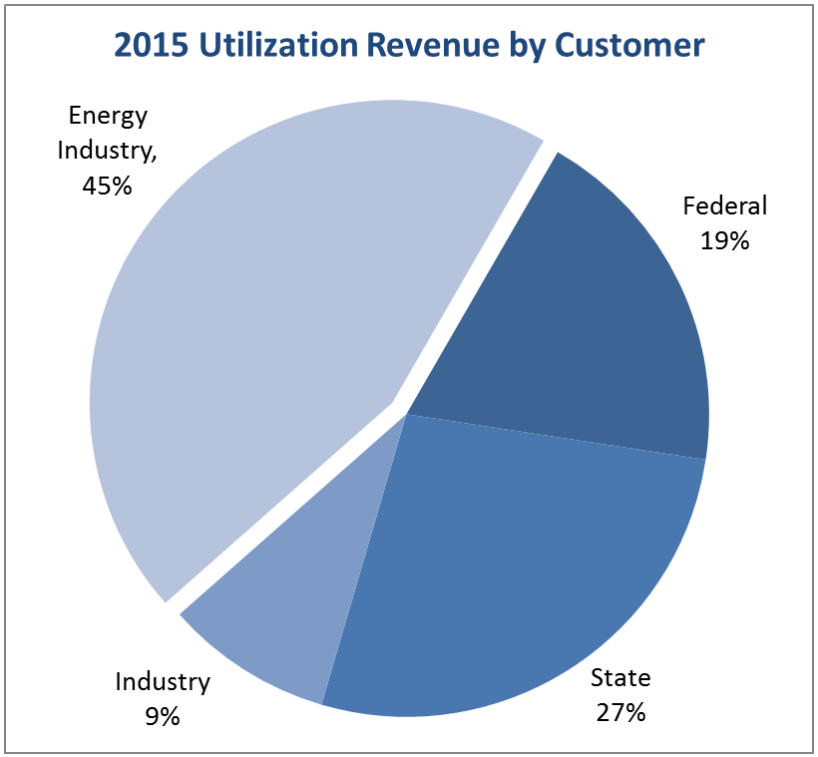
GTI's Utilization RD&D Portfolio

GTI has a balanced RD&D portfolio in four application sectors, led by Residential/Commercial, and four customer groups, led by the Energy Industry. We have about 120 energy professionals providing $25-30 million/year in value-added energy utilization services.





GTI Residential and Commercial RD&D Program

- Building energy efficiency initiatives focused on:
  - New appliance technology for hot water and space conditioning
  - Commercial food service technology
  - Solar thermal/natural gas hybrid systems
  - Carbon management solutions
  - Building systems integration
  - Distributed generation/CHP

GTI's Energy Utilization Subsidiary Companies

Energy Efficiency Professional Services

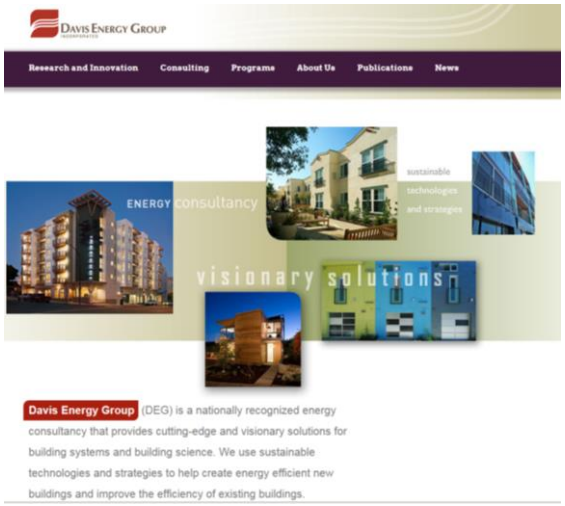
*Fishnick is a professional services firm with deep expertise in **commercial kitchen energy efficiency** and appliance performance testing. They are a dedicated team of engineers, technicians, culinary arts experts, educators, and energy specialists who use their expertise to encourage the commercial foodservice industry to become more sustainable in their purchasing decisions and operations.*

http://www.fishernickel.com/

*CDH is a professional services firm specializing in **monitoring and evaluating energy technologies** related to building efficiency, industrial processes, distributed generation (DG), combined heat and power (CHP), fuel cells, and solar power performance. They help clients assess building systems and equipment operations, create energy savings verification plans, and support energy efficiency programs.*

http://www.cdhenergy.com/

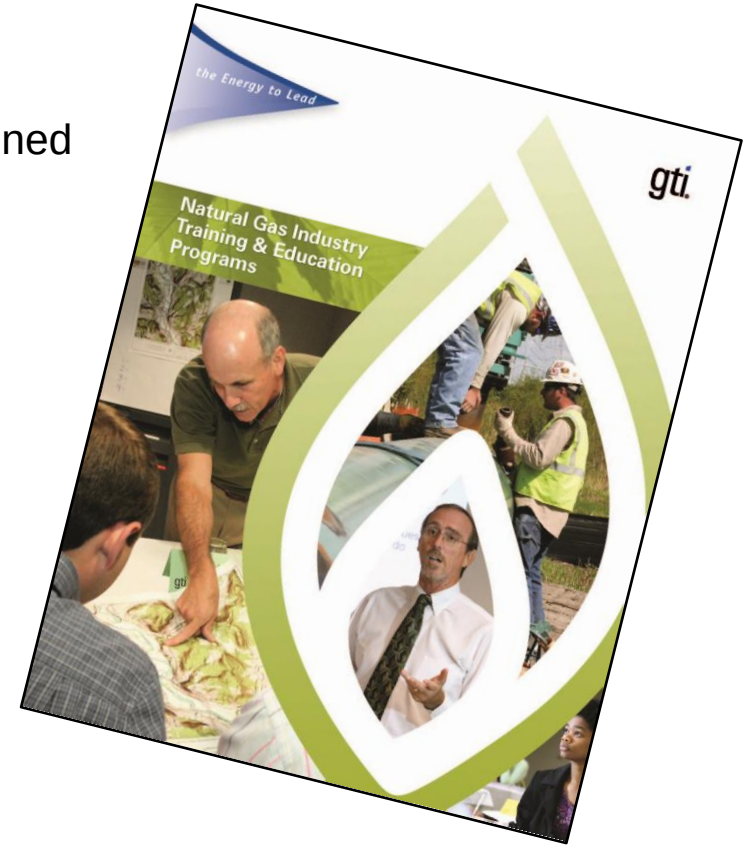
*Davis Energy Group (DEG) is a professional services firm that provides services encompassing **high-efficiency residential and green building design and certification**, sustainability consulting, energy product and system evaluation, building, HVAC and water heating research, and technology assessment and standard development.*



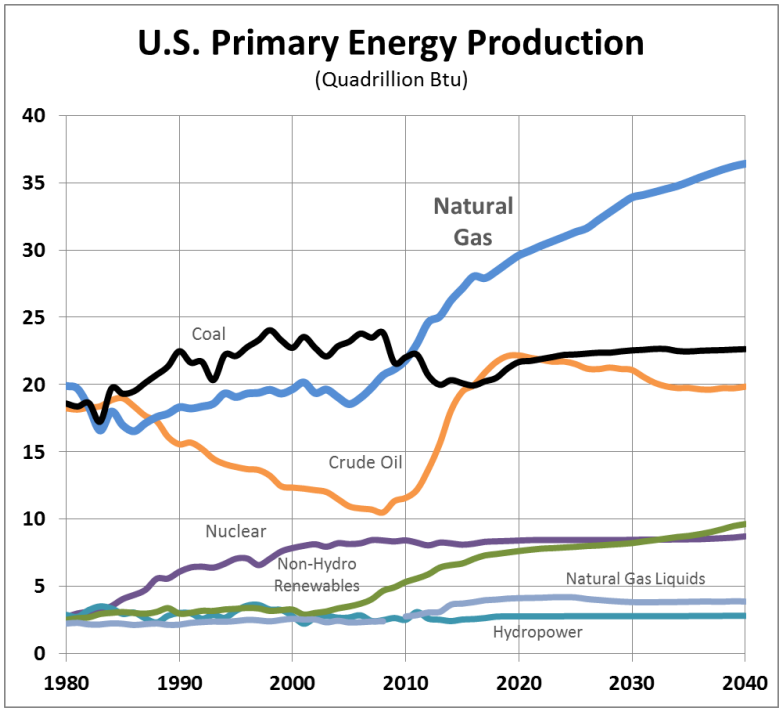
http://www.davisenergy.com/

GTI Energy Education Programs

- GTI programs in gas industry training
  - Offered since 1941
  - Over 40 courses offered annually
  - Over 55,000 gas industry professionals trained
- Broad array of topic areas
  - Gas supply
    - LNG
    - Unconventional gas
  - Gas distribution and transmission
  - Gas utilization and marketing
- Delivery Options
  - Open enrollment classroom courses
  - Onsite for energy industry customers
  - Online and self-guided programs
- Industry Conferences



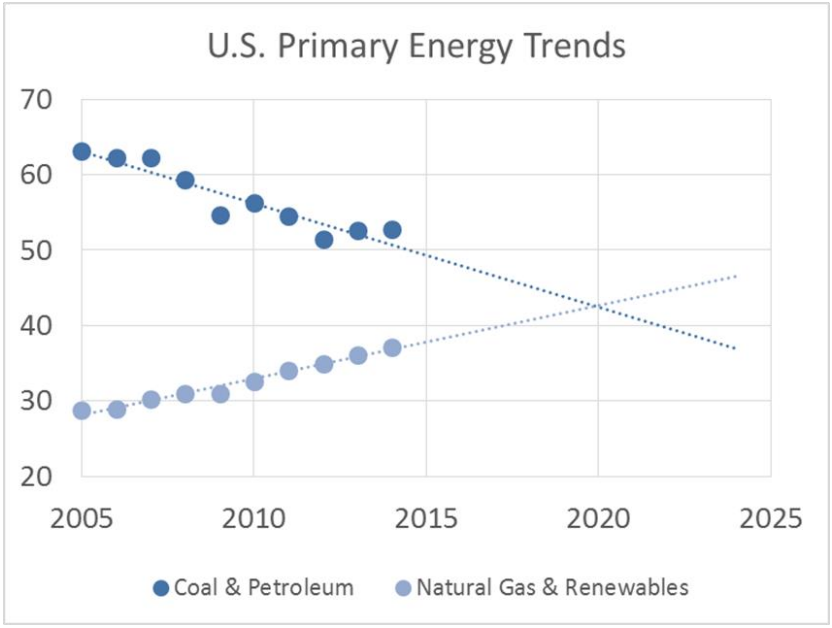
Natural Gas: A Clean Burning, Abundant Domestic Resource



> **Natural Gas** is a clean burning, low-cost domestic energy choice that is now the leading energy source produced in the U.S.

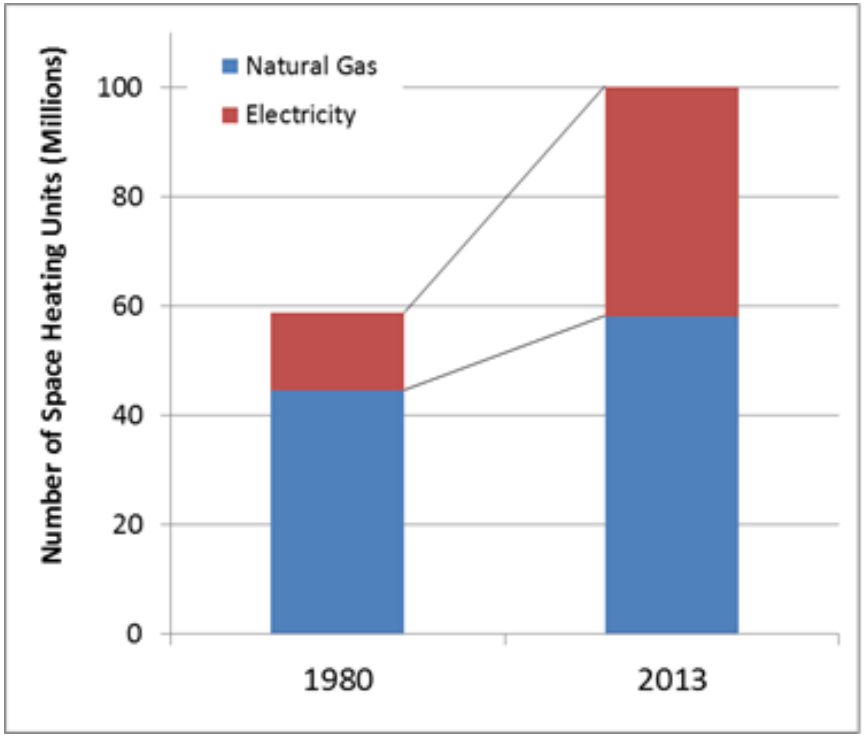
> Shale gas can enable the benefits of natural gas to be realized throughout the U.S. and the world.

