CHAPTER 5

COMMERCIAL SECTOR STRATEGIES

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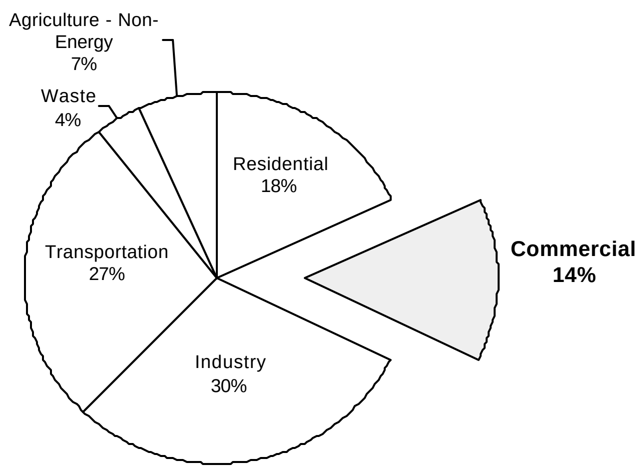
Overview

The commercial sector includes the wide variety of buildings used by businesses, organizations, and government agencies, including office buildings, hotels and multi-story apartments, beauty salons, bookstores, shopping malls, dry cleaners, lumber stores, and school buildings. The bulk of greenhouse gas emissions caused by these buildings is from energy use for heating, cooling, and lighting, with additional use for domestic hot water, refrigeration, cooking, electronic equipment, and other operations.

Figure 5-1: North Carolina Greenhouse Gas Emissions in 1990
Total Emissions in 1990: 145 Megatons eCO_2



Assumptions

Commercial Energy Forecasts

The first goal for the project team's investigation of commercial buildings was to forecast energy use through the year 2010. The commercial energy forecasts began with data from the U.S. Energy Information Administration (USEIA) on commercial energy use by sector through 1997 (USEIA 1998b; USEIA, 1995). The existence of data for the 1990 to 1997 time frame helped confirm that the forecast was reasonable.

According to the 1990 GHG inventory for North Carolina, the commercial sector's emissions were 3.73 megatons of eCO_2, or 2.7 percent of the state's total emissions (Appalachian State University 1996). However, commercial and institutional buildings are heavy electricity users and emissions from electricity were not assigned to sectors in the North Carolina inventory. Using the data from our forecasting method, which assigns utilities emissions to each sector, this sector produced 20.67 megatons in 1990—14% of total emissions (Figure 5-1). With business-as-usual forecasting, the commercial sector should produce 32.1 megatons in 2010. This will require that the commercial sector's target emissions level for 2010 be 19.2 megatons, or 7% below the 1990 level based on USEIA (1999b).

The other key statistic was the amount of commercial building floor space in North Carolina. The research team could not find an estimate specifically for North Carolina. However, the USEIA publications "Commercial Energy Consumption and Usage Patterns Survey" for the years 1989 and 1995 cite a strong correlation between population and commercial floor space (USEIA 1999a; USEIA 1995). USEIA's *1999 Annual Energy Outlook* (1998a) found that in 1995, the South Atlantic region--made up of Florida, South and North Carolina, Virginia, West Virginia, Maryland, Delaware, and Washington, DC -- had 676,000 buildings with 9,475 million square feet, while the larger South region had 20,830 million square feet. Interestingly, the 1989 publication found floor area of 22,039 million square feet in the South region, 3.5% more than six years later. Allocating this floor area among the various populations of the states yields an estimated 1,268 million square feet in North Carolina in 1995.

The USEIA commercial building survey (USEIA 1995) contained a substantial amount of data concerning the use of energy in buildings; however, the data was primarily aggregated on a national basis. The research team used the national estimates for North Carolina, realizing they introduced some degree of error.

To make the estimate of future energy use in commercial buildings as accurate as possible, the project team disaggregated energy use in the sector by end use and fuel use. The sources of information for this breakdown include USEIA's *State Energy Data Book, 1996* (1999), the *1997 State Profile: North Carolina* (Woods & Poole Economics, Inc. 1998), USEIA's *Commercial Buildings Energy Consumption and Expenditures, 1992* (1995), USEIA's *A Look at Commercial Buildings in 1995* (1998a), a series of computer runs using Energy 10, and at times, intuition. The key factors in the projection were:

- Current number of buildings and total square footage
- Average size of commercial buildings
- Projected number of new buildings and square footage by year
- Energy use characteristics of fully occupied new and existing buildings
- Percentage of floor space that is partially heated or unheated

- Percentage of floor space that is partially cooled or uncooled
- Percentage of floor space that has no water heating equipment
- Percentage of floor space that has no cooking equipment
- Percentage of floor space that has no refrigeration equipment
- Type of heating, cooling, and hot water appliances, allocated by floor area, type and efficiency

Using data or estimates for the above variables, the project team developed a computer spreadsheet to forecast future energy use in the commercial buildings sector by fuel type. The spreadsheet used the following approach to estimate energy use in the existing building and fuel type sector by end use and fuel type:

1. Estimate energy use for an "average" base case building.
2. Project energy use per million square feet by end use and fuel type for existing buildings.
3. Estimate the energy use by fuel type and end use in new commercial buildings -- per million square feet.
4. Estimate new commercial construction by year -- in million square feet.
5. Multiply the cumulative new construction square footage by average energy use per square foot by fuel type to find projected energy use in newer buildings (# 3 X #4).
6. Estimate the decline in use in existing commercial buildings and project the amount of commercial floor space from 1989 that is still in use in each future year.
7. Multiply the amount of existing floor space (as opposed to new floor space) by the energy use multipliers per square foot (#2 X #6) to project energy use in existing buildings.

