COLLABORATIVE AND TRANSPARENT

Production of Decision-Relevant Information for New Hampshire's Climate Action Plan

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ABSTRACT

Much of the response for reducing greenhouse gas emissions and dealing with the consequences of climate change requires significant action at the state level. New Hampshire has recently addressed the issue of climate change through the development of a multi-sector climate action plan written by a Governor appointed Climate Change Policy Task Force. The collaborative process integrated input from stakeholders and shared development of key assumptions with transparent quantitative analysis (performed by a team from the University of New Hampshire and Department of Environmental Service) that provided decision relevant information regarding the emission reduction recommendations adopted by the Task Force. To prepare for current and future changes in New Hampshire's climate, the plan also includes a section on adaptation.

The plan is aimed at achieving the greatest feasible reductions in emissions while also providing the greatest possible long-term economic benefits by substantially increasing energy efficiency in the building and transportation sectors, continuing to increase sources of renewable energy, designing communities to reduce reliance on automobiles, and preserving working forests. *Keywords: New Hampshire, climate change, mitigation, adaptation, economic benefits.*

Introduction

Earth's climate changes. It always has and always will. However, an overwhelming body of scientific evidence indicates that human activities — including the burning of fossil fuel for energy, clearing of forested lands for agriculture, and raising livestock — are now a significant and growing force driving change in the Earth's climate system (Solomon et al. 2007; National Research Council 2010). As human-derived greenhouse gas emissions continue to rise (Canadell et al. 2007; Friedlingstein et al. 2010), analysis of data collected around the globe clearly shows ongoing and often dramatic changes in our climate system such as increases in global atmospheric and sea surface temperatures (Hansen et al. 2010), increases in atmospheric water vapor, precipitation, and extreme precipitation events (Solomon et al. 2007), rising sea levels (Pfeffer et al. 2008; Vermeer and Rahmstorf 2009; Yin et al. 2010), reductions in the extent of late summer Arctic sea ice and northern hemisphere snowcover (Stroeve et al. 2007; National Snow and Ice Data Center 2011; Dery and Brown 2007), melting of mountain glaciers (Meier et al. 2007), increases in the flux of ice from the Greenland and West Antarctic ice sheets into the ocean (Rignot et al. 2011), and thawing permafrost and methane hydrates (Shakhova et al. 2010; Schaefer et al. 2011). The potential impacts on society and ecosystems have been well documented for the entire globe (Parry et al. 2007) and for the United States (Karl, Melilo, and Peterson 2009). In the northeast United States, the current and potential future impacts of climate change on the northeast were detailed by the Northeast Climate Impacts Assessment (Frumhoff et al. 2007) and in a series of related papers (Hayhoe et al. 2007; Wake et al. 2008).

Much of the response for both reducing greenhouse gas emissions (mitigation) and dealing with the consequences of climate change (adaptation) will require significant action at the state and local level. If either international agreements or United States federal legislation to set greenhouse gas emissions reduction goals were adopted, much of the development and testing of mitigation and adaptation strategies would still occur on local to state to regional scales. In light of the recent failure of both the international community and the United States government to adopt meaningful emission reduction goals, action at the local to state to regional level is even more imperative. Furthermore, different regions of the country will likely develop different solutions, based on their respective social circumstances and physical geographies. States and regions can therefore be viewed as valuable laboratories for what works and what doesn't in terms of planning and implementation of mitigation and adaptation strategies.

Many states across the country have already acted to reduce their emissions of greenhouse gases (e.g., Dutzik et al. 2009). For example, building on the leadership role it has played in energy efficiency and greenhouse gas emission reduction efforts and policies over the past two decades, California became the first state to adopt a binding cap on greenhouse gas emissions by passing the Global Warming Solutions Act in 2006. The six New England states adopted the 2001 Climate Change Action Plan signed by the New England Governors and Eastern Canadian Premiers, passed legislation enacting renewable portfolio standards or the equivalent, and helped lead the ten-state northeast Regional Greenhouse Gas Initiative.

Over thirty states, including all six New England states, have developed comprehensive greenhouse gas emissions reduction plans. These plans serve many purposes including: quantification of past, present, and potential future greenhouse gas emissions; collaboration with a range of stakeholders who provide diverse perspectives and input on how to reduce greenhouse gas emissions; identification of state goals for future reductions in greenhouse gas emissions; and the development of detailed recommendations regarding the best strategies and policies to meet those goals. After completing their respective climate action plans, two New England states (Connecticut and Massachusetts) passed legislation establishing comprehensive and binding caps on greenhouse gas emissions from their state economies.

The common practice for developing climate action plans has been for state government to collaborate with an external consultant (e.g., Northeast States for Coordinated Air Use Management [Boston, MA]; Raab Associates [Boston, MA]; Center for Clean Air Policy [Washington, DC]; Tellus Institute [Boston, MA]; Center for Climate Strategies [Washington, DC]) to organize the stakeholder advisory process and quantify the economic and greenhouse gas reduction impact of different strategies and policies (e.g. Rose et al. 2009; Center for Climate Strategies, 2011). While the resulting plans have received considerable attention in their individual states and have served as detailed roadmaps for action, there has been only limited analysis and dissemination of the process and of the results in the peer reviewed literature.

