2015

Dispatching Direct Use

ACHIEVING GREENHOUSE GAS REDUCTIONS WITH NATURAL GAS IN HOMES AND BUSINESSES

RICHARD MEYER
MANAGER ENERGY ANALYSIS & STANDARDS, AMERICAN GAS ASSOCIATION

November 11, 2015

Prepared by the American Gas Association
400 North Capitol Street NW
Washington, DC 20001
(202)-824-7000
www.aga.org

Principal Author
Richard Meyer
rmeyer@aga.org

Notice: In issuing and making this publication available, AGA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is AGA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstance. The statements in this publication are for general information and represent an unaudited compilation of statistical information that could contain coding or processing errors. AGA makes no warranties—express or implied—or representations about the accuracy of the information in the publication or its appropriateness for any given purpose or situation.

This publication shall not be construed as including, advice, guidance, or recommendations to take, or not to take, any actions or decisions in relation to any matter, including without limitation relating to investments or the purchase or sale of any securities, shares or other assets of any kind. Should you take any such action or decision, you do so at your own risk.

Contents

Introduction

This document serves as a resource to companies, policymakers, and other stakeholders to advance *direct use* of natural gas in homes and businesses as an emissions reductions tool.

Encouraging the increased use of natural gas by replacing electric or oil appliances with natural gas models can achieve significant carbon emissions reductions and should be considered among the suite of greenhouse gas emissions reduction tools.

> **DIRECT USE** REFERS TO NATURAL GAS USED FOR SPACE CONDITIONING, WATER HEATING, COOKING AND CLOTHES DRYING.

The opportunities for emissions reductions in buildings through the *direct use* of natural gas is well established in technical literature but often goes unrecognized by decision makers. This case rests on two facts. First, natural gas is a low-carbon fuel relative to coal and oil and can be used as a substitute. Second, the production and delivery of natural gas into buildings is much more efficient than grid-delivered electricity, which is still fossil-intensive with heavy losses at the power plant and though transmission lines. Even as the grid mix becomes cleaner during the coming years, natural gas *direct use* will remain a viable emissions reduction strategy.

This is why many states already have programs to encourage customers to switch to natural gas to improve energy savings or to reduce emissions. Some specifically incentivize the replacement of less efficient electric equipment with natural gas appliances to meet electric demand-side-management requirements, such as in Texas, Oklahoma and Washington. These gas utility efficiency portfolios, conversion programs, consumer education campaigns, and other efforts may be leveraged to count emissions reductions that are consistent with broader federal, state, and local environmental goals currently under consideration, such as the EPA Clean Power Plan (CPP).

As companies and the country continue to modernize the natural gas infrastructure base and connect homes and businesses to this system, new opportunities arise to achieve low-cost carbon emissions reductions by leveraging this existing infrastructure and the nation's abundant natural gas resources.

This document addresses these issues in three sections:

Section One provides the basis for reducing emissions from energy use by examining trends in building energy consumption and by comparing appliance efficiencies and carbon dioxide emissions in a way that allows for easy comparison of consumer options.

Section Two looks at gas utility activities already in place that encourage customers to switch to natural gas with the goal of increased energy savings and emissions reductions.

Section Three contains considerations for policymakers and stakeholders that may wish to use *direct use* as an emissions reduction tool or compliance option under the EPA Clean Power Plan.

If policy drives more efficient natural gas as a replacement for inefficient equipment and more carbon intensive fuels, the result will be lower emissions. The *direct use* of natural gas in homes and businesses, long recognized as a reliable and affordable energy source, should also be considered as a greenhouse gas reduction strategies at the local, state, and federal level.

1. Leveraging *Direct Use* of Natural Gas in Homes and Businesses to Reduce Emissions

The United States has undergone a transformational shift in the perceived role of natural gas. Once viewed as a scarce resource, North American natural gas is now recognized as an abundant low-cost fuel that serves as an essential component of a clean and secure energy portfolio. Today more than 70 million households and businesses in all 50 states utilize natural gas served by an infrastructure base that is unrivaled in the world. Local distribution companies in collaboration with policy makers are investing billions of dollars each year to modernize the nation's natural gas delivery infrastructure, making it safer and more reliable. At the same time many states are pursuing expansion efforts to connect unserved and underserved households and businesses. These investments are predicated on a recognition that access to natural gas enables economic and environmental benefits. But the full potential of natural gas as tool for greenhouse gas emissions reduction remains unrealized.

This document focuses specifically on natural gas *direct use* and its potential to reduce the carbon footprint of a buildings energy use. Natural gas is a low carbon fossil fuel. When used directly in homes or buildings for space conditioning and water heating applications, *direct use* can and should play a key role in achieving greater energy efficiency, reduce pollution, and lower greenhouse gas emissions all while generally reducing consumer utility bills. As states and the federal government pursue ways to reduce carbon dioxide emissions, the *direct use* of natural gas can and should be recognized as a low-cost emissions reduction tool.

This paper is intended to serve this vision in three ways. One, it provides a technical basis for recognizing and achieving carbon dioxide emissions reductions through the increased use of natural gas end use technologies in homes and businesses. Two, it describes the state of play with regard to natural gas utility programs that are designed to improve energy efficiency in homes and businesses. In some cases, those programs are specifically designed to remove inefficient electric appliances and replace them with natural gas. Third, it offers some considerations for companies and policymakers regarding integration into state and federal policy (specifically the EPA Clean Power Plan) aimed at reducing carbon dioxide emissions.

These three areas can help companies, policymakers, and other stakeholders recognize the role that efficient natural gas use can play in reducing overall greenhouse gas emissions.

1.1. Building Sector Consumption, Efficiency, and Emissions Trends

This section examines the trends in the residential building sector, noting in particular the rise in energy consumption and emissions in the sector and the role that increase in electricity consumption has played. Next this section inspects the energy trajectories of different end-use fuels. These trajectories are specifically the process energy efficiencies of different energy types starting with primary energy extraction, processing, transportation, conversion, and distribution, including a breakdown of the electric energy sources by primary fuel type. These *source-to-site* efficiency metrics can then be used in conjunction with end-use appliance efficiency to compare the *full-fuel-cycle* energy requirements of select residential appliances, space conditioning systems, and other end-use technologies, an approach which takes into account both appliance performance characteristics and differences in delivered energy requirements. Finally, this section compares the *full-fuel-cycle* efficiency and emissions for select residential space heating, water heating, and cooling systems. These elements provide the first step in a technically supportable case for leveraging natural gas for emissions reductions in many homes and businesses.

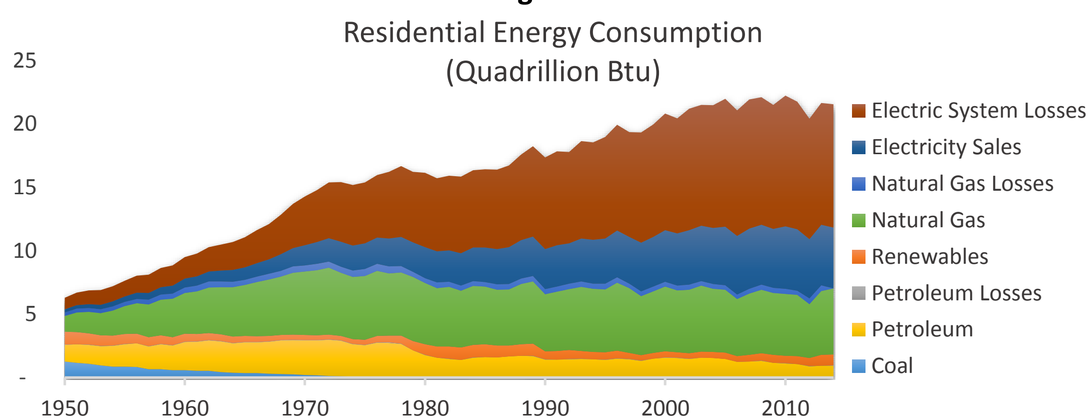
Buildings are a core driver of US energy use. The residential and commercial sector, which are comprised almost entirely of buildings, account for 40 percent of US primary energy consumption and 39 percent of carbon dioxide emissions.

Primary energy consumption has grown steadily as the US population has expanded, home sizes have increased, and consumers adopt more energy using devices and appliances. A new home today is more than 60 percent bigger than forty years ago. New appliances and devices are available for use. Cooling requirements have increased as households have migrated southward into warmer geographies. The United States, in general, is just using more energy.

