Paper #3-2

RESIDENTIAL AND COMMERCIAL NATURAL GAS AND ELECTRICITY DEMAND

Prepared by the Residential/Commercial Subgroup
of the
Demand Task Group

On September 15, 2011, The National Petroleum Council (NPC) in approving its report, *Prudent Development: Realizing the Potential of North America's Abundant Natural Gas and Oil Resources*, also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the study's Task Groups and/or Subgroups. These Topic and White Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

These Topic and White Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents, but approved the publication of these materials as part of the study process.

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached paper is one of 57 such working documents used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix C of the final NPC report provides a complete list of the 57 Topic and White Papers and an abstract for each. The full papers can be viewed and downloaded from the report section of the NPC website (www.npc.org).

Residential/Commercial Subgroup

Chair		
Thomas J. Massaro, Jr.	Vice President	New Jersey Natural Gas Company
Assistant Chair		
Richard D. Murphy	Senior Vice President	National Grid
Members		
Stanley Blazewicz	Vice President, Global Head of Technology	National Grid
Christopher R. Brown	Director – Central Services	UGI Utilities, Inc.
William O. Comstock	Operations Research Analyst, Office of Energy Consumption and Efficiency Analysis, Energy Information Administration	U.S. Department of Energy
Arthur C. Corbin	President and Chief Executive Officer	Municipal Gas Authority of Georgia
Herb Emmrich	Gas Demand Forecast and Economic Analysis Manager, Regulatory Affairs Department	Southern California Gas Company
Paula A. Gant	Senior Vice President, Policy and Planning	American Gas Association
Jonathan R. Gruchala	General Manager, Energy Services	National Fuel Gas Distribution Corporation
James E. Hearing	Director, Marketing	Laclede Gas Company
William C. Horak	Chair, Energy Sciences and Technology Department, Brookhaven National Laboratory	U.S. Department of Energy
Sini Jacob	Manager, Natural Gas Policy, Planning and Strategy	Pacific Gas & Electric Company
Carl W. Levander	President	Columbia Gas of Virginia
King Look	Director, Resource Planning	Consolidated Edison, Inc.
Russell Lovelace	Manager – Power Analytics	Shell Energy North America
Yvonne Merkel	Director, Strategic Partnerships & Alliances	AGL Resources Inc.

Richard Meyer	Energy Analyst	American Gas Association
John N. Moura	Manager, Reliability Assessment	North American Electric Reliability Corporation
Ken Newel	Technology Specialist, Strategy and Analysis	National Energy Board
Cassandra Newsome	Manager, Marketing and Business Support Services	Piedmont Natural Gas Company, Inc.
Donna N. Peeples	Vice President, Corporate Communications and Chief Marketing Officer	AGL Resources Inc.
Colin G. Shay	Director, Marketing and Sales	Washington Gas Light Company
Rodney Sobin	Senior Policy Manager	Alliance to Save Energy
Todd Strauss	Senior Director, Energy Policy, Planning and Analysis	Pacific Gas and Electric Company
Mary Usovicz	Vice President of External Affairs	Repsol Energy North America
Gregory K. Waller	Vice President of Finance, Kentucky/Mid-States Division	Atmos Energy Corporation
Paul L. Wilkinson	Vice President, Policy Analyst	American Gas Association

The Role of Natural Gas in a Carbon Constrained World

Report from the
Residential and Commercial Subcommittee
National Petroleum Council Demand Task Group

Final Report
April 6, 2011

Table of Contents

Introduction and Chapter Overview

This report represents the collective work of the Residential and Commercial Subgroup (RCS) of the National Petroleum Council (NPC) Demand Task Group. This document provides detailed information on residential and commercial natural gas demand and the contribution natural gas can make in these sectors in a transition to a lower carbon, more sustainable energy mix. The content herein is based on two sources: first, a detailed review of studies identified as relevant by the Demand Task Group; and second, output from the RCS discussions.

Executive Summary presents the key findings and top policy priorities of the RCS.

Chapter One provides a summary of the process used by the RCS, the findings including common threads that emerged from the report and recommendations on how natural gas could best be utilized to meet the objectives stated in Secretary Chu's letter to the NPC.

Chapter Two presents an analysis of the Annual Energy Outlook reports issued by the Energy Information Administration (EIA) from 2000 - 2009.

Chapters Three and Four delves deeper into trends and forecasts for natural gas and electricity demand in the residential and commercial sectors.

Chapter Five discusses at the impact of energy efficiency initiatives and programs on the demand for natural gas and electricity in the residential and commercial sectors.

Chapter Six provides a look out to the year 2050 and offers a perspective on the commercialization of existing technologies and the development of disruptive technologies that could impact natural gas and electricity demand curves.

Chapter Seven identifies the key drivers of residential and commercial energy demand that emerged from the RCS's review of the "study of studies" and recommends regulatory and policy levers to influence these drivers.

Executive Summary

Background

The Residential and Commercial Subgroup (RCS) of the Demand Task Group is comprised of 26 individuals with expertise in residential and commercial energy demand representing a diverse group of organizations. Subgroup members reviewed 30 studies deemed relevant to the requirements established for the RCS's scope of work. The Subgroup then analyzed the studies and developed a report detailing information on residential and commercial energy demand and the contribution natural gas can make to a lower carbon, more sustainable energy mix, as per Secretary Chu's guidelines. The following summary highlights the residential and commercial demand outlook, implications on policy development, and details the key findings and the policy priorities that emerged from this process.

Demand Summary

- Residential/commercial energy demand since 1970 has been driven by growth in electricity sales and related system losses, driven in turn by increasing electricity use per customer. These factors are expected to continue driving energy consumption upwards long-term in these sectors.

- Natural gas used directly in the residential and commercial sector, in contrast to electricity, has remained level since 1970 as efficiency improvements have contributed to lowering gas use per customer, thereby offsetting growth in demand attributable to a 71 percent increase in the total number of natural gas customers.

- Energy system losses from generation, transmission, and distribution of electricity represent half of all energy consumed in the residential and commercial sector.

- Energy efficiency improvements have weakened the link between economic and population growth and energy demand. There remains significant technological potential for efficiency improvements for both natural gas and electricity to reduce long-term demand. However, significant investment and R&D in residential and commercial technologies will be required to realize these potential improvements, particularly on the gas side, which has already demonstrated major gains.

- In contrast to many widely discussed energy technologies and strategies, directly using highly efficient natural gas equipment in residential and commercial applications has demonstrated success in economically reducing carbon emissions. It would seem prudent to focus increased attention, particularly over the next 10-20 years, on expanding the role of gas in these sectors.

Implications for Policy Development

- Residential and commercial natural gas markets have maintained a reliable baseline demand load while improving end-use efficiency and serving an expanding customer base.

- Meeting new energy demand will require a suite of options, such as expanding electric generation capacity, improving energy efficiency, and developing new end-use technologies and applications.

- Enhancing natural gas demand implies efficiently growing consumption, but also optimizing natural gas resources across all sectors to meet energy needs while contributing to economic growth, energy security and improved air quality.

- There is considerable potential in the Northeastern United States to reduce greenhouse gas emissions and lower energy usage by displacing fuel oil as a primary heating fuel.

- Energy usage and efficiency should be measured and assessed across the entire energy chain in order to maximize the value of energy resources. Energy losses should be considered in any comprehensive analysis, such as a full-fuel-cycle analysis. This kind of assessment can then, in turn, help to optimize energy resource utilization.

This comprehensive approach should be considered in the context of other policy options to enhance gas demand, support supply, and grow the economy. Based on this framework, the RCS Subgroup developed the following policy recommendations:

- Enhance the direct use of natural gas through the adoption of a full–fuel-cycle analysis, appliance labeling, and appropriate incentives.

- Utilize the suite of energy efficiency levers available to policymakers.

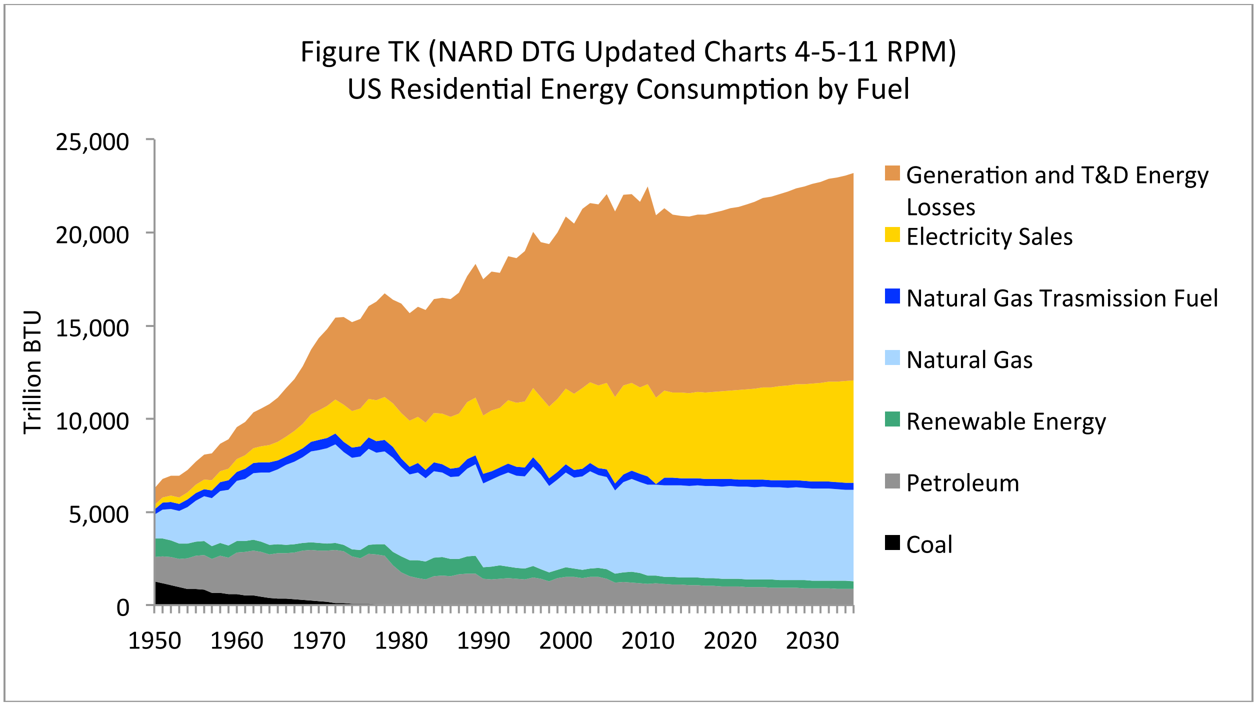
- Develop policies and promote innovative tariff designs that align the interests of consumers, utilities, and regulators.

Key Findings and Policy Suggestions

Finding 1: Energy losses related to the generation, transmission and distribution of electricity have increased to represent over 50 percent

of total energy consumption in the residential and commercial sectors in 2009.

Electricity sales and energy losses related to generation, transportation, and distribution of electricity are responsible for the growth in overall energy consumption in the residential and commercial sectors. This trend is projected to continue absent new policies.



A holistic energy measurement methodology, such as a full-fuel-cycle analysis, provides a means to promote a more comprehensive assessment of energy use, emissions, intensity, costs, benefits, impacts, and efficiency economy wide. The direct use of natural gas for residential and commercial heating and cooking applications can help offset losses related to electricity sales to these applications.

The energy consumed by a natural gas end-use appliance, when measured on a full-fuel-cycle basis, often offers higher efficiencies and lower carbon emissions compared to competing technologies and fuel sources.

Policy suggestions include:

- Source-based efficiency labeling for appliances and buildings.
- Direct funding of R&D towards increased efficiency of end-use applications and expanding the use of natural gas to displace higher carbon-emitting sources.
- Support for the development of distributed energy technologies.
- Promoting energy efficiency to reduce energy waste, emissions, and other impacts irrespective of energy source and at all fuel-cycle phases.

- Support expansion of the natural gas infrastructure, particularly in the Northeast, which has a heavy reliance on imported oil, so that more consumers have a gas option available.

A holistic measurement approach would include consideration of energy losses that promote a fuller evaluation of the economic and societal-wide costs, benefits, and impacts associated with a particular energy option. Enabled with this information, consumers, energy providers, policy makers, and regulators can make better informed decisions regarding energy choices.

Finding 2: Energy efficiency improvements have weakened the link between economic and population growth and demand for energy.

Reducing the need for all energy, regardless of source, can lower emissions, mitigate environmental impacts, and enhance energy security. If the United States used energy at 1973 efficiency levels in all sectors of the economy, about 56 percent more energy would be consumed today, or 52 quads.

Some question the ability to continue improving residential and commercial gas efficiency given the 40-year pattern of improvement that has already been realized. Various studies reviewed by our subgroup indicate that energy efficiency opportunities in the residential and commercial sectors remain vast. By not addressing all energy efficiency improvement opportunities, the potential for efficiency gains will not be realized in a cost effective nor timely manner.

Policy levers for increasing end-use energy efficiency include:

- Enhanced building codes and equipment standards
- Energy efficiency resource standards (EERS)
- Fiscal incentives (tax incentives, loan funds, property assessed clean energy [PACE] financing, etc.)
- Building labeling
- Improved consumer energy information would reduce energy waste, emissions, and other impacts irrespective of energy source and at all fuel-cycle phases, and could enhance energy security and reliability.
- Promotion of innovative tariff designs that align the interests of gas utilities, their customers, and policy makers.

These policy suggestions are based on these working assumptions:

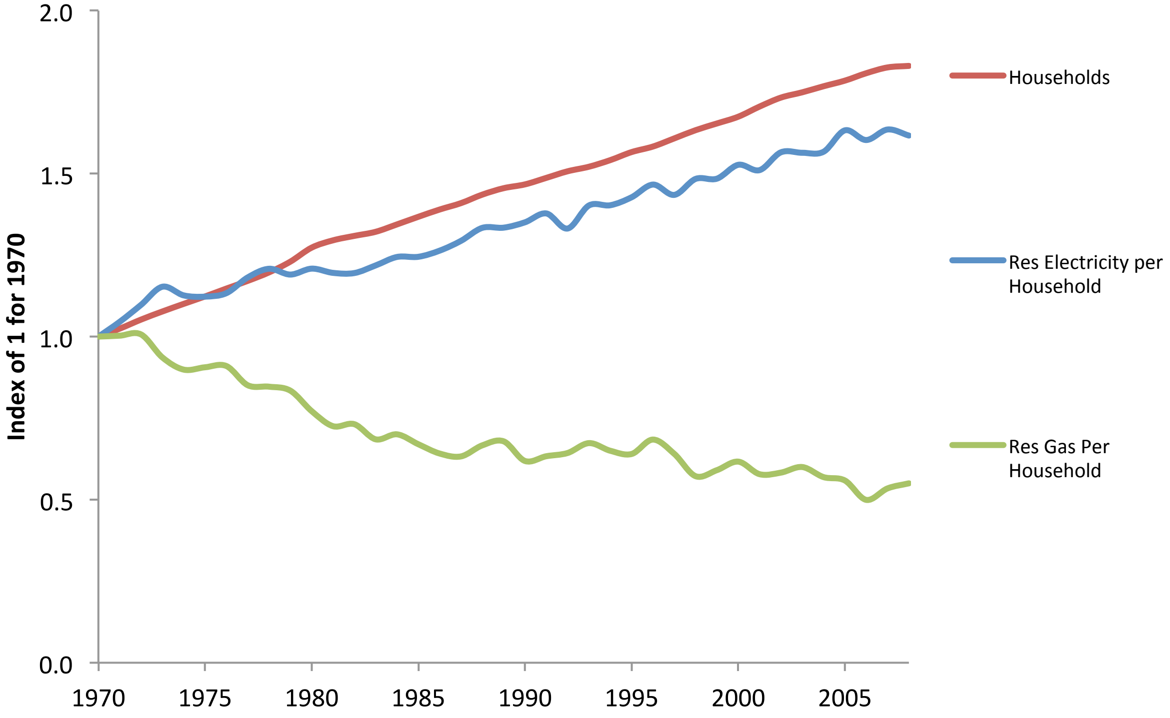
- Energy efficiency advancements have reduced the rate of growth in energy consumption
- Enhanced codes and standards improve energy efficiency of new buildings and equipment.

- Innovative tariff design, EERS, and utility demand-side management programs have yielded energy savings, more so in states with stronger requirements.
- Financial incentives (tax, loan funds, etc.) can incentivize more energy efficient new and retrofitted buildings and equipment.
- Labeling and information inform consumers of energy costs and impacts and ways to save.

Finding 3: Natural gas use per customer has decreased while electricity use per customer has increased.

Historical declines in natural gas demand per household and per person are expected to continue as existing natural gas heating and water heating equipment is replaced with new high efficiency equipment, new buildings are built with more efficient shells, and consumer behavior influences conservation. Efficiency of both natural gas and electric appliances and equipment has improved, but new electric applications have more than offset energy efficiency gains with other electric applications.

Figure TK (NARD DTG Updated 4-5-2011 RPM)
Change in Residential Gas and Electricity Use per Customer



Natural gas ratios for energy consumption per household and per population experienced the most dramatic reduction from 1970-2009. Electricity consumption per customer did not experience a reduction as new electric applications have more than offset the reductions in energy consumption associated with energy efficiency advancements.

Natural gas can reduce emissions by displacing more carbon-intensive fuels through increased high-efficiency end-use applications. Policies should recognize the historical gains in natural gas end-use efficiency and the future potential for gas applications to enhance demand, grow the economy, and support supply. Examples of polices to support this include:

- Enable growth in direct-use natural gas applications
- Policies to enhance and inform customer fuel choices
- Renewed emphasis on efficient demand-side gas technologies (e.g. gas heat pumps, desiccant dehumidifiers, micro-combined heat and power units)
- Incentives for the production of bio-gas from renewable sources, such as animal manure, forest residues, agricultural wastes, and municipal landfills that are similar to those that exist for renewable electricity and renewable transportation.
- Natural gas meters and appliances should be integrated into electric smart grid initiatives to promote a Smart Energy Grid.

The efficient, direct use of natural gas for home and building energy applications provides North America with an opportunity to significantly reduce economy-wide greenhouse gas emissions in a cost affordable and achievable manner and achieve the following objectives specified in Secretary Chu's letter to the National Petroleum Council:

- Environmental Protection
- Economic Growth
- National Security

Chapter One - Summary of Findings

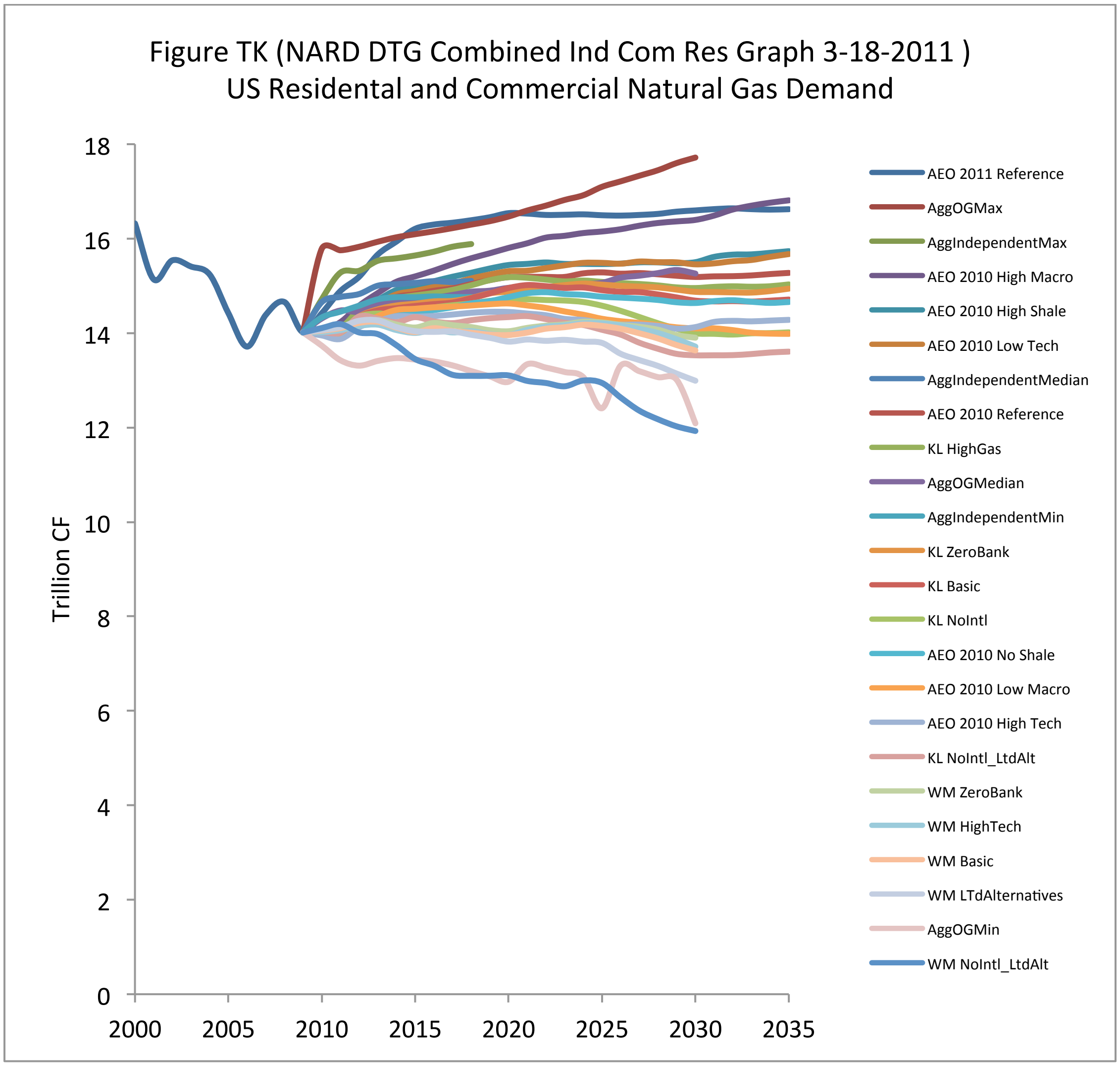
The Residential and Commercial Subgroup (RCS) of the Demand Task Group is comprised of 26 individuals with expertise in residential and commercial energy demand representing a diverse group of organizations (see Appendix A). Members of the Subgroup nominated 44 studies relating to natural gas and electricity demand for consideration in the "study of studies" work of the RCS. Of the 44 studies nominated, 30 studies (see Appendix B for listing of studies) were deemed to meet the requirements established for the RCS's scope of work. The 30 studies were broken out in to 10 categories based on key areas of focus. Study Review Teams were established for each of the 10 study categories (see Appendix C) and members of the Subgroup volunteered to participate in one or more of the Study Review Teams. Each Study Review Team identified the key drivers for natural gas and electricity demand referenced in the studies they reviewed. All key drivers of demand emerging from the Study Review Team's work were consolidated and the full RCS met to debate, categorize, and prioritize the key drivers. The prioritized drivers of demand in the residential and commercial sectors were utilized to help shape recommendations of how best to utilize North America's natural gas resources to meet the following government objectives specified in Secretary Chu's letter to the National Petroleum Council.

- Environmental Protection
- Economic Growth
- National Security

Energy demand projections reviewed by the RCS indicate factors associated with driving historical energy demand will remain the principal drivers of demand in the future. Since energy demand in the residential and commercial sectors is directly correlated to the emissions levels generated in the residential and commercial sectors, the mix of fuel sources to meet future energy demand, the technological advancement in energy consuming equipment, and new codes and standards for residential and commercial building shells are all critical factors in meeting the objectives articulated by Secretary Chu. Many of the studies reviewed by the Subgroup have demonstrated the significant progress that has been achieved by the natural gas industry in the efficient use of the product in space and water heating direct use applications. The efficiency of natural gas direct use applications represents an opportunity for the nation to reduce its overall energy consumption, emissions levels and petroleum imports by utilizing natural gas to displace more carbon intensive fuels in the residential and commercial markets.

Long-term projections of natural gas demand in the residential and commercial sector show little variation compared with the power and industrial market. Projections show that U.S. natural gas demand in the combined residential and commercial sector across the studies reviewed show a range between 6.6 to 9.7 Tcf in 2035.[1]

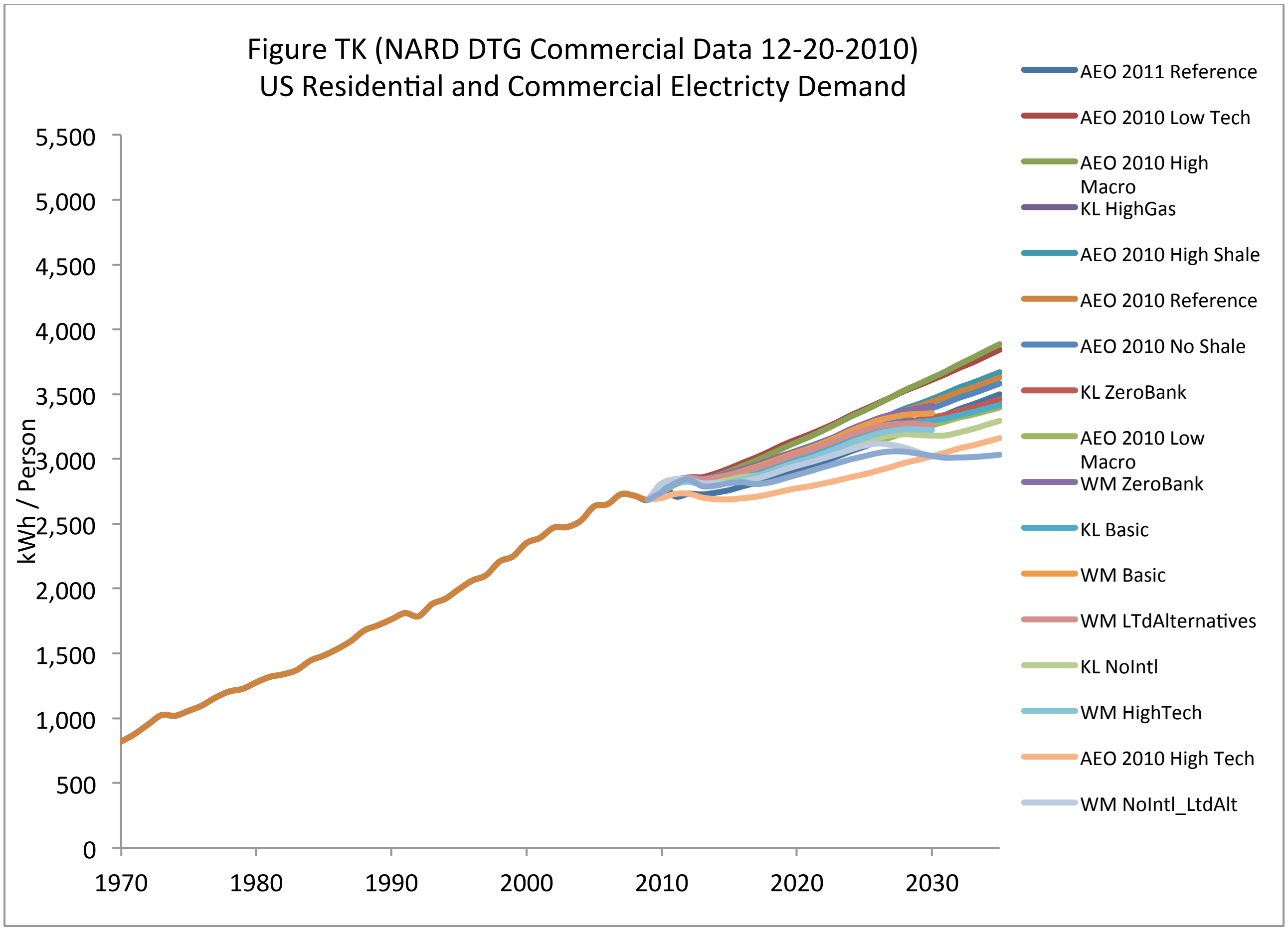
Figure 1
Residential and Commercial Natural Gas Demand Range of Study Projections



---

[1] Projections for both the high and low cases were aggregated from proprietary oil and gas industry sources, which extend through 2030. Projections for demand during the 2031 to 2035 are based on the compound annual growth rate multiplied by the annual demand from 2030 onwards.

Figure 2
Residential and Commercial Electricity Demand Range of Study Projections



A summary of the key observations of the RCS are provided below with more detailed information and policy recommendations presented in succeeding chapters of this report.

- Energy demand at the point of use grew considerably during the period 1950 to 1970 and then the growth moderated from 1970 to 2009.
- Total energy demand grew significantly from 1970 to 2009 as energy demand at the site served by electricity grew resulting in a significant increase in energy consumption from energy system losses since losses associated with electricity are significantly greater than other fuel sources.
- Energy system losses accounted for more than 50% of total energy consumption in the residential and commercial sectors in 2009.
- Energy efficiency advancements have reduced the rate of growth in energy consumption. Population expansion alongside household and commercial floorspace growth was identified as the primary drivers of energy demand in the residential and commercial sectors. Overall site energy demand growth did not correlate to the growth in population and households during the period 1970 to 2009. This was primarily attributable to the following factors.

  - Efficiency advancements in energy-consuming appliances and equipment serving the residential and commercial markets.
  - Housing and building stock turnover coupled with the adoption of more energy efficient building codes and standards.
  - The implementation of energy efficiency programs and consumer conservation accelerated in part by increasing fuel prices.

As a result of the above factors, natural gas ratios for energy consumption per household and per population experienced the most dramatic reduction. Unlike natural gas, energy consumption per customer for electricity did not experience a reduction from 1970 - 2009 since new electric applications that have entered the market during this period of time have more than offset the reductions in energy consumption associated with energy efficiency advancements. In fact, the studies and data reviewed by the RCS have reported that electricity consumption ratios for the two sectors have actually increased during this time period.

Studies and data on energy consumption have illustrated indirect energy consumption associated with electrical energy system losses is a significant percentage of overall energy consumption in the residential and commercial sectors. Policies designed to address energy consumption in the residential and commercial sectors must utilize a holistic approach toward management of the nation’s energy resources. As such, policies developed must be coupled with or analyzed using a comprehensive methodology such as a *full-fuel-cycle* analysis for measuring the intensity, efficiency and emissions impact of fuels and energy consuming equipment. See adjacent text box for further description of a full-fuel-cycle measure of energy consumption.

Site vs. Full-Fuel-Cycle Measurement

Site (point-of-use) measure of energy consumption reflects the use of electricity, natural gas, propane, and/or fuel oil by an appliance at the site where the appliance is operated, based on specified test procedures.

