Energy Efficiency Benefits of Natural Gas Programs

Pennsylvania En Banc Hearing on Alternative Energy, Energy Conservation and Efficiency, and Demand Side Response

November 19, 2008

PAUL H. RAAB
ECONOMIC CONSULTING

5313 PORTSMOUTH ROAD
BETHESDA, MD 20816
(301) 320-7549 • FAX: (301) 320-6369

Qualifications

- My name is Paul Raab and I am an independent economic consultant.
- I have been providing consulting services to the utility industry for over thirty years, having assisted electric, gas, telephone, and water utilities; Commissions; and intervenor clients in a variety of areas.
- I have been working on similar issues in Kansas, Maryland, Oklahoma and Virginia.
- I have provided expert testimony before many state regulatory authorities, the Federal Energy Regulatory Commission, the Michigan House Economic Development and Energy Committee, the Province of Saskatchewan and the United States Tax Court.

Introduction

Primary Message: The direct use of natural gas at the end-use level has the potential to contribute significantly to electricity reduction goals and reduce natural gas usage, thereby enhancing overall energy efficiency in the Commonwealth.

Introduction

– Secondary Messages

- Electric DSM programs are relevant to the NGDCs because payments to incent electricity efficiency will influence the fuel selection decision and can result in increased usage of electricity, in conflict with electricity reduction goals.
- The Commission should adopt a set of policies to guide its decision-making on energy efficiency issues.

How Natural Gas Can Help

- Definitions
  - Source energy represents the total amount of raw fuel that is required and incorporates all transmission, delivery and production losses, thereby enabling a complete assessment of energy efficiency.
  - Site energy is the amount of heat and electricity consumed as reflected in utility bills.
  - Primary energy is the raw fuel that is burned to create heat and electricity, such as natural gas or fuel oil used in onsite generation.
  - Secondary energy is the energy product (heat or electricity) created from a raw fuel, such as electricity purchased from the grid or heat received from a district steam system.

  Source: United States Environmental Protection Agency, ENERGY STAR Performance Ratings Methodology for Incorporating Source Energy Use, December 2007, page 2.

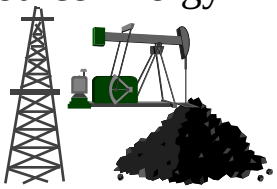
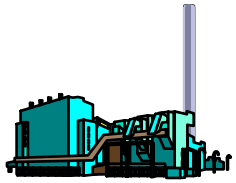
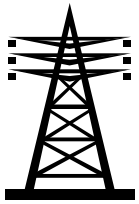
How Natural Gas Can Help

Table 1 **Source-Site Ratios for all Portfolio Manager Fuels**	
Fuel Type	**Source-Site Ratio**
Electricity	3.340
Natural Gas	1.047
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.01
Propane & Liquid Propane	1.01
Steam	1.45
Hot Water	1.35
Chilled Water	1.05
Wood	1.0
Coal/Coke	1.0
Other	1.0

How Natural Gas Can Help

- More raw energy is required to produce one unit of site energy in the form of electricity than any other type of fuel. This means that all other fuels evaluated have an energy efficiency advantage over electricity at the site, assuming equivalent efficiency characteristics of the end use. It also means that energy efficiency is improved every time one of these other sources is substituted for electricity at the site of usage, again assuming equivalent efficiency characteristics of the end use.
- When natural gas, for example, is substituted for electricity at the site of usage, it enjoys a three times energy efficiency advantage over electricity. Although not the only argument favoring natural gas for electricity fuel switching, this is certainly a powerful one.

How Natural Gas Can Help

	Extraction, Processing, & Transportation	Conversion[1]	Distribution	Delivered To Customer	
Electricity	100 MMBtu Source Energy	88	29	27	
27% Efficient					
CO_2 emissions from typical household use* (tons)	1.5	9.3	0	0	**10.8**