Important to this view is not only end use energy, but also the requirements to deliver that energy to end users. Within this view, electricity has played a disproportionate role in shaping building energy usage during the past four decades.

When consumption is broken down by energy type, nearly all of the increase is in electricity usage and, importantly, the electric system *losses* associated with those sales. We define losses to include the energy lost during the conversion of primary fuel to electric energy, as well as transmission and distribution losses on the system as electric energy passes from a generation unit to and end user. This is consistent with the EIA definition of the same term. These electric system *losses* account for an astounding *half* of the primary energy consumed in the residential sector.

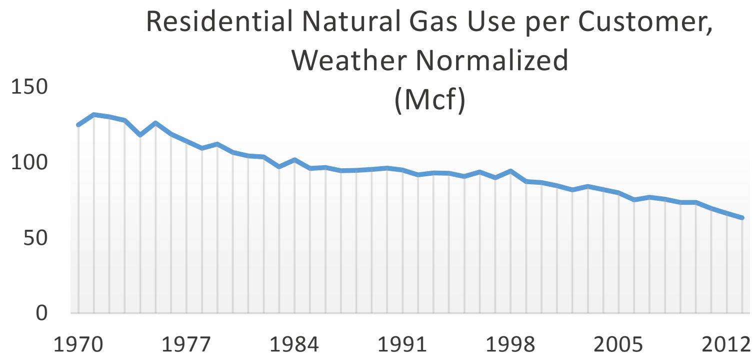
Figure 1



Electric system *losses* account for half the energy consumed in the US residential sector.
Source: EIA Monthly Energy Review; AGA calculations of natural gas and petroleum losses estimated from EIA data

By contrast, natural gas use during the past forty years has been relatively flat, even though the natural gas market has grown substantially during this time. Since 1970, more than 30 million more customers have been added onto the natural gas system. While the system has grown, the use of natural gas by individual customers has declined. The result is that the average household today uses 50 percent less natural gas than in 1970. This decline in use per customer results from steady improvements to appliance efficiencies, tighter building shells, behavioral changes in gas consumption, and the effectiveness of gas utility efficiency programs.

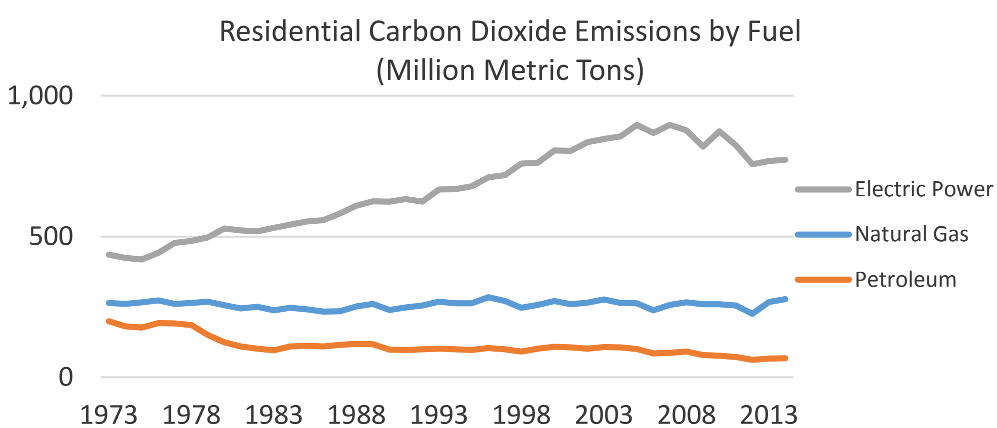
Figure 2



Average household consumption of natural gas has dropped 50 percent
Source: AGA Calculations based on EIA consumption & customer data, NOAA HDD

This efficiency of the gas system and its users has led to no material increase in annual CO_2 emissions from natural gas use during this time. However, during this same time carbon emissions associated with electricity use have risen dramatically. Residential CO_2 emissions have increased 23 percent since 1973, mostly associated with growth in residential electric power, which increased 78 percent during this time (Figure 3). By contrast, residential carbon dioxide emissions from natural gas *direct use* have remained relatively flat.

Figure 3



Growth in residential CO_2 emissions has been driven by greater use of electric power.
Source: EIA

1.2. Comparison of Energy Trajectories

The primary method for estimating the likely impacts of fuel and equipment choices is the use of full-fuel-cycle measures of energy use and emissions. This is in contrast to site energy measurements, which only include energy consumed at the point of use. Full-fuel-cycle measures of energy use and greenhouse gas emissions can be used for impact analyses, environmental assessments, and rulemakings for energy conservation standards.

Full-fuel cycle energy used in this report can be defined as “the energy consumed by an appliance, system, or building as measured at the building site plus the energy consumed in the extraction, processing, and transport of primary fuels such as coal, oil, and natural gas; energy losses in thermal combustion in power-generation plants; and energy losses in transmission and distribution to the building site.[1]"

Table 1

National average full-fuel-cycle energy factors for electricity generated with different fuel types and for fossil fuels

Energy Type	Process energy efficiency (percent)						
	Extraction	Processing	Transportation	Conversion	Distribution	Cumulative Efficiency	FFC Energy Conversion Factor
Electricity							
Coal	98.0	98.6	99.0	32.9	93.5	29.4	3.40
Oil	96.3	93.8	98.8	32.0	93.5	26.7	3.75
Natural Gas	96.2	97.0	99.3	43.2	93.5	37.4	2.67
Nuclear	99.0	96.2	99.9	32.6	93.5	29.0	3.45
Hydro	100.0	100.0	100.0	90.0	93.5	84.2	1.19
Biomass	99.4	95.0	97.5	24.4	93.5	21.0	4.76
Wind	100.0	100.0	100.0	26.0	93.5	24.3	4.11
Solar	100.0	100.0	100.0	12.0	93.5	11.2	8.91
Geothermal	100.0	100.0	100.0	16.0	93.5	15.0	6.68
U.S. Average	98.0	97.8	99.3	35.7	93.5	31.8	3.15
Fossil Fuels Used in Buildings							
Natural Gas	96.2	97.0	99.0	100.0	99.0	91.5	1.09
Heating Oil	94.9	89.1	99.7	100.0	99.6	84.0	1.19
Propane/LPG	94.6	93.6	99.2	100.0	99.2	87.1	1.15

Source: *Full-Fuel-Cycle energy and Emissions Factors for Building Energy Consumption – 2013 Update*. Gas Technology Institute.[2]

This important methodology has begun to be incorporated into governmental policy and proceedings. The Department of Energy in a 2011 Statement of Policy declared its intent to use full-fuel-cycle measures of energy use and emissions in national impact analyses and environmental assessments included in future energy conservation standards rulemakings.[3]

---

[1] *Full-Fuel-Cycle energy and Emissions Factors for Building Energy Consumption – 2013 Update*. Gas Technology Institute. January 2014. https://www.aga.org/full-fuel-cycle-energy-and-emission-factors-building-energy-consumption-20node3-update-jan-20node4

[2] Emissions factors used in the calculation of full-fuel-cycle emissions comes from several different sources. The ANL GREET Model v1 2012 rev2 and the US EPA Inventory of US Greenhouse Gas Emissions and Sinks (2013) were sources of information on pre-combustion air emissions. Combustion emissions for conversion to electricity are calculated using EPA eGRID2012 v1.0.

[3] "Energy Conservation Program for Consumer Products and Certain Commercial and Industrial Equipment: Statement of Policy for Adopting Full-Fuel-Cycle Analyses into Energy Conservation Standards Programs." Department of Energy. 10 CFR Part 431 Docket No. EERE-2010-BT-NOA-0028. https://www.federalregister.gov/articles/2011/08/18/2011-21078/energy-conservation-program-for-consumer-products-and-certain-commercial-and-industrial-equipment

Most of the energy associated with the delivery and utilization of *direct use* fuels is associated with consumption on site. By contrast, site electricity use is only about one third of the total primary energy associated with electric end use.

The energy required in the extraction, processing, and transport of natural gas, including losses, has a *source-to-site* efficiency of 92 percent. Electricity use on average has a *source-to-site* efficiency of 32 percent, based on generation data available for 2012 in the EPA Emissions & Generation Resource Integrated Database (eGRID).[4] In other words, only one third of primary energy associated with energy generated and transmitted along the electric system is associated with final useful energy delivered to the consumer.[5]

The choice of boundary for the electric grid can change the relative estimated emissions impact of electricity usage. The figures above are developed at the state, eGRID sub-region, NERC region, and US average level for electricity for all power plants, in order to provide a range of geographical and system regions from which to draw. Any accounting of emissions reductions from the *direct use* of natural gas must rely on a technically accurate metrics that reflect a close approximation to energy consumption and environmental impacts.

