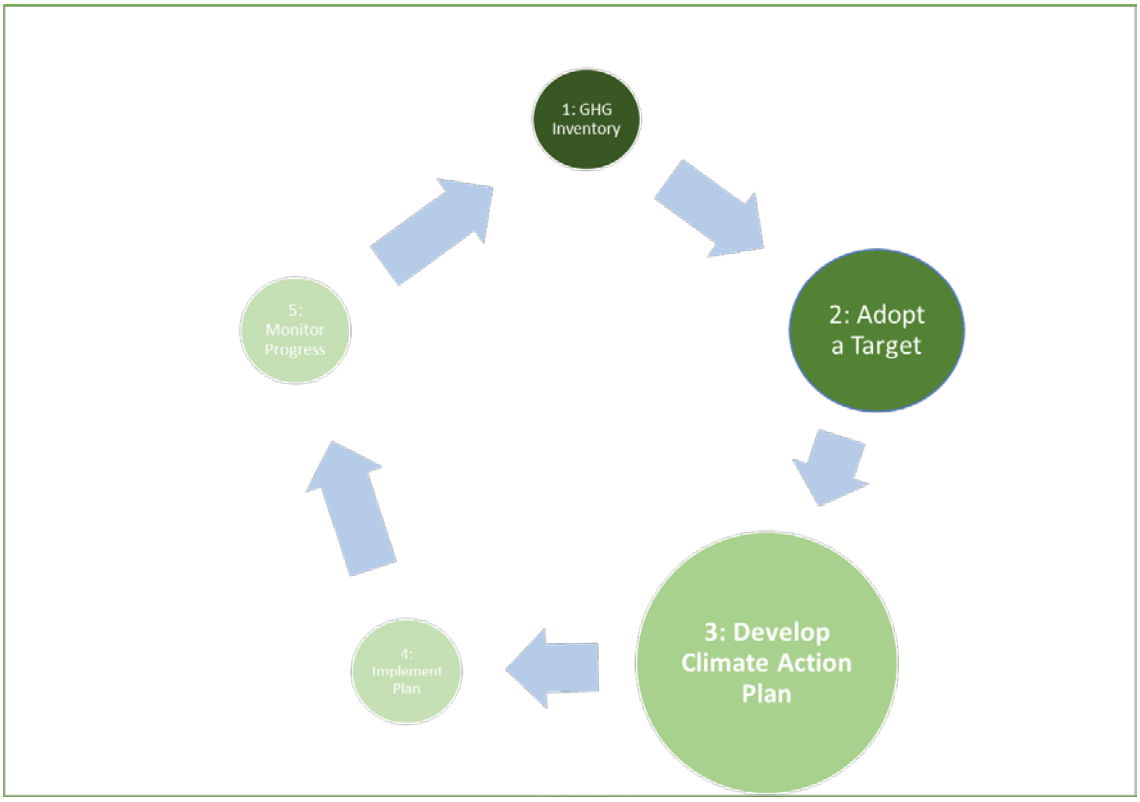
Community Climate Action Plan

Reducing Greenhouse Gas Emissions, Saving Energy, Generating Renewable Energy, and Enhancing Ecosystems



Town of Carrboro, North Carolina

PUBLIC HEARING DRAFT (April 8, 2016)

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Executive Summary

In 2009, the Carrboro Board of Aldermen passed a resolution committing the Town to take steps to reduce emissions of greenhouse gases that are causing global climate change. In doing so, and through work leading up to the resolution with other Orange County governments, the Town joined a group of more than 1000 cities, towns and metropolises around the world who are taking part in the Cities for Climate Protection Campaign. The campaign follows a 'Five Milestone' process that includes a greenhouse gas (GHG) emissions inventory, establishment of an emissions reduction target, development and implementation of an action plan to reduce emissions, and monitoring of emissions reductions measures.

This document expands on previous efforts, with an emphasis on completion of the second milestone – further articulation of a reduction target, and the third milestone – the drafting of a Local Climate Action Plan. In 2014, Carrboro developed a plan focusing on the Town's municipal operations. This plan is a companion and follow up to that effort with an emphasis on measures that the broader community is asked to take in order to achieve GHG reduction targets. The recommendations offered are intended to reduce greenhouse gas emissions, while raising the community's awareness of and involvement in solutions to global climate change and a post-carbon energy future, adaptation to changes and enhancement of ecosystem resilience.

