Energy

The following appendices are available to provide valuable background information that helped to generate the conclusions and perspectives of this chapter:

I. Climate Change Basics

The need to reduce energy consumption is a based on the limited supply of fossil fuels and the impacts on climate generated by the impacts of burning fossil fuels. The public, particularly in the US, has been quite confused about the causes of observed 20th and 21st century warming, and the role that human activities have on climate. This confusion has arisen from the fact that there are a great many factors that control climate, including, but not limited to, sun spots, ocean currents, cycles such as El Nino, other regional effects, volcanic activity, land use changes, marine biological activity, among others. These complexities are the realm of "earth system science," a very complicated business, indeed. It has taken generations of scientific investigation just to begin to understand what is involved, but headway is being made.

Energy conservation is a measure that reduces the amount of energy that is used by either cutting back on use or making use more efficient.

Energy efficiency is the goal of efforts to reduce the amount of energy needed to provide products and services.

Energy resilience is the ability to adjust to interruptions in the supply of energy. A diversity of energy supply sources reduces vulnerability to potential disruption in the supply from any single source.

Energy sustainability means producing and consuming today's energy without compromising the ability of future generations to meet their energy needs.

However, there is one aspect of earth's climate that is relatively simple to understand, and that is the balance of energy between the sun and the earth's surface. Sunlight comes through a fairly transparent atmosphere, heats the earth's surface, and then heat is radiated back to space as infra-red radiation. However, the atmosphere is not quite as transparent for infra-red radiation, so it absorbs this energy, warming the atmosphere. This process is called the greenhouse effect. If we make the atmosphere more or less transparent to infra-red radiation by adding or subtracting certain gases, we can cool or warm it directly. These effects are very simple physics, and are well understood, explained in introductory textbooks such as Botkin and Keller (*Environmental Science*) or Withgott and Brennan (*Environment: The Science Behind the Stories*).

Figure 1, below, shows an estimate of the Earth's annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth's surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. Source: IPCC, 2007.

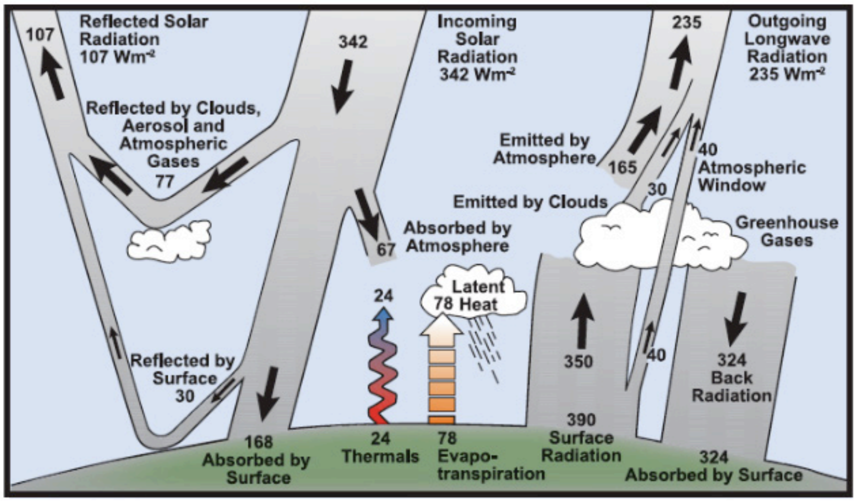
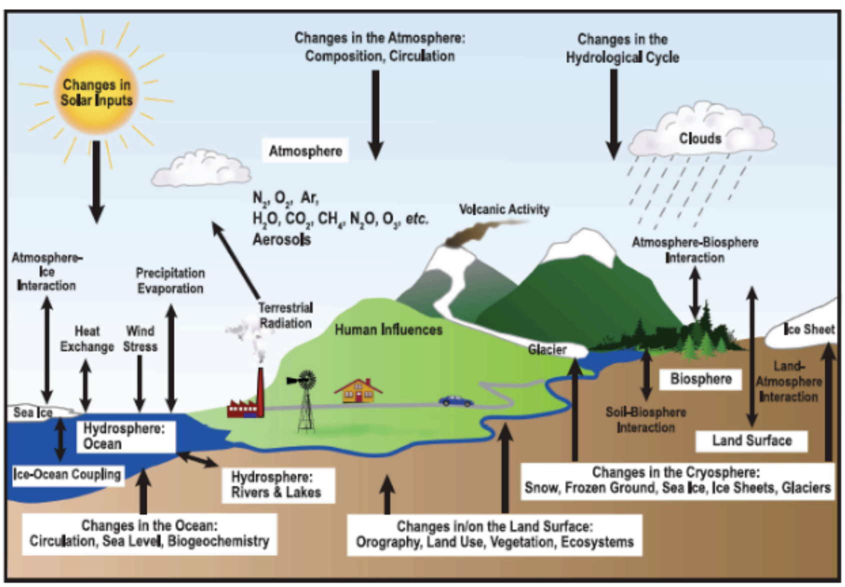


Figure 1. Earth's energy balance (Source: IPCC, 2007)



FAQ 1.2, Figure 1. *Schematic view of the components of the climate system, their processes and interactions.*

Figure 2. Components of the climate system, their processes, and interactions (source: IPCC, 2007)

Further, CO_2 is a trace gas that warms the atmosphere, thus enabling it to hold more water vapor. CO_2 is the dominant greenhouse gas generated by human activity. CO_2 acts as a trigger to load more water vapor into the atmosphere, which warms more, thus holding more water, warming more. On top of this vicious cycle, the warming atmosphere warms the ocean which then could begin to release some of its CO_2 into the atmosphere, causing further warming (because warm water cannot hold as much CO_2 in solution as cold water – try opening a warm seltzer!). Feedback between CO_2, temperature, and water vapor is the primary concern about CO_2 and other greenhouse gas emissions. These processes are explained in the comprehensive report of the Intergovernmental Panel on Climate Change (IPCC, 2007), which summarizes and double checks publications of the international scientific community in the area of climate change. While there may be a great deal of discussion within the scientific community about the details of the interactions between the various components of the earth system, the basic physics of radiation and absorption has been settled for over a century. In sum, if CO_2 or other greenhouse gases are added to the atmosphere, it must get warmer.

There are four basic questions about climate change:

1. Is climate changing?

Yes. There is undeniable instrumental data that temperatures are increasing, precipitation patterns are changing, and ocean and atmospheric circulation systems changing throughout the 20th century and continues into the 21st century.

2. Do people have anything to do with it?

Yes. Greenhouse gas emissions (primarily CO_2 from the burning of fossil fuels) cannot help but warm the atmosphere. The consensus is that models of global climate change are sufficiently sensitive to historic human CO_2 emissions to reflect the amount temperatures actually increased over the last 150 years. While the human influence on climate has been recognized for decades, additional data and model results now demonstrate its importance (IPCC, 2007).

3. Can we do anything about it? **Yes**. Because much of the warming caused by past emissions has already occurred, reducing or ending emissions can stabilize the earth's climate in the 21st century. Until the oceans are overwhelmed, natural carbon sinks in the ocean and on land can continue to absorb previously emitted carbon and return global climate to the stable state in which civilization evolved over the last 10,000 years.

4. Is climate change bad?

Yes. While this is a question to be considered by the general public, history has shown that a change in the environment of stable civilizations is disruptive to those civilizations. Alterations in areas in which crops can grow; changes in when plants bloom and leaves fall and when insects emerge; shifting storm tracks; extreme precipitation events; and rising sea level will have devastating economic, social, and political consequences for modern societies.

In a demonstration of humanity's influence on 20th century climate, model results were compared to observed temperature data. Models were run with natural climate forcing factors alone, human forcing alone (e.g. CO_2 emissions), and then with natural plus human forcing factors. Only the combined natural plus human forcing factors resulted in climate that matches observations (IPCC, 2007). In fact, what we learn from the past is that nearly every major climate change in earth's history has been accompanied by changes in greenhouse gases, with warming associated with more CO_2 and cooling associated with less. In the geologic past, before humans existed, climate and atmospheric CO_2 concentrations varied together, with CO_2 not always predating climate change. This was due to the feedback between temperature, CO_2 in the atmosphere and ocean, and water vapor in the atmosphere. However, now that we have devised a way to inject CO_2 directly into the atmosphere (through the burning of fossil fuels) CO_2 is preceding climate warming, which is responding to the additional greenhouse gases. See Figure 3.

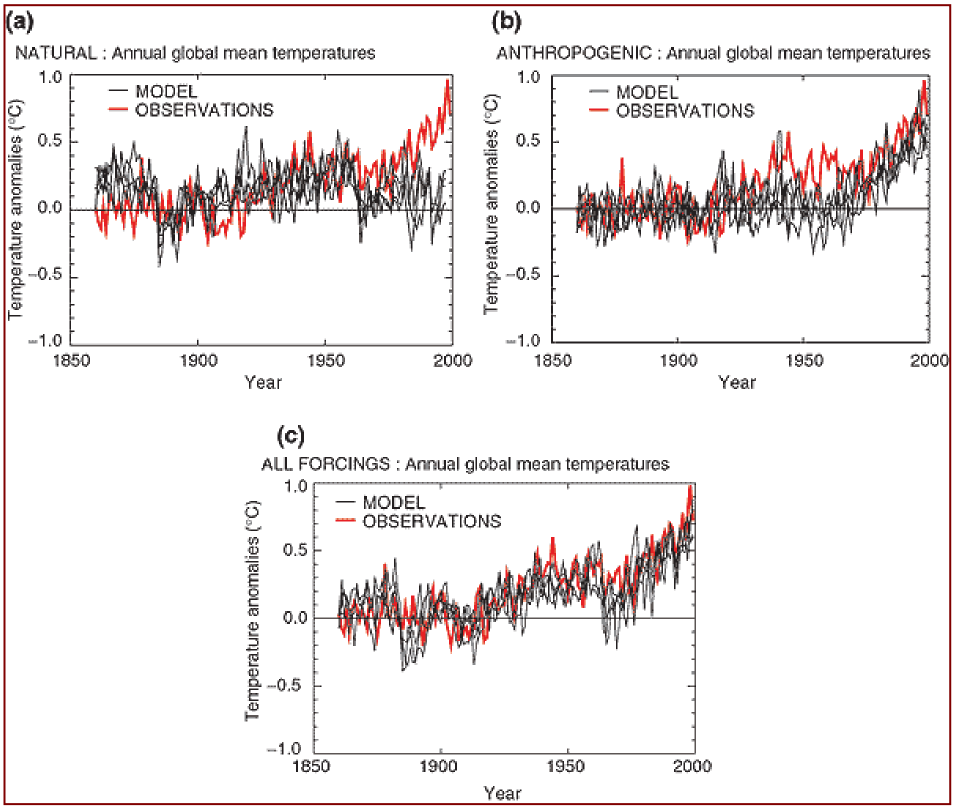


Figure 3. Natural and human induced climate change (Source: IPCC, 2007)

Numerical models have compared observations of average global temperature since the industrial revolution. Note that when models only account for natural variations (a) or only for human influence (b), they cannot accurately reconstruct observed climate, but when the two are combined (c), they match well. It is clear from these curves that the human influence is much greater than the natural variation of climate, which shows no appreciable warming over the course of the 20th century.

In 1995, the second IPCC Report stated that "The balance of evidence suggests that there is a discernible human influence on global climate." In 2001, the third IPCC Report stated that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activity." Most recently, in 2007, the fourth assessment IPCC Report stated that "Most of the observed increase in globally averaged temperatures since the mid-

20th century is very likely due to the observed increase in anthropogenic [human] greenhouse gas concentrations." While scientific conclusions have remained essentially unchanged since the early 1990's, the mounting scientific evidence clearly demonstrates the magnitude of human influence on climate change through greenhouse gas emissions, as exacerbated by land use changes.

In 2011, Carbon Solutions New England released a report called *Climate Change in the Piscataqua/Great Bay Region: Past, Present, and Future.* The report discussed changes in the region's climate over the last four decades and anticipated changes based on two scenarios regarding future carbon emissions. The report noted that the region's mean annual temperatures have warmed; average minimum and maximum temperatures have increased; coldest winter and warmest summer nights have warmed; annual precipitation has increased; extreme precipitation events have increased; annual discharge in the Lamprey and Oyster rivers has increased; lake ice-out dates are occurring earlier; and the rate of warming of sea surface temperatures in the Gulf of Maine have increased.

The report predicts that the region will experience increased temperatures, most dramatically in the summer; large increases in the number of days (11-51) when temperatures rise above 90°F; less frequent extreme cold, with very cold days projected to drop; warming of the coldest temperatures of the year, which may reduce winter heating bills but also may make the region susceptible to southern pest and invasive species and reduce the chilling hours necessary for the region's iconic crops (berries, fruits); increased precipitation, larger increases for the winter, raising concerns about increased flood risk; limited impact on drought conditions. According to the report "global sea level rise by 2100 will range from 1.7 to 6.3 feet, not including wave effects.[The] analysis shows that this results in 100-year flood stillwater elevations at Fort Point (at the mouth of the Piscataqua River) will range from 9.4 to 12.9 feet by 2050 and 10.9 to 17.5 feet by 2100. These estimated stillwater elevations do not include wave effects, which can be significant."

The true cost of burning fossil fuels, including the "levelized cost," which excludes the effects of subsidies or support mechanisms, is rarely identified or discussed. It is well established in the scientific literature that there are many costs associated with production of electricity that are not captured in its market price. These costs are called "externalities," because they are external to the market and are costs incurred by certain populations or society in general. Examples of levelized cost factors that are associated with electricity production from coal include environmental degradation associated with mining activities, health effects associated with degraded air quality, and health impacts from consumption of fish contaminated with mercury that is emitted from combustion of coal.

According to Epstein et al. (2011), "accounting for the damages conservatively doubles to triples the price of electricity from coal per kilowatt hour (kWh) generated, making wind, solar, and other forms of nonfossil fuel power generation, along with investments in efficiency and electricity conservation methods, economically competitive." Thus, while we may pay $0.15 / kWh on our electric bill, the true costs that we pay (e.g., in health care) may be $0.25-$0.30/kWh.

References:
Botkin and Keller, 2010. Environmental Science, 7th Ed. Wiley & Sons, ISBN 9780470118559.

Department of Defense, February 2010. Quadrennial Defense Review Report. Available at http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf

International Panel on Climate Change, 2007. Climate Change 2007: IPCC Fourth Assessment Report. World Meterological Organization & United Nations Environment Programme.
http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf;
(http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml)

International Panel on Climate Change, 2001. Climate Change 2001: IPCC Third Assessment Report. World Meterological Organization & United Nations Environment Programme.

International Panel on Climate Change, 1995. IPCC Second Assessment. Climate Change 1995: A Report of the IPCC. World Meterological Organization & United Nations Environment Programme.

International Panel on Climate Change, 1990. Climate Change: IPCC First Assessment Report. World Meterological Organization & United Nations Environment Programme.

Wake, Cameron P., Burakowski, E., Kelsey, E., Hayhoe, K., Stoner, A., Watson, C., & Douglas, E. 2011. Climate Change in the Piscataqua / Great Bay Region: Past, Present, and Future. Carbon Solutions New England, University of New Hampshire.

Withgott and Brennan, 2011, Environment: The Science Behind the Stories, 4th Ed., Benjanmin Cummings, ISBN 9780321715340.