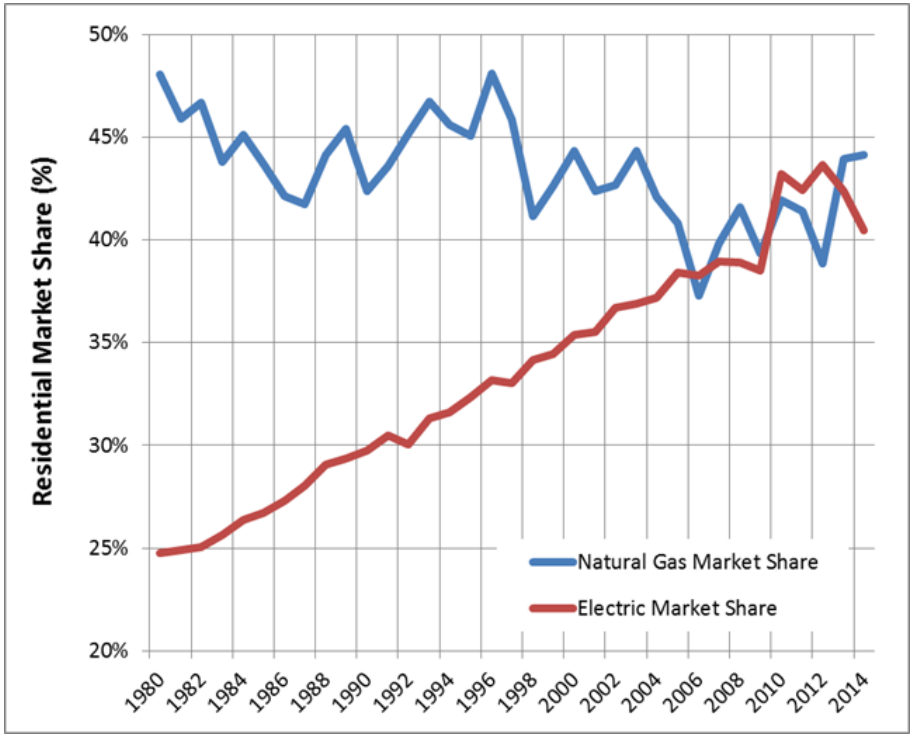
> Natural gas technologies are a great complement to renewable resources.



Residential Market Dynamics

<u>Natural gas facing strong competition from electricity</u> – which has gained a larger portion of space heating and overall residential market during the past three decades.





Source: US Census Bureau, American Housing Survey; DOE-EIA

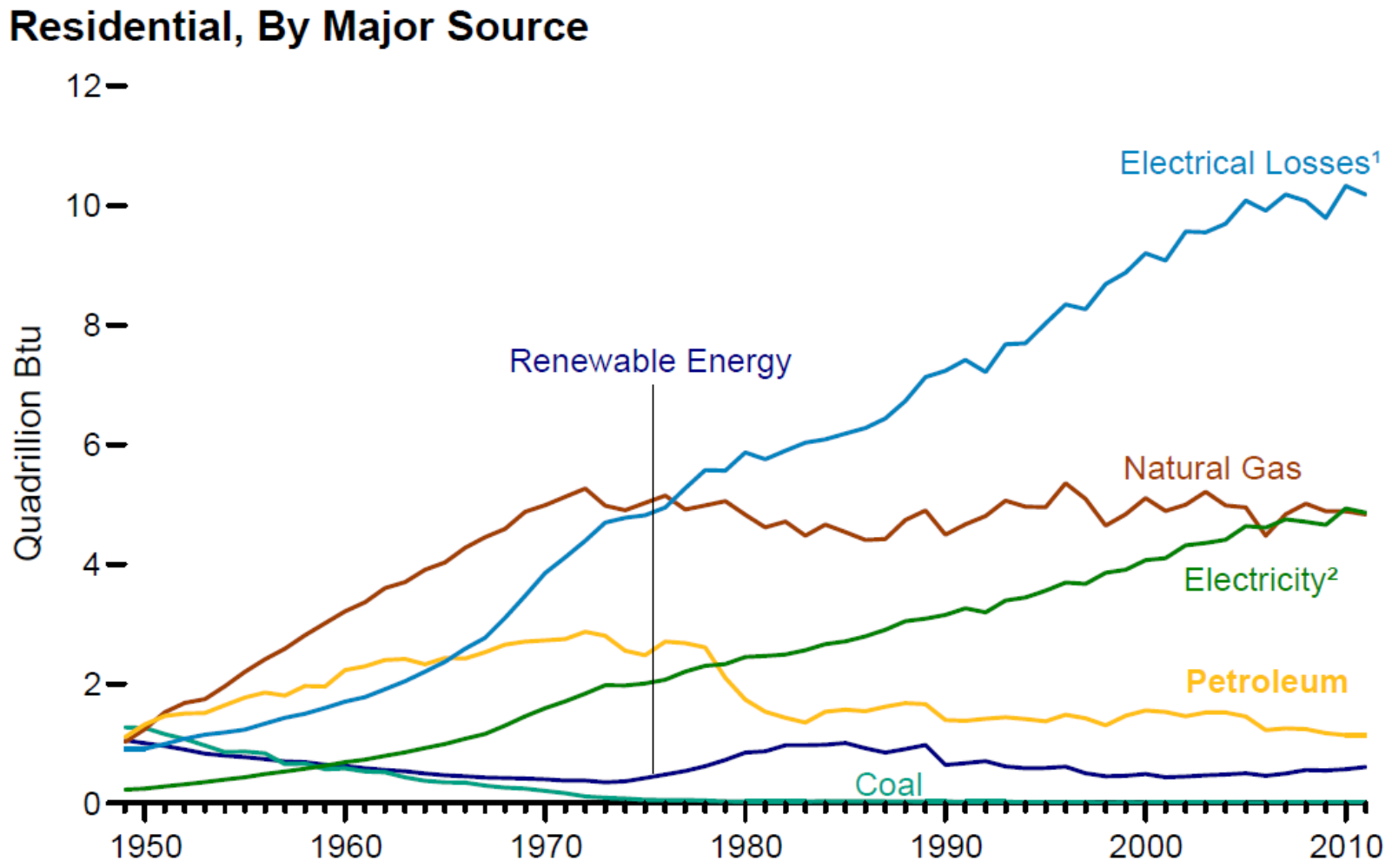
What Next For Natural Gas In Homes and Businesses?

- More competition, more policy & regulatory pressure…
- Continued Federal pressure for setting higher appliance, equipment, and building energy standards
- Policy/regulatory bias towards electrification
  - Perceptions of greater efficiency, cleaner
  - Policies that promote renewable energy (e.g., net zero energy), lower carbon emissions, and phase out fossil fuels

Source Energy Use Reduction by Increased Natural Gas End Use

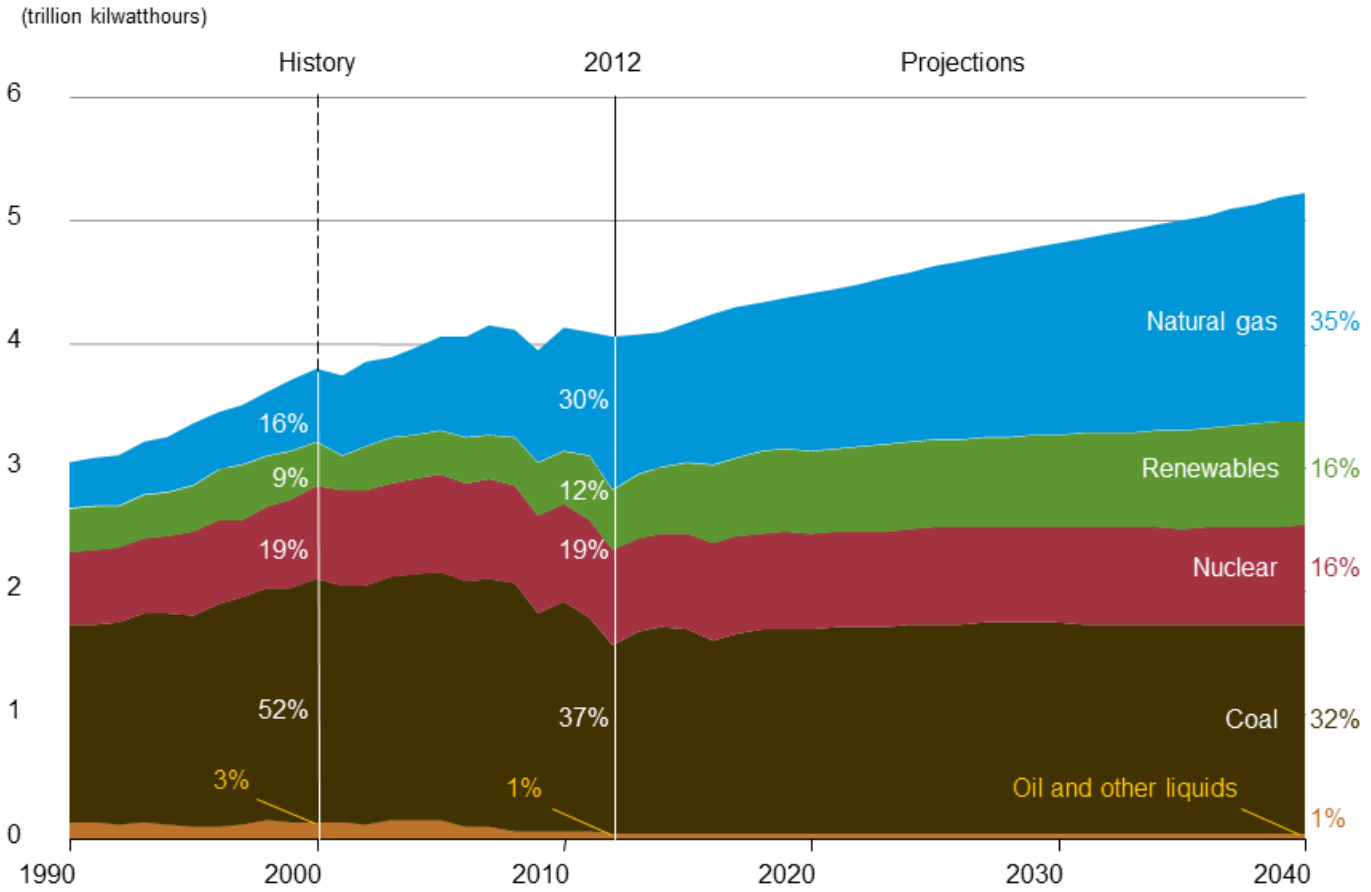
- Efficient direct use of natural gas can significantly reduce full-fuel-cycle energy consumption compared to electric resistance technologies
- Natural gas end use technologies uniquely positioned for long term societal benefits
  - Low life-cycle costs to consumers
  - High source energy efficiency
  - Low carbon emissions
  - Energy security
  - Domestic employment
  - Compatible with renewable methane

Electrical Losses in Buildings Equal Gas and Electric Site Consumption



Source: DOE EIA Annual Energy Review 2011

US Electricity Generation Mix - EIA Forecast through 2040

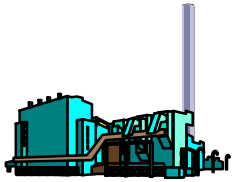
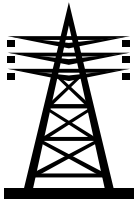


Coal and gas dominate U.S. power generation mix through 2040

Source: EIA Annual Energy Outlook 2014

Comparison of Source Efficiencies Delivered to Customers (%)

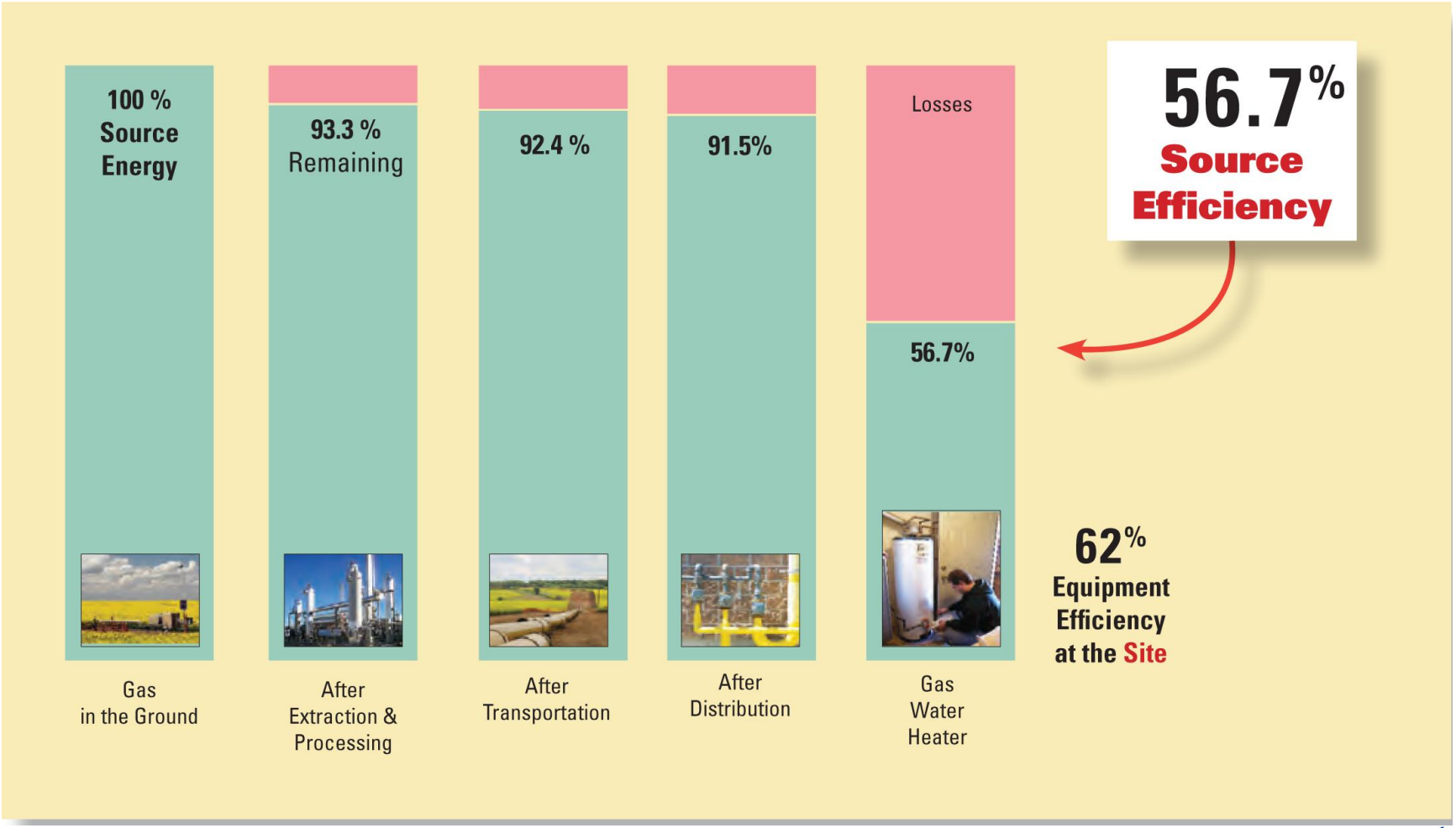
	Extraction, Processing, & Transportation		Conversion[1]		Distribution		Delivered To Customer
Electricity from Coal **29% Efficient**	100 MMBtu Source Energy	→	96	→	31	→	29
Natural Gas **92% Efficient**	100 MMBtu Source Energy	→	93	→		→	92