The forecast of energy use in commercial buildings was thus grounded in estimates of energy use by fuel and end use. The project team estimates an approximate 2.3% annual increase of energy use in the sector from 1990 until 2010. During this same time period, commercial floor space should grow at a 1.9% annual rate; thus, energy use per square foot is expected to increase annually at a 0.5% rate -- a substantial decrease in building energy efficiency. With the wide array of energy conservation opportunities available, there is ample opportunity to increase the overall efficiency of buildings in the sector.

Emission Reduction Strategies

A variety of energy saving options was considered for the commercial building sector. To forecast their overall impact on energy use and greenhouse gas emissions, the project team first found savings from efficiency options on the model commercial building. For each option, the expected market potential and penetration rate was estimated and overall savings were calculated.

Energy 10 software provided an analytical tool by which to model the buildings. The project team developed lists of energy efficiency and greenhouse gas reduction measures for which they projected energy consumption and savings using Energy 10. A wide variety of measures was considered:

- Existing Buildings
  - Thermal Efficiency Strategies
    - Improved insulation -- roof/ ceiling, added window glazing
    - Shading of windows
    - Air sealing measures
  - Lighting Efficiency Measures
    - Replace incandescent lamps with fluorescent
    - Replace standard fluorescent with higher efficiency fluorescent
    - Replace exterior incandescent and halogen lighting with high pressure sodium
    - Install controls to reduce operating time of lighting
  - HVAC Efficiency Measures
    - Maintenance and repair improvements
    - Higher efficiency equipment
  - Energy management systems
  - Domestic Hot Water Efficiency Measures
    - Tank insulation
    - Heat traps
    - Controls on circulation pumps
    - Higher efficiency units
  - Appliance and Office Equipment Efficiency Measures
    - Install covers on open freezers and refrigerators
    - Increase temperatures of freezer compartments by 3 degrees
    - Improve efficiency of cooking operations
    - Other appliance efficiency measures
    - Higher efficiency equipment
    - Reduce on-time without lowering productivity

- Fuel Switching Strategies -- Solar Water Heating and Space Heating
  - Existing Buildings
  - New Buildings
- New Buildings
  - Thermal Efficiency--Insulation, Air Sealing, Windows, Shading
  - HVAC Efficiency
  - Solar Energy and Alternative Energy Options
  - Hot Water Efficiency

The energy simulation software developed estimates of energy savings for the above measures for a base case building using Energy 10 software. To find the total expected savings from the measure on a statewide basis, the savings per square foot were calculated and multiplied by the expected market penetration of the measure.

Estimating the market for the measures relied upon USEIA (1995, 1998a) data for aggregated estimates of the percentage of buildings that contained certain energy conservation measures nationally. The project team used these estimates to project the amount of square footage that currently did not have the efficiency measures. For example, USEIA (1995) projected that 79% of building square footage had roof or ceiling insulation; thus, the total market for the measure was 100% - 79%, or 21%.

USEIA reports also contain data on the number of buildings that are not totally heated and cooled. Because there was no breakdown of the insulation qualities of heating and unheated buildings, the project team assumed that some of the newly insulated space may be only partially heated and may not provide as much savings as fully insulated spaces (Table 5-1).

Given the total market for a given efficiency measure, the project team forecasted the likely market penetration of the measure based on its cost effectiveness and total savings. Each measure received a market potential rating of High (payback period of 1 to 2 years), Medium (2 to 5 years), and Low (over 5 years). Measures with higher ratings were assumed to achieve a higher market penetration:

High payback-- 65% market penetration
Medium payback-- 40% market penetration
Low payback -- 10% market penetration

Table 5-1: Energy Conservation Features in Commercial Buildings by Year Constructed

	Percent of Floor Space in Buildings Having Each of These Characteristics					
Year Constructed	Roof or Ceiling Insulation	Wall Insulation	Other Shell Insulation	At Least 50% High-Efficiency Lighting	Computerized Energy Mngmt. and Controls	Regular HVAC Maintenance
1945 or before	51.8	23.7	68	80.1	12.1	54.9
1946-1959	70.2	37.5	80.9	86	19.9	65.2
1960-1969	69.8	44.9	84.1	88.9	24.2	72.3
1970-1979	82	55.6	86.9	90.2	26.3	75
1980-1989	83.6	72.5	87.7	80.5	34.1	73.4

Source: USEIA 1998a.

The project team then needed a market implementation schedule for each technology. The schedule showed what percentage of the total market penetration would occur in each future year. A general schedule used for the measures is as shown in Table 5-2.

Table 5-2: Sample Implementation Schedule

1990	0%	2001	5%
1991	0%	2002	10%
1992	0%	2003	15%
1993	0%	2004	15%
1994	0%	2005	20%
1995	0%	2006	15%
1996	0%	2007	10%
1997	0%	2008	5%
1998	0%	2009	5%
1999	0%	2010	0%
2000	0%		

The final projections of savings by fuel by year for each measure were then calculated as follows:

1? Calculate average savings per million square feet by fuel type
2? Calculate total market in million square feet
3? Estimate market capture using market potential factor based on cost effectiveness of technology
4? Forecast savings per year based on the market implementation factor. Of course, once a measure has been implemented, it keeps saving energy in all future years.

Existing Buildings: Thermal Efficiency Strategies

Strategy: Improved Insulation and Window Glazing

Heating and cooling energy use is less dependent on the level of insulation in the exterior walls of buildings than residences; however, substantial savings are still available. The main targets are roof and ceiling spaces. Many buildings have solid, built-up roofs containing little, if any insulation. Using batt insulation on top of dropped ceilings is actually a poor strategy due to the many air leaks through around the edges of the dropped ceiling tiles and insulation. However, a solid layer of R-30 is certainly an improvement over no insulation and should provide a payback of 1 to 3 years.

A better, albeit more expensive, strategy is to insulate the roof system directly, by attaching insulation to the underside of the roof, or to the top during reroofing. It is important to completely enclose metal structural members, such as web trusses, with insulation to avoid thermal bridging -- heat escaping via conduction -- through the metal.