This paper describes the highly collaborative process, transparent quantitative analysis, and application of decision-relevant information that served as the foundation for the development of New Hampshire's Climate Action Plan (New Hampshire Climate Change Policy Task Force, 2009). The plan calls for a reduction in greenhouse gas emissions of 20 percent below 1990 emissions by 2025 (or 44 percent below 2005 emissions) and 80 percent below 1990 emissions by 2050. The New Hampshire process was different from other states in that the ongoing and iterative stakeholder engagement was facilitated by New Hampshire Department of Environmental Services (NHDES) staff, and the collaborative and transparent greenhouse gas emission and economic analysis was performed by a team of faculty and staff from the University of New Hampshire's (UNH) Carbon Solutions New England with staff from the NHDES. The analysis team is represented by the authors on this paper. The active participation of UNH faculty and staff was driven, in part, by the University's commitment to engaged scholarship (Wake 2009) which is defined at UNH as a mutually beneficial collaboration with community and external partners for the purpose of generating and applying relevant knowledge to directly benefit the public. UNH participation was also driven by the University's commitment to sustainability which includes foci on research and engagement with the broader community (Aber et al. 2009). Furthermore, previous economic analyses (Gittell and Magnusson 2007; 2008) have proven to be a key component in New Hampshire for passage of legislation related to renewable energy and climate change.

The primary objectives of this article are to (1) share the process and the results of the economic and greenhouse gas emission analyses for the state of New Hampshire (performed in close collaboration with the New Hampshire Climate Change Policy Task Force and Technical Working Groups) and (2) discuss how research and transparent analysis informed Task Force decision making regarding the selection of emissions reduction and economic development strategies to be included in New Hampshire's Climate Action Plan.

Process for the Development of the Newhampshire Climate Action Plan

Under the leadership of Governor John Lynch, the New Hampshire Climate Change Policy Task Force (Task Force) was established through Executive Order in December 2007. The Governor charged the Task Force with developing greenhouse gas emission reduction goals and recommending policies (including regulations, incentives, technical assistance, investments, education and training, and voluntary programs) that the state should consider to meet those goals. The Task Force, led by NHDES Commissioner Tom Burack, consisted of twenty-nine members, representing a broad range of sectors and interests in New Hampshire including the New Hampshire House and Senate, state agencies, municipal government, business and industry, environmental interests, the forestry sector, science/academia, public utilities, and the insurance industry.

Working Group	Acroynm
Electric Generation and Use	EGU*
Residential, Commercial, Industrial Buildings	RCI*
Transportation and Land Use	TLU*
Agriculture, Forestry, Waste	AFW*
Government Leardership and Action	GLA
Adaption	ADP

* Working Groups whose strategies were analyzed by CSNE

Table 1. Names of the six Working Groups that provided input to the New Hampshire Climate Action Plan

In support of the Task Force, six Working Groups (Table 1) were formed to investigate, discuss, and develop a suite of possible strategies for greenhouse gas reductions as well as options for adaptation. Over 125 individuals, representing a wide range of interests and expertise, participated in these working groups. Most of the Task Force members also served on the Working Groups. The groups initially received a list of nearly 220 actions that had been considered in the climate action plans of other states from across the country. The groups reviewed these potential actions, developed additional or modified emission reduction strategies, and identified the most promising actions. This information was then summarized in the form of individual action reports that provide detailed information on program description (e.g., mechanism, implementation, parties affected, related existing policies and programs, complimentary policies, timeframe for implementation, anticipated timeframe of outcome) and program evaluation (e.g., carbon dioxide reductions [for 2012, 2025, and 2050] and economic impacts [costs and benefits], other environmental, health, and social benefits, potential for implementation, and level of working group interest). All of the individual action reports are available in Appendix 4 of the Climate Action Plan.

As the action reports were being developed by four of the six Working Groups (Electric Generation and Use; Residential, Commercial, Industrial Buildings; Transportation and Land

Use; Agriculture, Forestry, Waste), they were shared and discussed with the analysis team to determine potential carbon dioxide emission reductions, costs of implementation, and cost savings associated with each potential action. The strategies developed by the Adaptation Working Group were not analyzed for emissions or economic impacts because they lacked the requisite specificity for quantification. The government leadership and action strategies were considered supporting actions and therefore were not quantified separately because their emissions reduction and economic impact were already accounted for in actions identified by the other working groups.

Detailed and transparent analyses were conducted within an iterative and collaborative process over a period of several months to ensure that the emission reductions, costs, and savings projections for each analyzed potential action were based on grounded and shared assumptions and reflected the collective wisdom of the Working Groups. The analysis team met weekly to discuss the details of the analytical approach and ensure integration of the environmental and economic analyses. The Working Groups were also routinely consulted to discuss the methodology and assumptions used in the analyses, share preliminary results, and prioritize actions to research and analyze in more detail. When necessary, experts outside of this process were consulted. One author (Wake) served on the Task Force and the analysis team routinely attended Task Force meetings. The results of our analysis were also formally presented the to the entire Task Force on two occasions (August and October 2008) to solicit additional feedback. This iterative and collaborative process encouraged open and honest dialogue that not only led to revisions and improvements in the analysis, but also enhanced the understanding and shared ownership of the results by Task Force members.

One of the first analyses completed was projecting business-as-usual greenhouse gas emissions out to the year 2050. Given the considerable uncertainty in future economic activity and future emissions, the Task Force decided to use a relatively simple and straightforward approach by extrapolating historical emissions data (Figure 1). Linear extrapolations of 1990-2005 emissions data (Energy Information Administration 2011) were used to project emissions from the transportation and building sectors. Projected emissions from the electricity generation sector were calculated differently because the historical New Hampshire emissions are punctuated by large fluctuations between 2002 and 2005, due primarily to an increase in the number of major natural gas generation plants as well as a combination of economic and climatic conditions that reduced demand, encouraged fuel switching, and reduced capacity. Linear extrapolation of total New England generation was extrapolated and future New Hampshire generation was projected based on the assumption that New Hampshire will continue to contribute 17.3 percent of New England generation. Projected business-as-usual emissions were calculated based on the assumption that all future expansion of New Hampshire generation capacity is provided by natural gas plants.