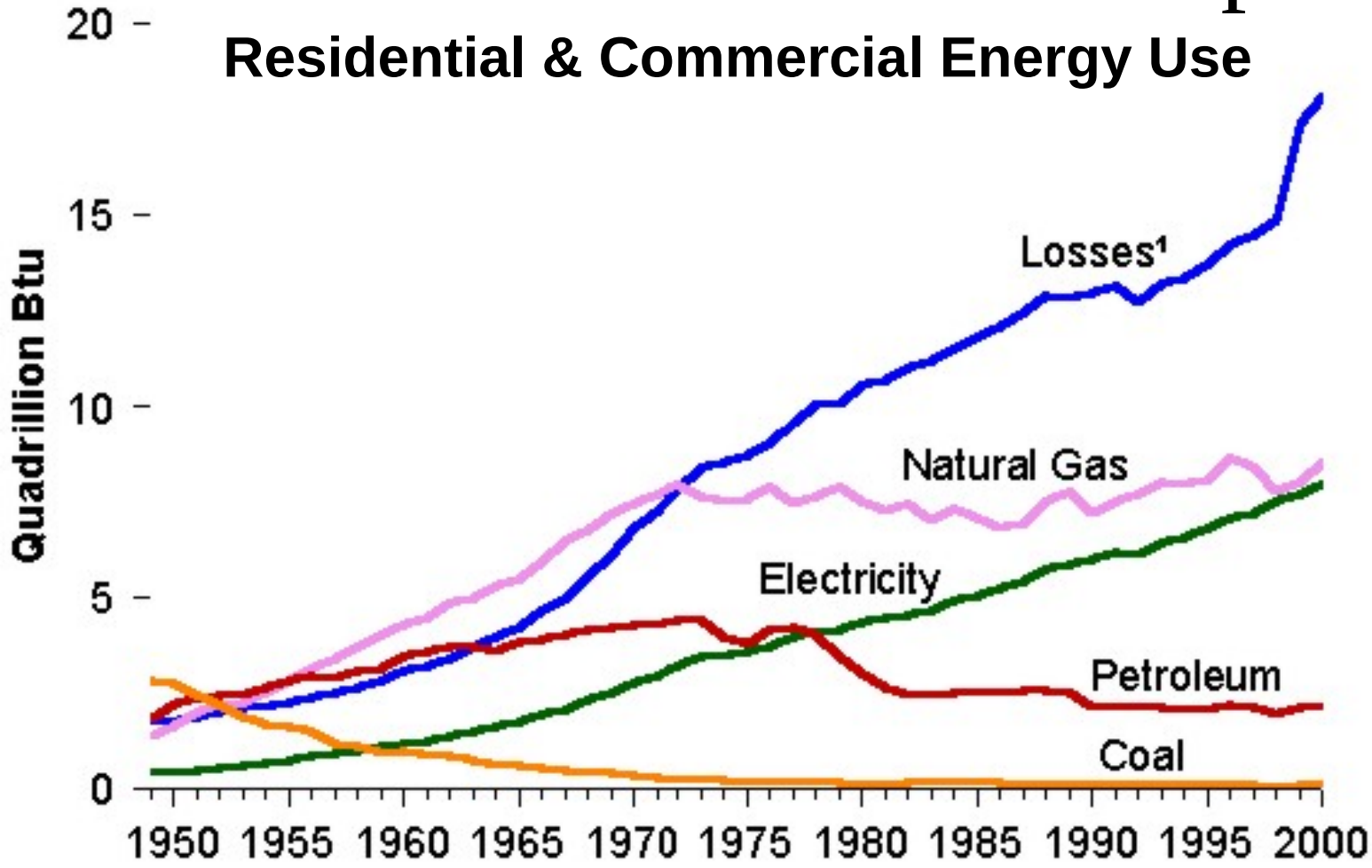
1. Based on 2005 actual generation mix of all energy sources

Natural Gas	100 MMBTU Source Energy	Not Applicable	92	90	
90% Efficient					
CO_2 emissions from typical household use* (tons)	0.6		0.1	6.5	**7.2**

How Natural Gas Can Help

- Electric power generation, T&D are major source of energy losses.
- **Losses alone** now greater than point of use consumption of natural gas AND electricity in res/comm sector.
- Major opportunity energy savings, energy cost savings, carbon reduction, and a host of other societal benefits.