Full-fuel-cycle measure of energy consumption includes, in addition to site energy use, 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 homes and commercial buildings.

Source: National Research Council

Natural gas provides a clean, affordable, and readily available pathway toward reducing carbon dioxide (CO2) emissions and offers the lowest greenhouse gas emissions of combustible carbon-based fuels. The efficient, direct use of this abundant, domestic resource in home and building energy applications provides North America with an opportunity to significantly reduce economy-wide CO_2 emissions in a cost affordable and achievable manner. To attain maximum value of our domestic, abundant natural gas resources and to best utilize its low-carbon attributes, policies enabling the availability of natural gas in the residential and commercial sectors while promoting improvements in energy efficiency should be strongly considered in the final report presented to the National Petroleum Council.

Chapter Two - Analysis of the EIA's Annual Energy Outlook Reports

In recent years, EIA's projections for overall energy consumption have declined because of the expansion of existing energy efficiency programs, the introduction of new energy efficiency programs, and overall economic factors. The declines have been much more significant in natural gas demand for residential and commercial energy use as compared with electricity.[2]

As shown in Figure 3, EIA's AEO commercial and residential energy forecasts increased between 2000 and 2009. The 2009 AEO forecast for the year 2020 at 44 quads was about 3 quads or 8 percent higher than the 2000 AEO forecast at 41 quads for 2020. Since the 2005 EIA annual forecast, total energy consumption in the combined residential and commercial sectors has decreased due to the proliferation and expansion of energy efficiency programs, codes and standards, and consumer conservation.

As shown in Figure 4, EIA's AEO residential and commercial natural gas demand forecasts have steadily decreased over the years 2002-2009. The 2009 AEO forecast for the year 2020 at 8.3 quads was about 1.3 quads or 15 percent lower than the 2000 AEO forecast at 9.6 quads for 2020.

As shown in Figure 5, EIA's AEO commercial and residential energy forecasts for electricity demand increased between 2005 and 2009. The 2009 AEO forecast for the year 2020 at 33.3 quads was about 3.4 quads or 9 percent lower than the 2005 AEO forecast at 36.7 quads for 2020. A principal reason was the proliferation of electricity-using devices and the expansion of air conditioning demand.

---

[2] Based on an analysis of Annual Energy Outlook reports published by the Energy Information Administration, 1999-2010.

Figure 3

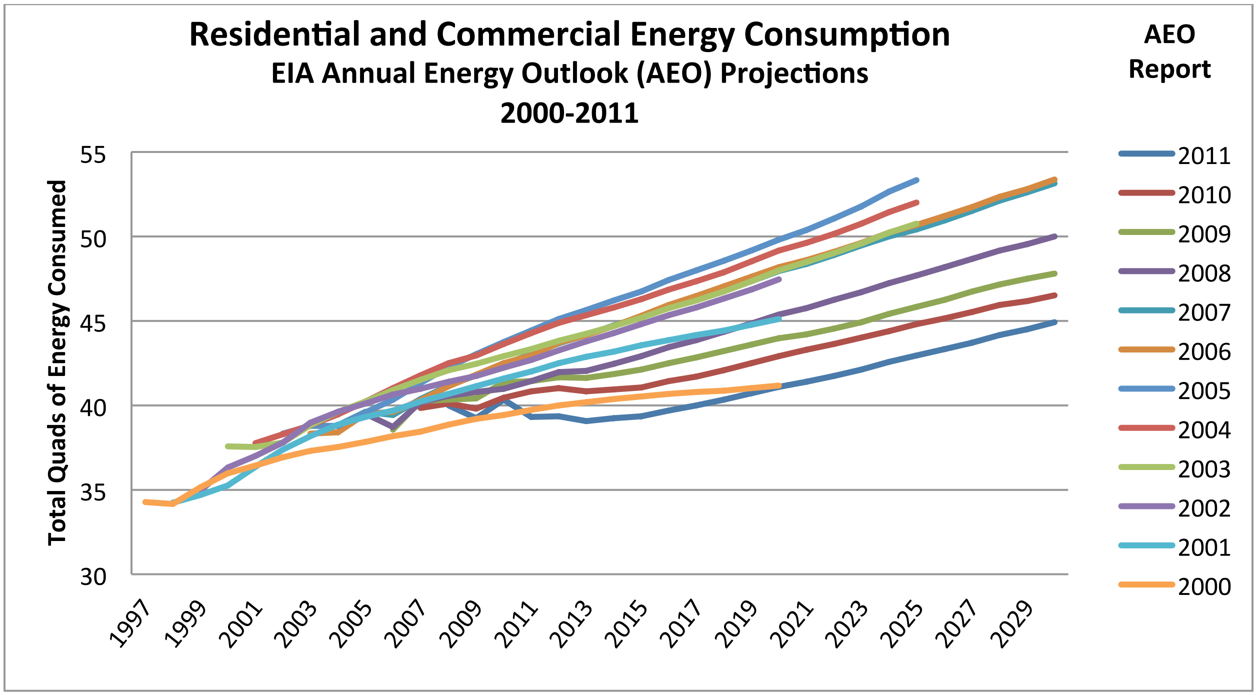


Figure 4

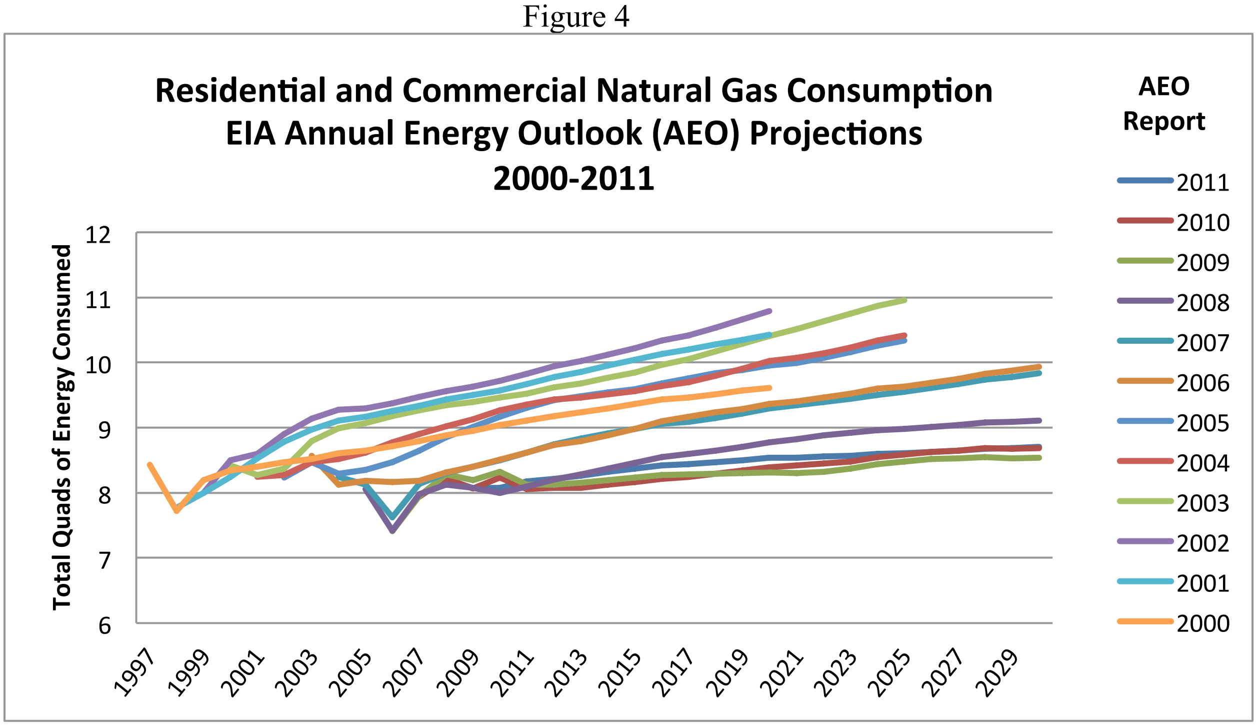
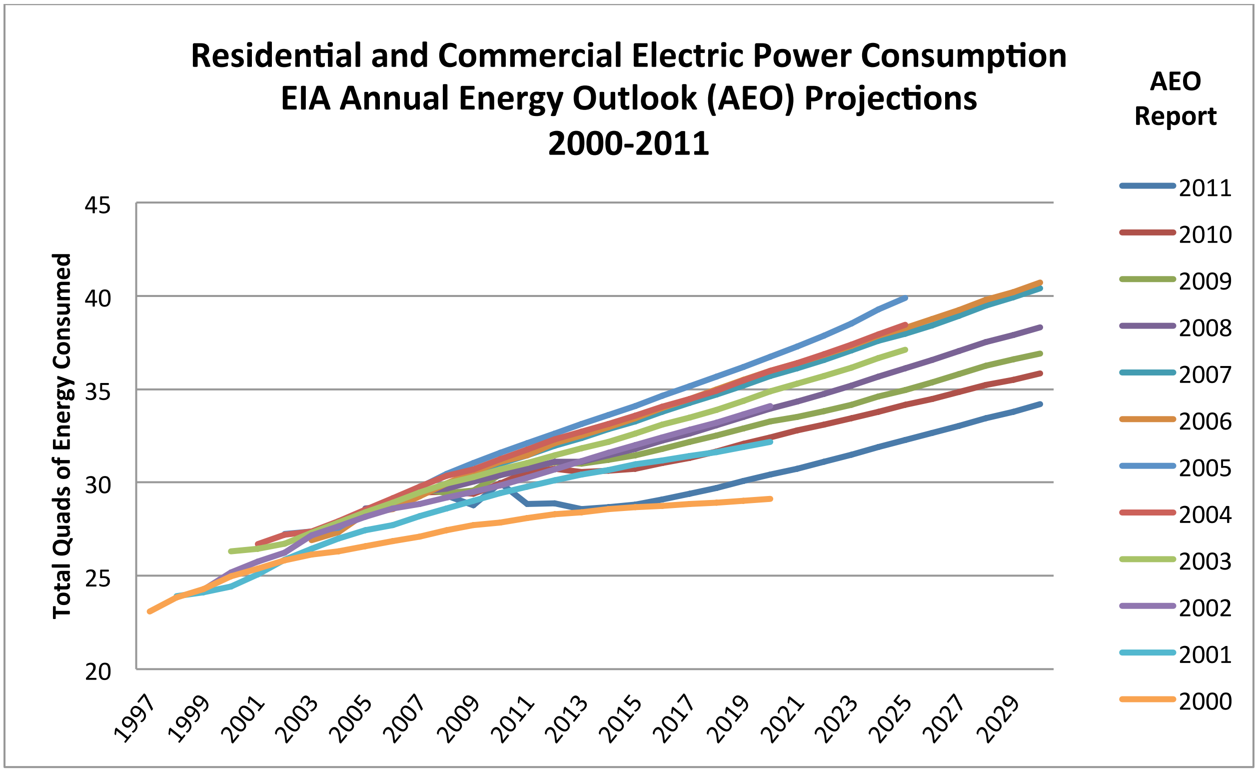


Figure 5

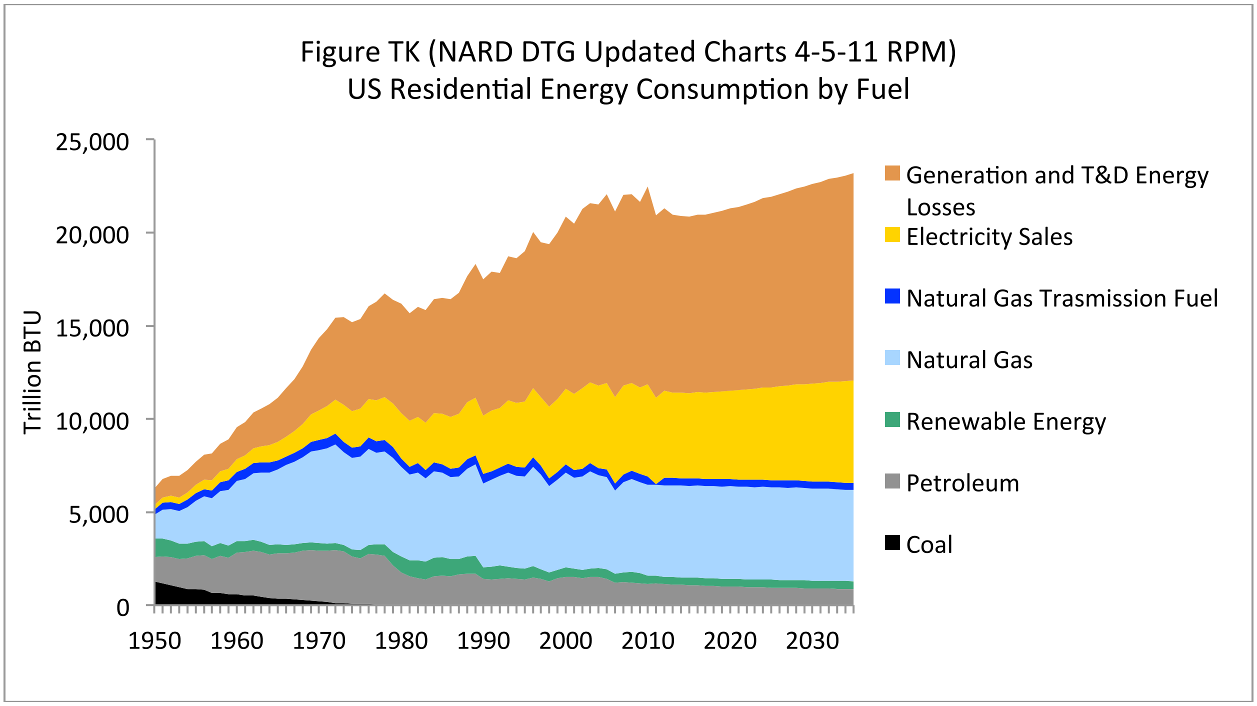

Residential and Commercial Electric Power Consumption
EIA Annual Energy Outlook (AEO) Projections
2000-2011
Total Quads of Energy Consumed
45
40
35
30
25
20
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
AEO Report
2011
2010
2009
2008
2007
2006
2005
2004
2003
2002
2001
2000

Chapter Three - Residential Natural Gas & Electricity Demand for North America

The fuel source distribution in the residential sector has changed significantly over the last 60 years with natural gas and electricity representing more than 85 percent of the energy consumed in the sector in 2009. The primary drivers of energy consumption growth in the residential sector are population, households, and technology. Population growth has resulted in an increase in the number of U.S. households. However, natural gas consumption growth associated with the growth in households during the period 1970-2009 was offset by energy efficiency gains in natural gas space and water heating equipment as well as other energy efficiency measures. On the other hand, electricity consumption increased during this same period as new electric devices more than offset energy efficiency gains in the home.

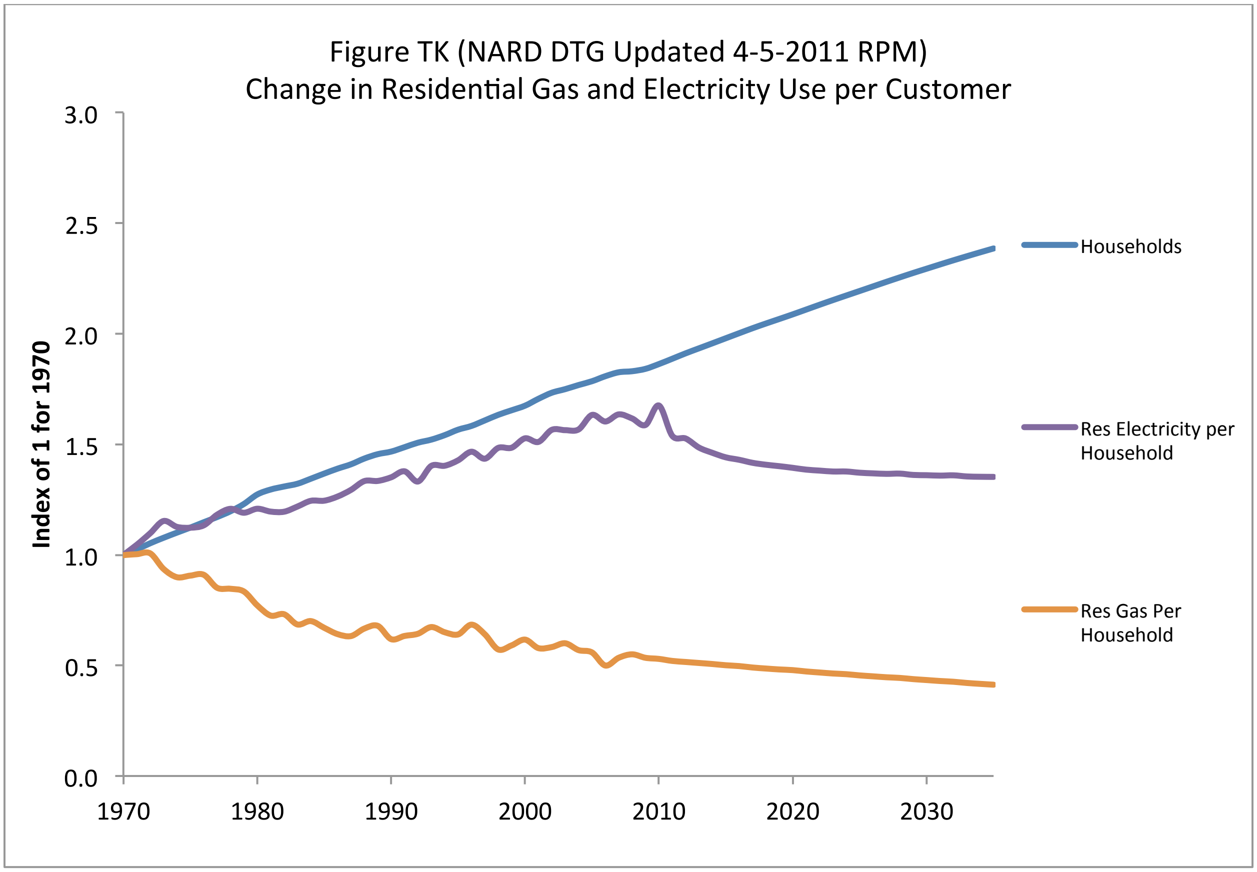
The graph below provides historical and projected overall energy consumption in the residential sector, comprised of direct and indirect energy consumption. Direct energy consumption is the energy that is consumed at the point of use. Indirect energy consumption represents the energy lost while generating and distributing the energy needed for consumption at the site. As shown in the graph below, both direct and indirect energy consumption in the residential sector experienced significant growth during the period of 1950–1970 with natural gas representing the largest percentage increase among the various fuel sources. However, during the period of 1970–2009 overall energy consumption in the residential sector continued to grow while direct energy consumption leveled off. The growth in overall energy consumption is directly attributable to the growth in indirect energy consumption as electricity gained share among fuel sources in the residential sector. Electrical system energy losses accounted for approximately 50 percent of the total energy consumption in the residential sector in 2009.

Figure 6



The graph below shows natural gas consumption per household declining over last 30 years while electricity consumption per household has been increasing.

Figure 7

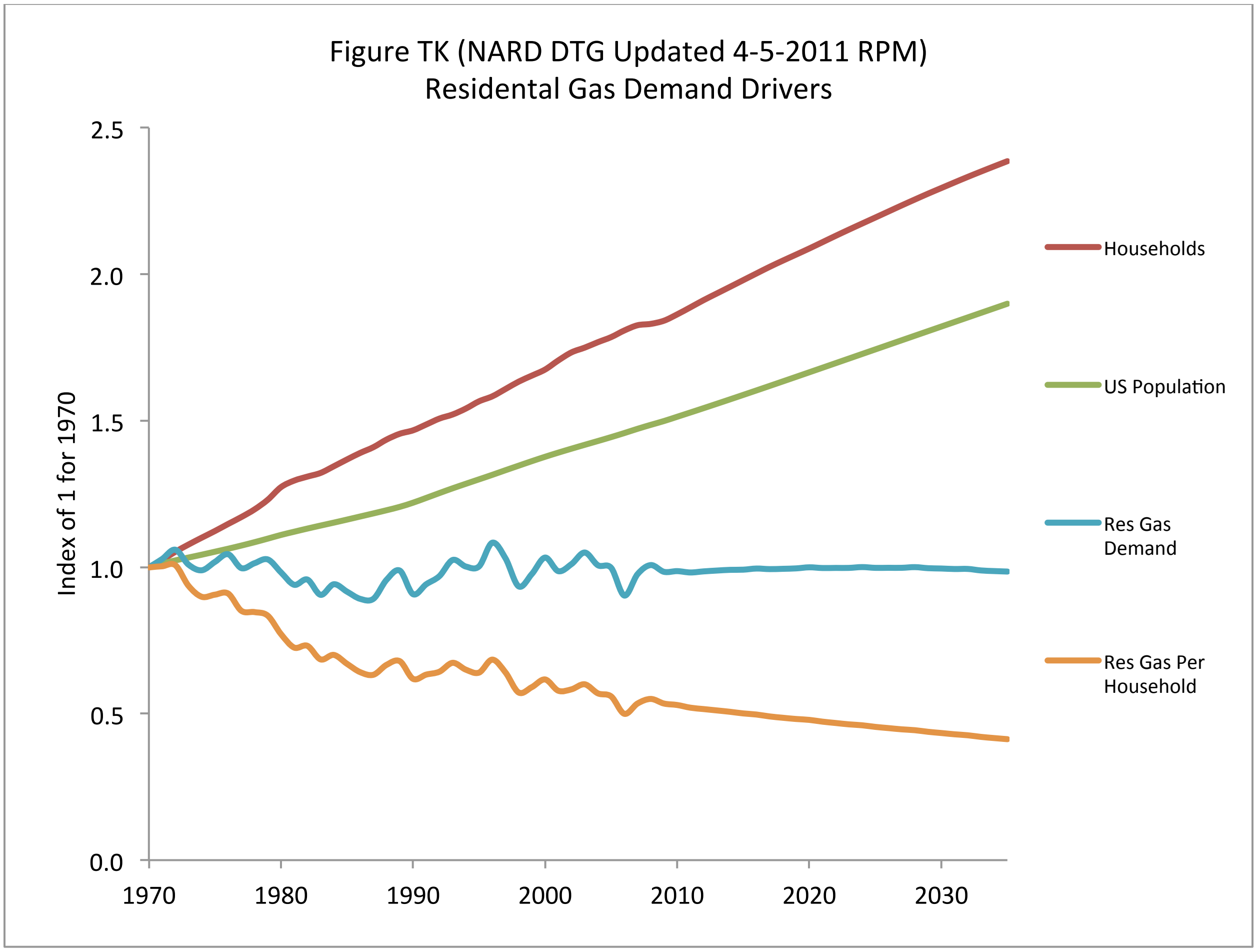


Residential Natural Gas - Historical Demand

Residential natural gas demand in the United States grew rapidly from 1930 to 1970 (Energy Information Administration 2010). However, with rapid natural gas price increases in the 1970's, implementation of energy efficiency programs and conservation efforts significantly reduced the growth of natural gas demand. On the other hand, the number of residential natural gas customers experienced significant growth during the period of 1970 through 2008 (American Gas Association 2008), (Energy Information Administration 2010). The overall customer base increased at an average annual rate 1.4 percent, peaking at a high of 2.8 percent in 1991 and seeing a low of 0.4 percent in 1993. Meanwhile residential use per customer on a weather normal basis has declined 1.3 percent annually from 1970 to 2008. The continued implementation of residential energy efficiency and conservation programs during this period resulted in the decline in use per customer holding overall residential gas demand flat for the past 40 years.

In terms of absolute growth, from 1930 to 1970 residential gas demand grew from 0.296 TCF in 1930 to 4.956 TCF in 1970, a compound annual growth rate of 7.3 percent. However, since 1970, residential gas demand has remained essentially flat due to rising delivered gas prices and extensive energy efficiency and conservation programs throughout the United States, as shown in Figure 8. The cost increases and the energy efficiency and conservation effects are demonstrated by the declining use per customer. Based on EIA data, over the past two decades U.S. residential natural gas customers have grown from 47.7 million in 1987 to 65.3 million by year-end 2008. That is a growth rate of 1.5 percent per year. However, during the same period, residential use per customer declined from an average of 90.4 thousand cubic feet per customer in 1987 to just 72.6 thousand cubic feet in 2008, a decline of 1.1 percent weather normalized compound annual decline rate that has offset customer growth to a large degree over the past 20 years.

Figure 8



Residential Natural Gas - Demand Projections

As illustrated in the graph above, historical declines in natural gas consumption per household are expected to continue for the foreseeable future as existing natural gas heating and water heating equipment is replaced with new high efficiency equipment, new homes are built with more energy efficient shells, utility energy efficiency programs expand and conservation influences consumer behavior. Forecasts for future natural gas consumption do not anticipate any new natural gas applications emerging in the residential sector.

Figure 9

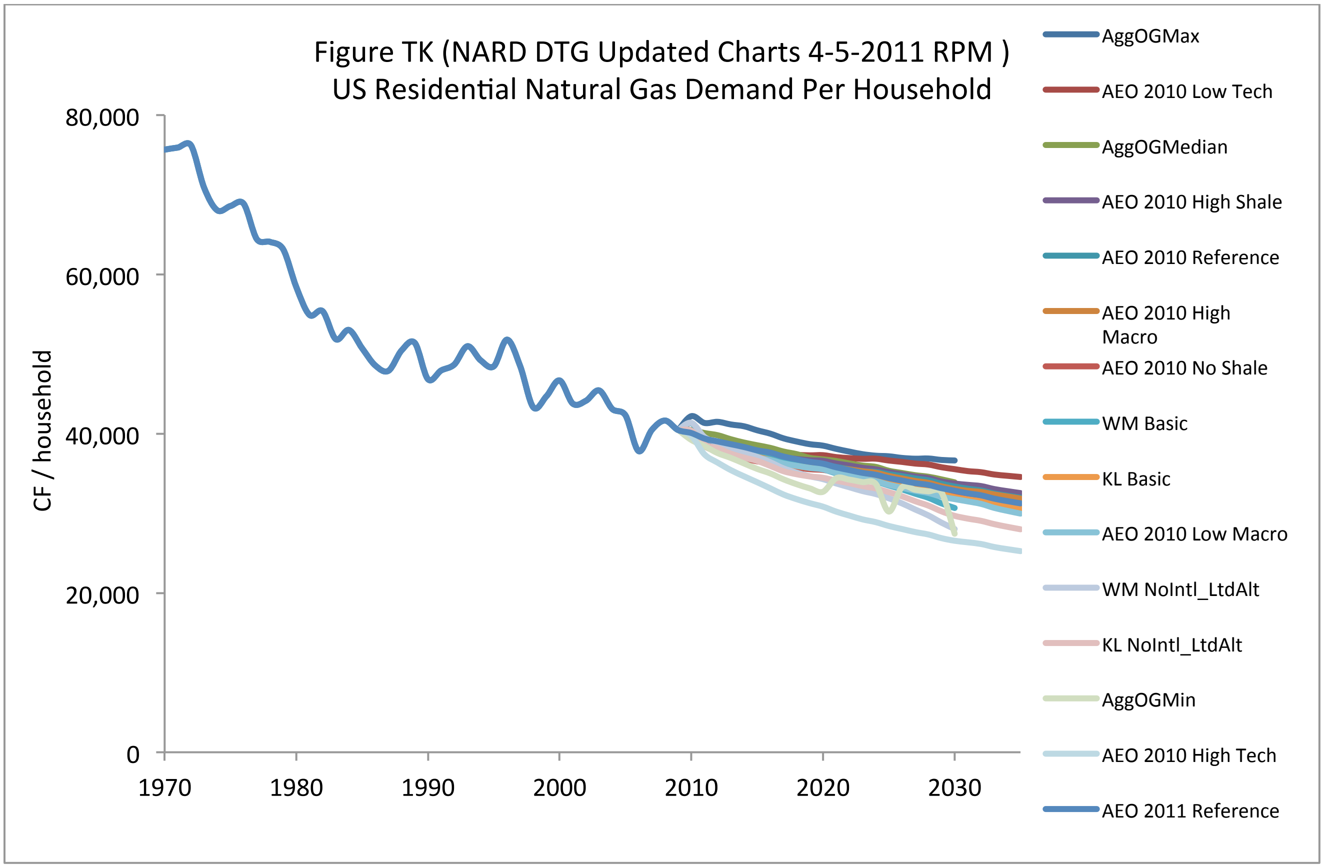
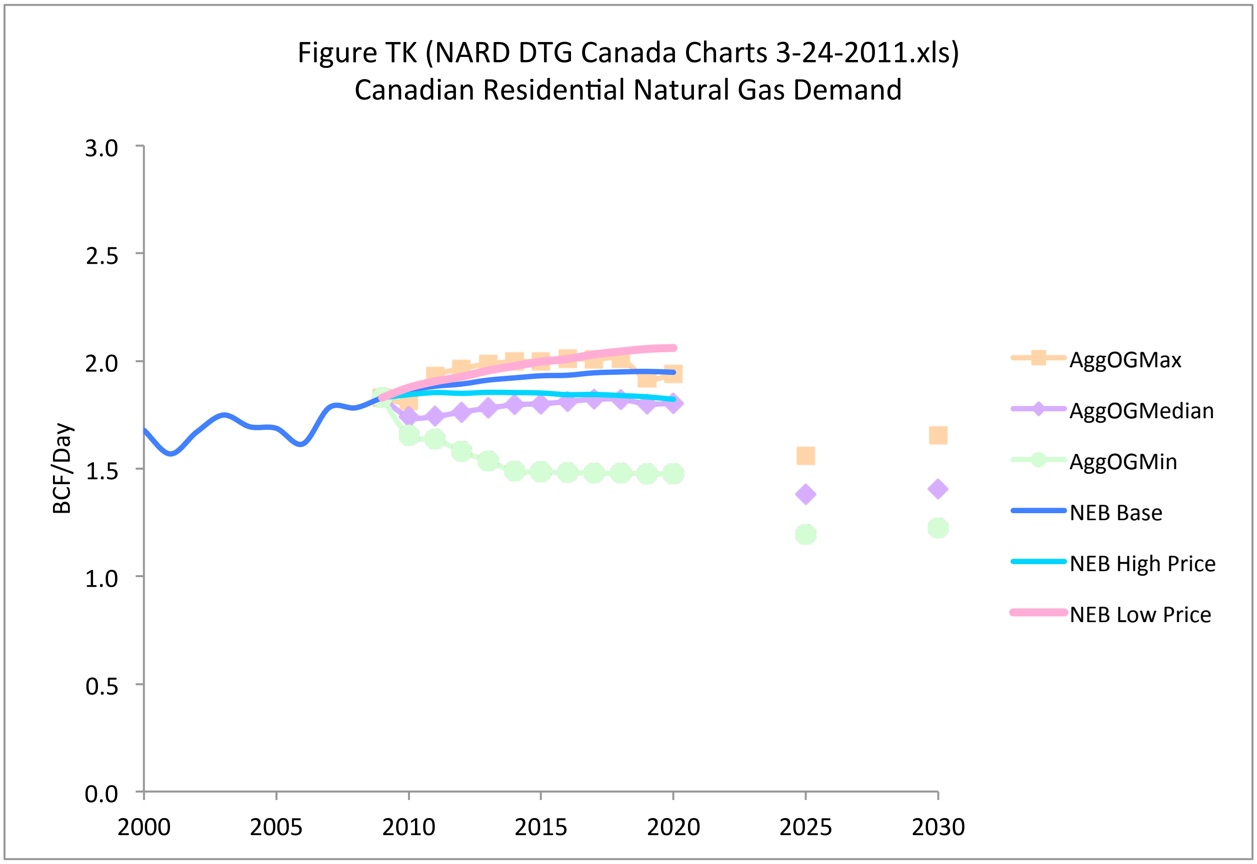


Figure 9 shows the range in projections of natural gas demand per household by 2035. All projections expect a continually decrease in use per customer. The range reflected above corresponds to a demand outlook between 4.7 to 5.2 Tcf per year.