A significant recommendation of this report is for the Town and community to adopt a goal of a 50% reduction in greenhouse gas emissions by 2025, as supported by a broad community campaign. Additional recommendations are provided around the themes of community integration, energy efficiency of buildings, transportation, renewable energy, and ecosystem protection and restoration. Measures outlined in the Plan to reduce greenhouse gas emissions not only contribute to overall climate change mitigation, but can also provide the community with many local benefits such as financial savings through energy efficiency, the creation of new jobs, improved air quality and public health, and a healthier forest and streams.

The degree to which the broad campaign advocated for in this plan takes off will depend on many factors. The following direction is suggested to build momentum: 1) focused attention is needed to more rapidly reduce energy use in buildings; 2) similarly, the efforts underway to increase transit, bicycling and pedestrian modes of travel as well as vanpooling, carpooling, and carsharing need to gain even more traction; 3) innovative efforts are needed to support residents with limited opportunities for renewable energy; 4) grass roots efforts and new partnerships need to be fostered; 5) the paradigm for local environmental/ecosystem protection and restoration needs to expand to consider the stress of climate change; and 6) last not but not least, individuals, businesses, and in effect the entire community need to take the recommendations in this report to heart.

Introduction

"Recognizing that all human economic activity is a subset of nature's economy and must not degrade its vitality is the starting point for systemic transformation of the energy system."[1]

There is widespread scientific agreement that the increasing quantity of greenhouse gases (GHGs) in the atmosphere is causing temperatures to rise and increasing the frequency and severity of extreme weather events, and that human activities are the primary cause.[2] The accumulation of greenhouse gases is a major threat to the climate stability of the earth. Arguably, no other issue threatens our planet with such dramatic, far-reaching impacts, and no other issue is so clearly a worldwide problem. The world's leading scientists predict that, in the absence of radical societal change, global average temperature will rise from 2.7 to 11 degrees F. within our children's lifetimes. Already, effects of climate change are being seen, from melting of the Arctic permafrost, to the disappearance of glaciers worldwide, to rising sea levels around islands and other low-lying areas, and the acidification of oceans. Erratic weather and extreme events such as droughts, floods, heat waves, avalanches and hurricanes are becoming more common.

The primary cause of global climate change is the burning of fossil fuels such as petroleum, coal, and natural gas. These activities release gases such as carbon dioxide and methane that accumulate in the atmosphere and trap the sun's heat, thereby warming the earth – the so-called "greenhouse effect". The greenhouse effect is essential for life on earth, but rapidly increasing levels of greenhouse gases during the past 200 years are now destabilizing the climate. Average global temperature have already risen an unprecedented 1-2 degrees F during this period, and the impacts of emissions that have already occurred will take decades to cycle through ecosystems. Carbon dioxide concentrations in the atmosphere have reached their highest level in 160,000 years, and are rising at a rate 500 times higher than ever before in history.

Richard Heinberg, Senior Fellow of the Post Carbon Institute regarded as one of the world's foremost energy and climate action experts, says this: "The most important thing to understand about the energy transition is that it's not optional. Delay would be fatal. It's time to make a plan—however sketchy, however challenging—and run with it, revising it as we go." [3]

In Carrboro, the effects of climate change over the next century are likely to be significant. They may include the migration of hardwood forests northward to cooler areas. We will have to cope with hotter summers and more frequent floods, droughts, and intense storms, with more money diverted to repair damage from these events. Our local ecosystems could experience a broad range of negative trends and

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[1] The Energy Reader: Overdevelopment and the Delusion of Endless Growth, Tom Butler, Daniel Lerch, and George Wuerthner, eds. (Healdsburg, CA: Watershed Media, 2012)

[2] http://www.townofcarrboro.org/DocumentCenter/Home/View/1213

[3] http://www.yesmagazine.org/issues/life-after-oil/100-renewable-energy-what-we-can-do-in-10-years-20160222

losses, and ecological diversity will likely decline. All of the careful planning, stewardship of beautiful natural places, promotion of biodiversity, and other crucial work at the local level will be rendered meaningless if we cannot stave off the worst consequences of climate change. As members of the world community, we will have to deal with challenges involving food security, human health, and scarce resources. Humanity is beginning to respond to the unprecedented transition from the industrial era to the era that is to follow. Local governments and communities can address the challenge and opportunity of the transition and specifically reducing greenhouse gases in a number of creative ways.