Windows in commercial buildings are a target from both insulation and shading standpoint. USEIA (1995) projects that about 50% of the windows in the nation have single-paned glazing. Based on the same percentage in North Carolina, 50% of commercial building floor space have single-paned windows. Adding an additional layer of glazing is expensive with paybacks of 8 to 12 years.

Buildings with walls having open cavities -- either open framing studs or concrete block with open cores -- are candidates for retrofit using blown-in foam insulation. A number of elementary schools in the Southeast have selected this strategy under the state-funded Energy Conservation Program for Schools and Hospitals. The payback for this measure rests in the higher payback realm of 7 to 11 years.

Few commercial buildings are candidates for floor insulation as most have concrete slab foundations that are difficult to retrofit.

The projected energy savings from thermal envelope measures for a typical commercial building of North Carolina are found in Table 5-3. Total energy savings for all of the thermal envelope measures are projected to b 6.8 trillion Btu per year by year 2010.

Table 5-3: Average Savings in Million Btu per Year for Thermal Envelope Measures for a Typical 9,000 square foot Building

	Ceiling Insulation	Additional Glazing Layer	Retrofit Wall Insulation
Space Heating	135	51	115
Space Cooling	66	30	10
Fans and Blowers	16	5	5
Total	217	86	130

Strategy: Shading Measures

Shading windows in commercial buildings has a market of millions of dollars for private contractors. Strategies vary considerably:

- Install reflective films -- attach to the exterior surface of windows and work by reflecting incoming sunlight away from the building and absorbing some of the sunlight than is not reflected. Typical costs for the films, installed, are in the $2 to $4 per square foot range.
- Replace windows with units having lower Solar Heat Transmission Coefficients (% of sunlight transmitted through the glass) to allow less sunlight into the building) -- considerably more expensive than reflective films, but should be considered when upgrading windows, especially when replacing east- or west-facing single-paned units with double-paned glazing. Cost $10 to $30 per square foot.
- Install outside shade screens -- mount in a frame just like insect screen, but absorb 30 to 60% of incoming sunlight. Work best when combined with blinds on the interior. Cost in the same range as reflective window films.
- Add overhangs or awnings to the exterior structure -- work best on the southeast, south, and southwest facades of the buildings as the sun is higher in the sky during the middle of the day and overhangs cast a longer shadow during these times. Long overhangs (approximately as long as the height of the window) can be effective on the east and west sides. Cost $10 to $100 per linear foot.
- Plant trees strategically so as to shade the grounds around windows and shade the windows as well -- suitable primarily for single-story buildings. Shading the ground around a commercial building adds to its aesthetics and can reduce summer air temperatures by as much as 10 degrees.

Table 5-4 shows average energy savings per building for shading measures. Based on a market potential of 35% and a payback period of 3 to 5 years, shading measures would have a market penetration of 17.5, saving 0.83 trillion Btu/year.

Table 5-4: Average Savings in Million Btu per Year for Shading Measures for a Typical 9,000 sq ft Building

Energy Use	Savings, MBtu
Space Heating	-5
Space Cooling	77
Fans and Blowers	9
Total	81

Strategy: Air Sealing Measures

Too often, designers, builders and policy makers believe that the major sources of air leakage in buildings are through doors and windows. In commercial buildings, especially multi-story units, the largest air leaks are often in the chases, elevator shafts, and stair wells of the buildings. Tall vertical spaces create high pressure, known as the stack effect, that pulls air into buildings' bottom floors and exhausts it through the roof of the building.

These pressures that cause air leakage throughout the building not only waste energy, but also can cause indoor air quality problems, such as:

- Drawing outdoor pollutants (such as automotive exhaust) or irritants (such as pollen) into the building
- Backdrafting fuel-burning appliances that have flues and causing dangerous carbon monoxide pollution problems
- Spreading odors around the building
- Bringing in outdoor humidity, which aids in the growth of mold
- Transmitting outdoor noise more freely

Forecasting the effects of air leakage control are difficult. The assumptions made for the base case building are:

- Seal two vertical, two-story chases, each with an area of 24 square feet
- Seal 15 square feet of other holes through the ceiling structure
- Seal 4 square feet of cracks around windows and doors

The economics of the air sealing measures is quite positive. The cost of doing the air sealing would be $500-1,500, and the efforts save about $400 of energy per year -- a 1- to 3-year payback (Table 5-5). With a market penetration of 32.5%, air sealing measures could save 3.5 trillion Btu/year.

Table 5-5: Average Savings in Million Btu per Year for Air-Sealing Measures for a Typical 9,000 sq ft Building

Energy Use	Air Sealing Measures Savings, MBtu
Space Heating	68
Space Cooling	5
Fans and Blowers	2
Total	75

Total savings for all of the envelope measures—insulation, air sealing, and shading—could be about 9,300 billion Btu/year, or a decrease of 12%.

