Tompkins County Energy Roadmap

Evaluating Our Energy Resources

March 4, 2016

Tompkins County Planning Department

Energy Roadmap Steering Committee

The Tompkins County Energy Roadmap was identified as a priority action in the Tompkins County 2020 Energy Strategy (2010) and was developed over a number of years, beginning with a series of projects by Cornell University graduate students from 2011 to 2013. In 2014 a steering committee was created and Professor Max Zhang from the Cornell School of Engineering was hired to complete the project. The steering committee brought together a group of individuals, listed below, who represent the breadth of experience, interest and perspectives within the community regarding our energy future.

- Martha Armstrong, VP & Director of Economic Development Planning, TC Area Development
- Peter Bardaglio, President, Black Oak Wind Farm & Coordinator, TC Climate Protection Initiative
- Scott Bochenek, Manager of Smart Grid Programs, Iberdrola USA/Avangrid
- Carol Chock, Tompkins County Legislator
- Linda Copman, Climate Action Coordinator, Cornell University
- Lew Durland, Director of Energy Management and Sustainability, Ithaca College
- Brian Eden, Tompkins County Environmental Management Council Energy Committee
- Nick Goldsmith, Sustainability Planner, City and Town of Ithaca
- Jerry Goodenough, Chief Operating Officer, Upstate New York Power Producers
- Tony Ingraffea, Dwight C. Baum Professorship in Engineering, Cornell University
- Tim Mount, Dyson School of Applied Economics and Management, Cornell University
- Gay Nicholson, President, Sustainable Tompkins
- Bob Pass, Manager of Regional Outreach and Development, NYS Electric and Gas
- Leslie Schill, University Planner, Cornell University
- Ken Schlather, Executive Director, Cornell Cooperative Extension of Tompkins County
- Ian Shapiro, Chairman, Taitem Engineering

Draft resource potential and scenario chapters were reviewed by the committee and then offered for public review and comment. The draft Energy Roadmap was presented to 18 different community groups, organizations and the public during the summer and fall of 2015. The Steering Committee oversaw completion of the final documents by Professor Zhang, his assistants and staff of the Tompkins County Planning Department and endorses the recommendations for future action.

The Planning Team

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March 2016, Tompkins County Planning Department

The purpose of the Tompkins County Energy Roadmap is to evaluate local energy resources and develop scenarios to meet our County's 80% greenhouse gas (GHG) emission reduction goal and projected energy needs through 2050. The Roadmap has two objectives:

1. To evaluate whether achieving 80% emission reductions is possible primarily using local renewables and demand reduction.
2. To identify local actions that can be taken in the short and long term to achieve our goal.

Our evaluation focuses on technical feasibility and undertakes rigorous analyses to quantify both the potential to reduce energy demand and the potential to produce energy using local renewable resources. The Roadmap quantifies the potential energy that could be generated from solar, wind, micro-hydro, and biomass resources within Tompkins County.

The Roadmap demonstrates that, in spite of the fact that Tompkins County has no exceptional renewable energy resources, it is possible to achieve our goal.

Table 1: Percent of 2008 demand that could be met by local energy resources

	Energy Resource	Annual Energy Potential	% of 2008 Electricity Demand[1]	% of 2008 Thermal Demand[2]	% of 2008 Total Energy Demand[3]
Renewable Supply	Wind	2,646 GWh	327%	n/a	63%
	Solar	2,453 GWh	303%	n/a	58%
	Micro-Hydro	726 GWh	90%	n/a	17%
	Biomass	3,626,477 MMBtu	n/a	59%	25%
Demand Reduction	Building Efficiency: Heating Portion	3,350,604 MMBtu	n/a	54%	23%
	Building Efficiency: Electrical Portion	401 GWh	50%	n/a	9%
	New Construction to Code	1,152,880 MMBtu	n/a	19%	n/a

[1] The grid supplied 809 gigawatt hours (GWh), a measure of electrical energy, of electricity in the community in 2008.