To estimate the future emissions from woody biomass (i.e., the northern forest), a model of net carbon emission/sequestration was constructed incorporating data obtained from the Forestry Inventory and Analysis National Program (United States Department of Agriculture, 2011), a report on land use change in New Hampshire (Society for the Protection of New Hampshire Forests, 2005), and from personal communication with experts in the forestry and wood products industry (Aber and Frades 2009). This model estimates exchanges of carbon between terrestrial woody biomass sinks and the atmosphere. Changes in standing woody biomass are modeled for all ten New Hampshire counties and for four forest classes (pine, other softwoods, soft hardwoods, and hardwoods) as a result of primary productivity, mortality, forest conversion, and harvest. Decomposition and storage in the dead wood pool is included in the model. The fate of harvested wood is partitioned into slash and cull, low grade products (pulp, cordwood, or bark), and mill products (rough lumber, chips, sawdust, or bark). Mill product use is modeled as durable product, non-durable product, or wood for energy (electricity generation or home heating).

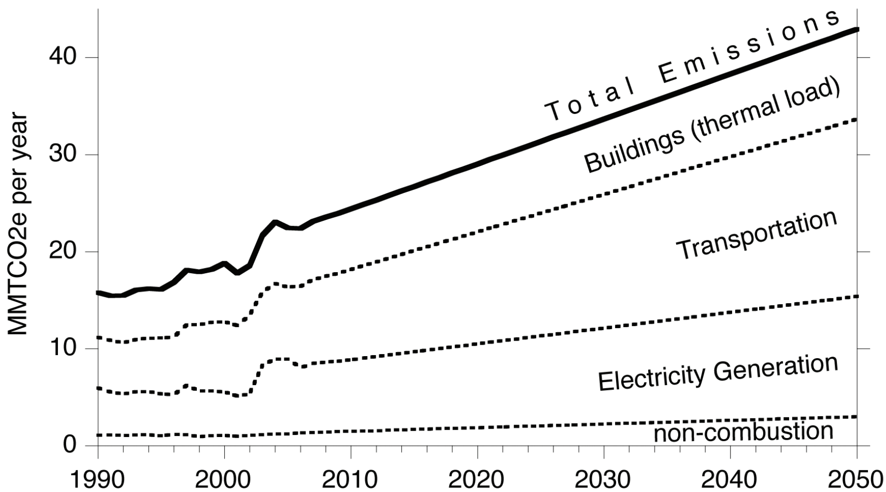

Figure 1. New Hamphire's cumulative historical (1990-2005) and projected greenhouse gas emissions (business-as-usual) by sector. The emissions for the building sector only represent the thermal load; electricity use is captured in the Electricity Generation sector.

To accommodate the large number of actions that required analysis over a relatively short period of time from January to August 2008, numerous assumptions were made ranging from population growth to the future cost of fossil fuel to the average cost to renovate a home so it uses 60 percent less energy to the average amount of wood biomass harvested each year. These assumptions were grounded in the best available information from the literature, from expert interviews, and from discussions with the Working Groups and Task Force. The approach and all of the key assumptions made for each of the suite of analyses that were performed are detailed in Appendix 7 of the Climate Action Plan.

The objective of the economic analysis was to estimate approximate "levels of magnitude" of the economic impacts of each proposed action item and was meant to provide economic context to assist in the decision making process for the Task Force. The analysis is conservative because it is limited to direct New Hampshire costs/benefits and does not include a broad assessment of social impacts. As much as possible, direct employment impacts were considered in calculating economic benefits. The analysis does not consider potential benefits associated with actions such as reduced health costs due to reduced air pollution emissions (which could be considerable) and also does not include avoided costs in calculating economic impacts. In this regard, the analysis serves as a conservative estimate of the economic benefits. Where appropriate, an economic multiplier was used to estimate the broader state-wide economic impacts of cost savings, such as for reduced fuel consumption. Based on knowledge of the New Hampshire economy and to be conservative, a one dollar economic multiplier was applied for each dollar of fuel savings attributed to an action. For example, if improving energy efficiency in a home saved $1000 per year in fuel costs, we estimated the total economic impact on the New Hampshire economy to be $2000 ($1000 in fuel savings and an additional $1000 related to the indirect and induced impacts from that additional $1000 being spent in the New Hampshire economy). Details of actions where the economic multiplier was applied are provided in Appendix 7 of the Climate Action Plan. The economic analysis does not discount costs and benefits of climate change policies to reflect timing or uncertainty. This is consistent with the approach used in the widely cited Stern Review on the Economics of Climate Change (Stern 2007).

In the process of quantifying the impact of various actions and via feedback from the Working Groups and the Task Force, it became clear that there were significant interactions among actions within each working group. As a result, while the impact of several of the individual actions was quantified, the cumulative impact could not be obtained by simply summing the results of the individual actions. For example, enforcing existing speed limits based on the current and future business-as-usual fleet of vehicles on the road would result in larger savings compared to a more fuel efficient fleet of vehicles (a separate recommendation). To assist the Task Force to consider the comprehensive effects of combinations of policies without double counting impacts, scenarios of suites of strategies (combination strategies) were analyzed for the four working groups.

Five of the six working groups represented different policy and action categories that have been used in several other state climate action plans. The Task Force also included a sixth working group focused on adaptation that was formed to identify potential actions that should be taken to help society adapt (and thereby reduce vulnerability) to current and future changes in climate. While not typically included in the climate action plans of other states, the Task Force believed that adaptation was a critical issue as the state is already experiencing the impacts of a changing climate, and these changes will likely become more pronounced in the future (Hayhoe et al. 2007; Wake et al. 2008). Consequently, the adaptation working group looked at what actions should be considered to prepare New Hampshire for a changing climate even as the state begins to reduce its greenhouse gas emissions.