Paul R. Epstein, Jonathan J. Buonocore, Kevin Eckerle, Michael Hendryx, Benjamin M. Stout III, Richard Heinberg, Richard W. Clapp, Beverly May, Nancy L. Reinhart, Melissa M. Ahern, Samir K. Doshi, and Leslie Glustrom. 2011. Full cost accounting for the life cycle of coal in "Ecological Economics Reviews." Robert Costanza, Karin Limburg & Ida Kubiszewski, Eds. Ann. N.Y. Acad. Sci. 1219: 73–98.

II. Historic Storm and Flood Hazards

Table 1. Historic Hazard Identification

Hazard	Date	Location	Remarks	Source
Past or Potential Flooding Hazards: Riverine flooding is the most common disaster event in the State of New Hampshire (aside from frequent inconveniences from rather predictable moderate winter storms). Significant riverine flooding impacts upon some areas in the State in less than ten year intervals. The entire State of New Hampshire has a high flood risk.				
Flooding	March 1936	State-wide	Worst flooding in NH history. In Durham roads were repaired due to flood damage (10 workers).	"Raging Rivers and the WPA" by William P. Fahey. New Hampshire Administrator.

Hazard	Date	Location	Remarks	Source
				October 1936.
Flooding	Recurrent	Route 108 where Lamprey River runs along road	Regularly floods during large rainfall events; state road, so is NHDOT's responsibility to fix it	Durham Hazard Mitigation Committee
Flooding	July 1973	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties	Severe storms, flooding	FEMA Disaster Declaration #399
Flooding	March 1987	Carroll, Cheshire, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, Sullivan Counties	Severe storms, flooding	FEMA Disaster Declaration #789
Flooding	October 1996	Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties, NH.	Severe storms, flooding	FEMA Disaster Declaration #1144
Flooding	May 2006	Belknap, Carroll, Hillsborough, Merrimack, Rockingham, and Strafford Counties.	Severe storms and flooding	FEMA Disaster Declaration #1643 *(Individual Assistance)* & Local Knowledge
Flooding	April 16-27, 2007	Grafton, Hillsborough, Merrimack, Rockingham, and Strafford Counties.	During this event, which lasted approximately 6 days, many roads in Durham were closed or damaged by flooding. The roads that most affected residents and travel were Bennett Road and Longmarsh Road. These closures affect travel times for residents and due to various detours may	FEMA Disaster Declaration #1695 *(Individual and Public Assistance)* &

Hazard	Date	Location	Remarks	Source
			increase the number of people traveling on these roads to around 17,000. We are assuming using previous (2006) data that approximately 120 residents were stranded in the Bennett Road in the Cold Springs area	Local Knowledge
Flooding	March 14-16, 2010	Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties.	Flooding started on March 14, 2010 and continued for a number of days. The Hamel Brook rose substantially resulting in the flooding and closure of Route 108, parts of Bennett Road and Longmarsh Road. This 100-year storm was not declared.	FEMA Disaster Declaration #1892 *(Public Assistance)* & Local Knowledge
Past or Potential Wildfire Hazards: New Hampshire is heavily forested and is therefore vulnerable to wildfire, particularly during periods of drought. The proximity of many populated areas to the state's forested lands exposes these areas their populations to the potential impact of Wildfire.				
Forest Fire	1990's	Open land along south edge of Woodridge development, west-central Durham	No structural losses, only forest damage	Durham Hazard Mitigation Committee
Past or Potential Tornado, Downburst (Wind Shear) & Hurricane Hazards: Tornados are spawned by thunderstorms and, occasionally by hurricanes, and may occur singularly or in multiples. A downburst is a severe localized wind blasting down from a thunderstorm. Downburst activity is very prevalent throughout the State, yet most go unrecognized unless significant damage occurs. Hurricanes develop from tropical depressions, which form off the coast of Africa. New Hampshire's exposure to direct and indirect impacts from hurricanes is real, but modest, as compared to other states in New England.				
Hurricane	September 1938	Town-Wide	Winds blow down trees closing roads, loss of electricity.	Durham Hazard Mitigation Committee
Hurricane Carol	November 1954	Town-Wide	Winds blow down trees closing roads.	Durham Hazard Mitigation Committee
Hurricane Bob	August 1991	State-wide	Hurricane Bob, Severe storm	FEMA Disaster Declaration #917
Thunder	June 2001	Western Durham	Brought down power lines and felled large trees,	National Climatic Data

Hazard	Date	Location	Remarks	Source
Storm/Wind			closing roads between Durham and Lee	Center website (NCDC 2005)
Severe Storm Event	July 2008	Belknap, Carroll, Merrimack, Rockingham, and Strafford Counties	Severe storms, Tornado, and Flooding	FEMA Disaster Declaration #1782
Wind Storm	February 2010	Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties.	Power outages in some areas. Property damage. Schools were closed for a few days.	FEMA Disaster Declaration #1892 *(Public Assistance)* & Local Knowledge
Tropical Storm Irene	August 2011	Belknap County, Carroll, Coos, Grafton, Merrimack, Strafford, and Sullivan Counties	Tropical Storm Irene	FEMA Disaster Declaration #4026
Past and Potential Severe Winter Weather Hazards: Severe weather in New Hampshire may include heavy snowstorms, blizzards, Nor'easters, and ice storms. Generally speaking, New Hampshire will experience at least one of these hazards during any winter season. Most New Hampshire communities are well prepared for such hazards.				
Snowstorm	March 1993	New England	Snow removal.	FEMA Emergency Declaration # 3101,
Ice Storm	January 1998	NH – Statewide; Durham – various locations	Major tree damage, electric power interrupted for many days. Schools were closed. Extensive damage to trees.	Committee and FEMA Disaster Declaration # 1199
Snowstorm	March 2001	Cheshire, Coos, Grafton, Hillsborough, Merrimack, Rockingham, and Strafford Counties, NH.	Incident Period: March 5th – 7th. Public Assistance. (Assistance to State and local governments and certain private nonprofit organizations for emergency work and the repair or replacement of disaster-damaged facilities).	FEMA Emergency Declaration #3166.

Hazard	Date	Location	Remarks	Source
Winter Storm	February 2003	Cheshire, Hillsborough, Merrimack, Rockingham, and Strafford Counties, NH.	Incident Period: February 17th – 18th. Public Assistance. (Assistance to State and local governments and certain private nonprofit organizations for emergency work and the repair or replacement of disaster-damaged facilities).	FEMA Emergency Declaration # 3177.
Snowstorm	January 2005	Belknap, Carroll, Cheshire, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties, NH.	Incident Period: January 22nd – 23rd. Public Assistance. (Assistance to State and local governments and certain private nonprofit organizations for emergency work and the repair or replacement of disaster-damaged facilities).	FEMA Emergency Declaration # 3207.
Snowstorm	March 2005	Belknap, Carroll, Cheshire, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan	Incident Period: January 22nd – 23rd. Public Assistance for 48 hours. Minor Impact.	FEMA Emergency Declaration #3207 *(Public Assistance)*
Ice Storm	December 11-16, 2008	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan Counties.	Durham received over 3/4 inch of ice, multiple hours of rainfall/freezing rain and snow during the December ice storm. Durham had to close fourteen roads, some multiple times, for several days due to falling tree limbs and downed utility wires, which created public safety issues during this disaster.	FEMA Disaster Declaration #1812 *(Public Assistance)* & Local Knowledge
Snowstorm	December 2008	Belknap, Carroll, Cheshire, Coos, Grafton, Hillsborough, Merrimack, Rockingham, Strafford, and Sullivan	Incident Period: December 11th. Public Assistance for 48 hours. Minor Impact.	FEMA Emergency Declaration #3297 *(Public Assistance)*
Ice Storm	December 25-28,	Town-Wide	Multiple hours of freezing rain and ice.	Durham Hazard Mitigation

Hazard	Date	Location	Remarks	Source
	2010			Committee

Blue = Past Events Red = Recent & Potential Hazards

Source: Strafford Regional Planning Commission, 2012. Draft Hazard Mitigation Plan.

III. Regional, State, and Local Efforts to Date

The mainstream global scientific community holds a broad consensus that greenhouse gas emissions from the combustion of fossil fuels are a predominant contributor to well-documented global climate change trends (IPCC, 2007).[12] In acknowledgement of that view, residents across New Hampshire voted in 2007 to adopt the New Hampshire Climate Change Resolution. In the past decade, there has been increased recognition of the fact that the burning of fossil fuels adds greenhouse gases to the atmosphere, causes warmer global temperatures, alteration of ocean and atmospheric circulation, extreme precipitation events, migration of storm tracks, and rising sea level. Although many factors affect the climate system, the balance of energy between the sun and the earth's surface is simple physics, known and very well understood for more than a century. The atmosphere is transparent to incoming sunlight (visible), but not to outgoing re-radiation (infra-red) due to the greenhouse effect. As we add CO_2 to the air, the air warms and can thus hold more water vapor, which in turn warms the air more, thus holding more water vapor, in a positive feedback cycle. Science has shown that climate is changing, that people have been the primary driver of observed 20th century climate change, and that we can stabilize climate if we stop burning fossil fuel burning (IPCC, 2007).

[1] According to the Union of Concerned Scientists (http://www.ucsusa.org/ssi/climate-change/scientific-consensus-on.html), the following scientific societies and scientists have released statements and studies showing the growing consensus on climate change science – American Association for the Advancement of Science, American Chemical Society, American Geophysical Union, American Institute of Biological Sciences, American Meteorological Society, American Physical Society, American Society of Agronomy, American Society of Plant Biologists, American Statistical Association, Association of Ecosystem Research Centers, Botanical Society of America, Crop Science Society of America, Ecological Society of America, Geological Society of America; National Research Council of the National Academies, Natural Science Collections Alliance, Organization of Biological Field Stations, Society for Industrial and Applied Mathematics, Society of Systematic Biologists, Soil Science Society of America, University Corporation for Atmospheric Research, US Climate Change Research Program, US National Academy of Sciences. In addition, the International Panel on Climate Change and the US Global Change Research Program endorse the finding that climate change is occurring and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver."

The March 13, 2007 ballot included a New Hampshire Climate Change Resolution. Durham voters adopted the Resolution 1,447 to 254. The following month, the Durham Town Council formed an Energy Committee to advise the Council on ways to reduce energy use, develop alternative energy sources, and increase the economic security and energy independence of the Town.

In 2009, the State responded by releasing the *New Hampshire Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future* (the "Action Plan") to identify and mitigate adverse trends throughout the state (NH DES, 2009). The following year, a private/public partnership, the New Hampshire Energy and Climate Collaborative (NHECC), was formed to track and facilitate implementation of the 67 recommendations of the Action Plan.

As a long-term goal, the Action Plan proposes that New Hampshire reduce its greenhouse gas emissions to 80% of the 1990 levels by the year 2050, with a mid-term goal of a 20% reduction below 1990 levels by 2025. To accomplish these goals, the Action Plan outlined a wide range of recommendations to: maximize energy efficiency in buildings, develop renewable energy sources, support regional and national initiatives, reduce total vehicle emissions through individual vehicle emission controls, optimize land use patterns to minimize vehicle-miles driven, and expand public transportation options.

The State also formed the Greenhouse Gas Emissions Reduction Fund (GHGERF) in 2008 to work with the Regional Greenhouse Gas Initiative (RGGI), a regional cap and trade program that specifically targets CO_2 emissions from fossil fuel electric power generation. Proceeds paid into the GHGERF are administered by the Public Utilities Commission (PUC) in New Hampshire. The RGGI funds a wide range of projects in the State enhancing energy efficiency, conservation, development of in-state energy sources, and reduce the export of energy dollars to other regions of the country and around the world. The PUC competitively awarded 36 grants for a total of $31.3 million in 2009 and 2010. A 2012 report shows that grants awarded by the GHGERF generated an annual energy use reduction of 182,800 million BTUs, 18,99 metric tons of CO_2, and a savings of more than $5 million to state businesses, communities, and residents in the second year of the program. The lifetime savings from the $18.1 million spent from the fund are projected to be $84.5 million in energy costs based on current energy prices. For every dollar invested by GHGERF there will be a return of $4.67 in energy savings over the lifetime of the projects.

In April 2007, the Durham Town Council formed the Durham Energy Committee to advise the Council on ways to reduce energy use, develop alternative energy sources, and increase the economic security and energy independence of the Town. In August 2008, New Hampshire amended the statute requiring municipalities to have a Master Plan to allow the addition of a new chapter on energy, to include "an analysis of energy and fuel resources, needs, scarcities, costs, and problems affecting the municipality and a statement of policy on the conservation of energy." In mid-2008, the Durham Planning Board asked the Energy Committee to draft an energy chapter for the updated Master Plan to guide town actions with respect to energy.

The Energy Committee conducted a greenhouse gas inventory to estimate the amount of energy Durham uses annually and to identify the attendant emissions from fuel consumption. This inventory became the first step in benchmarking efforts to reduce emissions over a longer period. The results indicated that the majority of greenhouse gas emissions are generated by the use of personal vehicles and for heating homes.

In 2010, the Energy Committee, UNH faculty and students, and Town departments completed a three-year profile of Durham's municipal energy use and converted data into a format that allows the NH Office of Energy Planning to compare the energy usage of New Hampshire communities.

Among several broader insights, the committee found that a relatively high proportion of Durham's municipal energy use was devoted to wastewater treatment, town vehicles, and inefficient buildings. On the upside, the data suggest potential savings from more active account management, including (1) working with wholesale energy providers and (2) energy generation, through joint ventures with UNH and/or municipal renewable energy production.

References:

International Panel on Climate Change, 2007. Climate Change 2007: IPCC Fourth Assessment Report. World Meterological Organization & United Nations Environment Programme.
http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf;
(http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml)

New Hampshire Department of Environmental Services, March 2009. The New Hampshire Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future, New Hampshire Climate Change Policy Task Force.

IV. Pillar 1. Architecture and Land Use

International and domestic climate policy discussions generally embrace the goal of limiting the temperature increase to 2°C to 3°C by cutting greenhouse gas emissions by 60 – 80% below 1990 levels by the year 2050. For the US to do that, we will have to do more than modify vehicle and fuel technology. We will have to sharply reduce the growth in vehicle miles driven. To do this, we must build more compactly, reversing decades of building and transportation trends. To meet this goal, we will need to reduce CO_2 emissions with vehicle fuel efficiency, reduce the carbon content of the fuel itself, and reduce the number of vehicle miles we travel (VMT).

Compact development involves somewhat higher densities, a mix of land uses, development of strong population and employment centers, interconnected streets, and structures and spaces that are designed at a human scale. It does not imply high-

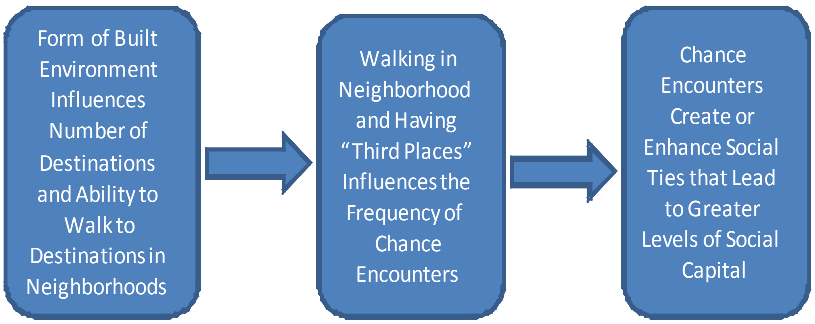
Since 1980, the number of miles Americans drive has grown three times faster than the US population and almost twice as fast as vehicle registrations. (Ewing, 2007) This increase in VMT is due in large part to the fact that we have built our homes farther from workplaces, schools, shopping, and recreation, based on the assumption that people will use cars virtually every time they travel. As we have become more automobile dependent, the number of car trips and the distances we travel have increased. At the same time, walking and use of public transit has decreased. Population growth has been responsible for only a quarter of the increase in VMT over the last couple of decades. Both increase in VMT and consumption of land for development has increased at a rate almost three times faster than population growth. (Ewing, 2007) Sprawling development has caused CO_2 emissions from cars to rise even as it has reduced the amount of forest land, a valuable carbon sink.