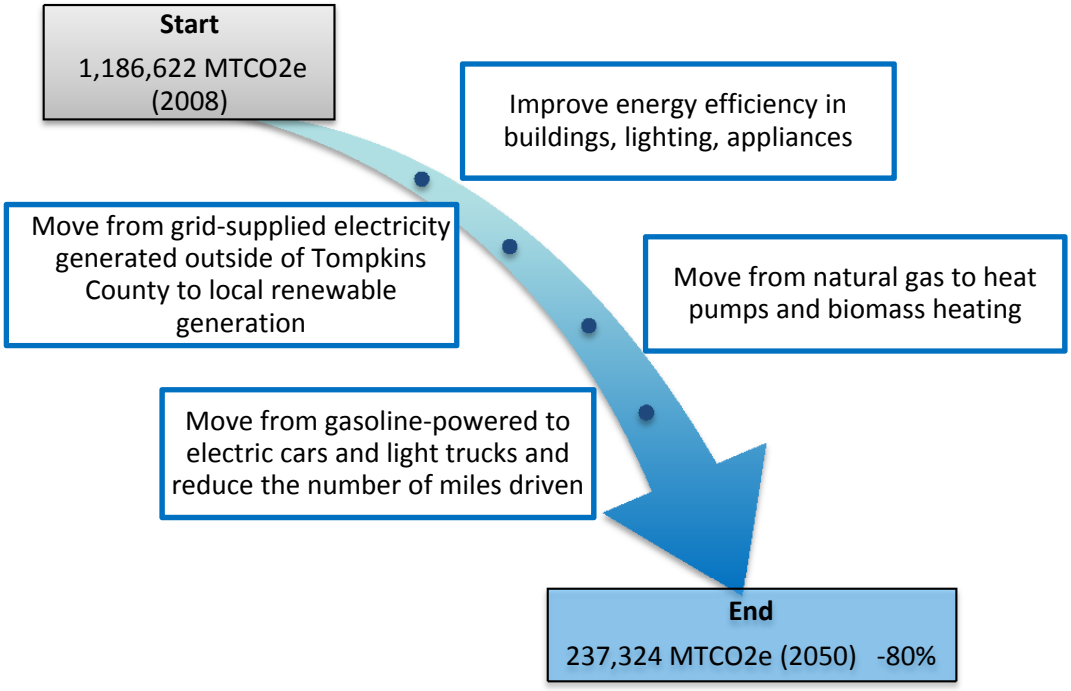
[2] In 2008, the thermal demand in the community was 6,169,985 million British Thermal Units (MMBtu), a measure of the energy content in fuel.

[3] Total energy demand, including electrical, thermal and transportation, was 14,438,224 MMBtu, or 4,231 GWh in 2008.

In addition to the thermal and electrical demand, the Roadmap also analyzes the potential to reduce transportation emissions by transitioning light-duty vehicles to electric and reducing the number of vehicle miles traveled (VMT) with strategies such as transit, car sharing, walking, biking, etc. The Roadmap finds that all 37.6 million gallons of gasoline used in 2008 could be replaced with electricity, though this transition would require an additional 21% of electricity over 2008 levels. Transportation demand management could eliminate 48% of the projected VMT in 2050.

The Roadmap presents three alternative energy scenarios that utilize local potentials to reduce greenhouse gas emissions by 80% and meet the County's projected energy needs in 2050. To develop these three scenarios, we used a model which balances grid-supplied electricity and fossil fuel energy with local renewable energy generation and energy efficiency/demand reduction. The three scenarios represent a wide range of conditions which reflect the divergent ways that energy systems might evolve in the next 35 years but all include the elements shown in Figure 1. Any of the three scenarios will still allow the County to meet its 80% emissions reductions goal.

Figure 1: Key strategies for reducing GHG emissions in Tompkins County[4]



The first scenario, "Business As Usual," serves as a point of reference to illustrate where we will be in 2050 if no further changes are made to the current energy system. The BAU and three alternative energy scenarios are summarized here:

- The **Business As Usual (BAU) Scenario** quantifies GHG emissions and energy consumption in 2050 assuming that no particular actions to reduce emissions, other than those already implemented or planned by 2015, are taken. Emission reductions of 31% are achieved based on adopted U.S. EPA Corporate Average Fuel Efficiency standards and New York State's Renewable

[4] MTCO2e is million metric tons of carbon dioxide equivalent – a measure of the combined ability of emitted GHGs to trap heat.

Energy Portfolio Standard and Energy Conservation Construction Code. These assumptions are applied to all of the scenarios.