How Natural Gas Can Help



Source: DOE/EIA

(1) Energy lost during generation, transmission, and distribution of electricity

How Natural Gas Can Help

- Converting electric end uses to natural gas can provide significant improvements in energy efficiency.
  - This energy efficiency advantage of natural gas-based homes stems from the fact that only about ten percent of the gas energy produced is used or lost from the point of production to the residence. In contrast, approximately 73 percent of the fossil fuel energy produced to satisfy the electricity needs of consumers is used or lost in the process of energy production, conversion, transmission and distribution. Source: American Gas Association, Energy Efficiency, Economic and Environmental Comparison of Natural Gas, Electric, and Oil Services in Residences, May 26, 1999.

How Natural Gas Can Help

Typical Site-Use and Total Energy Requirements for New Homes (MMBtu per year)			
	Gas	**Electricity**	**Oil**
1,500 Square Feet			
Heating [1]	41.0	14.8	45.2
Other	22.4	15.3	20.2
Total Site Use	**63.4**	**30.9**	**65.4**
Energy Losses [2]	6.3	84.7	24.1
TOTAL ENERGY [3]	**69.7**	**115.6**	**89.5**
3,000 Square Feet			
Heating [1]	68.0	24.9	75.1
Other	22.4	15.3	20.2
Total Site Use	**90.4**	**40.2**	**95.5**
Energy Losses [2]	8.9	110.3	28.8
TOTAL ENERGY [3]	**99.3**	**150.5**	**124.3**
[1] Includes end-use energy requirements for water heating, cooking, and clothes drying.			
[2] Includes energy used or last in extraction, processing, conversion, transportation and distribution of energy.			
[3] Sum of Site Use and Energy Losses.			

How Natural Gas Can Help

Space Heating

DOE site-specific energy ratings are misleading. *While DOE rates an electric appliance with a more efficient energy rating than a similar gas appliance, in reality that electric appliance consumes more source energy, pollutes more, and costs the consumer more to operate.*

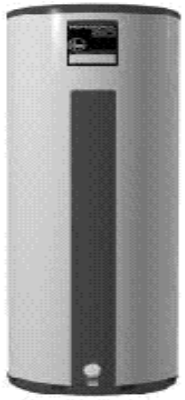
	Electric Heat Pump	Electric Resistance Furnace	Natural Gas Furnace
			
DOE NAECA Efficiency Rating:	**7.7 HSPF**	**99 AFUE**	**80 AFUE**
Source Energy Consumption (MMBtu/yr):	**96.6**	**229.1**	**85.2**
Energy Cost[1]/year	**$814**	**$1,930**	**$924**
CO_2 Emissions (tons/unit/yr)[2]:	**5.9**	**12.1**	**5.0**
2006 Shipments (Sales)	**1,330,000[3]**	**800,000[3]**	**3,197,000[4]**

[1]Energy Cost is based on 2007 DOE representative average unit costs for energy where electric rate is 10.65 cents/kWh; gas rate is $12.18/MMBtu
[2]Emission estimates are based on DOE's electric power emission estimates for all generation energy sources from Electric Power Annual, 2005 data
[3]Estimated
[4]Based on data from GAMA - *Consumers Continued to Choose Efficient Heating Equipment in 2006,* February 2007
HSPF=Heating Seasonal Performance Factor, AFUE=Annual Fuel Utilization Efficiency

How Natural Gas Can Help

Water Heating

DOE site-specific energy ratings are misleading.
While DOE rates an electric appliance with a more efficient energy rating than a similar gas appliance, in reality that electric appliance consumes more source energy, pollutes more, and costs the consumer more to operate.

	Electric Resistance	Natural Gas
		
DOE NAECA Efficiency Rating [1]:	**.90 EF**	**.59 EF**
Source Energy Consumption (MMBtu/yr):	**61.4**	**28.2**
Energy Cost[2]/yr :	**$517**	**$309**
CO_2 Emissions (tons/unit/yr)[3]:	**3.8**	**1.7**
2006 Shipments (Sales) [4]:	**4,792,000**	**4,654,000**
Equipment Cost	**$340**	**$415**

[1]Energy factors based on a 40-50 gallon storage water heaters
[2]Energy Cost is based on 2007 DOE representative average unit costs for energy where electric rate is 10.65 cents/kWh; gas rate is $12.18/MMBtu
[3]Emission estimates are based on DOE's electric power emission estimates for all generation energy sources from Electric Power Annual 2005 data
[4]Gas Appliance Manufacturers Association
EF=Energy Factor