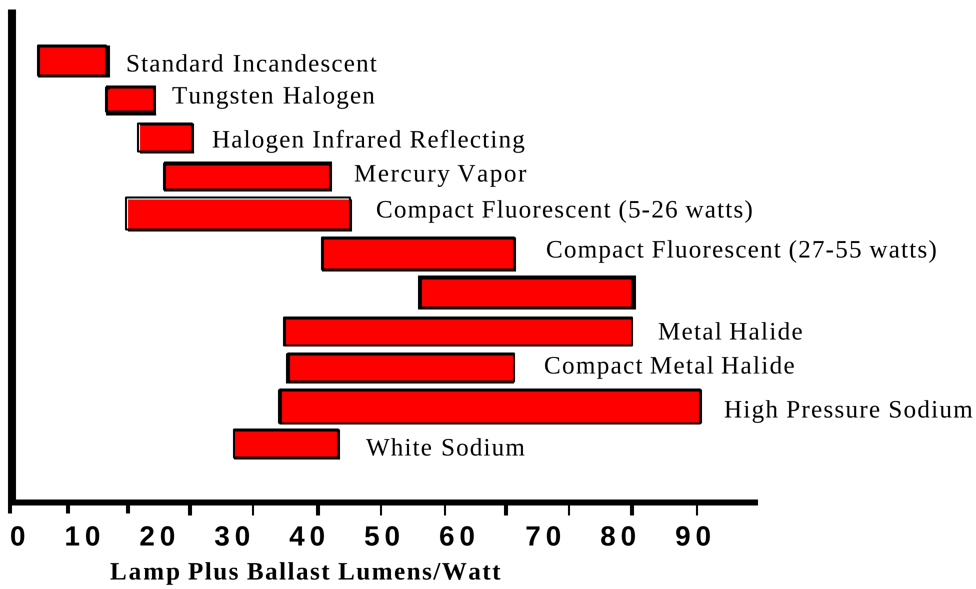
Existing Buildings: Lighting Efficiency Measures

Strategy: Incandescent to Fluorescent

In many commercial buildings, lighting accounts for up to 40% of total energy use. Manufacturers of lighting equipment now offer a host of efficient lighting products for lamps of all sizes. Figure 5-2 shows the efficacy -- amount of lighting (in lumens) provided per watt of electricity used. Incandescent lamps have very low efficiencies, while low-pressure sodium lamps provide high levels of lighting per watt of electric power required.

Perhaps no area of lighting has seen more innovation than compact fluorescent lamps. These products replace incandescent bulbs in most fixtures. Over the years they have become more reliable and more compact. They reduce energy use by about 1/3 and last 9 to 12 times longer than standard incandescents. In commercial buildings, savings in the labor cost of replacing incandescent lamps alone often pay for lighting replacements independently of the energy savings.

Figure 5-2: Efficacy (Lumens per Watt) for Electric Lamps



The energy savings of compact fluorescents are remarkable. For example, a meeting room with 50, 150-watt can (recessed) lights that operate 5 hours per workday will use about 9,300 kilowatt-hours per year. Compact fluorescent lighting would use only 3,200 kilowatt-hours per year and save about $550 per year on electrical costs. The lamps may cost $20 to $40 to retrofit, or $1,000 to $2,000 for the room. The payback period is in the 2- to 4-year range.

Strategy: Fluorescent to Higher Efficiency Fluorescent

The common fluorescent tube and fixture has evolved considerably as well. Fluorescent lamps, as well as lamps know as high intensity discharge (HID) lamps -- metal halide, mercury vapor, high-pressure sodium and low-pressure sodium -- require a ballast that provides electricity of the proper frequency and quality. Electronic ballasts are considerably more efficient and longer lasting than the older magnetic ballasts. The tubes themselves have gained in efficiency. Thinner, T-8 tubes require fewer watts for the same lumen output than older, T-12 lamps.

For example, older lamps containing four, T-12, 40-Watt lamps and two magnetic ballasts draw about 160 watts of power when operating. A building with 100 similar lamps that are turned on 10 hours per day for a year will use about 60,000 kilowatt-hours per year for operating the lights plus additional energy to provide air conditioning for the overheating produced by the lights.

Substituting energy efficient ballasts and T-8, 32-Watt lamps for older models will provide the same amount of lighting, but will use only about 45,000 kilowatt-hours per year -- saving about $1,500 annually on energy bills. The retrofit cost for the lamps is about $4,000 to $5,500 -- a 2 1/2 to 4-year payback.

Strategy: Replace Exterior Lighting

There are some common misconceptions about exterior lighting. Many building operators consider mercury vapor lamps energy efficient, but their efficacy is just slightly better than incandescent lamps. While low-pressure sodium lamps have the highest efficacy, their lighting quality is far less than high-pressure sodium lamps.

Suppose a parking lot, that measures 200 feet by 200 feet, has 20 mercury vapor fixtures that use about 35,000 kilowatt-hours per year. Replacing the fixtures with high-pressure sodium units will save at least 17,500 kilowatt-hours per year for cost savings of about $1,500. There are retrofit kits available to switch from mercury vapor to high-pressure sodium. At a cost of $125 each for installation, the $2,500 cost would pay for itself in less than two years.

The lighting industry has also evolved technologies to keep lights off when not needed.

Options include:

- Occupancy sensors which turn lights on when rooms are occupied, but turn them off several minutes after left vacant.
- Lighting management systems that set a building's lighting system to follow a preset schedule.
- Rooms with various lighting levels so that only rarely are all of the lights turned on.
- Remote control devices to dim or increase lighting levels automatically.

Consider a meeting room with a ceiling-mounted occupancy sensor costing $100. The sensor controls 8 fluorescent lamps with total power requirement of 1,000 watts. If the device keeps the lights off 2 hours more per day than typical, it will reduce energy needs about 500 kilowatt-hours per year for savings of about $45. Thus, the payback period is about two years.

The lighting efficiency measures present a very cost effective way to save energy and increase comfort in buildings by reducing summer cooling demands. The projected savings in the commercial sector used data from EIA (USEIA 1995) about current lighting levels shown Table 5-6.

Table 5-6: Type of Lighting

Lighting Type	Percentage of Buildings Using Lamp Type
Standard Fluorescent	95
Incandescent	64
High-Intensity Discharge	30
Compact Fluorescent	27

The specific energy measures included in the lighting energy efficient measure are:

- Replace existing incandescent and halogen lighting with fluorescent
- Replace standard fluorescent with energy efficient fluorescent (T-8 lamps and electronic ballasts)
- Replace exterior mercury vapor, incandescent, and halogen lighting with high pressure sodium
- Install lighting control equipment to reduce the amount of lighting in vacant spaces where not needed

The savings are based on converting an existing building with the following lighting fixtures to the more efficient lamps shown in Table 5-7.

