Alternatives for the Residential Energy Consumption Baseline

Executive Summary. Should the baseline for energy consumption in the Northeast Neighborhoods development area be changed from the current citywide average to one that reflects more recent construction?

There is not an existing analysis that compares the energy consumption of newly constructed homes to a citywide or other average. However, based on available evidence there is likely a difference in energy consumption of old versus new homes. To provide a more relevant comparison, it is recommended that the baseline be changed to reflect recent construction.

Staff's recommended language for Goal #2 is: "Reducing household consumption of natural gas and fossil fuel-generated electricity by 25% compared to a baseline reflecting recent residential construction, which will be established and included in the Northeast Neighborhoods Development Plan."

This baseline could be drawn from service records of Madison residents for natural gas and electricity. Prior to publication of the Northeast Neighborhoods plan, every effort will be made to calculate a baseline using service data from local utilities. To account for seasonal variance, the average will be taken over three years and will be normalized for extreme winter and summer weather conditions.

A goal to reduce natural gas and fossil fuel-generated electricity consumption by 25% is an aggressive, but attainable, goal. It will require enhanced construction and energy efficiency, but alternative energy technologies and consumer behavior are also critical elements

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The Issue. A resolution under Legistar #12771 identifies four sustainability goals that will guide the development of the Northeast Neighborhoods plan. Goal #2 relates to reduced household consumption of natural gas and fossil fuel-generated electricity in the development area. The current version of the resolution compares future household energy consumption for this area to current city-wide household levels. More simply put, how will it compare to the current citywide average?

The question has been asked: Because the citywide average includes so many older homes, is using a baseline that includes so many less energy efficient buildings setting the goal too low? Will the goal be attained simply by what we are already building and doing?

Energy Efficiency vs. Energy Consumption. Several observations can be made about energy efficiency and energy consumption. Because we are concerned about the overall environmental impact of this area, energy consumption is an important macro-scale concept that must be kept separate and distinct from the often micro-scale concept of energy efficiency.

Energy Efficiency. In a general sense, "energy efficiency" is a feature built into something that is bought or used. It can be considered a tool for potentially lowering energy consumption.

As it relates to the physical structure of a home, efficiency refers to the energy needed to heat and cool the home and run all of the things inside it on a per square foot or item basis. A big part of this measurement is the ability of the home to retain heat in the winter and keep cool in the summer.

The energy efficiency of individual appliances (especially furnaces and air conditioning units) plays a role in this measurement. However, there are too many other factors (especially the choices and behavior of the occupants) that can cause a highly efficient home to use more energy than one that is not. Accordingly, a home's energy efficiency is only one way to help reduce overall energy consumption.

Energy Consumption. While related to efficiency, "energy consumption" relates to the way a home and all the things in it are used and the subsequent energy that is consumed. Because it is heavily influenced by the way a tool is used, consumption is largely driven by behavior. From the MGE website, "Energy use… will vary depending on a number of factors, including lifestyle, the type, age and condition of appliances and equipment used, weather (wind, amount of sunshine, etc.), number of people living here and conservation measures."

The current average single-family home in the MGE service area consumes about 875 therms of natural gas and about 8,700 kWh of electricity. Multifamily units use slightly less on average, but that figure is not available at this time.

Historic and Recent Trends. We do not currently have an estimate for household energy consumption for recent construction or houses built to a specific code. However, several conclusions can be drawn from what we know about improvements in energy efficiency and changes in energy consumption.

Energy Efficiency – Natural Gas. Newer homes are better insulated, and the citywide average includes a large number of older homes. According to Focus on Energy, 46% of houses statewide were built in the 1960's or earlier and were built with little or no insulation. According to Building Inspection staff, about 80% of Madison's housing stock was built before 1978 when the first Uniform Dwelling Code was adopted in reaction to the energy crises of the 1970's.