Not Applicable

1. Based on 2009 average generation efficiency

Full-Fuel-Cycle Efficiency of Natural Gas Storage Water Heater



Source: Reducing Source Energy in Commercial Buildings (January 2014)

Full-Fuel-Cycle Efficiency of Electric Resistance Storage Water Heater

Source: Reducing Source Energy in Commercial Buildings (January 2014)

External Factors Influencing Direct Use of Natural Gas and Propane

O Opportunities

Inflection point for recognition of source energy benefits from direct use of natural gas
- Fuel-blind source energy metrics in codes and standards
- Rational fuel switching in EE programs

Benchmarking legislation using EPA Portfolio Manager®

Alignments with other stakeholders
- Environmental benefits
- Operating cost savings

T Threats

"Renewable power-ready" all-electric buildings

Net zero energy building initiatives

Fossil fuel reduction legislation

Declining gas use per building

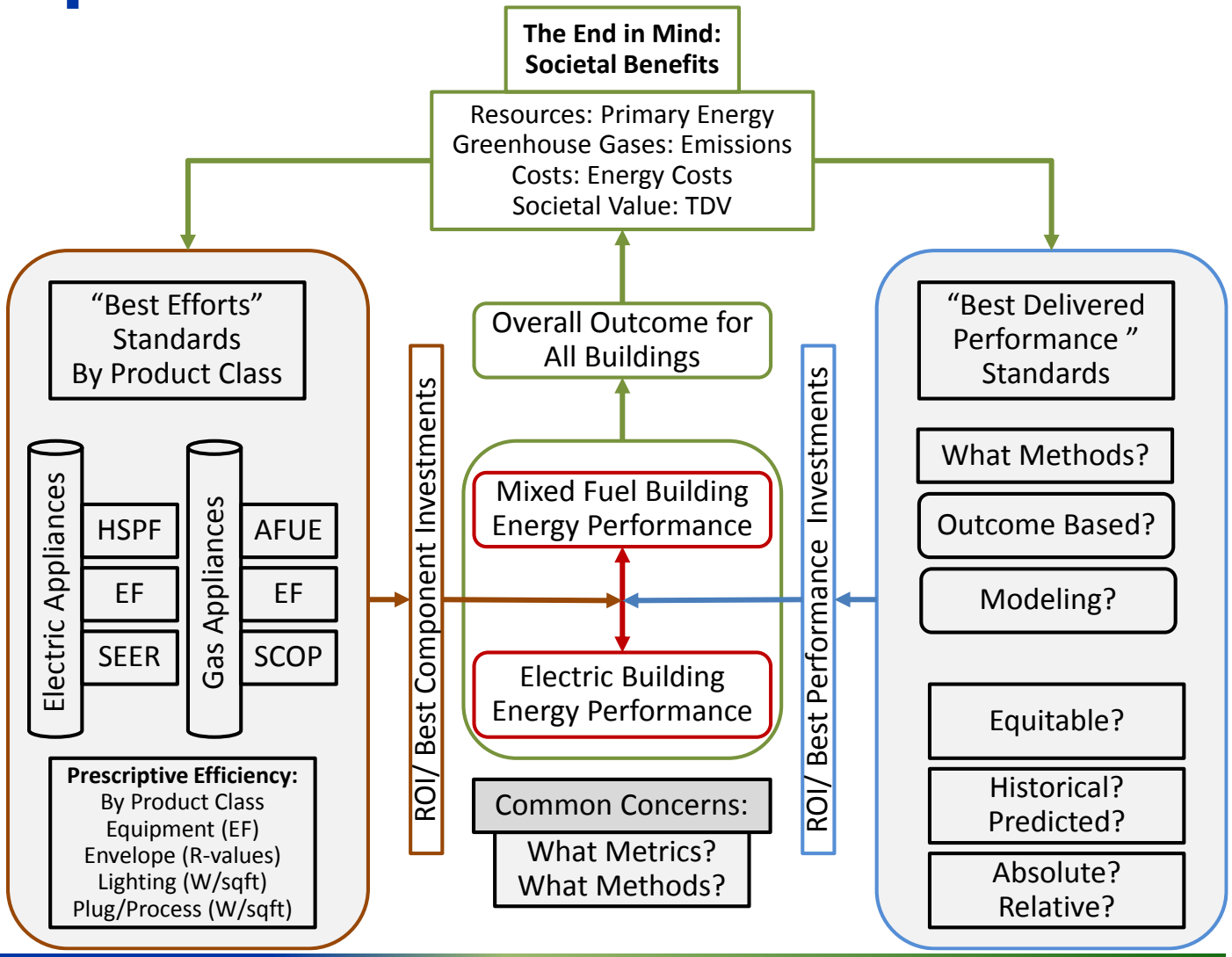
Executive orders, agencies, and appointments

Court rulings

Owner Investments Impact Natural Resources and the Environment

- Owners impact natural resources and the environment every time they make a technology investment choice
  - If owners don't use the energy, it will not be supplied
  - Owners have control over their investment decisions
- Standards that drive owners to make poor building energy investment choices cause negative impact on natural resources and the environment
  - Increased consumption of higher impact energy
  - Decreased consumption of lower impact energy
  - Net increase in negative impacts

Energy Standards Are Extremely Complex



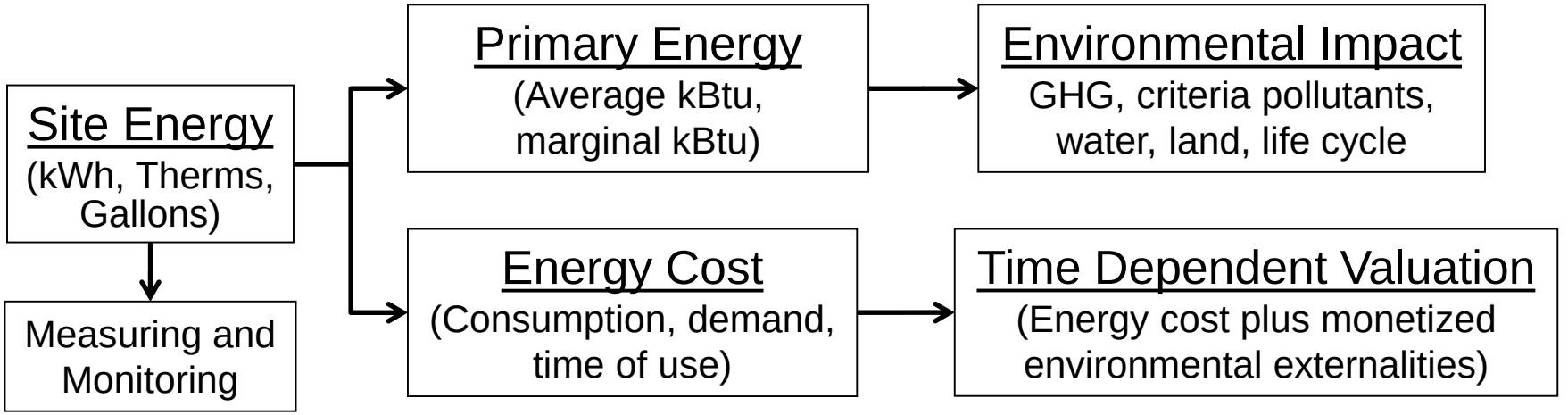
Questions

- What is the primary intent of the initiative?
- What metrics, methodologies, factors, and values best achieve the primary intent with minimal unintended consequences?
  - Is it more equitable to set a single performance target for ratings, comparisons, or benchmarking for an individual building? If so, how should it be done?
  - Is it more equitable to set a “best components” efficiency target for an individual building? If so, how should it be done?

Energy Standards Are Challenging to Develop Fairly

- Selecting and using fair criteria is complicated
  - Multivariate, interdependent parameters
    - Use, location, orientation, size, components
    - Envelope affects mechanical systems
    - Lights and internal loads affect heating and cooling
  - Multiple, conflicting objectives with different priorities
    - Significant market impact, market transformation
    - Equitable, transparent, defensible
    - Easy to use, adoptable, enforceable
    - Balancing competing stakeholder interests
  - Different measures lead to different outcomes
    - Efficiency, consumption, environmental impact
    - Alignment with equitable primary intent

Different Metrics and Methods Needed Depending on Primary Intent



- Site energy is needed when the primary intent focuses on measuring and monitoring, and is the essential starting point for converting to energy costs, primary energy, and greenhouse gas emissions attributable to design options or building operation.
- Energy cost is needed when the primary intent focuses on economic objectives.
- Primary energy is needed when the primary intent focuses on natural resources, the environment, or other societal impacts of energy use.
- Environmental impacts need supplemental metrics using factors that convert site energy to primary energy and associated greenhouse gas emissions or other impacts.

Similar Energy Metrics Lead to Different Results

- Energy efficiency, energy consumption, normalized consumption are all different metrics
  - Efficiency = energy out / energy in (%)
  - Consumption = energy used (kWh, therms)
  - Normalized consumption = energy used per normalizing metric (kWh/ft^2/yr, kWh/person/yr)
- Choice of metric can lead to different results
  - Energy efficiency leads to “best efforts” results
    - Component focus, “bottom up” accounting
  - Energy consumption leads to “best performance” results
    - Total and normalized have different “top down” accounting

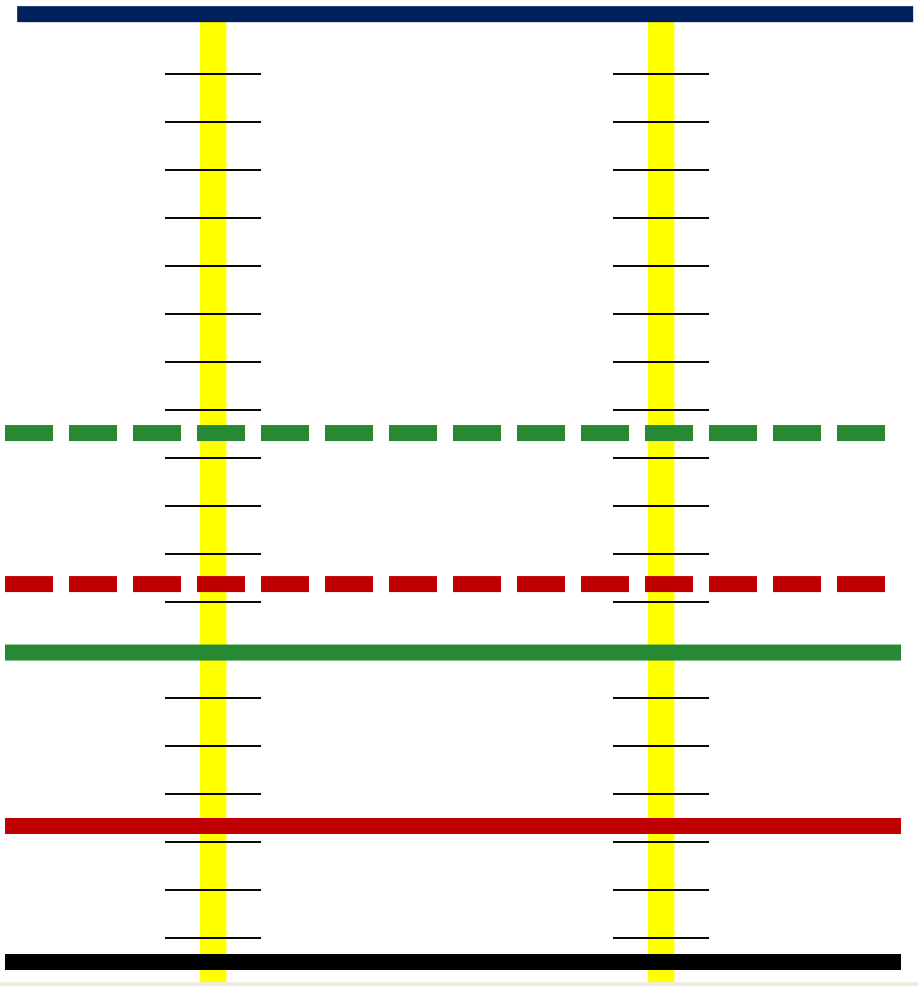
Choice of Many Different Boundary Conditions Adds Further Complexity

- Efficiency, consumption, normalized consumption can be used with many boundary conditions
  - Energy cost (average, marginal, time of use, time dependent valuation, life cycle costs)
  - Primary energy, source energy, full-fuel-cycle energy (average, marginal, time of use)
  - CO_2 emissions, CO_2e emissions (average, marginal, time of use)
- Each boundary condition will yield a different end result. It is critical to choose carefully to minimize unintended consequences and avoid harm.