1.3. Comparison of Appliances to Identify Energy and Emissions Reduction Opportunities

The broad range of efficiency metrics in use today makes comparison of appliances difficult, especially across fuel types. The differences in approaches to heating and cooling efficiencies can create conceptual challenges for consumers and policymakers that wish to directly compare performance.

For example, the site efficiencies of a natural gas fired furnace are expressed in different units than an air-source heat pump, a necessary consequence of operational differences in these appliances. A natural gas fired furnace's thermal efficiency measure of combustion is rated with an Annualized Fuel Utilization Efficiency, AFUE, which is a value less than 100. By contrast, an air-source heat pump may be rated with a Heating Seasonal Performance Factor for heating or a Seasonal Energy Efficiency Ratio for cooling, both of which can be converted to a coefficient of performance, which is a value that can correspond to "efficiencies" greater than 100%. This is because a heat pump does not combust air; rather heat pumps move warm air from one location to another.

To make standardized comparisons, MIT in the *Future of Natural Gas*[6] normalized the diverse efficiency metrics for select residential appliances and space conditioning systems. The table below shows the site and source energy efficiency of residential heating, cooling, and hot water systems.

---

[4] Emissions & Generation Resource Integrated Database (eGRID). Environmental Protection Agency. Released 10/08/2015. http://www2.epa.gov/energy/egrid

[5] *Full-Fuel-Cycle energy and Emissions Factors for Building Energy Consumption – 2013 Update*. Gas Technology Institute. January 2014. https://www.aga.org/full-fuel-cycle-energy-and-emission-factors-building-energy-consumption-20node3-update-jan-20node4

[6] *The Future of Natural Gas: An Interdisciplinary MIT Study.* Massachusetts Institute of Technology Energy Initiative. 2011. http://mitei.mit.edu/publications/reports-studies/future-natural-gas

Table 2
Site vs. Source Energy Efficiency of Residential Heating, Cooling, and Hot Water Systems

	Site Energy Efficiency (SCOP*)			**Source-to-Site Efficiency**	**Full-Fuel-Cycle Efficiency (FFC)**		
	Low	**Energy Star**	**Best**		**Low**	**Energy Star**	**Best**
Heating System Type							
Electric Furnaces	0.95	—	0.99	0.32	0.3	—	0.3
Oil-Fired Furnaces	0.78	0.83	0.95	0.88	0.7	0.73	0.8
Gas-Fired Furnaces	0.78	0.9	0.98	0.92	0.7	0.83	0.9
Air Source Heat Pumps†	2.3	2.4	5.2	0.32	0.7	0.77	1.7
Ground Source Heat Pumps‡	2.5	3.3	4.8	0.32	0.8	1.06	1.5
Cooling System Type							
Central AC†	3.81	4.25	6.74	0.32	1.2	1.37	2.2
Air Source Heat Pumps†	3.81	4.25	4.98	0.32	1.2	1.37	1.6
Ground Source Heat Pumps‡	2.55	4.13	6.57	0.32	0.8	1.33	2.1
Hot Water System Type							
Electric Storage Tank	0.92	—	0.95	0.32	0.3	—	0.3
Oil-Fired Storage Tank	0.51	—	0.68	0.88	0.5	—	0.6
Gas-Fired Storage Tank	0.59	0.62	0.7	0.92	0.5	0.57	0.6
Electric Heat Pump Tank	0.92	2	2.35	0.32	0.3	0.64	0.8
Electric Instantaneous	0.93	—	0.99	0.32	0.3	—	0.3
Gas-Fired Instantaneous	0.54	0.82	0.94	0.92	0.5	0.75	0.9

*COP for Ground Source Heat Pump Systems, †Split Systems, ‡Closed Loop Systems
Source: MIT *Future of Natural Gas*[7]

The first three columns in Table 2 represent site efficiency, classified as low, minimum Energy Star equivalent, and best-in-class. The middle column, labeled *source-to-site,* represents the average full-fuel-cycle energy efficiency factor, similar to the approach described in the previous section. The final three columns are the full-fuel-cycle energy efficiency, which is equal to the site efficiency multiplied by the *source-to-site* factor. This approach offers an approximate measure on an equivalent basis of the overall energy requirements for the select appliances.

As an example: an Energy Star rated natural gas-fired furnace has an 83 percent full-fuel-cycle (FFC) efficiency. By comparison, an electric furnace has a 30% FFC efficiency, and an air-source heat pump shows a 77% FFC efficiency of an Energy Star air source heat pump. In this case, the Energy Star rated natural gas-fired furnace has a higher full-fuel-cycle efficiency than the Energy Star rated heat pumps and electric furnaces.

These efficiencies can then be used to evaluate normalized energy requirements and emissions from operation of the select applications. Table 3 shows the energy consumption and full-fuel-cycle carbon dioxide emissions of select systems for heating, cooling, and hot water systems. The efficiencies for each application are consistent with the minimum rating for an Energy Star appliance. The values are normalized for an equivalent load or useful energy, per 100 MW. The CO2 emissions are listed using both national averages and by NERC region.

[7] Ibid.

Table 3
Combined Energy and Emissions Impacts of Using Full-Fuel-Cycle Efficiency
for Select NERC Regions for Energy Star Appliances

	Energy Consumption (MWh)			Full Fuel Cycle CO2 Emissions (Ton CO2)				
	Useful	Site	FFC	National	MRO	NPCC	SPP	TRE
Heating System Type								
Electric Furnaces	100	101	314.2	74	114	49	104	75
Oil-fired Furnaces	100	120.5	136.7	45				
Gas-Fired Furnaces	100	111.1	120.7	27				
Air Source Heat Pumps	100	41.7	129.6	31	47	20	43	31
Ground Source heat Pumps	100	30.3	94.3	22	34	15	31	23
Cooling System Type								
Central AC	100	23.5	73.2	17	27	11	24	17
Air Source Heat Pumps	100	23.5	73.2	17	27	11	24	17
Ground Source Heat Pumps	100	24.2	75.3	18	27	12	25	18
Hot Water System Type								
Electric Storage Tank	100	105.3	327.4	77	119	51	109	78
Oil-Fired Storage Tank	100	147.1	166.9	55				
Gas-Fired Storage Tank	100	161.3	175.2	39				
Electric Heat Pump Tank	100	50	155.5	37	56	24	52	37
Electric Instantaneous	100	101	314.2	74	114	49	104	75
Gas-Fired Instantaneous	100	122	132.5	29				

Note: FFC CO2 Emissions are based on an average grid mix. However, assessing the emissions impact of substitution from one technology to another should be based on an analysis using a marginal or non-baseload grid.
Source: MIT *Future of Natural Gas*[8]

An energy star natural gas-fired furnace results in more than 60 percent less carbon dioxide emissions than the average electric furnace, the most common electric home heating appliance.

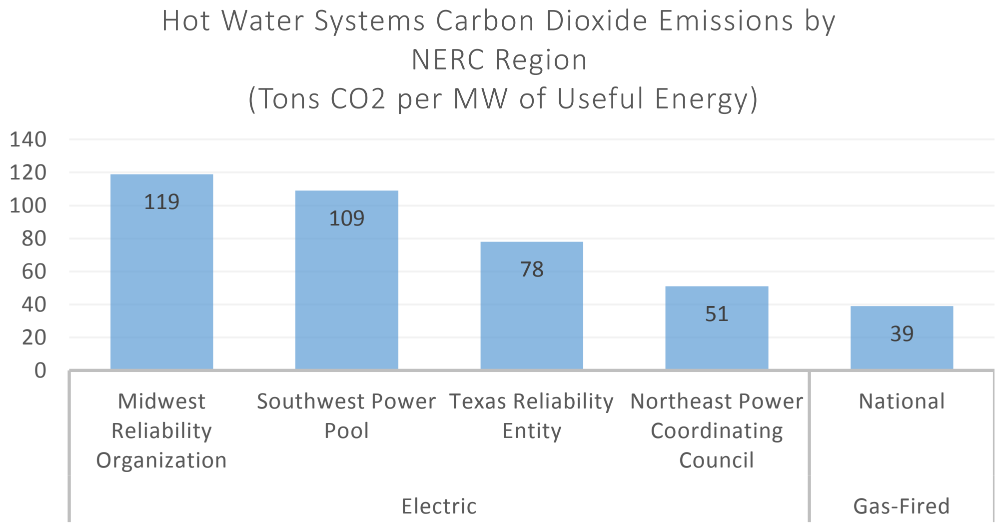
Natural gas-fired storage tank hot water systems similarly exhibit lower energy requirements and less CO2 emissions when compared to electric and oil-fired storage tank hot water systems. Using the prior table, a gas-fired storage tank hot water system results in 39 tons of CO2 per 100 MWh of useful energy output. An electric storage tank system assuming an average grid mix results in 77 tons of CO2 per 100 MWh, a 97 percent increase. [9]

Proper accounting of emissions from electric appliances must take into account the composition of regional primary fuel inputs for electric generation. The figure below shows carbon dioxide emissions from water heating systems in different regions defined by the National Energy Reliability Council (NERC). In this case, even in the least carbon-intensive grid mix, the Northeast Power Coordinating Council, which has a higher-than-average share of hydroelectric and nuclear electricity generation, a natural gas fired water heater system is still more efficient and produces less carbon than an electric storage water heater.