The body of research surveyed by Ewing et al (2007) shows that, with more compact development, people drive 20-40% less, at minimal or reduced cost, while reaping the other fiscal and health benefits."

One of those benefits of a walkable community may be the generation and maintenance of Durham's social capital, an important component of quality of life. Rogers et al (2010) undertook case studies of residents living in neighborhoods of varying built form and thus varying levels of walkability in three New Hampshire communities, including the Faculty and Longmarsh neighborhoods in Durham. Comparisons between the more walkable and less walkable neighborhoods show that there are strong differences in transportation behaviors, especially in the frequency of walking to destinations in the community, and that levels of social capital are higher in more walkable neighborhoods.

Social capital is defined as the "features of social organization, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions" (Putnam 1993, p. 167).

Figure 4. Logic Behind Possible Link Between Walkability and Social Capital



Logic behind the possible link between walkability and social capital

Source: Applied Research Quality of Life – Rogers, Shannon H., Halstead, J. M., Gardner, & K. H., Carlson, C. H. (2010). Examining Walkability and Social Capital as Indicators of Quality of Life at the Municipal and Neighborhood Scales. The International Society for Quality-of-Life Studies (ISQOLS).

By building mixed use developments that site homes close to other destinations, interconnecting streets rather that cul-de-sacs that direct traffic onto overused arterial roads, "complete streets" with safe and convenient places to walk, bicycle, and wait for the bus, using and redeveloping vacant lots and "brownfields," revitalizing traditional town centers and downtowns, building more condominiums, townhouses, and detached houses on smaller lots and build offices, stores, and other destinations 'up' rather than 'out,' communities can shorten distances between destinations, make neighborhood stores more economically viable, allow more frequent and convenient transit service, and shorten car trips. (Ewing 2007)

Ewing et al cited a study by Larry Frank of the University of British Columbia, which found that residents of the most walkable neighborhoods drive 26% fewer miles per day than those living in developments with twice the density, diversity of uses, accessible destinations, and interconnected streets. The most walkable neighborhoods drive 33% less than those who live in areas of low-density sprawl.

Ewing et al found that compact development will reduce the need to drive between 20 – 40%, realistically assuming a 30% cut in VMT. "Making reasonable assumptions about growth rates, the market share of compact development, and the relationship between CO_2 reduction and VMT reduction, smart growth could, by itself, reduce total transportation-related CO_2 emissions from current trends by 7-10% as of 2050. This reduction is achievable with land-use changes alone." This estimate does not account for the impact of higher fuel prices and carbon taxes, peak-period road tolls, pay-as-you drive insurance, paid parking, other measures to make drivers pay more of the full social costs of auto use, energy saved in buildings with compact development, CO_2 absorbing capacity of forests preserved by compact development.

Ewing et al calculate that shifting 60% of new growth to compact patterns would save 85 million metric tons of CO_2 annually by 2030.

Durham can significantly reduce the number of miles traveled by residents in private vehicles through close attention to siting of new development close to already developed areas, increasing density of settlement, mixing uses, expanding access to pedestrian and bicycle routes that link to the downtown, and by requiring amenities that support mass transit. Innovative and emerging technologies, including green building technologies that seek to not only minimize damage to the environment but result in net benefits, and the expansion and creation of traditional neighborhoods near the core of the community hold promise for energy savings as well as support for a vibrant downtown. Conservation and open space goals must be balanced with the improved energy and resource efficiency of smaller, denser development close to the community's core. [3]

In addition to regulating or providing incentives specific to the location and siting of dwellings to optimize energy conservation and efficiency, Durham must continue to encourage the highest level of building code enforcement and energy efficiency best practices in architecture and construction. In New England, beyond transportation, the largest portion of energy consumption goes to heat homes and businesses. Much of this heat comes from fossil fuels, including relatively inefficient and costly heating oil.

As the Town courts new businesses, reviews land use and development plans, approves building permits, and revises zoning and building codes, it should seek to shape municipal, residential, and commercial development and redevelopment that maximizes energy efficiency, contributes less environmental pollution, and reduces the need for motorized vehicles for daily activities.

Tools the Town might use to support a goal of 60% of new growth in compact patterns include:

- Density transfer tools, like transfer of development rights (TDR) or modified TDRs

---

[3] Compact residential development makes efficient use of the site with smaller lots and buildings that often have a smaller footprint on the property than a more sprawling pattern that covers more surface area. Building "compactly" often creates a more walkable neighborhood.

- Downtown revitalization and expansion
- Form based code
- Traditional neighborhood design (TNDs)
- Lot size averaging.

References:

Ewing, Reid, Bartholomew, K., Winkelman, S., Walters, J., & Chen, D., 2007. Growing Cooler: The Evidence on Urban Development and Climate Change. Urban Land Institute, Smart Growth America, Center for Clean Air Policy, National Center for Smart Growth Research & Education.

Putnam, R. D., 1993. Making Democracy Work: Civic Traditions in Modern Italy. Princeton University Press.

Rogers, Shannon H., Halstead, J. M., Gardner, & K. H., Carlson, C. H., 2010. Examining Walkability and Social Capital as Indicators of Quality of Life at the Municipal and Neighborhood Scales. The International Society for Quality-of-Life Studies (ISQOLS).

New Hampshire Department of Environmental Services, NH Association of Regional Planning Commissions, NH Office of Energy and Planning, & NH Local government Center, 2009. Innovative Land Use Planning Techniques: A Handbook for Sustainable Development; Multi-Density Zoning.

V. Traditional Neighborhood Design

People often think that cluster or conservation development is the same as compact or traditional neighborhood development (TND). While the two design approaches have some elements in common – primarily smaller house lots, they really are approaches that are most appropriate in different areas of the community.

Conservation subdivisions are characterized by relatively compact lots and common open space where the natural features of land are maintained to the greatest extent possible. In return for smaller lot sizes than what would be required for conventional subdivisions, residual land is protected as common open space. The result is a development that may not exceed the overall density of a conventional project, and which can conserves a significant amount of land. Conservation development is one way to accommodate development in suburbanizing and rural areas in a way that is less erosive of rural visual character than are conventional subdivisions.

Compact development or a TND also has smaller lot sizes, but open space is designed into the neighborhood through active and passive park areas, the streetscape, and individual yards. Compact development or TNDs are most appropriate in intown locations, within walking distance of a downtown, school, or other civic center.

A Guide to Livable Design: The Great American Neighborhood describes traditional neighborhoods as follows. (SPO, 2004)

- **They are compact, safe, and walkable** from end to end. A walkable neighborhood is defined by the distance a person can walk in about 10 minutes. People are less likely to think of areas further away as part of their neighborhood.
- **They offer elements of surprise, variety, and variability.** They have a diversity of housing types and a mix of neighborhood uses. Homes are attractive and well sited on reasonably sized lots with private outdoor spaces. Lot sizes often vary to cater to two or more market segments. Differences in building design, architectural detail, landscaping, and side yard setbacks break the mold of a cookie cutter pattern. Unique and varied treatments of side yards surprise and delight the senses as one traverses the streetscape.
- **There is a network of interconnected streets with few dead ends.** Streets are narrow and designed to minimize speeding and shortcuts. Local streets do not carry through traffic. They also have strong links – via sidewalks and trails – to adjoining neighborhoods, schools, shopping areas, and parks.
- **They have a recognizable identity and boundaries** that separate one neighborhood from another. They may also have a green or a crossroad with civic buildings, community center, and/or small shops and services, that are readily recognizable and often gives the neighborhood its identity.
- **They have a human scale** that makes people feel comfortable in them. Civic amenities, landscaped streets, shaded sidewalks, and open space enrich the quality of life in these neighborhoods.
- **They provide for both chance meetings and personal privacy** through their street, pedestrian network, and lot design. The 'public face' of most houses (front door, porch, front yard) faces the street, increasing the opportunity for chance meetings with neighbors. These are also places for planned meetings, from common greens to public community centers. Back yards are private.
- **The offer a connection to nature** through a consciously designed open space system. The open space system is made up of formal elements (tree lined streets, walkways, parks, greens), recreational elements (playgrounds, fields, courts), and informal elements (trails, buffer zones, wildlife habitat, preserved natural feature, scenic views). All three types of open space are critical to creating a 'livable' neighborhood that balances the public with the private, the convenient access of town with the restorative power of nature, the best of the city with the contemplative tranquility of the country."

Original work, done in Falmouth, ME by Planning Decisions, Terrence J DeWan & Associates, and Spatial Alternatives, illustrates four different development patterns. The analysis offers a way to think about different development patterns for Durham.

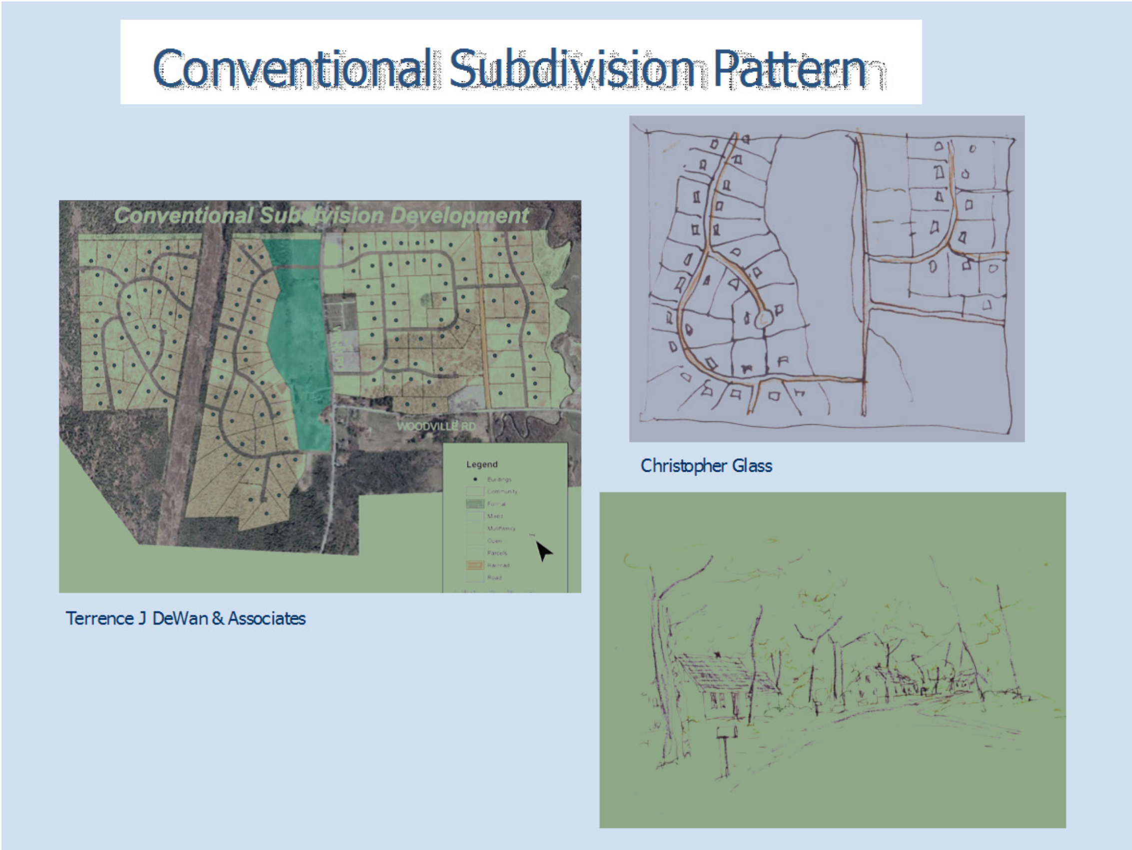
Figure 5. Alternative Development Patterns

Source: Terrence J DeWan & Associates, Yarmouth, ME

The first image is a build-out analysis of a large section of Falmouth, ME, although it could be almost any community. The road and home locations were determined by an assessment of grades, wetlands (shown in olive), sight distance, maximum length of dead-end road requirements, and zoning ordinance.

Potential development of the same area is illustrated using four different design approaches – Conventional, Conservation/Cluster, County Estates, and Compact. The result is the same number of housing units, but varying percentages of land retained in open space.

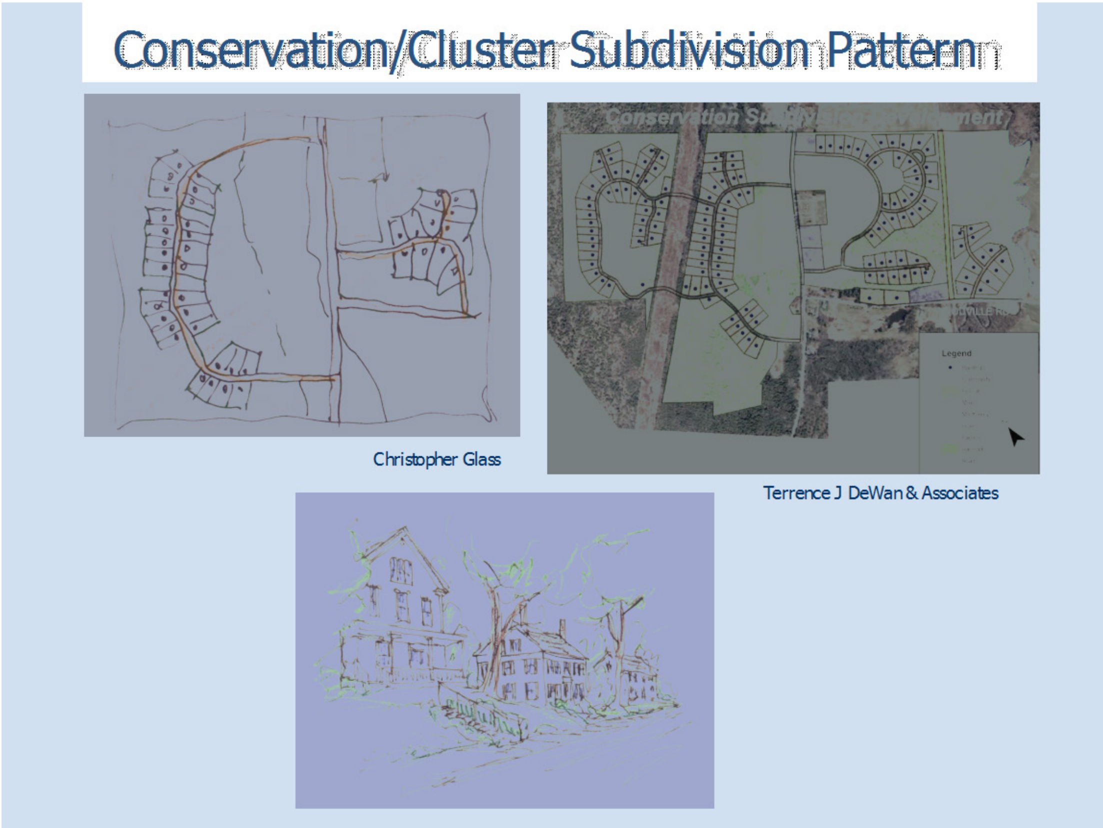
Figure 6. Conventional Subdivision Pattern



Source: Terrence J DeWan & Associates, Yarmouth, ME

The conventional approach uses a standard two acre house lot (or 80,000 sq. ft.). Given Falmouth's desire to preserve open space for view corridors, two pods of development are separated by the green area).