- The **Mixed Scenario** assumes that energy services are provided by a mixture of fossil fuel and renewable resources and that the total amount of natural gas used equals that used by the industrial sector in 2008. This means that this scenario caps future natural gas use at 10% of the volume of natural gas consumed in 2008. This approach requires 2.7 times more electricity generation in 2050 compared to the 2008 baseline, due to increased demand and the need to provide excess renewable energy capacity to account for intermittent availability of some of these resources.
- The **All-Electric Scenario** assumes that all energy services (except heavy-duty and medium-duty vehicles) are provided by electricity. Moving to an all-electric energy system requires 3 times as much electricity generation in 2050 compared to 2008.
- The **Half-Natural Gas Scenario** maintains half the amount of natural gas used by the community in 2008. This approach requires 2.4 times more electricity generation in 2050 compared to the 2008 baseline.

New York State's plan to generate half of grid-supplied electricity from carbon-free sources by 2030 will help, but it will not be enough to achieve Tompkins County's 2050 emission reduction goal. Meeting our 80% emissions reduction goal will require us to go beyond the State's goals and further reduce our reliance on natural gas and on electricity generated from a grid based on centralized generating plants.

Tables 2 and 3, below, summarize the findings of the three scenarios, as well as business as usual.

Table 2: Three future energy scenarios and business as usual

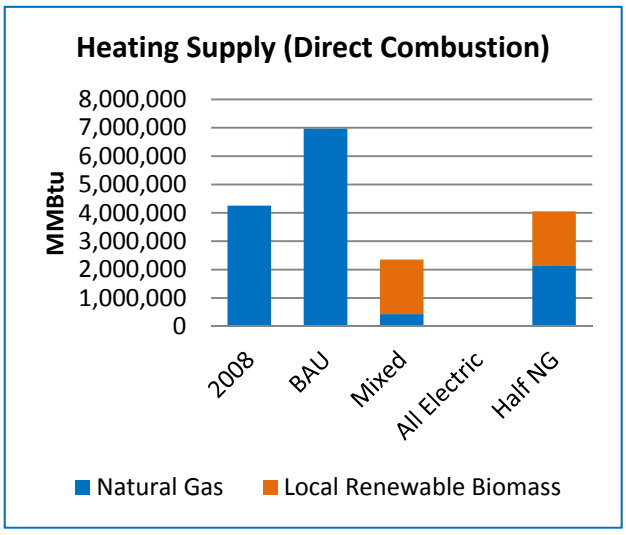
Scenarios	Business As Usual	Mixed	All Electric	Half Natural Gas
% of 2008 Natural Gas Usage Maintained	164%	10%	0%	50%
% of Heating Demand Met by Local Renewables (including heat pump systems and biomass)	0%	67%	72%	29%
% of Projected Energy Demand Provided by Efficiency Improvements	4%	25%	25%	31%
% of Transportation Demand Met by Light-Duty Electric Vehicles	0%	36%	71%	71%
% of Electricity Demand Met by Local Renewables	3%	63%	49%	71%
% of MTCO2e Reduction	31%	80%	80%	80%

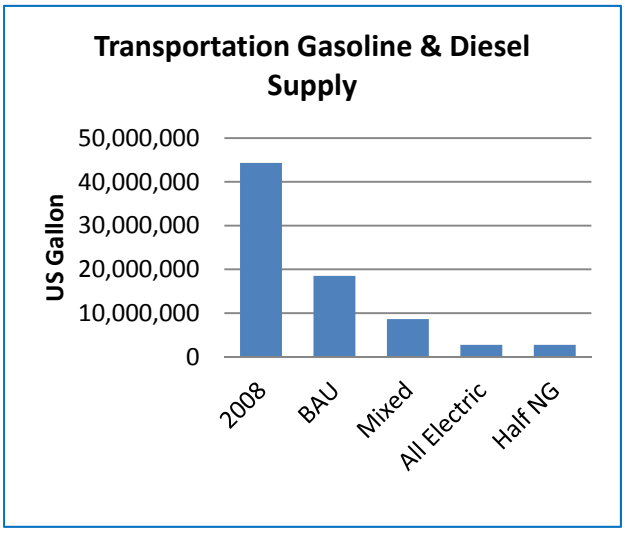
Table 3: Energy sources and GHG emissions—BAU, and three future energy scenarios