Table 5-7: Average Savings in Million Btu per Year for Lighting Efficiency for a Typical 9,000 sq ft Building

	Fluorescents for Incandescent	**Fluorescents for Existing Fluorescent**	**Efficient Exterior Lighting**
Reduction in Watts/ sq ft	0.45	0.30	0.01
Average Hours on / day	4	4	8
	Energy Savings, MMBtu/year	**Energy Savings, MMBtu/year**	**Energy Savings, MMBtu/year**
Space Cooling	5.0	3.4	0
Fans and Blowers	0.2	0.2	0
Lighting Energy	20.0	13.5	9.0
Total	25.2	17.1	9.0

In addition to the savings on lighting energy, more efficient lighting will reduce space cooling needs, as well as the operating time of central blowers. Total energy savings could be about 2,200 billion Btu/year, a 16% improvement.

Existing Buildings: HVAC Efficiency Measures

Strategy: HVAC Maintenance and Repair

Many buildings contain efficient equipment for space heating and cooling, yet due to poor installation and maintenance, the performance falls short of that desired. The survey of energy use in commercial buildings (USEIA 1992), polled building owners on their maintenance practices. According to the respondents, only 52% of buildings, representing 73% of all floor space, had HVAC maintenance. In general, larger buildings were more likely to have regular maintenance than smaller buildings.

Typical maintenance procedures depend on the type of equipment used by the building. In general, the following should be checked:

- Air-based systems
  - proper damper operation; acceptable air flow and delivery temperatures to each zone
  - clean, efficient combustion if applicable
  - clean filters and blowers
  - tight fan belts
  - no duct leaks
  - insulated ductwork in good condition
  - proper refrigerant charge
  - controls for outside air dampers work properly
  - thermostatic control systems work
  - no blockage of supply diffusers or return grilles
  - proper operation of cooling towers where applicable

  - ◊ lubrication of all equipment
  - ◊ Proper operation of VAV boxes
- ♦ Water/ steam/ fluid-based system
  - ◊ boiler/ chiller operation
  - ◊ proper refrigerant charge
  - ◊ proper operation of cooling towers where applicable
  - ◊ check for failed steam traps
  - ◊ piping insulated continuously
  - ◊ efficient pumps and pump controls operation
  - ◊ correct operation of thermostatic control system
  - ◊ boiler combustion clean and efficient

Companies often skimp on maintenance even though an investment of a few hundred dollars can save thousands of dollars on energy bills. The payback period is often measurable in months rather than years. A major constraint is the limited number of highly skilled maintenance practitioners in the state. North Carolina does have several facilities that offer training in HVAC maintenance and repair including North Carolina State University, the State's Energy Division, and the Advanced Energy Corporation. Table 5-8 shows the energy savings from maintenance for a typical building.

The project team assumed the following regarding implementation of an improved HVAC maintenance and repair program.

- ♦ 17.5% of floor space without maintenance would adopt a maintenance program. The savings are based on an average heating and cooling efficiency improvement of 10%.
- ♦ 29% of floor space would improve existing maintenance programs; heating and cooling energy use would drop 5% in these buildings.

Table 5-8: Average Savings in Million Btu per Year for HVAC Maintenance of a Typical 9,000 sq. ft. Building

Energy Use	Institute New Maintenance	Improve Existing Maintenance
Space Heating	20	10
Space Cooling	15	7.5
Fans and Blowers	2	1
Total	37	18.5

Strategy: Higher Efficiency HVAC Equipment

Manufacturers of heating and cooling equipment introduce hundreds of new products every year to improve comfort, efficiency, and cost. The best time to improve efficiency is when older equipment needs replacement. The economic payoff for replacing equipment that is currently somewhat inefficient, but still in working order, is much longer.

Equipment over 15-years old is nearing the end of its operational life. It may prove economical for many companies to accelerate the substitution of higher efficiency systems, since new standard heating and cooling equipment can be 20 to 30% more efficient than HVAC units 15-years old and older. Higher efficiency units may double the savings. Options that may increase savings even more are:

- ♦ Add economizer cycles to existing systems to reduce cooling bills during cool or mild outdoor weather
- ♦ Install innovative new technologies, such as:
  - ◊ Increase duct and pipe insulation
  - ◊ Ground source heat pump systems for heating and cooling
  - ◊ Solar-assisted heat pump systems
  - ◊ Natural gas heat pumps
  - ◊ Central dehumidification systems
  - ◊ Obtaining steam for space heating from nearby electrical generation plants via cogeneration

The project team made the following assumptions about the implementation of higher efficient equipment (Table 5-9):

- 35% of buildings would install economizers.
- 16% of buildings would repair ducts and pipes and improve insulation.
- 13% of existing floor space will replace older equipment with newer, more efficient models during the normal depreciation cycle.
- 2% of existing floor space will replace currently operating equipment with newer, more efficient models.
- 4% of existing floor space will install an innovative energy system, such as gas-fired heat pump, central dehumidification, or cogeneration.

Table 5-9: Average Savings in Million Btu per Year for Higher Efficiency Equipment for a Typical 9,000 sq ft Building

Energy Use	Economizer Installed	Duct/Pipe Insulation	Install Higher Efficiency Equipment
Space Heating	-	8	14
Space Cooling	2	3	5
Fans and Blowers	-	0.7	1
Total	**2**	**11.7**	**20**

Strategy: HVAC Energy Management Systems

According to the EIA (USEIA 199a; USEIA 1995), 25% to 30% of commercial floor space is without automatic controls over heating and cooling systems. Some buildings require complete heating and cooling 24 hours per day, but most buildings are unoccupied in the later evenings and can have lower temperatures with no impact on human comfort.

Energy Management Systems (EMS) automatically operate the heating and cooling system of a building, along with other components, such as lighting. The building supervisor presets the schedule, temperature settings, and lighting protocol and lets the EMS take over. Not only will the system control operation, it will also monitor energy use and help reduce bills by reducing the peak use of electricity.