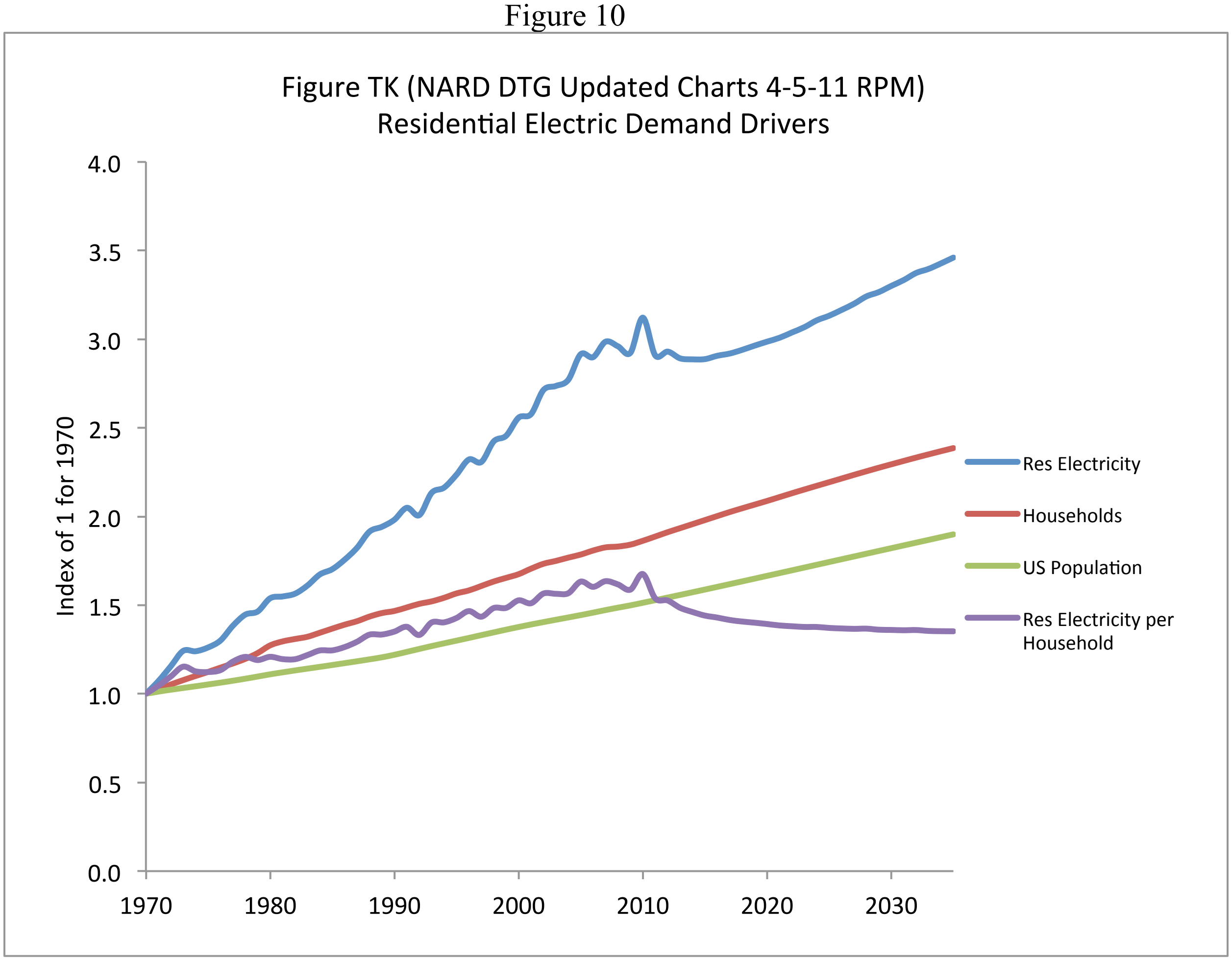
Consumption in Canada is significantly smaller compared to the United States, but some growth is projected over the next decade. In 2009, the residential sector in Canada consumed 0.64 Tcf of natural gas. Projections from the National Energy Board show a 6.8 percent growth from this baseline to 0.69 Tcf by 2020. Of the various Canadian studies reviewed, there was a range of demand between 0.49 to 0.74 Tcf per year by 2030.



Residential Electricity - Historical Demand

Electricity consumption in the residential sector has grown steadily from an annual demand of 67 billion kilowatt hours (kWh) in 1947 to 1,363 billion kWh in 2009 translating to a compound annual increase of 5.16 percent per year. As shown in the graph below, residential electricity demand since 1970 has grown at a much lower compound annual growth rate of 2.9 percent because of higher electricity prices, energy efficiency and conservation programs and slower GDP growth (Energy Information Administration 2010).

Figure 10



Residential Electricity - Demand Projections

As illustrated in the graph below, historical electricity demand per kWh is expected to level off and then decline as high efficiency electric appliances, building shell improvements, and changes in consumer behavior offset the increased number of electric appliances and devices. This corresponds to a demand range between 1404 and 1844 billion kWh in 2035. In the Canadian studies by the National Energy Board that were reviewed, Canadian electricity demand showed a range between 170 to 172 billion kWh by 2020.

Figure 11

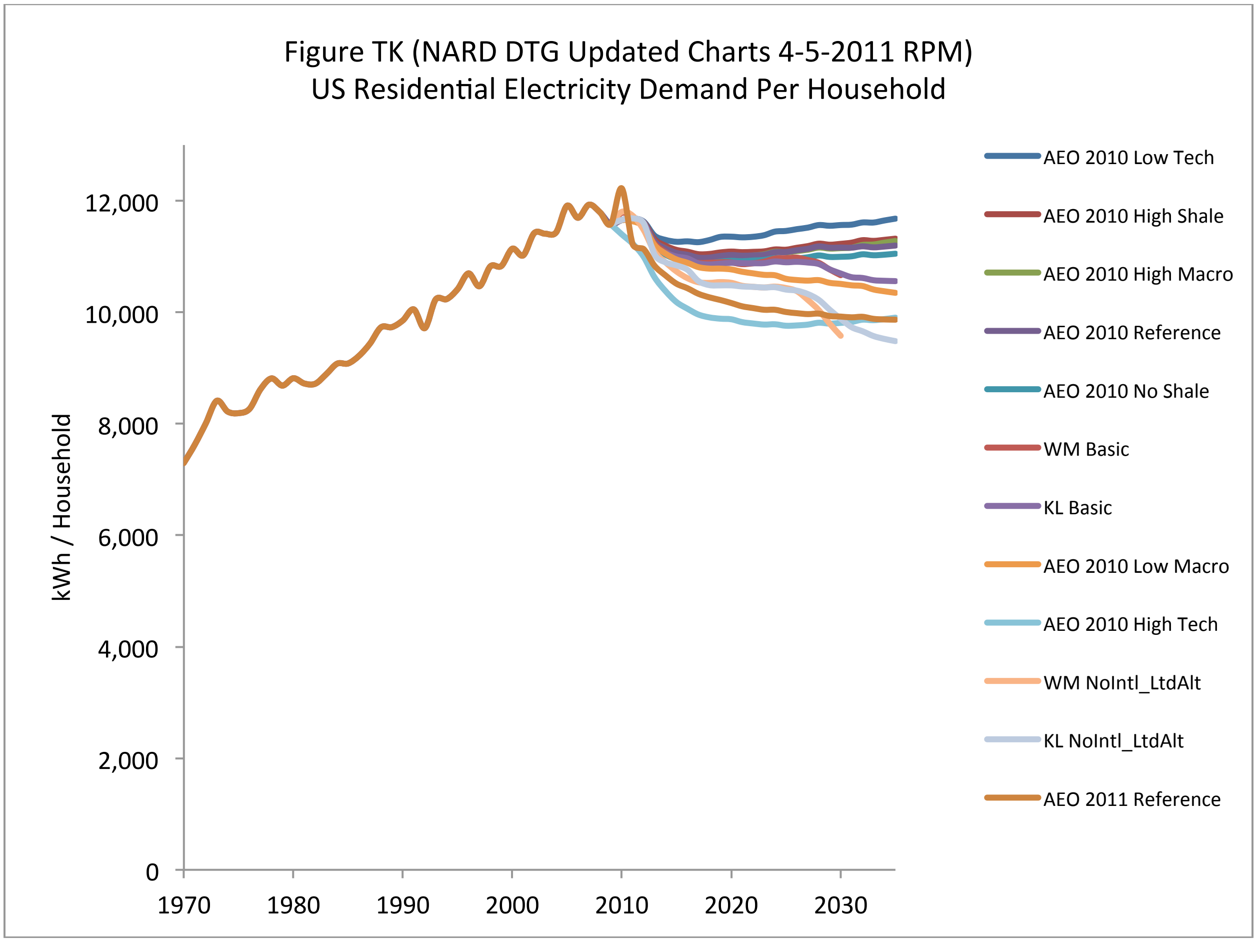
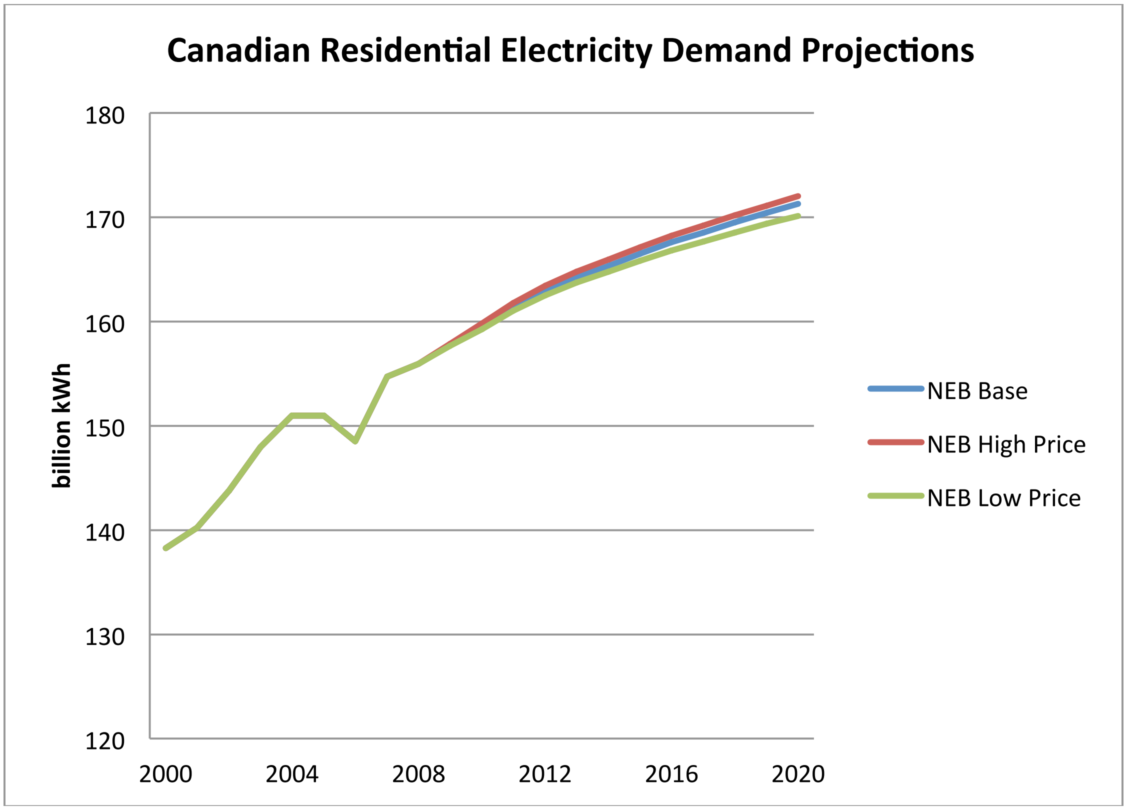


Figure TK (NARD DTG Updated Charts 4-5-2011 RPM)
US Residential Electricity Demand Per Household
kWh / Household
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1980
1990
2000
2010
2020
2030
AEO 2010 Low Tech
AEO 2010 High Shale
AEO 2010 High Macro
AEO 2010 Reference
AEO 2010 No Shale
WM Basic
KL Basic
AEO 2010 Low Macro
AEO 2010 High Tech
WM NoIntl_LtdAlt
KL NoIntl_LtdAlt
AEO 2011 Reference

Figure 12

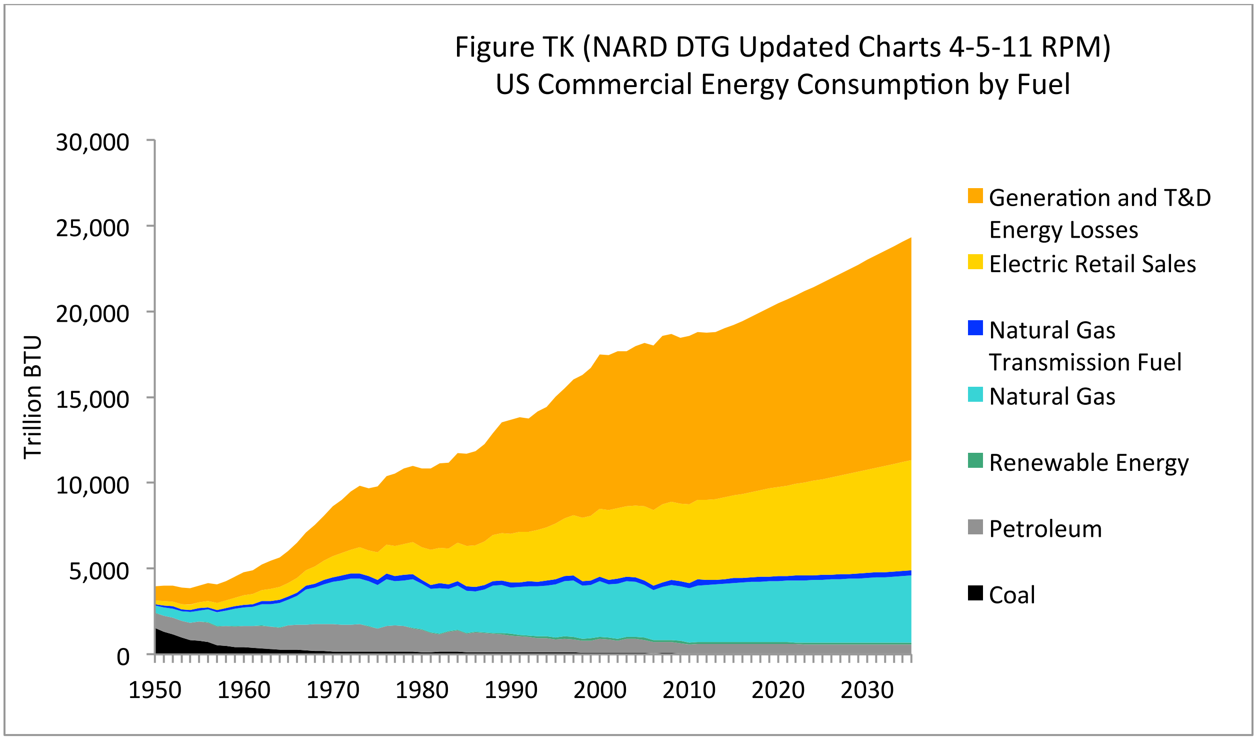

Canadian Residential Electricity Demand Projections
billion kWh
180
170
160
150
140
130
120
2000
2004
2008
2012
2016
2020
NEB Base
NEB High Price
NEB Low Price

Chapter Four - Commercial Natural Gas and Electricity Demand for North America

Similar to the residential sector, the fuel source distribution in the commercial sector has changed significantly over the last 60 years with natural gas and electricity representing more than 92 percent of the energy consumed in the sector in 2009. The primary drivers of energy consumption growth in the commercial sector are population, Gross Domestic Product, and technology. Population growth has resulted in growth in the number of business establishments. Economic growth and clean air regulations have been the main drivers of commercial natural gas demand, while new electric applications have resulted in the increased demand for commercial electricity use.

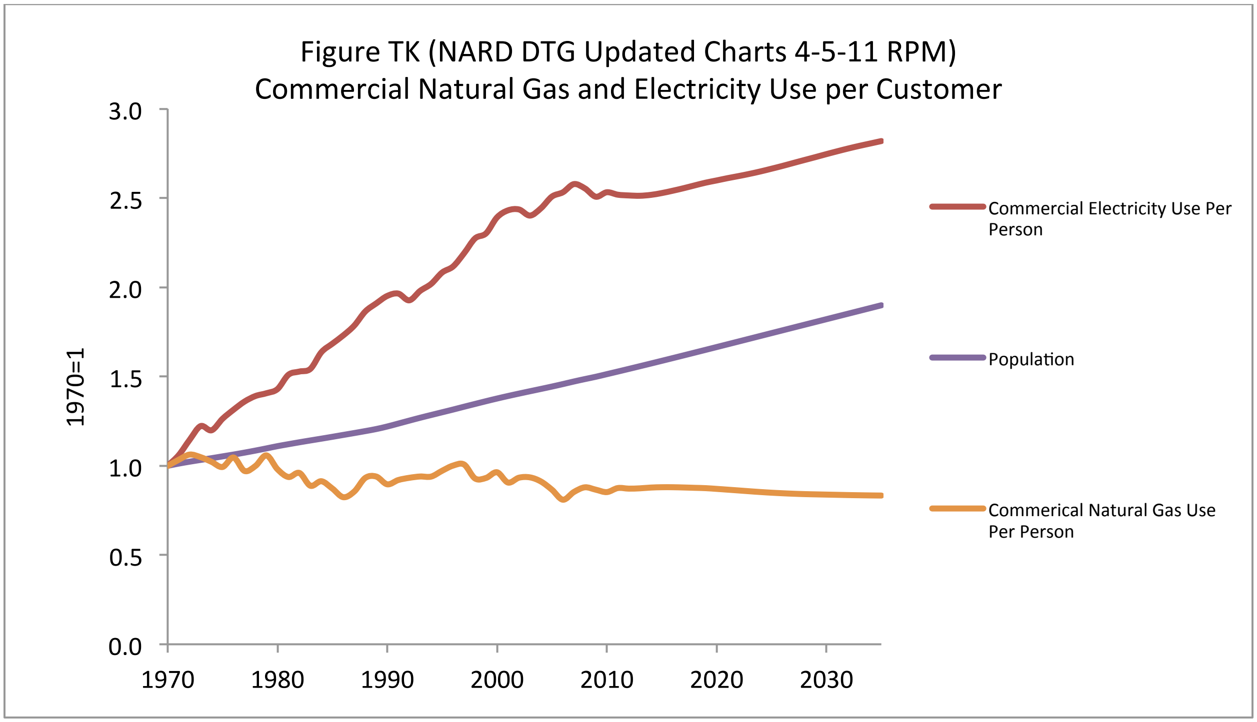
The graph below provides historical and projected overall energy consumption in the commercial sector, comprised of direct and indirect energy consumption. Direct energy consumption is the energy that is consumed at the point of use. Indirect energy consumption represents the energy lost when converting Btu to kWh and transmission and distribution losses from the source of generation to end user meter, but does not include any energy used upstream to generation. Indirect consumption for natural gas represents the energy use to gather, process, transmit, and distribute natural gas from the wellhead to the end user meter, but does not include energy upstream of the wellhead including energy used during exploration and development nor does it include any methane losses from the wellhead to the end user meter. As shown in the graph below, both direct and indirect energy consumption in the commercial sector experienced strong growth during the period of 1949–2009. The strong growth in direct electricity consumption since 1970 has resulted in significant growth in overall energy consumption. Consumption associated with electrical energy system losses grew from 35 percent of total energy consumption in 1970 to 53 percent in 2009.

Figure 13



The graph below shows natural gas consumption per person in the commercial sector declining over last 30 years while electricity consumption per person has been increasing. Both natural gas and electricity have been able to improve the efficiency of appliance and equipment but new electric applications have more than offset energy efficiency gains in the commercial sector.

Figure 14



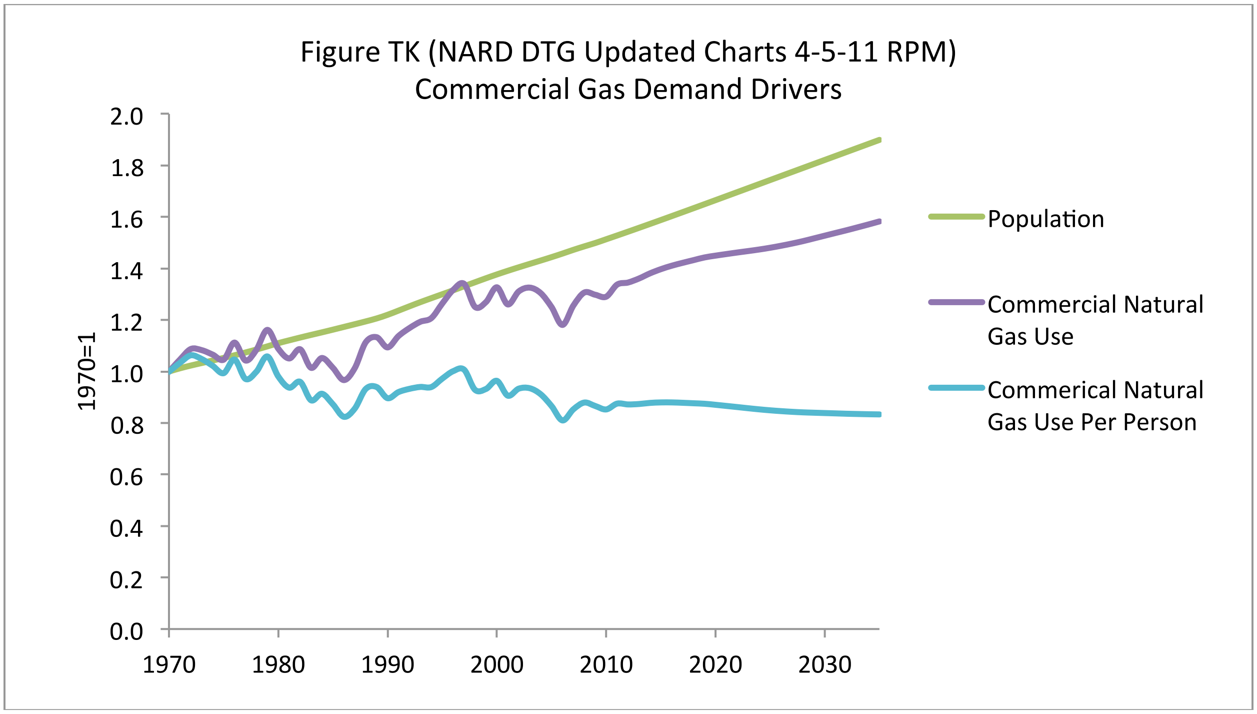
Commercial Natural Gas - Historical Demand

Commercial natural gas demand has steadily increased from 1930 to 2009. Commercial demand grew from 0.08 TCF in 1930 to 3.1 TCF in 2009 an annual growth rate of 19.1 percent per year. Demand grew rapidly from 1930 to 1970 and then started to flatten out as higher gas prices and energy efficiency and conservation programs took hold. However, since 1970, commercial gas demand has grown more slowly because of rising delivered gas prices and energy efficiency and conservation programs throughout the United States (Energy Information Administration 2010). Commercial delivered gas prices rose from $0.77 (4.26 in 2009$[3]) per thousand cubic feet in 1970 to $9.86 per thousand cubic feet in 2009. These cost increases set into motion extensive energy efficiency and conservation programs throughout the United States and commercial gas demand that totaled 2.399 TCF 1970 increased to only 3.094 TCF by the end of 2009. The gas cost increases and energy efficiency and conservation programs reduced the compound annual growth rate in the past two decades to 0.65 percent.

---

[3] CPI Inflation Calculator, *Bureau of Labor Statistics*, http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=.77&year1=1970&year2=2009

Figure 15



Commercial Natural Gas – Demand Projections

As illustrated in the graph below, historical declines in natural gas demand per person are expected to continue for the foreseeable future as existing natural gas heating and water heating equipment is replaced with new high efficiency equipment, new buildings are built with more energy efficient shells, and conservation influences consumer behavior. Projections for future natural gas consumption do not anticipate any new natural gas applications emerging in the commercial sector.

Figure 16

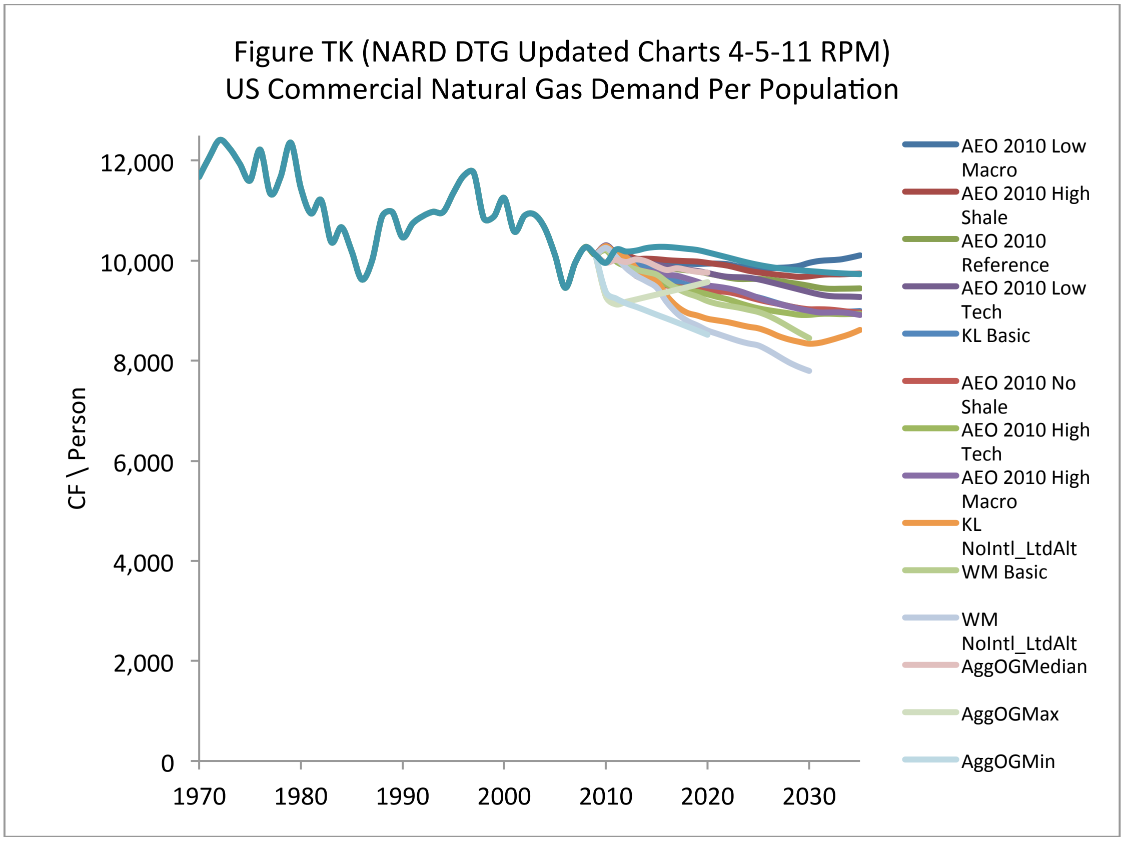
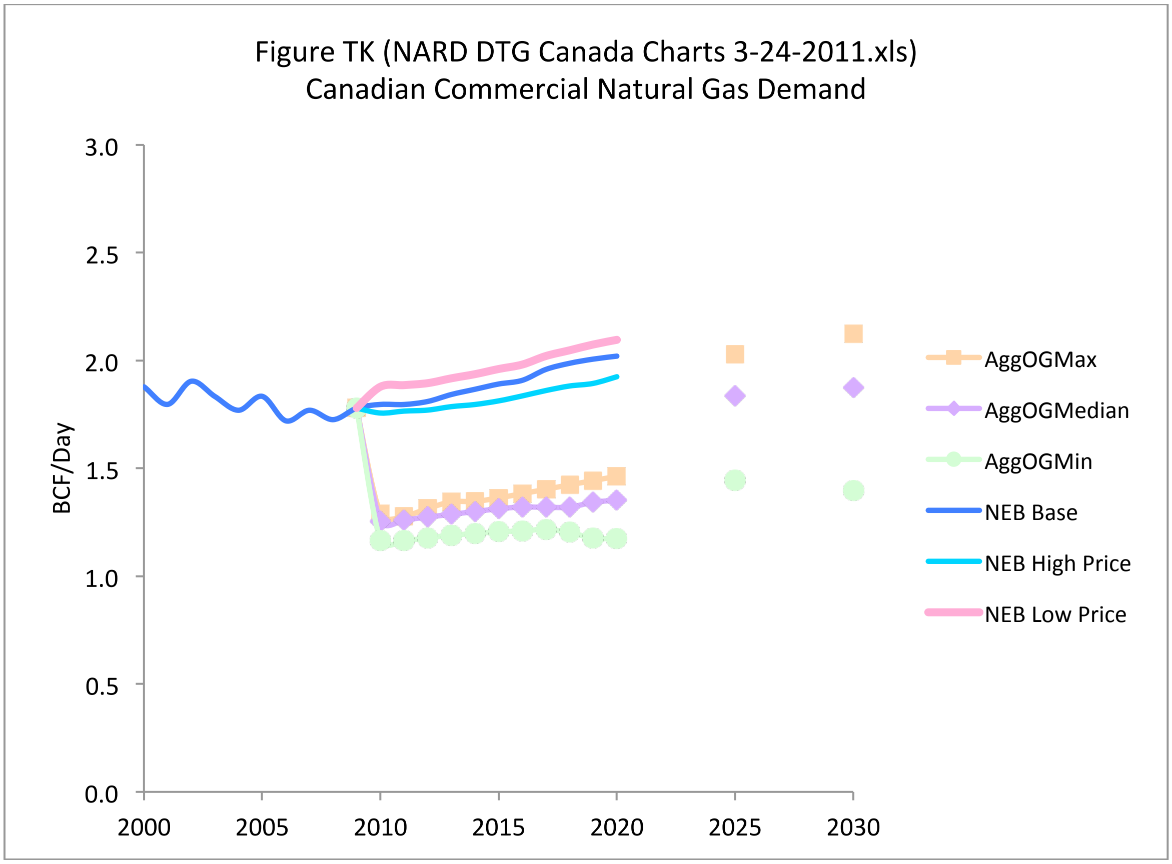


Figure 16 shows the range in projections of natural gas demand per person by 2035. Most projections show a decrease in use per person. The range of projected demand based on these scenarios is 9.1 to 10.6 Tcf of natural gas demand in the commercial sector by 2035 based on the U.S. studies reviewed.