Since 1970, gains were made in home insulation, the efficiencies of furnaces, and programmable thermostats. Furnace efficiency was a two-part equation of natural gas systems replacing less efficient electric units and improvements in fuel efficiency of gas units themselves.

According to Building Inspection staff, since 1978 the insulating quality of ceilings and walls have increased 63% and 185% respectively.[1] Natural gas furnaces are now 92% efficient compared to 85% in 1999 and 78% in 1978. The same size home built to the 1999 state Uniform Dwelling Code would use 25% more energy to heat when compared to a home built after April 1, 2009 when the new 2008 Uniform Dwelling Code goes into effect for single- and two-family homes. The same home built to the 1978 code would use 161% more energy to heat.

According to Focus on Energy, a newly built Wisconsin EnergyStar Home is 25 percent more efficient than homes built to the Uniform Dwelling Code. This relates to the energy efficiency of the structure itself – its air tightness, overall thermal usage, and ventilation. It relates only to the efficiency of the shell of the building and does not necessarily mean that the house and its occupants are guaranteed to consume 25% less energy.

Efficiency is often calculated on a per square foot basis, but homes have gotten bigger. A recent issue of *The Economist* states that in 1980 the average American home was 1,570 square feet. By 2005, it had expanded to 2,235 square feet for an increase of as much as 42%. In 2000, the Energy Center of Wisconsin published *Energy and Housing in Wisconsin: A Study of Single-Family Owner-Occupied Homes*. The study included a random sample of 299 single-family homes in Wisconsin. About 70% of the homes in the state are single-family. One of its key findings is that new homes use 23% less heating energy per square foot than homes built prior to 1978, but they are also 22% larger. This suggests that efficiency gains can be eroded by consumer choices.

There are still efficiency improvements to be made, particularly for older homes. Based on numbers in *2008 Wisconsin Energy Statistics* published annually by the Wisconsin Office of Energy Independence, as little as 10% of Wisconsin's housing has benefited from state and utility funded weatherization programs. According to *Energy and Housing in Wisconsin*, a quarter of Wisconsin homes are excessively leaky, 15% have un-insulated walls and 20% have under-insulated ceilings. These are primarily older homes, and construction since 1980 has substantially lower natural gas consumption.

[1] Ceiling and wall efficiency change calculation:
12/1/1978; Uniform Dwelling Code required an assembly conductance of less than U 0.033 for ceilings and U 0.15 for walls.
2/1/1999; Uniform Dwelling Code required an assembly conductance of less than U 0.026 for ceilings and U 0.11 for walls.
4/1/2009; Uniform Dwelling Code will prescribe R49 ceiling and R19 insulation in exposed exterior walls.

Energy Consumption – Natural Gas. The first attachment is a page from *2008 Wisconsin Energy Statistics*. It indicates that statewide since 1970, the average residential consumption of natural gas has decreased 44%. This is largely the result of improved insulation and more efficient heating systems described above.

Energy and Housing in Wisconsin provides some evidence that new construction uses less heating energy than the overall average. Forty-four new homes consumed 6.8% less heating energy than the overall average. "New construction" was defined as being built in the last five years.

Energy Efficiency – Electricity. There have been great improvements in electrical efficiency since 1970. The popularity of compact fluorescent bulbs, motion sensors, and energy efficient appliances and electronics are recent examples.

However, electricity consumption is largely driven by consumer choices and the behavior of the users. More recent construction has a higher "plug load", which means that more appliances and electronics are typically used in newer homes. For example, homes have gone beyond basic lighting and appliances like stoves and clothes dryers and now include computers, microwaves and flat screen televisions. While the individual appliances and electronics acquired today may be energy efficient, their increased number and use has resulted in higher overall electricity consumption.

Energy Consumption – Electricity. The first attachment is a page from *2008 Wisconsin Energy Statistics*. It indicates that statewide since 1970, the average residential consumption of electricity has increased 29%. It is clear that electrical efficiency has not kept pace with acquisition and usage.