		BAU	Mixed	All Electric	Half NG
Heating (Direct Combustion) (MMBtu)	Natural Gas	6,966,253	427,810	0	2,130,034
	Local Renewable Biomass	0	1,923,505	0	1,923,505
Transportation (US Gallon)	Gasoline & Diesel	18,509,924	8,654,674	2,742,849	2,742,849
Electricity (Including Heat Pumps and EVs) (kWh)	Grid	946,530,985	237,815,624	618,313,764	50,678,194
	Local Renewable Electricity	59,099,648	1,941,064,889	1,820,724,109	1,868,823,694
CO2e Emissions (MT)		815,165	237,311	237,322	237,324

The Heating Supply table in Figure 2 below shows that natural gas use will need to be curtailed under any of the future energy scenarios that allow the community to achieve its GHG reduction goals. The decreases in Transportation Sector Supply shown below result from the transition to electric vehicles and the reduction in vehicle miles traveled envisioned in the Roadmap, combined with projected decreases resulting from federal Corporate Average Fuel Efficiency standards.

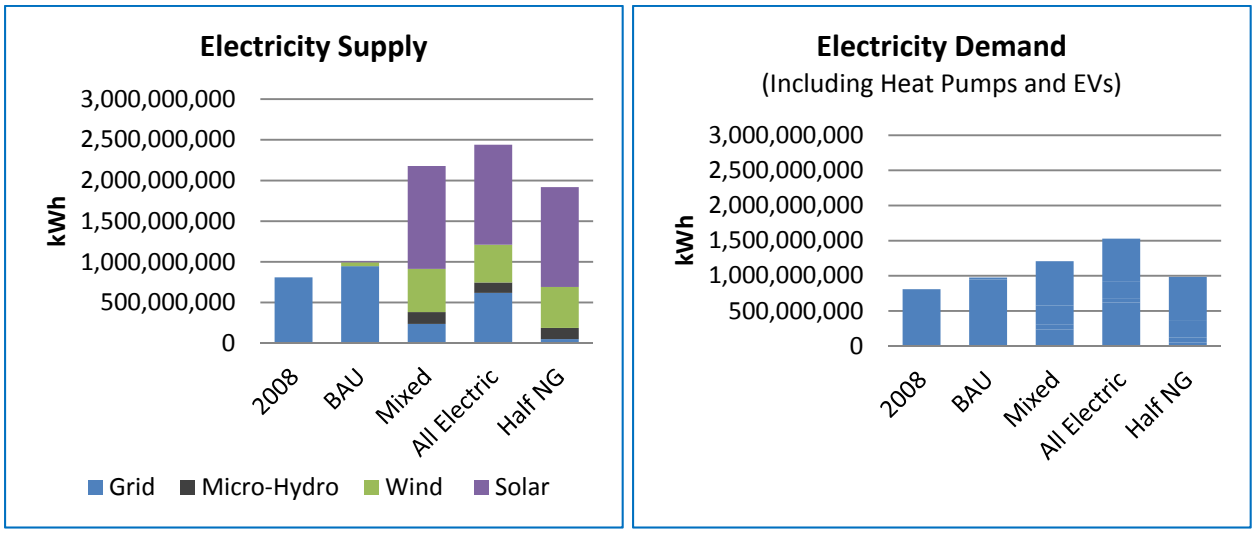
Figure 2: Heating and Transportation supply for 2008, BAU and the three future energy scenarios





The renewable systems in the Roadmap were designed to generate 2 MWh for every 1 MWh of demand in order to compensate for the intermittent nature of renewables and the need to serve peak loads. The 2x design factor causes the electricity supply to be greater than the demand. This can be seen in the charts below.

Figure 3: Electricity supply and demand for 2008, BAU, and the three future energy scenarios



Due to limited resources this Roadmap does not include a financial feasibility analysis or try to predict future government policy or forecast future energy markets. Lifecycle emissions from the production of fossil fuels or renewable energy generation equipment are not included, nor are emissions associated with methane leaks from the natural gas transmission and distribution system. The scenarios incorporate emissions from automobiles and trucks, but do not include rail or air travel. Other sources of emissions such as solid waste and agriculture are accounted for in the scenarios, but potentials for reducing these emissions are not evaluated or included.