How Natural Gas Can Help Clothes Drying

DOE site-specific energy ratings are misleading. *While DOE rates an electric appliance with a more efficient energy rating than a similar gas appliance, in reality that electric appliance consumes more source energy, pollutes more, and costs the consumer more to operate.*

	Electric	Natural Gas
		
DOE NAECA Efficiency Rating:	**3.01 EF**	**2.67 EF**
Source Energy Consumption (MMBtu/yr):	**12.2**	**4.6**
Energy Cost[1]/yr:	**$95**	**$56**
CO_2 Emissions (tons/unit/yr)[2]:	**0.7**	**0.3**
2006 Shipments (Sales)[3]:	**6,360,000**	**1,614,000**

[1]Energy Cost is based on 2007 DOE representative average unit costs for energy where electric rate is 10.65 cents/kWh; gas rate is $12.18/MMBtu
[2]Emission estimates are based on DOE's electric power emission estimates for all generation energy sources from Electric Power Annual, 2005 data
[3]Appliance Magazine
EF = Energy Factor

How Natural Gas Can Help Cooking Equipment

DOE site-specific energy ratings are misleading. *While DOE rates an electric appliance with a more efficient energy rating than a similar gas appliance, in reality that electric appliance consumes more source energy, pollutes more, and costs the consumer more to operate.*

	Electric	Natural Gas
Energy Factor	**10.9 EF**	**5.8 EF**
Source Energy Consumption (MMBtu/yr):	**6.7**	**4.0**
Energy Cost[1]/yr:	**$56**	**$42**
CO_2 Emissions (tons/unit/yr)[2]:	**0.4**	**0.2**
2006 Shipments (Sales)[3]:	**6,228,000**	**3,726,000**

[1]Energy Cost is based on 2007 DOE representative average unit costs for energy where electric rate is 10.65 cents/kWh; gas rate is $12.18/MMBtu
[2]Emission estimates are based on DOE's electric power emission estimates for all generation energy sources from Electric Power Annual, 2005 data
[3]Appliance Magazine

How Natural Gas Can Help

- Converting electric end uses to natural gas can provide significant emissions reductions.
  - "Optimizing *how* the U.S. uses energy has the potential to reduce carbon dioxide (CO_2) emissions by 375-565 million metric tons/yr." This strategy would bring the "net CO_2 levels for natural gas end-use and the natural gas industry to 15% lower than the 1990 levels, well beyond the Kyoto Accord goals (5% lower than 1990 levels)." Source: Gas Technology Institute, A Lower-Cost Option for Substantial for Substantial Carbon Dioxide Emission Reductions in the U.S., January 2008, page 1.