Changing Energy Codes Landscape

- Inflection point for recognition of source energy benefits from direct use of natural gas
  - Fuel-blind source energy metrics in codes and standards
  - Rational fuel switching in EE programs
- Benchmarking legislation using EPA Portfolio Manager®
- Alignments with other stakeholders
  - Environmental benefits
  - Operating cost savings

Evolution of Building Energy Codes



Net Zero Use

New “Beyond Code”

New Minimum Code

Original “Beyond Code”

Original Minimum Code

Average Buildings

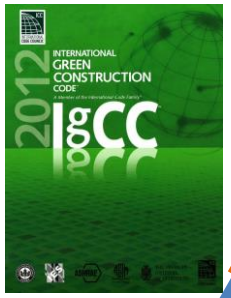
LEED and Green Globes

- LEED, or Leadership in Energy & Environmental Design, is a green building certification program from the US Green Building Council.
- Green Globes is a green building certification program from the Green Building Initiative.
- To receive LEED or Green Globes certification, building projects satisfy prerequisites and earn points to achieve different levels of certification. Prerequisites and credits differ for each rating system and between US GBC and GBI.

LEED, Green Globes, ICC 700, IgCC, and ASHRAE Standard 189.1

- Energy is one of many criteria for certification
- LEED, Green Globes, ICC 700 differ from IgCC, Std. 189.1
  - Menu of options, several certification levels (e.g., silver, gold, emerald)
- IgCC and 189.1 provide code-minimum green building compliance requirements
  - ASHRAE, ICC, USGBC agreement for next version
  - 189.1 provides technical content, IgCC adds administrative language, LEED adds more options
- ICC 700 (Residential) similar to LEED approach

Source Energy-Based Building Energy Codes and Standards



ICC 2015 International Green Construction Code

ICC 2015 International Energy Conservation Code

ASHRAE Standard 189.1
Design of High-Performance, Green Buildings

Source Energy-Based Codes & Standards

ASHRAE Standard 105
Determining, Expressing, and Comparing Building Energy Performance and GHG Emissions

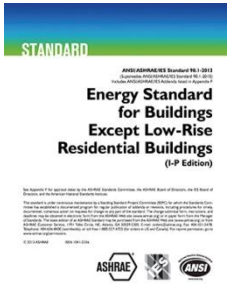
ASHRAE Standard 90.1
Energy Standard for Commercial Buildings

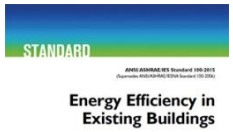
ASHRAE Standard 100
Energy Efficiency in Existing Buildings

Source energy-based

Energy Cost, Single Baseline

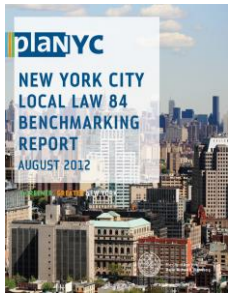
Site Energy, Single Baseline





Source Energy-Based Government Initiatives

DOE Better Buildings Challenge Program

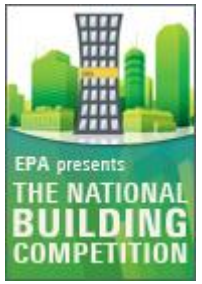


NYC Law Reporting Energy and Water Use

Source Energy Government Programs

EPA Energy Star Buildings Program

Portfolio Manager
Target Finder



DOE Home Energy Score Tool

Washington Law Reporting Energy and Water Use

CERTIFICATION OF ENROLLMENT

ENGROSSED SECOND SUBSTITUTE SENATE BILL 5854

Chapter 423, Laws of 2009

61st Legislature
2009 Regular Session

CLIMATE POLLUTION REDUCTION--ENERGY EFFICIENCY

EFFECTIVE DATE: 07/26/09

DOE Superior Energy Performance Program

Superior Energy Performance
Measurement and Verification Protocol for Industry

November 19, 2012

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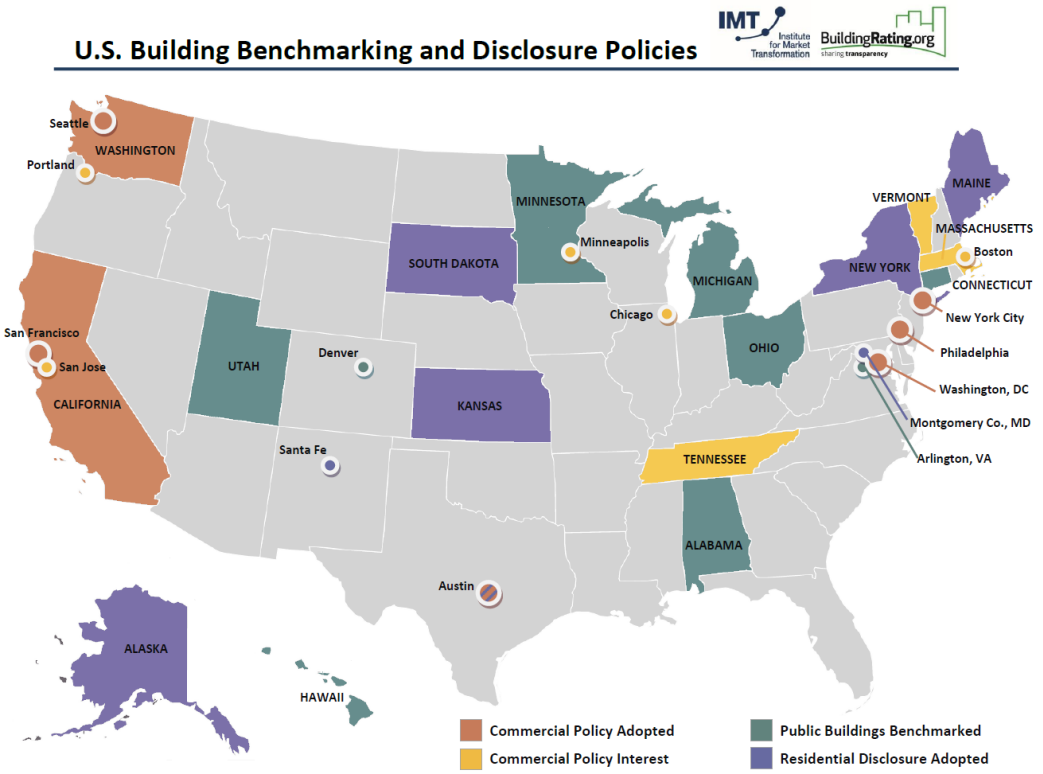
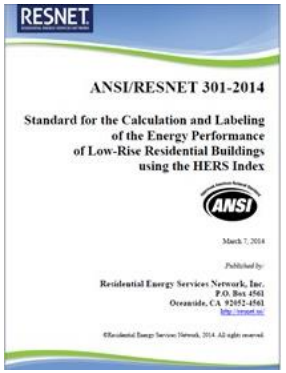
US Buildings Benchmarking and Disclosure Legislation

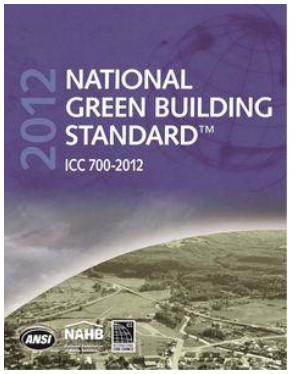
- Commercial and public buildings
  - Portfolio Manager® methodology
  - Gaining traction throughout the US
- Residential
  - Energy bills for Transactions
  - HERS Index for asset rating



HERS Index, NAHB Green Standard, Energy Star Homes

- RESNET HERS Index (ANSI/RESNET 301-2014)
  - Separate criteria for gas and electric homes
  - Gaining market traction
- Residential Green Standard 700 (under revision)
  - Based on IECC (separate criteria for gas and electric)
  - Separate energy cost improvements in performance path
  - Points for high efficiency natural gas options
- EPA Energy Star Homes
  - Separate criteria for gas and electric homes
  - Energy Star appliances
  - RESNET HERS Index performance path

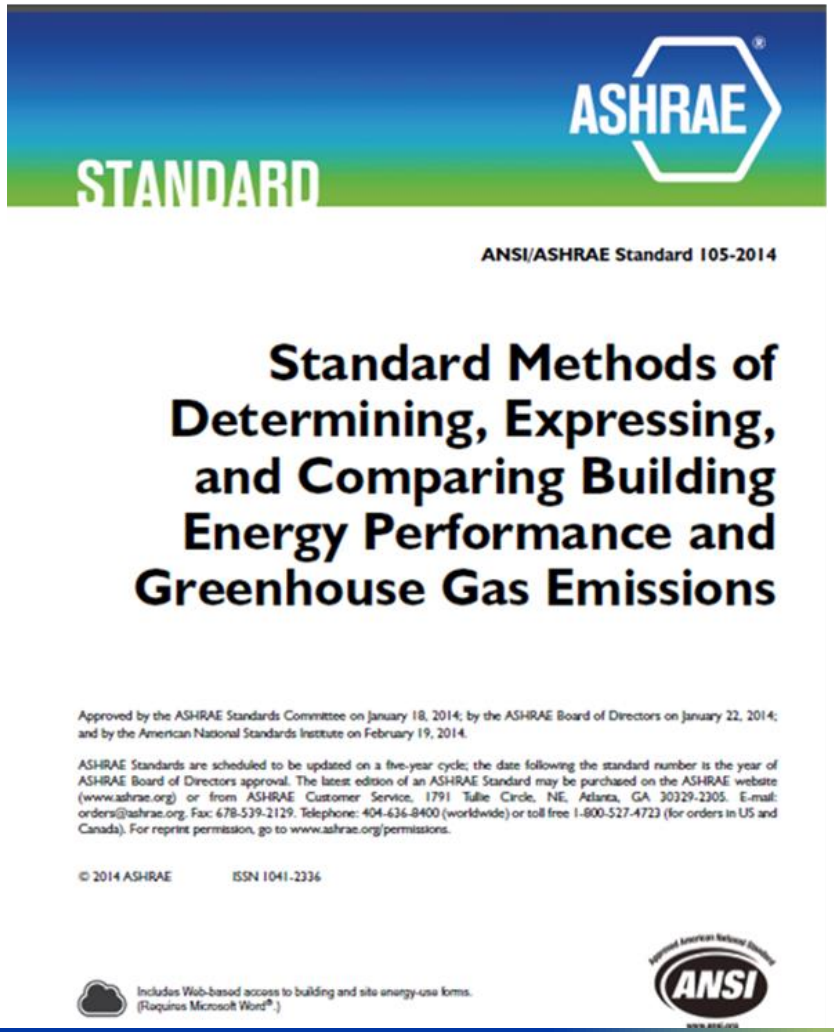




ASHRAE Method of Test Standards

- Technical Committees
  - Hydronic & Steam Heating Equipment & Systems (TC 6.1); Central Forced Air Heating & Cooing Systems (TC 6.3); Water Heating (TC 6.6); Fuels & Combustion (TC 6.10); Cogeneration Systems (TC 1.10)
- Method of Test Standards
  - Furnaces (103), Water Heaters (118.1, 118.2), Combo Systems (124), Boilers (155), µCHP (204)

ASHRAE Standard 105-2014 Has Source Energy and GHG Provisions



- Average, marginal source energy, GHG emission compliance requirements
- Reference standard for codes, standards, policies
  - IgCC-2015
  - ICC 700-2015
  - ASHRAE Standard 100-2015, 189.1-2017
  - DOE Zero Energy Building definition

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ASHRAE Standard 100-2015 Is the First Consensus Standard to Use Site Energy

- Technical appeal upheld October 2014
  - Single baseline site energy-based compliance requirement for all buildings is technically flawed
  - Compliance will be significantly more difficult for a mixed fuel building than for an all electric building
- Site energy-based standard published February 2015
  - No changes to normative provisions
  - Converted to SSPC (continuous maintenance)
  - Task groups formed to address flaws