The 2014 Orange County State of the Environment[4] report provides a similar message:

"A report focused on Orange County alone also risks underemphasizing global climate change, the most pressing environmental threat we face. Our use of fossil fuels here, whenever we start a car engine or run our air conditioners, adds to the accumulation of carbon in the atmosphere that is rapidly destabilizing our climate. In 2012, leading climate activist and writer Bill McKibben summarized how close we are to reaching the limits of our carbon budget: *Scientists estimate that humans can pour roughly 565 more gigatons of carbon dioxide into the atmosphere by midcentury and still have some reasonable hope of staying below two degrees [Celsius] increase in global temperature. ("Reasonable," in this case, means four chances in five, or somewhat worse odds than playing Russian roulette with a six-shooter)….Reaching or surpassing that two degree rise in average global temperatures risks catastrophic consequences for our ability to grow food, maintain access to drinking water, and generally perpetuate human civilization as we now know it."*

Beyond Doom and Gloom

What we're for is leaving behind the current energy economy, which is wasteful, polluting, and centralized; assumes perpetual growth; and is anchored by nonrenewable fuels. We envision a bold leap toward a future energy economy that fosters beauty and health; that is resilient because it emphasizes renewable, community-scale energy generation; that supports durable economies, not growth; and that is informed by nature's wisdom.[5]

The previous section presents a stark, sobering, and ominous picture and one that we all need to acknowledge and recognize. Only laying out the danger associated with climate change neglects humanity's capacity, ingenuity, and adaptability. It also can be counterproductive by effectively triggering a "fight and flight" response, or being received as a judgment for denial and lack of action. The reality of climate change also presents tremendous opportunity for transition to living in a more satisfying, resilient, and connected community that is less reliant on fossil fuels. [6] In addition, some measures are often necessary and/or more effective at the municipal/community level than at other levels. This plan is intended to inspire this community and others to accelerate and ramp up efforts, and begin to make significant reductions in the level of climate-changing gases now being produced.

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[4] http://www.orangecountync.gov/document_center/DEAPR/2014_SOE_complete_report.pdf

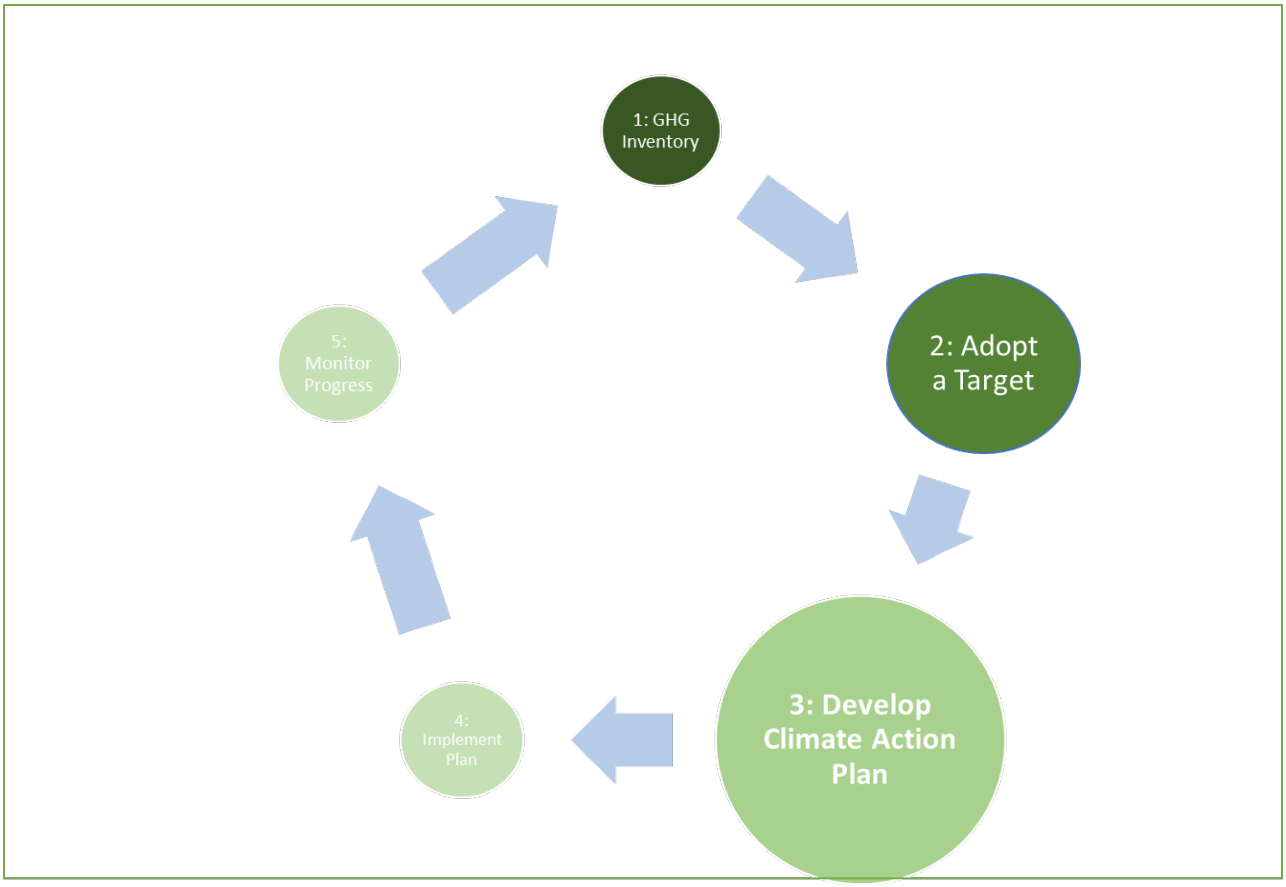
[5] The Energy Reader: Overdevelopment and the Delusion of Endless Growth, Tom Butler, Daniel Lerch, and George Wuerthner, eds. (Healdsburg, CA: Watershed Media, 2012)