Results

The Task Force set a goal for greenhouse gas emission reductions of 20 percent below 1990 emissions by 2025 (or 44 percent below 2005 emissions) and 80 percent below 1990 emissions by 2050 (Figure 2). This was driven by the desire to be consistent with reductions initially agreed to in the New England Governors and Eastern Canadian Premiers 2001 Climate Change Action Plan, by the desire to be consistent with similar reduction goals adopted in the climate action plans of the other New England states, and by the results of the detailed greenhouse gas reduction analysis which clearly showed that meeting the mid-term (2025) goals were feasible if concerted actions were taken.

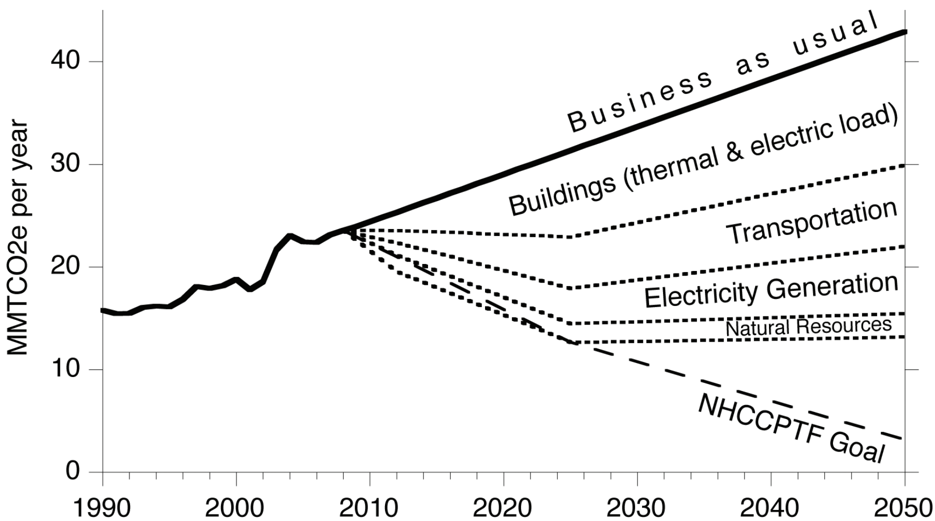

Figure 2. Project emissions reduced from implementation of recommended actions in New Hampshire's Climate Action Plan. The building sector wedge represent emissions reductions due to actions on both thermal and electrical loads. The electricity generation wedge reflects actions in how electricity is generated, not how electricity is used.

Based in part on the detailed and collaborative greenhouse gas reduction and economic impact analysis, the Task Force organized the sixty-seven recommended actions in the Climate Action Plan into ten overarching strategies (Table 2) necessary to position the state to meet the greenhouse gas emissions goals. Implementation of all of these strategies is required to comprehensively address the causes and the impacts of climate change. Each of the sixty-seven specific recommendations is described in further detail in the action reports in Appendix 4 of the

Climate Action Plan.

The greenhouse gas emission reduction and economic impact of fifty-one recommendations from four Working Groups for which analyses were completed are summarized in Table 3. Estimates of the reduction in greenhouse gas emissions are provided for three time periods: short-term (2012), medium term (2025), and long-term (2050). The results of the economic impact are provided in three categories: amount (in $2008), timing, and parties impacted. For each category, the costs and benefits are listed. An explanation of the symbols used is provided at the bottom of the table. The actions included in the combination strategies are also identified in Table 3. These form the basis for the depiction of potential emission reductions in Figure 2.

1. Maximize energy efficiency in buildings
2. Increase renewable & low-CO_2-emitting sources of energy in a sustainable manner
3. Support regional and national actions to reduce greenhouse gas emissions
4. Reduce vehicle emissions through state actions
5. Encourage appropriate land use patterns that enable fewer vehicle-miles traveled
6. Reduce vehicle-miles traveled through an integrated multi- modal transportation system
7. Protect natural resources to maintain the amount of carbon fixed or sequestered
8. Lead by example in government operations
9. Plan for how to address existing and potential climate change impacts
10. Develop an integrated education, outreach and work-force training program

Table 2. Ten overarching strategies to reduce greenhouse gas emissions that serve as the foundation for the New Hampshire Climate Action Plan

The most significant reductions in greenhouse gas emissions in the future come from the building and transportation sectors (Figure 2). By 2025, implementing key actions results in an annual reduction of greenhouse gas emissions by 8.4 and 5.0 million metric tons carbon dioxide equivalent (MMTCO_2e) for the building and transportation sectors, respectively. Key actions in the building sector include renovating existing residential, commercial and industrial buildings so they use 50-60 percent less energy and minimizing net CO_2 output in new buildings. For transportation, the key actions are improving fuel efficiency standards in light and heavy-duty vehicles, developing a low-carbon fuel standard, and reducing vehicle miles traveled. Implementation of the Regional Greenhouse Gas Initiative and extending the emissions cap beyond 2018 results in an annual emissions reduction of 3.4 MMTCO_2e in the electricity generation sector by 2025. Implementing an integrated forestry and wood use plan results in annual emission reductions of 1.8 MMTCO_2e by 2025.

While the assessment of economic benefits of various policy actions was conducted for all years (results for three time periods provided in Table 2), the year 2025 benchmark was selected to illustrate that up-front costs in many cases are investments that can have a positive return, but that it would take some time for that positive return to be realized (Figure 3). We identified that much of the economic benefit of actions to reduce greenhouse gas emissions stem from