Consumption in Canada is significantly smaller compared to the United States and is expected remain relatively flat or drop over the coming decades. In 2009, Canadian natural gas demand in the commercial sector was 0.62 Tcf. The projected range Canadian natural gas demand in the commercial sector is 0.42 to 0.57 Tcf in 2030. All scenarios reviewed with projections through 2035 show demand at levels below that recorded in 2009.

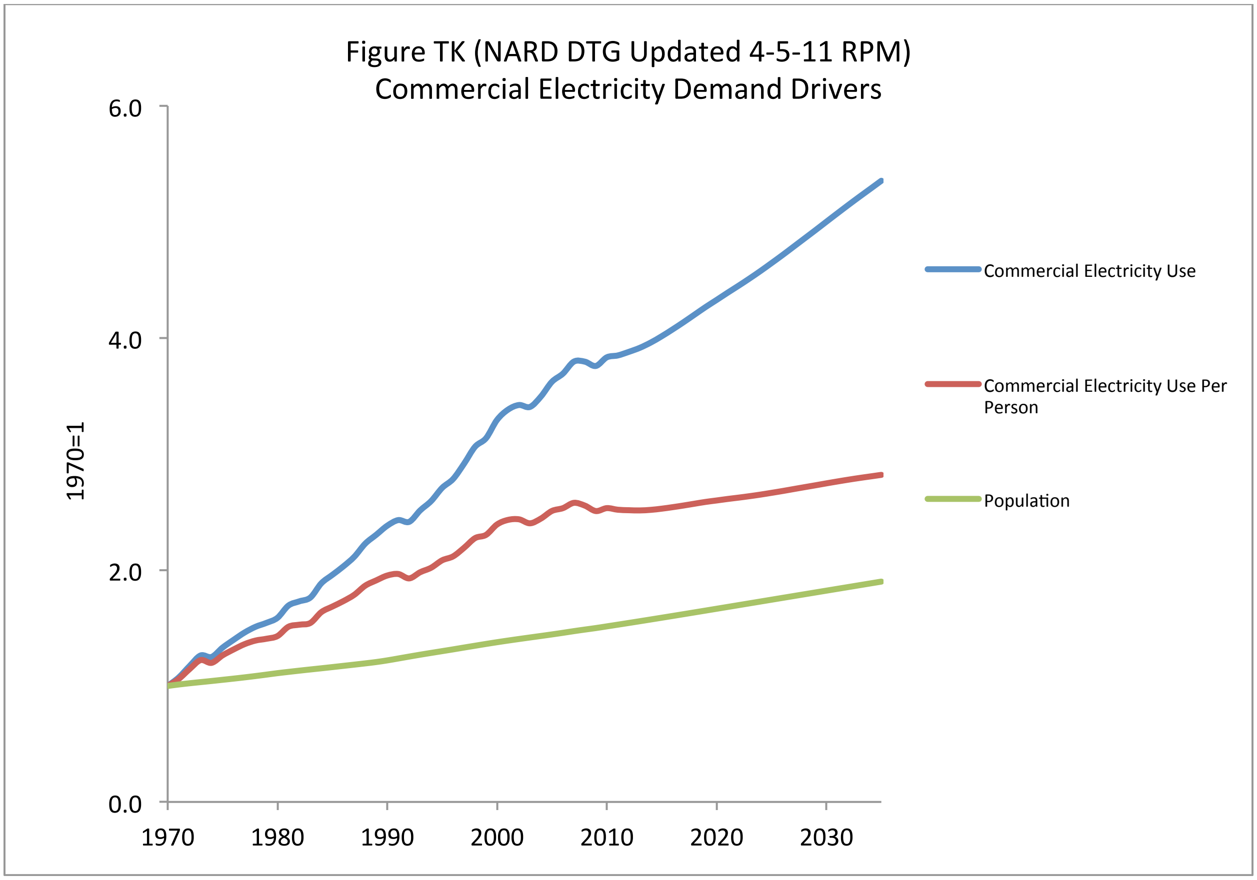
Figure 17



Commercial Electricity – Historical Demand

Commercial electricity demand has grown steadily from 1949 to 2009. In 1949 U.S. commercial electricity demand totaled 59 billion kilowatt hours (kWh) and increased to 1,323 billion kWh in 2009 a compound annual increase of 5.32 percent per year. Since 1970, commercial electricity demand has grown at a much lower compound annual growth rate of 3.45 percent because of higher electricity prices, energy efficiency and conservation programs, and slower GDP growth (Energy Information Administration 2010).

Figure 18

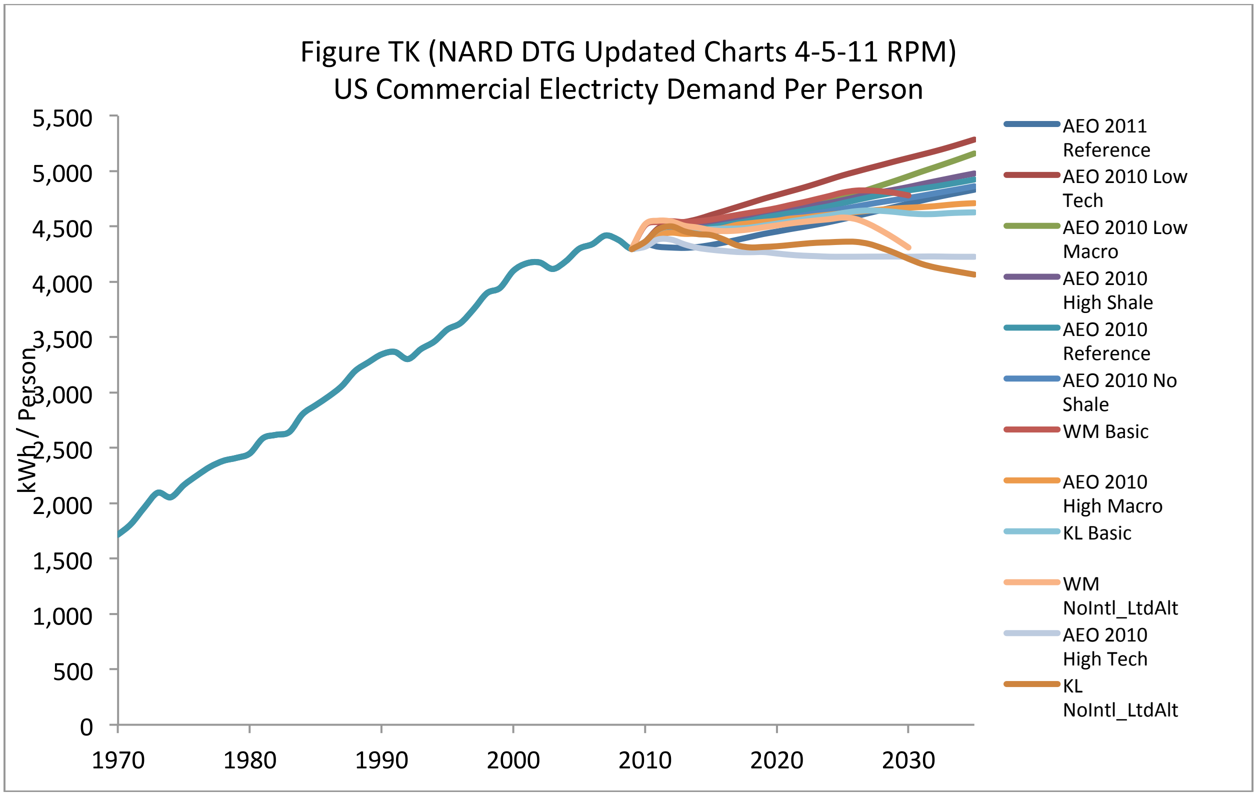


Commercial Electricity - Demand Projections

As illustrated in the graph below, historical electricity demand per kWh is expected to level off or increase at a slower rate as high efficiency electric appliances, building shell improvements, and changes in consumer behavior offset the increased number of electric appliances and devices. The expected range of electricity usage in the commercial sector is 1,586 to 2,061 billion kWh in 2035, up from the 2009 levels of 1,322 kWh.

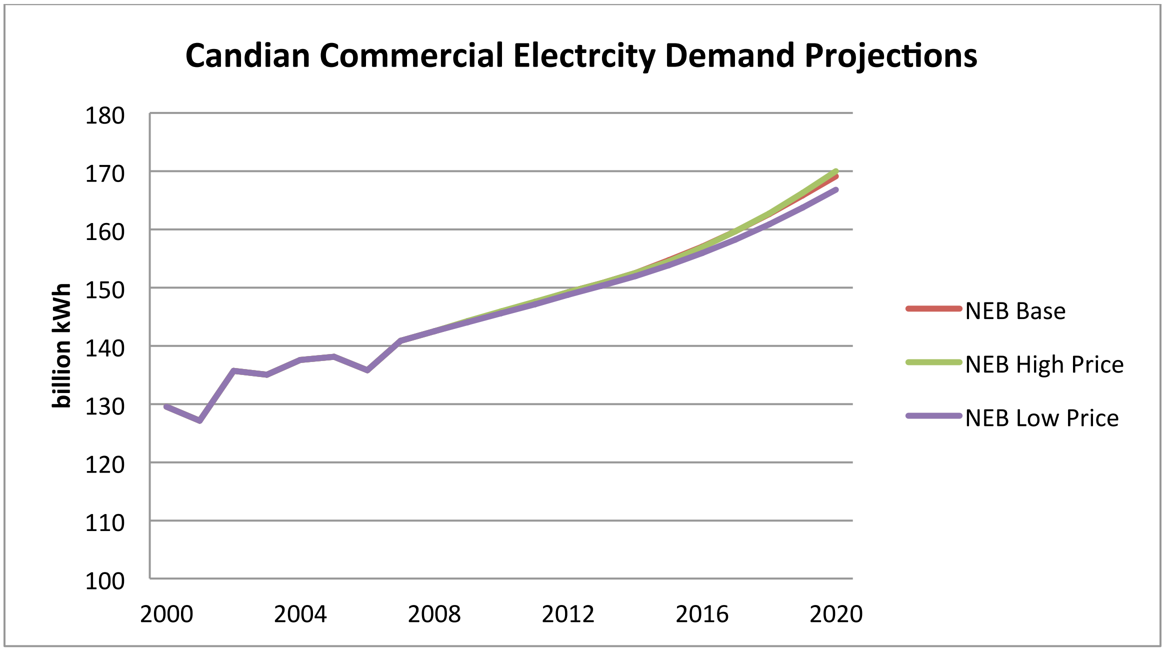
Canadian electricity demand is expected to grow over the projected period. In 2009, Canadian commercial electricity demand was 144 kWh. The projected range of demand in 2030 is 167 to 170 kWh based on the scenarios reviewed.

Figure 19



The National Energy Board reports Canadian electricity demand to be 158 billion kWh in 2009. Based on projections, also provided by the NEB, the range of projections for Canadian commercial electricity demand varies between 167 to 170 billion kWh consumed by 2020.

Figure 20


Candian Commercial Electrcity Demand Projections
billion kWh
180
170
160
150
140
130
120
110
100
2000
2004
2008
2012
2016
2020
NEB Base
NEB High Price
NEB Low Price

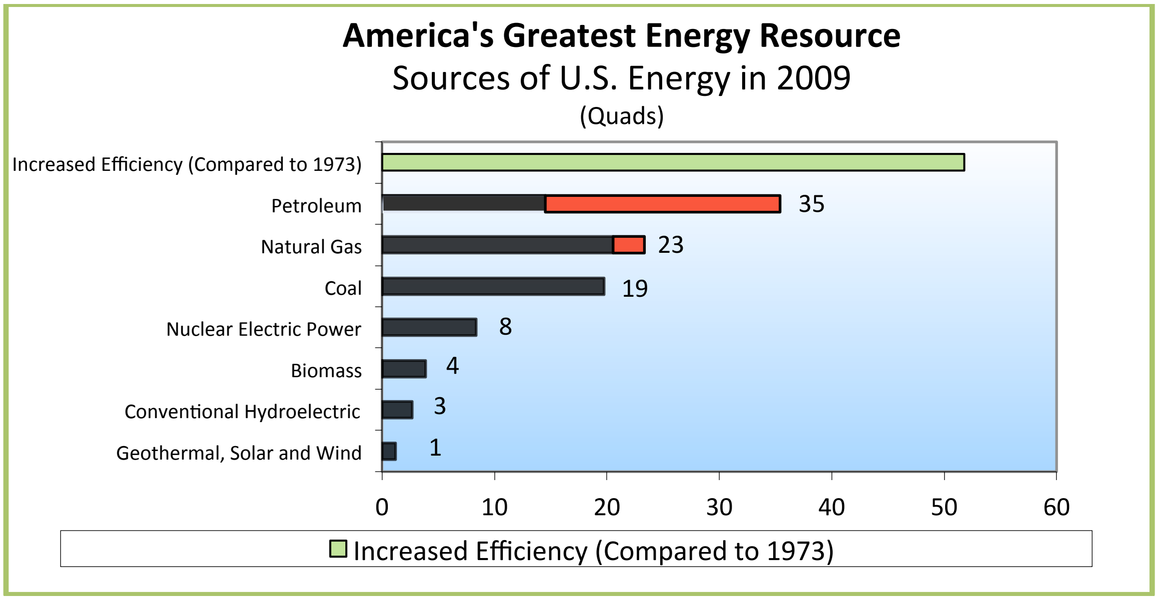
Chapter Five - Energy Efficiency Impacts on Natural Gas and Electricity Demand

The historical record presented in previous chapters has shown the improving efficiency trends of natural gas usage over the past three decades. Residential and commercial gas use per customer has decreased significantly since 1970, and major strides in appliance efficiency standards and advances in gas heating technologies, such as the condensing furnace and the elimination of a standing pilot, alongside improvements in building energy codes, regulations, and standards, have led to significant reductions in energy usage. Yet the potential to realize further efficiency improvements remains, and there are a number of pathways and technological options available to help realize this potential.

Historical Gains in Energy Efficiency

Today, energy efficiency is being recognized as the cheapest, fastest, and cleanest energy resource to implement. If the United States used energy at 1973 efficiency levels, about 56 percent more energy would have been consumed in 2009, about 52 quads (Figure 21). Such improvements in energy use have precluded even higher greenhouse gas emissions and other environmental impacts, energy security and reliability implications, and energy costs to consumers.

Figure 21

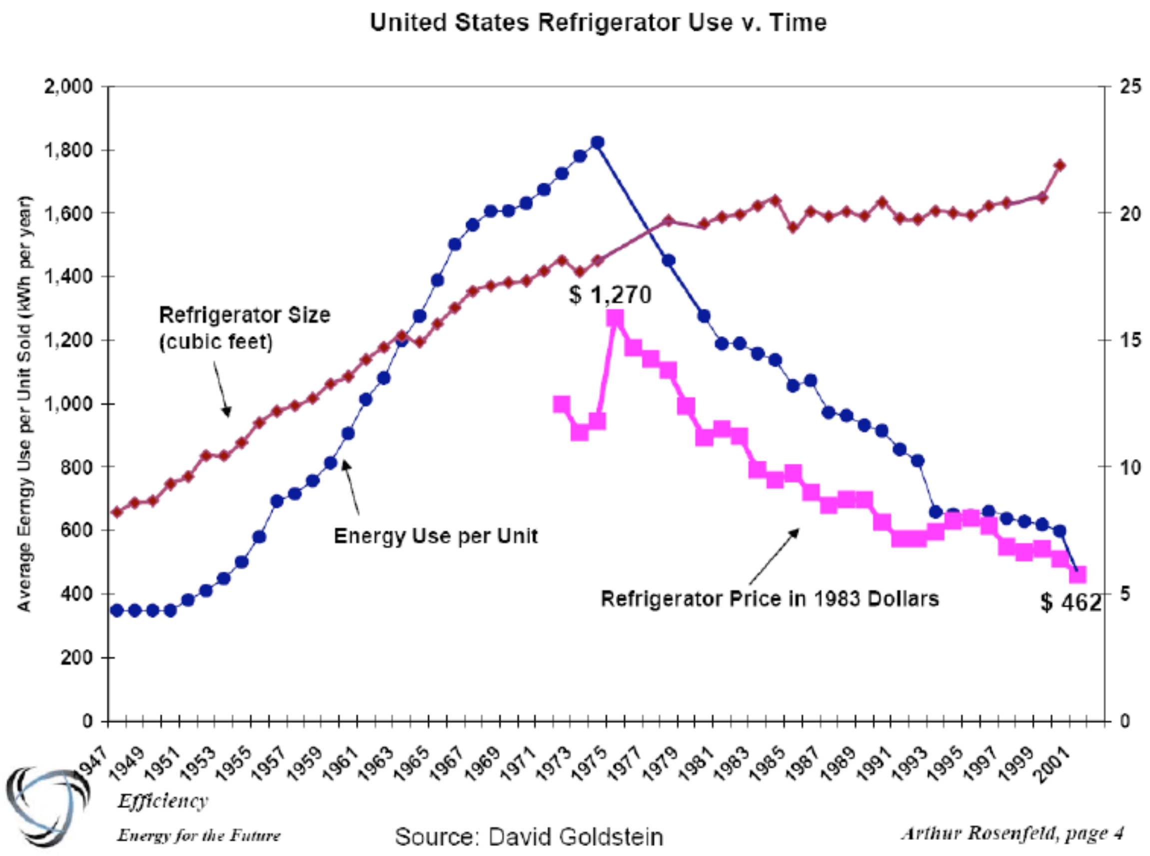


(Alliance to Save Energy 2010)

As was illustrated in a working paper for a previous NPC study, Facing the Hard Truths about Energy 2007, significant gains have been made in building and residential/commercial efficiency.

Figure 22, which appeared in that paper, shows how the average refrigerator sold in the 2000s consumes about a quarter of the energy of the average one sold in 1973 despite new refrigerators being larger and less expensive. (National Petroleum Council 2007).

Figure 22

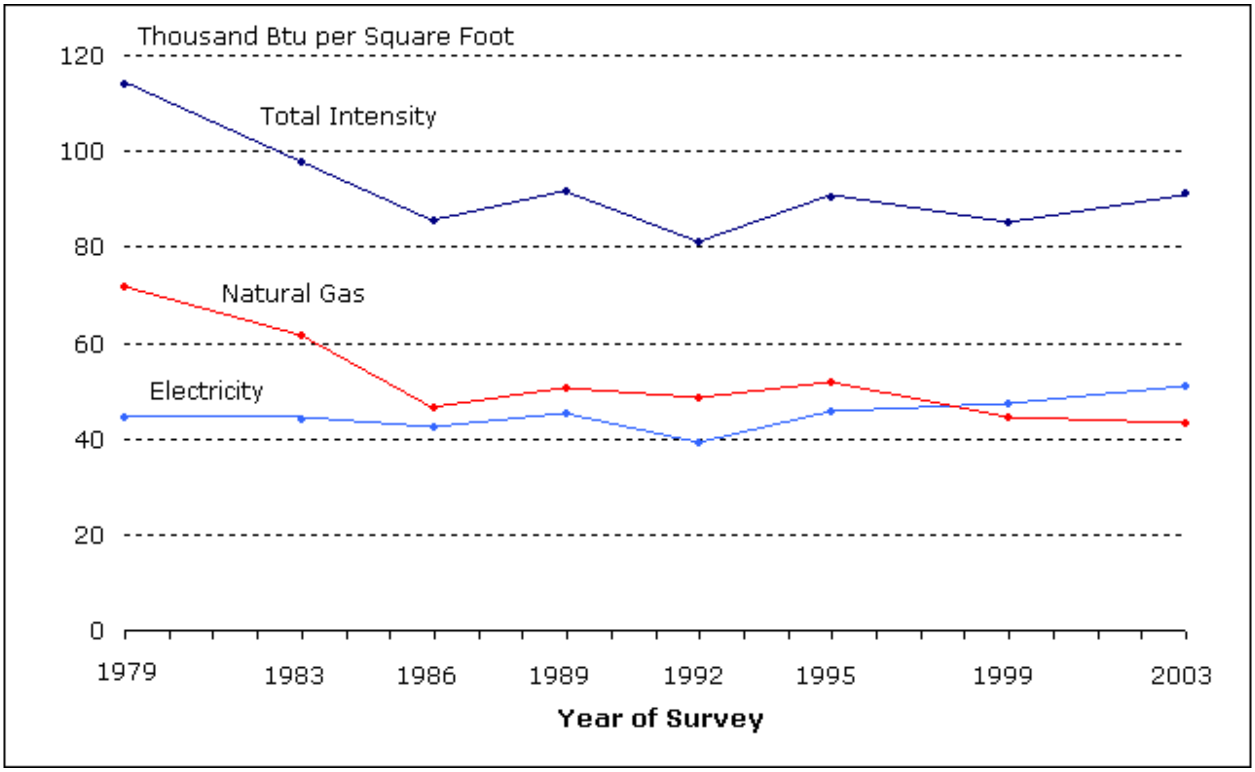


Source: David Goldstein

Actual efficiency and efficiency standards for various electric and natural gas appliances and equipment have become more stringent over time and this is scheduled to continue under current law, such as the Energy Independence and Security Act of 2007.

The Department of Energy (DOE), Energy Information Administration (EIA), Commercial Building Energy Consumption Survey indicates that energy intensity of U.S. commercial buildings fell from 113,000 Btu per square foot in 1979 to about 92,000 Btu per square foot in 2003 (see Figure 23) although energy intensity has roughly leveled since the late 1980s. (Energy Information Admistration 2003).

Figure 23



While significant improvements in gas energy efficiency have been made, there remain a number of potential pathways to further realize efficiency savings and extract extra value from natural gas resources. In addition to the menu of available policy options described in this chapter, improvements to existing direct use application efficiencies, as well as development of advanced technological options can also improve energy efficiency and reduce greenhouse gas emissions while simultaneously providing extended value for end-use consumers.

Drivers and Potential Policy Levers of Energy Efficiency Programs

The drivers of improved energy efficiency are varied, including technological change and capital turnover, the changing composition of the nation’s economy, price effects, and policy. These drivers interact in various ways. For instance, residential electricity and natural gas use are affected by interactions among consumers’ choices of where to live and of home size and style, local land use decisions, availability of natural gas service, building energy codes, appliance energy standards, utility and government incentives (for instance, rebates and tax incentives), consumers’ purchases and use of energy-using equipment, and energy costs.

The effect of enhanced energy efficiency has been to mute the growth in energy demand. The reduced slope of the projected growth curves result from EIA modeling of various influences but include energy efficiency impacts of the Energy Policy Act of 2005, the Energy Independence and Security Act of 2007, and the American Recovery and Reinvestment Act of 2009, also known as the Stimulus Act. Those Acts include provisions for appliance and equipment energy efficiency standards and labeling; grants, loans, and tax incentives for energy efficient buildings and equipment; financial support for state and local energy efficiency programs; and weatherization of low-income family's homes, among other provisions. Table 1 highlights major U.S. federal energy legislation adopted over the years

Table 1 - Major U.S. Federal Energy Legislation

1975 Energy Policy and Conservation Act
• Industrial efficiency, Corporate Average Fuel Economy standards for autos, Federal conservation
1976 Energy Conservation and Production Act
• Low-income weatherization, appliance standards, state energy programs
1978 National Energy Act (NECPA: National Energy Conservation Policy Act, PURPA: Public Utility Regulatory Policies Act, PIFUA: Power Plant and Industrial Fuel Use Act)
• Energy efficiency tax credits, Fed energy efficiency standards, industrial and utility measures
1989 National Energy Conservation Policy Act
• Consumer appliance efficiency, alternate fuels light vehicles, utility conservation, Fed fleet, state programs, ESCOs
1992 National Energy Policy Act of 1992
• Model energy efficiency bldg. codes; appliance, window standards; office equip standards; industrial & utility energy efficiency grants; Fed training, audits, procurement
2005 Energy Policy Act of 2005
• Appliance standards, rebates; commerce equip standards; transportation efficiency studies; net-metering, interconnect, PURPA relief; energy efficiency in Fed buildings
2007 Energy Independence and Security Act of 2007
• Lighting and appliance standards; grants, loans; zero-energy commercial buildings programs; industrial waste energy recovery; new CAFE; smart grid; energy efficiency block grants to states/localities; Fed fleet; Fed hi-performance buildings.

2009 ARRA (Stimulus)
• Weatherization/low-income assistance; electric vehicle funding; smart grid funding; transmission study; large amounts of funding to states/localities.

Included within and in addition to federal and state energy legislation, there are a number of energy efficiency policy levers that can enhance the effectiveness of energy efficiency programs and measures. The following section discusses three major categories of energy efficiency levers.

Utility Programs, Incentives, and Requirements

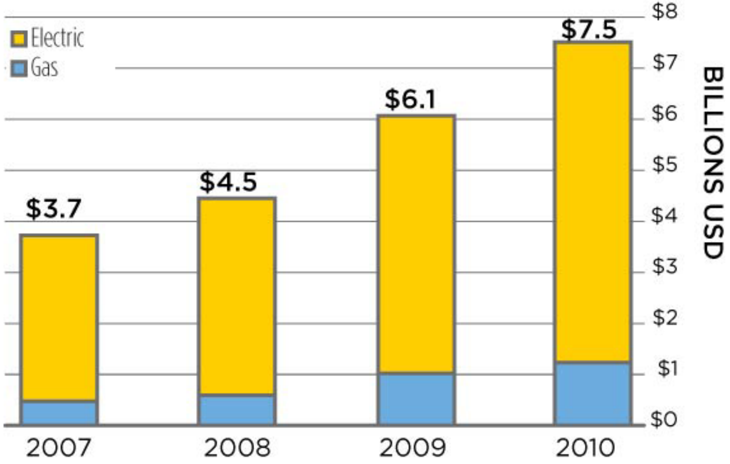
Utility energy efficiency programs

One way to deploy energy efficiency is through ratepayer-funded energy efficiency programs. Various states require or provide incentives for electric and/or natural gas utilities to achieve energy savings through the implementation of energy efficiency programs, which may include equipment installation projects, distribution of compact fluorescent light bulbs (for electricity programs), rebates and other financial incentives, and awareness and education programs.

These programs may be implemented in conjunction with energy efficiency resource standards (EERS), renewable electricity standards (RES, also called renewable or alternative energy portfolio standards [RPS and AEPS]), and rate decoupling and related tariff design mechanisms (discussed below). Some states, most notably California, have created shareholder incentive programs that offer financial bonuses for investor-owned utilities to achieve certain levels of energy savings. Such programs are often managed by the energy utilities or distribution companies, although some have third party administrators (for example, Efficiency Vermont serves as the state's "energy efficiency utility"). Nineteen states have public benefit funds generated from electricity and/or gas utility bills to fund renewable energy and energy efficiency projects (Pew Center on Global Climate Change 2010).

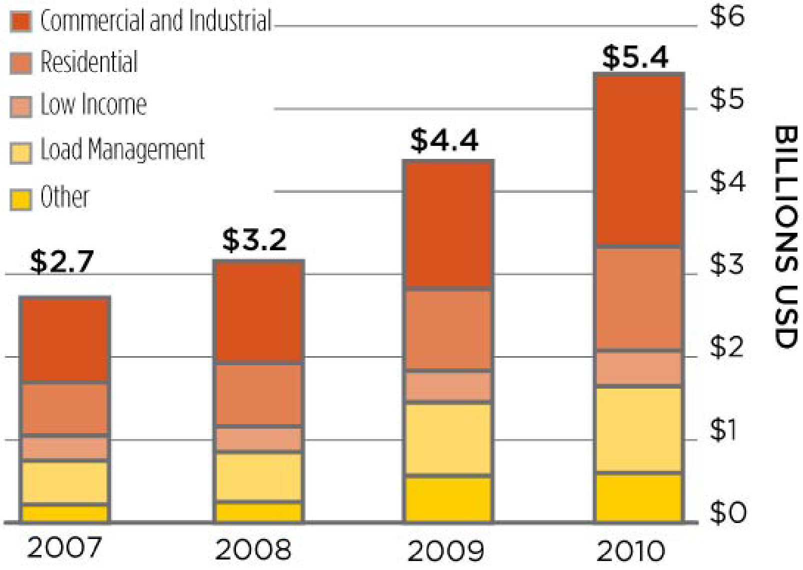
The Consortium for Energy Efficiency (CEE) estimated that 2010 budgets for U.S. and Canadian ratepayer funded electricity and natural gas energy efficiency programs amounted to $7.5 billion as compared with $6.1 billion in 2009. The 2009 programs yielded 104,000 GWh and 89.8 trillion Btu of gas savings, avoiding over 79 million metric tons of carbon dioxide emissions or the equivalent of about 20 typical coal-fired electric power plants (Consortium for Energy Efficiency 2010). Electricity savings from the 2009 programs were estimated at about 92,600 GWH for the United States and 11,600 GWh for Canada (Consortium for Energy Efficiency 2010, fig 20.). For natural gas, 2009 program savings were 52.9 trillion Btu in the United States and 36.9 trillion Btu in Canada (Consortium for Energy Efficiency 2010, fig 22.). Figure 24- Figure 28 provide more information on budgets by country and energy form (electricity and natural gas).