EMS vary dramatically in cost, but most systems offer paybacks in the 2 to 3-year range. The assumptions on market penetration for the moderate greenhouse gas reduction scenario are:

- 13% of buildings install EMS.
- A 9,000 square foot building would save about 15.7 million Btu per year with a new, effective EMS.

Total energy saving from all of the HVAC measures could be about 1,800 billion Btu/year, or a 14% decrease.

Existing Buildings: Domestic Hot Water Efficiency Measures

Strategies: Tank Insulation, Heat Traps, Controls on Circulation Pumps, Higher Efficiency Units

Most commercial buildings contain water heating equipment to provide for needs such as hand washing, bathing, clothes, washing, and dishwashing. Increasing insulation of the hot water storage tank can pay back in less than one year.

Many buildings have recirculating hot water systems, which use pumps to circulate hot water continuously throughout the building. Recirculation systems consume energy in two ways – electricity needed to drive the pump and the energy required to reheat the water after it travels throughout the building. Installing a timer switch on a recirculating pump can have a quick payback of 1 to 2 years.

Domestic hot water (DHW) systems also lose energy by thermosiphoning action. If the water heater is located on the bottom floors of a building, hot water will rise naturally throughout the plumbing system. As hot water leaves the tank, it begins losing heat through the piping. Cooler hot water sinks back to the tank, where the electric heaters or fuel-fired burners must switch on to reheat the water. Devices called heat traps, which can either be purchased and installed or manufactured on site with simple piping materials, prevent thermosiphoning.

Projected savings for efficiency measures in DHW systems for a typical 9,000 square-foot commercial building are shown in Table 5-10. Overall energy efficiency measures applied to water heating equipment save 576 billion Btu annually—a 16% savings.

Table 5-10: Savings from Hot Water Measures in Million Btu per Year for a Typical 9,000 Square-Foot Building

Strategy	Savings, MBtu/year
Tank insulation	2
Timer switch	1
Heat traps	1
Efficient equipment	4

Existing Buildings: Appliance and Office Equipment Efficiency Measures

Strategies: Freezer, Refrigerator, and Other Appliance and Office Equipment Improvements

Commercial buildings differ substantially in regard to their use of appliances. Restaurants contain refrigeration, cooking, and dishwashing equipment; hotels have clothes washing and drying facilities; and office buildings use a multitude of computer-related equipment. Energy efficiency opportunities are available for virtually any energy-using device.

Some energy efficiency measures reduce the operating cost of existing equipment. Options include covering for open bay freezers and coolers, raising the temperature of refrigeration equipment, changing cooking practices to reduce energy waste, turning off computer and electronic equipment in the evening, recapturing heat from clothes drying equipment and the like.

When equipment requires replacement, energy efficient units should always be selected. The payback period for the added investment is usually quite short. Total savings from appliance efficiency measures in commercial buildings could be about 125 Billion Btu/year—a 5% savings.

Fuel Switching

Strategy: Solar Water Heating and Space Heating

Commercial buildings often have higher rates for electricity and other energy sources than residential buildings. The higher rates mean greater dollar savings for solar energy equipment. In addition, the North Carolina Solar Tax Credit provides an attractive 35% income tax credit for investments in solar energy by the commercial sector.

Solar water heaters can provide payback period of five to ten years on electric water heating systems. Such equipment has been on the market for the past two decades and has provided reliable service for many businesses.

Solar space heating has a longer payback and is not as attractive in the current energy price market as solar water heating. As such, the GHG mitigation scenario projects a small role for space heating from solar energy. Solar water heating should play a much larger part in the coming years.

Typical annual energy savings from solar equipment are:
Solar water heating: 16.8 Million Btu per building
Solar space heating: 40 Million Btu per building

Strategy: Electricity to Natural Gas for Water and Space Heating

Switching from electricity to natural gas for space and hot water heating for commercial buildings can provide significant reductions in emissions. The project team assumed that 25% of space heating would convert from electric to natural gas, providing a total savings of .33 megatons of eCO_2 in North Carolina. Switching 50% of all electric hot water heating in commercial buildings to natural gas would reduce emissions by 0.08 megatons of eCO_2.

New Commercial Buildings

Strategies: Thermal Efficiency, HVAC Efficiency, Alternative Energy Options, Hot Water Efficiency

New commercial building construction offers numerous opportunities to institute new energy savings. Because this is a fast-growing sector in North Carolina and is one of the heaviest users of electricity for lighting and heating and cooling, considerable GHG emissions savings can be realized through new construction techniques and increasingly efficient equipment. Nearly all of these strategies are listed in the discussions above, however, implementing them during new construction offers far greater efficiencies at less cost than attempting to retrofit existing buildings.

Figure 5-3 provides a forecast of energy use for new commercial buildings through year 2010, with three scenarios: basic case, moderate case, and aggressive case. Figure 5-4 shows the savings of eCO_2 through 2010.

Figure 5-3: Energy Usage Projected to 2010.