NH CAP Recommendation	CO2 Emissions Reduction (MMTCO2e/year)			Economic Impact ($2008)		Timing of Economic Impact		Parties Economically Impacted	
	2012	2025	2050	Costs	Benefits	Costs	Benefits	Costs	Benefits
ELECTRICITY GENERATION AND USE (EGU)									
1.1 Alternative Rate Design	-	-	-	$	-		-	Gs	-
1.3 Combined Heat & Power	0.15	0.53	0.69	$$$$	$$$$$			E	B
2.1 Renewable Portfolio Std.	0.28	1.40	1.81	$$	$$$			E	E
2.2* RGGI	0.47	2.79	5.92	$$$	$$$$			E	E
2.4 Low-CO2 Supply Side	-	-	-	$	-		-	Gs	-
2.6 Import low CO2 power	6.09	6.09	6.09	-	-	-	-	-	-
2.7 New Renewable Gener.	0.14	0.56	1.12	-	-	-	-	-	-
2.8 Next Gen. Electric Grid	-	-	-	-	-	-	-	-	-
2.9 Low-CO2 Distributed Gener.	-	-	-	-	-	-	-	-	-
RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL BUILDINGS (RCI)									
1.1* Energy Eff. New Constr.	0.46	2.85	6.93	$$$$$$	$$$$$$			E	E
1.2* Energy Eff. Residential	0.78	3.29	3.29	$$$$$	$$$$$$			C	C
1.3* Energy Eff. Comm.& Ind.	0.54	2.29	2.80	$$$$	$$$$$$			B	B
1.4A Upgrade Energy Codes	0.21	0.87	2.13	$$$$	$$$$$			E	E
1.4B Energy Code Compliance	0.03	0.12	0.28	$	$$$			Gl	-
1.5 Energy Eff. in MLS Listings	-	-	-	$$	-		-	C	C
1.8 Conserve Embodied Energy	-	-	-	$$$$	$$$$$			-	-
2.1 High Eff. Equip. & Systems	-	-	-	$$$	-		-	Gs	B
3.1 Renew. & Low-CO2 Thermal	0.03	0.13	0.24	$$$	$$$			C	C
4.1 Energy Eff. in School	-	-	-	$	-		-	-	-
4.2 Building Management	-	-	-	$$	$$$$			Gs	B
4.3 Residen. Ed. & Outreach	-	-	-	$	-		-	Gs	C
4.4 Comprehensive Energy Eff. Ed.	-	-	-	$$	$$$			Gs	B
4.5 Web Portal	-	-	-	$	-		-	Gs	-
4.6 Outreach & Education Plan	-	-	-	-	-	-	-	-	-
TRANSPORTATION AND LAND USE (TLU)									
1.A1* CAFE Standards	0.27	2.37	3.75	$$$$	$$$$$$			C	C
1.A2* Heavy-Duty Vehicles Stds.	0.22	0.94	1.82	$$$$	$$$			B	-
1.A3 Low Emission Vehicle Stds.	0.16	1.78	2.62	$$$	$$$$			C	-
1.B1 $500 Feebate	0.23	0.73	1.00	$	$$$$$			Gs	C
$1000 Feebate	0.34	1.07	1.47	$	$$$$$			Gs	C
1.C1* Low-Carbon Fuel Standard	0.00	0.89	1.32	$	$$$			Gs	C
1.C2 Advan. Technology Vehicles	-	-	-	$$$$	$$$$$$			C	C
1.C3 Reduce Black Carbon Emissions									
Diesel oxidation catalysts	0.07	0.40	0.70	$$$	$			B	-
Flow through filters	0.14	0.80	1.39	$$$	$			B	-
Diesel particulate filters	0.23	1.30	2.25	$$$$	$			B	-
1.D1 Enforce Current Speed Limits	0.06	0.18	0.25	$	$$$			Gs	C
1.D1Lower Posted Speed Limits	0.11	0.35	0.48	$	$$$$			Gs	C
1.D2 Reduce Vehicle Idling	0.01	0.02	0.03	$	$$			B	B

Table 3. Carbon dioxide reductions and economic impact of NH Climate Action Plan recommendations.

NH CAP Recommendation	CO2 Emissions Reduction (MMTCO2e/year)			Economic Impact ($2008)		Timing of Economic Impact		Parties Economically Impacted	
	2012	2025	2050	Costs	Benefits	Costs	Benefits	Costs	Benefits
1.D3 Improve Traffic Flow	0.01	0.04	0.06	$	$$	▭	◿	Gs	E
2* Reduce VMT-Light Duty	0.16	0.95	3.27	-	$$$$$$	-	◿	-	C
2* Reduce VMT-Heavy Duty	0.05	0.38	1.68	-	$$$$	-	◿	-	B
2.A1 Trip Reduction	0.03	0.13	0.17	$$	$$$	▭	◿	B	C
2.B1 Local/Intra-Regional Transit	0.01	0.11	0.29	$$	$$$	▭	◿	C	C
2.B1 Bicycle&Ped. Infrastructure	0.02	0.08	0.11	$$	$$$	▭	◿	C	C
2.B2 Passenger Rail Service	0.00	0.05	0.15	$$$	$$$$$$	▭	▭	E	E
2.B2 Stable Funding Public Trans.	-	-	-	$	-	-	-	-	E
2.B2 Park-and-Ride	0.03	0.04	0.05	$$	$$	▭	◿	-	C
2.B2 Inter-City Bus Service	0.01	0.02	0.15	$$	$$$	▭	◿	C	C
2.C Develop Land Use Patterns that Support a Balanced Multi-Modal Transportation System and Reduce VMT									
In-community only growth	0.00	0.03	0.16	-	$$	-	◿	-	C
60% growth 14 largest commun.	0.00	0.24	0.65	-	$$$	-	◿	-	C
90% growth 14 largest commun.	0.00	0.42	0.90	-	$$$$	-	◿	-	C
2.C1 GHG Development Fees	-	-	-	$	-	▭	-	Gs	-
2.C1 Approve Low-GHG Projects	-	-	-	$	-		-	Gs	-
2.C2 Model Zoning (Bus/Rail)	-	-	-	$	-	▭	-	Gs	-
2.C3 Model Zoning (High Density)	-	-	-	$	-	▭	-	Gs	-
2.C8 Assistance to Municipalities	-	-	-	$	-	▭	-	Gs	-
AGRICULTURE, FORESTRY AND WASTE									
1.1.3 Protect Agriculture Land	-	-	-	$$	$$	▭	◿	Gl	E
1.2* Avoid Forest Land Conversion	0.17	0.33	0.52	$$$$	$$$	▭	◿	Gl	E
1.3* Promote Durable Wood Prod.	0.10	0.10	0.10	$	$$$	▭	▭	Gs	B
2.2* Max. Biomass for Energy	1.63	1.81	2.25	-	-	-	-	-	-
2.2.1 Maintain Biomass Infrastruc.	-	-	-	$$	$$$	▭	▭	Gs	B
2.2.2 Sustainable Biomass Consum.	-	-	-	$	-	▭	-	Gs	B
2.2.3 Efficient Use Biomass Stock	-	-	-	$	-		-	Gs	B
3.1 Pay-As-You-Throw Initiative	-	-	-	$$	$$$	◺	▭	Bm	E