Figure 24
U.S. and Canadian Efficiency Program Budgets, 2007-2010



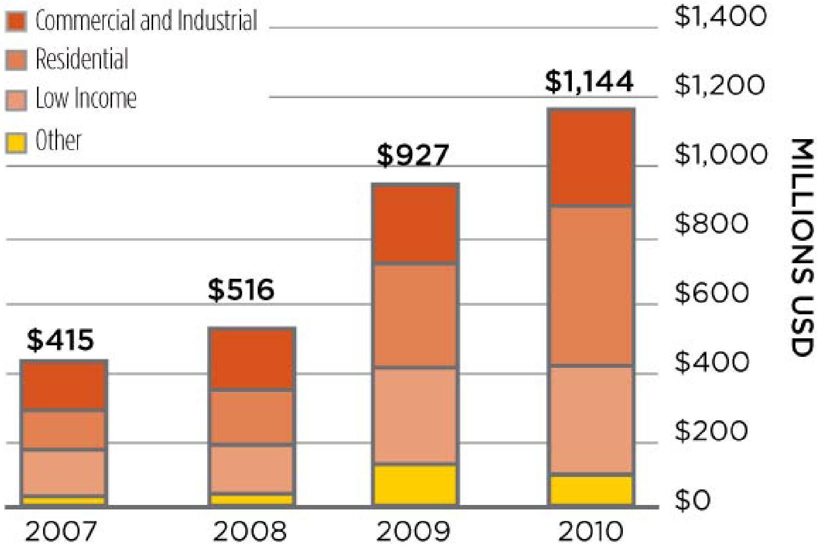
(Consortium for Energy Efficiency 2010)
(© 2011 Consortium for Energy Efficiency, Inc. All rights reserved)

Figure 25
U.S. Electric Program Budgets, 2007-2010



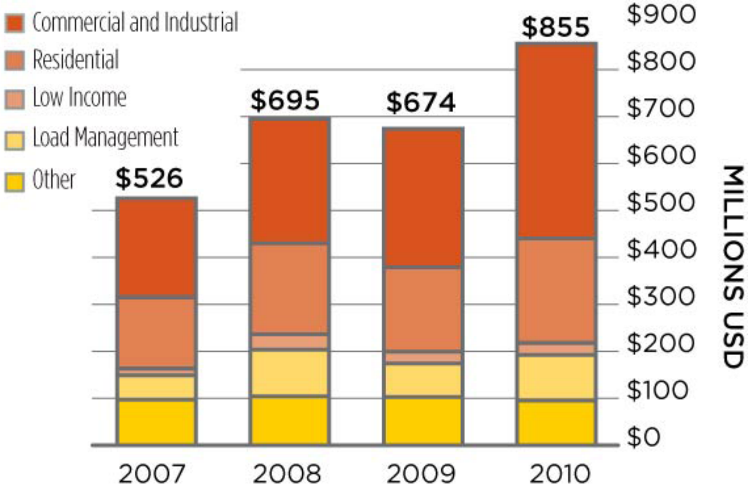
(Consortium for Energy Efficiency 2010)
(© 2011 Consortium for Energy Efficiency, Inc. All rights reserved)

Figure 26
U.S. Gas Program Budgets, 2007-2010



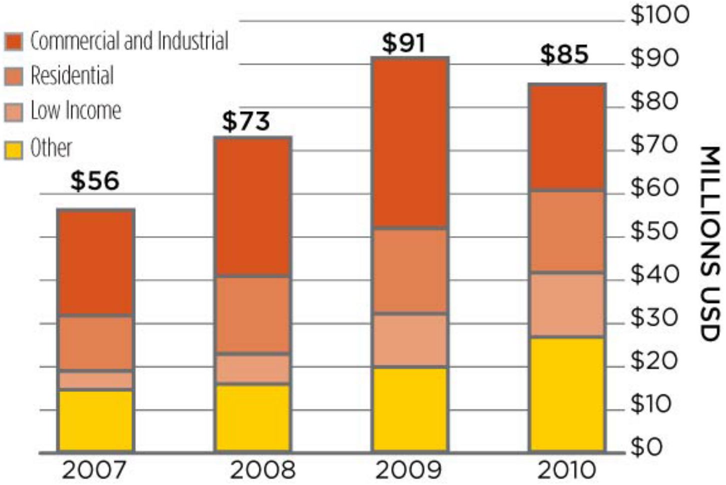
(Consortium for Energy Efficiency 2010)
(© 2011 Consortium for Energy Efficiency, Inc. All rights reserved)

Figure 27
Canadian Electric Program Budgets, 2007-2010 (in U.S. dollars)



(Consortium for Energy Efficiency 2010)
(© 2011 Consortium for Energy Efficiency, Inc. All rights reserved)

Figure 28
Canadian Gas Program Budgets, 2007-2010 (in U.S. dollars)

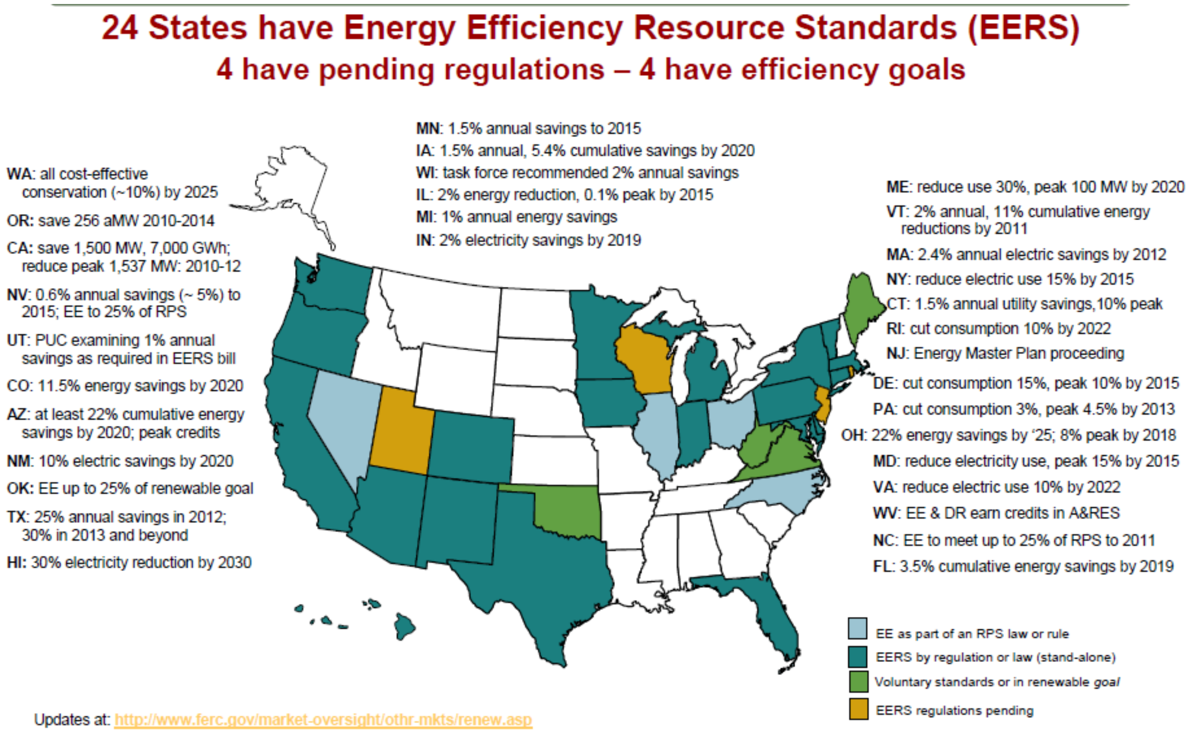


(Consortium for Energy Efficiency 2010)
(© 2011 Consortium for Energy Efficiency, Inc. All rights reserved)

Energy Efficiency Resource Standards and Renewable Electricity Standards

In recent years, 24 states have adopted energy efficiency resource standards (EERS), energy efficiency eligibility in renewable electricity standards (RES), or other energy efficiency targets and requirements. See Figure 29 (Federal Energy Regulatory Commission 2010). In an EERS, electric and sometimes natural gas utilities are typically required to achieve a certain percentage reduction in energy use by customers as compared to a business-as-usual baseline. Requirements may be annual or cumulative or both. Sometimes energy efficiency measures may be counted toward fulfilling part of a state RES (for instance, Pennsylvania and Nevada) or there may be a separate energy efficiency category within a RES (for instance, Connecticut). Related to and sometimes counted as EERS are requirements for energy utilities to achieve all "cost-effective" energy efficiency options (for example, Massachusetts and Washington state).

Figure 29



24 States have Energy Efficiency Resource Standards (EERS)
4 have pending regulations – 4 have efficiency goals

Updates at: http://www.ferc.gov/market-oversight/othr-mkts/renew.asp

(Federal Energy Regulatory Commission 2010)

Aligning Utility Incentives with Energy Efficiency

An important development for pursuit of energy efficiency is the move in some states to re-align utility ratemaking and compensation approaches to reduce or remove the traditional bias favoring increased energy sales over energy use efficiency and conservation. There are several approaches, including the "decoupling" (or "revenue decoupling") of utility revenues from throughput or sales of energy, lost revenue compensation mechanisms, and shareholder incentives (such as financial bonuses for achieving certain thresholds of verified energy savings). These approaches are credited with helping California achieve level per capita electricity and natural gas consumption.

Figure 30[4]

States with Natural Gas Revenue Decoupling
As of January 2011

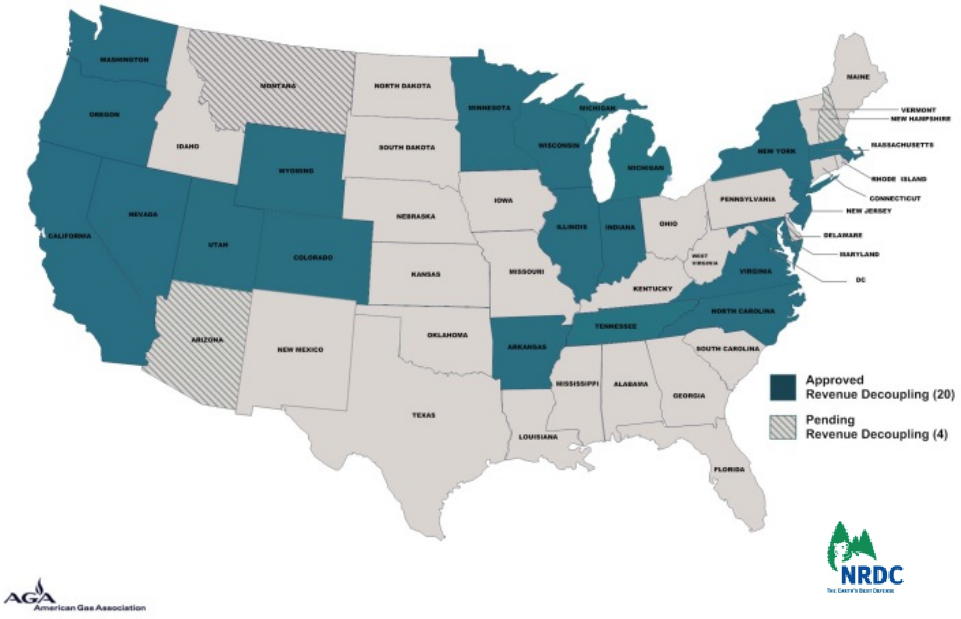
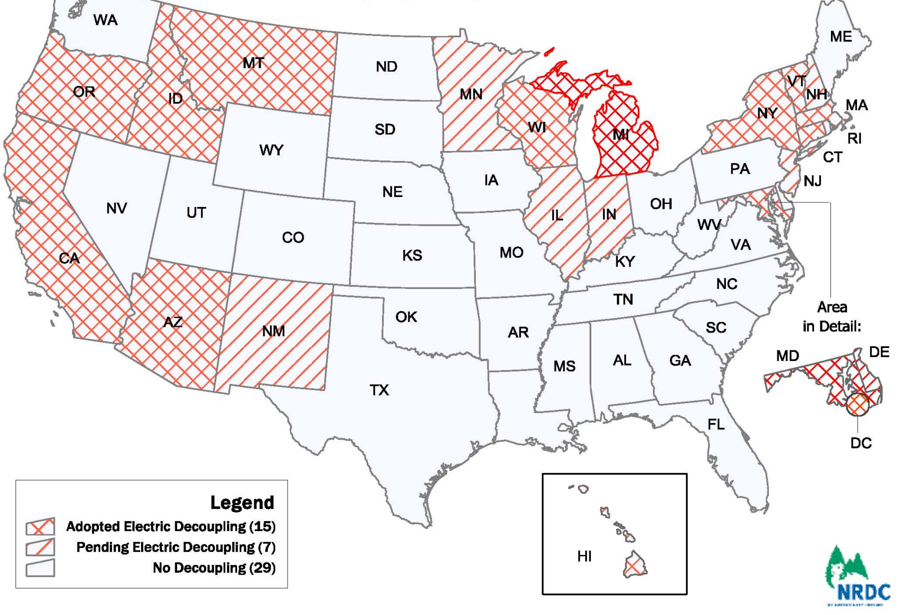


Figure 31

Electric Decoupling in the US

JANUARY 2011



---

[4] Graphics provided by Ralph Cavanagh, NRDC, and Cynthia Marple, American Gas Association.

As of January 2011, 24 states enacted or had pending rules for the decoupling of gas utility revenues from throughput and sale of energy; 20 states adopted (with four pending) gas decoupling while 15 had adopted (with 7 pending) electric decoupling, see Figure 30 and Figure 31. (Natural Resources Defense Council & American Gas Association 2011)

Under traditional energy utility regulation revenues are the product of price and units sold; utilities make money either by reducing costs or increasing sales (Weston 2010). With marginal costs almost always being less than marginal revenue, there is strong incentive to increase sales. Under decoupling, utility regulators establish an allowed or target revenue level (which may be adjusted for non-sale factors, such as inflation or customer numbers), and utilities can increase profit by cutting costs. Under full decoupling, utilities should be indifferent to volume of energy sold, removing disincentives for investing in energy efficiency but also not creating incentives for it (National Association of Regulatory Utility Commissioners 2007).

While full revenue decoupling makes utilities indifferent to volumetric energy sales, utility tariffs can be designed to create positive incentives for energy efficiency. There can be performance incentives in which utilities achieving verified energy savings objectives can earn a bonus (California's shareholder incentive program for investor-owned utilities is the most prominent). Some states (for instance, Virginia) created rate-of-return incentives for certain generation asset investments (such as, renewable, nuclear, and certain clean coal generation).[5] The extension of rate-of-return incentives to energy efficiency investment can help even the playing field with supply investment and even favor energy efficiency, if so designed.

Utility investment incentives also depend critically on benefit-cost tests applied by utility commissions for determining which projects and investments can be rate-based and earn returns. There are numerous types and variations of benefit-cost tests applied but, in short, there is the utility cost test that evaluates costs (including avoided costs) and benefits to the utility alone, the total resource cost test that includes both utility and customers'/participants' costs, and, most broadly, is the societal cost test that includes social and environmental externalities. Such externalities can be either negative (for example, pollution impacts) or positive (enhanced customer comfort) (Administration for Children and Families, US Department of Health and Human Services 2010).

As discussed elsewhere, a growing number of states have placed responsibilities on electric and gas utilities to invest in and achieve energy efficiency through establishment of energy efficiency resource standards, the inclusion of energy efficiency as portions of renewable or alternative electricity standards (sometimes called alternative energy or renewable portfolio standards), and directing utilities to achieve "all cost-effective" energy efficiency. Also discussed elsewhere is the use of system benefit charges on utility bills to raise funds for energy efficiency programs and projects, which are often

---

[5] Code of Virginia: § 56-585.1

operated by utilities though sometimes may be administered by third parties (for instance, Efficiency Vermont).

Codes and Standards

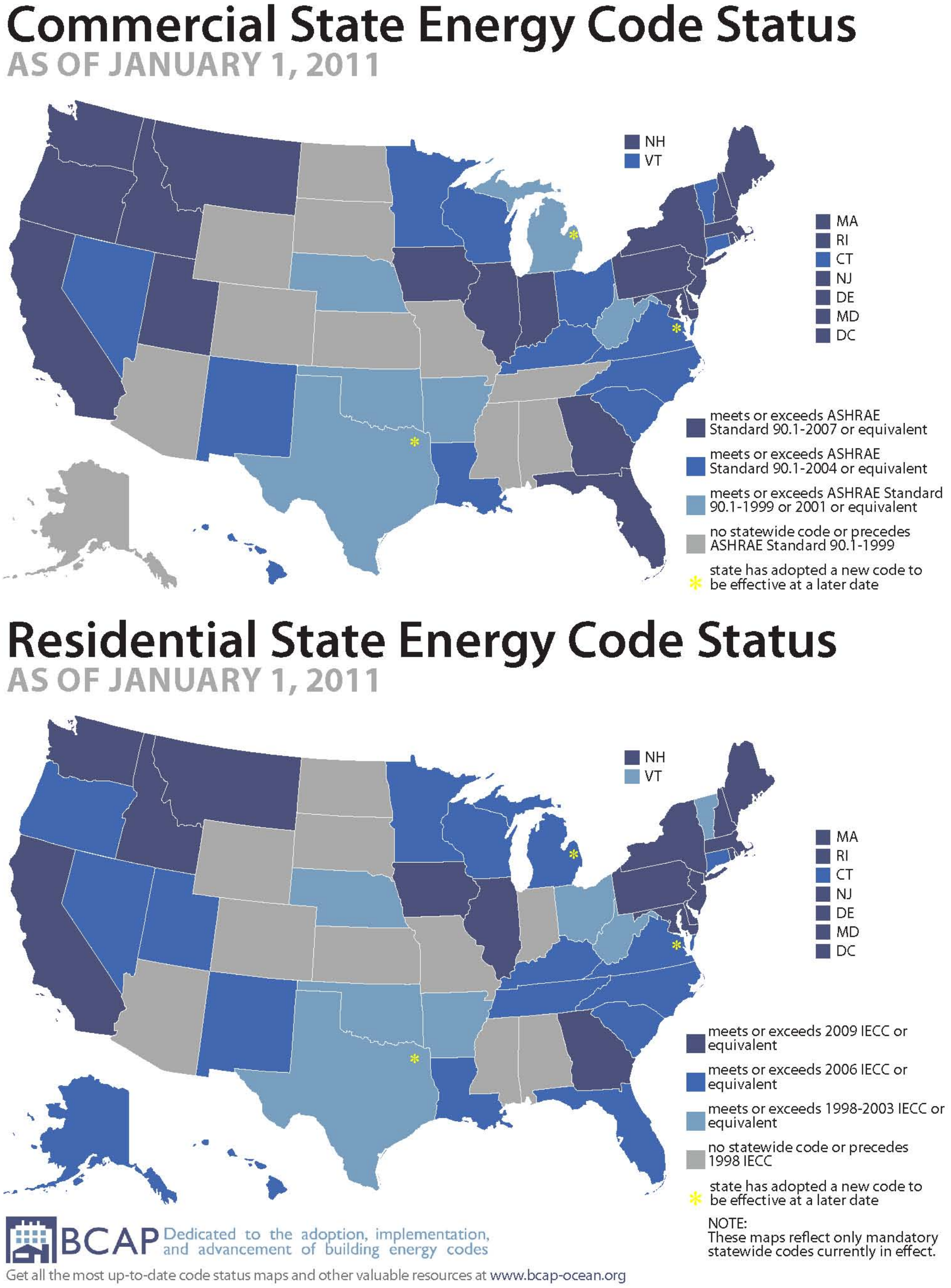
Building Codes

Most states have adopted and periodically update residential and commercial building energy codes, see Figure 32. These codes require that structures achieve certain minimum criteria for such things as insulation; windows; doors; heating, ventilation, and air conditioning (HVAC) systems, and lighting.

Building energy codes emerged from the 1978 energy shock. Model codes are periodically updated but in the United States it is up to states to decide which, if any, codes to adopt. Also, compliance and enforcement is typically the responsibility of local building code officials. Adoption of codes is uneven among states and compliance rates are also uneven.

In 2010, the U.S. Department of Energy reports that increasing the stringency of the 2006 International Energy Conservation Code (IECC) and the ANSI/ASHRAE/IENNA Standard 90.1-2002 by 30 to 50 percent, if adopted and effectively implemented by the states would yield significant energy savings with concomitant reductions in energy bills and CO2 emissions. Primary energy use in buildings could be reduced by 0.5 quads annually by 2015 and by 3.5 quads by 2030, yielding $4 billion and more than $30 billion annual savings during those years, respectively. About 3 percent of U.S. CO_2 emissions projected for 2030 would be saved (U.S. Department of Energy 2010).

Figure 32



(Building Codes Assistance Project 2011)

Appliance & Equipment Standards

A variety of residential and commercial equipment is subject to federal minimum energy efficiency standards. In some states, certain equipment not covered by federal standards is covered by state standards. The Appliance Standards Awareness Project (ASAP) estimates that existing standards for electricity-using equipment will avert the need to build 186 400MW power plants by 2030 in the United States and that potential savings from new standards introduced or to be introduced during 2009-2013 could potentially avoid the need for 63 plants (Appliance Standards Awareness Project n.d.).

The following is an illustration of energy savings opportunities from enhanced equipment energy efficiency standards. The annual fuel utilization efficiency (AFUE) for non-weatherized gas furnaces is currently 78 percent. If the minimum mandated AFUE level were increased to 80 percent for the South and Southwest, and 90 percent in the North, approximately 46 trillion Btu annual savings could be realized in 2020 and 108 trillion Btu savings in 2030. The 2030 savings would be equivalent to heating 2 million typical U.S. homes and would avoid 5.6 million metric tons of carbon dioxide (Appliance Standards Awareness Project n.d.).

Current or pending federal standards are or will apply to dozens of product categories from battery chargers and general lighting to residential and commercial boilers and furnaces and commercial refrigeration equipment.[6]

Financial Incentives

As previously noted, various utility ratepayer-funded energy efficiency programs fund consumer rebates and provide other financial support to consumers purchasing and installing energy efficient equipment or features, such as improving insulation. In addition, some states and localities have additional energy efficiency programs oriented toward reducing first-cost barriers to energy efficiency improvements.

There have been federal and some states offer tax credits and deductions for certain energy efficiency purchases and investments. Some states have periodic sales tax “holidays” for selected Energy Star related products during which time sales tax is not charged. A number of states have found state funds or used federal support, such as stimulus funding under the American Recovery and Reinvestment Act of 2009, to create rebate programs for certain Energy Star or other high efficiency equipment. Stimulus funds

State, local and federal funds (including stimulus funds) have also been used to create state or local revolving loan funds supporting energy efficiency retrofits.

Twenty four states and the District of Columbia have passed legislation authorizing localities to operate property assessed clean energy (PACE) financing programs (Alliance to Save Energy 2011). With PACE financing a property owner borrows money to make an energy efficiency or renewable energy upgrade, but repayment is made usually

---

[6] List can be found at ASAP website http://www.standardsasap.org/federal.htm.

through the local property tax bill (though some localities payment may be via local trash or water and sewer bills). In contrast to conventional financing, the lien stays with the property should the owner sell before the loan is fully paid off. The PACE mechanism can provide low interest-rate financing, helps overcome first cost barriers, and reduces owner concerns that they may not fully recoup their energy investments prior to sale of the property. This approach has had success for renewable energy investments in some California localities and has financed energy efficiency in such locations as Boulder, CO and Babylon, NY. However, the Federal Housing Financing Agency, Fannie Mae, and Freddie Mac voiced concerns about PACE liens having superiority to mortgages, leading to suspension of many residential PACE programs pending resolution of these concerns.

Members of Congress from both parties have proposed federal credit support or a Clean Energy Deployment Administration (CEDA) to help support energy efficiency and other clean energy investments (Alliance to Save Energy 2011).

Another important energy efficiency policy tool is support for weatherization of low-income households that face the greatest financial burdens in meeting utility bills and making even the most cost-effective efficiency investments. The Department of Energy reports that the Weatherization Assistance Program (WAP) has served 6.3 million households over 33 years. Average beneficiaries save $437 per year in energy costs, but with weatherization measures lasting many years the accrued benefits are great. The program operates through Department of Energy disbursement of funds to state, territorial and tribal governments, which manage the program. Those entities then fund local community action agencies, non-governmental organizations, and local governments that provide weatherization services (U.S. Department of Energy n.d.). The program received a large infusion of funding ($5 billion) through stimulus funding.

Public Procurement and Incentives

Under various legislation and executive orders, most recently Executive Order 13514,[7] federal agencies are obligated to give preferences to energy efficient products during procurement and to achieve certain energy efficiency and savings objectives.

With respect to building energy use, EO 13514 will require new construction and major renovations (subject to certain minimum size thresholds) to meet Energy Star targets for whole building performance. In accordance with a 2006 interagency memorandum of understanding, new construction should meet 30 percent energy cost reductions relative to the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., (ASHRAE) and the Illuminating Engineering Society of North America (IESNA) Standard 90.1-2004, Energy Standard for Buildings except Low-Rise Residential baseline. Major renovations need to reduce the energy cost budget by 20 percent below pre-renovations 2003 baseline (U.S. Department of Energy 2006).[8] In addition, EO

---

[7] Executive Order 13514 (2009), *Federal Leadership in Environmental, Energy, and Economic Performance,* http://www1.eere.energy.gov/femp/regulations/eo13514.html

13514 will require that all new federal buildings entering the design phase in 2020 or later be designed to achieve net zero energy performance by 2030.

The DOE Federal Energy Management Program (FEMP) and the General Services Administration Office of Federal High-Performance Green Building are assisting federal agencies to meet these mandates and in some cases go beyond mandated requirements, including ahead-of-schedule design and construction of net zero energy buildings (for instance, the national Renewable Energy Laboratory's new Research Support Facility (National Renewable Energy Laboratory 2010) .[9]

Some states and localities have also implemented energy savings and green building requirements for public buildings.

Local Green Building Policies

A number of localities have been at the forefront of green building incentives and requirements, of which energy efficiency is a component. For instance, New York City has enacted ordinances requiring large commercial buildings to perform audits and building commissioning (Office of the Mayor [NYC] 2009). Arlington County, VA, for example has implemented land-use processes that promote the use of the Leadership in Energy and Environmental Design (LEED) standards (Arlington County Green Building Incentive Program 2010). These are just two examples.

Information and Awareness

Information and awareness are vital for consumers and home and business owners to make sound decisions on energy use and to be empowered to better control their energy use and expenses.

For many years there have been energy use labels on certain appliances. Efforts have been undertaken to improve such labeling so that they contain more comprehensive information on energy usage and carbon emissions. Consideration is being given to labeling buildings for their energy performance so that potential buyers and renters can make better informed decision. (For instance, see U.S. Department of Energy, National Energy Rating Program for Homes: Request for Information http://www1.eere.energy.gov/buildings/home_rating_rfi.html).

In addition, there is growing interest in energy efficiency and green buildings irrespective of government regulation and policy. Increasingly consumers, homeowners, business owners, commercial property owners, architects, engineers, and building trade professionals see benefits in building green and engaging in energy efficient behavior.

---

[9] National Renewable Energy Laboratory, Research Support Facility, http://www.nrel.gov/sustainable_nrel/rsf.html

Information and awareness is a key component of promoting energy efficiency and affecting end-user behavior. These include:

- Consumer preferences, voluntary programs, and markets.
- Energy Star equipment and appliance energy labeling (those these are sometimes linked to policy incentives as well).
- Private green building initiatives—LEED, Energy Star for Buildings, residential programs.
- Commercial building owner, operator, and designer practices and technologies—building energy management systems; improved lighting, HVAC, etc. technology; and building commissioning, retro-commissioning, and re-commissioning.

More timely information on utility energy usage can also support energy efficiency as well as demand response for reducing peak electricity demand. Some utilities have used firms such as OPOWER and Efficiency 2.0 to provide customers feedback via utility bills on how their energy use compares with (anonymous) peers and to suggest cost saving energy efficiency practices. Microsoft and Google are among the companies that have teamed up with hardware suppliers to offer web-based dashboard systems to allow consumers to better monitor and control energy use. In the 111th Congress, Sen. Mark Udall (D-CO) and Rep. Ed Markey (D-MA) proposed corresponding versions (S 3487 and HR 4860) of the Electric Consumer Right to Know or "e-KNOW" Act which would have obligated electric utilities to make more and more timely consumption information available to consumers (particularly those with advanced or smart meters) and third parties authorized by consumers.

Comprehensive Assessment of Energy

Part of evaluating energy efficiency is employing a holistic methodology of energy measurement and assessment. One such comprehensive measurement methodology recommended by this subgroup, and which has emerged from the study of studies, is a "full-fuel-cycle" approach. The National Research Council (or National Academy of Sciences), at the direction of the Department of Energy, Office of Energy Efficiency and Renewable Energy, convened a committee to study the merits of assessing energy efficiency standards on a site (point-of-use) versus source (full-fuel-cycle) basis. The National Research Council report describes how a source or full-fuel-cycle based measurement approach leads to a more comprehensive evaluation of total energy consumed:

> "Although the site measure of energy consumption allows easy comparison of the operating efficiency of one appliance over another in isolation, it gives only a partial picture of total energy use because it omits the energy needed to mine, process, and transport the primary fuel to a generating plant; the energy used at the generating plant; and the energy used in delivering electricity or fuel to the site of operation of an appliance. For example, based on their site energy

> consumption, an electric storage water heater might operate with 90 percent efficiency and a natural gas water heater with 70 percent efficiency. But for the electric storage water heater, energy losses of about 70 to 75 percent occur in acquiring the primary fuel and in the generation, transmission, and distribution of electricity, yielding overall energy efficiency for the electric storage water heater of about […] 27 percent. This figure is much lower than the gas-fired storage water heaters overall energy efficiency of about […] 64 percent, when full-fuel cycle energy consumption is the measure employed. In general, energy losses in heating applications with electric resistance water heaters are greater than in heating applications with natural gas when the measure is full-fuel-cycle energy use."

The National Research Council recommended that DOE/EERE consider moving over time to the use of a full-fuel-cycle measure of energy consumption for the assessment of national and environmental impacts. The Residential and Commercial subcommittee of the Demand Task Group has arrived at a similar conclusion based on the review of studies and evaluation of key drivers of demand and policy levers to affect those drivers (National Research Council 2009).

The National Academies of Sciences defines a site (point-of-use) measure of energy consumption reflects the use of electricity, natural gas, propane, and/or fuel oil by an appliance at the site where the appliance is operated, based on specified test procedures. Alternatively, a full-fuel-cycle measure of energy consumption includes, in addition to site energy use, 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 homes and commercial buildings (National Research Council 2009).