Metric and Methodology Example for a Typical Single Family Home

2,171 SF Single Family Home									
	Site Energy (Mbtu)	Source Energy (Mbtu)	Energy Cost ($)	CO_2e Emissions (1000 lb)	HERS Index	Site EUI (kBtu/SF)	Source EUI (kBtu/SF)	ECI ($/SF)	GHGI (klb/SF)
Chicago									
Gas Heat/WH	134	200	1,534	29	100	62	92	0.71	13
Res. Heat/WH	107	352	3,594	57	146	49	162	1.66	26
Heat Pump	73	241	2,456	39	100	34	111	1.13	18
Target					NA	46	94	0.88	NA
Atlanta									
Gas Heat/WH	88	153	1,308	23	100	40	71	0.60	10
Res. Heat/WH	71	229	2,401	37	129	33	105	1.11	17
Heat Pump	56	178	1,867	29	100	26	82	0.86	13
Target					NA	33	68	0.50	NA

Metric and Methodology Example for a Typical Office Building

30,000 SF Office								
	Site Energy (Mbtu)	Source Energy (Mbtu)	Energy Cost ($)	CO_2e Emissions (1000 lb)	Site EUI (kBtu/SF)	Source EUI (kBtu/SF)	ECI ($/SF)	GHGI (klb/SF)
Chicago								
Gas Heat/WH	1,752	3,707	28,954	5,665	58	124	0.97	189
Res. Heat/WH	1,537	5,054	43,279	8,162	51	168	1.44	272
Heat Pump	1,141	3,751	32,123	6,058	38	125	1.07	202
Target					48	122	0.95	NA
Atlanta								
Gas Heat/WH	1,170	3,148	26,812	499	39	105	0.89	17
Res. Heat/WH	1,105	3,536	31,134	571	37	118	1.04	19
Heat Pump	1,000	3,198	28,158	516	33	107	0.94	17
Target					42	114	0.92	NA

Net Zero Energy (NZE) Homes Issues

- Policy movement promoting NZE
- Several definitions for net zero energy, but site energy definition is prevalent
  - Bias toward all-electric buildings to achieve net zero site energy
  - No role for direct gas use based on site efficiency
- Potential role for direct gas use with source energy, cost, TDV*, or emissions definition
  - High efficiency components, structure first priority
  - Natural gas direct use can reduce PV array size and cost compared to all-electric building with these metrics
  - First priority is net zero electricity

* TDV = time-dependent valuation; used in CA building codes

NIBS/DOE Zero Energy Buildings Definition

- Definition in National Institute of Building Sciences (NIBS) draft report (published 11/26/14)
  - Zero Energy Building (ZEB) – an energy-efficient building where the actual annual source energy consumption is balanced by on-site renewable energy.
- DOE Request for Information (comment period closed 2/20/15) on issues associated with definition
- Focus of potential changes is on source energy conversion factors (full-fuel-cycle instead of EPA Portfolio Manager boundary condition)

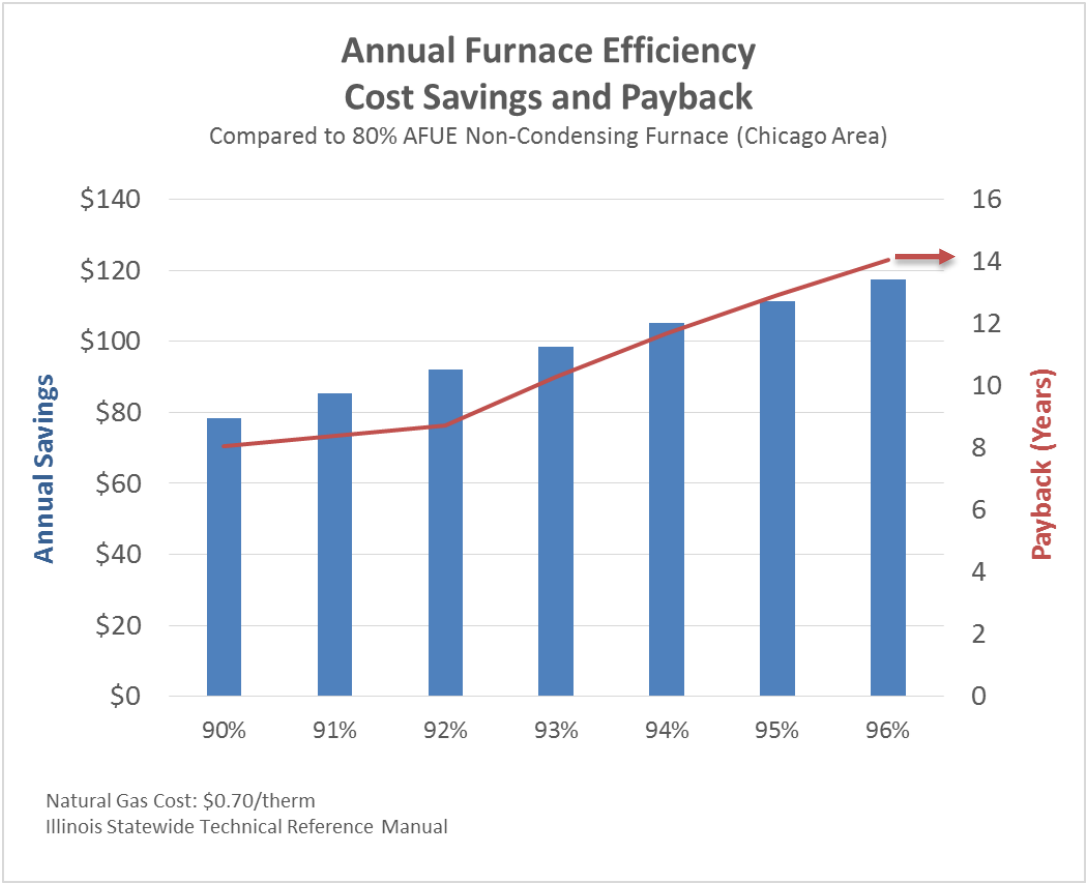
Net Zero Energy Buildings Activities

- GTI technical support to APGA and AGA
- Gas industry outreach to New Buildings Institute, other stakeholders
- AGA ZEB Workshop at GTI Summer 2015, for gas industry, NBI, others
- Advanced gas technologies (SMP, UTD)
  - Single thermal source for heating, cooling, water heating (e.g., combo units)
  - Smaller capacity heating and cooling systems
  - Technologies with COP>1.0 (e.g., Gas Heat Pumps for water heating, space conditioning)

Furnace Efficiency:

Example Economic Benefits

Utility efficiency programs help reduce condensing furnace first costs by 20-25% and lower payback periods by 1-3 years through upfront incentive rebates.



Efficiency Requirement	Rebate
≥ 97% Annual Fuel Utilization Efficiency	$400
≥ 95% Annual Fuel Utilization Efficiency	$300
≥ 92% Annual Fuel Utilization Efficiency	$200

AFUE	Installed Cost	Cost Premium
80%	$2,011	
90%	$2,641	$630
91%	$2,727	$716
92%	$2,813	$802
93%	$3,025	$1,014
94%	$3,237	$1,226
95%	$3,449	$1,438
96%	$3,661	$1,650

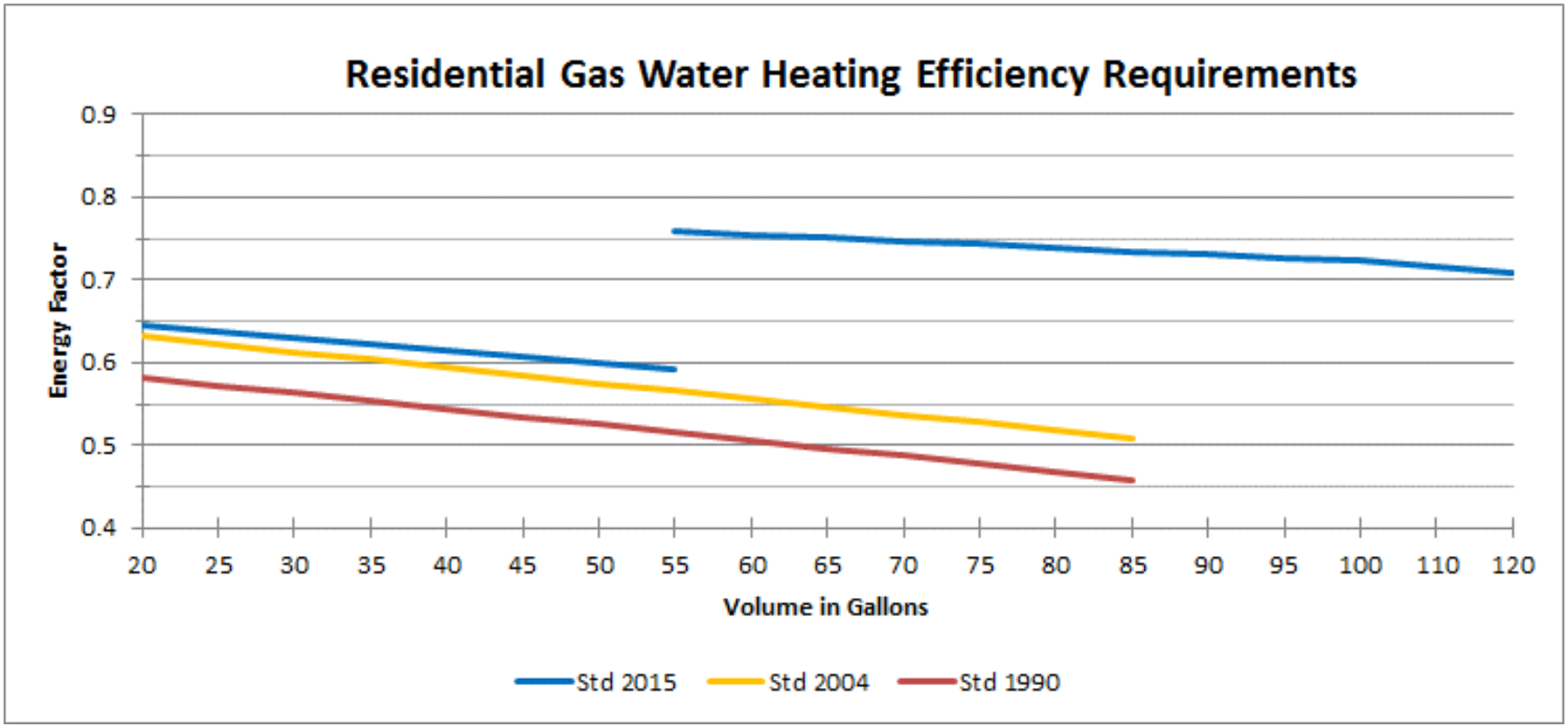
DOE Residential Furnace Efficiency Proposed Rulemaking

- DOE published a proposed furnace efficiency standard on 3/12/15; 90 day public comment period ends 6/10/15.
  - Proposed 92% AFUE (condensing furnace) standard nationwide, effective 5 years after final rule is published
  - AGA and APGA funding GTI to conduct technical analysis; AHRI and SoCalGas are conducting independent technical analysis
  - Parametric analysis focusing on technical support document and accompanying life cycle cost & national impact analysis
  - Understand potential unintended consequences and possible negative lifecycle cost impacts on some natural gas customers

DOE Furnace NOPR Activities

- Technical Analysis
  - Conduct parametric analysis focusing on technical and logical flaws in technical support document and accompanying LCC & NIA spreadsheets
  - Coordinate technical analysis and results with AHRI contractor and Laclede staff
  - Provide technical questions at DOE public meeting(s)
- Stakeholder Interactions
  - AGA Sustainable Growth Committee, Furnace working group, APGA members
  - AHRI, ACCA, NRDC, ACEEE, ASE, States, others

Residential Gas Water Heating Efficiency Standards



Residential Clothes Dryers Primary Energy Performance

Dryer Type:	Electric	Natural Gas
Federal Minimum Efficiency Rating:	3.73 EF	3.30 EF

EF = Energy Factor = pounds of clothes per kWh

What are the primary energy efficiencies if each dryer type (assuming primary energy efficiency of 34% for electricity & 92% for natural gas)?