[8] Ibid.

[9] Ibid.

Figure 4



Source: MIT Future of Natural Gas

1.4. Electricity Conversion Factors

The emissions reduction potential of *direct use* gas applications will vary depending on the primary fuel input composition of the electric grid mix. The use of regional values can improve the accuracy of a full-fuel-cycle calculation. This can be done on geographical bases, such as a state-level analysis, or a systems-based approach like EPA eGRID or NERC regions.

It is also important to distinguish between electricity conversion factors for inventory and investment purposes. For inventory purposes, such as evaluating the energy and emissions footprint of an established set of buildings, the use of average factors is appropriate.

For purposes of investment, which includes incentivizing *direct use* as an emissions reduction tool, it is appropriate to estimate the marginal impact to emissions. A marginal methodology is more accurate to the effect of *changes* to electricity consumption on energy and emissions.

Average emissions rates will typically under-predict emissions reductions achieved through efficiency improvements. Inclusion of baseload generators such as nuclear and hydropower brings down the overall rate of electric system emissions. Except these generators are unlikely to be affected by energy efficiency improvements.

However, energy efficiency will affect *marginal* generators, which are almost always fueled with natural gas or coal: "Marginal generation represents the next generation plant used, built, or avoided with that particular fuel type and heat rate, and can be complicated to determine precisely. Marginal generation may be location specific, or it may be generated from the local or regional power pool. In other cases it may involve determining the location of the ultimate power plant avoided or built within or across power pools, and may even cross international boundaries that are grid-connected. Marginal and average FFC energy and carbon dioxide-equivalent (CO_2e) emission results can be significantly different, especially in regions dominated by hydropower generation. In addition, displacing coal plants has a higher impact on CO_2e emissions and FFC energy use than displacing natural gas plants."[10]

Marginal generation methodologies vary, but EPA recognizes several valid and established approaches to quantify emissions reductions using the non-baseload or fossil fuel electricity mix. Use of eGRID sub-region non-baseload emission factors are recommended as a simple, low-cost method to estimate emissions reduction potential and to demonstrate emissions benefits. More information on these methodologies can be found in the Appendix.

1.5. Conclusion

These facts demonstrate the opportunity to leverage natural gas most effectively as an emissions reduction tool. In 2013, the Center for Climate and Energy Solutions, which is the former Pew Center on Climate Change, put *direct use* of natural gas as its top opportunity for greenhouse gas reductions.

Their report notes that "onsite natural gas use has the potential to provide lower-emission energy compared with oil or propane and electricity in most parts of the country."[11] As the facts in this section demonstrate, there indeed are significant opportunities for *direct use* to contribute to emissions reductions goals.

Many natural gas utilities already use natural gas to achieve emissions reductions through existing rate payer funded efficiency programs. The next section will detail the varied types of gas utility programs in operation today and how these programs might be incorporated into larger policy frameworks designed to achieve emissions reductions.

[10] Gas Technology Institute. "Full-Fuel-Cycle Energy and Emissions Factors for Building Energy Consumption – 2013 Update" Page 11 https://www.aga.org/sites/default/files/21504_final_report_rev4_2014-01-30.pdf

[11] http://www.c2es.org/docUploads/leveraging-natural-gas-reduce-ghg-emissions.pdf

2. Gas Utility Programs to Reduce Emissions

One pathway toward achieving carbon dioxide emissions reductions with *direct use* is by leveraging existing natural gas utility programs. Energy companies, and utilities in particular, are in a unique position to work with customers to improve energy efficiency and identify low-cost emissions reductions opportunities. Existing programs are typically paid for, often with well-established protocols to identify, measure, and verify energy and emissions reductions, which means lower costs of compliance compared with programs that are not yet implemented.

Any programs that promote energy efficiency or seek to convert new customers to natural gas could be leveraged within a larger policy framework designed to reduce greenhouse gas emissions. Companies and state regulators may consider how existing gas utility portfolios could be implemented in a way to gain credit for the emissions reductions achieved through these programs.

By "larger policy framework", this section specifically means any goal or target set through policy or regulation. For example, the proposed EPA Clean Power Plan directs states to develop state implementation plans to achieve the required emissions reductions targets. States may choose to implement a flexible plan that relies on emissions reductions outside the electric generation plant. Emissions reductions achieved through other technologies, programs, and policies could qualify for credit under these plans, even if these programs were initially designed for a different purpose.

End use electric energy efficiency is one such resource proposed to help achieve carbon dioxide emissions standards.[12] In this context, a utility-funded program may have complimentary objective with a "larger policy framework," and through these programs companies and states may be able to count low-cost emissions reductions that are happened but would go otherwise uncredited.

The starting point for this recognition is the existing portfolio of gas utility programs that achieve emissions reductions through *direct use.* This section examines two broad categories of gas utility programming: ratepayer funded energy efficiency programs, and in particular those programs that incentivize or otherwise encourage users to switch to natural gas from another fuel; and other programs outside of a gas utility energy efficiency portfolio that promote conversions.

2.1. Gas Utility Energy Efficiency Programs

Energy efficiency has become an increasingly important driver shaping end use patterns and emissions, as well as an important growth opportunity for local distribution companies. Consequently, natural gas utilities with state regulators have established a variety of demonstrated, customer-focused, cost-effective energy efficiency programs. Today, natural gas utilities work with their customers to reduce energy and emissions and to increase cost savings. And utilities work with regulators to implement policies that support these initiatives.

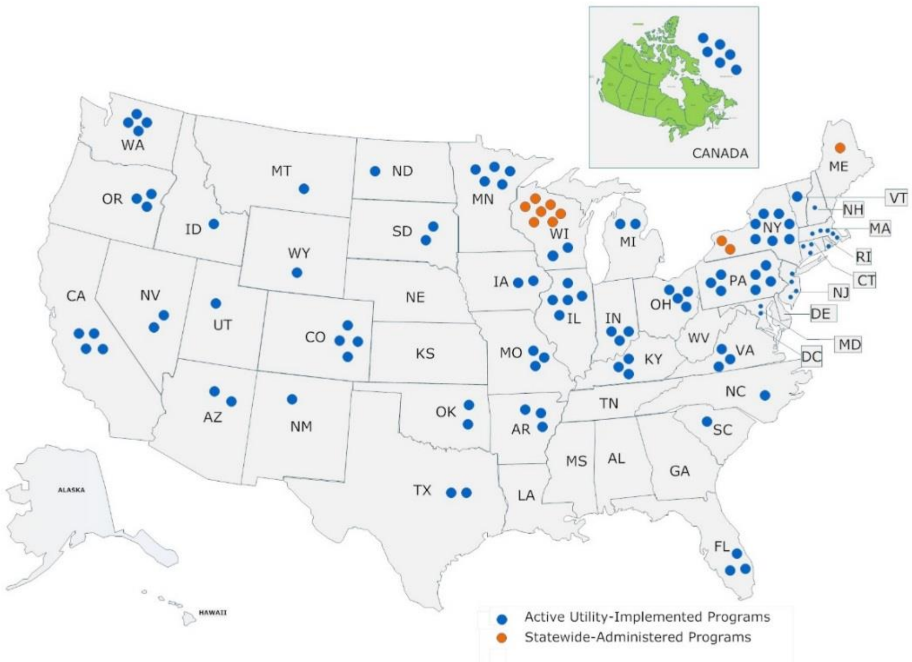
Ratepayer funded natural gas efficiency programs have grown significantly during the last decade, both by count and by expenditure. According to an informal AGA survey, the US has 121 natural gas utility

[12] *Implementing EPA's Clean Power Plan: A Menu of Options*. National Association of Clean Air Agencies.

rate-payer funded efficiency programs in 39 states as of 2013. Programs in 2007 reported a total expenditure of $220 million. By 2013, programs accounted for $1.1 billion in expenditures in 2013.[13]

Figure 5

Rate Payer-Funded Natural Gas Efficiency Programs – 112 in 39 states, 6 in Canada (2013)



Source: AGA Informal Energy Efficiency Survey of Members

Based on survey responses, more than 151 Bcf of natural gas was saved in 2013 due to investments made in energy efficiency since 2008. That gas volume is equivalent to nearly 11 days of residential use and amounts to 8.9 million metric tons of avoided carbon dioxide emissions.