[6] http://www.wri.org/news/2014/10/release-new-analysis-highlights-opportunities-economic-gains-climate-action-united

The Cities for Climate Protection Campaign and the Five Milestone Process

The Cities for Climate Protection (CCP) campaign is a global project led by the International Council for Local Environmental Initiatives (ICLEI), a membership association of local governments dedicated to addressing global environmental problems through local action. The CCP was established by ICLEI in 1993 at an international summit of municipal leaders. The CCP has engaged many municipal governments in North Carolina, the U.S and abroad in a worldwide effort to slow the earth's warming. The CCP campaign follows a 'Five Milestone' process (Figure 1).

Figure 1:
Cities for Climate Protection Five Milestone Climate Action Planning Process.



The size of each circle indicates the relative emphasis in this plan. The darkness indicates the amount of attention already given to each milestone based on work in Carrboro over the past decade, as discussed in the text.

The Greenhouse Gas Emissions Inventory[7]

Carrboro collaborated with other jurisdictions in Orange County and ICLEI to complete the first county-wide Greenhouse Gas Emissions Inventory for the baseline year of 2005. In 2011, a UNC Capstone Team completed a community scale inventory specifically for Carrboro based on data for 2009. Every year beginning in 2012, the Town has updated the municipal operations inventory, and in 2015, a second UNC Capstone Team updated the community inventory based on data for 2012 and assisted the Town in entering the inventory data into the ClearPath software which will help the Town with future climate action planning steps. These inventories help establish a baseline and guide the community to develop and implement strategies to mitigate emissions by understanding the sources and quantity of emissions. They also provide a means to monitor changes over time.

Establishing Emissions Reductions Goals

The county-wide inventory included an initial attempt to identify potential goals in terms of "tiers" of "least aggressive" to "most aggressive" climate action strategies. In 2009, the Board of Aldermen passed a resolution resolving that the Town "will seek, and will facilitate the community at large, to cut CO_2 emissions by its proportion of the amount which is required to stabilize the climate back to <350 ppm of CO_2 …, and asks staff to evaluate how to achieve this target for municipal operations and the community". [8] As part of municipal inventories, annual reduction goals of 2-7% have been discussed and the 2014 plan set a goal of a reduction in emissions from municipal operations on the order of 5-10% within a 2 year time frame. Other notable climate goals are listed in the table below.[9] In its Clean Power Plan to reduce carbon dioxide emissions in the power sector, EPA has set a unique target emissions rate for each state to achieve by 2030. 8 states are asked to reduce emissions by 41%-50%, 24 states are asked to reduce emissions by 31%-40%, and the remainder of the states are asked to reduce emissions by 30% or less. 8 large US cities have signed on to the Carbon Neutrality Alliance.