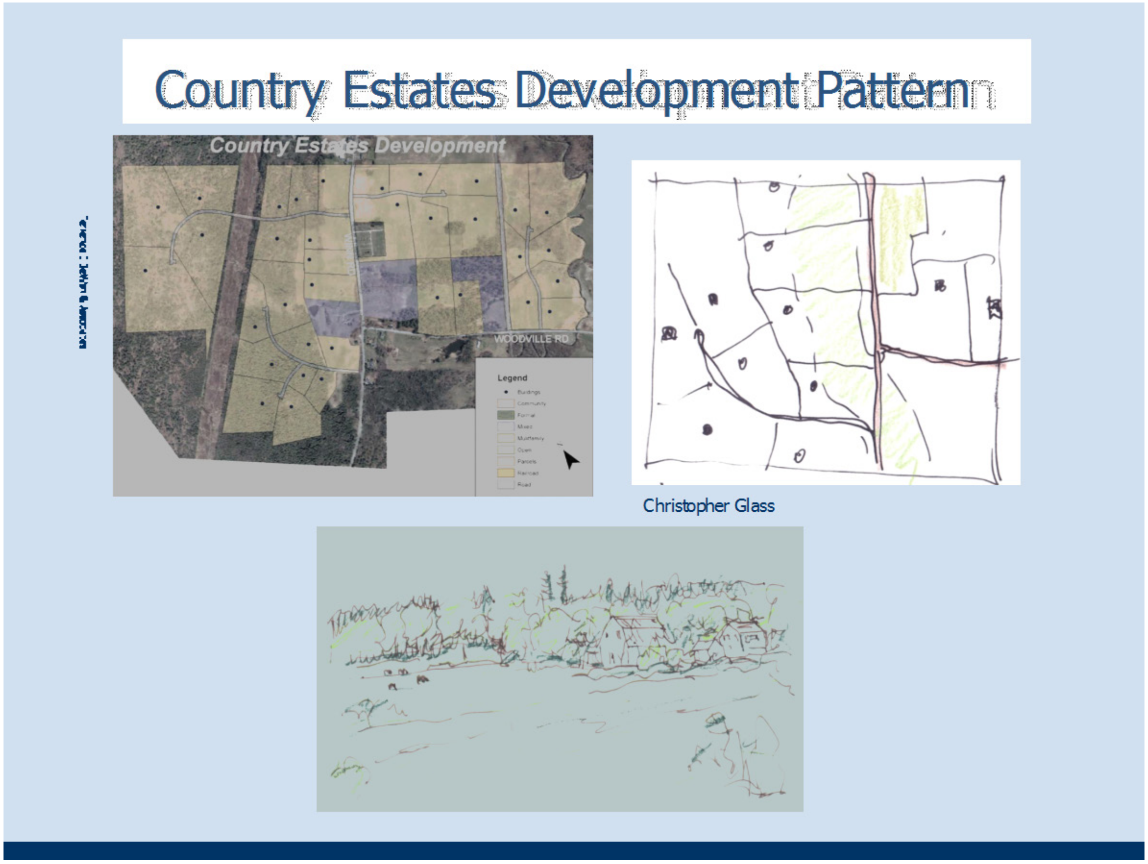
Figure 7. Conservation/Cluster Subdivision Pattern



Source: Terrence J DeWan & Associates, Yarmouth, ME

Under a conservation or cluster subdivision approach, the number of house lots remains the same as in the conventional approach, but lot sizes are reduced (in this case to one acre). The resulting open space may be used to continue agricultural operations, forest management, wildlife habitat, and recreational open space.

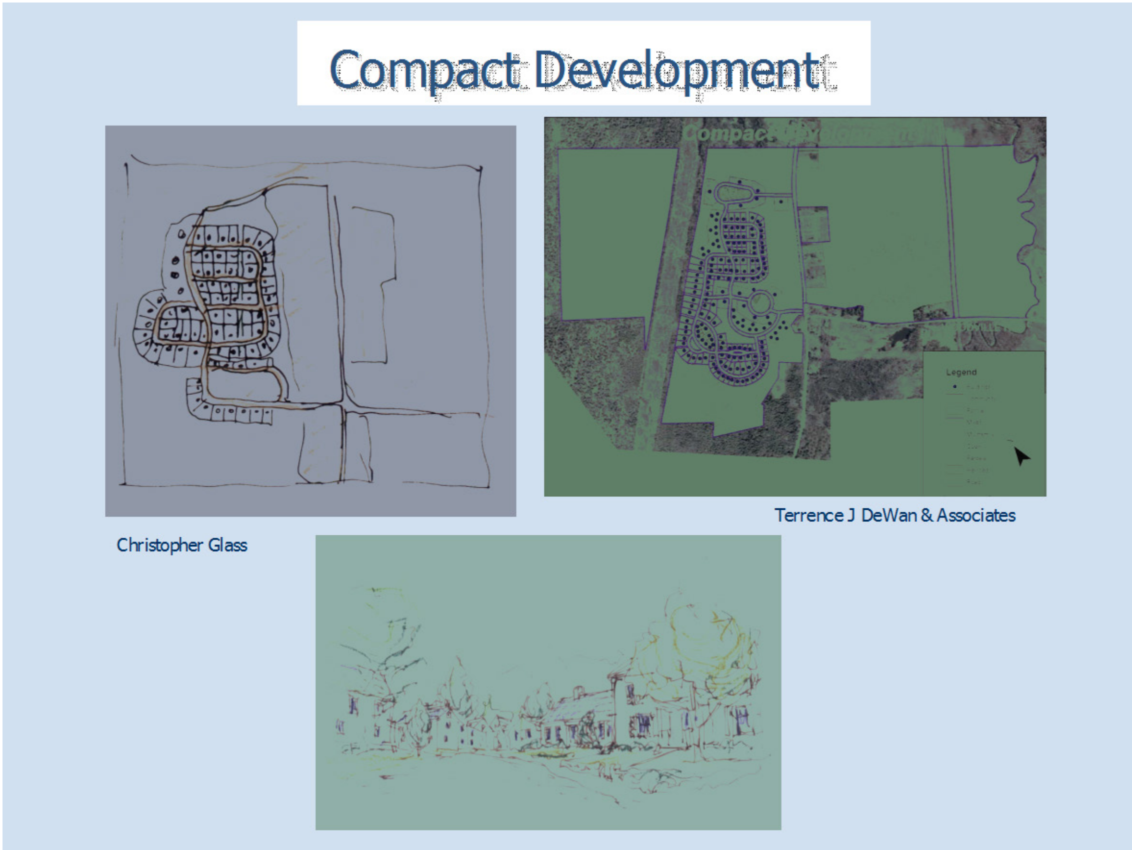
Figure 8. Country Estates Development Pattern



Source: Terrence J DeWan & Associates, Yarmouth, ME; Christopher Glass, Camden, ME.

Country Estates are ten± acres of land, with no common open space. Roads may be private and gravel, so there is no burden on the community to maintain them. With proper siting, the homes can be situated so they are out of sight, preserving the visual rural character of the landscape. Without proper planning, homes may be placed in the middle of fields or in other visually inappropriate locations.

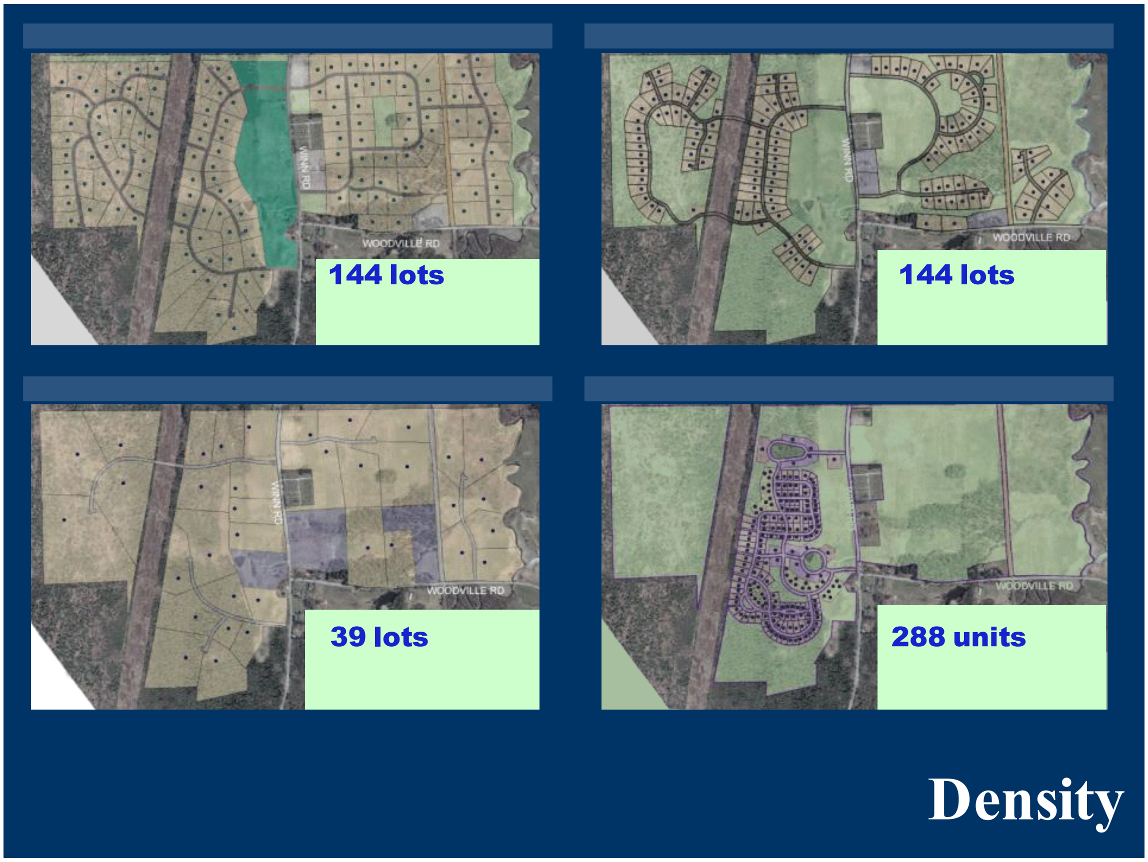
Figure 9. Compact Development



Source: Terrence J DeWan & Associates, Yarmouth, ME; Christopher Glass, Camden, ME.

Compact development may include mixed use or small, neighborhood oriented retail, for example, a corner store or laundromat, following the principles of traditional neighborhood development, or it may be made up exclusively housing. Density can be significantly increased over single lot subdivisions by incorporating multiplex housing.

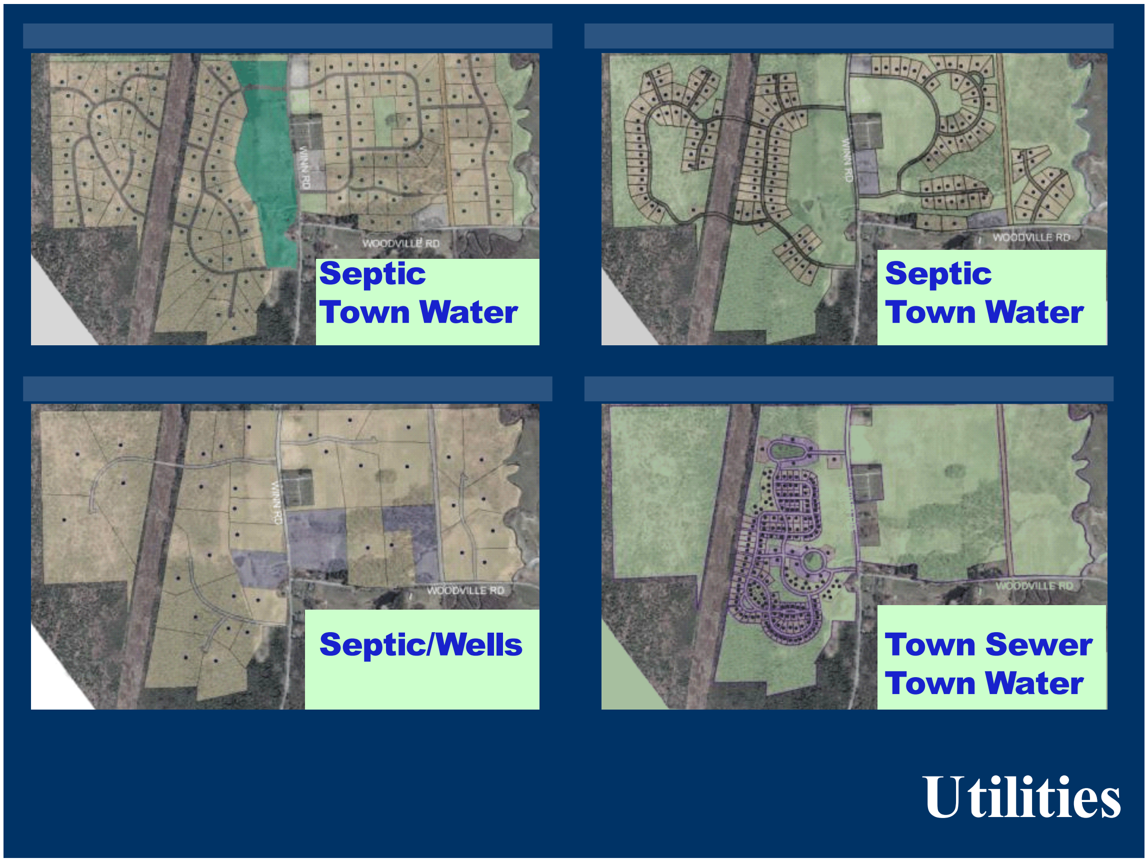
Figure 10. Comparison of Density



Source: Terrence J DeWan & Associates, Yarmouth, ME.

These charts compare the four approaches for 478 acres, following the principles outlined earlier.

Figure 11. Comparison of Utilities



Source: Terrence J DeWan & Associates, Yarmouth, ME.

Note that most of these development approaches only work at the specified density with municipal services or community systems. With community wells and wastewater systems, lot sizes may be reduced to the ½ acre range.

Figure 12. Comparison of Land Use

Source: Terrence J DeWan & Associates, Yarmouth, ME.

Mixed use may include a number of different types of housing (such as senior/retirement community, garage apartments, mid-rise, garden apartments, townhomes, apartments over commercial space, live/work units, etc.).

References:

DeWan, Terrence J. & Associates; Kent, B., 2004. A Guide to Livable Design: The Great American Neighborhood. Maine State Planning Office.

VI. Municipal Buildings – Energy Efficiency, Emissions, and Costs

Town-Owned Facility Energy Use

The Town has recently taken steps to identify and track the energy use at all of its facilities to assess areas where management or efficiency improvements could lower the Town's energy use. The Town's Energy Committee provided assistance with compiling this data with the help of University of New Hampshire graduate students, the Strafford Regional Planning Commission and the New Hampshire Energy Technical Assistance & Planning Program (ETAP).

Finally, through the ETAP program an energy audit at Town-owned facilities was performed in 2011 and resulted in a report of "Energy Efficient Opportunities for Town Buildings in Durham, New Hampshire," published in February 2012.