This growth is a result of collaboration between states and utilities to develop policies and regulations to support the implementation of gas utility efficiency portfolios. Specifically, two broad regulatory precepts have encouraged expansion of gas utility efficiency programming.

First are non-volumetric rate designs, which allow utilities to recover commission-authorized fixed costs. This removes the disincentive for energy efficiency that would otherwise exist with traditional rate designs where energy efficiency leads to reduced variable charges and therefore lower revenues for the utility company. These mechanisms include revenue decoupling, straight fixed variable rates, and rate stabilized mechanisms.

[13] Information on gas utility energy efficiency programs reference the *Natural Gas Efficiency Programs Report 2011 Program Year* and *Natural Gas Efficiency Programs Brief Investments and Savings Impacts 2012 Program Year*. Data for 2013 not yet released. These reports present data collected from members of the American Gas Association and the Consortium for Energy Efficiency on ratepayer-funded natural gas efficiency and conservation programs.

The second precept are direct program cost recovery and utility performance-based incentives, which are designed to encourage and reward investment into energy efficiency. Efficiency performance-based incentives for utilities involve three mechanisms: shared savings, performance targets, and rate of return incentives.

Ratepayer funded efficiency programs are established for many purposes. The goals that drive efficiency program funding requirements, which may involve more than one, include energy conservation and savings, customer dollar savings or bill reduction programs, greenhouse gas or carbon emission reductions, green jobs creation, renewable portfolio standards, reduced usage for low income customers, to meet electric demand side management requirements, and to reduce supply infrastructure costs.

No two programs are the same. Even within a state, gas utilities may administer and implement programs in different ways unique to the company and its service territory. Some programs are administered by the utility; others through a nonprofit organization or government agency. In some utility-implemented programs, specialized staff dedicate full time to projects and implementations. In others, energy efficiency projects may constitute only a fraction of employee time.

The few examples here demonstrate the need for companies, state regulators, and other stakeholders to consider carefully the applicability of gas utility programs within an emissions reduction policy framework. Program design, administration, and the types of regulatory precepts in place to encourage energy efficiency vary state by state, and often even within a state. While there are many cross-cutting features of gas utility programming that may apply broadly to state emission reduction plans, companies and stakeholders must take care with evaluating the range of considerations and elements that comprise these programs.

Program heterogeneity aside, the mechanisms described here may be well suited to achieve emissions reductions in another policy context. That is, a utility-funded program may achieve the same desired policy goals even though funding requirements were initially established to accomplish another outcome. There remains the prospect of incorporating those savings into a larger policy framework and crediting the appropriate parties for those reductions where utility efficiency programming can demonstrate realized emissions savings.

2.1.1. Programs that Encourage Switching from Electricity to Natural Gas

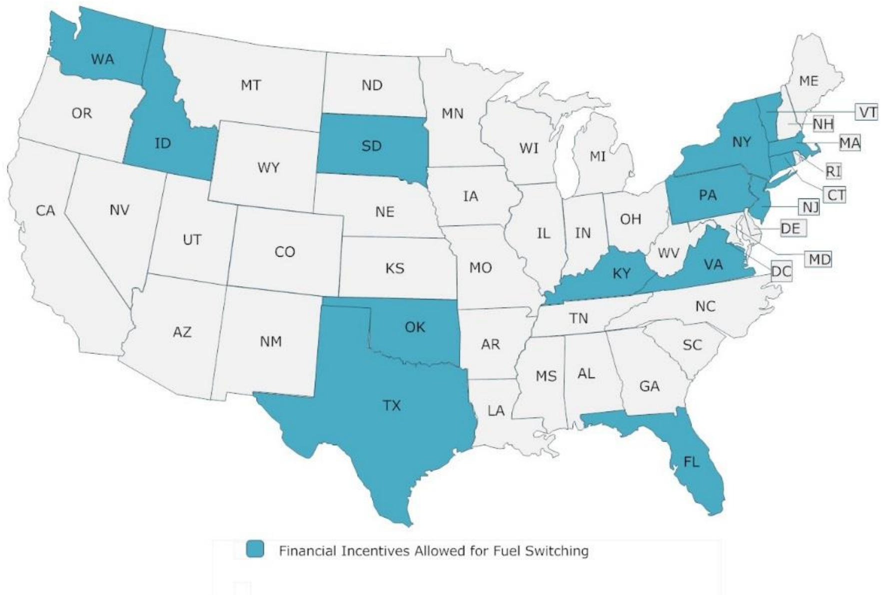
A number of programs in utility funded efficiency portfolios are designed to incentivize or otherwise encourage customers to adopt natural gas appliances as a substitute for another fuel. Some others are fuel oil conversion programs or unspecific toward fuel; some specifically target electricity. Any gas program that demonstrates electricity savings—a type of electricity efficiency— could be considered in a larger policy framework, the goal of which is to encourage energy efficiency.

There are 24 gas utility programs in 17 states that feature a conversion program either allowed by the state regulator or specifically authorized by legislation. These states include Texas, California, Colorado, Connecticut, Florida, Idaho, Illinois, Kentucky, Massachusetts, New Jersey, New York, Oklahoma, Pennsylvania, South Dakota, Virginia, Washington, and Vermont.

Of these, 17 provide financial incentives for electricity conversions (and in some cases other fuels). These are the states in which these programs currently operate:

Figure 6

States that Allow Financial Incentives for Fuel Switching within Energy Efficiency Portfolio



There are 17 programs in 14 states where the state regulator allows financial incentives for fuel-switching within the energy efficiency portfolio. Source: AGA Informal Survey of Members

All of the 17 programs target residential customers. Seven of these offer fuel conversion incentives to low income customers; ten target commercial customers; and six offer incentives to industrial customers.

Financial incentives offered to consumers may include low interest financing, equipment rebates, and in some cases free measures to low income customers. Equipment targeted includes water heaters, furnaces, boilers, and clothes dryers.

Programs that use gas utility efficiency programming as an electric demand side management tool may be considered a useful model for how gas utilities can leverage *direct use* to achieve emissions reductions from electric generating units. Currently, programs in Oklahoma, Pennsylvania, and Texas specifically target electric-only conversions as electric demand side management.

However, many states explicitly prohibit fuel switching from electric to natural gas. In these cases, established precedence and regulation would limit if not eliminate the possibility of using *direct use* as an electric demand side management tool.

2.2. Other Gas Utility Programs

Many gas utilities administer programs that target fuel switching to natural gas but are implemented outside of the energy efficiency portfolio. Typically, these activities are related to marketing or the education of consumers aimed at converting a household or business to natural gas. Some companies are allowed to promote fuel switching and conversions, but are disallowed from doing so within energy efficiency programs. In other instances, direct incentives are not available but companies may have tariffs designed to make it more affordable to extend natural gas access to other fuel source customers.

In some cases conversion customers may qualify for energy efficiency incentives; while the program is not designed specifically to incentivize fuel switching, incentives may be available to assist in the conversion of a customer to natural gas.

According to the AGA energy efficiency survey, 27 companies in 14 states pursue fuel switching programs outside of their energy efficiency programming portfolio. This is likely a lower bound for the number of these types of programs since the survey, which is designed to query gas utilities on their energy efficiency programming, may not capture fuel switching programs that exist outside of the utility programming. States with fuel switching programs outside of the energy efficiency portfolio are Arizona, Connecticut, Indiana, Massachusetts, Michigan, Minnesota, New Jersey, New York, Ohio, Oregon, Pennsylvania, Rhode Island, and Wisconsin.