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[7] More information on previous inventories is available on the Town's website: http://www.townofcarrboro.org/271/Greenhouse-Gas-Inventories

[8] 1990 is when global CO_2 concentrations first surpassed 350 ppm. To date, Carrboro emissions have not been estimated for 1990. Town staff have asked those providing support with completing emissions inventories to attempt to estimate emissions for 1990. The uncertainties due to the lack of data and difficulty deriving credible assumptions have proven too great to complete this task. It is certainly hypothetically possible to "backcast" emissions. For example, some factors could lead to lower per capita emissions such as industry/technology standards (e.g. more efficient vehicles, buildings, and appliances), more availability of transit and bicycle and pedestrian infrastructure, economic factors leading to changing behavior (e.g., fuel costs), and growing awareness and concern. Other factors could lead to higher per capita emissions, such as suburbanization, less affordable housing locally, and social/cultural norms and consumer choices with higher footprints (e.g., larger vehicles and homes and less active lifestyles and more emphasis on comfort and convenience) leading to more single occupancy vehicle trips, vehicle miles traveled (this has been documented) and use of fossil fuels. Assumptions could also be derived from national/international reports, however the bias that could be introduced is uncertain.

[9] Appendix 2 outlines a hypothetical example of a "typical" American household becoming carbon neutral in 10 years.

Table 1: Examples of Climate Action Goals

Scale	Entity	Reduction Goal	Date
National/Countries	United States	26 - 28% of 2005	2025
	Department of Defense	30% reduction in energy use; 20% of energy from renewable sources	2020
	China	20% of energy from non-fossil sources	2030
States	California	40%	2030
Cities	Seattle	Net zero/climate neutral (community)	2050
	Asheville	80% from 2011 (4%/year; municipal)	2030
	Chapel Hill	60% of 2006[10]	2050
	Durham	30% (community) 50% (municipal) of 2005	2030
	Boulder, CO[11]	80% (community)	2050
Businesses	Weaver Street Market	Net zero via efficiency, rooftop solar, purchased green power	2020
Utilities	OWASA (2015 draft)	35%/5% reduction in purchased electricity/natural gas (2020 vs. 2010) Pursue biogas to energy and renewable energy projects	2020
Universities	UNC	Net zero/climate neutral	2050
	Warren Wilson College	80% of 2007/8	2020

One purpose of this Plan is to provide a new recommendation on a community scale emissions reduction goal. Climate action goals can be framed in a variety of ways to best meet a particular entity's needs and values. The Energy and Climate Action Task Force has recommended that Carrboro's Climate Action Goal: meaningfully reduce greenhouse gas emissions at a time scale that is urgent; encourage growth and shared prosperity; and be able to be measured and certified. With these criteria in mind, the Task Force has recommended this Carrboro Climate Action Goal:

It is recommended that Carrboro adopt the goal of a 50% reduction in per capita greenhouse gas emissions by 2025. We recommend a goal to cut the carbon footprint in half over the next 10 years for the entire community, Town operations, the buildings and transportation "sectors", and ultimately each resident and business.

[10] Reduction is on a per capita basis. Interim goals are 5 percent by 2010, 10 percent by 2015, 20 percent by 2030, 30 percent by 2040; 45 percent by 2045, and 60 percent by 2050.
[11] Appendix 1 provides more information on the leadership Boulder is providing with local climate action.

This goal is a meaningful reduction in carbon/greenhouse gas pollution that is consistent with the scientific recommendations calling for the large emission reductions needed to reduce the risk of dangerous climate change. It is both ambitious and achievable with the support of the Town and community. It is framed in per-capita terms to recognize that Carrboro continues to attract new residents and businesses and to make it easy for any individual, business, or organization to measure and demonstrate their progress toward the goal. Investments in energy efficiency and renewable energy offer very favorable returns and substantial reductions in energy costs. This can power a virtuous cycle, where more energy costs are reduced and more income is available for local consumers and businesses.