The preceding chapters have demonstrated that the energy needs in the residential and commercial sector, as well as economy wide, will be met with a mixed fuel portfolio. For a given application, certain fuels for may perform better than others when measured on a site or point-of-use basis. Yet this approach neglects the full appreciation and consequences of upstream energy costs, benefits, and impacts to the wider economy and society. A full-fuel-cycle approach help fills this knowledge gap. The result of establishing such a comprehensive context for the measurement of efficiency, impact and cost will result in a marketplace in which consumers are led to pick to the "right fuel for the right application," enabling consumers, policy makers, regulators, and other stakeholders to make informed decisions on energy usage.

Energy Efficiency Programs – Future Potential

Various studies indicate that remaining energy efficiency opportunities in the residential and commercial sectors remain vast. Some of these studies evaluate the technical, economic, or "achievable" potential for energy savings while others model the influence of exogenous factors, such as policy, price, and economic growth scenarios on energy consumption and savings and, indirectly, greenhouse gas emissions and other effects.

An analysis of residential and commercial building energy efficiency potential prepared for the 2007 NPC *Facing the Hard Truths about Energy* study remains. It found that:

> If "achievable" cost-effective energy-efficiency measures were deployed in residential and commercial buildings, energy use could be reduced by roughly 15-20 percent below business as usual projections. The potential for cost-effective energy-efficiency improvements is heavily dependent on the price of energy, consumer awareness and perceptions, and the availability of energy-efficient products in the marketplace. These factors are significantly influenced by government policies.

The findings were based on review of several studies and "achievable" was acknowledged as being loosely defined as "measures are currently available and the savings can be realized with a reasonable level of effort and with acceptable reductions, if any, in perceived amenity value," valid (National Petroleum Council 2007).

Another approach to potential studies is to project potential impacts of policy options on energy demand and greenhouse gas emissions. This was the approach of an Alliance to Save Energy study prepared for the Presidential Climate Action Project in 2008 (Alliance to Save Energy 2008). The study (which employed savings calculations performed by ACEEE) found that aggressive but cost-effective energy efficiency measures (not including carbon pricing through caps or fees) could reduce projected 2050 carbon dioxide emissions from building energy use by 35 percent, keeping such emissions essential level with today's emissions. In other words, projected increases in building energy use could be eliminated.

Alliance to Save Energy staff revised the spreadsheets used for the 2008 study to project year 2020 and 2030 energy savings, carbon dioxide emissions avoidance, electricity and natural gas (both direct use and indirect use for electricity generation), and fuel cost savings from a menu of policy options under "most likely" and "enhanced" scenarios. The projected savings are presented in Table 2.

Table 2

Savings from Alliance to Save Energy Recommended Policies in an Energy-Only Bill[10]

		Primary Energy Savings (quads)		**Annual CO2 Avoidance** (MMT)		**Electricity Savings** (billion kWh)		**Net Consumer Savings** (billion 2007 USD)		**Direct Natural Gas Savings** (TBtu)		**Indirect Natural Gas Savings** (TBtu)	
		2020	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**	**2020**	**2030**
Most Likely Policy Savings	EERS *(ACES)*	1.0	1.0	73.0	76.0	98.5	102.7	5.0	5.9	-	-	126	148
	Building Codes *(ACELA)*	0.3	0.7	17.1	42.0	22.9	59.2	1.4	3.9	66	125	29	85
	Appliance Standards *(ACELA amended)*	0.5	1.1	27.7	63.6	39.9	93.5	4.0	9.8	72	161	51	134
	Retrofits *(ACES)*	0.2	0.3	8.6	16.1	12.9	24.7	1.0	2.2	16	158	17	35
	Building Labeling *(ACELA)*	0.0	0.1	2.0	4.0	2.7	5.1	0.2	0.6	7	15	3	7
	BICAD *(ACES)*	0.0	0.1	1.4	2.7	2.2	4.5	0.1	0.5	1	-	3	6
	Total	***2.0***	***3.3***	***129.8***	***204.4***	***179.1***	***289.7***	***11.7***	***22.9***	***162***	***459***	***230***	***416***
Enhanced Policy Savings	EERS *(10percent standalone)*	1.8	1.8	129.0	134.0	176.4	183.0	4.3	11.1	-	-	226	263
	Building Codes *(ACELA with full funding)*	0.5	1.2	27.6	74.0	32.2	92.9	2.6	8.2	157	343	41	133
	Appliance Standards *(ACELA amended with S. 1637 and S. 1639)*	0.8	1.3	45.1	74.6	76.8	115.5	6.0	11.1	72	161	51	134
	Retrofits *(ACELA with full funding)*	0.6	1.1	33.4	63.0	48.6	93.0	4.8	9.5	86	280	62	134
	Building Labeling *(ACELA with full funding)*	0.1	0.4	10.1	20.0	13.3	25.5	1.1	3.2	36	74	17	37
	BICAD *(ACES)*	0.0	0.1	1.4	2.7	2.2	4.5	0.1	0.5	1	-	3	6
	Total	***3.8***	***5.9***	***246.6***	***368.3***	***349.5***	***514.4***	***18.9***	***43.6***	***352***	***858***	***401***	***707***

Legend
EERS (ACES)—analysis of clean energy renewable energy standard in ACES (HR 2454)
Building Codes (ACELA)—analysis of building codes provisions in ACELA (S 1462)
Appliance Standards (ACELA)—analysis of appliance standards in ACELA
Retrofits (ACES)—analysis of ACES state energy efficiency retrofit program
Building Labeling (ACELA)—analysis of building energy labeling provisions in ACELA
BICAD (ACES)—Best In Class Appliance Deployment in ACES
American Clean Energy and Security Act (*ACES*), American Clean Energy Leadership Act (*ACELA*), and American Power Act (APA)

---

[10] Savings taken or based on calculations by the American Council for an Energy-Efficient Economy. See especially John A. "Skip" Laitner, et al., *The American Power Act and Enhanced Energy Efficiency Provisions: Impacts on the U.S. Economy*, ACEEE Report E103, June 2010.

Residential Energy Efficiency Potential

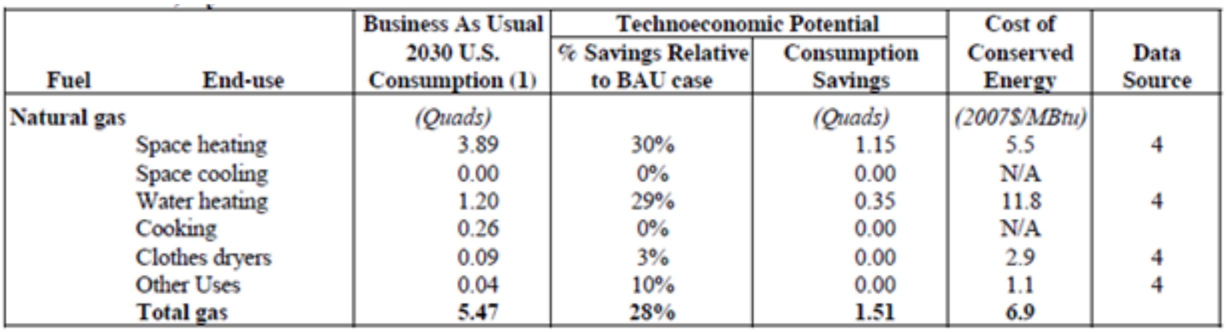
Various studies indicate that remaining energy efficiency opportunities in the residential and commercial sectors remain vast. Some of these studies evaluate the technical, economic, or "achievable" potential for energy savings while others model the influence of exogenous factors, such as policy, price, and economic growth scenarios on energy consumption and savings and, indirectly, greenhouse gas emissions and other effects.

In a study prepared for the National Academies' "America's Energy Future" project, analysts from Lawrence Berkeley National Laboratory assessed the techno-economic potential for electricity and natural gas savings for selected measures in residential dwellings and the cost of such savings (Lawrence Berkeley National Laboratory 2008). Feasible year 2030 savings, relative to the AEO 2007 reference case, were roughly one-third for both natural gas and electricity in the residential sector at an average of $6.90 (residential) per million Btu natural gas and 2.7 cents per kWh, respectively. The study assumes a phase-in of efficient technologies with no early replacement of equipment.[11] Tables 8 and 9 below provide the findings of the study for the Residential gas and electric sectors, respectively.

---

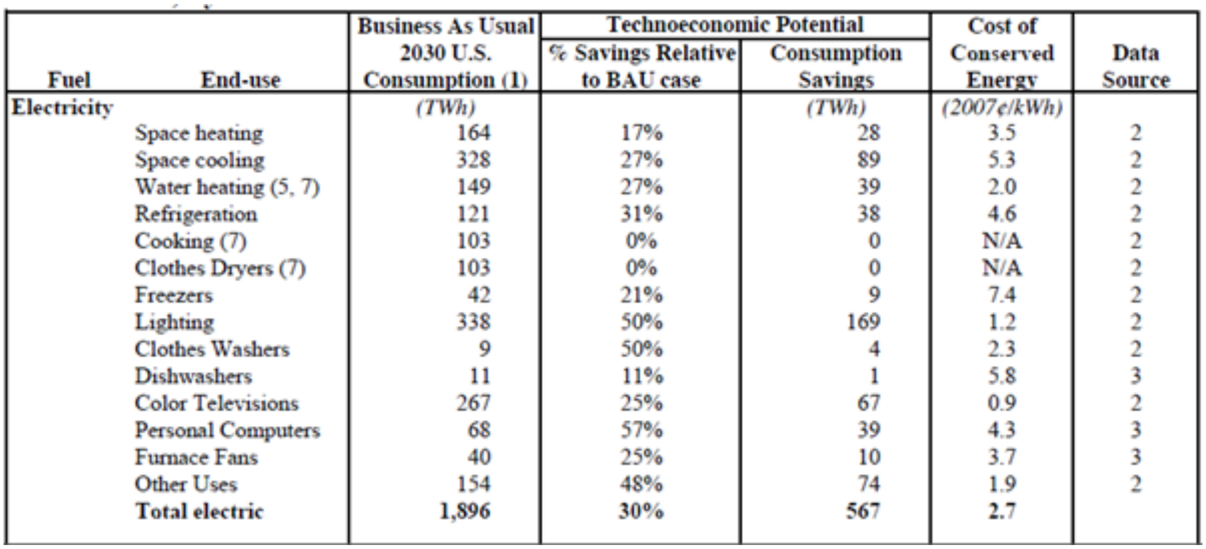
[11] A caution is that the natural gas analysis extrapolates nationally from a New York State focused study.

Table 3
Summary of Residential Buildings Consumption, Savings Potential and Measure Costs in 2030,
by End Use



Fuel	End-use	Business As Usual 2030 U.S. Consumption (1)	Technoeconomic Potential		Cost of Conserved Energy	Data Source
			% Savings Relative to BAU case	Consumption Savings		
Natural gas		*(Quads)*		*(Quads)*	*(2007$/MBtu)*	
	Space heating	3.89	30%	1.15	5.5	4
	Space cooling	0.00	0%	0.00	N/A	
	Water heating	1.20	29%	0.35	11.8	4
	Cooking	0.26	0%	0.00	N/A	
	Clothes dryers	0.09	3%	0.00	2.9	4
	Other Uses	0.04	10%	0.00	1.1	4
	Total gas	**5.47**	**28%**	**1.51**	**6.9**	

Table 4
Summary of Residential Building Consumption, Savings Potential, and Measure Costs in 2030, by end use.



Fuel	End-use	Business As Usual 2030 U.S. Consumption (1)	Technoeconomic Potential		Cost of Conserved Energy	Data Source
			% Savings Relative to BAU case	Consumption Savings		
Electricity		*(TWh)*		*(TWh)*	*(2007¢/kWh)*	
	Space heating	164	17%	28	3.5	2
	Space cooling	328	27%	89	5.3	2
	Water heating (5, 7)	149	27%	39	2.0	2
	Refrigeration	121	31%	38	4.6	2
	Cooking (7)	103	0%	0	N/A	2
	Clothes Dryers (7)	103	0%	0	N/A	2
	Freezers	42	21%	9	7.4	2
	Lighting	338	50%	169	1.2	2
	Clothes Washers	9	50%	4	2.3	2
	Dishwashers	11	11%	1	5.8	3
	Color Televisions	267	25%	67	0.9	2
	Personal Computers	68	57%	39	4.3	3
	Furnace Fans	40	25%	10	3.7	3
	Other Uses	154	48%	74	1.9	2
	Total electric	**1,896**	**30%**	**567**	**2.7**	

Among the studies reviewed was EIA AEO 2007. Its reference case projects significant improvements in residential stock space conditioning and refrigeration through 2030 and beyond (Table 5). However, residential energy consumption (electric and direct fuel use) is projected to be 24 percent below the reference case in 2030 if "consumers purchase the most efficient products available at normal replacement intervals regardless of cost, and that new buildings are built to the most energy-efficient specifications available, starting in 2007," (Lawrence Berkeley National Laboratory 2008).

Table 5

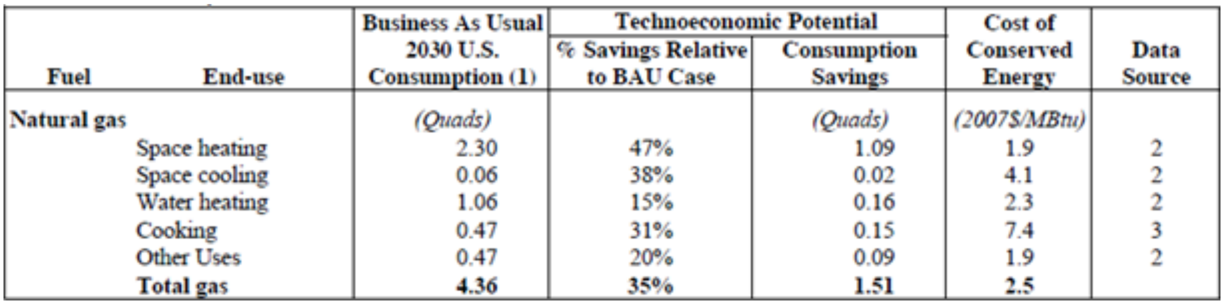
Residential Stock Efficiency Improvements 2007-30 (EIA Projections)		
Category	Appliance	Efficiency Improvement (percent)
Appliance	Refrigerator	22
	Freezer	8
Space heating	Electric heat pumps	9
	Natural gas heat pumps	14
	Geothermal heat pumps	5
	Natural gas furnace	5
	Distillate furnace	2
Space cooling	Electric heat pumps	20
	Natural gas heat pumps	10
	Geothermal heat pumps	6
	Central air conditioners	22
	Room air conditioners	7
Water heaters	Electric	3
	Natural gas	6
	Distillate fuel oil	0
	Liquefied petroleum gases	6
Building shell efficiency	Space heating – Pre 1998 homes	2
	Space cooling – Pre 1998 homes	2
	Space heating – New construction	7
	Space cooling -- New construction	1
(Energy Information Administration 2007, table 21)		

Commercial Energy Efficiency Potential

Various studies indicate that remaining energy efficiency opportunities in the residential and commercial sectors remain vast. Some of these studies evaluate the technical, economic, or "achievable" potential for energy savings while others model the influence of exogenous factors, such as policy, price, and economic growth scenarios on energy consumption and savings and, indirectly, greenhouse gas emissions and other effects.

In a study prepared for the National Academies' "America's Energy Future" project, analysts from Lawrence Berkeley National Laboratory assessed the techno-economic potential for electricity and natural gas savings for selected measures in commercial buildings and the cost of such savings (Lawrence Berkeley National Laboratory 2008). Feasible year 2030 savings, relative to the AEO 2007 reference case, were roughly one-third for both natural gas and electricity in the commercial sector at an average of 2.7 cents per kWh and $2.50 (commercial) per million Btu natural gas. The study assumes a phase-in of efficient technologies with no early replacement of equipment. A caution is that the natural gas analysis extrapolates nationally from a New York State focused study. Table 6 below provides the finding for the Natural Gas Commercial sector.

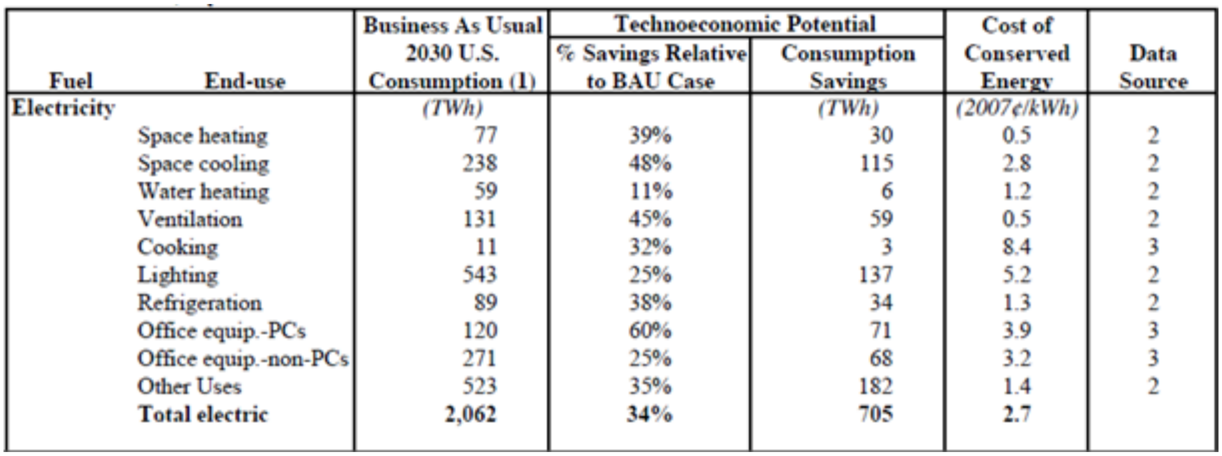
Table 6
Summary of Commercial Buildings Natural Gas Consumption, Savings Potential, and Measure Costs in 2030, by End Use.



		Business As Usual	Technoeconomic Potential		Cost of	
Fuel	**End-use**	**2030 U.S. Consumption (1)**	**% Savings Relative to BAU Case**	**Consumption Savings**	**Conserved Energy**	**Data Source**
Natural gas		*(Quads)*		*(Quads)*	*(2007$/MBtu)*	
	Space heating	2.30	47%	1.09	1.9	2
	Space cooling	0.06	38%	0.02	4.1	2
	Water heating	1.06	15%	0.16	2.3	2
	Cooking	0.47	31%	0.15	7.4	3
	Other Uses	0.47	20%	0.09	1.9	2
	Total gas	**4.36**	**35%**	**1.51**	**2.5**	

Table 7 below provides the finding for the Electricity Commercial Sector

Table 7
Summary of Commercial Buildings Electricity Consumption, Savings Potential, and Measure Costs in 2030, by End Use.



		Business As Usual	Technoeconomic Potential		Cost of	
Fuel	**End-use**	**2030 U.S. Consumption (1)**	**% Savings Relative to BAU Case**	**Consumption Savings**	**Conserved Energy**	**Data Source**
Electricity		*(TWh)*		*(TWh)*	*(2007¢/kWh)*	
	Space heating	77	39%	30	0.5	2
	Space cooling	238	48%	115	2.8	2
	Water heating	59	11%	6	1.2	2
	Ventilation	131	45%	59	0.5	2
	Cooking	11	32%	3	8.4	3
	Lighting	543	25%	137	5.2	2
	Refrigeration	89	38%	34	1.3	2
	Office equip.-PCs	120	60%	71	3.9	3
	Office equip.-non-PCs	271	25%	68	3.2	3
	Other Uses	523	35%	182	1.4	2
	Total electric	**2,062**	**34%**	**705**	**2.7**	

The study based on a review of EIA AEO 2007 indicated that commercial energy consumption (electric and direct fuel use) was 13 percent below the EIA reference case if “only the most efficient technologies are chosen, regardless of cost, and that building shells in 2030 are 50 percent more efficient than projected in the reference case [including] the adoption of improved heat exchangers for space heating and cooling equipment, solid-state lighting, and more efficient compressors for commercial refrigeration,” (Lawrence Berkeley National Laboratory 2008).

Chapter Six - Looking Ahead: Demand Evolution through to 2050

Beyond 2030, there is increased uncertainty about the use of natural gas in homes and buildings in the United States. The extent to which measures are taken to address climate change, to which overall energy efficiency improvements are achieved, and how renewables are integrated into the U.S. energy portfolio will have tremendous influence on the role of natural gas in the 2035-2050 energy mix. However, pathways that leverage direct and distributed natural gas use provide diversity, reliability, and cost-efficiency benefits relative to pathways that rely exclusively on large-scale electricity generation.

Although a good deal of analysis has been done to assess the role of natural gas in the near- to medium-terms, relatively little attention has been paid to the long-term potential for natural gas to contribute as a cost-effective means for achieving carbon-reduction targets. This is especially true with respect to assessing the long-term use of natural gas in the residential and commercial sectors. This chapter seeks to set out a framework for thinking about such a long-term role for natural gas in serving the energy needs of homes and buildings – whether directly, in a distributed fashion or by way of electricity generated in large scale plant. Uses of gas are identified, as are key drivers that may enable natural gas to realize its potential across those uses.

As noted in other areas of this report, significant investments in technological research, development, and commercialization – coupled with timely adoption of those new technologies – are necessary for achieving notable and long-term reductions in carbon emissions.

When considering scenarios in which natural gas will continue to serve a major role in meeting the energy needs of homes and buildings while also lowering the carbon-intensity of that energy use, it will be critical to make significant investments in the following areas:

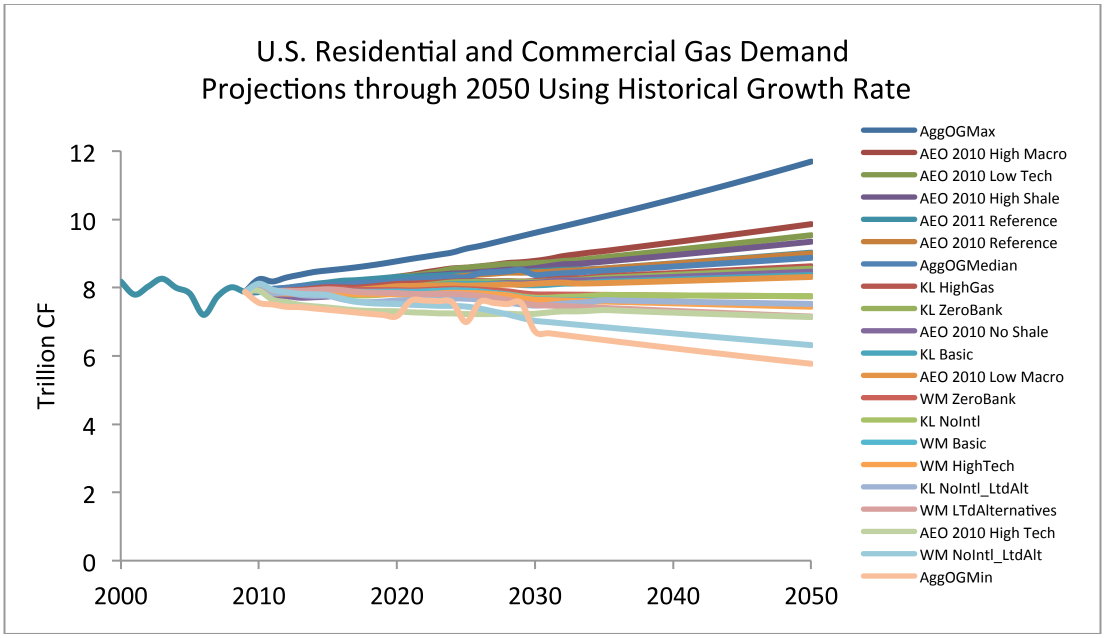
- Development and commercialization of carbon capture and sequestration technologies, both pre- and post-combustion, to facilitate natural gas in the central generation mix as well as in distributed residential and commercial uses.
- Commercialization of residential-scale CHP and fuel cells.
- Smarter energy systems which integrate natural gas and electricity in a broader energy context while implementing a diverse and low-carbon resource mix that includes renewables and natural gas. Investments in smart technologies should be considered equitably across the energy value chain.
- Renewable natural gas (pipeline-quality) injection into the gas distribution network.
- District heating and cooling solutions by local governments and community planners.

To begin, this chapter presents an extrapolation of the projections compendium discussed in Chapters 1 to illustrate the variation and potential level of uncertainty in natural gas demand in the long-term.

Assessing Long-Term Demand Potential through 2050

None of the studies reviewed by the Residential and Commercial Subgroup provided projections of natural gas demand in the residential or commercial sector beyond 2035. Therefore, in order to provide context for a long-term view of natural gas demand in these sectors, the projections summarized in Chapters 1 have been extrapolated to 2050. The result is a spread of possible demand scenarios that varies between 5.4 Tcf to 11.6 Tcf of total gas consumed in 2050 in the combined residential and commercial sectors (see
Figure 33). The range of demand illustrates significant variation due to the assumptions involved. As an example of high demand in 2050, one set of projections that were aggregated from proprietary sources shows a linearly projected demand level of 11.6 Tcf for the combined residential and commercial sector by 2050. The lowest of these projections, by contrast, is 5.7 Tcf in 2050, less than half the maximum projected level of demand. The Annual Energy Outlook 2011 reference case shows residential and commercial natural gas demand at 8.6 Tcf in 2050. Driving variation of the long-term demand outlooks are assumptions concerning availability and access to shale gas supplies, the pace of technological development, improvements in energy efficiency, and the nature and magnitude of any mandated greenhouse gas reductions regime (such as the *Waxman-Markey* climate legislation).

Figure 33: U.S. Residential and Commercial Gas Demand Projections through 2050[12]



The presence of a mandated reduction in greenhouse gas emissions could place binding commitments on residential and commercial natural gas use and significantly impact and restrict long-term utilization of gas these sectors. However, meeting these commitments may be achieved, depending on the magnitude of the mandated reductions, though efficiency and technological development. Initial analysis presented in the MIT study on the *Future of Natural Gas* suggests that natural gas efficiency policies and regulations will likely lead to residential and commercial demand reductions in the range of 1-2 Tcf per year by 2030, and that these reductions could take place even if there were no policy on greenhouse gas emissions (MIT Energy Initiative 2010). While the nature and possibility of a greenhouse gas regulatory regime remains uncertain, the potential for significant greenhouse gas reduction commitments underscores the importance of focusing efforts toward the efficient direct-use of natural gas and development of low- or no-emission new technologies to reduce long-term emissions.

---

[12] The long-term demand outlook is an extrapolation of existing projections and should be treated as an illustrative example of the greater uncertainty of long-term demand and the varying potential for both increases and reductions in residential and commercial natural gas demand. This projection is a combination of the projections presented in Chapter 1 (Figure 1) with a linear extrapolation of these projections out to 2050. The post-2035 data presented here is not based forecasting methods normally utilized in long-term demand projections. Rather, the linear extrapolation is based on the compound annual growth rate of data over the time period available for that given projection.

The Long View on Natural Gas use in Homes and Buildings

The role of natural gas in homes and buildings likely will evolve over the long-term because of a variety of factors. Governmental regulations and policy, consumer preferences for energy, change in household size and population migration, and technological advances will all shape the future energy profile of natural gas in the residential and commercial sectors.

In the medium to long-term, options to meet new demand for energy will be likely coupled to efficiency targets and carbon reduction requirements, which will necessitate a broad exploration today of a broad portfolio of energy solutions. While renewable sources such as solar and wind can mitigate greenhouse gas emissions, natural gas too will help form the backbone of low-carbon electricity generation for the coming years. This will require near-term capital investments that can then be leveraged over the long term, both for new central electrical generation capacity expansion but also for increases in direct use and distributed generation capacity in the residential and commercial sector. Direct use applications, combined heat and power, gas backup for solar-thermal heat, distributed generation, fuel cells, and other technologies can play an expanded or enhanced role in meeting the heating and electricity needs of homes and buildings in the medium and long term. In particular, direct and distributed uses of natural gas offers one of the most efficient and lowest-carbon energy delivery systems (National Research Council of the National Academies of Sciences 2010).

Direct Thermal

Direct use of natural gas has the potential to significantly reduce carbon emissions from existing, more carbon-intensive sources such as fuel oil, and electricity from coal-fired generation. As advanced buildings programs and policies encourage more sustainable use of energy in 'hybrid' space- and water-heating systems, natural gas heating will be relied upon as a compliment to solar water heating, ground-source heat pumps, and solar-assisted air-source heat pumps. The longer-term potential remains uncertain, however, though natural gas can certainly play a role when used in the context of high-efficiency applications coupled to low- or no-carbon technologies alongside combined heat and power and distributed generation.

Combined Heat and Power

Combined Heat and Power (CHP) is one promising option within the U.S. long-term energy portfolio. A proven technology with a 100-year history, CHP generates electricity from fuels such as natural gas while simultaneously re-appropriating captured waste heat for use. Efficiencies achieved rise upwards of over 80 percent. A report by the Oak Ridge National Laboratory characterizes the benefits of CHP as an efficiency technology that "lowers demand on the electricity delivery system, frequently reduces reliance on traditional energy supplies, makes businesses more competitive by lowering their costs, reduces greenhouse gas and criteria pollutant emissions, and refocuses infrastructure investments towards a next-generation energy system." However high equipment costs have hindered commercialization. As a result, for example, in the near-term, combined heat and power applications are more likely seen in the commercial sector in situations that involve high utility retail electricity prices, appropriate heating and electricity requirements, and a need for uninterrupted power supply and peak shaving. However, it is likely that production costs will lessen for these technologies and help increase the commercialization and integration of these technologies in homes and buildings.

CHP provides a effective and economically beneficial option for greenhouse gas abatement. A 2007 McKinsey & Company study on carbon abatement potential of various technologies shows that CHP use in commercial buildings and the industrial sector can deliver carbon reduction options at a negative marginal cost (McKinsey & Company December 2007). Long-term investments in CHP can mitigate greenhouse gas emissions while generating a positive return on investment.

Distributed Energy

In the long run, greenhouse gas emissions cannot be dramatically reduced without dramatic technological breakthroughs. The energy business has traditionally been one of resource management, but is evolving and is increasingly infused with technology enabling consumers *and* businesses to make more intelligent and proactive energy decisions. Technological advances make energy production and use decisions more "local" while also attracting new entrants to the energy space.[13] Investments being made in "smart" electric grids and in "smart" electric and natural gas metering technology will enable this transformation over the coming decades.

Distributed energy technologies fit into this evolving electric smart grid and presents an effective solution toward long-term reduction of greenhouse gases. Natural gas-fired technologies, such as fuel cells, micro-turbines, turbines smaller than utility capacity, and natural gas engines are currently available. The United States has a well-developed natural gas distribution system which will serve an important role in producing energy for buildings, factories, neighborhoods and large-scale facilities. This network can serve as the backbone for a clean, distributed energy system.