Natural Gas Direct Use as Electric Demand Side Management Examples

Texas

CenterPoint Energy Houston Electric has implemented a Multifamily Water & Space Heating Market Transformation Program, in accordance with the energy efficiency goals outlined by Public Utility Commission of Texas. According to the rule, energy efficiency projects allow switching from electricity to another energy source, such as natural gas, provided that the energy efficiency project results in lower overall energy costs, lower energy consumption, and the installation of high efficiency equipment. The company offers financial rebates through project sponsors or developers that purchase and install high efficiency natural gas space and water heating solutions with the goal of lowering overall energy use and costs. For projects involving the installation of individual water heaters and central service water heaters, the program provides different incentive levels for market-rate (residential) and affordable (hard-to-reach or HTR). The incentive rates are:

Equipment Type	Electric to Natural Gas Equipment Rebate
Forced Air Furnace	$2,000
Water Heater	$900
Dryer	$450
Cooking Range	$300

--

In 2013, the Austin City Council ordained amendments to city code whereas residential buildings having existing or planned natural gas service or equivalent district gas service located within the adjacent right-of-way shall not use electric resistance as the primary means for water heating. In addition, the Texas Gas Service Conservation Program, established in 1991, provides Austin-area customers with money-back rebates on efficient natural gas appliances. The goal of this rate-payer-funded program is incentivizing customers to take the “next step up” in energy efficient appliances, with rebates available to retrofit customers, commercial customers, and new construction. The Conservation Program also includes the Free Equipment Program, which serves low-income, elderly or mobility-challenged customers who old natural gas appliances replaced with a more efficient model. In 2014, the Texas Gas Service Conservation distributed $2.1 million on 14,104 efficient natural gas appliances or weatherization measures.

Natural Gas *Direct Use* as Electric Demand Side Management Examples

Oklahoma

In 2010, the Oklahoma Corporation Commission (OCC) approved a program allowing CenterPoint Energy to offer rebates to customers to install high efficiency natural gas space heating and water heating equipment in place of electric equipment. The rebate provides greater incentive to purchase and install higher efficiency natural gas space heating and water heating solutions in place of less efficient electric alternatives by offsetting the higher incremental purchase and installation cost of the more efficient equipment. Under the program, energy savings counted are from a total efficiency standpoint, considering the full fuel cycle approach (FFC). The gas utility may claim the energy savings taking FFC into account, based on the difference between the load of the gas equipment and the total energy input for a comparable electric unit. CenterPoint Energy counts FFC savings toward their Oklahoma energy savings goal, but not toward earnings on utility financial incentives. The current 2014-2016 program portfolio continues rebates for high efficiency natural gas space heating and water heating solutions as well as residential rebate programs that incentivize the purchase and installation of gas dryers and gas cooking ranges in place of electric equipment. The customer rebates for qualifying natural gas equipment are:

Equipment Type	Residential (Market Rate) Incentive Per Unit	Hard-to-Reach (Affordable) Incentive Per Unit
Individual Water Heaters	$250	450
Central Service Water Heaters (Boilers)	$150	250
Combo Unit/Gas Heating System	$350 – $500	$550 – $750

The Oklahoma Natural Gas Energy Efficiency Program was established in September 2011. The ratepayer-funded program provides rebates to customers and builders who install high efficiency natural gas equipment in their homes and businesses. The Energy Efficiency Program includes two electric to natural gas conversion programs offered for furnaces and water heaters. The Heating-System Replacement Program provides $1,950 rebate for electric to natural gas furnace conversions and $850 for electric to natural gas water heater conversions. In 2015 Oklahoma Natural Gas partnered with the two largest electric utilities in the state, Public Service Company of Oklahoma and Oklahoma Gas and Electric, to provide weatherization assistance to low income customers. In 2014, the Energy Efficiency Program distributed more than $8 million to more than 44,000 participants in the program.

Washington

Puget Sound Energy offers incentives of up to a $3,550 rebate to switch home and water heating sources to natural gas. The incentives vary depending on the type of space or water heating in the home and annual electricity usage. Customers are able to switch from PSE electric to any natural gas provider. Because the program is funded as an electric efficiency measure, PSE is able to aid customers in other natural gas utility service territories in switching to natural gas.
https://pse.com/savingsandenergycenter/Rebates/Pages/Converting-to-natural-gas.aspx

In both Washington and Idaho, Avista Utilities Electric to Natural Gas Conversion Program provides a fuel efficiency rebate to eligible residential electric customers who heat their homes and water with Avista electric and switch to natural gas. The base prescriptive rebates for switching are $2,300 for home furnaces, $600 for water heaters and $3,200 if customers convert both systems at the same time. Customers may also convert from electric baseboard to a direct vent natural gas wall heater/stove for a $1,300 rebate. There are additional financial incentives for installing high-efficiency equipment. In both Idaho and Washington there is a $100 variable speed motor incentive available and a $100 (contractor installed) or $50 (self-installed) smart thermostat rebate. In Washington Avista offers; a $250 furnace rebate for unit with 90% AFUE or greater, $20 water heater rebate for 50 gallon tank type of 0.60 EF or greater, 40 gallon tank type of 0.62 EF or greater, and a $130 tankless water heater rebate for equipment with 0.82 EF or greater. Avista has filed to bring back high efficiency natural gas incentives in Idaho. Incentives are reviewed at least annually and adjusted based on market, savings and other cost-effectiveness inputs.

3. Including *Direct Use* in the Clean Power Plan

Natural gas *direct use* can make significant contributions to compliance obligations under state or federal requirements. This section is designed to touch on some of the consideration for companies and policy makers that wish to leverage natural gas *direct use* for emissions reductions. As with Section 2, the primary policy vehicle within which *direct use* may be incorporated is the Environmental Protection Agency's Clean Power Plan and specifically State Implementation Plans that the CPP requires. *Direct use* though may be considered under other contexts as well.

3.1. Background

In June of 2014, the EPA proposed new carbon dioxide emissions standards for existing electric generating units. The standards, which are state-specific, are based on state's unique energy mix and potential for using four "building blocks:" 1) fossil electric generation unit upgrades; 2) electric generation re-dispatch; 3) non-fossil generation unit actions; and 4) demand-side energy efficiency. The EPA's adjusted emissions rate targets are what EPA believes to constitute a *best system of emissions reduction* that is *adequately demonstrated.*

The CPP could provide an opportunity to credit emissions reductions achieved through the greater use of natural gas in homes and businesses as a means of compliance. Specifically, where electric energy efficiency (Block 4) is pursued as a compliance strategy in state implementation plans, natural gas used as an electric demand side management resource could help achieve low-cost emissions reductions and thus incorporated into a state plan. If *direct use* can reduce electric load on the grid and generate emissions reductions from affected electric generating units (EGUs), *direct use* and distributed generation natural gas may be considered as energy efficiency for purposes under the Clean Power Plan.

EPA requires that each state develop, adopt, and submit a plan in compliance under Clean Air Act (CAA) 111(d). Requirements under the proposed rule:

The state must first determine the emissions performance level it will include in its plan and decide whether it will adopt the rate-based CO2 goal set by EPA or translate the rate-based goal to a mass-based goal. States will have to submit implementation plans between 2016 and 2018. EPA encourages states to work together to develop multistate plans that align with regional power pools and electric power markets.

The EPA is proposing that all measures relied on to achieve the emissions performance levels be included in the state plan, and that inclusion in the state plan renders those measures *federally enforceable*.

The EPA in the proposed Clean Power Plan preamble describes three important issues in design of state plans:

- Whether a state plan should only require the affected EGUs to be subject to emissions limits
- Whether the plan could rely on measures such as renewable energy and energy efficiency.
- Whether responsibility for all measures, other than emissions limits, should fall on the affected EGUs, or could fall on other affected entities; and
- Whether the fact that requiring all measures relied on to achieve emissions reductions renders those measures federally enforceable.

States with emissions reduction obligations under the CPP may choose to implement an approach that relies on a variety of non-affected EGU emissions reductions resource or options. These states may wish to consider natural gas *direct use* as one of these compliance options.

Companies may wish to explore inclusion of *direct* use because new incentives under the Clean Power Plan could bring financial value to companies to support greater use of natural gas in homes and businesses

In many cases state, tribal, and local governments have already adopted natural gas efficiency programs that include switching to natural gas as a substitute fuel for reasons other than emissions reductions. It may be a matter of simply accounting for the emission impacts of these existing initiatives.