It is possible that many people will sense that the goal is too ambitious: too much change too quickly. Richard Heinberg recently concluded that, globally, we can achieve at least a 40 percent reduction in carbon emissions in 10 to 20 years." While there are challenges (e.g., dropping petroleum prices, technology advances allowing for new extraction practices), there are also external factors that will help, most notably a rising global awareness and conviction. Solar power is accelerating; fuel economy standards will likely continue to reduce gasoline use. The proliferation of more energy efficient lighting, appliances and heating/cooling equipment is already reducing household energy use, and transportation options with smaller emissions footprints are expanding.[12]

The Local Climate Action Plan

The U.S. Department of Energy has developed a "Guide to Community Strategic Energy Planning" that identifies two types of planning efforts: one focusing on the government operations and one focusing on the community at large. The former: includes a focus on government buildings, facilities, infrastructure, and transportation; concentrates on activities for which the government has direct influence – e.g., personnel, planning, and budgeting – which means tighter control over implementation. The latter (community-wide plan) is a broader plan to address activities that: expands the focus to include energy saving activities across the jurisdiction (residential, commercial, industrial, transportation, and other sectors) of the broader community; recognizes that, while local government actions can greatly influence, energize, and leverage effective activities in the broader community, the government has less direct control over these activities in comparison to a government-only plan. This plan focuses on the community-wide plan.

[12] Appendix 2 provides a hypothetical example of how a household can become carbon neutral in 10 years. Appendix 3 presents a discussion of how to approach this goal from a social and psychological perspective.

The measures recommended below provide the basis for the first comprehensive community scale climate action plan specifically for Carrboro. They are a companion to measures presented in the 2014 plan that focused on municipal operations. Other local governments and agencies and UNC continue to be engaged in similar locally relevant efforts[13,14,15]. To emphasize, the Task Force has recommended that the Town pursue a two-part climate action strategy. Strategy 1 is to provide leadership by following through with the recommendations outlined in the 2014 report. The Town of Carrboro efforts to reduce emissions sets an example for residents, businesses, and institutions. Strategy 2 is to further develop a community based initiative as detailed in this document and guided by the recommended Carrboro Climate Action Goal in tandem with a goal to protect and restore local ecosystems. Details for how to pursue these broader goals is provided in the following sections, starting with the critical element of the mobilization of the Carrboro community in support of the goals of this plan.

Community Integration

"Local" climate action planning has important but limited influence within a personal to global continuum (Table 1). The collective choices, behaviors, norms, requirements, and plans and agreements at lesser and greater social scales than that of a town of ~20k people arguably have greater influence on GHG than the municipal/community scale. A very large share of the GHG footprint in the community occurs because of the collective impact of private decisions made by residents and businesses for which the Town has very limited involvement and oversight, and also within a global social context and the constraints of state, federal, and international laws, regulations, agreements and corporate (large scale) decisions. In terms of other levels of organization and governance and how they interact with community scale climate action planning, the following are important (and in some cases unique) points in Carrboro and indicate the Town's interdependence with many other entities in pursuing climate action planning:

[13] http://www.townofchapelhill.org/town-hall/departments-services/planning-and-sustainability/sustainability
[14] http://www.owasa.org/energy-management
[15] https://climate.unc.edu/GreenhouseGasInventory

1) The Chapel Hill-Carrboro City School system and OWASA both have separate policy, fiscal, and administrative processes from the Town, and therefore, different boards and staff. They also have larger emissions, facilities and operating budgets than Carrboro has, and therefore, an ability to have a greater influence on emissions reductions;
2) Transit is a public service that has the ability to significantly mitigate emissions. Chapel Hill Transit is a cooperative effort between Carrboro, Chapel Hill and UNC; GoTriangle is a multi-county/regional transit authority serving over a million people;
3) Currently, Carrboro on its own has very limited influence on larger electricity and natural gas utilities. Duke Energy provides electrical service to over 90% of Carrboro. Carrboro is also served by Piedmont Electric Membership Cooperative, which buys its electricity from Duke for resale. PSNC is the local natural gas provider. This is in contrast to local governments operating municipal utilities.
4) Carrboro's largest emissions sector is buildings, with most building emissions being residential, and most of the residential building sector being non-owner occupied. Oversight by the North Carolina Utilities Commission, management by the above utilities, and regulation by building codes (which are established at state/federal levels) are strong non-market/public sector drivers that influence emissions from buildings. Landowner and landlord management and decisions are strong private sector drivers. Social/cultural norms influence both public and private sectors.
5) The Town has very limited oversight of Homeowners Associations (HOAs) (less in fact than the state of North Carolina). Carrboro did recently update regulations to limit new HOAs ability to constrain an individual homeowner's desire to pursue sustainability measures.