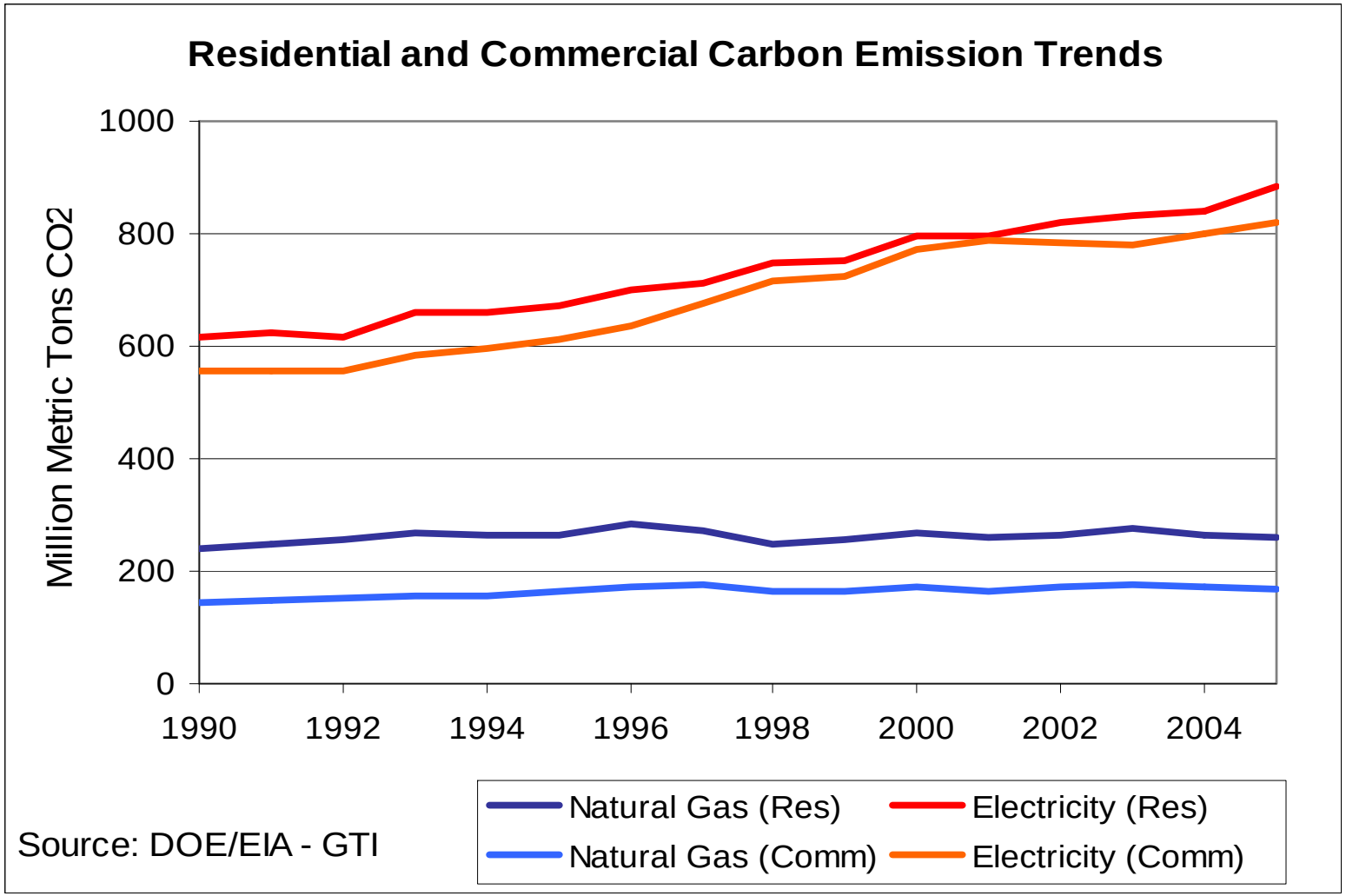
How Natural Gas Can Help

Energy End-Use Sector Sources of U.S. Carbon Dioxide Emissions, 1990-2005

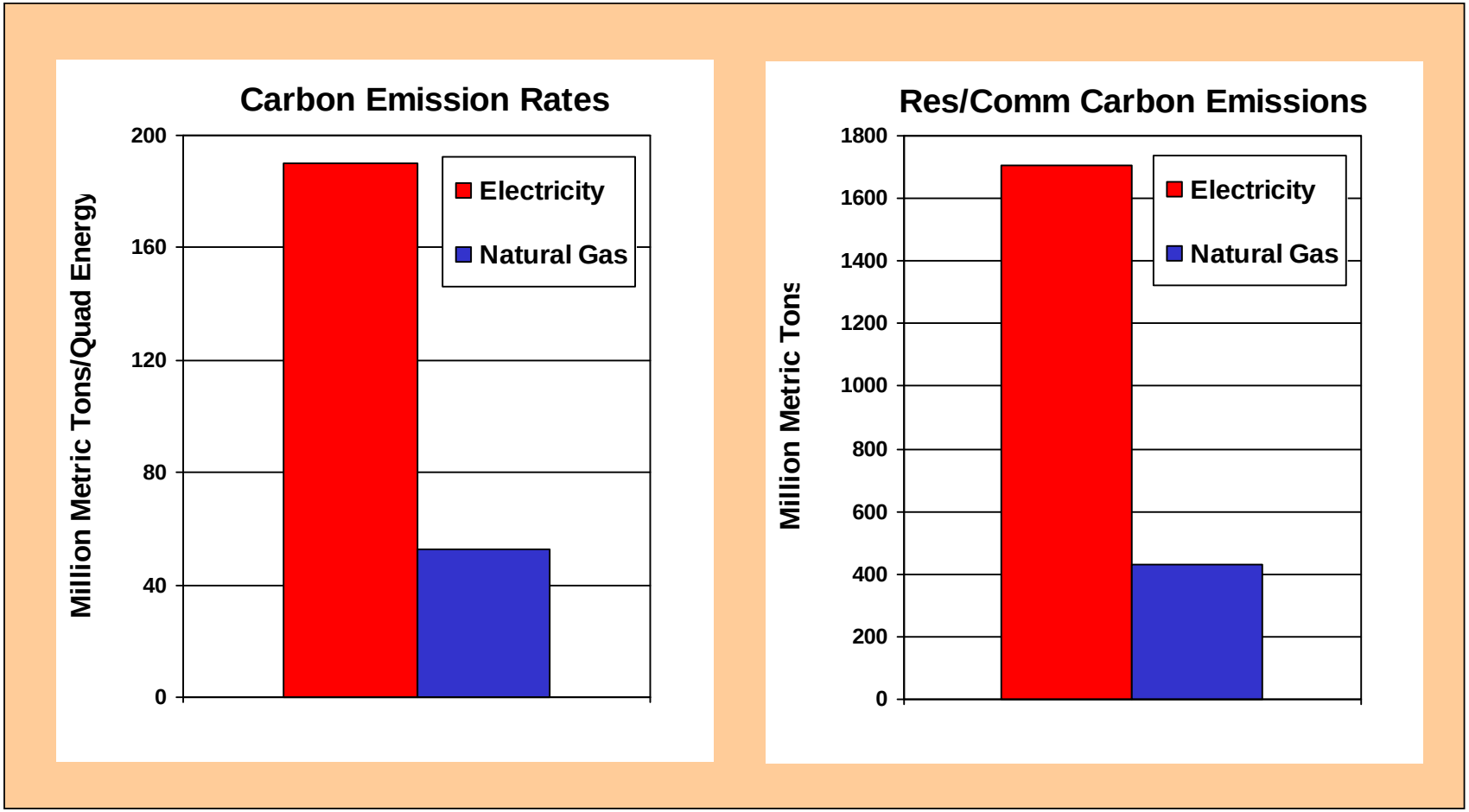
Sector	Million Metric Tons Carbon Dioxide 1990	2005	*Percent Change* 1990-2005	2004-2005
Residential	953.7	1,253.8	*31.5%*	*3.3%*
Commercial	780.7	1,050.6	*34.6%*	*1.6%*
Industrial	1,683.6	1,682.3	*-0.1%*	*-3.1%*
Transportation	1,566.8	1,958.6	*25.0%*	*1.0%*

Note: Electric power sector emissions are distributed across sectors.

How Natural Gas Can Help



How Natural Gas Can Help



Composite data for residential and commercial sectors compiled by GTI from DOE EIA AEO 2007 (2005 data)

How Natural Gas Can Help

Total Energy Efficiency Carbon Dioxide Emissions for New Homes[1] (lbs of CO_2 per Average Household Energy Use[2])		
	1,500 SQ. FT.	**3,000 SQ. FT.**
Natural Gas	**7,423**	**10,583**
Oil	**13,095**	**15,198**
Electricity[3]:		
Coal-Based	17,560	22,828
Oil-Based	582	757
Natural Gas-Based	1,561	2,029
Total Electricity	**19,703**	**25,614**
[1] Based on hypothetical fuel generating mix.		
[2] Excludes energy use for cooling and base electric requirements.		
[3] For existing generating capacity only.		