Where existing gas utility-administered programs are already in place or where program elements are well-tested or in place, lessons learned and precedents may make inclusion of *direct use* more cost-effective and emissions reductions well-defined and rigorous.

3.2. Considerations for Policy Makers

There are many points for deliberation by federal and state policymakers, companies, and other stakeholders that wish to consider natural gas *direct use* under Clean Power Plan compliance. Generally, areas for consideration may include:

1. Identify approvable pathways
2. Recognize existing programs
3. Aggregation of *direct use* emissions reductions
4. Provide states flexibility in creating incentives to reduce emissions
5. Count contributions to avoid future emissions
6. Consideration of past contributions that have enabled an easier pathway to compliance
7. Avoidance of penalties for non-compliance

These points of consideration reflect comments from energy efficiency advocates that wish to more broadly incorporate energy efficiency resources under the Clean Power Plan.[14]

In addition to the points for guidance and deliberated enumerated here, inclusion of *direct use* programs will be determined by factors that are largely beyond the scope of this document. These include state choice of goal setting (rate-based vs mass-based), enforceability, performance, and measurement and verification of energy and emissions savings. Many of these considerations are beyond the scope of this paper. However, the question of enforceability is a key issue for many natural gas utilities.

3.3. On Enforceability

The meaning of "enforceability" under the Clean Power Plan is uncertain and not well established.

---

[14] List adopted from *Greenhouse Gas Reductions through Performance Contracting under EPA's Clean Power Plan* Executive Summary. ESCO Technical Paper on Performance Contracting in Section 111(d). 2014. http://ajw-inc.com/pc/

The proposed EPA Clean Power Plan has identified various approaches for development and enforcement of submitted state plans. The portfolio approach, the default proposed, which would include emissions limits for affected EGUs along with other enforceable measures, such as renewable energy and other demand-side energy efficiency measures, which would in theory include the *direct use* of natural gas as a substitution fuel. Under this approach, emissions limits enforceable against the affected EGUs would not on their own assure or be required to assure achievement of the emissions performance level. The state plan would include measures enforceable against other entities that support reduced generation by the affected EGUs. These measures could include the direct and distributed use of natural gas. The portfolio approach could be *utility-driven* (implemented consistent with a utility integrated resource plan) or *state-drive* (emissions standards plus requirements for other entities). Under this approach, demand side energy efficiency and renewable energy measures could be enforceable or complementary.

The second is a state commitment approach. Under this scheme, state requirements for entities other than the affected EGUs would *not* be components of the state plan and therefore *would not be federally enforceable*. The state plan would include an enforceable commitment by the state itself to implement state-enforceable (but not federally enforceable) measures.

Specific utility programs that may be considered within a State Implementation Plan (SIP) are already overseen and regulated by state utility commissions. The creation, administration, and verification of gas utility efficiency programs is well established and works well to align the goals of customers, utility companies, and state regulators.

EPA has signaled that it would grant states broad flexibility to choose a policy pathway. However, EPA has the authority to ensure a SIP is implemented and apply CAA-authorized penalties against a noncompliant party. Many utilities may not want additional regulatory oversight or burden on efficiency programs, or additional costs associated with compliance, which could affect cost-effectiveness of existing programs.

State plans may wish to exempt existing utility programs from CAA-authorized penalties or be structured such the issue is rendered moot. One option would be to exempt gas utility programs from federal enforceability. Short-falls in achieving goals could be made up for using other "outside-the-fence" policies or measures within the larger portfolio of options.

A document developed for AGA for combined heat and power (CHP) policies under the CPP describes this approach offers useful guidance for considering outside-the-fence resources as part of state implementation plans. This approach is specific for CHP but in principal could be tailored for *direct use*:[15]

> "[E]mission targets in the state plan itself, rather than the individual elements of a compliance strategy, are likely to be enforceable…[16] end users that participate in a state or utility CHP

---

[15] "Combined Heat and Power (CHP) as a Compliance Option under the Clean Power Plan: A Template and Policy Options for State Regulators." Prepared by David Gardiner and Associates and the Institute for Industrial Productivity for the American Gas Association. https://www.aga.org/natural-gas-compliance-option-epa%E2%80%99s-clean-power-plan-july-20node5. Page 10.

[16] Ibid. "Under this approach, a state compliance plan may project that a set of CHP incentives (managed by a state agency or under a utility DSM [demand side management] program) will achieve a certain amount of energy savings or CO_2 tonnage reductions. The state strategy is enforceable because it is based on a series of contractual

program that generates credits for CPP compliance should not be subject to state or federal enforcement. As voluntary suppliers of emission reduction credits, their only obligations would be to satisfy the terms of emission credit sales contracts, agreements, or efficiency programs under which they receive financial incentives. Similarly, states will not face penalties if a CHP program does not deliver as expected. Rather, the state will monitor performance of each element in its strategy, periodically report progress to EPA, and if the overall mix of strategies is underperforming, it will make adjustments in programs and strategies to make up the short fall. Such adjustments need not be specific to the CHP elements of the plan."

It is important to avoid federalizing utility program energy efficiency enforcement.
Utility efficiency programs operate at the state-level and are overseen and enforced through state regulators. Allowing states flexibility to modify goals and implementation approaches during the compliance period can help maximize the effectiveness of these programs.

The same guide also points out that "state compliance plans must show that included measures will reduce the emissions rate of affected EGUs to the required standard of performance within the designated timeframe." It goes on to describe how measurement and evaluation should be considered:

State plans must include mechanisms to report progress toward the applicable emission target and to take corrective actions if performance under the plan *as a whole* falls short. It should not be a problem that there will be some uncertainty about performance of particular CHP measures in a state compliance plan. Indeed, there will be some level of uncertainty about every element of a state's plan. It is the collective impact of all strategies that matters, not the performance of any one element of the plan. Accountability will be determined based on a state's ability to monitor performance over time and to identify correction/ contingency mechanisms if projected strategies underperform.

3.4. Steps towards a *Direct Use* Compliance Module

These elements are all critically important for implementing any menu of options into State Implementation Plans. More work would be needed to evaluate how a utility-administered program such as *direct use* incentives could be tailored to fit within the larger portfolio of a State Implementation Plan. These are elements and steps towards creating a *direct use* compliance module to fit into a SIP:

- Survey *direct use* potential and build on existing state and utility programs.
- Evaluate options for customers to earn carbon reduction credit
- Adopt an Evaluation, Measurement, & Verification (EM&V) Protocol. This may be already established through an existing utility-administered program.
- Estimate energy savings and emissions reductions
- Identify and remove regulatory barriers to *direct use*[17]

agreements with entities that receive incentives or other financial support to invest in CHP. If that estimate is wrong, neither that state, nor participants in the program are subject to federal enforcement. It is the overall performance of a state plan that is federally enforceable, and if one strategy falls short it may be made up by over-performance from other plan elements, or by corrective measures (to improve the CHP strategy, or other elements of the compliance plan) taken in later years of the applicable three-year compliance period."

[17] List adopted from "Combined Heat and Power (CHP) as a Compliance Option under the Clean Power Plan: A Template and Policy Options for State Regulators." Prepared by David Gardiner and Associates and the Institute for

Appendix - Calculating *Direct Use* Emissions Reductions

An accurate reflection of the carbon dioxide and other emissions savings associated with a fuel conversion requires a comprehensive full-fuel-cycle approach that measures and accounts for

- Efficiency of electric transmissions and distribution and the corresponding electric power generation required
- Power plant source fuel mix
- Conversion efficiency for each fuel used for power generation, and corresponding pollutant emissions including carbon dioxide
- Energy efficiency of fuel extraction, processing, and transportation, and corresponding pollutant emissions.

The following examples show selected input parameters and application of the calculation methodology to compare the site energy, full fuel cycle energy, and pollutant emissions of an electric water heater with an energy factor (EF) of 0.95 and a natural gas water heater with an EF of 0.62 with a fixed load of 10.8 MMBtu. The intent of these examples is to illustrate the potential societal benefit of optimizing the use of the nation's primary energy in buildings. While there is no single best choice for the entire country, it is possible to demonstrate the societal value of decisions that increase site energy consumption but decrease overall energy use and emissions.

Industrial Productivity for the American Gas Association, et. al. https://www.aga.org/natural-gas-compliance-option-epa%E2%80%99s-clean-power-plan-july-20node5.