Electric: 3.73 lb/kWh ÷ 3,413 Btu/kWh × 0.34 ×100,000 Btu/therm = **37 lb/therm**

Gas: 3.30 lb/kWh ÷ 3,413 Btu/kWh × 0.92 ×100,000 Btu/therm = **89 lb/therm**

Gas to Electric Primary Energy Efficiency Ratio: 89 lb/therm ÷ 37 lb/therm = **2.4/1**

Conclusion: Natural gas dryers at present Federal minimum efficiency levels dry 2.4 times as many clothes as electric dryers for the same primary energy consumption

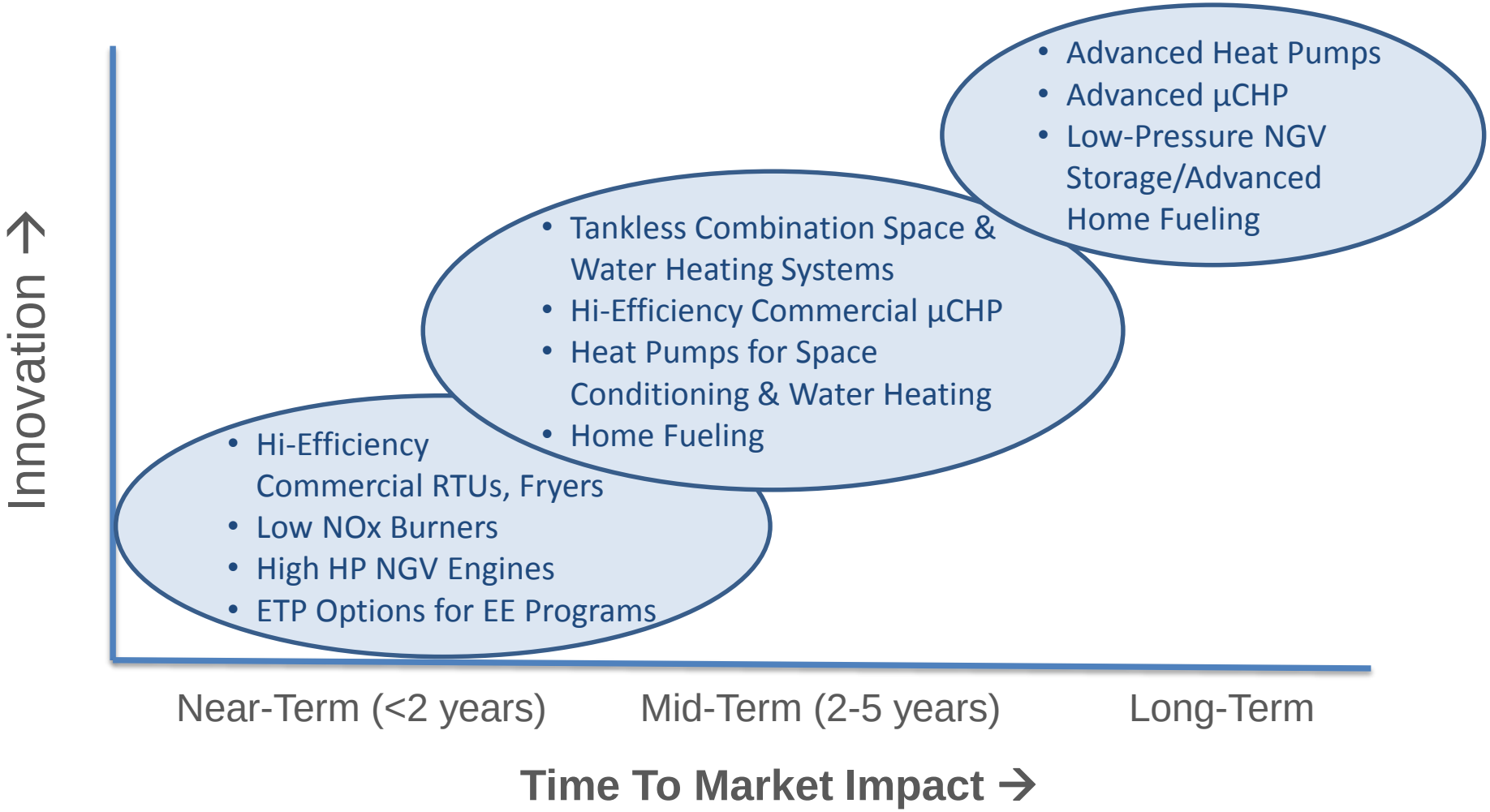
Source: Laclede Gas

GTI's Energy Utilization RD&D Program

Five Areas of Focus for Efficient, Clean Uses of Natural Gas

Highly Efficient Appliances (Including over 100% efficiency)	• Combination Space/Water Heating Systems • Gas Heat Pumps (Space Conditioning, Water Heating) • Ventilation, Indoor Air Quality • Commercial Foodservice		
Efficient, Clean Industrial Processes	• Efficient, low NOx Boilers • Advanced Process Heating • Heat Recovery Systems • Process Controls and Sensors		
Combined Heat & Power	• Integrated Commercial/ Industrial CHP Systems • Micro CHP Systems		
NGVs and Alternative Vehicles	• Ultra-Clean, Efficient HD NGVs • NGV Storage • Advanced NGV Fuel Stations • Home Fueling		
Renewable Energy	• Solar Thermal/Natural Gas Hybrid Systems • Bio-Methane Production, Clean-Up, and Use		

Utilization RD&D Portfolio Examples

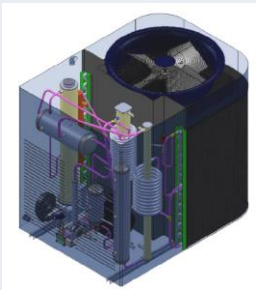


Time To Market Impact is related to the pace of technology development and speed of market adoption (which is highly dependent on value proposition and first cost premium).

Natural Gas Space Heating – Next Generation Options

- Heat Pump Technology – provides next-level increase in energy efficiency
  - Furnaces – up to 96-98%
  - Heat Pumps – 120 to 180% (possibly higher)
- However, first cost premiums are steep
  - Furnaces: $15-25 per kBtu/hr of heat delivered
  - Heat Pumps: Typically $100 per kBtu/hr or greater
    - About 5-10 times greater first cost
    - Technology advancements, manufacturing advancements, and greater production volumes needed

Natural Gas Residential & Commercial Heat Pumps

Gas Engine Heat Pumps (up to 15 ton capacity)	• IntelliChoice Energy • NextAire • Southwest Gas • Aisin	Heating COP ~1.3-1.7		
Absorption Heat Pumps	• Robur • Stone Mountain Technologies	Heating COP ~1.2-1.6		
Others	• ThermoLift (Stirling-type)	Heating COP ~1.5-1.8		

Includes commercially available and pre-commercial technologies. Main hurdles: first cost and increasing COP/efficiency (vis-à-vis electric heat pump and geothermal units).

Air-to-Water Gas Heat Pump

System Specifications: Direct-fired NH_3-H_2O single-effect absorption cycle with integrated heat recovery. Outdoor installation, hydronic heating, optional indirect-fired storage tank for combination space/water heating. Prototypes undergoing laboratory evaluation and modeling with SMTI, GTI, and OEM.

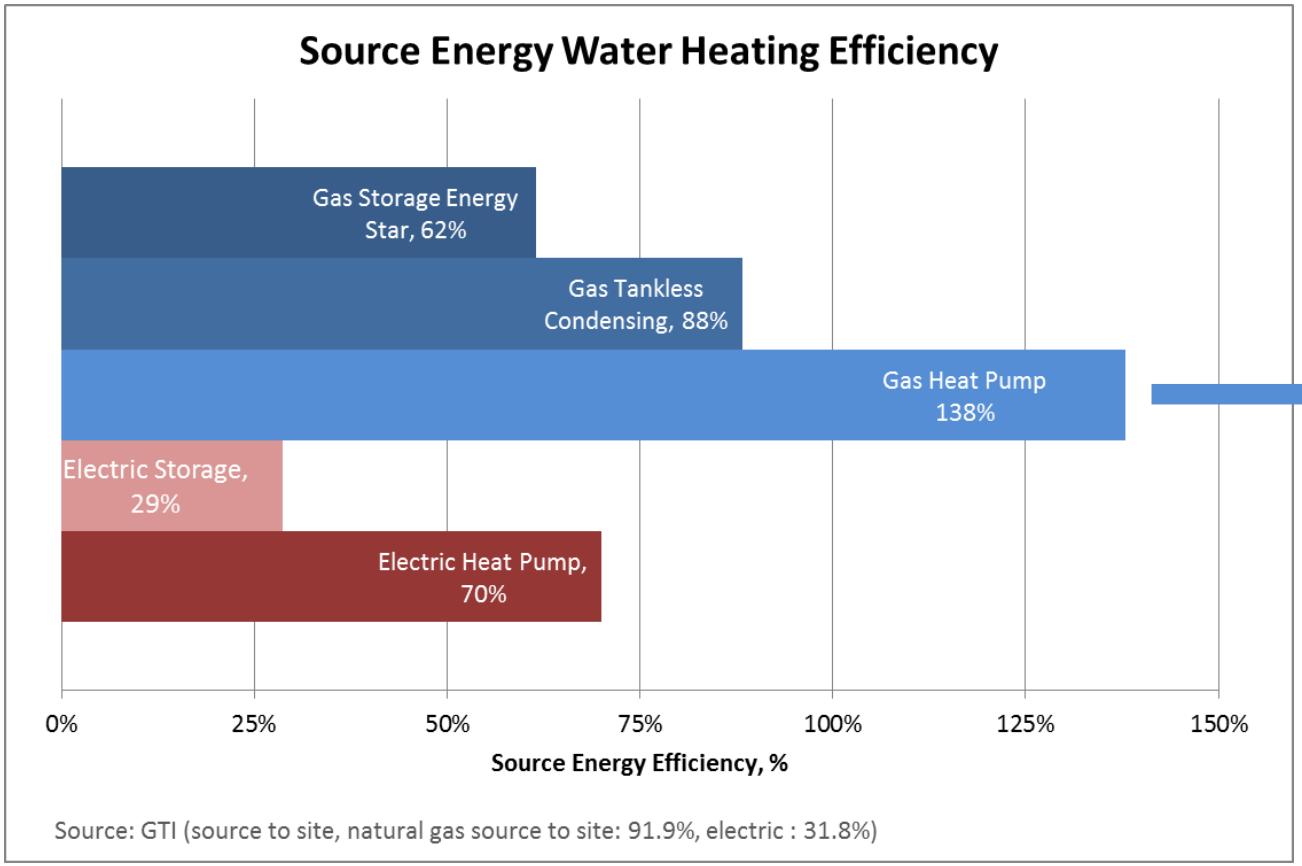
	Air-to-Water GHP	Units/Notes
Technology Developer	Stone Mountain Technologies	OEM support
Heat Pump Output	80,000	Btu/hr, with 3:1 modulation
Maximum Firing Rate	55,000	Btu/hr
Efficiency	COP > 1.4 at 45°F	Projected
Emissions (projected)	14 ng NO_x/J	From SMTI laboratory testing
Commercial Introduction	2018	Projected
Installation	Outdoors	Hydronic heating to radiators, in-floor, or forced air via air coil
Venting	N/A	Outdoors
Gas Piping	3/4”	
Consumer Cost Target	Competitive with condensing furnaces	

Information and graphics courtesy of Stone Mountain Technologies, Inc.

Gas-Fired Water Heating Solutions

- Condensing Storage Water Heaters and Tankless Water Heaters
  - Thermal efficiency up to 0.96 (rated)
  - Can be used as combination space and water heating systems
- Heat Pump Water Heaters
  - Energy Factor/Thermal Efficiency/COP > 1
  - Ammonia/water absorption
    - Pre-commercial field testing underway for residential/small commercial applications
- Hybrid solar thermal/natural gas systems
  - Water heating or combination space and water heating
- Micro CHP systems

Water Heating Efficiency Improvements With Natural Gas Heat Pumps

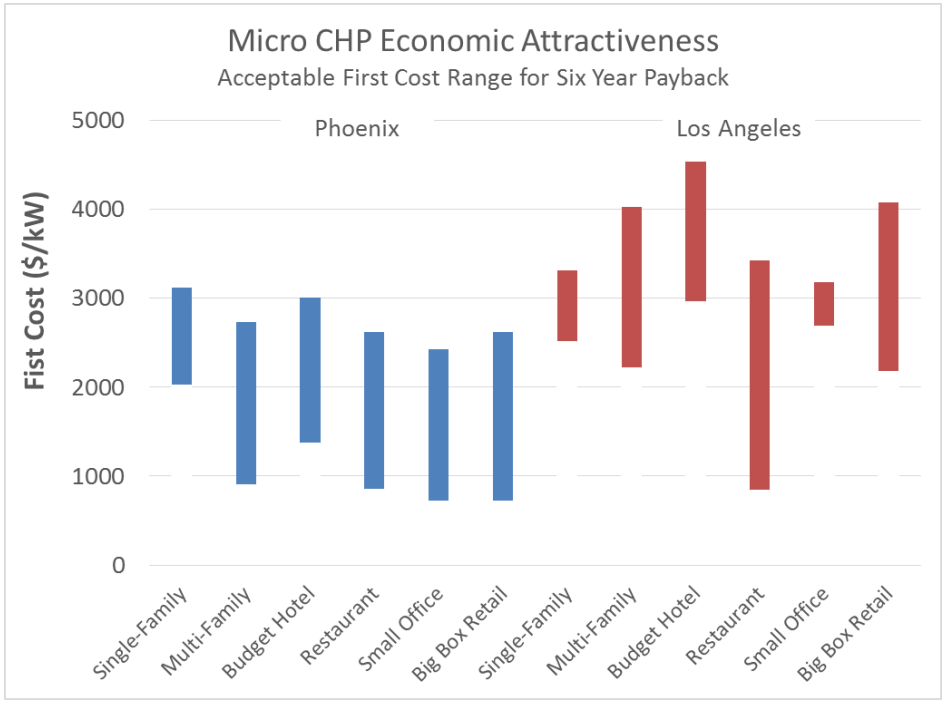


Natural gas heat pump water heater provides highest-rated source energy efficiency – over 50% advantage over electric heat pump water heaters.