According to *Energy and Housing in Wisconsin*, forty-four new homes consumed 3.1% less electricity than the overall average.

The 25% Reduction Goal. The second and third attachments compare historic consumption of natural gas and electricity to the proposed 25% reduction goal. It illustrates that a 25% reduction is a significant amount.

Efficient construction is not the only source of energy savings. Efficient construction aids in reducing consumption of natural gas, but has less of an impact on consumption of electricity. Some could also argue that recent substantial gains in heating efficiency and insulation may be met with diminishing returns in the near future. For these reasons, strategies should include improved construction but also education and outreach, district heating, alternative non-fossil fuel energy sources, and so on.

Given the size of the development area a mix of land uses, housing types and incomes is not only desirable, but also required. Typically, affordable older construction lacks sufficient insulation

and/or air tightness, which will result in higher heating bills. Current code requires better insulation, so energy bills for newly built affordable units in this area will have the added benefit of lower energy bills. Further, construction is not the only way to reduce energy consumption. Again, a multi-tiered approach is needed to reduce energy consumption in the Northeast Neighborhoods area.

Natural Gas. As shown in the attachments, overall per unit residential consumption of natural gas has been declining. From 1980 to 2007, statewide residential natural gas consumption declined 38%. From 1990 to 2007, it declined 20%. From 2000 to 2007, it declined 13%.

Given a likely diminishing return on improvements in insulation and heating efficiency, the goal of a 25% reduction is significant. Energy efficient construction is needed, but so are education and outreach efforts, personal behavior, alternative non-fossil fuel sources and other applications.

Electricity. As shown in the attachments, overall per unit residential consumption of electricity has been increasing. From 1970 to 2007, statewide residential electrical consumption increased 29%. From 1980 to 2007, it increased 12%. From 1990 to 2007, it increased 7%. From 2000 to 2007, it increased 1%. Given increasing trends, the goal of a 25% reduction is significant and represents a return to pre-1970 consumption levels. Again, the need for a multi-tiered approach is apparent.

Limited Data. There is an interest in comparing the energy consumption of future construction in the Northeast Neighborhoods area to recent construction or construction to a certain code. However, to date there has not been an existing data source or study identified that illustrates the difference in energy consumption for new construction versus overall construction.

Several organizations have been contacted on the subject including MGE, Wisconsin Energy Conservation Corporation, Focus on Energy, Midwest Energy Efficiency Alliance, Energy Center of Wisconsin, Wisconsin Office of Energy Independence, and American Council for an Energy-Efficient Economy. All could offer at least some perspective on the subject, particularly for energy efficiency. However, none could provide a specific number or estimate or refer us to an existing study that explored this issue for Madison, the state or any other area.

The MGE website provides some data regarding residential energy consumption by address. With the "Average Energy Use and Cost" query function, the energy use of any address in the MGE service area can be obtained. For our purposes it is limited in two ways. The volume of properties needed to establish a reliable baseline would be cumbersome to enter. More importantly, the query provides only one year of data and accessing multiple years would help account for seasonal variance.

Two years of data are available using the MGE "Compare My Energy Use" query function. However, the information provided is limited to the address of the registrant and cannot be used to access information on other addresses. The "Calculate My Home Heating Rating" function

compares the property's efficiency to others by date of construction, but not enough information is provided to calculate actual or estimated figures for natural gas consumption.

Because this analysis has not been done before, the City and MGE are exploring the sharing of service records so such a number can be calculated. Ideally, citywide records from MGE would be made available by address and by meter with three years of consumption of both natural gas and electricity. Records from the Assessor's Office would be used to select only those properties considered "recent construction". Because about 10% of Madison residents are Alliant Energy customers, a similar effort would be made to obtain service records.

Alternative #1 – Current language: "Reducing household consumption of natural gas and fossil fuel-generated electricity by 25% compared to current city-wide household levels."