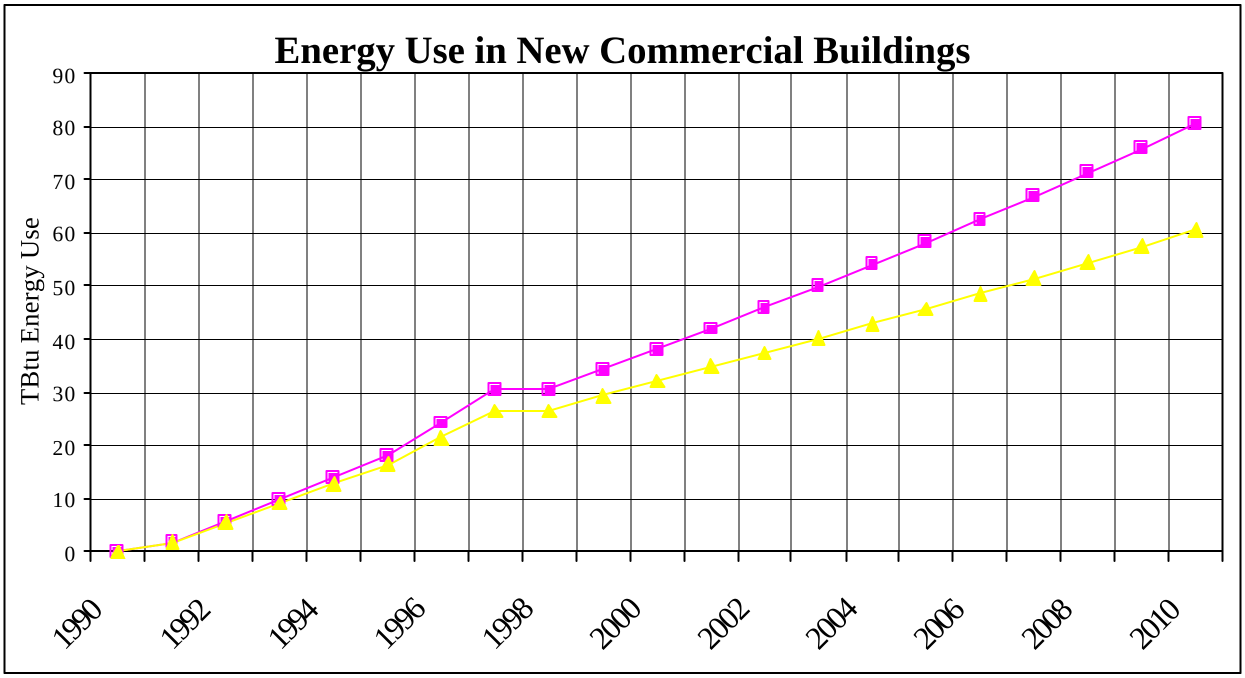
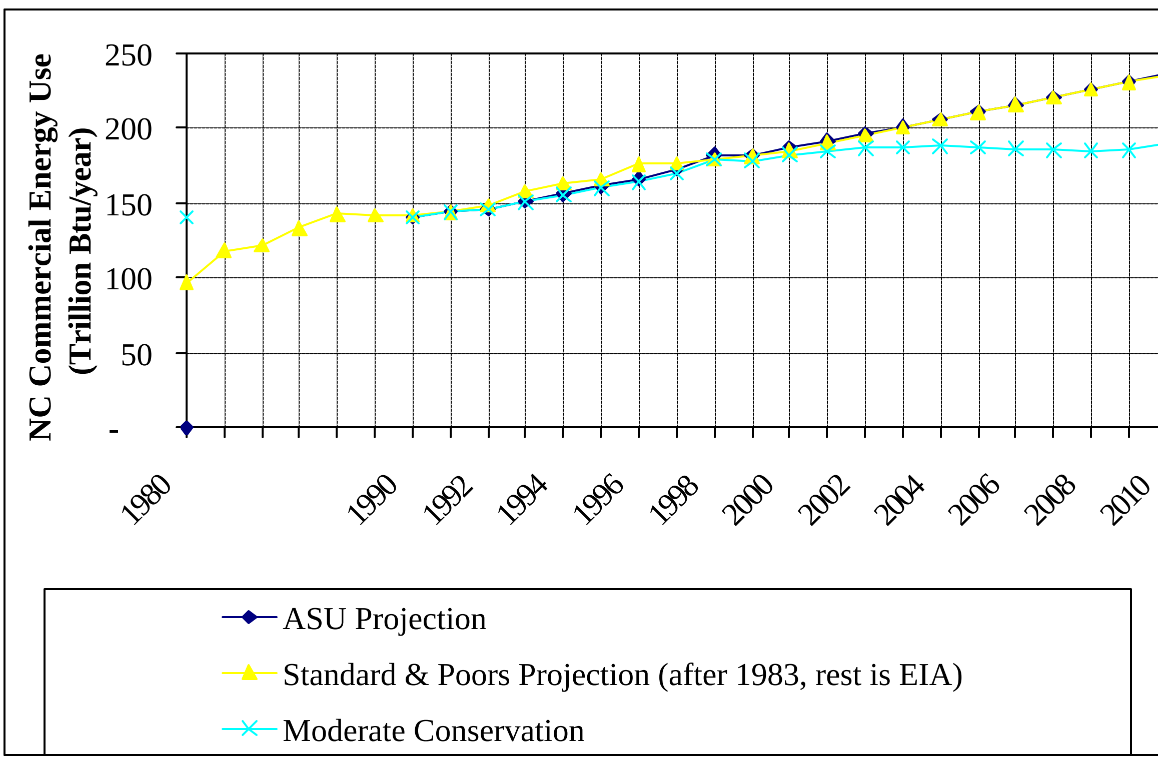


Figure 5-4: Savings of eCO_2 Projected to 2010



Commercial Sector Policy Options

Within the commercial building sector, wide-ranging policy options exist to provide incentives or requirements for commercial building owners to adopt energy efficient strategies. Many of the policies have been tried in the past two decades in individual states. Options include:

State Tax Credits. North Carolina has maintained solar income tax credits for many years. Well designed credits provide a win-win situation, as the reductions in direct tax receipts from those companies claiming the income tax credit are compensated for by taxes on increased state income from companies installing energy measures and additional business profits due to reduced energy bills for companies that have measures installed.

For example, if in 2001 a company invests $15,000 in energy efficiency measures and receives a 15% income tax credit, state tax revenues for 2001 will drop $2,250. However, in the same year, if the company that installed the measures receives 20% profit on their sales and pays 7% state income tax, state taxes will increase 1.4% -- a small contribution of $210 to state tax coffers. Thus, the net tax reduction in 2001 would be $2,040.