The Conclusions and Recommendations section of the Roadmap identifies priority actions the County must take to meet our 2050 energy needs and emissions goal. The following interim goals will help inform our work over the next several months as we update the Tompkins County's Energy Strategy:

- Reducing natural gas use by 50% and grid electricity generated outside of Tompkins County by 24% from current levels.
- Developing 50% of solar potential, 20% of wind potential and 20% of micro-hydro potential.
- Developing 50% of biomass potential, and installing significant numbers of ground and air source heat pumps particularly in new construction; buildings that use fuel oil, propane, or electric resistance heat; or when existing heating systems have surpassed their useful life.
- Achieving efficiency potentials averaging 35% in existing buildings should be a high priority for short-term action.
- Transitioning 50% of light vehicles from gasoline to electric and avoiding any growth in vehicle miles traveled.

Moving forward, the goals, assumptions, and opportunities identified in the Roadmap will be reviewed periodically and adjusted as necessary to reflect future climate science, government policies, and economic factors.

Conclusions and Recommendations

The Energy Roadmap undertakes rigorous analyses to:

A. Quantify both the energy production potential of local renewable energy resources and the potential to reduce energy demand through air-sealing and insulating existing buildings and upgrading lighting, appliances and building systems, and

B. Develop alternative future energy scenarios that tap the identified potentials to both meet the projected energy needs of the community and reduce greenhouse gas emissions 80% by 2050.

The intent is for the analysis, conclusions and recommendations in the Roadmap to be used as the basis for updating the County's Energy Strategy, scheduled for 2016, which will identify concrete action steps to achieve the goals outlined in the Energy Roadmap.

Conclusions

1. The GHG emissions goal of an 80% reduction from 2008 levels by 2050 is feasible to achieve. This transition will require willpower, resources and work, but it is possible to do, even in an area with moderate energy resources and primarily relying on local efforts to develop renewable energy resources and reduce energy demand through efficiency.
2. Federal and State policies, especially around energy changes that require no overt decision-making by consumers, have huge impacts on GHG emissions reductions. This can be seen in the Business As Usual Scenario, which results in a 31% reduction in emissions by 2050 simply based on applying Federal CAFE vehicle emissions standards and New York State's Renewable Portfolio Standard and Energy Conservation Construction Code.
3. It may be possible to maintain up to 50% of the 2008 levels of natural gas use and still achieve GHG emissions goals. However, this would require achieving levels of efficiency and deployment of local renewables that would be extremely challenging. In addition, maintaining such a level of natural gas use will require addressing fugitive methane emissions from the production and transmission of natural gas.

Recommendations to Consider in Developing the Energy Strategy

Energy Strategy Update: The Energy Roadmap will be one of the major inputs to an update of the Tompkins County Energy Strategy which was initially adopted in 2010. In evaluating near term priorities for action, the Energy Strategy should conduct an economic feasibility assessment of these recommendations to consider which are the most feasible. This should be contrasted with the expected costs that will be incurred if global GHG reduction goals are not met. The Strategy may also include actions to pilot demonstration projects to prove the feasibility of some of these recommendations, such as development of medium scale wind and micro-hydro facilities. Development of the Strategy will also be the appropriate process for setting interim goals.

Reducing demand for energy is critical to address GHG emissions, especially in the long-term. Less demand means less need to build new and costly infrastructure and renewable energy systems. By 2050, we should:

1. Achieve a 35% reduction in energy use in existing buildings through retrofits and upgrades. Approximately 2/3 of these savings, or 1.7 million MMBtu, are anticipated to come from reductions of thermal energy demand as a result of building envelope, insulation and HVAC system improvements. About 1/3, or 321 GWh, would likely come from improvements in electrical efficiency such as lighting and refrigeration.
2. Construct new buildings that are extremely energy efficient, aiming for a 70% reduction in energy use compared to the national median for comparable buildings, and increasing to net zero carbon emissions between 2030 and 2050. While the scenarios only included the 15% reduction in energy demand due to new construction built to the Energy Conservation Construction Code, building to these higher levels of efficiency would decrease demand and either lessen the need for development of renewable energy resources or further reduce emissions.
3. Hold vehicle miles traveled at roughly the 2008 level of 672.3 million miles despite anticipated increases in population.