The adoption of "smart" electric transmission and metering technologies will provide for greater demand response capabilities, which should have a positive impact on the adoption of distributed energy solutions. In addition, there is significant value to be extracted from integrating this "smarter" electric grid with a "smarter" natural gas grid to best enable a transition to a "smart" energy system overall. For example, communications between metering technologies will enable not only demand response from distributed resources in response to market price changes but also coordinated dispatch.

---

[13] Google is one such new entrant, having applied at FERC to be a power marketer and currently investing in energy technologies, including turbines that would run on solar power.

The costs of maintaining the existing natural gas transmission and distribution networks are relatively small in comparison with the other system costs associated with a low-carbon transition. In addition, there is a well-established and well-functioning process for expanding this highly efficient transmission and delivery system. Together these findings suggest a compelling economic rationale for maintaining and enhancing natural gas distribution infrastructure and services for the foreseeable future.

Renewable Gas

The increased use of renewable gas has the potential to displace natural gas produced from traditional resources. Renewable gas has the potential to realize the medium and long-term targets of increased renewable energy, reductions in carbon emissions, and enhanced energy supply security. The technology for renewable gas exists today, and there are no insurmountable technical or safety barriers. However, the role of government regulation and policy will prove critical toward developing this potential resource and utilizing it for power needs and as a renewable source of heat in the residential and commercial sectors.

Renewable gas is produced from the byproducts of anaerobic digestion or thermal gasification of biodegradable waste from agricultural and municipal waste sites. Renewable gas can then be used on site for heat or electricity uses, or can be processed and “upgraded” to pipeline quality by removing carbon dioxide and hydrogen sulfide. The resulting pipeline-quality biogas can then be injected into the existing transmission and distribution network and used as renewable form of residential and commercial heat. Since renewable gas would utilize the existing transportation and distribution pipeline networks, fewer capital costs would be associated with this alternative compared with other renewable options. As a long-term renewable energy resource, renewable gas can be utilized alongside solar, wind, and hydropower. In addition it can serve as a renewable source of direct use heat and as a distributed generation fuel.

Greening of the Electricity Grid

Long-term reductions in residential and commercial greenhouse gas emissions will likely be achieved, in part, through the “greening” of the electrical grid and the utilization of renewable resources such as solar cells, solar thermal, micro-wind turbines, geothermal technologies, and others. But there still exist many uncertainties in technological feasibility, economic viability, and implementation that surround these and other possible carbon mitigation options. It also remains unclear whether the costs associated with a singular focus on electrification of homes and businesses and the expenses associated with full-scale grid de-carbonization is superior to other options such as those discussed in the preceding sections.

The uncertain nature of how energy will be utilized within a carbon-constrained future necessitates exploration of a broad and comprehensive portfolio of energy solution options. Alongside the “greening” of the electricity grid, other less-explored and currently less-incentivized options that utilize natural gas may provide significant long-term benefits in reducing overall energy demand and reduce carbon emissions. Natural gas technologies, such as fuel cells and other distributed generation technologies have significant potential value. It is possible more ambitious carbon reduction targets may be realized at lower overall costs to the consumer and economy-wide by utilizing these technologies instead of other alternatives. More study and research must be done to explore and fully understand the potential for natural gas to meet these energy needs and carbon reduction requirements now and through 2050.

What is needed to realize this potential?

All potential pathways to a low-carbon future will involve significant investment in new technology. Uncertainty and risks are associated with the pace of technology development and feasibility of deployment, consumer adoption of new technologies, and policy actions. Given the level of uncertainty regarding these issues, there appears to be significant value in providing options for natural gas to contribute over a long-term horizon.

Changes in market conditions and other factors that could affect natural gas market penetration in homes and buildings include:

- Comprehensive cost-benefit analysis at the point of purchase, specifically full-fuel-cycle analysis of energy use and air emissions, rather than assessing them solely at the point of use;
- Appropriate interconnection and net-metering standards;
- Continued availability and deliverability of natural gas supplies;
- Supportive main line extension policies; and
- Continued refinements and structural adjustments to utility regulation at the state level, including proper alignment of shareholder and ratepayer incentives, appropriate and timely infrastructure cost recovery mechanisms, and frameworks for implementing value-added investment programs which go beyond business as usual.

Conclusion

Continued technological development and the commercialization of distributed natural gas solutions will serve as important drivers influencing the role of natural gas in a lower-carbon future. In addition, natural gas transmission and distribution infrastructure provides a relatively low-cost, efficient and highly reliable enabler for these uses.

In the time between now and 2050, disruptive technologies that use natural gas to produce electricity may surface. A likely driver for such a technology breakthrough is research and development conducted for national defense and transportation applications.

Once such technologies are established, they could potentially be adapted for distributed electricity generation in residential and commercial applications. Progress in the development of electricity storage technologies could have a disruptive influence on the development of commercialization of specific distributed energy technologies.

Chapter Seven – Policy Options

Dependable, affordable energy is required to support economic growth and enhanced quality of life in the United States. Protection of our environment is also needed to protect economic well being and human health and safety. Using energy more efficiently in the residential and commercial sectors can simultaneously serve economic, environmental, human health, and energy security and reliability objectives.

Efficient energy use has several facets. It includes more efficient end-use in buildings, equipment, and appliances. It also includes—whether electricity, natural gas, or other fuel—greater efficiency on the supply side, such as at fuel extraction and processing, power generation, and the transmission and distribution of energy.

Further, and importantly, it should include a holistic approach toward management of energy resources that promote a fuller evaluation of the economic and societal-wide costs, benefits, and impacts associated with a particular energy option. To fully realize and optimize the value of natural gas, policies developed must be coupled with or approached using a comprehensive methodology such as a full-fuel-cycle analysis for measuring the intensity, efficiency, and emissions impact of fuels and energy-consuming equipment. Enabled with this information, consumers, energy providers, policy makers, and regulators can make better informed decisions regarding energy choices.

Introduction

Over the coming decades overall energy use will continue to grow. Population growth coupled with economic expansion will increase the demand for energy, and technological innovations will create new applications for both natural gas and electricity. But while growth proceeds, advances in technology will accelerate appliance and building efficiencies and drive down energy consumption per application, offsetting to some degree new demand related to economic and population expansion. Meanwhile, new and evolving uses for energy will require new obligations to safely and reliably fulfill this demand. Critical energy delivery infrastructure maintenance, enhancement, and expansion are critical to ensure energy security, dependability, and economic vitality. The shape of the nation's energy growth, and the extent that domestic energy sources are utilized thoughtfully, efficiently, and cost-effectively, will be impacted by market forces, governmental policies, regulatory actions, and the pace of technological development.

The residential and commercial sectors are no exception to this outlook. The number of residential and commercial consumers of natural gas and electricity are projected to increase in the decades ahead, but appliance and building shell efficiencies will suppress growth in overall energy demand. How consumers use energy will continue to evolve as population migration to southern and western climates shift consumer's energy requirements proportionally away from winter heating needs and towards other end-uses like water heating and air conditioning. Meanwhile, federal and state efficiency and greenhouse gas policies are changing the incentive structures for energy use in these markets.

Natural gas demand for residential and commercial uses is likely to remain relatively flat or show very little growth over the coming decades. This horizontal outlook results largely from decreasing gas use per customer despite a growing number of consumers of natural gas. In contrast to gas, electricity use per customer is expected to intensify over the coming decades, thus driving demand for electricity higher. Residential and commercial electricity demand will be a function of similar drivers, including new efficiencies mitigating economic-related growth. These drivers are likely to impact demand in varying degrees.

The key issue for this chapter is how residential and commercial natural gas and electricity usage can serve to further the goals specified by the Secretary of Energy. That is, what role does natural gas usage play in the residential and commercial market toward increasing energy security, mitigating greenhouse gas emissions, and ensuring a safe and reliable source of domestic abundant energy into the future?

The preceding chapters have presented a number of key facts and opportunities with regard to natural gas use in the residential and commercial sector. This chapter will explore further these opportunities and outline policies that will enable residential and commercial consumers to make the right energy choice for the right application and to leverage the maximum value of natural gas across all sectors of the economy and society– the value of natural gas as a clean, domestic, and cost-effective low-carbon fuel.

To Maximize Natural Gas Value Requires Comprehensive Measurement of Total Energy Usage

It is the policy objective of the United States to protect against the economic and security risks of relying on foreign oil and the destabilizing effects of climate change. To this end, "[a]ll energy uses and supply sources must be reexamined in order to enable a transition towards a lower carbon, more sustainable energy mix."[14] A key component of this reexamination is the comprehensive appraisal of energy consumption in the residential and commercial sector and the associated energy losses that occur prior to delivery to the consumer. A comprehensive assessment of energy usage entails a methodology to accurately measure and evaluate a fuel's energy value chain, from initial primary fuel extraction through transmission, distribution, and then to consumer consumption. A comprehensive measurement approach would permit a full evaluation of the economic and society-wide costs, benefits, and impacts associated with a particular energy source. Enabled with this information, key stakeholders such as consumers, energy providers, policy makers, and regulators can make informed and intelligent

---

[14] Chu, Steven, Secretary of Energy. Letter to Clairborne P. Deming, Chair of National Petroleum Council. September 16, 2009.

decisions regarding energy choices. **All policies including the establishment of regulations, codes, standards, financial incentives, and other governmental actions should incorporate a comprehensive methodology into the decision making and analytical process. Furthermore, policies should be considered and implemented with care to avoid any unintended consequences.**

U.S. energy policy should endeavor to create an environment in which there are no regulatory impediments or unintended consequences that impede consumers' motivation to choose the right fuel for the right application. To the extent policy makers feel more aggressive policies are warranted to speed the rate at which optimum outcomes are achieved, it is vitally important that the full-fuel-cycle context be considered to avoid any unintended consequences of end-use energy choices.

The full-fuel-cycle approach, as discussed in Chapter 5, should be considered in the context of all policies that are recommended in this chapter, including:

- Energy efficiency policy levers.
- Incentives for direct-use of natural gas.
- Main line extension policies.
- Aligning Consumer and Utility Financial Interests

The Residential and Commercial Demand subgroup emerged through consensus that these policy levers can have the most significant impact in attaining the goal of meeting the nation's comprehensive energy needs most efficiently, with the least amount of environmental impact, and with an appropriate cost benefit tradeoff.

Energy Efficiency Policy Levers

As discussed in Chapter Five, there are various energy efficiency policy levers that can enhance the energy goals outlined by the Secretary of Energy. To reiterate, they include:

- Utility programs, incentives and requirements, such as energy efficiency resource standards and targets, inclusion of efficiency in renewable electricity standards, and ratemaking processes that reward or at least do not impede utility efficiency investments.
- Building codes and appliance and equipment standards.
- Financial incentives, such as tax incentives, loan funds, innovative financing (for instance, property assessed clean energy—PACE—financing and inclusion of energy costs in mortgage underwriting).
- Public procurement and incentives.
- Local green building policies and preferences, including local codes, standards, tax, and land use processes.

- Information and awareness, including building and appliance labeling, Energy Star, better energy and cost information feedback to utility customers, and education and technical assistance.
- Comprehensive assessment of energy.

The full-fuel cycle, source-based, carbon footprint measure of energy efficiency for appliances currently proposed by the DOE would help relevant stakeholders recognize natural gas appliances as the more efficient choice for a number of applications. Extending it to buildings would serve as a market indicator to encourage builders, architects, engineers and others to incorporate lower carbon dioxide emissions as a factor in new construction and remodeling projects, thereby increasing the likelihood that builders will install natural gas lines to new residential and commercial communities. With the adoption of source-based efficiency labeling for appliances and buildings, regulators may be better able to quantify natural gas utility contributions toward reducing the carbon emissions of their customers.

Appliance and building efficiency labels are intended to help consumers, builders, architects, code officials, and enforcement agencies understand and make decisions regarding the relative average energy efficiencies of appliances and buildings. Enhancing labels could include expanding the current EnergyGuide labeling in more detail, ideally with an example that shows how this tool is being used by consumers to make energy decisions. Without full-fuel-cycle information and understanding, consumers would be mistaken about the efficiency and environmental impacts of their choice.

Energy utility and distribution company incentives and requirements can deliver significant energy savings as illustrated by Consortium on Energy Efficiency data on U.S. and Canadian ratepayer funded efficiency program impacts. Again, various U.S. states have established EERS, RES with energy efficiency components, shareholder financial incentives for investor-owned utilities, and rate “decoupling” and related tariff mechanisms to either incentivize or require end-use energy efficiency measures. Further establishment and enhancement of such tools by states can accelerate energy efficiency gains. There is the potential and an option for a federal “clean energy standard” that may include energy efficiency as well as low- or no-carbon energy supply options (such as renewable and nuclear power generation and fossil fuel generation incorporating carbon capture and storage), or a RES with energy efficiency, or an EERS.

Building energy codes can be tightened to enhance the energy efficiency of buildings regardless of energy source (electricity, gas, propane, oil, or biomass). In the United States, building codes have been the purview of states. Federal assistance and incentives for state adoption and enforcement of up-to-date codes are a policy option as can be requirements for federally funded projects to meet such codes. (There are already requirements for certain new federal buildings and those undergoing major renovation to meet recent standards.)

Federal standards for various residential and commercial appliances and equipment can also be tightened, and Congress could consider expanding the categories of equipment that could be subject to standards. Further, there can be policies for federal support of enhanced industry consensus standards as well as voluntary standards and labeling.

Incentives for Direct-Use Applications and the Potential for Natural Gas Conversions

Direct-use of natural gas – such as for space heating, water heating, cooking, and clothes drying – is the most environmentally beneficial and efficient use of natural gas energy. The efficient, direct utilization of natural gas within the residential and commercial sectors is critical toward maximizing the value of natural gas across all sectors of the economy. To attain maximum value of domestic natural gas resources and to best utilize its low-carbon attributes, policies should enable growth in direct-use applications while promoting improvements in efficiency.

Direct use of natural gas and the conversion from more carbon-intensive fuels to natural gas presents a significant opportunity to support important environmental quality and national security objectives. The energy consumed by a natural gas end-use appliance, when measured on a full-fuel-cycle basis, often offers higher efficiencies and lower carbon emissions compared with competing technologies. Based on this finding, therefore, policies aimed at promoting efficient buildings and appliances should include gas as a viable clean energy option to consumers.

The value of natural gas as a viable solution in the nation's energy future can be enhanced if the proper incentive structure is in place and established on equal footing with other alternative, clean energy options. End-user financial incentives provide one important pathway toward the adoption of highly efficient appliances and applications.

Financial incentives can take many forms including federal or state funded rebates, tax credits, loan guarantees, grant programs, and others. Similar incentives can be administered by utilities as well. Utility sponsored incentives would require mechanisms to properly align consumer interest with the financial interests of the utility. They can take the form of de-coupled rate designs that align the incentives of utilities with those of their customers in the promotion and adoption of conservation measures (for more see "Aligning Consumer and Utility Financial Interests" on page 84).

Less direct but nonetheless impactful incentives can be channeled through utilities to encourage their customers to adopt efficient energy solutions. These incentives include gas main line extension policies or other infrastructure programs that reduce the risk utilities face in achieving a fair and timely regulated return on their investments and enable customer choice with regard to fuel sources (see "Main Extension Policies" page 84).

Fuel Oil to Natural Gas Conversions

Converting a home from fuel oil to natural gas, for example, using standard-efficiency equipment will reduce associated greenhouse gas emissions by 27 percent. Incentives such as federal tax credits for conversion and direct-use of gas in households and businesses would support these objectives. Furthermore, on a full-fuel-cycle basis, natural gas use in residential applications generates significantly less greenhouse gases than electricity, oil, and propane.

If all oil-heated homes were converted to natural gas, 100 million barrels of oil imported annually would be offset (EIA). Approximately 648 Tbtu of fuel oil is consumed for heating in the Northeast, equal to about 3 percent of annual U.S. gas consumption.[15] This equates to 3.5 Bcf per day new gas demand during the winter heating season (October through March), or 1.7 Bcf per day averaged over a year.

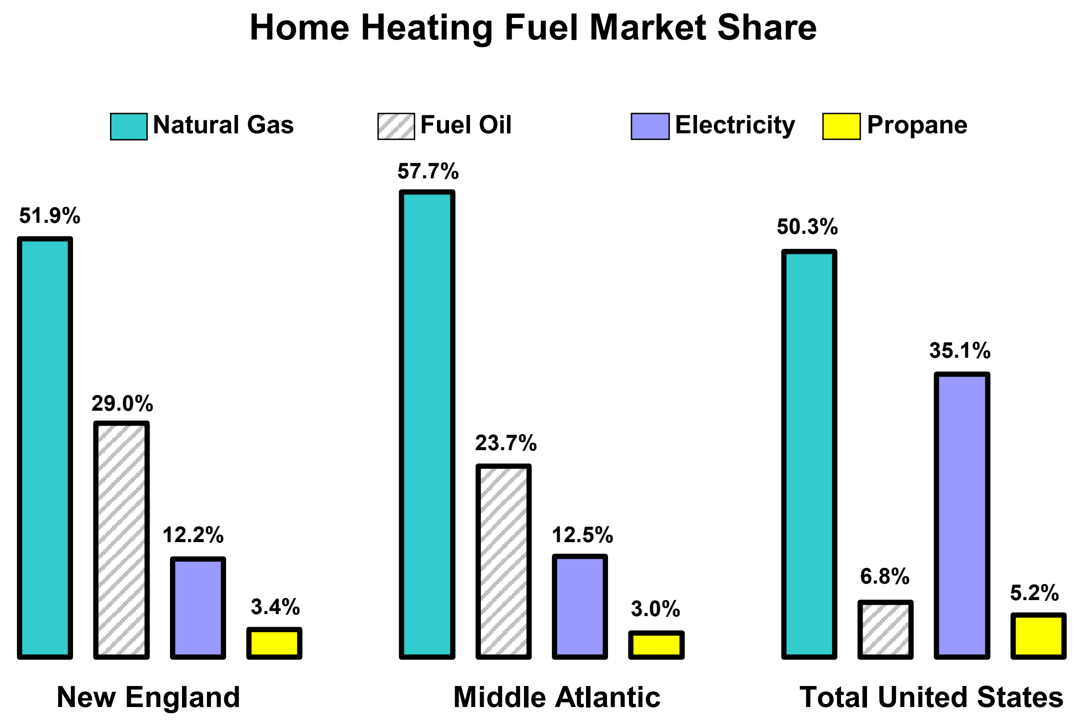
Natural gas is the leading space heating fuel for homes in the United States at just over 50 percent (U.S. Census Bureau 2009). Natural gas is also the leading fuel choice for new home construction in the United States – with 62 of new single-family homes sold opting for gas heating systems (including propane), 37 percent for electricity, and about 1 percent for heating oil (see Figure 34) (U.S. Census Bureau Manufacturing, Mining, and Construction Statistics 2010). In the Northeast, heating oil represents 29 percent of the nine-state Northeast space heating fuels market, and 44 percent of the six-state New England market (U.S. Census Bureau 2009).

New York and the six New England states in particular have much higher usage of heating oil as the main heating fuel than the national average. For example, only 4 percent of Maine's home heating is supplied by natural gas, compared with 76 percent for oil. Heating oil supplies about one-third of New York State's home heating, compared with 53 percent for natural gas; and 46 percent of the New England regional market, compared with 35 percent for natural gas.

---

[15] Based on the EIA Short Term Energy Outlook (Dec. 2010), the consumption of heating oil per household in the 2010-2011 winter is projected to be 708.1 gallons, which equates to 98.2 MMBtu (138,690 Btu/gal). Based on the 2009 American Housing Survey of the Census Bureau, 8.2 million housing units heat with fuel oil in the U.S., 6.6 million of which are in the Northeast. Multiplying 6.6 million units times 98.2 MMBtu/unit gives a total 648 Tbtu of fuel oil.

Figure 34



(U.S. Census Bureau 2009)

Utility saturation rates vary by natural gas infrastructure availability. Certain parts of New England, particularly the three northern states (ME, NH, VT), have limited gas pipeline infrastructure, which accounts for the predominant reliance on heating oil and propane. Conversions from alternate fuels to natural gas continue to accelerate in many states, but are often restrained by the cost of infrastructure extensions.

The 2011 Annual Energy Outlook of the U.S. Energy Information Administration (EIA) nevertheless projects that over the next 25 years, home heating oil consumption will *decline* at an annual rate of 1.6 percent in New England. At the time, natural gas consumption in the residential sector is expected to *increase* by 1.1 percent in the region. Consumption for the residential sector in the Northeast states in 2008 in physical units is shown in Table 8, and on a comparable BTU basis in Table 9.

Table 8
Distillate Fuel Oil and Natural Gas Consumption in the Northeast 2008 (Physical Units)

	Distillate Oil	**Natural Gas**

	(million barrels)	**(billion cubic feet)**
Connecticut	12.6	43
Maine	6.0	1
Massachusetts	15.2	113
New Hampshire	4.0	7
New York	26.7	394
Rhode Island	2.8	18
Vermont	1.9	3
Total	**69.2**	**579**

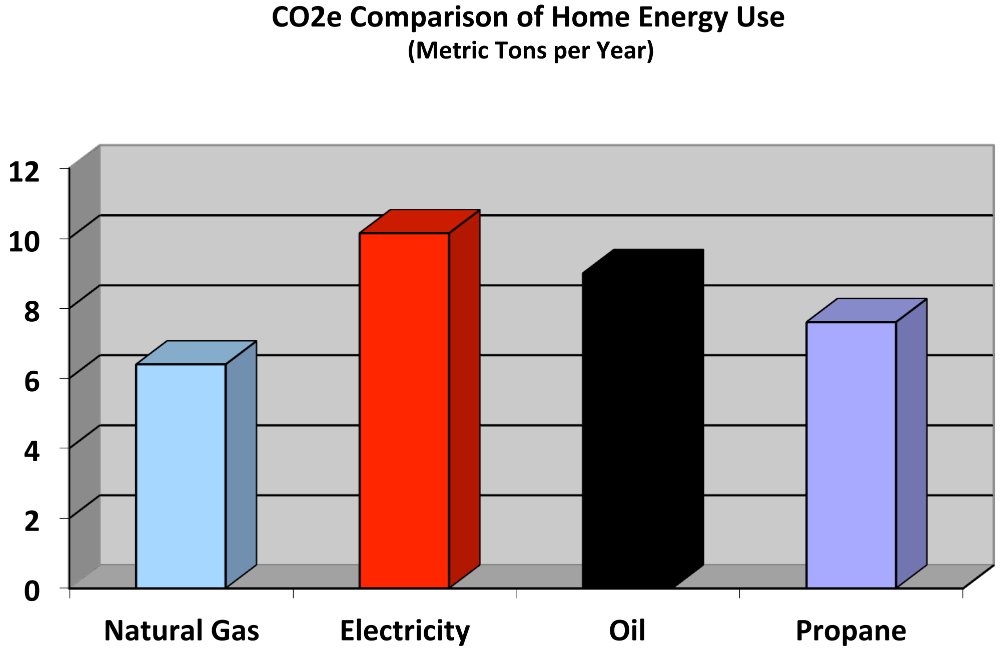
Table 9
Distillate Fuel Oil and Natural Gas Consumption in the Northeast 2008 (BTU-equivalent)

	Distillate Oil (TBtu)	**Natural Gas (TBtu)**
Connecticut	73.7	43.8
Maine	35.5	1.2
Massachusetts	88.9	114.4
New Hampshire	23.8	7.2
New York	156	402.7
Rhode Island	16.5	18.1
Vermont	11.4	3.1
Total	**405.8**	**590.5**

(Energy Information Administration 2010)

While natural gas maintains a strong market position, there still exists substantial opportunity for carbon reductions through the increased direct use of natural gas in the residential and commercial sectors. In particular, conversion from fuel oil to a less carbon-intensive fuel such as natural gas presents real opportunities to mitigate greenhouse gas emissions. To the extent that electricity space heating is drawing its fuel source from a carbon-intensive source such as coal generation and fuel oil, consumers generating heat with electricity contribute more in overall residential carbon emissions compared to a similarly sized natural gas furnace in terms of heat capacity and requirements. In an October 2010 report, the National Research Council observed that "health and environmental damages related to obtaining heat directly from natural gas combustion are much less than damages from the use of electricity for heat," (National Research Council 2010).

Figure 35



Emissions from space heating, water heating, cooking, and clothes drying
Note – includes impact on CO_2 equivalent from unburned methane
(American Gas Association 2009)

There are significant greenhouse gas emission reduction potential associated with a full fuel cycle analysis and the conversion from oil or electricity to natural gas. The American Gas Association conducted a study utilizing the full fuel cycle methodology that analyzed the relative contributions of various fuels to consumer cost, total energy consumed, and carbon dioxide equivalent emissions in residential households. It found that

> "The total efficiency advantage of natural gas, coupled with the fact that natural gas combustion emits approximately 44 percent, 27 percent, and 16 percent of the CO_2 emissions of coal, oil, and propane per MMBtu consumed, respectively, results in significantly lower emissions for natural gas. For the natural gas appliances, annual overall CO_2e emissions were 6.4 metric tons. In comparison, the all-electric option was 10.1 metric tons CO_2e annually, the oil home produced 9.0 metric tons, and the propane home produced 7.6 metric tons. [See Table 10.]"

Table 10: Full-Fuel-Cycle Carbon Dioxide Equivalent Emissions for New Homes[1]
(Metric tons of CO_2e^2 per Average Household Energy Use)

Natural Gas	6.4
Electricity[3]	10.1
Oil[4]	9.0
Propane	7.6

[1] Space heating, water heating, cooking, and clothes drying only

[2] Includes impact of unburned methane

[3] Based on actual generating mix in 2007

4 Assumes electric appliances for cooking and drying applications.

(American Gas Association 2009)

Converting homes from heating oil to natural gas would result in reduced emissions, from particulates to sulfur dioxide in addition to carbon dioxide. Efforts are underway in several Northeast states to reduce the sulfur content in heating oil but the environmental disparity with natural gas will still remain significant. The Northeast states are considering a low-carbon fuel standard for transportation, similar to California, but also, unlike California, for heating oil. As the Northeast States Center for a Clean Air Future pointed out in its July 2009 report: “If the LCFS [Low Carbon Fuel Standard] includes highway diesel but excludes No. 2 heating oil, ‘leakage’ of high-carbon fuels into the heating sector could negate any benefits achieved from transportation fuels,” (Northeast States Center for a Clean Air Future 2009).

The conversion market and new installations are currently being pursued in the Northeast. Gas conversions and installations have been increasing over the past few years. Conversions to natural gas have been on the rise in recent years thanks to the arrival of new infrastructure in the region and the increasing cost-effectiveness of natural gas compared to oil and propane. The Northeast Gas Association reports an average of 40,000 to 50,000 annual conversions and new installations in the region over the last decade. Challenges remain however. Natural gas pipelines are not available in areas of northern New England in particular due in part to low population density and granite making it costly to install pipeline and distribution systems. And even if gas infrastructure is available, the cost of installing new services to individual homes can be high for a local utility and daunting for a customer, despite incentive programs offered by many utilities.

In addition to the carbon mitigation potential of natural gas conversions, gas demonstrates a clear price advantage over oil and propane in the Northeast, presenting a clear market opportunity for those households and businesses with the ability to switch. Consumers switching from fuel oil or more expensive electricity to natural gas see immediate savings in their monthly heating bill.

While many customers on the natural gas main line can make these energy decisions, many customers are not. The primary restriction in the Northeast and elsewhere is the inability of extending the natural gas main line to new customers. Cost often is the largest inhibition, in addition to state regulations. Therefore, in order to fully realize and leverage the value of direct natural gas use, it may be necessary to consider new policies regarding main line extension. More detail on main extension policy is found on page 84.

Other Carbon Mitigating Opportunities

Electric appliances often use less site energy than natural gas counterparts. However, a full-fuel-cycle view of energy consumption shows this disadvantage is often offset by greater efficiency of the overall gas production and delivery system. Where the electric generation portfolio is relatively carbon intensive – where coal generation represents a significant portion of the generation mix – direct gas use within existing applications presents new opportunities for both energy and carbon mitigation options.

One such opportunity is natural gas air conditioning. In some warmer climates, air conditioning represents a significant portion of the total electric load during the summer months. In those areas that rely on a significant portion of coal-fired power for electricity, natural gas air conditioners could serve as an alternative appliance option to this specific market while offering distinct advantages in terms of total greenhouse gas emissions saved and energy required. Substituting natural gas for electricity in powering air conditioning would take pressure off the electric grid during peak-load periods. Areas in the South and Midwest in particular require coal for over 50 percent of required electricity generation. In some places, such as Kentucky and Missouri, coal represents over 80 percent of net electricity generation. Natural gas air conditioning could help offset some of this load and reduce greenhouse gas emissions associated with coal-fired generation. Where natural gas electric generation is used to meet peaking requirements, direct use of natural gas for air conditioning would offset this electricity requirement as direct use natural gas presents higher efficiencies per unit of energy delivered to the end user compared to electricity generated from gas.

Beyond gas air conditioning, there may be additional opportunities with regard to non-traditional gas technology for consumers to utilize lower-emission applications that also offset electric grid requirements. In all cases a full-fuel-cycle methodology of assessing carbon emissions and energy expended is required. These may include but are not limited to:

- Gas heat pumps
- Gas desiccant dehumidifiers
- Micro-CHP systems
- Combination space/water heaters
- Gas commercial food service equipment

These natural gas technologies should be considered in the full palette of options available to consumers, and amongst those incentivized as part of a clean energy portfolio.

Main Extension Policies

In order to extend service to new customers served by a main extension, natural gas utilities make an upfront capital investment given certain levels of risk and require a reasonable return on investment. In some cases, the expected delivery volumes of natural gas through the new mains will not be sufficient over the regulator-authorized time horizon to recover all costs without raising rates for all customers. In other cases, regulators require a contribution in aid of construction (CIAC) fee from new customers to make the investment financially viable.

Certain options for main extension cost recovery policies will increase utilities' abilities to offer service to more customers without compromising a reasonable rate of return. Adapting these policies to allow natural gas utilities to serve a broader base of customers can take a variety of forms:

- increasing the time period over which extension costs are recovered from all customers, though not so long as to put the utility at financial risk;
- government subsidies to natural gas utilities that decreases the total cost of the main extension (some states do this today for water main extensions);
- a longer time period over which the CIAC is recovered; CIAC financed by ratepayers or governments instead of the developer; and acceptance of higher rates for all customers (though not so high that it drives attrition).