Pros:

- The baseline is readily available for the MGE service area.
- A large sample size helps improve accuracy of the estimate.

Cons: Enough evidence suggests that, because it includes so many older and less efficient homes, using a citywide baseline sets the goal too low.

Alternative #2 – Baseline reflecting current code: "Reducing household consumption of natural gas and fossil fuel-generated electricity by 25% compared to current building code standards."

Pros:

- Houses built to current code are more energy efficient than a majority of the housing stock in Madison. Using building code as the baseline accounts for better building practices that have developed over the last several decades.
- Builders and developers are familiar with the code and its requirements.
- It would provide a more direct comparison of what homes in the area would consume both with and without the goal in place.
- It would reflect the Wisconsin EnergyStar Home program, which is presented as being 25% more efficient than current code.

Cons:

- Code deals primarily with energy efficiency ratings of individual structures. In contrast, our main concern is for energy consumption.
- The baseline is not readily available and would have to be modeled based on several assumptions.
- Building a home to code is only a part of the equation that determines how much energy a home consumes. For example, a home built to code that is twice the size of one next door still consumes more energy. What is plugged in and how it is used matters more in overall electricity consumption than the energy efficiency of the building's shell.

- Uniform Dwelling Code addresses only single- and two-family homes. Because this area will include multi-family homes, they should be part of the baseline and their energy consumption should be considered.
- The year a home is built does not automatically indicate whether it is built to code. In fact, many builders exceed code to enhance energy savings and marketability. Building Inspection staff confirm that it is not uncommon to see submittals where computerized energy modeling sheets indicate the proposed building exceeds the current code by 10%.
- Electrical appliances and other amenities are largely ungoverned by a building code. Using a baseline based on current building code suggests the only, or at least primary, way to reduce energy consumption is through the construction of the building itself.
- Depending on how it is defined, "current code" can be a moving target and one that may be increasingly hard to exceed through construction alone. For example, the Uniform Dwelling Code going into effect in April 2009 has substantial increases in energy efficiency requirements. At least in the near term, these would be hard to exceed by 25%.

Alternative #3 – Baseline using recent construction: "Reducing household consumption of natural gas and fossil fuel-generated electricity by 25% compared to a baseline reflecting recent residential construction, which will be established and included in the Northeast Neighborhoods Development Plan."

"Recent construction" could be defined as homes built from January 1, 2000, through March 31, 2009. These dates reflect the 2002 Uniform Dwelling Code (effective since July 1, 2002), 2006 Uniform Dwelling Code (effective since March 1, 2008) and 2008 Uniform Dwelling Code (to be effective on April 1, 2009). It also includes some construction prior to the 2002 Uniform Dwelling Code.

Pros:

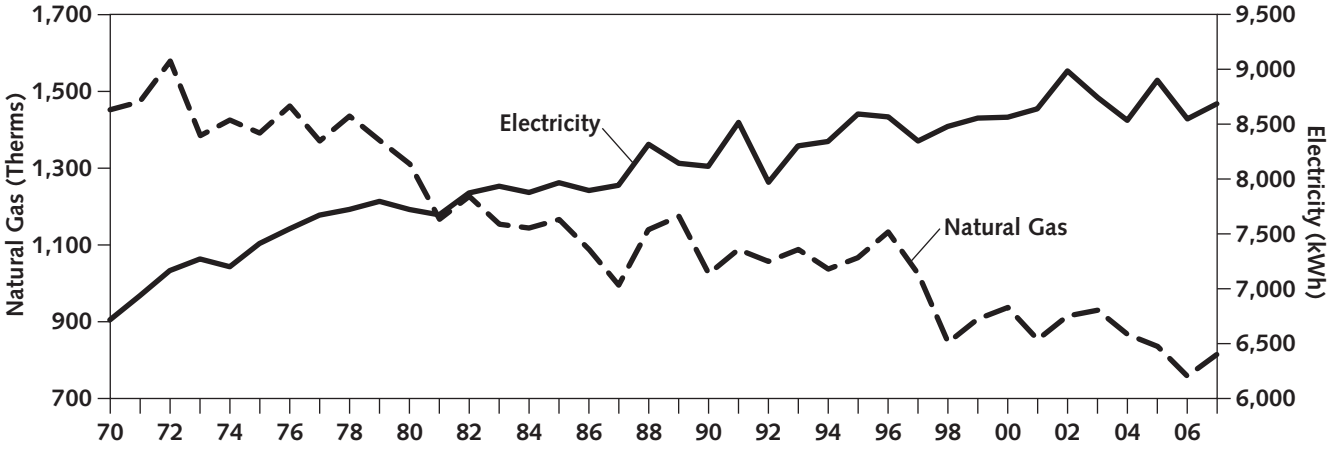
- Rather than making assumptions regarding building code and resulting energy consumption, actual energy consumption could be the foundation for a baseline. This would require fewer assumptions than estimating one based on code.
- Using the dates above would capture the energy use of over 16,300 units. The advantage of a large sample size is increased accuracy of the baseline.
- Using three editions of the code provides a mix of construction standards and practices that favors older codes and helps average out the potential of homes being built better than code. This happens frequently according to local builders and developers.
- Reflecting weather conditions, consumption fluctuates greatly from year to year. Even statewide, annual average natural gas consumption can fluctuate 9.0% or more; electricity can fluctuate 4.0% or more. This could be addressed using a three-year average and accounting for heating degree days (HDD) and cooling degree days (CDD).

Cons:

- The baseline is not readily available and would have to be calculated. It could, however, be a compilation of actual uses which would not be subject to the modeling required for a "built to code" baseline.
- Under previous codes, more recent construction was held to a higher standard and this time period reflects a few different code editions. However, knowing that construction frequently exceeds code, the long time period would likely average out to reflect a commonly held standard.

Wisconsin Residential Electricity and Natural Gas Use Per Customer, 1970-2007

Electricity use per customer increased 1.6 percent in 2007, while natural gas use increased 7.5 percent.



Year	Natural Gas[a]		Electricity[b]	
	Number of Customers (Thousands)	Use Per Customer (Therms)	Number of Customers (Thousands)	Use Per Customer (kWh)
1970	754.5	1,450	1,429	6,711
1975	857.9	1,389	1,607	7,407
1980	951.3	1,309	1,801	7,716
1985	1,010.8	1,164	1,870	7,960
1990	1,122.1	1,022	2,017	8,109
1995	1,291.4	1,065	2,170	8,586
2000	1,458.0	935	2,329	8,557
2001	1,484.5	851	2,365	8,634
2002	1,514.7	913	2,404	8,976
2003	1,541.5	928	2,445	8,736
2004	1,569.7	865	2,486	8,526
2005	1,592.6	834	2,526	8,890
2006	1,611.8	756	2,550	8,540
2007[p]	**1,626.6**	**813**	**2,560**	**8,680**