Transitioning to Renewable Sources of **Energy** is also critical to address GHG emissions. Achieving emissions goals will require development of renewable energy systems to supply the majority of our energy needs. By 2050, we should:

4. Reduce natural gas use by at least 50% from 2008 levels, or 21 million therms, by reducing demand for thermal energy, deploying significant numbers of ground and air source heat pumps, and utilizing biomass resources.
5. Reduce demand for grid electricity generated outside of Tompkins County by at least 24% from 2008 levels, or at least 190 million kWh, primarily by reducing demand and transitioning to local renewables.
6. Develop at least 50% of the identified solar energy production potential, or at least 1,225 GWh of solar production. One way this deployment could be achieved is by doing all of the following: 1 in 4 urban residential properties install a 4 kW PV system, 1 in 2 suburban and rural properties install a 7 kW system, 30% of commercial, institutional and industrial roof areas install PV, and 944 MW of PV farm capacity developed on 4,720 acres, or 1.5% of the County's land area.
7. Develop at least 20%, 530 GWh, of identified wind energy production potential. One way this deployment could be achieved is by installing 300 medium-scale 500-KW turbines and 20 large-scale 2.3-MW turbines.
8. Develop at least 20%, 145 GWh, of identified micro-hydro energy production potential. This could be achieved by installing 60 micro-hydro 300 kW systems.
9. Develop up to 50%, 1.8 million MMBtu, of identified biomass energy production potential. One way this deployment could be achieved is by doing all of the following: managing 36,700 forest acres for sustainable biomass yield, planting 15,600 acres of inactive agricultural or grasslands in energy crops, and managing 12,900 acres of crop or forage land for sustainable crop residue harvesting
10. Transition at least 50% of light-duty vehicles from gasoline to electric, or at least 33,500 vehicles, from the 67,000 that could be on the road in 2050, if automobile ownership rates remain at 2008 levels.

Setting interim goals and tracking progress is crucial to keeping us on track to achieving our long-term goal and encouraging us to re-evaluate policies and program direction in an ever evolving energy future. In the years between 2016 and 2050, we should:

11. Set interim GHG emissions goals for 2020, 2025, 2030 and appropriate intervals thereafter, and track progress in achieving them. Every 2 years review scenarios and update as necessary to reflect changes in technology, government policies, climate science, economic conditions, or other factors. These interim goals should be set by the Tompkins County Planning Department when the Energy Strategy is updated in 2016.
12. Semi-annually convene stakeholders to evaluate progress, opportunities and barriers to achieving these recommendations, with a particular focus on whether the positive and negative impacts of the energy transition are being distributed equitably throughout the community.

Guidance for Energy Planning

Use of Natural Gas and Grid Electricity Generated Outside of Tompkins County: The scenario that maximizes natural gas usage accounts for 26% of future thermal demand from natural gas which amounts to the equivalent of 50% of 2008 usage, or 21 million therms. The scenario that envisions an All Electric future requires that three times as much electricity be generated in 2050 compared to 2008, with 25% of that future electric demand coming from grid electricity generated outside of Tompkins County, requiring that 618 million kWh be supplied by the grid in 2050. This is still a 24% reduction from the amount of grid electricity used in 2008, due to the anticipated use of locally generated renewable electricity.

These two "bookends" should be considered to be the maximum amounts of outside energy for the purposes of long range energy planning. Given the current assumptions of the Roadmap, we would not be able to meet an 80% reduction in emissions if we maintained both 50% of current natural gas use and 76% of electrical energy generated outside of Tompkins County from the grid. These constraints should serve as a solid framework in which to operate over the next 15 years, as we take strong action to achieve the penetration levels necessary for locally generated electricity, biomass, and demand reduction.

- Reducing natural gas use by 50% and grid electricity generated outside of Tompkins County by 24% from current levels are appropriate intermediate planning goals.

Renewable Deployment, Electrical: The scenarios also consider varying amounts of renewable energy development in the county. Generally it is anticipated that 53% of solar potential, 20% of wind potential and 20% of micro-hydro potential would be needed to meet local energy demand and also achieve an 80% reduction in GHG emissions. This is based on grid energy generated outside of Tompkins County reaching, and staying at, 50% renewable low- or no-emission sources in accordance with the NY State Energy Plan. If higher levels of renewable energy became available from the grid this could decrease the need for as much local renewable generation. However, given that the NY State Public Service Commission's Reforming the Energy Vision (REV) process envisions more distributed energy generation, and that larger metropolitan areas may have a more difficult time generating as much of their energy needs locally, we should plan for ultimately reaching the level of deployment of local renewables suggested in the Roadmap. Identifying specific appropriate locations for solar, wind and micro-hydro

development should begin immediately and be incorporated into both current and long-range land use planning efforts.