* indicates recommendation was used to quantify emissions reduction for sector

Economic Impact

$	$0 - $2.5 million
$$	$2.5 - $25 million
$$$	$25 - $125 million
$$$$	$125 - $500 million
$$$$$	$500 million - $1 billion
$$$$$$	greater than $1 billion

Timing of Impact

▭	constant/even
◿	low short term/mostly long term
◺	immediate/higher upfront

Parties Impacted

E	evenly distributed
C	consumers
Gl	government - local
Gs	governement - state
B	business - evenly distributed
Bs	business - small
Bm	business - medium
Bl	business - large

Table 3. Carbon dioxide reductions and economic impact of NH Climate Action Plan recommendations.

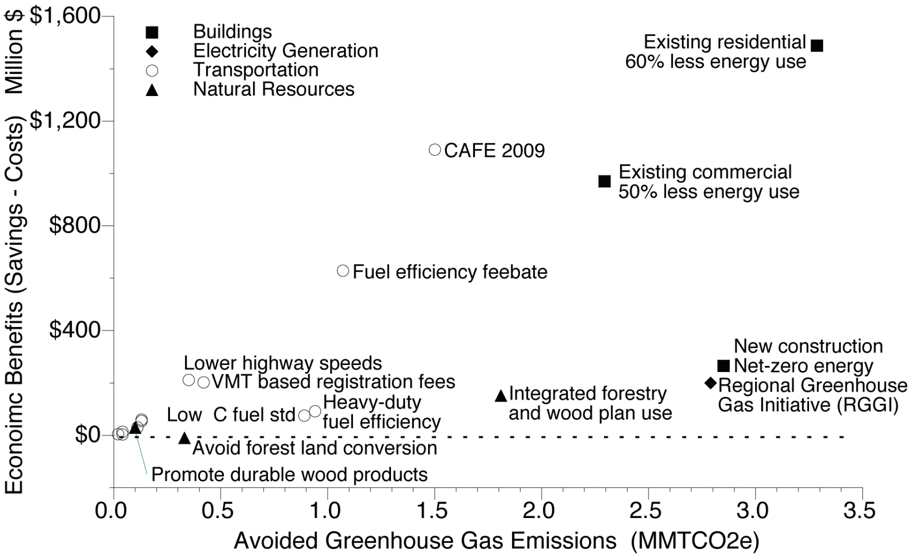

Figure 3. Economic benefits and avoided emissions of greenhouse gases in the year 2025 for actions recommended in New Hampshire's Climate Action Plan.

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the reduction in expenditures on fossil fuels (all of which are imported into New Hampshire) and the recycling of these savings in New Hampshire's economy. Although not always quantified, additional economic benefits are expected from new job creation, and investments in New Hampshire's green economy. We expect there are additional economic benefits not captured in our analysis, such as the positive impact on human pulmonary and cardiac health (e.g., Landen et al. 2006) as a result of reductions in air pollution that would accompany reductions in greenhouse gas emissions.

Discussion

The relatively straightforward, collaborative, and open source approach used to quantify the greenhouse gas reductions and economic impact of a wide range of actions in four sectors of the economy, combined with clear documentation of all assumptions and sources of information, resulted in a transparent process with several benefits. First, the transparency and clarity of the assumptions allowed the Working Group and Task Force members to question the assumptions directly and better understand the analyses as well as the results. Second, an update of the analyses and tracking of progress can be easily completed in the future without the need for proprietary models linking carbon emissions with economic activity. Third, the frugal models were appropriate given the considerable uncertainty regarding the state's and the nation's future economic activity. A review of other state climate action plans suggests that the assumptions used in their analyses that determined the potential economic savings and emission reduction were not always evident. Instead of using complicated models, we focused our efforts on grounding and clarifying assumptions, and enhancing the Task Force's and Working Group's understanding of the results.

The results of the detailed analyses (e.g., Figures 2 and 3; Table 3) were provided to the Working Groups and Task Force to assist in their deliberations concerning which actions to include in the final Climate Action Plan. In addition, a web-based visualization (Carbon Solutions New England 2009) was developed so Task Force and Working Group members could view the potential greenhouse gas emission reductions out to the year 2050 of individual and combinations of actions compared with the "business-as-usual" scenario, and the economic impact compared to the greenhouse gas emissions reduction potential. The availability of these results was critical for generating interest and discussion, and for informing the decisions of Task Force members regarding which recommendations to include in the final Climate Action Plan.