Summary of Town-Owned Facility Energy Usage and Costs

The town buildings use electricity, oil and natural gas as the primary utility supply. The wastewater treatment plant uses propane to heat the dewatering building. Electricity is supplied by Public Service of New Hampshire (PSNH) and distributed in facilities at 208 volts, three phases in most town facilities. The average cost of electricity for recent twelve month period (2011) was $0.12/kWh. The average cost of heating oil in 2011 was $3.13/gallon. The average cost of natural gas was $1.37/Therm. The average cost of propane at the wastewater treatment plant was $2.23/gallon.

The data collected by the Town for energy usage and uploaded to ETAP program encompasses the 2008 to 2011 time period. After review of this data it was determined that the data collected for 2011 was the most comprehensive and thus, would provide a good baseline for town facility usage and comparison of improvements moving forward. The following is a summary of this data by facility and type of energy used:

Table 2. Municipal Facility Energy Usage, 2011

Facility	Electric Kwhrs	Electric Cost	Oil Gallons	Oil Cost	Gas Therms	Gas Cost	Propane Gallons	Propane Cost
Town Hall*	3,606	$1,066	3,915	$12,378				
District Court	10,054	$1,726	1,745	$5,465				
Street Lights	61,037	$8,309						
Public Works	68,534	$8,725			6,815	$9,440		
Transfer/Recycling	18,919	$3,679	1,503	$4,624				
WstWtr Treatment	1,454,800	$157,698					4,870	$10,853
WstWtr Pump St	12,075	$2,594					1,306	$2,891
Lee Water Well	117,342	$17,518						
Wtr Boost Pumps	24,105	$3,755						
Water Tanks	7,656	$1,523						
Police Station	4,919	$912			2,457	$3,317		
Hockey Rink	221,116	$31,059						
Misc. Facilities*	25,306	$5,090						

* Miscellaneous facilities include; 11 School House, Smith Chapel Fund, Wagon Hill, Metered Parking Lot, Flashing street light, and the Library (the current Library only pays for electricity, heating is included in the lease agreement). Some electrical use data is missing from Town Hall.

Source: Durham Energy Committee, 2012.

The two town facilities that utilize the most energy are the wastewater treatment facility and the Hockey Rink. According to discussions with Public Works staff the wastewater use is necessary to pump and treat the waste going through the facility and that compared with other wastewater systems they use only 13% of their overall operating budget for this component, versus an industry average of 30%. The recent replacement of blowers at the facility with high efficiency units has helped to keep usage down.

The Hockey Rink is also a large user of electricity. Exploring opportunities to reduce its energy consumption could have merit. According to Plymouth State University's website, their new Ice Arena will be built to meet LEED Silver standards by installing sophisticated geothermal heating/cooling design to maximize energy conservation opportunities. It is projected that this technology will reduce their energy consumption by approximately 30 percent over a traditional arena. The combination of geothermal and the capture of waste heat generated by ice making equipment will provide the heat for the facility thereby removing reliance on traditional fuel-based heating system.

The Town Hall is the largest user of heating oil. A discussion of potential ways to reduce its consumption was included in the energy audit performed in 2011 by ETAP.

Energy Efficiency Opportunities for Town Buildings

Peregrine performed an Energy Opportunity Assessment in 2011 to guide the Town in developing and implementing an energy reduction strategy. The assessment included specific recommendations and next steps to reduce energy use and increase energy efficiency. It also provided summary information on the buildings with recommendations that can provide a starting point for securing bids from installation contractors for suggested projects. Peregrine estimated that several specific improvements will result in significant energy reduction and that those improvements would save the Town approximately $8,000 per year.

A copy of this Assessment was presented to the Town in February 2012. It is recommended that the Town proceed with pursuing the recommended upgrades as presented in the report. For those that can be included as routine maintenance items it is recommended that they be done as soon as possible. For those that will take more time and funding it is recommended that the Town include them as items in future Town annual budgets.

VII. Agriculture

Produce grown outside and brought into the region incurs significant energy and transportation costs. Conventionally produced products often depend on petroleum-based fertilizers and pesticides. Increasing access to locally grown produce potentially could reduce dependence on fossil fuels.

Organic farming sequesters atmospheric carbon and nutrients in soils, offering a powerful tool in reducing the impact of carbon emissions. The Rodale Institute's 23-year Farming Systems Trial® (FST) compared organic and conventional cropping systems and demonstrated that organic/regenerative agriculture systems effectively reduce carbon dioxide. In addition to being a significant carbon sink, organic systems use about 1/3 less fossil fuel energy than that used in conventional corn/soybean cropping systems.

References:

Hepperly, Paul. 2012. Organic Farming Sequesters Atmospheric Carbon and Nutrients in Soils, The New Farm® The Rodale Institute.

VIII. Pillar 2. Transportation

Transportation accounts for a significant portion of Durham's annual residential and municipal energy use and cost. Through appropriate planning, Durham can reduce transportation costs and carbon emissions and enhance the quality of residents' lives. In 2008, the Greenhouse Gas Emission inventory for the Town of Durham determined that approximately 43% of the Town's greenhouse gas emissions come primarily from residents driving in personal vehicles.

Bicycle and pedestrian transportation is a healthy, low cost mode of travel that is available to almost everyone in Durham. However, through the years, with more motor vehicles occupying the Town's streets, riding a bicycle and walking has become more of a challenge. Recognizing this fact, both the Town and the UNH community have taken efforts to address this problem. UNH has added bicycle trails to its transportation network and improved its walkways and crosswalks. Likewise, the Town recently created bicycle lanes on some roads and worked toward calming traffic with additional stop signs and speed tables in the center of Town. However, there is much yet to be done to truly make Durham a bicycle and pedestrian friendly community. Congested intersections in the center of Town are difficult to cross on foot and maneuver through with a bicycle. And roadway linkages between surrounding communities are generally dangerous because there is often no space delineated for bicycles and pedestrians.

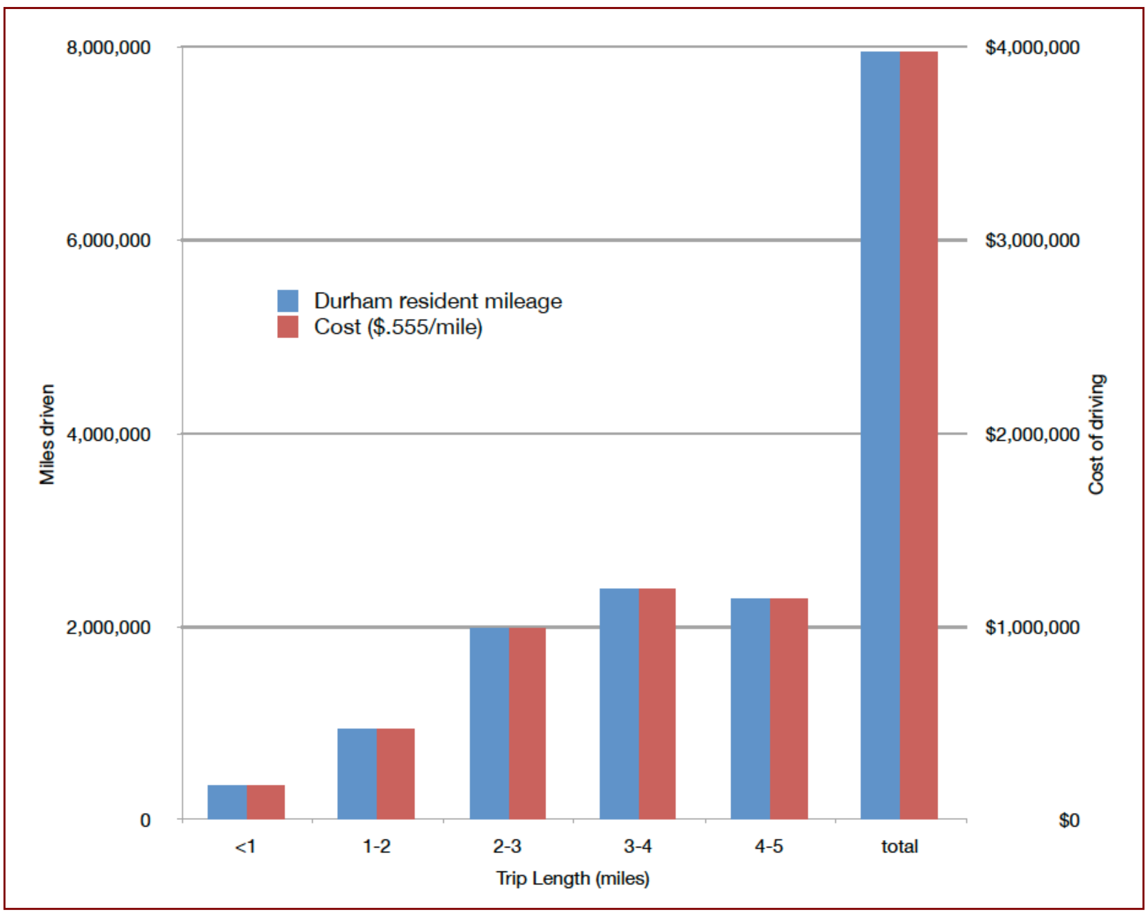
According to the American Association of Highway and Transportation Officials (AASHTO), "Surveys show that people support bicycling because it makes neighborhoods safer and friendlier, saves on motorized transportation costs, provides a way to routinely get physical activity, and reduces transportation-related environmental impacts, emissions, and noise. Bicycling increases the flexibility of the transportation system by providing additional mobility options, especially for short-distance trips that are too far to walk and too close to drive. Bicycle transportation is particularly effective in combination with transit systems, as when used together, each expands the range of the other mode. Bicycling is also the most energy-efficient form of transportation available. For communities working to address a wide range of issues from traffic congestion to climate change, bicycling is a transportation solution that works at both local and global levels." (AASHTO, 2010)

Likewise, Durham's Master Plan Survey showed overwhelming support for alternative modes of transportation. Of the 391 responses to the question about pedestrian and bicycle friendliness, 52% said that it was very important and 30% said that it was somewhat important. When asked about sidewalks, 73% responded that they were somewhat or very important. They also supported better crosswalks and "better biking and walking access to the downtown from where I live."

UNH performed a Transportation Survey in 2011. One of its goals was, "To improve sustainability (by encouraging alternative transportation: walking, biking, carpools, public transit, etc.)". UNH compared data from surveys done in 2001, 2007, and 2011. With respect to modes of transportation, the percentage of faculty and staff that commuted to campus via bicycling/walking increased from 2 to 7%, while students use of bicycling/walking for their commutes rose from 2% to 17%.

To understand the impact that changes in transportation in Durham might have, an analysis was conducted using the 2009 National Household Transportation Survey ("NHTS") and 2010 Census Data. Using national figures for single-vehicle transportation behavior and population (the 2010 figure for Durham was 10,345), Figure 5 shows the number of miles driven for various trip lengths.

Figure 13. Durham Drivers Estimated Mileage and Costs

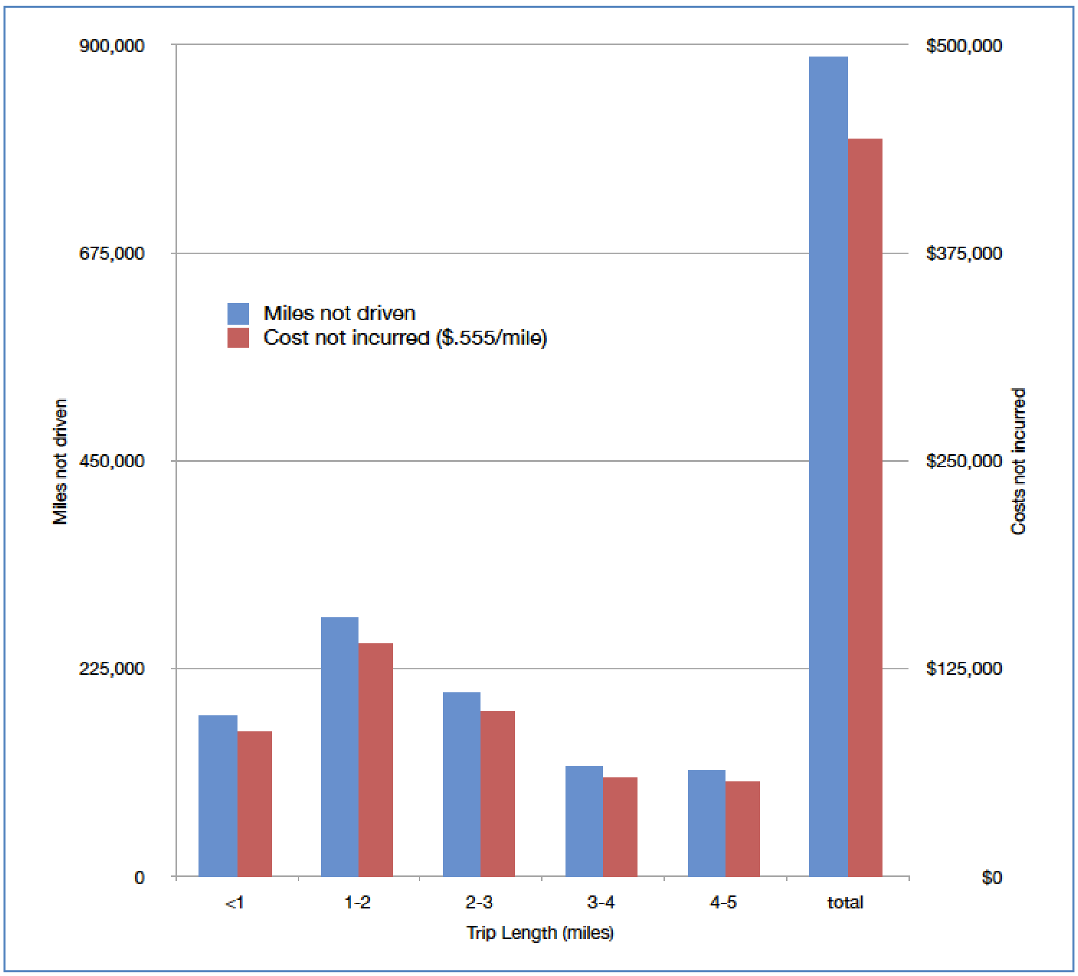


Source: 2009 National Household Transportation Survey; 2010 Census.

For example, approximately 930,000 miles per year are driven by Durham residents for trips of between only 1 to 2 miles in length, and 2 million miles per year are driven for trips of between 2 to 3 miles. Costs associated with driving only reflect the direct fixed and variable costs of driving automobiles, such as purchase, insurance, maintenance, and fuel. They omit social and health costs. Based on automobile use reimbursement cost data is from the Internal Revenue Service, gasoline usage associated with trips of 1 to 5 miles is $1.1 million per year (390,000 gallons per year with an average fuel economy of 20.4 mpg at $3.00/gallon) and the associated release of 3,475 metric tons of CO_2.

The potential for reducing vehicle miles for short trips by bicycling or walking is greater than it is for longer trips, with bicycling or walking replacing 50% of trips of than 1 mile, 30% of trips of 1-2 miles, 10% of trips of 2-3 miles, and 5% of trips of 3-5 miles. These results are illustrated in Figure 6. The cumulative impact of such trip replacements has the potential to reduce driving around Town by approximately 900,000 miles per year, saving Durham residents on the order of $500,000 per year in driving costs and reducing greenhouse gas emissions by 390 metric tons per year.