U.S. Micro CHP

Status

- Several companies pursing U.S. micro CHP market
  - Significant efforts: Japan, Europe
  - High electric price regions most attractive early entry markets
  - Economic fit varies depending on residential/commercial use
  - Providing year-round heating and cooling highly desirable
  - Possible large value-added with emergency power capability
    - Not all units have this feature or sufficient capacity



First Cost Needed for 6-Year Payback About $1200-$4000/kW (Gas Prices $6-10/MMBtu)

M-TriGen PowerAire MicroCHP

> GTI evaluation of 6kW micro CHP system

- 6 kW power generation
- 50 kBtu/hr heat recovery for space heating or hot water
- 4 tons of cooling capacity
- Compact design
- Back-up power
- Grid inter-connection capability

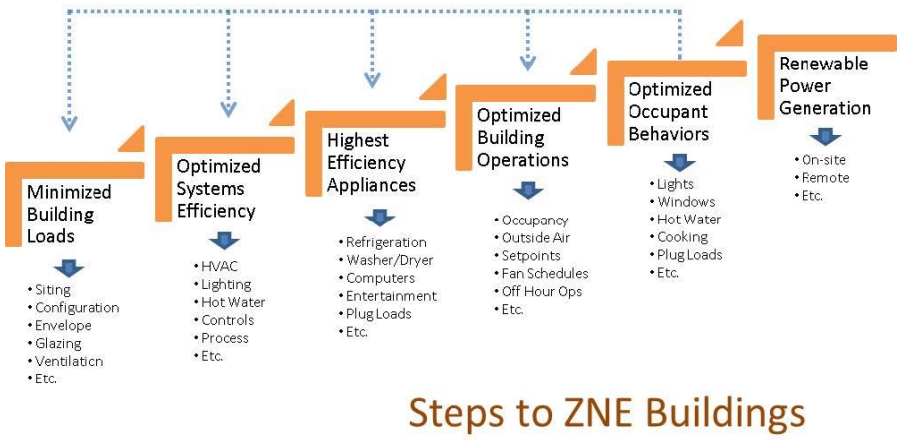
Air-to-Water Gas Heat Pump Laboratory Evaluation and Modeling

- Simulate performance in environmental chamber
  - Space heating
  - Combined space and water heating
- Develop performance curves
- Model performance in EnergyPlus for energy and utility cost savings

Low Btu Furnaces - Drivers

> Thermal performance of envelopes in single family new construction improving significantly
  - Heating and cooling loads are 30% below the 2009 IECC
  - Building America gas a goal to drive loads to 50% below the 2009 IECC
  - Zero Energy Ready and Zero Net Energy concepts are driving the regulators

> Growing multifamily sector a key target



Steps to ZNE Buildings

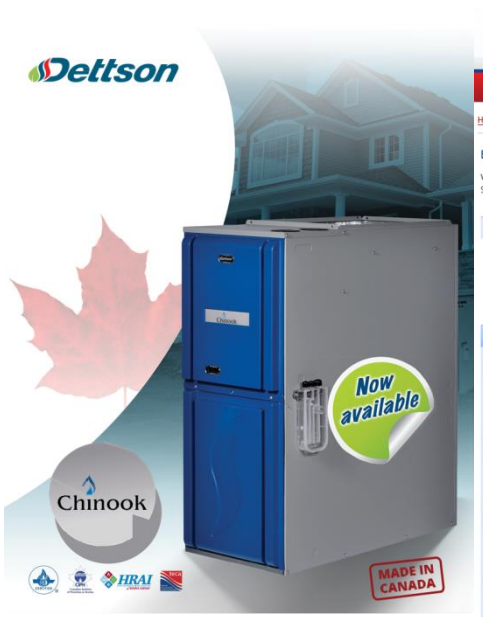
Source: Heshong Mahone Group, *Road to ZNE*

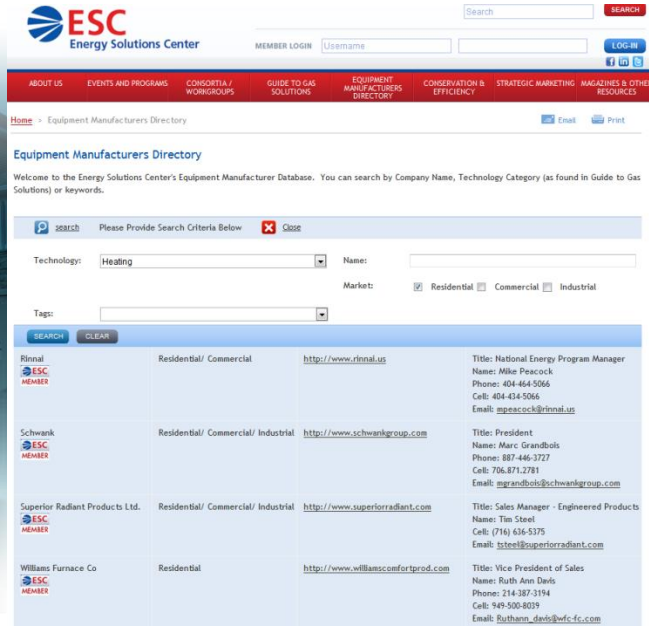
Low Btu Furnaces – Products and Resources

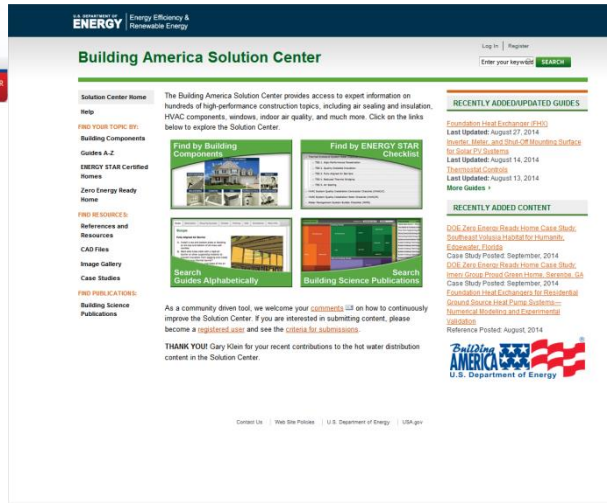
>Dettson Industries: http://dettson.com/en/products

>ESC: www.energysolutionscenter.org

>Building America: https://basc.pnnl.gov

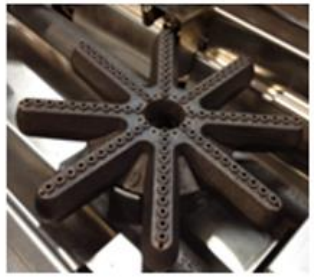
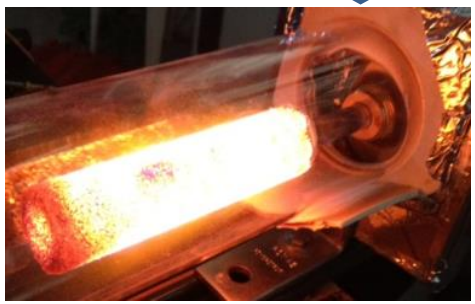


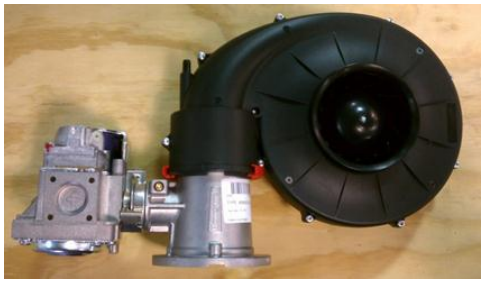




Commercial Foodservice: New Technology

- Efficiency
  - New burner materials
    - New materials such as metal mesh and metal foam for replacing standard drilled or punched port burners
  - Power burners vs. atmospheric
    - Converting standard atmospheric burners to power burners for better control of air to fuel ratios
    - Improved efficiency and emissions



Commercial Foodservice: New Technology

- Water Conservation
  - California initiative
  - Dish Machines
    - Low flow rinse valves
    - More efficient use of water for cleaning and rinsing
  - Wok
    - More efficient and better insulated burner designs to eliminate the need for cooling water

Multi-Family Solution Options

- Diverse market, diverse set of space heating solutions. What they have in common:
  - High efficiency
  - Emerging market with limited product availability and distribution
  - Unfamiliarity in market
  - Addresses builder preferences while promoting benefits and features that matter
  - Positioned to earn efficiency incentives
- Some solutions target low load dwellings, either mild climates and/or efficient construction market segment

Through wall packaged heating, cooling systems

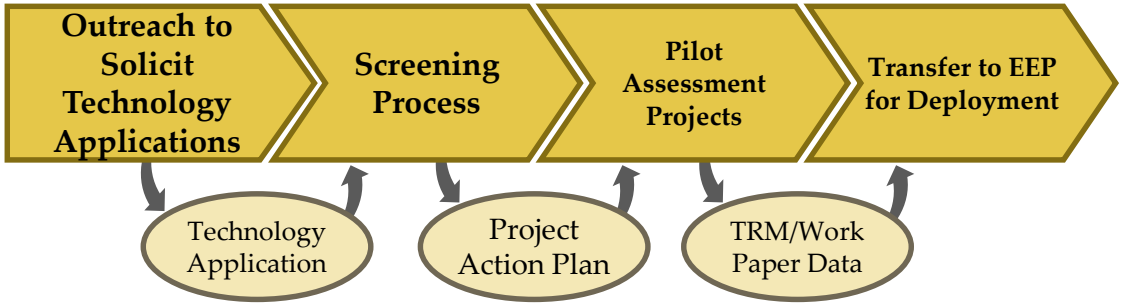
Combined Space and Water Systems

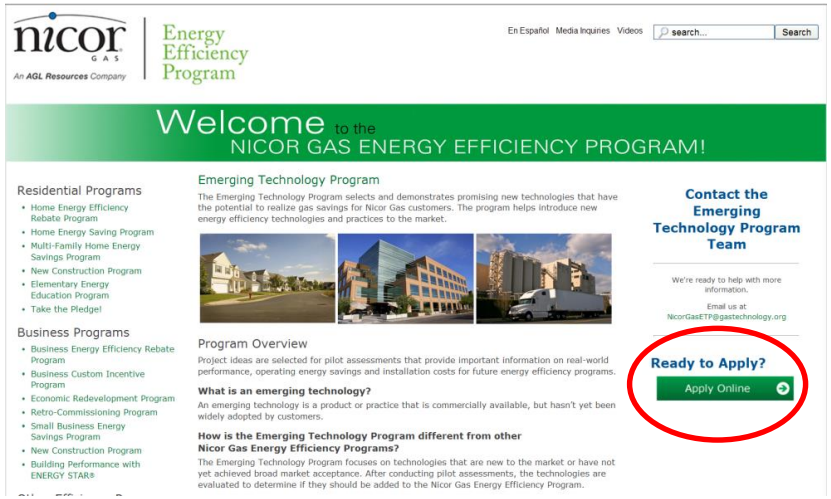
Low capacity 'right-sized' furnace

Hearth products with enhanced distribution

Nicor Gas
Emerging Technology Program

GTI implements the Nicor Gas ETP. Nicor Gas serves more than **2.2 million gas customers** across Chicagoland





70+ Applications

Received more than **70 applications** from manufacturers, sales representatives and contractors

12+ Pilot projects

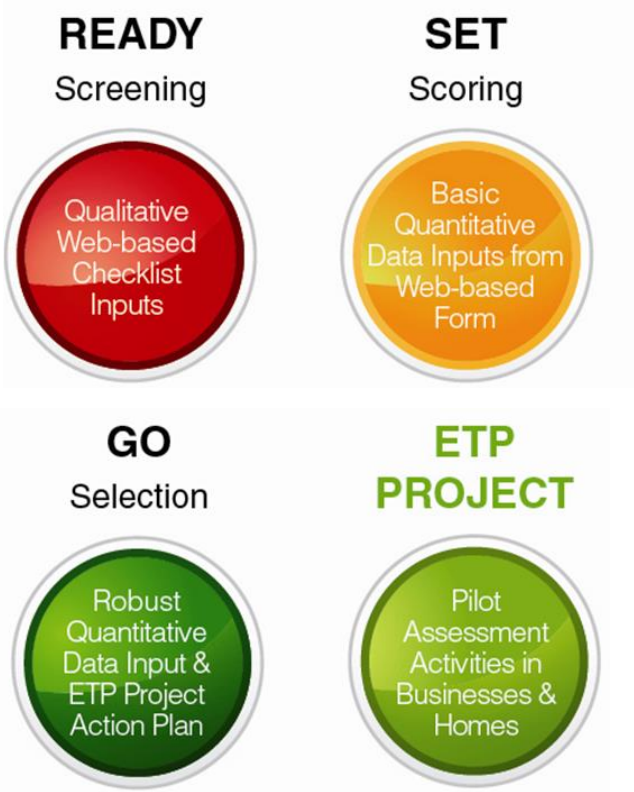
Launched more than a **dozen pilot projects** in residential, commercial and industrial markets

3 new rebates launched

Identified, evaluated and facilitated **3 emerging technologies** as new rebates through the Nicor Gas Energy Efficiency Program.