How Natural Gas Can Help

COMPARISON OF ELECTRICITY VERSUS NATURAL GAS ENERGY EFFICIENCY AND POLLUTION BENEFITS

	Electric Water Heater	Natural Gas Water Heating	Natural Gas Water Heating Advantage
Average Annual Site Usage (kWh/therms)	4,811 (4)	250 (3)	-
Source Energy Used (Btu)	58,226,748	27,322,404	30,904,344
CO_2 Emissions (lbs)	6,216	2,925	3,291
NOX Emissions (lbs)	12.46	2.30	10.16
SO_2 Emissions (lbs)	40.85	0.03	40.82
CO_2 Emissions (lbs/MWh; lbs/therm) (1)	1292.03	11.7	
NOX Emissions (lbs/MWh; lbs/therm) (1)	2.59	0.0092	
SO_2 Emissions (lbs/MWh; lbs/therm) (1)	8.49	0.0001	
Source-to-Site Efficiency (2)	28.20%	91.50%	
Btus per kWh	3,413		
Btus per therm		100,000	

Notes:
(1) Source: Baltmore Gas & Electric
(2) Source: American Gas Association
(3) Source: Washington Gas
(4) Source: Pepco

How Natural Gas Can Help

- Fuel Switching Programs can reduce rates for both electric and natural gas customers, something that single fuel incentive programs are unlikely to do.
- The RIM test for the utility sponsoring the program measures potential rate increases by determining whether:

UAC > RL + PRC + INC

where:

UAC	equals the life cycle avoided costs over the life of the DSM measure
RL	equals the life cycle revenue losses over the life of the DSM measure
PRC	equals the life cycle program costs over the life of the DSM measure
INC	equals the life cycle incentive costs over the life of the DSM measure.

- Since the marginal cost of electricity is generally greater than the average embedded cost, load decreases on the electric system generally translate into rate reductions.

How Natural Gas Can Help

- The RIM test for the alternate fuel utility measures potential rate increases by determining whether:

$$UACa > RLa$$

where:

UACa equals the life cycle natural gas avoided costs over the life of the DSM measure

RLa equals the life cycle natural gas revenue losses over the life of the DSM measure.

- Since the marginal cost of delivered natural gas is generally less than the average embedded cost, load increases on the natural gas system generally translate into rate reductions.

How Natural Gas Can Help

- Fuel Switching programs can and have been implemented in many jurisdictions.
  - A 2007 survey of LDC natural gas energy efficiency programs published in January 2008 reports that "[s]even (7) of the regulator-approved natural gas [energy efficiency] programs in the survey encourage fuel switching, by, for instance, providing financial incentives (e.g., rebates, low-interest loans, reduced costs, construction allowances) for replacing, switching to, or installing new gas water heaters, boilers, furnaces, and cooling equipment to residential and commercial customers." Source: American Gas Association, LDC Natural Gas Energy Efficiency Programs Report 2007, January 2008.
  - Programs have been approved in Florida, Missouri, New Jersey and Wisconsin.
  - The Large Commercial and Industrial Standard Offer Program proposed by Public Service Company of Oklahoma (PSO) for implementation in Oklahoma provides incentives for "any measure that produces savings through…a substitution of another energy source for electricity supplied through the transmission grid." Source: Cause No. PUD200700449, Direct Testimony of Billy G. Berny on Behalf of Public Service Company of Oklahoma, December 10, 2007.

Unintended Consequences of Incentives

- Simple economics dictates that incentives paid to encourage the purchase of higher efficiency appliances of a particular fuel type must lower the life cycle costs of appliances of that fuel type and will impact the fuel selection decision.
- This occurs as a result of the simple economics of life cycle costs:

$$LC_i = CC_i + OC_{i,1}/(1+r)^0 + \ldots + OC_{i,n}/(1+r)^{(n-1)}$$

Unintended Consequences of Incentives

Rationale for DSM Incentive Payments			
	Standard Efficiency Appliance	High Efficiency Appliance	High Efficiency Appliance With Rebate
Up-Front Cost	$ 1,000	$ 1,500	$ 1,250
Annual Operating Costs	$ 500	$ 450	$ 450
Appliance Lifetime (Years)	15	15	15
Discount Rate	10%	10%	10%
Life-Cycle Cost	$ 5,183	$ 5,265	$ 5,015

Unintended Consequences of Incentives

Impact of DSM Incentive Payments on the Fuel Selection Decision			
	High Efficiency Electrical Appliance	High Efficiency Electrical Appliance With Rebate	Gas Appliance
Up-Front Cost	$ 1,500	$ 1,250	$ 2,500
Annual Operating Costs	$ 450	$ 450	$ 320
Appliance Lifetime (Years)	15	15	15
Discount Rate	10%	10%	10%
Life-Cycle Cost	$ 5,265	$ 5,015	$ 5,177

Unintended Consequences of Incentives

- Even programs that are touted as "fuel-neutral," such as the Energy Star® program, will likely have fuel selection consequences:

  "[I]t is often cheaper to build a house meeting the electric-heating criteria for Energy Star than for the gas heating criteria." Alan Meier, The Future Of Energy Star And Other Voluntary Energy Efficiency Programs, Proceedings of the ECEEE 2003 Summer Study – Time to Turn Down Energy Demand, 2003, page 677.