Figure 14. Durham Potential Mileage and Cost Savings



Source: 2009 National Household Transportation Survey.

The obviously conclusion is that many of these trips are very short in distance and yet costly in terms of fuel and carbon emissions. Since many of Durham's transportation patterns are rooted in its fundamental suburban, semi-rural setting and the nature of the regional economy, this Chapter will focus on aspects of this complex issue that are amenable to change over time through municipal planning and public education.

Given the improvements that the Town and UNH have already made, the potential positive impact, the support and expressed desires of the community, Durham should continue to upgrades its transportation infrastructure to improve bicycling and walking options. Opponents will often argue that these modes of transportation do not pay their way because they do not pay gasoline taxes, a major source of highway funding. However, town property taxes fund a good portion of Durham's roadway maintenance and improvements, roads that should accommodate all the ways that Durham residents choose to travel. Therefore, the Town should endeavor to make sure that when roadway projects and budgets are put forward, that a portion of the funding be dedicated to bicycle and pedestrian infrastructure.

Minneapolis, Minnesota Mayor, R.T. Rybek, was recently quoted in Jay Walljasper's *Yes Magazine* article that, "In these lean economic times, cities need to be creative about how they spend transportation dollars. Big-ticket engineering projects to move ever more cars must give way to more efficient projects that move people by a variety of means—including foot, bike, transit. "We need to get more use from all the streets we already have," Rybak said. "It really is the idea that bikes belong." (Walljasper, 2011)

The article goes on to describe how Minneapolis has transformed its city into a bicycle-friendly community. "Minneapolis is committed to creating separate rights-of-way for bikes (i.e. keeping them a safe distance from cars) wherever feasible. Research shows that most people—including many women, families, and older citizens—are wary of biking alongside motor vehicles on busy streets. Having the option to ride apart from heavy traffic encourages more people to try out biking as a form of transportation." It goes on to add that, "Statistics show that as the number of riders rises, their safety increases. Shaun Murphy, Non- Motorized Transportation Program Coordinator for the city of Minneapolis, notes that, though bicycle ridership is much higher, your chances of being in a car vs. bike crash in the city are 75 percent less than in 1993." Walljasper concluded his article by saying that, "even people who haven't ridden a bike in years cheered when Minneapolis was named America's #1 biking city—biking has now become part of our positive self-image."

Durham should also recognize that long-term improvements to their pedestrian and bicycle infrastructure may be accomplished through leveraging regional partnership and cooperation. The 2005 Strafford Regional Master Plan outlines the region's goals looking toward 2020. Regarding transportation it states that, "Choices and safety in transportation will be provided to create livable, walkable communities that increase accessibility for people of all ages, whether on foot, bicycle, or in motorized modes." (Strafford Regional Planning Commission, 2011). The Plan's policy goals include having, "a more pedestrian friendly environment through pedestrian walkways separated from the travel way, lighting and landscaping." It goes on to add that walkable communities should link destinations and existing roadways should incorporate all modes of transportation.

The Strafford Plan's Transportation Policy Principals include:

- Projects, designs, and initiatives that promote a shared, safe transportation system for bicyclists, motorists, transit users, and pedestrians will be encouraged.
- A regional network of safe, direct bicycle routes between and within communities.
- Awareness and enforcement of traffic laws related to bicycles and pedestrians.

With respect to the future of pedestrian walkways and bicycle routes, Strafford's plan calls for:

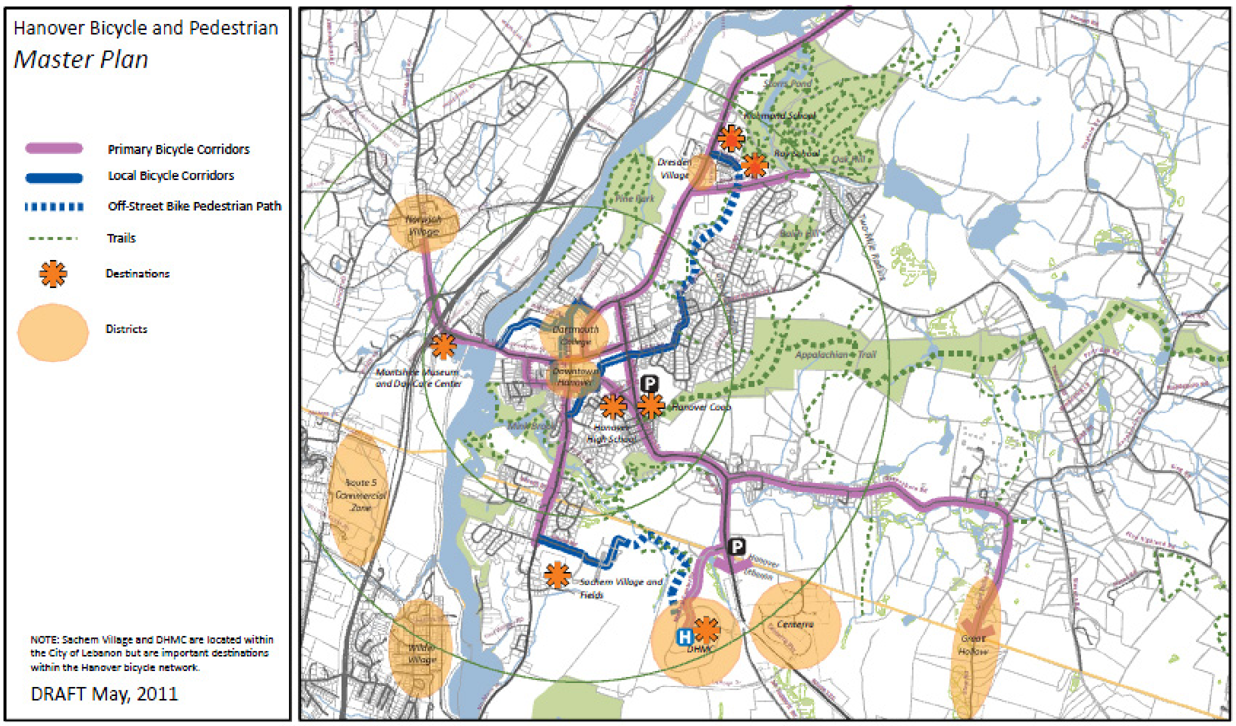
1. Projects to increase the safety of pedestrians and cyclists along all roads in the region and in each municipality should be implemented.
2. Pedestrian and bicyclist safety and beautification by requiring additional right-of-way for pedestrian walkways, bicycle ways and trees along roadways and walkways so people can be separated from vehicular traffic should be provided for and increased.
3. The dedication of land for a pedestrian walkway easement and the installation of pedestrian paths or walkways setback or separated from paved roads in all new developments to provide safe pedestrian movement will be encouraged or required.
4. A municipal pedestrian walkway or trail greenbelt system with trails that protect resources and are sensitive to property owners will be provided for and proactively managed.
5. Recreational activities along roads and trails, such as walking, jogging, stretching/exercising, biking, rollerblading, cross-country skiing and/or snowmobiling will be provided.
6. The needs of pedestrians and bicyclists will be accommodated by using natural paths that do not place an undue burden on taxpayers.

The community of Hanover, New Hampshire recently published its vision of creating a more bicycle-friendly community. (Hanover, NH 2011) Highlights of this vision include:

1. Developing a comprehensive bicycle transportation plan based on the Five E's (education, engineering, encouragement , enforcement, and evaluation) that combine bike lanes, paths, and "bicycle boulevards" connecting transit centers, downtown, village districts, workplaces, schools, the college, and neighborhoods.

- Disseminate information to inform and educate residents of Hanover and seek public comment and participation by working with town and media outlets, and through internet resources (i.e. Town's website and/or create a blog).
- Support promotional activities encouraging bicycle use for town/campus errands, commuting to work/class and to slow down traffic and share the road (i.e. commute another way day, safe routes to school, way to go week, share the road campaign, etc.).
- They also developed a Bicycle and Pedestrian Master Plan that lays out the primary and local corridors for bicycling and walking via the publication of a draft map of this vision:

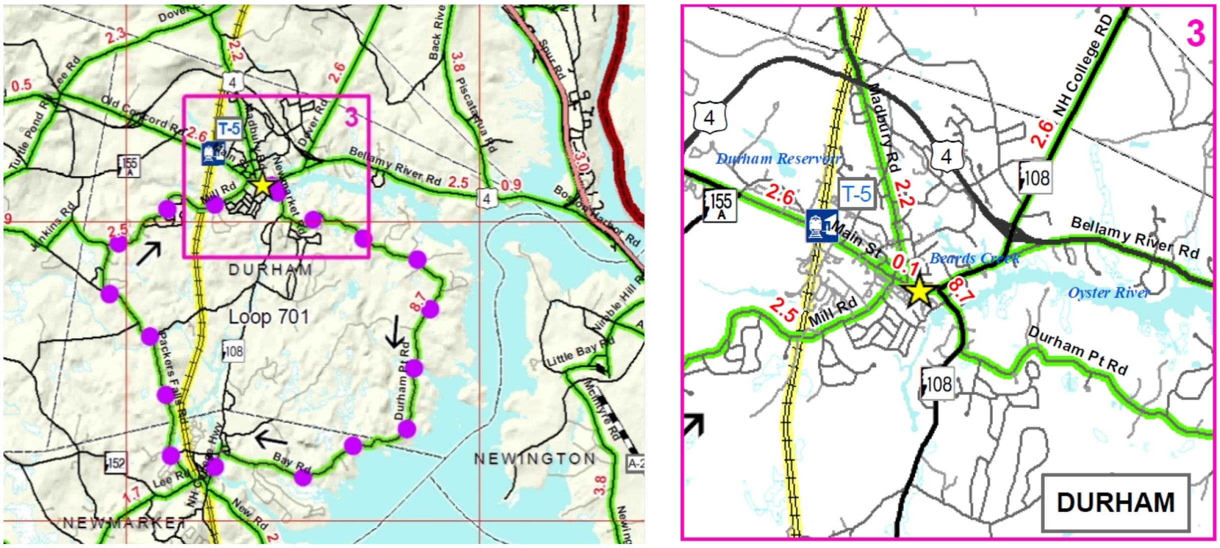
Figure 15. Hanover Bicycle and Pedestrian Master Plan



Source: Hanover Bicycle and Pedestrian Master Plan, 2011.

Durham should use examples like this plan to guide its own planning for improved bicycling and walking access throughout the Town and between adjacent communities. With respect to these linkages, the NHDOT's mapping of bicycle routes in the seacoast region would be a good starting point. The following excerpts show their identified primary travel routes for bicycling in the region (NH DOT, 2010):

Figure 16. Seacoast Region Bike Map



Source: New Hampshire Department of Transportation,2010, http://www.nh.gov/dot/programs/bikeped/maps/seacoast.htm.

Since many of Durham's transportation patterns are rooted in its fundamental suburban, semi-rural setting and the nature of the regional economy, this Chapter will focus on aspects of this complex issue that are amenable to change over time through municipal planning and public education.

The recommendations in this Chapter, together with those of other chapters in the updated Master Plan, provide a roadmap to achieving a lower overall consumption of resources in the transportation sector through increased proximity of residents to work, school, goods, and services (see Pillar 1, greater residential and commercial compactness and mix of uses), along with other strategies for long-term gains in efficiency.

Fleet Analysis - True Cost to Own of Potential Police Fleet Vehicles [4]

The Table below reflects a summary of the True Cost to Own (TCO) data obtained for some representative vehicles. The price of a 2006 Crown Victoria Commercial Police Package Fleet 4dr Sedan LWB is only $10,031 whereas the other cars are almost new or new and thus more expensive. [Note: although the Town does not pay for these vehicles, they do forego selling them and so can be considered in this analysis.] When one takes the cost of maintenance, repairs, and fuel into consideration, it becomes evident that the cars researched, with the exception of the 2010 Chevrolet Impala LS 4dr Sedan (3.5L 6cyl 4A), are less expensive to own and provide significant savings to the Town. One significant factor to take into consideration is that all the repairs and maintenance costs provided will be different than reported as the Town fleet is repaired by the town mechanics and not by the dealership. Other costs may vary as well, such as

[4] Prepared by By Vasiliki Partinoudi, Volunteer of the Durham Energy Committee.

insurance or assumptions about financing. The following tables provide a breakdown of the TCO calculation – with State bid information on specific cars, gas mileage and maintenance/repair data could provide a more precise comparison.

Taken at face value, these results show that, over a five year period, total cost of ownership of many vehicles would be much lower than the used Crown Victoria (up to $7,900). Though Edmunds does not provide the data, extending the analysis to a ten-year vehicle life would likely exaggerate the TCO figures even more.

Table 3. Price Comparison

Car/ Model/Style	Original Price	TCO	Comparison to 2006 Crown Victoria over 5 years*
2006 Crown Victoria Commercial Police Package Fleet 4dr Sedan LWB	$10,031	$31,222	
2010 Chevrolet Impala LS 4dr Sedan (3.5L 6cyl 4A)	$20,484	$33,455	+ $2,333
2010 Toyota Prius II 4dr Hatchback (1.8L 4cyl gas/electric hybrid CVT)	$21,747	$26,436	- $4,786
2010 Honda Insight EX 4dr Hatchback (1.3L 4cyl gas/electric hybrid CVT)	$20,445	$25,622	- $5,600
2010 Honda Fit 4dr Hatchback (1.5L 4cyl 5M)	$15,290	$25,243	- $5,979
2009 Pontiac G3 4dr Hatchback	$10,494	$23,310	- $7,912
* Negative values represent TCO is less than the comparison car, the Crown Victoria.			

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Edmonds.com uses proprietary True Cost to Own (TCO) algorithms based on the five-year cost of owning to compare the cost of owning a vehicle currently in the market. A vehicle's competitive segment was determined by (i) its body type, and (ii) the sales-weighted average MSRP of all available styles (excluding destination charges) of that vehicle's body type. TCO is a valuable tool as it can show how a lower priced car can cost more in maintenance, fuel and repairs than a higher priced item. All estimates are based on 15,000 miles per year.