While it is evident that a handful of actions result in the majority of greenhouse gas emission reductions and positive economic benefits by the year 2025, it would be incorrect to assume that the state should focus its collective effort solely on this small subset of actions. Rather, many of the other recommendations provide critical support for the actions that have the largest impact, and therefore progress on most (if not all) of the recommendations is necessary to fulfill the broader-based emission reduction goals. For example, a broad-based education and outreach plan (overarching strategy number 10, Table 2) as well as several marketing, education and outreach efforts included in the residential, commercial, and industrial building sector (Table 3) represent actions that, if implemented, could provide the necessary groundswell of support for a wide-ranging and challenging effort of renovating the entire stock of buildings in New Hampshire over the next 15-20 years. Within the transportation sector, there are several actions related to public and alternative transportation, and land-use patterns that are required to provide access and mobility while reducing vehicle miles traveled. To achieve the broader impacts of reducing greenhouse gas emissions while supporting significant economic development, it is critical to view the recommendations in the Climate Action Plan as an integrated whole, rather than a set of discrete actions.

Implementation of all sixty-seven recommendations in the Climate Action Plan that support the ten overarching strategies will enable New Hampshire to continue to do its part to address climate change immediately as well as position the state and its citizens to implement even greater reductions in the future. These actions will benefit the economy, increase state and regional energy security, and preserve the environment. However, even if fully implemented, these recommendations alone will not be sufficient to achieve the long-term emission reduction goal by 2050 (Figure 2). These recommendations do constitute critical steps that would enable emission reductions to occur via a phased-in approach. Moreover, the recommended actions will meet the emissions reduction goal by 2025, a time period which represents common planning horizons for states (i.e., one to two decades). A phased-in approach will allow New Hampshire to focus its resources early on those opportunities that are currently most cost-effective and, subsequently, to consider other opportunities as technology, political will, and public support evolves and markets develop. This Climate Action Plan contains those measures that the Task Force considered would be most effective in rapidly addressing the state's greenhouse gas emissions over the next one to two decades while positioning New Hampshire's citizens, government, businesses, industries, and not-for-profits to achieve still greater future reductions as technological, economic, political and social changes allow.

The analysis team addressed several challenges during the fourteen months that we worked with the Task Force to collaboratively generate decision relevant information that provided the foundation for a well articulated and grounded Climate Action Plan. One challenge was the allocation of the greenhouse gas emission reductions and economic impacts to specific actions that are in reality integrated on regional scales. For example, the team attempted to isolate the impacts of electricity generation and the northeast Regional Greenhouse Gas Initiative on New Hampshire; however electricity purchase and sales are managed as a regional grid across New England. In addition, New Hampshire is a net exporter of electricity as it generates approximately twice as much electrical power as it consumes. This was eventually addressed by adopting three key assumptions: New Hampshire will continue to contribute 17.3 percent of New England generation; all future expansion of New Hampshire generation capacity will be provided by natural gas plants; and greenhouse gas emissions reductions resulting from the Regional Greenhouse Gas Initiative are spread evenly across the states based on their level of generation. Another challenge that ultimately expanded the scope and improved the relevance of the analyses was addressing the questions, ideas, and information resulting from interaction with the Working Groups and the Task Force. This was particularly true for the forest and wood products model. Detailed discussions with the Agriculture, Forestry and Waste Working Group helped transition the initially very simple model of the use of forest products (i.e., burning maximum sustainable yield for energy) to one that included changes in carbon storage in forests and a variety of types of forest products (Aber and Frades, 2009). A third issue was structuring the presentation of the results of the analyses to maximize the usefulness of the individual analyses and integrate these into a coherent whole without confusing or overwhelming the members of the Task Force. We addressed this using a layered approach that provided information in a variety of formats ranging from detailed to overall summaries, and by developing and presenting combination strategies. Elements of this approach included the detailed action reports, summary tables (Table 3), graphical formats (Figures 2, and 3), on-line visualizations, and interim reporting and discussion of results.

In recent years, the role of adaptation as a strategy to reduce vulnerability to our changing climate has risen in prominence. Adaptation has now joined mitigation as parallel strategies that are required to respond meaningfully to global climate change (e.g., Parry et al. 2007; National Research Council 2010b). Vulnerability to the impacts of climate change varies by region, sector, scale, and segment of our society. As a result, adaptation planning is required across all levels of government, the private sector, nongovernmental and community organizations. Adaptation plays a central role in New Hampshire's Climate Action Plan. Recommendations include developing a statewide adaptation plan, assessing and communicating the impacts of climate change, promoting action to help populations most at risk, dealing with emerging infectious disease, improving the resilience of ecosystems, increasing society's resilience in the face of extreme weather events, and strengthening the adaptability of New Hampshire's economy to respond to climate change over years to decades.

Conclusions and Outlook

Through a collaborative process initiated by New Hampshire Governor John Lynch and led by New Hampshire DES Commissioner Tom Burack, the 29 members of New Hampshire's Climate Change Policy Task Force engaged over 125 stakeholders in six Working Groups, received input from over 200 citizens, directed detailed analyses, and developed a Climate Action Plan (New Hampshire Climate Change Policy Task 2009). The Plan is aimed at achieving the greatest feasible reductions in greenhouse gas emissions while also providing the greatest possible long-term economic benefits to the citizens of New Hampshire. The most significant reductions in greenhouse gas emissions and greatest economic savings come from substantially increasing energy efficiency in the building and transportation sectors, continuing to increase sources of renewable energy, designing our communities to reduce our reliance on automobiles for transportation, and preserving our working forests. In essence, a response to climate change and our economic future are inextricably tied to how much energy we use and how that energy is produced. Future economic growth in New Hampshire as well as mitigation of, and adaptation to, a changing climate will depend on how quickly we transition to a new way of living that is based on a far more diversified energy mix, more efficient use of energy, and development of our communities in ways that strengthen neighborhoods and urban centers, preserve rural areas, and retain New Hampshire's quality of life. As a result, New Hampshire's Climate Action Plan presents an opportunity to spur economic growth through investment in the state's economy of monies currently spent on energy imports, to create jobs and economic growth through development of in-state sources of energy from renewable and low-emitting resources and through green technology development and deployment by New Hampshire businesses, and avoid the significant costs of responding to a changing climate on the state's infrastructure, economy, and the health of our citizens.