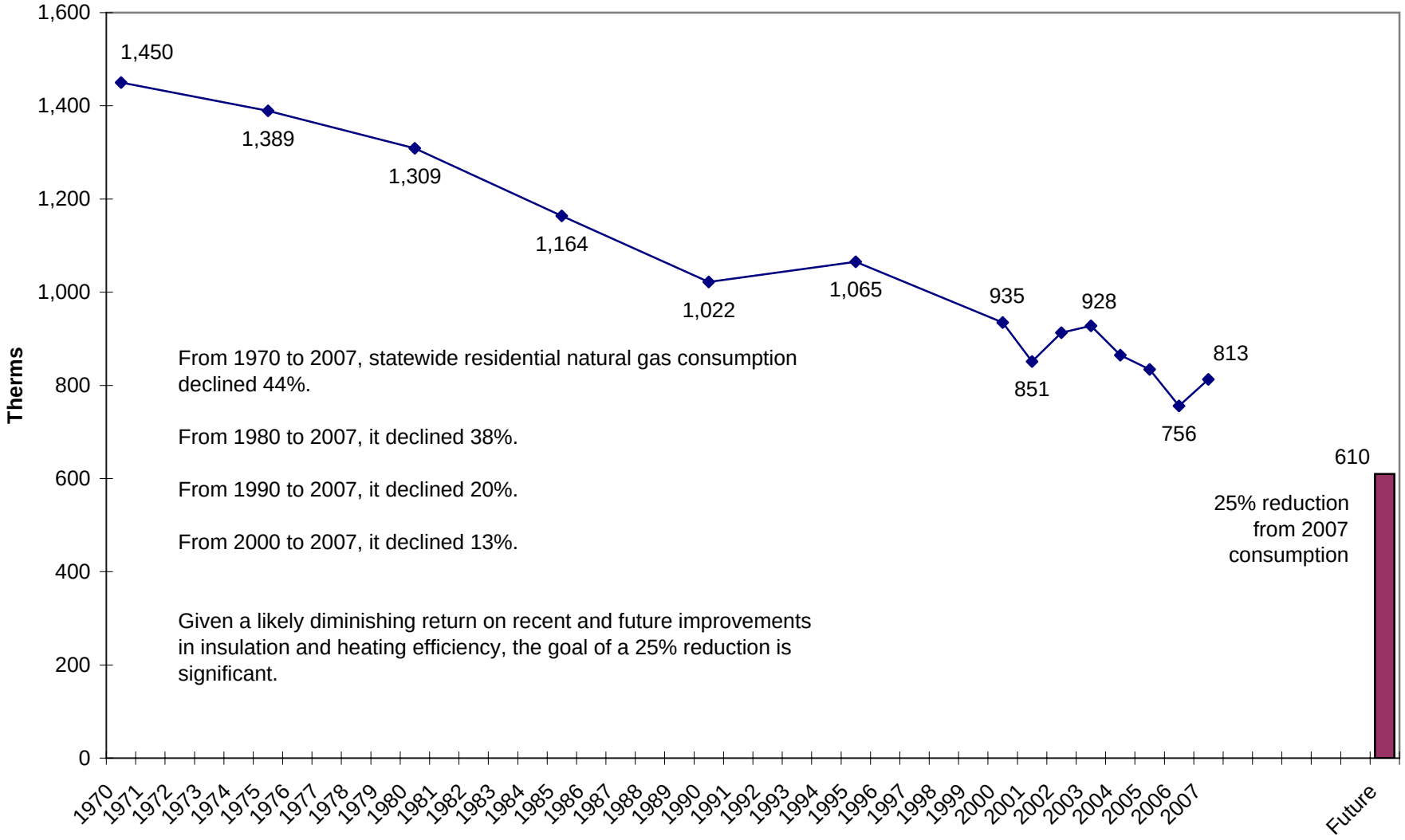
[a] U. S. Department of Energy data.

[b] Edison Electric Institute data.

[p] Preliminary estimates.