Table 4. 2006 Crown Victoria Commercial Police Package Fleet 4dr Sedan LWB Cost Summary

True Cost to Own® *	$31,222
Total Cash Price	$10,031
Average Cost per Mile*	$0.42

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 5. Crown Victoria Commercial Police Package Fleet 4dr Sedan LWB Cost

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$1,401	$1,229	$1,082	$959	$861	$5,532
Taxes & Fees	$60	$40	$40	$40	$40	$220
Fuel	$2,174	$2,239	$2,306	$2,375	$2,446	$11,540
Maintenance	$1,155	$511	$437	$745	$880	$3,728
Repairs	$330	$384	$446	$519	$603	$2,282
Financing	$479	$384	$283	$177	$64	$1,387
Get Pre-Approved Financing--Apply for a Car Loan						
Insurance	$1,218	$1,261	$1,305	$1,351	$1,398	$6,533
Compare Insurance Rates						
Yearly Totals	$6,817	$6,048	$5,899	$6,166	$6,292	$31,222

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

According to Edmonds.com the Lowest *True Cost to Own*® Vehicles under $0.35 for December 2009 are:

Sedans:

Table 6. 2009 Pontiac G3 4dr Hatchback Summary

True Cost to Own® *	$23,310
Total Cash Price	$10,494
Average Cost per Mile*	$0.31

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 7. 2009 Pontiac G3 4dr Hatchback

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$1,421	$1,246	$1,097	$972	$873	$5,609
Taxes & Fees	$60	$40	$40	$40	$40	$220
Fuel	$1,305	$1,344	$1,384	$1,426	$1,469	$6,928
Maintenance	$566	$258	$1,085	$785	$776	$3,470
Repairs	$0	$89	$213	$311	$361	$974
Financing	$501	$402	$296	$185	$67	$1,451
Insurance	$869	$899	$930	$963	$997	$4,658
Yearly Totals	$4,722	$4,278	$5,045	$4,682	$4,583	$23,310

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 8. 2010 Honda Fit 4dr Hatchback (1.5L 4cyl 5M) Summary

True Cost to Own® *	$23,310
Total Cash Price	$10,494
Average Cost per Mile*	$0.31

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 9. 2010 Honda Fit 4dr Hatchback (1.5L 4cyl 5M)

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$3,009	$1,475	$1,298	$1,151	$1,032	$7,965
Taxes & Fees	$60	$40	$40	$40	$40	$220
Fuel	$1,349	$1,389	$1,431	$1,474	$1,518	$7,161
Maintenance	$123	$343	$215	$823	$991	$2,495
Repairs	$0	$0	$82	$199	$290	$571
Tax Credit	$0	$0	$0	$0	$0	$0
Financing	$695	$557	$410	$256	$92	$2,010
Insurance	$899	$930	$963	$997	$1,032	$4,821
Yearly Totals	$6,135	$4,734	$4,439	$4,940	$4,995	$25,243

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 10. 2010 Chevrolet Impala LS 4dr Sedan (3.5L 6cyl 4A) Summary

True Cost to Own® *	$23,310
Total Cash Price	$10,494
Average Cost per Mile*	$0.31

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 11. 2010 Chevrolet Impala LS 4dr Sedan (3.5L 6cyl 4A)

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$6,826	$1,723	$1,516	$1,344	$1,206	$12,615
Taxes & Fees	$60	$40	$40	$40	$40	$220
Fuel	$1,780	$1,833	$1,888	$1,945	$2,003	$9,449
Maintenance	$103	$385	$240	$674	$874	$2,276
Repairs	$0	$0	$93	$221	$322	$636
Tax Credit	$0	$0	$0	$0	$0	$0
Financing	$932	$746	$550	$342	$123	$2,693
Insurance	$1,036	$1,072	$1,110	$1,149	$1,189	$5,556
Yearly Totals	$10,737	$5,799	$5,437	$5,715	$5,757	$33,445

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Hybrids:

Table 12. 2010 Honda Insight EX 4dr Hatchback (1.3L 4cyl gas/electric hybrid CVT) Summary

True Cost to Own® *	$25,622
Total Cash Price	$20,445
Average Cost per Mile*	$0.34

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 13. 2010 Honda Insight EX 4dr Hatchback (1.3L 4cyl gas/electric hybrid CVT)

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$2,966	$2,101	$1,847	$1,638	$1,470	$10,022
Taxes & Fees	$60	$40	$40	$40	$40	$220

Fuel	$955	$984	$1,014	$1,044	$1,075	$5,072
Maintenance	$108	$336	$214	$825	$883	$2,366
Repairs	$0	$0	$89	$213	$312	$614
Tax Credit	$0	$0	$0	$0	$0	$0
Financing	$930	$745	$549	$342	$123	$2,689
Insurance	$865	$895	$927	$959	$993	$4,639
Yearly Totals	$5,884	$5,101	$4,680	$5,061	$4,896	$25,622

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 14. 2010 Toyota Prius II 4dr hatchback (1.8L 4cyl gas/electric hybrid CVT) Summary

True Cost to Own® *	$26,436
Total Cash Price	$21,747
Average Cost per Mile*	$0.35

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

Table 15. 2010 Toyota Prius II 4dr hatchback (1.8L 4cyl gas/electric hybrid CVT)

	Year 1	Year 2	Year 3	Year 4	Year 5	5-yr Total
Depreciation	$3,402	$1,989	$1,752	$1,552	$1,393	$10,088
Taxes & Fees	$60	$40	$40	$40	$40	$220
Fuel	$783	$806	$830	$855	$881	$4,155
Maintenance	$24	$302	$461	$662	$1,291	$2,740
Repairs	$0	$0	$82	$199	$290	$571
Tax Credit	$0	$0	$0	$0	$0	$0
Financing	$989	$792	$584	$363	$131	$2,859
Insurance	$1,082	$1,120	$1,159	$1,200	$1,242	$5,803
Yearly Totals	$6,340	$5,049	$4,908	$4,871	$5,268	$26,436

Source: Vasiliki Partinoudi, Durham Energy Committee, 2010.

References:

American Association of State Highway and Transportation Officials, February 2010. DRAFT - AASHTO Guide for the Planning, Design, and Operation of Bicycle Facilities. American Association of State Highway and Transportation Officials.

Federal Highway Administration, 2009. National Household Transportation Survey. US Department of Transportation.

International Panel on Climate Change, 2007. Climate Change 2007: IPCC Fourth Assessment Report. World Meterological Organization & United Nations Environment Programme.
http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf;
(http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml)

New Hampshire Department of Transportation, 2010. Seacoast Region Bicycle Routes. New Hampshire Department of Transportation.

Town of Hanover, 2011. New Bicycle and Pedestrian Committee Vision. Town of Hanover, New Hampshire.

Strafford Regional Planning Commission, 2011. Regional Master Plan: Toward the Year 2020. Strafford Regional Planning Commission.

University of New Hampshire, 2011. Transportation Survey Presentation. University of New Hampshire Transportation Policy Committee. September 27, 2011.

Walljasper, Jay, September 28, 2011. Lessons from America's Surprise #1 Bike City. Yes Magazine.

IX. Pillar 3. Alternative and Renewable Energy Resources

The centrality of energy in our daily lives, quality of life, and economic and national security is undeniable. Climate change, caused largely by the combustion of fossil fuels, is also a major factor in the future security of fossil fuel supplies. The *2010 Quadrennial Defense Review* from the Pentagon states:

> "Assessments conducted by the intelligence community indicate that climate change could have significant geopolitical impacts around the world, contributing to poverty, environmental degradation, and further weakening of fragile governments. Climate change will contribute to food and water scarcity, will increase the spread of disease and may spur or exacerbate mass migration."

The report also describes the Department of Defense's focus on cutting the use of fossil fuels, which has uncertain and, typically, large costs (30% of the cost of each individual soldier in Afghanistan) and is a security concern on the battlefield.

Improving Durham's transportation network, land use patterns, and building construction practices are essential to reducing the Town's energy consumption. Such steps reduce the need for energy outright and offer the best payback and environmental gains. Even under the best circumstances such energy efficiency and conservation measures only reduce the total demand for energy; there will still be a gap that must be filled with energy from the outside to provide heat and power and to move vehicles.

Currently, New Hampshire is reliant on other states and nations for the vast majority of its energy sources. According to the NH Office of Energy and Planning, the state of New Hampshire imported nearly 90% of the energy that drove the economy in 2008. (NH OEP, 2010) As a result of this dependence on regional and international energy supplies, New Hampshire is uniquely vulnerable to the dynamics of the global energy market. Of the $6 billion that was spent on energy in New Hampshire, $4.1 billion (or 68%) left the state immediately to pay for the imported fossil and nuclear fuels. A significant portion of these exported energy costs left the country entirely. (VEIC, 2011) This dependence not only threatens the stability of the state's energy supplies, but it is also a drain on the economy. (NHDES, 2009)

Going forward in time, there are several drivers that will increase pressure on the global energy markets to meet demand. This includes the fact that the easily accessible fossil fuel energy sources will become increasingly exhausted and the economies of developing nations will continue to expand and seek out new sources of energy. The combustion of fossil fuels is also a leading driver of global climate change and fossil fuel consumption must fall dramatically in the next 40 years if the international community is to avoid the worst of the projected impacts. (IPCC, 2007)

Those impacts of climate change are anticipated to stress the global food system, regional water availability and lead to catastrophic weather events, all of which could destabilize countries and lead to civil or regional wars. As the 2010 Quadrennial Defense Review from the Pentagon states,

> "Assessments conducted by the intelligence community indicate that climate change could have significant geopolitical impacts around the world, contributing to poverty, environmental degradation, and further weakening of fragile governments. Climate change will contribute to food and water scarcity will increase the spread of disease and may spur or exacerbate mass migration." (US DOD, 2010)

As these trends and events occur, it is anticipated that global fossil fuel supplies will tighten and energy prices will rise, and that the global market will experience periodic shortages with concomitant price spikes. Even with a reduction in total demand for energy, a reliance on fossil fuels to meet the remaining limited demand could compromise the ability of the municipality to provide services and manage costs.

To mitigate the impact of such trends and events on energy costs, the Town of Durham and its residents and businesses must also provide corresponding attention to and investment in alternative and sustainable energy sources. Sustainable energy sources include geothermal, passive and active solar, wind, hydro, and biomass, while alternative energy sources can include combined heat and power (CHP), as well as district heating systems. By increasing reliance on alternative and sustainable energy sources the municipality could diversify its energy supply mix and therefore hedge against increasing fuel prices and potential reductions in supply. (VEIC, 2011) In some instances, investment in alternative and sustainable energy could allow the municipality to stabilize costs by locking in long-term rates. However, alternative and sustainable energy sources are best when paired with energy efficiency and conservation. By first reducing the total demand for energy, the alternative and renewable energy projects can be reduced in size and therefore keep upfront capital costs low.

As the alternative and sustainable energy technologies are part of a still emerging segment of the energy market, the upfront capital costs associated with these energy projects may seem substantial. In many cases, however, those upfront costs can be offset by significant reductions in the operating and maintenance costs. Through existing and emerging financing measures, such as energy performance contracting and power purchase agreements, the municipality is increasingly able to structure project financing that allows projects to go forward and "pay for themselves" through the savings achieved. In fact, the NH legislature has enabled municipalities to enter into such contracts in RSA 21-I: 19-d[5]. Financing measures for residents and businesses are currently under development and will continue to evolve in the future. In the end, the municipality, residents or businesses can take full ownership of the equipment and reap full benefit of the cost savings and any other co-benefits.

Durham must take action on a municipal level to reduce consumption of fossil fuels. While alternative and sustainable energy options may have a higher upfront capital cost associated with them, they provide a viable means to stabilize and reduce costs. When paired with energy efficiency and conservation projects, costs can be reduced and key financing mechanisms can allow projects to go forward with limited to no upfront investment. Taken together, such measures can reduce exposure to volatile imported energy prices, enabling a more stable budgetary process. The balance between reduction in demand and new forms of alternative or sustainable supply will have a profound effect on the affordability, environmental sustainability, and security of Durham over the coming century.

References:

International Panel on Climate Change, 2007. Climate Change 2007: IPCC Fourth Assessment Report. World Meterological Organization & United Nations Environment Programme.

http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf;
http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

New Hampshire Department of Environmental Services, March 2009. The New Hampshire Climate Action Plan: A Plan for New Hampshire's Energy, Environmental and Economic Development Future, New Hampshire Climate Change Policy Task Force.
http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/nh_climate_action_plan.htm.

New Hampshire Energy Facts 2008: Overview Based on EIA Data for 2008, NH Office of Energy and Planning
http://www.nh.gov/oep/programs/energy/nhenergyfacts/2008/documents/08_overview.pdf, accessed on February 15, 2012.

US Department of Defense, 2010. Quadrennial Defense Review Report. US Department of Defense,
http://www.defense.gov/qdr/images/QDR_as_of_12Feb10_1000.pdf.

Vermont Energy Investment Corporation, 2011. New Hampshire Independent Study of Energy Policy Issues, Vermont Energy Investment Corporation.
http://www.puc.nh.gov/Sustainable%20Energy/Reports/New%20Hampshire%20Independent%20Study%20of%20Energy%20Policy%20Issues%20Final%20Report_9-30-2011.pdf.

[5] NH RSA 21-I:19-d, Energy Performance Contracting, http://www.gencourt.state.nh.us/rsa/html/I/21-I/21-I-19-d.htm (Last accessed on February 15, 2012)

X. Innovative Technologies

Reduced energy use lowers operating costs for home and business owners and lowers total greenhouse gas emissions from electricity generation.

Newly installed green roof at Bowdoin College, Brunswick, ME (Image Credit: Richard Renner

Durham should allow, and in some cases, encourage use of new, new to the region, and emerging, energy conservation technologies. Two examples are green roofs and green walls (also known as biowalls, vertical gardens, vertical vegetated complex walls).

Green roofs have a long history of use in Europe and a growing body of experience in the US. While structural considerations may limit use in existing buildings, they are a viable option in many cases. American Rivers et al (2012) cite considerable potential benefits in northern climates with high temperature extremes and shorter growing seasons.

Both green roofs and walls are partly composed of or filled in with growing plant matter, which lowers absorption of solar radiation and thermal conductance, substantially reducing the annual energy consumption.

In addition to the aesthetics, green roofs and green walls filter air and water, soak up carbon dioxide, and help lessen the "heat island" effect of built up areas while reducing air conditioning and heating costs.[6]

A living wall at the Anataeum Hotel in London (Image Credit: © Niall Napier, Flickr)

Green roofs provide energy savings. Green roofs provide insulation and shade for buildings, reducing the need for heating in the winter and air conditioning in the summer.

Spolek (2008) studied the energy performance of a green roof in Portland, Oregon, and found that overall heat flux going in and out of the roof was reduced by 72% in the summer and13 % in the winter. The temperature at the surface of a traditional, flat, rock ballast roof fluctuated over the course of a day by as much as 30ºC, whereas green roofs fluctuations were limited to around 5ºC. Moreover, the peak temperature on a rock ballast roof was sometimes 6ºC higher than the ambient temperature and lower than the lowest temperatures of the day.

---

[6] Much of this inventory is taken from "Benefits of Green Roofing for Site Design and Incentives to Increase Implementation. Final Research Report by Gordon Lane, May 13, 2010 for ESP 417, University of Southern Maine.

Simmons et al (2008) studied the cooling effect of green roofs in Austin, Texas, by building several platforms in a former pasture, enclosing and insulating the underside, and recording the internal temperatures. The authors compared several different designs of green roofs to traditional, black-shingled roofs as well as to a roof with a white reflective surface. The internal temperature of green roofs (platforms under the roofing) was 13°C cooler than white roofs and 18°C cooler than black roofs.

Greg Robbins FLICKR

Roof tiles on Toyota Roof Garden.

The type and thickness of the substrate affects the insulating properties of green roofs (Simmons et al, 2008). Regional climate would have to be considered to determine the appropriate standards to guide design of a green roof in Durham.

American green roof, Oswego, Illinois (Image Credit: Greg Robbins FLICKR)

Martens et al (2008) used a computer model to estimate the effect of green roofs on buildings of different sizes in Toronto, Ontario. Martens et al found that green roofs on low, flat, single story buildings use less energy at much higher rates than do tall, skinny, multi-story buildings. Green roofs reduced energy use for air conditioning for all building sizes, but there was a direct relationship between the performance of green roofs and building envelope ratios.

Japanese green roof, Tokyo.(Image Credit: Dissonanc3 FLICKR)

The simulations, in Martens et al (2008), did not account for substrate depth – though a thin layer was included in the model. Instead, heat flux was attributed solely to evapotranspiration from the green roof vegetation. Sailor (2008) also showed that the difference in energy use between buildings with high and low amounts of vegetation was as much as 2,000 mega-joules. In summer months, green roofs with large amounts of leafy vegetation reduced energy use at a greater rate than green roofs with low amounts of vegetation, or with non-leafy vegetation. Higher amounts of leafy vegetation increase transpiration, and thus latent heat loss. In winter, the reverse happens – increased transpiration increases heat loss from the building. The loss is lower than that of a traditional roof, but still relevant enough that the type of vegetation should be considered in adjusting green roof design in the context of Durham's climate.