In contrast to other states where external consultants were hired, many of the sixty-seven recommendations adopted by the New Hampshire Task Force were informed by the transparent and collaborative research, data collection, and analysis performed by a team faculty and staff from the University of New Hampshire and staff from the Department of Environmental Services. This collaboration included a well-defined process, frequent communication, open dialogue, shared development and clear articulation of key assumptions, and clear and effective graphics and data tables. As a result, the recommendations in New Hampshire's Climate Action Plan are grounded in a shared quantitative understanding of the greenhouse gas emission reduction and economic impacts. The relevance and quality of the analyses were substantially improved as a result of several factors including: the broad base of expertise and information provided by the Working Groups; an iterative, collaborative process that relied upon frequent communication within and among the Task Force, and diverse membership in the Working

Groups, Task Force, and analysis team. This approach helped establish trust among the diverse set of individuals involved in the process, which in turn allowed for more honest and open discussions.

As illustrated by the New Hampshire Climate Action Plan and also reflected in the recent set of reports on America's Climate Choices (National Research Council 2010a, b, c, d), meeting the challenges associated with mitigation of, and adaptation, to climate change on regional and national levels requires engagement from all sectors of society, including academics and universities. Higher education has been criticized for focusing on disciplines while ignoring societal problems (e.g., Kellog Commission 1999). The engagement of UNH faculty and staff in the research, analysis, deliberation, and communication of New Hampshire's Climate Action Plan, as well as one faculty member serving on the Task Force (Wake), is but one example of engaged scholarship for sustainability that has become a core value at UNH. We argue that more frequent and deeper engagement and collaboration by universities with external partners is critical as our state, region, and nation grapple with responding to global climate change.

Much has transpired to support implementation of recommendations since New Hampshire's Climate Action Plan was accepted by the Governor in March 2009. Approximately $26.5 million in revenues from allowance auctions as part of the Regional Greenhouse Gas Initiative have funded a wide variety of energy efficiency programs across New Hampshire via the Greenhouse Gas Emissions Reduction Fund (Magnusson and Wake, 2011). The New Hampshire

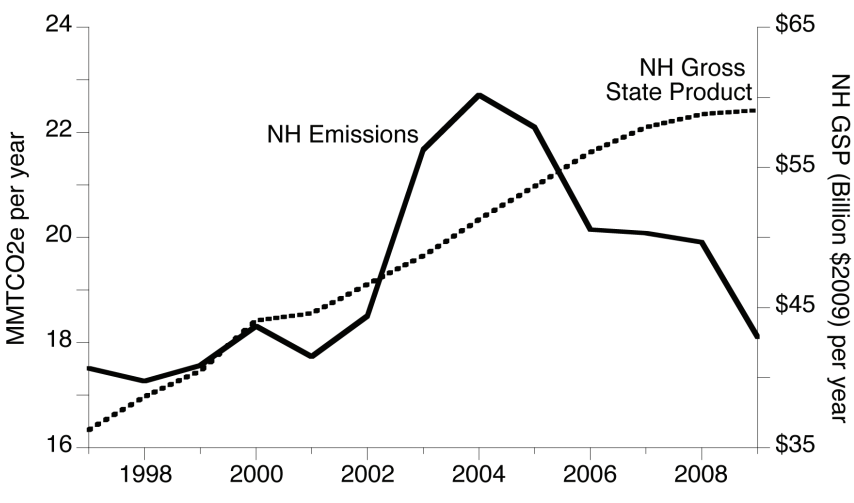

Figure 4. New Hampshire's historical (1997-2009) greenhouse gas emissions (solid line, left hand axis) and gross state product (dashed line, right hand axis).

Office of Energy and Planning has received over $72 million from the American Recovery and Reinvestment Act (ARRA) to fund energy programs including low income weatherization, Energy Efficiency and Conservation Block Grants, State Energy Program, the Green Launching Pad and the Better Buildings/Beacon Communities project. The New Hampshire State Legislature created the Energy Efficiency and Sustainable Energy Board that is charged with promoting and coordinating energy efficiency, demand response, and sustainable energy programs in the state. Three groups working on adaptation plans for specific sectors or regions (costal adaptation, public health, and wildlife) are making progress. The New Hampshire Energy and Climate Collaborative was formed in 2009 to facilitate and track progress of implementation of the climate action plan. And an effort in 2011 to repeal the Regional Greenhouse Gas Initiative led by the New Hampshire House failed, due to action by the Senate and the Governor. Recently, a comprehensive evaluation of the "clean economy" across the United States indicates that while clean economy jobs make up 2.0 percent of the all the jobs in the state (compared to, for example, 3.0 percent in Vermont), these jobs grew at a rate of 5.3 percent annually between 2003 and 2010, the fastest rate in New England and 11th best in the country (Munro et al. 2011)

Analysis of New Hampshire greenhouse gas emissions from all sectors (Energy Information Administration 2011) shows that emissions peaked in 2004 and have since been declining (Figure 4). This is due in part to an increase in the share of electricity generated by natural gas (which has half the carbon dioxide emission per unit of energy generated compared to coal), a steep increase in gasoline and heating oil prices in 2005 and 2006, and the global economic recession that began in 2008. As a result, state greenhouse gas emissions are well below the emissions goals set in the climate action plan. One of the significant challenges for the state will be to continue these emission reductions after the ARRA funded projects wind down in 2012 and as the New Hampshire economy continues to grow. An encouraging trend in this respect is the continued growth in New Hampshire's gross state product (United States Department of Commerce 2011) while greenhouse gas emissions have declined over the past five years. New Hampshire will need to continue this decoupling if we are to realistically meet our greenhouse gas emissions reduction goals in 2025 and 2050 while continuing to provide economic opportunities for our citizens.

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