- Developing 50% of solar potential, 20% of wind potential and 20% of micro-hydro potential and tracking progress are appropriate intermediate planning goals.

Renewable Deployment, Thermal: With respect to thermal energy, the Roadmap envisions a transition away from natural gas and other fossil fuels to high efficiency electrical systems including ground and air source heat pumps for anywhere from 6% to 72% of future needs. Biomass is also an important thermal resource that could reasonably supply up to 23% of future thermal energy needs by utilizing 53% of its potential. Given the particular characteristics of these energy sources it may be appropriate to initially focus biomass deployment in rural areas. Some types of industrial applications may continue, at least for the near future, to require high heat output which can be best achieved with fossil fuels and, in some instances, biomass.

- Developing 50% of biomass potential, and installing significant numbers of ground and air source heat pumps particularly in new construction; buildings that use fuel oil, propane, or electric resistance heat; or when existing heating systems have surpassed their useful life, are appropriate intermediate planning goals.

Efficiency: The Roadmap also relies upon improvements in efficiency to contribute to greenhouse gas emissions reductions. In general, existing residential buildings could achieve up to a 67% improvement in overall efficiency with 29% of that coming from electrical efficiency improvements and 71% from thermal efficiency. With existing commercial buildings the overall potential is a 55% reduction and about 71% of that potential coming from thermal energy and 29% from electrical energy. The Roadmap envisions achieving 50% of the thermal potential and 80% of the electrical efficiency potential resulting in overall building efficiency improvements of about 35% on average. Ground or air source heat pumps may be appropriate in urban, suburban and rural areas depending on the characteristics of specific sites and needs of individual residents or businesses. Efficiency improvements are often the most cost-effective means of energy and emissions reductions and should be emphasized in near term planning

- Achieving efficiency potentials averaging 35% in existing buildings should be a high priority for short-term action.

Transportation: The Transportation component of the Roadmap largely relied on a transition to electric vehicles and a 24% reduction in projected vehicle miles traveled by 2050. This essentially means keeping VMT at 2008 levels in spite of projected growth. The level of electric vehicle deployment required varies based upon the level of emissions reductions achieved from efficiencies in building energy use. Under every scenario at least half of light duty vehicles will need to be electric by 2050. Building an electric vehicle friendly community should be a high priority for near term action. To achieve reductions in VMT several strategies will be necessary. Land use planning needs to focus on providing housing closer to places of employment, services and commuter transit routes. Transit service will need to be expanded as will other Transportation Demand Management options such as ride sharing, parking policy and pricing, guaranteed ride home, etc.

- Transitioning 50% of light vehicles from gasoline to electric and avoiding any growth in vehicle miles traveled are appropriate intermediate planning goals.

Evaluation: The energy environment in which this analysis was developed is dynamic and uncertain. The Roadmap should be revisited at least every two years to determine if changes in State or Federal policy,

technology, economic or other factors impact the underlying assumptions of the Roadmap and require adjustments to the 2050 scenarios.

Other Emission Reduction Strategies: The Energy Roadmap examined only those GHG emissions associated with fossil fuel energy use in Tompkins County. There are also potentials to reduce emissions associated with agriculture and waste management, as well as strategies to sequester greater amounts of carbon in soils and forests. These should also be explored and specific strategies identified that can complement and enhance efforts at energy GHG reductions.

Using the Roadmap

While the Energy Roadmap is primarily intended to present somewhat hypothetical options for meeting our long-term greenhouse gas emissions reduction goals, it contains detailed analyses that can inform decisions about specific projects, as well as the development of public policy to help hasten and smooth the energy transition that is needed to achieve emissions reduction goals. It identifies and discusses the opportunities and constraints that will impact future development of renewable energy resources and improvements in efficiency. It also identifies challenges that must be overcome and may suggest areas for further analysis and research. Finally, it is hoped that the Roadmap helps make thinking about a clean energy future more tangible, and that it provides hope that we can take concrete steps locally, which complement needed action at the state, national and global levels, to avert the most disastrous impacts of climate change.