Table 1: Local Climate Action Planning is One Layer in a Continuum [16]

Organizational Scale Examples	**General Scale (population)**	**Climate Action "Primary Domain" Examples**
Personal	1 person	Personal choices (e.g., dietary, housing, transportation, vocation, financial, consumer)
Household/family	~2-10 people	"Home economics" (e.g., housing, transportation, landscaping/gardening, financial, consumer)
Neighborhoods, small businesses, clubs, nonprofits, congregations	~10-100 people	Small organization organizing, management, fossil fuel divestment
Schools, co-ops, larger clubs, businesses, congregations, corporations	~100-1000 people	Business/organization planning and management; fossil fuel divestment

[16] This table does not fully address continuums of access to capital and decision making authority, nor to sociological and cultural dimensions; all add complexity. The point of this table is to illustrate that climate action transcends all scales, and to help define the "space" in which community scale climate action planning occurs.

Small towns, colleges, co-ops	~1k-10k people	Sustainability plans; land use and transportation; local living economy; fossil fuel divestment
Towns, small utilities, universities	~10k-100k people	Local climate action plans; land use and transportation; local living economy; fossil fuel divestment
Cities, medium utilities, counties	~100k-1M people	Local climate action plans; land use, transit/transportation; local living economy; fossil fuel divestment
Regions, states, large utilities/utility commissions	~1M-10M people	Transit/transportation/utility policy and regulation; State law; Building Code; fossil fuel divestment
Nations, international	~>10M people	Climate summits/agreements; carbon pricing; IPCC; building code; federal laws; trade agreements; multinational corporate policy; fossil fuel divestment

6) At a municipal scale, Carrboro's "primary domain" or area of most effective focus for local climate action planning could be in partnership with organizations and entities operating at a similar scale. Similarly, for work in the community, it is important to establish initiatives and measures that work at the appropriate scale, and to bridge gaps across the different scales.

7) The community sector accounts for 93% of greenhouse gas emissions within Carrboro; the remaining 7% comes from local government operations. Significant community buy-in in every aspect of this plan is essential for emissions reduction and climate change mitigation.

Recommendations are offered in this section that focus on grassroots/neighborhood scale efforts and enhanced Town and community capacity for supporting climate action. The recommendations are integrative in that they apply to all of the other recommendations provided, and are focused on community enhancement and participation.

Community Integration Recommendation #1: Create Grass Roots Partnerships to Engage Community

Create new Grass Roots Partnerships and Engage Community to be a Part of the Solution

Widespread community participation is needed to meet the emissions reduction and climate change mitigation goals of this plan. Carrboro is fortunate to have many local groups already involved in environmental outreach and climate action. In addition, many successful models for community engagement in climate action can be adapted and used here. While these are mostly grassroots efforts, leadership is needed to coordinate, adapt, promote, and sustain efforts over the long term.

Implementation Opportunities	Many local and other groups are involved in environmental outreach and/or climate action. These include but are not limited to Transition Streets, Pete Streets, NW Earth Institute community action courses, the Solarize Carrboro model, Awakening the Dreamer Symposiums and Game Changer Intensive, K-12 Sustainability Curriculums (Chapel Hill-Carrboro City Schools is currently developing a local version), Grey to Green Initiatives, HEAT (Heat Energy Assessment Technologies), Meatless Monday Communities, Backyard Wildlife Habitat Certification Programs, and Incentive Programs. Carrboro can adapt and use programs with proven track records for community engagement.
Implementation Challenges	• Who will bring partners together? • Who will recruit and train community facilitators? • How can diverse populations be reached? • Who will modify programs if needed? • How will engagement/momentum be sustained considering the relatively transient population? (59% of Carrboro's residential properties are rentals).
Resources Needed (human and material)	• Money for education and promotion materials. • Leadership ideally from a nonprofit, along with Town staff. • Support such as technical assistance and loans or grants for low-income households, stakeholder incentives, etc.
Leadership	Grassroots but will need a leader or nonprofit organization to adapt, promote, and sustain efforts.
Partners	Pickards Mountain Eco-Institute, Chapel Hill-Carrboro City Schools (including District Sustainability Group and Student Environmental Groups), UNC Sustainability Program, Orange County Solid Waste Program, NC Cooperative Extension Service, Chapel Hill Sustainability Officer and Committee, Transition Carrboro- Chapel Hill, NC Botanical Gardens, Carrboro Greenspace, Carrboro Bike Coalition, Solarize Carrboro, Carrboro Farmers Market, Irvin Learning Farm and Nature Center, NC Sierra Club, Friends of Bolin Creek, Morgan Valley Alliance, Home Builders Association of Durham, Orange, and Chatham, Neighborhood Homeowners Associations, Faith Based Environmental Groups, Carrboro Farmers Market, Carrboro Business Alliance, businesses, utility providers, Homeowner associations, former Pete Street participants and more
Fit with Items	Every section of this Action Plan
Time Frame	This can move forward as soon as leadership is identified.
Next Step(s)	• Identify partners; • Bring partners together and choose programs; • Modify programs for Carrboro if needed; • Work with partners to recruit and train diverse group of facilitators. • Pilot program in facilitator's neighborhoods • Debrief with pilot neighborhoods and modify programs as needed. • Install neighborhood and/or town wide dashboard to show progress, and build a climate change action oriented community.
Evaluation Criteria	People reached. Energy saved. Forest and soil protected or gained.