If the energy measure has a 3-year payback, it will save $5,000 per year in energy. If the energy savings go directly to cost savings for the company, and thus net profit, state taxes will increase $250 per year. The cash flow, shown in Table 5-11, yields a net positive return in seven years.

Utility Demand-Side Management Programs. During the past two decades, many electric and gas utilities have designed and implemented programs intended to reduce demand for energy and consequently save on the cost of supplying energy. In fact, utilities have been one of the leading institutions providing incentives for cost effective energy efficiency and solar energy strategies. However, the utility industry is currently in flux due to uncertainties about deregulation efforts. Many demand side programs have been canceled in recent years as utilities prepare for a more competitive future.

Utility programs have included incentives for lighting retrofit, insulation and window efficiency, energy management systems, and maintaining or replacing heating and cooling systems. The programs in some states have been quite successful, but few have achieved market penetrations over 10%.

Energy Audit Programs. State energy offices and some private companies have offered thorough energy audits of existing public buildings to evaluate the most cost- effective improvements. In some cases, the audits are free, while in many cases, the companies must pay for the audit. While a comprehensive audit provides excellent information to the client, it does not guarantee that the recommended energy measures will be installed.

Loans, Grants and Incentive Programs. State energy offices have been able to provide either direct matching payments or loans for energy conservation measures in some states. In general, these payments are available for buildings owned or operated by state or local governments, or nonprofit organizations. Grants and incentives work similarly to tax credits, but companies must go through an application procedure prior to receiving any payment. The procedure can help police the program. Loans require administration, but do not reduce state government tax revenues directly.

Shared Savings Programs. Some energy service companies offer to provide energy conservation products and equipment to other businesses in exchange for obtaining the savings on energy bills. For example, an energy service company may offer the energy measures described under the tax credit section above to a commercial building owner. The energy service company negotiates with the owner of the commercial building to obtain all energy bills over the next 5 to 10 years and receive 75% of savings on bills. Thus, the energy service company would invest $15,000 in the building and hope to recoup the capital expense in annual energy savings. Table 5-12 depicts the cash flow for the hypothetical project.

Table 5-11: Hypothetical Cash Flow from State Income Tax Credit

Initial Cost for Energy Efficiency Measures = $15,000
Tax Credit (15%) = $2,250
Annual Energy Savings = $5,000
State Tax Rate = 7%
Increased Taxes Due to Energy Savings Contribution to Net Profit = $350
Income Tax Credit = 15%
Reduction in State Tax Revenues in 2001 = $2,250
Tax on Income for Installer of Energy Measures in 2001 = $210

Year	Reduction in State Taxes	Additions to State Taxes	Cumulative State Taxes Paid
2001	-2,250	210	-2,040
2002		350	-1,690
2003		350	-1,340
2004		350	-990
2005		350	-640
2006		350	-290
2007		350	60
2008		350	410
2009		350	760
2010		350	1,110

Table 5-12: Hypothetical Cash Flow for Shared Savings Company

Initial Cost = $15,000
Annual Energy Savings = $5,000
Shared Savings Amount (75% of annual savings) = $3,750/year
Duration of Shared Savings Agreement = 10 years

Year	Investment	Shared Savings	Cumulative Gain (Loss)
2001	-15000	3,750	(11,250)
2002		3,750	(7,500)
2003		3,750	(3,750)
2004		3,750	-
2005		3,750	3,750
2006		3,750	7,500
2007		3,750	11,250
2008		3,750	15,000
2009		3,750	18,750
2010		3,750	22,500
Internal Rate of Return =			30%

State Energy Code. Much of the savings for the greenhouse gas mitigation scenario come from new buildings. Unfortunately, buildings constructed under current state energy codes will not accomplish the goals for greenhouse gas reduction. To succeed in a meaningful reduction, the following changes are needed:

a. Increase wall and roof insulation requirements
b. Increase window insulating values and require shading devices
c. Eliminate major sources of air leakage
d. Require more efficient heating and cooling systems
e. Increase required efficiencies of lighting systems
f. Require better control over all energy-using devices when the building is not occupied

Specific requirements should provide demonstrated positive economic returns. A minimum payback period or rate of return should be set by regulating organizations with input from businesses, designers, contractors, utilities, and the general public.

Conclusions

The commercial sector of North Carolina is a large producer of GHG, even when compared to industrial, transportation, and residential sectors. Figure 5-3 shows the outcome of the implementation of energy and GHG savings strategies projected to 2010 by the commercial sector. Table 5-13 summarizes the emissions savings from commercial sector strategies.

If the commercial sector can implement the strategies listed below, a savings of 5.4 megatons of eCO_2 is projected for year 2010 (Figure 5-3). This would provide an energy cost savings of more than $324 million, and 5.1% of the total target of emissions savings for the state.

Table 5-13: Emissions Impacts from Mitigation Strategies – Commercial Sector

	Reductions	
	eCO_2 (megatons)	Percent of Total
Existing Buildings: Thermal Efficiency Improvements	1.38	1.3
Existing Buildings: Lighting Efficiency Measures	0.40	0.4
Existing Buildings: HVAC Efficiency Measures	0.23	0.2
Existing Buildings: Domestic Hot Water Efficiency Measures	0.07	0.1
Existing Buildings: Appliance and Office Equipment Measures	0.05	0
Fuel Switching Strategies: Solar Water and Space Heating	0.05	0
Fuel Switching Strategies: Electric to Natural Gas for Space Heating	0.33	0.3
Fuel Switching Strategies: Electric to Natural Gas for Water Heating	0.08	0.1
New Buildings: Improvements in Thermal Efficiency, HVAC Efficiency, Alternative Energy Options, and How Water Efficiency	2.82	2.7
Sector Total	5.40	5.1

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