Unintended Consequences of Incentives

Likely Electricity Savings Impact			
Action Stimulated	Savings	Likelihood	Expected Savings
A/C to efficient A/C	10%	25%	2.5%
A/C to efficient H/P	<50%>	25%	<12.5%>
H/P to efficient H/P	10%	50%	5.0%
Total Impact			<5.0%>

Unintended Consequences of Incentives

- Even programs that are touted as "fuel-neutral," such as the Energy Star® program, will likely have fuel selection consequences:
  - The criteria for an Energy Star home cover less than half of the home's total energy use, with the remainder caused by appliances. Because of the areas ignored, an Energy Star house could be easily outfitted with average efficiency appliances, resulting in a high overall energy use.
  - Most of the Energy Star performance specifications are expressed in terms of an efficiency, that is, a unit of service per unit of energy expended. The constant efficiency approach is biased towards larger products. It is typically easier to meet the efficiency criteria with a larger product than a small product because there are various economies of scale. The impact of this bias is most evident for energy targets for new homes. It is relatively cheaper to build a very large Energy Star home than a small one, even though the greenhouse gas emissions from the larger home will be greater than those from a small, inefficient house.

Unintended Consequences of Incentives

- Incentives that are provided by electric utilities to entities that do not have natural gas service currently or potentially available to them for the purpose of encouraging the installation of “efficient heating and cooling appliances” have the great potential to increase electricity at the expense of natural gas and to increase overall energy usage.
- Any natural gas to electricity fuel switching that occurs as a result of energy efficiency programs is likely to result in the increased consumption of electricity, in direct conflict with implementation of Act 129.

Unintended Consequences of Incentives

- Any program that influences the fuel selection decision should be accompanied by a requirement that the offering entity maintain and report on a real-time basis, those situations in which a fuel switch has taken place.
- Require that programs be evaluated using the cost-effectiveness tests that are developed and explained in the California Standard Practice Manual, considering source-to-site energy efficiency and including the impact on alternate fuel suppliers.

Recommended Policies

- Conservation and energy efficiency programs for application in competitive markets should be analyzed on a multi-fuel and comprehensive basis, looking at all reasonably available competing energy products and services and taking into consideration all likely impacts of the proposed programs (including impacts on load growth).

Recommended Policies

- Conservation and energy efficiency programs should be analyzed on a full fuel cycle (source-to-site plus appliance efficiency) basis.
- Conservation and energy efficiency programs and utility rates should be constructed in a manner designed to create incentives for consumers to use energy wisely and remove disincentives for utilities to promote energy efficiency.

Recommended Policies

- Conservation and energy efficiency programs should promote the use, among feasible alternatives, of the most efficient and lowest emitting energy sources in particular applications.

Recommended Policies

- Any electric-only DSM proposal should be required to demonstrate that any programs submitted for Commission approval will be implemented in a fuel-neutral manner, should monitor for fuel switching caused by the programs or, if these programs do result in fuel-switching, that fuel-switching serves the overall public interest.

Recommended Policies

- The cost-effectiveness evaluation of proposed programs should be performed using the cost-effectiveness tests that are developed and explained in the California Standard Practice Manual. These tests recognize explicitly that the promotion of any DSM program could have a significant impact on alternate fuel suppliers.

Recommended Policies

- Electric programs should be approved only after it has been demonstrated that the offering entity has considered and evaluated all potential programs, including perhaps the most important resource for reducing electricity consumption and CO_2 emissions, while simultaneously improving the efficiency with which energy in consumed: encouraging the usage of natural gas where it is a viable substitute for electricity and converting loads currently served by electricity to natural gas.