Table A-1

Example of CO2 Savings for a Natural Gas Water Heater

Water Heating Load	10.8	MMBtu/year
NATURAL GAS WATER HEATER		
Unit Efficiency	0.62	EF
Natural Gas Full-Fuel-Cycle Energy Conversion Factor	1.09	No Units
Site Energy Consumption	17	MMBtu/year
Full-Fuel-Cycle Energy Consumption	19	MMBtu/year
Pollutant Emissions Factor (CO2e)	147	lbs/MMBtu
FFC Emissions (CO2e)	2,561	lbs CO2/year
ELECTRICITY WATER HEATER		
Electric Water Heater Efficiency	0.95	EF
Electric Full-Fuel-Cycle Energy Conversion Factor	3.15	No Units
Electric Site Energy Consumption	11.37	MMBtu/yr
Electric Full-Fuel-Cycle Energy Consumption	35.8	MMBtu/yr
Conversion to MWh	3,412	BTU/kWh
Electric Site Energy Consumption	3.3	MWh/Year
Electric Full-Fuel-Cycle Energy Consumption	10.5	MWh/Year
Non-Baseload Electricity Pollutant Emissions Factor (CO2e)	1,826	lbs CO2/MWh
Electric FFC Emissions (CO2e)	6,084	lbs CO2 / year
Displaced EGU Emissions	**3,523**	**lbs**

Source: AGA Calculations using GTI data.[18]

A public domain analysis methodology is available from the EPA to quantify the emissions reduction due to energy efficiency measures or clean energy policy. The importance of these analysis to accurately capture the correct level of emissions reduction possible arises from the recognition that clean energy policies and energy efficiency improvements reduce emissions from the last source of electricity generation dispatched onto the grid – so called marginal or non-based load electric

[18] *Full-Fuel-Cycle energy and Emissions Factors for Building Energy Consumption – 2013 Update*. Gas Technology Institute. January 2014. https://www.aga.org/full-fuel-cycle-energy-and-emission-factors-building-energy-consumption-20node3-update-jan-20node4

Natural gas Full-Fuel-Cycle Energy Conversion Factor, Table 13
Electric Full-Fuel-Cycle Energy Conversion Factor, Table 6
Natural Gas Pollutant Emissions Factor (CO2e), Table 25
Non-baseload Electricity Pollutant Emissions Factor (CO2e), Table 30
Water heating load consistent with sample calculation, discussed page 38.

generating units. The Gas Technology Institute describes the factors necessary in the consideration of emissions rates:

> "Average electricity generation emission factors can be used appropriately to determine carbon footprint or GHG inventory. However, average emission rates typically under-predict the emission reduction when used for energy savings through efficiency improvements because these averages include baseload generation such as nuclear or hydro power, which would not be affected by the efficiency improvement."[19]

EPA recognizes several valid and established approaches to quantify emission reductions using the non-baseload electricity mix.[20] Non-baseload CO_2emission factors are published by the EPA to facilitate the calculation of emissions reduction due to energy efficiency improvements. The use of eGRID sub-region non-baseload emission factors is recommended by the EPA as a simple, low-cost method to estimate emission reduction potential, to explain emission benefits to the general public, or to determine annual emission reductions or regional / national estimates.[21] EPA's non-baseload emission rates and methodology are currently used in several tools, including EPA's Greenhouse Gas Equivalencies Calculator (http://epa.gov/cleanenergy/energy-resources/calculator.html) and Green Power Partnership's Green Power Equivalency Calculator (http://www.epa.gov/greenpower/pubs/calculator.htm).[22]

EPA's non-baseload emission rate methodology also provides a convenient way to determine the primary energy factor associated with marginal non-baseload power plants for each eGRID sub-region. The emission factors can be correlated with the associated generation mix of oil, natural gas, and coal. Knowing this mix, the aggregate primary energy conversion factor can be calculated based on marginal power plant efficiency levels for each fuel type. In the absence of marginal power plant efficiency level information, average power plant efficiency levels may provide an acceptable substitute.

With regard to the EPA Clean Power Plan, specific guidance will be necessary to establish the appropriate displaced grid emissions rate to be used in the savings calculation. A standard approach is to use the EPA eGrid data on emissions for either non-baseload or fossil fuel generation mix on a regional or sub-regional basis in order to reflect the differences in a service territory grid mix. The non-baseload or fossil fuel mix represents those electric generating units that operate at the margin and which would be displaced by the substitution of gas equipment for an electric counterpart. This approach is consistent with the EPA SIP Guidance.

The following tables are derived from the Gas Technology Institute Report "Full-Fuel-Cycle Energy and Emissions Factors for Building Energy Consumption." The data below provides a comparison between natural gas and electric water heater in different regional and sub-regional grid mixes using the eGRID database. The natural gas energy requirements are the same in all cases; the full-fuel-cycle electricity

---

[19] Jacobson, D., Flawed Methodologies in Calculating Avoided Emissions from Renewable Energy , The GW Solar Institute, October 24, 2009. (http://solar.gwu.edu/index_files/Resources_files/DJ_REILPresentation.pdf)

[20] DeYoung, R., *Deciding an Approach for Quantifying Emission Impacts of Clean Energy Policies and Programs*, U.S. Environmental Protection Agency, State Climate and Energy Program, January 30, 2012. (http://www.epa.gov/statelocalclimate/documents/pdf/DeYoung_presentation_1-30-2012.pdf)

[21] DeYoung, R., *Quantification Methods using eGRID State and Local Examples*, U.S. Environmental Protection Agency, State Climate and Energy Program, March 31, 2011. (http://www.epa.gov/statelocalclimate/documents/pdf/DeYoung_presentation_3-31-11.pdf)

[22] Collison, B., *Green Power 101*, US EPA Green Power Partnership, Renewable Energy Markets Conference, Atlanta, GA, September 13, 2009 (http://www.renewableenergymarkets.com/docs/presentations/2010/Wed_RE%20101_Blaine%20Collison.pdf)

requirements will vary depending on the electric generation composition. Similarly, the emissions reductions achieved through a natural gas water heater will vary depending on the electric generation baseline from which emissions reductions are calculated. This table is meant to be illustrative of the distribution in possible emissions savings achievable through the *direct use* of natural gas.

Table A-1

eGRID 2012 Sub-region	**eGRID 2012 Sub-region Name**	**FFC Energy**		**FFC Energy Savings**	
		Electric WH (MMBtu)	Gas WH (MMBtu)	Gas WH savings (MMBtu)	Gas WH savings (%)
AKGD	ASCC Alaska Grid	37.2	19.0	18.2	49%
AKMS	ASCC Miscellaneous	21.9	19.0	3.0	13%
ERCT	ERCOT All	35.4	19.0	16.4	46%
FRCC	FRCC All	36.0	19.0	17.1	47%
HIMS	HICC Miscellaneous	43.0	19.0	24.0	56%
HIOA	HICC Oahu	37.4	19.0	18.4	49%
MROE	MRO East	37.3	19.0	18.3	49%
MROW	MRO West	39.7	19.0	20.7	52%
NYLI	NPCC Long Island	38.8	19.0	19.8	51%
NEWE	NPCC New England	33.4	19.0	14.4	43%
NYCW	NPCC NYC/Westchester	35.1	19.0	16.1	46%
NYUP	NPCC Upstate NY	29.0	19.0	10.0	35%
RFCE	RFC East	36.7	19.0	17.7	48%
RFCM	RFC Michigan	37.4	19.0	18.4	49%
RFCW	RFC West	37.2	19.0	18.2	49%
SRMW	SERC Midwest	37.9	19.0	18.9	50%
SRMV	SERC Mississippi Valley	35.6	19.0	16.6	47%
SRSO	SERC South	34.8	19.0	15.8	45%
SRTV	SERC Tennessee Valley	35.2	19.0	16.3	46%
SRVC	SERC Virginia/Carolina	36.7	19.0	17.7	48%
SPNO	SPP North	40.7	19.0	21.7	53%
SPSO	SPP South	36.6	19.0	17.6	48%
CAMX	WECC California	33.3	19.0	14.3	43%
NWPP	WECC Northwest	26.8	19.0	7.8	29%
RMPA	WECC Rockies	39.6	19.0	20.6	52%
AZNM	WECC Southwest	36.2	19.0	17.2	47%
US Average		**35.8**	**19.0**	**16.8**	**47%**

Source: *Full-Fuel-Cycle energy and Emissions Factors for Building Energy Consumption – 2013 Update*. Gas Technology Institute.