Aligning Consumer and Utility Financial Interests

New and innovative approaches to utility tariff design can help align consumer interests with the business requirements of delivering energy to customers. New policies that enable utilities and state regulators to reform the way rate recovery is designed can help promote energy efficiency while preventing the erosion of margins typically associated with declining delivered gas volumes resulting from consumer conservation and increased efficiency.

Traditional rate designs allow utilities to collect payments from consumers every month to cover the actual cost of delivering natural gas. These rates tie a utility's profitability to the volume of gas delivered, leaving no incentive to increase efficiency or promote consumer conservation. Under this scheme fixed delivery and service fees, and therefore utility profits, are coupled to the increased gas usage of customers.

Innovative rate schemes "de-couple" or separate the service rates and revenue streams from the volume of natural gas delivered. These rate designs remove the disincentive for utilities to promote energy efficiency and consumer conservation, allowing the business to have a better chance at fixed-cost recovery compared with a traditional rate design approach. This would better align utility-sponsored programs, such as incentives for higher-efficiency equipment and consumer conservation, with consumer interests without putting utility finances in jeopardy.

Innovative rate designs have been implemented in a number of states already. According to a July 2008 report from the American Gas Association, currently 26 utilities in 13 states have implemented decoupling tariffs that serve 20 million residential customers. Revenue decoupling cases are pending for eight utilities, and generic proceedings are before three state utility commissions, potentially serving another 5 million residential customers.

Policies could include the decoupling of investor returns from commodity throughput to better align consumer interests with utility profits and therefore encourage utilities to promote energy efficiency programs; tiered tariff rates that raise costs for customers using more energy, which reduced demand, thereby reducing greenhouse gases; and real-time pricing to impact consumer behavior more directly and immediately.

Additional Policy Prescriptions

Market Stability Enhancement

Volatility in natural gas prices undermines consumer confidence and cost competitiveness of natural gas. Policies to ensure supply reliability would help limit price volatility and promote a stable price for producers and LDCs. Policies could include adequate guarantees of cost recovery for long-term supply contracts and ramping up education and advocacy with policymakers and customers regarding the link between limiting volatility and development of unconventional resources, liquefied natural gas, and other supply sources.

Natural gas end-use research and development

Research and development can advance the commercial development of end-use natural gas technologies that improve efficiency and contribute to the overall reduction of greenhouse gas emissions. Residential and commercial R&D programs should be focused and allocated in areas that maximize the useful impact of natural gas toward enhancing energy security, reducing greenhouse gas emissions, and promoting economic growth. To this end, R&D should be focused on the following areas:

1) Increased efficiency of current end-use applications (for example, improved condensing boilers)

2) Technologies and processes to utilize natural gas to displace higher carbon energy sources (expanding the transmission and distribution system in a cost effective manner to areas that depend on oil heat).
3) Cutting-edge, high efficiency technologies (gas-fired heat pumps, gas/renewable energy hybrid systems, combined heat and power, fuel cells, super low-emission natural gas appliances).

Historically, the residential and commercial portion of existing research programs has been under funded. Yet the development of new, highly efficient, low emission technologies provides builders, homeowners, and commercial and industrial consumers with natural gas options consistent with the objectives above. The development and commercialization of these appliances can help lower the first cost for consumers as well. New laws, regulations, and stricter building and appliance efficiency codes and standards will require the development of new technologies to bring competitive end-use applications to market. Direct funding of R&D through appropriations or authorizations, or legislation that allows natural gas utilities to assess a modest fee on customers to fund an R&D program managed by the industry is one possible way to make R&D viable in the industry.

Support for distributed energy technology

Distributed energy involves using natural gas or other fuel sources at or near the customer's site to provide energy needs either directly or through the generation of electricity, with or without the reuse of waste heat in combined heat and power applications. In a carbon-constrained future, distributed energy is an important component to ensure the long-term success and growth of natural gas utilities, while further maximizing the value of the nation's domestic natural gas resources. Distributed energy technology envisions a future in which natural gas is used not only to heat homes and businesses and provide hot water and process heat, but is used also for air conditioning and distributed electricity generation. It could be located in a customer's home or business, or used as district heating, cooling, and electricity for a neighborhood or industrial park. Integrated systems could include solar or other renewable energy sources as well as natural gas to serve multiple needs, thereby creating demand for natural gas while helping to reduce energy waste and greenhouse gas emissions.

Policies that support the development of distributed energy technology and incentives that encourage the adoption of on-site generation will make this a viable option for many businesses, allowing them to enjoy energy and cost savings as well as reduced emissions.

Smart Energy Grid and Consumer Information

Smart grid initiatives being advanced by electric power industry have the potential to increase demand response resources through greater communication between individual residential and commercial meters and appliances and the electric grid. Natural gas meters and appliances should be integrated into these efforts to promote a Smart Energy

Grid. The participation of both electric and gas resources in residential and commercial establishments would enhance reliability, lower costs to consumers, and maximize environmental benefits. In addition, integrated smart metering would enable the coordinated dispatch of distributed natural gas-fired generation.

While the impacts and opportunities are still being assessed, there is concern that some current Smart Grid initiatives have the potential to remove fuel choice at the end-user appliance level, and instead default to electric. As the studies show, electric appliances are not necessarily the most energy efficient or environmentally responsible choices for an end-user. Taking a closer look at the initiatives in progress, and ensuring that natural gas meters and appliances are integrated into current efforts would ensure the end-user has the information necessary to make the 'right energy choice' for the 'right application' at the 'right time' to meet his needs.

Renewable natural gas

Providing tax incentives for the production of bio-gas from renewable sources such as animal manure, forest residues, agricultural wastes, and municipal landfills that are similar to those that exist for renewable electricity and renewable transportation will create a level playing field for investors in the renewable energy industry. A renewable bio-gas Production Tax Credit (PTC) will encourage the development of significant new supplies of clean-burning gas (positively impacting market volatility), and could catalyze hundreds of thousands of new jobs. The technology to produce renewable bio-gas exists today, and tax incentives can expedite its development as a diverse, reliable, and environmentally responsible supply source.

Greenhouse Gas Regulation

Over the next 15 to 20 years, legislation to reduce GHG emissions should produce a price advantage for natural gas relative to oil and coal, and relative to electricity in most market areas due to the lower carbon content of natural gas. In addition to lower fuel costs for natural gas, electricity prices will also be pushed higher because of a need to spend hundreds of billions of dollars in construction new low-carbon generating facilites. CHP and other high efficiency commercial and industrial applications will likely be favored.

While cap and trade is the most likely form of carbon constraint, other approaches such as a carbon tax, cap-and-dividend, hybrid, or "programmatic" approach could emerge. Some approaches such as the hybrid approach will enhance the ability of natural gas use in the residential and commercial sector to contribute to meaningful carbon reductions. A flat carbon tax or sector-inspecific cap on emissions could penalize natural gas use in the residential and commercial sector and hinder the potential for these same kind of emissions reducutions. Such taxes or caps would also tend to impact certain geographic regions more intensely than others (higher heating demand regions, for example) which could create unintended economic consequences in the long-run.

Bibliography

- Administration for Children and Families, US Department of Health and Human Services. "Utility Deregulation Glossary." *LIHEAP Clearinghouse.* January 2010. http://liheap.ncat.org/iutil2.htm (accessed November 30, 2010).
- Alaska Department of Natural Resources. "Alaska Natural Gas In-State Demand Study." January 23, 2002. http://www.dog.dnr.state.ak.us/oil/products/publications/otherreports/demand/instate_gas_v1.pdf.
- Alliance to Save Energy. "Energy Efficiency Policies and Energy Demand Projections." Analysis prepared by Alliance to Save Energy staff, 2010.
- —. "Energy Efficiency: America's Greatest Energy Resource." August 2010. http://ase.org/resources/energy-efficiency-americas-greatest-energy-resource (accessed November 17, 2010).
- Alliance to Save Energy. "Property Assessed Clean Energy Financing fact sheet." http://ase.org/resources/property-assessed-clean-energy-financing-pace, 2011.
- Alliance to Save Energy. "Reducing Carbon Dioxide Emissions through Improved Energy Efficiency in Buildings." Prepared for Presidential Climate Action Project, 2008.
- American Council for an Energy-Efficient Economy. "2010 State Energy Efficiency Scorecard." http://www.aceee.org/research-report/e107, Washington D.C., 2010.
- American Council for an Energy-Efficient Economy. "The Technical, Economic, and Acheivable Potential for Energy-Efficiency in the U.S. - A Meta-Analysis of Recent Studies." 2004.
- American Gas Association. "A Comparison of Energy Use, Operating Costs, and Carbon Dioxide Emissions of Home Appliances." Washington, D.C., 2009.
- American Gas Association. "Gas Facts: A Statistical Record of the Gas Industry." Data Periodical, Washington DC, 2008.
- American Gas Association. "Patterns in Residential Natural Gas Consumption Since 1980." Washington D.C., 2000.
- American Gas Association. "Space Heating Market Share Trends in the New Single Family Home Market." Washington D.C., 2006.
- Appliance Standards Awareness Project. "Efficiency Standards Fact Sheet: Residential Gas Furnaces." http://www.standardsasap.org/documents/FACT_SHEET_Gas_Furnaces.pdf (accessed January 5, 2011).
- —. "Why Standards?" http://www.standardsasap.org/why.htm (accessed January 5, 2011).
- Arlington County Green Building Incentive Program. November 12, 2010. http://www.arlingtonva.us/departments/environmentalservices/epo/environmentalservicesepoincentiveprogram.aspx (accessed January 5, 2011).
- British Columbia Government. "The BC Energy Plan: A Vision for Clean Energy Leadership." 2007.

- Brito, Dagobert L., and Robert L. Curl. *Economics of Pricing the Cost of Carbon Dioxide Reductions in the Production of Electricity.* Houston, Texas: James A. Baker III Institute for Public Policy, 2010.
- Building Codes Assistance Project. October 1, 2010. http://bcap-ocean.org/sites/default/files/Residential%20Status%20Map_1.jpg (accessed December 22, 2010).
- —. January 1, 2011. http://bcap-ocean.org/sites/default/files/Residential%20Status%20Map_1.jpg (accessed January 2011).
- California Energy Commission. "2009 Integrated Energy Policy Report." CEC-100-2009-003-CMF, December 2009.
- —. "2009 Integrated Energy Policy Report." 2009. www.cec.ca.
- California Gas and Electric Utilities. "California Gas Report." 2010. http://www.socalgas.com/regulatory/cgr.shtml.
- —. "California Gas Report." 2008. http://www.socalgas.com/regulatory/cgr.shtml.
- California Public Utilities Commission. "Interim Opinion on Greenhouse Gas Regulatory Strategies." March 2008. http://docs.cpuc.ca.gov/published/Final_decision/80150.htm.
- Canadian Association of Petroleum Producers. "CAPP 2008 Crude Oil Forecast, Market Assessment and Pipelines, Appendix B." www.capp.ca.
- —. "Crude Oil Forecast, Markets & Pipeline Expansions." June 2009.
- —. "Industry Facts and Information." http://www.capp.ca.
- Canadian Gas Association. "Natural Gas Technology Futures Workshop, Draft Final Report." Edited by Danielle Tanguay and Lynelle Spring. Ottawa, Ontario: Canadian Gas Association, March 2010.
- Consortium for Energy Efficiency. *State of the Efficiency Program Industry: 2009 Expenditures, Impacts and 2010 Budgets.* 2010. http://www.cee1.org/ee-pe/2010AIR.php3.
- Energy Information Administration. "Annual Energy Outlook 2000 with Projections to 2020." December 17, 1999. http://www.eia.doe.gov/oiaf/archive/aeo00/index.html.
- —. "Annual Energy Outlook 2007 with Projections to 2030." February 2007. http://www.eia.doe.gov/oiaf/archive/aeo07/index.html.
- —. "Annual Energy Outlook 2010." May 11, 2010. http://www.eia.doe.gov/oiaf/aeo/.
- —. "Annual Energy Review 2009." August 19, 2010. http://www.eia.doe.gov/aer/elect.html.
- —. *State Energy Data System.* June 30, 2010. http://www.eia.doe.gov/states/_seds.html (accessed January 2011).
- —. "U.S. Natural Gas Consumption by End Use." 2010. http://www.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm (accessed November 17, 2010).
- —. "U.S. Natural Gas Prices." 2010. http://www.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm (accessed November 17, 2010).

- —. "U.S. Number of Natural Gas Consumers." 2010. http://www.eia.doe.gov/dnav/ng/ng_cons_num_dcu_nus_a.htm (accessed November 17, 2010).
- —. "Voluntary Reporting of Greenhouse Gases Program Fuel Carbon Dioxide Emission Coefficients." *Energy Information Administration.* 2010. http://www.eia.doe.gov/oiaf/1605/coefficients.html (accessed November 16, 2010).
- Energy Information Admistration. "Commercial Building Energy Consumption Survey." 2003.
- Energy Resources Conservation Board. "Alberta Fuel Gas Efficiency in the Upstream Gas and Unconventional Oil Industry." April 2010. http://www.ercb.ca/docs/products/STs/ST110-2010.pdf.
- Energy Resources Conservation Board, Alberta, Canada. "Alberta's Reserves 2007 and Supply/Demand Outlook 2008-2017: Crude Bitumen, Crude Oil, Coalbed Methane, Natural Gas and Liquids, Coal, Sulphur, and Electricity." June 5, 2008. www.ercb.ca.
- Federal Energy Regulatory Commission. "Renewable Power & Energy Efficiency: Energy Efficiency Resource Standards (EERS) and Goals." September 7, 2010. http://www.ferc.gov/market-oversight/othr-mkts/renew/othr-rnw-eers.pdf (accessed November 16, 2010).
- Gormley, Byron. "Canadian Natural Gas Demand Trends." *Canadian Gas Association.* http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/cnslttnrnd4/prsnttn/bryan_gormley.ppt.
- IHS Global Insight. "U.S. Energy Outlook." 2009.
- International Energy Agency. "World Energy Outlook." http://www.worldenergyoutlook.org/, 2010.
- International Energy Agency. "World Energy Outlook." http://www.worldenergyoutlook.org/, 2009.
- —. "World Energy Outlook." 2008. http://www.iea.org/weo/2008.asp.
- Joutz, Frederick, and Robert P. Trost. *An Economic Analysis of Consumer Response to Natural Gas Prices.* Washington D.C.: American Gas Association, 2007.
- Laitner, John A. "Skip", and et. al. *The American Power Act and Enhanced Energy Efficiency Provisions: Impacts on the U.S. Economy.* American Council for an Energy-Efficient Economy Report E103, 2010.
- Lawrence Berkeley National Laboratory. "The Shifting Landscape of Ratepayer-Funded Energy Efficiency in the U.S." 2009. http://eetd.lbl.gov/ea/ems/reports/lbnl-2258e.pdf.
- —. "U.S. Building Sector Energy Efficiency Potential." 2008. http://enduse.lbl.gov/info/LBNL-1096E.pdf.
- McKinsey & Company . "Reducing U.S. Greenhouse Gas Emissions. How Much at What Cost?" December 2007.
- McKinsey & Company. "Unlocking Energy Efficiency in the U.S. Economy." July 2009.

- MIT Energy Initiative. "The Future of Natural Gas: An Interdisciplinary MIT Study." 2010. http://web.mit.edu/mitei/research/studies/naturalgas.html.
- National Association of Regulatory Utility Commissioners. "Decoupling for Electric & Gas Utilities: Frequently Asked Questions (FAQ)." September 2007. http://www.naruc.org/Publications/NARUCDecouplingFAQ9_07.pdf.
- National Energy Board, Canada. "2009 Reference Case Scenario: Canadian Energy Demand and Supply to 2020." *NEB - Energy Reports.* July 2009. http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2009/rfrnccsscnr2009-eng.html.
- —. "Canada's Energy Future Reference Case and Scenarios to 2030, An Energy Market Assessment." *NEB - Energy Reports.* November 2007. http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2007/nrgyftr2007-eng.html.
- —. "Canada's Energy Future to 2030: Appendices." *NEB - Energy Reports.* 2007. http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2007/fctsht0738ntrlgs-eng.html.
- —. "Canada's Energy Future: Reference Case and Scenarios to 2030 -- Natural Gas Highlights." *NEB - Energy Reports.* 2007. http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2007/fctsht0738ntrlgs-eng.html.
- —. "Canada's Energy Future: Scenarios for Supply and Demand to 2025." 2003. http://neb-one.gc.ca.
- National Petroleum Council. "Balancing Natural Gas Policy: Fueling the demands of a growing economy." Washington D.C., 2003.
- —. "Energy Efficiency Potential in American Buildings." 2007. http://www.npc.org/Study_Topic_Papers/6-DTG-ResComEfficiency.pdf.
- National Petroleum Council. "Meeting the Challenges of the Nation's Growing Gas Demand." Washington D.C., 1999.
- National Petroleum Council. "The Potential for Natural Gas in the United States." Washington D.C., 1992.
- National Renewable Energy Laboratory. "Research Support Facility." September 2, 2010. http://www.nrel.gov/sustainable_nrel/rsf.html.
- National Research Council. "Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use; Summary." 2010. http://www.nap.edu/catalog.php?record_id=12794.
- National Research Council of the National Academies of Sciences. *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use.* National Academies Press, 2010.
- National Research Council. *Review of Site (Point-of-Use) and Full-Fuel-Cycle Measurement Approaches to DOE/EERE Building Appliance Energy-Efficiency Standards.* National Academies Press, 2009.
- Natural Resources Canada. "Canada's Energy Outlook: The Reference Case." 2006. http://www.nrcan-rncan.gc.ca/com/resoress/publications/peo/peo2006-eng.pdf.
- Natural Resources Defense Council & American Gas Association. "Utility Decoupling in the United States." January 2011.

- Northeast States Center for a Clean Air Future. "Introducing a Low Carbon Fuel Standard in the Northeast: Technical and Policy Considerations." Northeast States Center for a Clean Air Future, 2009, 4-14.
- Northwest Gas Association. "Gas Demand Outlook: Natural Gas Demand, Supply, and Service Capacity in the Pacific Northwest Projections Through 2019." 2010. http://www.nwga.org/documents/2010outlook.pdf.
- Northwest Power and Conservation Council. "Sixth Northwest Power Plan." February 2010.
- Office of the Mayor [NYC]. "MAYOR BLOOMBERG AND COUNCIL SPEAKER QUINN ANNOUNCE PASSAGE OF LANDMARK PACKAGE OF LEGISLATION TO CREATE GREENER, GREATER BUILDINGS IN NEW YORK CITY ." *News from the Blue Room.* December 9, 2009. http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http://www.nyc.gov/html/om/html/2009b/pr532-09.html&cc=unused1978&rc=1194&ndi=1 (accessed January 6, 2011).
- Pew Center on Global Climate Change. "Public Benefit Funds." February 23, 2010. http://www.pewclimate.org/what_s_being_done/in_the_states/public_benefit_funds.cfm (accessed January 5, 2011).
- Statistics Canada. "Electricity generation, by utilities, by source." 2005. http://www.statcan.gc.ca/pub/16-002-x/2007002/t/4129477-eng.htm.
- U.S. Census Bureau. "American Community Survey." 2009. http://www.census.gov/acs/www/.
- U.S. Census Bureau Manufacturing, Mining, and Construction Statistics. "Characteristics of New Housing." *U.S. Census Bureau.* June 1, 2010. http://www.census.gov/const/www/charindex.html (accessed November 17, 2010).
- U.S. Department of Energy. "Building Energy Codes 101: An Introduction." February 2010. http://bcap-ocean.org/sites/default/files/resources/20100301_std901_codes_101.pdf.
- —. "Federal Leadership in High-Performance and Sustainable Buildings Memoradum of Understanding." 2006. http://www1.eere.energy.gov/femp/pdfs/mouhighperfsustainfedfacs.pdf (accessed January 5, 2011).
- —. *Weatherization Assistance Program.* http://www1.eere.energy.gov/wip/wap.html (accessed March 2011).
- Western Governors' Association. "Energy Efficiency Task Force Report." 2006.
- Weston, Frederick. "Principles and Mechanics of Decoupling: A Brief Overview." *Asia-Pacific Dialogue on Clean Energy Governance and Regulation, June 21, 2010.* Manila, Phillippines, 2010.

Appendix A : Participating Individuals and Organizations

NAME	ORGANIZATION	E-MAIL
Braitsch, Jay	Department of Energy	jay.braitsch@hq.doe.gov;
Blazewicz, Stanley	National Grid	stanley.blazewicz@us.ngrid.com
Brown, Chris	UGI Utilities, Inc.	cbrown@ugi.com
Callahan, Kateri A.	Alliance to Save Energy	kcallahan@ase.org
Comstock, Owen (William)	Energy Info. Administration	William.comstock@eia.doe.gov
Corbin, Arthur C.	Municipal Gas Authority of Georgia	acorbin@gasauthority.com
Emmrich, Herb	Southern Cal. Gas	hemmrich@semprautilities.com
Gant, Paula A.	American Gas Association	pgant@aga.org
Gee, Robert	Gee Strategies Group LLC	rwgee@geestrategies.com
Gruchala, Jonathan R.	Nat'l. Fuel Gas Dist.	gruchalaj@natfuel.com
Hearing, James	LaClede Gas	jhearing@lacledegas.com
Horak, William C.	Brookhaven Nat'l. Laboratory	horak@bnl.gov
Jacob, Sini	PG&E	sajl@pge.com
Kendell, James	Department of Energy	James.Kendell@eia.doe.gov
Levander, Carl	Columbia Gas of VA	clevander@nisource.com
Look, King Y.	ConEdison Co. of NY	lookk@coned.com
Lovelace, Russell	Shell Energy North America	russell.lovelace@shell.com
Massaro, Thomas J. ***(CHAIRMAN)***	New Jersey Natural Gas	tjmassaro@njng.com
Merkel, Yvonne	AGL Resources	ymerkel@aglresources.com
Meyer, Richard	American Gas Association	rmeyer@aga.org
Minor, Anastasia	MichCon (DTE)	minora@dteenergy.com
Moura, John	N. American Elect. Reliability Corp.	john.moura@nerc.net
Murphy, Rick ***(VICE-CHAIR)***	National Grid	Richard.Murphy@us.ngrid.com
Newel, Ken	National Energy Board	Ken.Newel@neb-one.gc.ca
Newsome, Cassandra	Piedmont Natural Gas	cassandra.newsome@piedmontng.com
Osten, Jim	IHS CERA	Jim.Osten@ihsglobalinsight.com
Peeples, Donna N.	AGL Resources	dpeeples@aglresources.com
Shannon, Michelle	Columbia Gas of VA	mpshannon@nisource.com
Shay, Colin	Washington Gas	cshay@washgas.com
Sobin, Rodney	Alliance to Save Energy	rsobin@ase.org
Strauss, Todd	PG&E	txsq@pge.com
Usovicz, Mary	Repsol Energy Nortth America	musoviczl@repsol.com
Waller, Greg	Atmos Energy	greg.waller@atmosenergy.com
Wilkinson, Paul	American Gas Association	pwilkinson@aga.org
Yeasting, Ken	IHS CERA	Ken.Yeasting@ihscera.com

Appendix B : Listing of Studies Reviewed

The following represents the initial list of studies reviewed by the Residential and Commercial subgroup. There are additional studies not listed here but that appear in the bibliography and that were included in the final subgroup report.

References – Demand

July 20, 2010

INTERNATIONAL

1. Energy Information Administration (EIA), International Energy Outlook 2010 (2010) highlights and tables, final report July 2010, and for previous years, website, www.eia.doe.gov
2. International Energy Agency, Executive Summary World Energy Outlook, 2009, website, http://www.worldenergyoutlook.org/docs/weo2009/WEO2009_es_english.pdf
3. International Energy Agency, World Energy Outlook, 2008, website, http://www.iea.org/weo/2008.asp
4. International Energy Agency, World Energy Outlook, 2009, website, http://www.worldenergyoutlook.org/
5. International Energy Agency, World Energy Outlook, 2010, planned for November 2010, website, http://www.worldenergyoutlook.org/

UNITED STATES

6. Alaska Department of Natural Resources, Alaska Natural Gas In-State Demand Study, ASP 2001-1000-2650, 2002, http://www.dog.dnr.state.ak.us/oil/products/publications/otherreports/demand/instate_gas_v1.pdf
7. American Gas Association, Natural Gas Utilities Winter Outlook: Customers Can Continue to Rely on Natural Gas to Meet Energy Needs, 2008, website, www.aga.org
8. American Gas Association, Space Heating Market Share Trends in the New Single Family Home Market, 2006, website, www.aga.org
9. American Gas Association, Patterns in Residential Natural Gas Consumption Since 1980, 2000, website, www.aga.org
10. California Energy Commission, 2008 California Gas Report, website, www.cec.ca
11. California Energy Commission, 2009 Integrated Energy Policy Report, Commission Final Report, website, www.cec.ca
12. Energy Information Administration (EIA), Annual Energy Outlook 2010 (2010) and for previous years, website, www.eia.doe.gov
13. Global Insight, U.S. Energy Outlook, Summer 2009, website, www.globalinsight.com
14. National Petroleum Council, (NPC), 1992, The Potential for Natural Gas in the United States, 1992, Washington, D.C. multiple volumes, multiple appendices, hardcopy only, website www.npc.org

15. National Petroleum Council, (NPC), 1999, Meeting The Challenges of the Nation's Growing Gas Demand, National Petroleum Council, 1999, Washington, D.C. multiple volumes, multiple appendices, website www.npc.org
16. National Petroleum Council, (NPC), 2003, Balancing Natural Gas Policy: Fueling the demands of a growing economy. National Petroleum Council, September 2003, Washington, D.C. multiple volumes, multiple appendices, website www.npc.org
17. National Petroleum Council, (NPC), 2007, Facing the Hard Truths About Energy, National Petroleum Council, July 2007, Washington, D.C. multiple volumes, multiple appendices, website www.npc.org
18. Natural Gas Council, Summary of Natural Gas Council's Analysis of the Lieberman-Warner Climate Regulation Bill (S. 3036), 2008, http://www.ipaa.org/news/docs/200806-NGCReviewofLieberman-Warner.pdf
19. Northwest Gas Association, 2010 Gas Outlook, Natural gas Demand, Supply and Service Capacity in the Pacific Northwest Projections Through October 2019, www.nwga.org

CANADA

20. Canadian Gas Association, Natural Gas Technology Futures Workshop, Draft Final Report March 2010, Ottawa, Ontario, http://www.cga.ca/events/presentations.htm
21. Canadian Gas Association, Canadian Natural Gas Demand Trends, Byron Gormley, Presentation, March 2010, Ottawa, Ontario, http://www.neb.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/cnslttnrnd4/prsnttn/bryan_gormley.ppt#898,1,Canadian Natural Gas Demand Trends Bryan Gormley Canadian Gas Association March 12, 2010
22. Canadian Association of Petroleum Producers, Industry Facts and Information, website, www.capp.ca
23. Canadian Association of Petroleum Producers, CAPP 2008 Crude Oil Forecast, Market Assessment and Pipelines, Appendix B, website, www.capp.ca
24. Canadian Association of Petroleum Producers, Crude Oil Forecast, Markets & Pipeline Expansions, June 2009 www.capp.ca
25. Energy Resources Conservation Board, Alberta, Canada. Alberta's Reserves 2007 and Supply/Demand Outlook 2008-2017: Crude Bitumen, Crude Oil, Coalbed Methane, Natural Gas and Liquids, Coal, Sulphur, and Electricity (Released: June 5, 2008), website www.ercb.ca
26. Energy Resources Conservation Board, Alberta Fuel gas Efficiency in the Upstream Gas and Conventional Oil Industry, April 2010, http://www.ercb.ca/docs/products/STs/ST110-2010.pdf
27. National Energy Board, Canada, Canada's Energy Future: Scenarios for Supply and Demand to 2025, (2003) website neb-one.gc.ca
28. National Energy Board, Canada, Canada's Energy Future: Reference Case and Scenarios to 2030 – Natural Gas Highlights, (2007) website neb-one.gc.ca
29. National Energy Board, Canada, Canada's Energy Future to 2030: Appendices, (2007) website neb-one.gc.ca
30. National Energy Board, Canada, Canada's Energy Future Reference Case and Scenarios to 2030, An Energy Market Assessment November 2007, (2007) website neb-one.gc.ca

31. National Energy Board, Canada, 2009 Reference Case Scenario: Canadian Energy Demand and Supply to 2020, (2009) website neb-one.gc.ca
32. Natural Resources Canada, Canada's Energy Outlook: The Reference Case 2006, www.nrcan.gc.ca

MEXICO

33. Gobierno Federal, Secretaria de Energia, Natural Gas Market Outlook, 2007-2016,(English) Gobierno Federal, SENER, Prospectiva del Sector Electrico, 2009-20204, Mexico 2010 (Español)
34. Index Mundi, Mexico, Natural Gas Consumption, http://www.indexmundi.com/mexico/natural_gas_consumption.html
35. The Energy Journal, The Economics of Natural Gas In Mexico: Revisited, 1993, Michelle Foss
36. The World Bank, Low Carbon Development for Mexico, 2010, http://www.esmap.org/filez/pubs/526201013944_FINAL_LCCGP-MX_Briefing_Note003-10.pdf

RECOMMENDED

37. MIT, The Future of Natural Gas, 2010
38. Baker Institute of Public Policy, Economics of Pricing the Cost of CO_2 Restrictions in the Production of Electricity, 2010
39. California Energy Commission, 2010 California Gas Report
40. National Academy of Sciences, Hidden Cost of Energy, Unpriced Consequences of Energy Production and Use, 2010
41. National Academy of Sciences, Review of Site and Full Fuel-Cycle Measurement Approaches to DOE/EERE Building Appliance Energy Efficiency Standards, 2009
42. Joutz and Trost, An Economic Analysis of Consumer Response to Natural Gas Prices, 2007
43. Lawrence Berkeley National Laboratory, US Building Sector Energy Efficiency Potential, 2008
44. Alliance to Save Energy, Reducing Carbon Dioxide Emissions through Improved Energy Efficiency in Buildings, 2008

Appendix C: Study of Studies Group Breakdown by Category

NPC Residential/Commercial Subcommittee References Divided by Study Groups

International			
	Group 1	EIA International	1
	Group 2	IEA	2,3,4,5
United States			
	Group 3	AGA	8,9,42
	Group 4	EIA Domestic	12,13
	Group 5	NPC	14,15,16,17
	Group 6	California	10,11,19,39
Canada			
	Group 7	NEB	27,28,29,30,31
	Group 8	Other Canada	21,25,32
Recommended			
	Group 9	Efficiency	20,41,43,44
	Group 10	Related Policy	37,38,40

References Not included: 6,7,18,22,23,24,26,33,34,35,36
Note: Reference numbers based on reference list dated July 20, 2010.