Nicor Gas ETP Application Scoring

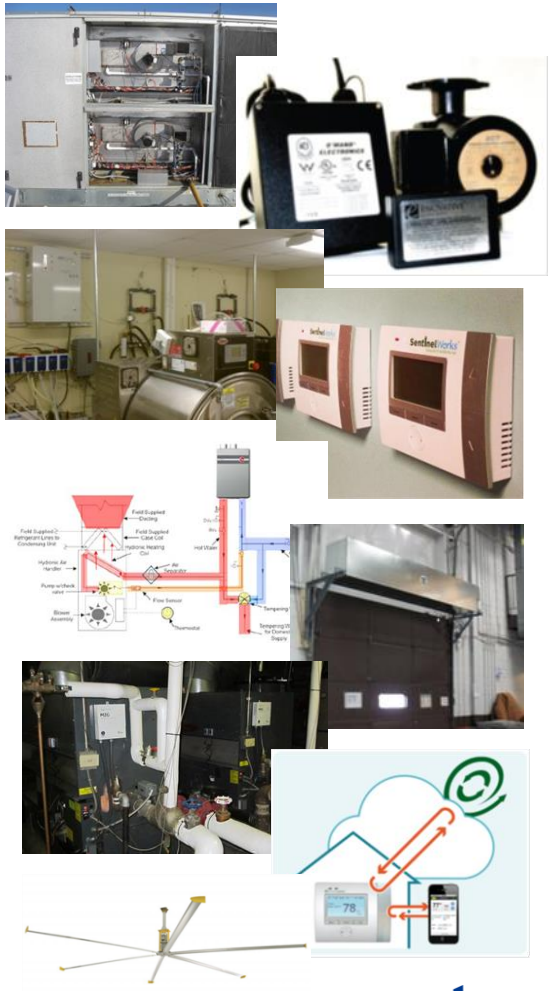
- Seven key criteria evaluated at **Set** and **Go** stages:
  1. Cost-effectiveness
  2. Gas savings potential
  3. Value to Nicor Gas portfolio
  4. Non-energy benefits
  5. Support/distribution in service territory
  6. Technological maturity
  7. Ease of implementation/market adoption



- Criteria are scored on a scale of 0-5
- Different weighting applied to each criterion
- Scores are totaled out of a possible 100 points to provide relative basis for prioritizing projects

Nicor Gas ETP Projects

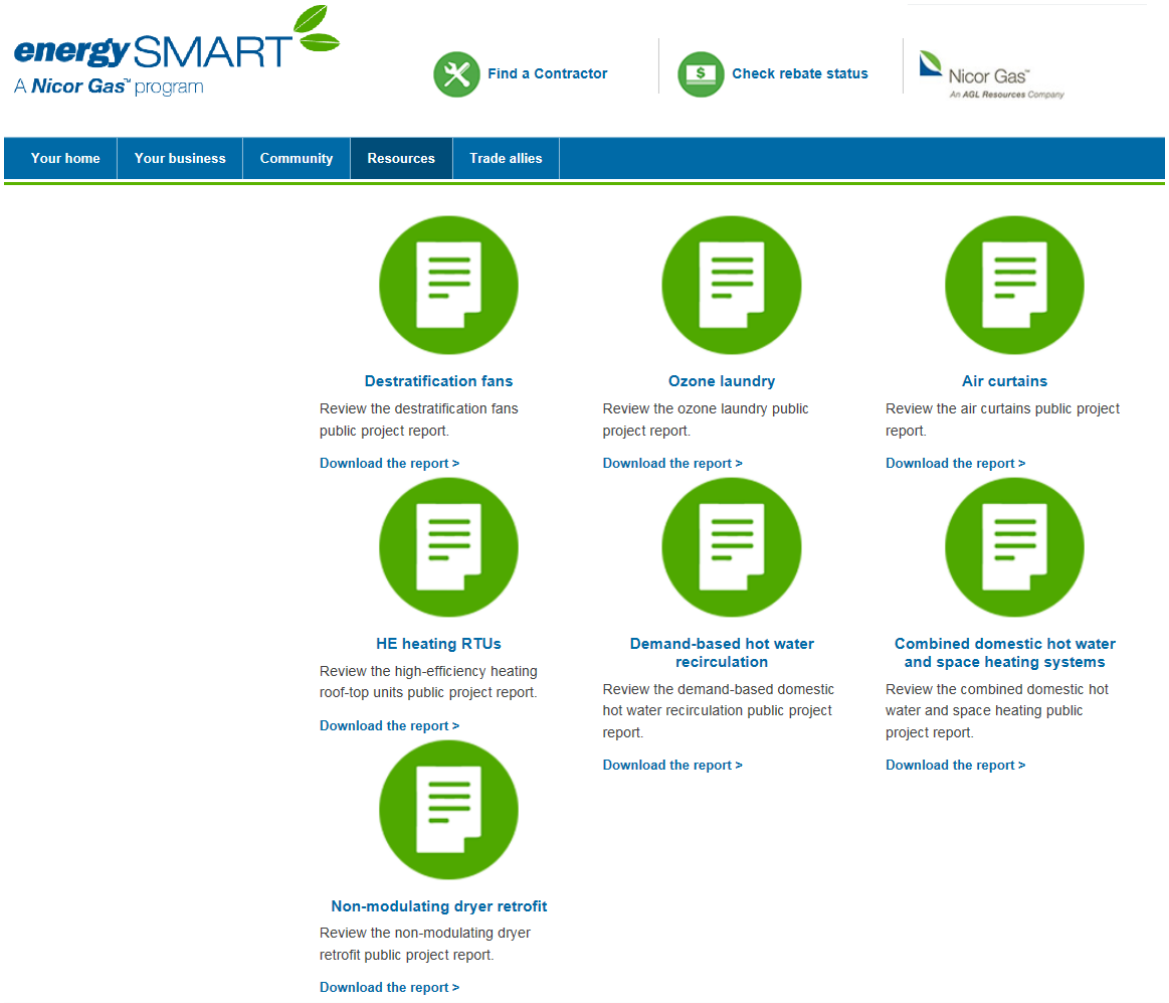
- Condensing Heating Rooftop Unit (RTU)
- On-Demand Multifamily DHW Recirculation
- Commercial Ozone Laundry
- Small Commercial EMS
- Residential Combined Space and DHW
- Commercial and Industrial Air Curtains
- Boiler Load Monitoring Controls
- Residential Smart Thermostat
- Commercial/Industrial Destratification Fans



Nicor Gas ETP Projects

- Wireless Steam Trap Monitoring System
- Commercial Dryer Modulating Gas Retrofit
- Commercial Dryer Moisture Sensor Retrofit
- Commercial Predictive EMIS
- Commercial Dynamic Air Balancing
- Residential Ozone Laundry
- Boiler Chemical Descaling Treatment
- Hydronic Heating HX Additive
- CFS Equipment Modulating Gas Retrofit

Nicor Gas ETP Project Reports



www.nicorgasrebates.com/resources/Emerging-technology

Natural Gas Industry Collaboration

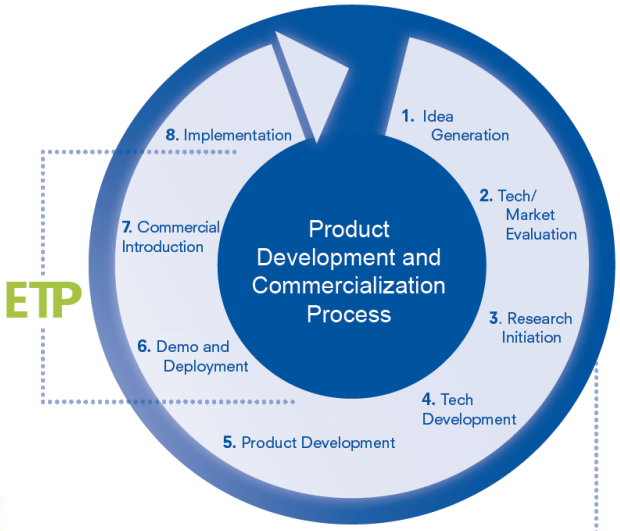
Emerging Technology Program

ETP Emerging Technology Program

> Gas Technology Institute led, utility supported, **North American collaborative** targeting **residential, commercial,** and **industrial** solutions

> ETP's principle goal is to **accelerate** the **market acceptance** of emerging gas technologies

Alagasco AN ENERGEN COMPANY
Ameren FOCUSED ENERGY. For Life.
APGA Research Foundation
ATMOS energy
CenterPoint Energy
CNG
DTE Energy
ENBRIDGE
Nicor Gas An AGL Resources Company Energy Efficiency Program
INTERMOUNTAIN GAS COMPANY
National Fuel
neea
NW Natural We grew up here.
NYSEG
PG&E Pacific Gas and Electric Company
QUESTAR Gas
uniongas A Spectra Energy Company
SDGE connected A Sempra Energy utility
Southern Connecticut Gas Service First! A UIL HOLDINGS COMPANY
Southern California Gas Company A Sempra Energy utility
TECO ENERGY



ETP activities are "beyond development" stage: Field Testing, Demonstration, Pilot Programs, and Deployment – a focused effort to ensure market acceptance of next-generation emerging technologies

gti

ETP National Pilot
Residential HE Combo Systems

- 94 EF condensing tankless water heater + hydronic air handler (Rheem pictured)
  - Improves utility/customer value proposition for water heating by piggy-backing on larger space heating load
- Multi-unit demonstrations/pilots in IL, NY, CT, and CA
  - At least 25 residencies with full data acquisition systems
- Measured field performance, energy savings, cost analysis, and customer reaction
- Contractor technical/sales training, consumer messaging, and rebate program pilot
- GTI is investigating *combi* systems for oil or gas hydronic (e.g. radiator) replacements as well


Ferguson Heating & Cooling Presents

Rheem Tankless Pilot Program

Nicor Gas Emerging Technology Program is partnering with Rheem to offer a Pilot Program for a number of combination space and water heating systems. The system will utilize the Rheem Hydronic Air Handler powered by a Rheem Tankless Water Heater. You have been selected for an opportunity to participate in this Pilot Program. The program features lower first cost for equipment and incentives to you and your customers offered by Rheem and Nicor.

If you are interested in participating, you must attend our Pilot Meeting on October 18th. This meeting will include full details of the Pilot Program as well as training on the tankless water heater and air handler.

West Branch
Thursday, October 18th
4:00 p.m. to 7:00 p.m.
Light dinner included
515 Factory Rd.
Addison, IL 60101
please register by 9/28

Registration is required by September 28, 2012
Fax form below to (773) 279-2973

FERGUSON Heating & Cooling

❑ Yes, I will attend the Tankless Pilot Program Meeting on October 18th.
❑ No, we are not interested

Company: _____

Participant(s): _____

Phone: _____ Email: _____

Salesman: _____ Fax: _____

PARR
The Partnership for Advanced Residential Retrofit

Southern California Gas Company
A Sempra Energy utility

UTD
Utilization Technology Development

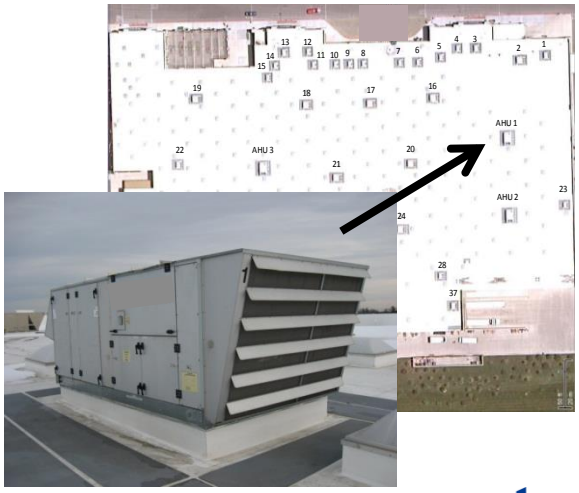
nicor GAS
An AGL Resources Company
Energy Efficiency Program

nyserda
Energy. Innovation. Solutions.

gti

Field Assessments
High Efficiency Gas PACs- RTUs

- Collaboration with NREL, DOE, **manufacturers**, **national accounts**, and utilities
- Large-scale monitoring shows **diverse runtimes for RTUs** and more therm use than energy models suggested
- **Dedicated outside air systems** (DOAS) **provide** high efficiency **market entry point** application
  - "big box" retail accounts with established DOAS vendors
  - high heating degree day (HDD)/heating load locations
  - 24/7 retail stores
- Retail partner projected $4,400 premium, = 4.1 years ROI @ 90%TE without incentives
- Northern climates see more than 2,500 therm savings/year/unit!



Condensing Heating DOAS Pilots in Big Box Retail Stores in IL and MN

- Nicor Gas ETP
  - Winter 2010/2011 baseline tests identified DOAS focus
  - Gas savings 11%, with added fan electricity for net energy cost savings of $1,444 (over 2,000 therms per unit annually)
- GTI NA ETP Collaborative
  - Condensing DOAS tests in winter 2013/2014 showed11% annual savings
  - Projected annual savings: similar but smaller due to differences in control schemes

Summary

- Natural gas critical part of future U.S. energy economy
  - Environmentally beneficial shift away from coal and oil, compatible with renewable energy
- Ongoing threats and opportunities affecting direct use of natural gas and propane in buildings
  - Stakeholder initiatives by ASHRAE, RESNET, ICC, DOE & EPA
  - Source energy progress; site-based ASHRAE Standard 100-2015
- New technology development portfolio
  - Near-term incremental, mid-term hybrid, long-term breakthrough
  - Evolving from economic to regulatory drivers
  - Technology, information, education, coordination with stakeholders

Thank You!

Neil Leslie
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Gas Technology Institute
Neil.leslie@gastechnology.org