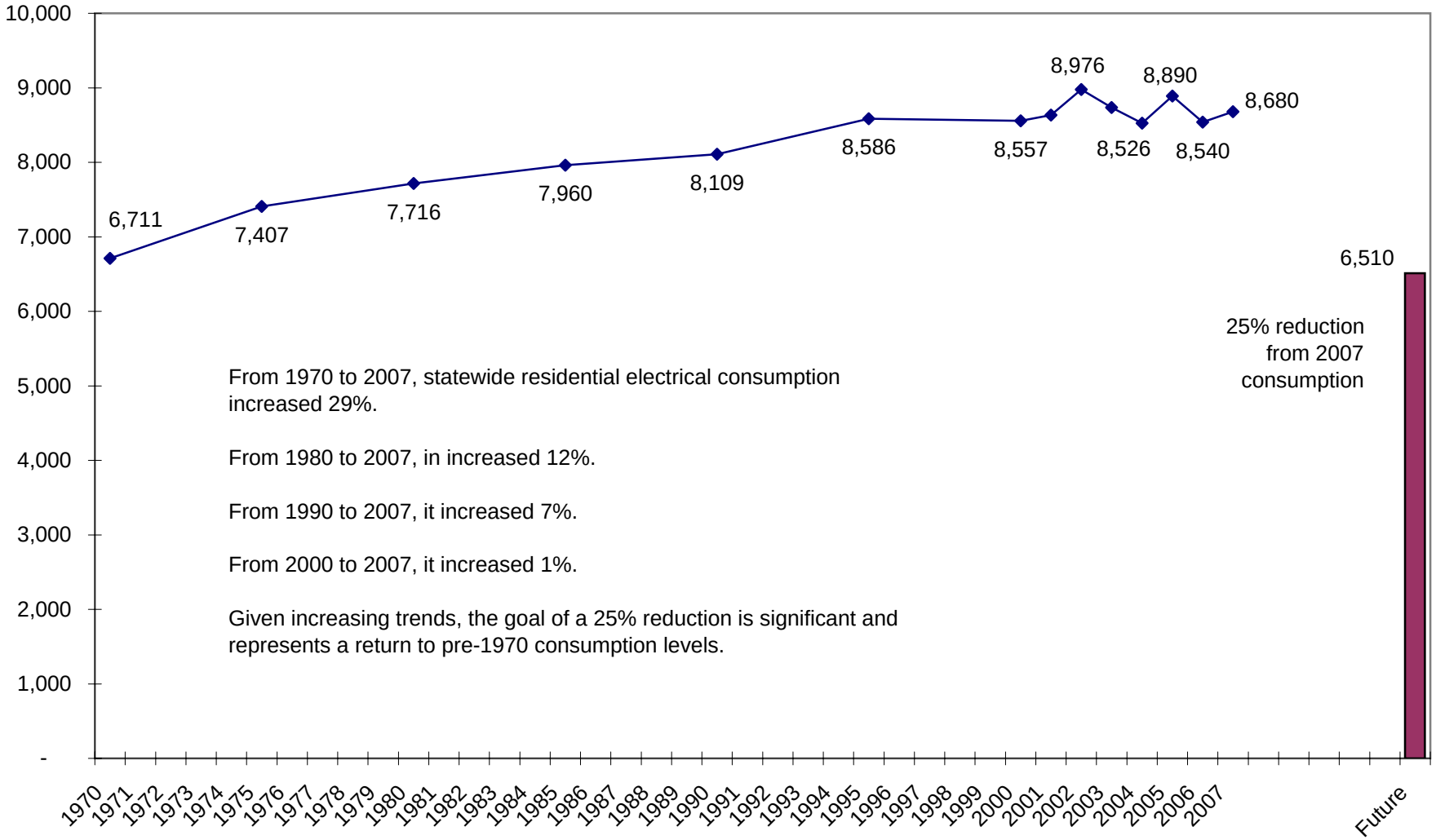
Source: Edison Electric Institute, *Statistical Yearbook* (1971-1996); American Gas Association, *Gas Facts* (1971-2000); U.S. Department of Energy, *Electric Sales and Revenues 1993-2000* [DOE/EIA-0540(2000)] (November 2001), *Natural Gas Annual, 1991-2006* [DOE/EIA-0131(06)] (October 2007) and *Natural Gas Monthly* [DOE/EIA-0130 (2008/06)] (June 2008).

Natural Gas Use per Customer
Historic averages and potential 25% reduction from current levels
Single- and Multi-family Units, Statewide



Wisconsin Residential Electicity and Natural Gas Use per Customer, 1970-2007
Wisconsin Office of Energy Independence

Electricity Use per Customer
Historic averages and potential 25% reduction from current levels
Single- and Multi-family Units, Statewide



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