It is difficult to calculate payback time for green roofs based on energy savings because of the volatility of construction markets, fluctuating energy prices, differences in efficiency of air conditioning and heat power sources, and regional climate differences. Carter and Keeler (2008) estimated that annual energy savings if all roofs in the Tanyard Branch watershed were greened would total $65,000. Other economic studies have been done to assess the overall, life-time value of green roofs.

An important aspect of green roofs is their extended life. Green roof life spans are double those of traditional roofs. While numerous economic benefits can be included in an assessment of green roofs, the largest payback occurs when the roof must be replaced with a new one. For traditional roofs, it's every 20 years; for a green roof it's every 40 years. Over the 40-year lifespan of a green roof, costs are reduced by 20 – 25%, despite the higher upfront costs (Clark et al, 2008).

Other benefits of green roofs reduce costs further. The sequestration of nitrogen oxides by green roofs, reduces costs 25 – 40% of a traditional roof (Clark et al, 2008). Other benefits, such as carbon dioxide sequestration, heat island mitigation and resulting health benefits, energy emission reductions climate change mitigation, stormwater runoff reductions, and aesthetic value, reduce costs further.

Overall benefits of green roofs are significant. Though green roofs embody 6.5 kilograms more carbon in the production of materials than traditional roofs, energy savings should make up for that (Getter et al, 2009). The costs of green roofs are, in the short term, quite high financially. But in the long term they are cheaper than traditional roofs.

References:

American Rivers, Water Environment Federation, American Society of Landscape Architects, *ECONorthwest,* 2012. Banking of Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide.

Carter, T. & Keeler, A., 2008. Life-cycle cost-benefit analysis of extensive vegetated roof systems. *Journal of Environmental Management, 87*, 350–363.

Clark, C., Adriaens, P., & Talbot, F.B., 2008. Green roof valuation: A probabilistic economic analysis of environmental benefits. *Environmental Science & Technology, 42*(6), 2155–2161.

Frazer, L., 2005. Paving paradise. *Environmental Health Perspectives, 113*(7), A457–A462.

Getter, K. L., Rowe, D. B., Robertson, G. P., Cregg, B. M., & Andresen, J. A., 2009. Carbon sequestration potential of extensive green roofs. *Environmental Science and Technology, 43*(19), 7564–7570.

Martens, R., Bass, B., & Alcazar, S. S., 2008. Roof-envelope ratio impact on green roof energy performance. *Urban Ecosystems, 11*, 399–408.

Sailor, D. J., 2008. A green roof model for building energy simulation programs. *Energy and Buildings, 40*, 1466–1478.

Simmons, M. T., Gardiner, B., Windhager, S., & Tinsley, J., 2008. Green roofs are not created equal: The hydrologic and thermal performance of six different extensive green roofs and reflective and non-reflective roofs in a sub-tropical climate. *Urban Ecosystems, 11*, 339–348.

Spolek, G., 2008. Performance monitoring of three ecoroofs in Portland, Oregon. *Urban Ecosystems, 11*, 349–359.

XI. Shade Trees

Trees are major capital assets. Just as streets, sidewalks, public buildings and recreational facilities are a part of a community's infrastructure, so are publicly owned trees. Collectively, they are known as the urban forest. Aside from the obvious aesthetic benefits, trees within our urban forest improve our air, protect our water, save energy, and improve economic sustainability. Healthy urban forests can help municipalities achieve goals of environmental, social, and economic sustainability while reducing greenhouse gas emissions and removing carbon for the atmosphere.

Source: USDA – Forest Service, Climate Change Resource Center

Trees actively remove CO_2 from the air in a process called sequestration. This natural process offers significant potential to reduce CO_2 by removing the carbon and storing it as cellulose in their trunk, branches, leaves, and roots (serving as a carbon sink) while releasing oxygen back into the air. CO_2 is released when the tree decomposes.

Trees also lower local air temperatures by transpiring water and shading surfaces. Because their physiological processes lower air temperatures, their mass shades buildings in the summer and blocks winter winds, they can reduce building energy use and cooling costs. On hot summer days, urban areas can be up to 8°F hotter than non-urban areas because they have large areas of pavement and dark surfaces (roofs, roads, parking lots) that absorb and store energy, causing surface and air temperatures to rise. A tree can be a natural air conditioner. The evaporation from a single large tree can produce the cooling effect of 10 room size air conditioners operating 24 hours/day.

Trees shade surfaces and reflect sunlight, reducing temperatures. Older buildings with less insulation and older cooling and heating systems will have a greater energy savings from trees than newer buildings with better insulation and technology.

When shade trees are planted along sidewalks, they create a pleasant pedestrian environment that shelters walkers from the sun and wind and buffers them from nearby traffic. A pleasant walking environment encourages additional walking. Beyond serving as a carbon sink, the primary energy savings from trees is shading and reduction of the urban heat island effect.

By maintaining a healthy urban forest, prolonging the life of trees, and continually increasing tree stock, communities can increase their net carbon storage over the long term. Planting species that require less maintenance and reducing the use of tools that require fossil fuels will help lower the emissions cost of tree maintenance.

This combination of CO_2 removal from the atmosphere, carbon storage in wood, and the cooling effect makes trees a very efficient tool in fighting the greenhouse effect.

A single mature tree can absorb as much as 48 lbs of CO_2 per year and release enough oxygen into the atmosphere to support two human beings. (Local Governments for Sustainability, 2006) Trees and shrubs have the highest capacity among all plants to store carbon, mostly in the trunk and branches. Large trees can store more carbon and shade buildings, thus reducing atmospheric CO_2 more than small trees.

One tree that shades a home in the city will also save fossil fuel, cutting CO_2 buildup as much as 15 forest trees. Planting trees remains one of the cheapest, most effective means of drawing excess CO_2 from the atmosphere.

Each person in the US generates approximately 2.3 tons of CO_2 each year. A healthy tree stores about 13 pounds of carbon annually – or 2.6 tons per acre each year. An acre of trees absorbs enough CO_2 over one year to equal the amount produced by driving a car 26,000 miles.

If every American family planted just one tree, the amount of CO_2 in the atmosphere would be reduced by one billion lbs annually. This is almost 5% of the amount that human activity pumps into the atmosphere each year. The US Forest Service estimates that all the forests in the US combined sequestered a net of approximately 309 million tons of carbon per year from 1952 to 1992, offsetting approximately 25% of U.S. human-caused emissions of carbon during that period.

Over a 50-year lifetime, a tree generates $31,250 worth of oxygen, provides $62,000 worth of air pollution control, recycles $37,500 worth of water, and controls $31,250 worth of soil erosion.

Homeowners that properly place trees in their landscape can realize savings up to 58% on daytime air conditioning and as high as 65% for mobile homes. If applied nationwide to buildings not now benefiting from trees, the shade could reduce our nation's consumption of oil by 500,000 barrels of oil/day. The maximum potential annual savings from energy conserving landscapes around a typical residence ranged from 13% in Madison up to 38% in Miami. Projections suggest that 100 million additional mature trees in US cities (3 trees for every unshaded single family home) could save over $2 billion in energy costs per year. The US Forest Service estimates the annual effect of well-positioned trees on energy use in conventional houses at savings between 20-25% when compared to a house in a wide-open area.

In addition, urban forests can extend the life of paved surfaces. Asphalt pavement on streets contains stone aggregate in an oil binder. Without tree shade, the oil heats up and volatizes, leaving the aggregate unprotected. Vehicles then loosen the aggregate and much like sandpaper, the loose aggregate grinds down the pavement. Streets should be overlaid or slurry sealed every 7-10 years over a 30-40 year period, after which reconstruction is required. A slurry seal costs approximately $0.27/sq.ft. or $50,000/linear mile. Because the oil does not dry out as fast on a shaded street as it does on a street with no shade trees, street maintenance can be deferred. The slurry seal can be deferred from every 10 years to every 20-25 years for older streets with extensive tree canopy cover.

References:

http://www.coloradotrees.org.

Bell, Ryan & Wheeler, J., 2006. Talking Trees: An Urban Forestry Toolkit for Local Governments, Local Governments for Sustainability.

USDA – Forest Service, Climate Change Resource Center, http://www.fs.fed.us/ccrc/topics/urban-forests/

XII. Community Forum Flyers

A note from the Durham Energy Committee:

We need **your vision of what Durham's energy profile should look like in the future.** We're preparing a brand new chapter in the Master Plan that will outline a comprehensive vision and strategy for Durham's energy future, one that could even help define **Durham's identity.**

Energy is at the heart of many issues that we all face going forward. Our current dependence on fossil fuel influences both our personal and our municipal decisions.

Should we plan ahead—or just wait to see what develops? Before you answer that question, look at what some of our neighbors are doing:

- **Saco, Maine** runs its wastewater treatment plant in part by wind, with plans to add solar panels and geothermal heat pumps
- **Kittery, Maine** just cut the ribbon on a wind turbine at its Solid Waste Transfer Station. The town could realize more than $15,000 annually in energy credit savings for the transfer station and more for its middle school, while slashing the town's carbon dioxide emissions by as many as 51 tons per year.
- **Portsmouth's** recycling center sends out residents' waste cooking oil for processing into biodiesel fuel.

Inside this flyer you'll find some questions to give you a head start for what we hope will be **a productive brainstorming session. Please come, and bring your family and friends.**

See you on November 19th!

What do *you* see in Durham's energy future?

We invite you to share your ideas and vision
at a participatory hearing presented by
the Durham Energy Committee

"Creating an Energy Vision for the Master Plan"

. . . with facilitators Walter Rous and Bill Schoonmaker, fresh from their collaborative work on the Mill Plaza Study Committee

Wednesday, November 19, 2008
7:30–9:00 PM
Durham Town Hall, Council Chambers

How do you see Durham **using energy** in 20 years?

A Northern Sweden town replaced its oil-burning plant with one that burns the city's solid waste, provides electrical energy and heat for the town and is 99.5% efficient. It's better for the environment and also creates sellable gypsum and a road aggregate material.

- Should Durham try to live in a sustainable way with regard to energy, drawing on renewable energy sources?
- Should we have local nuclear plants with the nuclear waste stored in nearby swimming-pool-like containers?
- Do you want to be independent of foreign sources of energy?

How do you see **new housing** in Durham in 20 years?

A development of 50 affordable rental units in Boston reduces energy and water use by 40% and cost 25% less to build than comparable new construction. Cities such as Austin, Denver, and Santa Monica have green-building programs with incentives for homeowners and builders to save water and energy, use recycled materials, and reduce solid waste. The city of Boulder requires houses larger than 5,000 square feet to be net zero energy.

- Should our building codes require that developers adhere to these green-building Best Practices?
- Should our zoning ordinance restrict the amount of new development beyond the Town Center so as to encourage walking and shared facilities?

How do you envision **transportation** in Durham and the vicinity 20 years from now?

- Should we create a pedestrian-only downtown?
- When should all Town and ORCSD vehicles run free of fossil fuels?
- Would you use small electric-powered public vans that run between your neighborhood and others?
- How can we help create the so-called Northern Connector to funnel UNH traffic to Routes 4 and 108 and away from our downtown and neighborhoods?

Do you see many ways to **conserve energy?**

- How will you stay warm in the Durham winters?
- Would you use public transportation if it were more convenient? If it cost less? To commute? To do errands?
- Would you be interested in a neighborhood????

How can Durham residents **pay for new energy technologies?** Imagine these scenarios:

- A Town-managed **energy bank,** similar in concept to microlending programs we've recently been hearing about, funded by cost savings resulting from the installation of new technologies in our homes, in turn would help fund more installations.
- Residents [or the Town] form an **energy co-op** through which they cut out the middle man and purchase solar panels at cost.

What are your ideas?

The Durham Energy Committee wants to know!

What can Durham do to ensure we have adequate future energy resources?

Starting last fall, the Durham Energy Committee (DEC) has been inviting residents to help develop an energy chapter for the town's Master Plan. Out of the well-attended November meeting came many terrific ideas. These primarily fell into three categories—**Transportation; Land Use and Architecture; and Alternative and Renewable Energy.**

From these, the DEC has drafted a vision toward greater energy independence and sustainable practices in Durham. Here's what we have so far:

The Three Pillars of Energy Sustainability

I. Transportation*

Transportation accounts for a significant portion of the average Durham resident's annual energy use and energy cost. Volatility in energy prices was reflected at the gas pump over the last year. Our experiences last summer with high fuel prices should serve as a wake-up call for us to reduce our vehicle-miles in leading our daily lives. By doing so, we can reduce transportation costs and carbon emissions, and enhance the quality of our lives.

Our vision:

- To provide community planning which encourages safe bicycling and walking for town residents and children.
- To support appropriate public transit that will allow commuters and others to travel within Durham and beyond to other popular regional destinations such as Dover, Portsmouth, Manchester and Boston.
- To route traffic away from downtown and provide park-and-ride facilities for carpoolers, to further lessen the impact of vehicular traffic.
  *We note that there is an existing chapter of Durham's Master Plan that addresses Transportation

II. Architecture and Land Use

Energy used in our buildings constitutes a huge amount of fossil fuel and electricity consumption. Increasing household energy costs challenge our budgets as well as deplete our resources. Typical New England homes use up to 1,000 gallons of heating oil during the winter season. In sharp contrast, energy-efficient homes in other countries with similar climates consume very little energy. In addition, the arrangement of neighborhoods relative to one another, and use of common neighborhood heating systems influence individual energy budgets and consumption.

Our vision:

- Buildings and houses constructed or renovated in Durham will meet the highest reasonable levels of energy efficiency.
- Resources will be established to provide incentives and assistance for improving the energy efficiency of existing commercial, industrial or residential properties.

See you on February 18th!

III. Alternative and Renewable Energy Sources

Although we may realize considerable success in energy conservation through our coordinated efforts, a significant amount of energy will yet be required to continue our current way of life. We must plan now to establish reliable energy sources if we wish to sustain workable levels of mobility, communication and comfort.

Our vision:

To establish reliable future energy resources for Durham residents and municipal operations, to hedge against the increasing volatility of petroleum prices, and to reduce the environmental impact of our energy use by expanding the role of clean alternative energy sources, including solar, wind, hydro (including tidal energy), biofuels, as well as other potential forms of energy yet to be realized.

What's the result? A sustainable Durham:

- Lower energy costs will reduce stress on household budgets and improve business profitability.
- Fewer vehicle-miles will reduce pollution, relieve congestion downtown, and reduce costs.
- Durham may form regional partnerships or invest in regional cooperatives to secure future energy sources.
- We will strive to generate our energy locally, ensure reliable energy for our citizens, and minimize environmental impacts associated with our energy use.

What do *you* think:
Are we on the right track?

Now what do YOU think of our Vision for the Energy Chapter of the Master Plan?

We invite you **once again** to share your ideas and vision at a participatory hearing presented by the Durham Energy Committee with facilitator Bill Schoonmaker:

Wednesday, February 18, 2009

7:00–8:30 p.m.

Durham Town Hall, Council Chambers

Our energy vision will build a sense of identity, community and pride for our town, which would in turn attract the type of socially-responsible business, industry and residents that could sustain a re-imagined Durham for our children.