Community Integration Recommendation #2: Expand Public Partnerships to More Explicitly Consider Climate Action

Pursuing Carrboro's Climate Action Goals Will Require Expansion of Current Partnerships and Creation of New Partnerships.

As a small town with limited capacity and jurisdiction and many existing partnerships, it makes sense for Carrboro to work cooperatively with a variety of partners to pursue Carrboro's Climate Action goals. In some cases, it may be possible to emphasize these goals through existing partnerships, and in other cases, it could make sense to create a new partnership. Collaborating with other local public sector partners has particular appeal. Examples of opportunities through both existing and new partnerships are discussed below and elsewhere in this report and summarized in the table.

Developing a partnership for improved energy efficiency of buildings is a special challenge. Carrboro and Chapel Hill, with support from federal stimulus funding and the Southeast Energy Efficiency Alliance, put considerable effort towards creating an energy efficiency alliance between 2010 and 2013 that has not come to fruition. Progress on this in the absence of clear interest and initiative from utility providers and partners may be difficult. In the short term, less ambitious efforts such as focusing on commercial and municipal buildings and focusing on other recommendations provided in this plan may be preferable to attempting to create an alliance. Local staff working on sustainability initiatives have recently begun to more specifically explore collaborative possibilities; it's likely some new recommendation(s) will emerge.

Implementation Opportunities	Existing and new partnerships could support improved building energy efficiency, transportation, renewable energy, community scale composting, and environmental community goals. Examples of existing partnerships include Chapel Hill Transit/Partners Committee, OWASA, Chapel Hill-Carrboro City Schools, Orange County Solid Waste/Solid Waste Advisory Group, GoTriangle, Durham/Chapel Hill/Carrboro Metropolitan Planning Organization. Examples of new partnership opportunities include: creating a building energy efficiency alliance; expanding car/bike/ride sharing and transit services; partnership at the nexus of water supply and wastewater/energy; stormwater utility across municipal boundaries; county/regional scale sustainability partnership (either general or more focused, e.g., on public buildings and/or renewable energy installations); downtown geothermal partnership.
Implementation Challenges	Attempt through WISE program to create Regional Energy Alliance was unsuccessful and indicates general challenges in working in buildings sector Unclear as to interest from others in partnering Town has limited capacity to investigate and work with local partners to pursue these programs on its own. New funding may be needed in some cases
Resources Needed (human and material)	Staffing and funding
Anticipated Cost	Cost of additional staffing/contracting to coordinate

Leadership	Board of Aldermen; staff managers; staff
Partners (selected)	Chapel Hill-Carrboro City Schools, UNC Sustainability Program, Orange County Solid Waste Program, Chapel Hill Sustainability Committee, OWASA, NC Botanical Gardens
Fit with Items	Many of the other recommendations depending on details
Time Frame	Exploration can begin immediately. Some partnerships will take longer to develop.
Next Step(s)	Staff and Board of Aldermen to consider in operating budget development and community champions to self-identify
Evaluation Criteria	Track adoption of efficiency measures incentivized by programs facilitated/supported by the Town.

Community Integration Recommendation #3: Create Green Neighborhood Program

Create Participatory Green Neighborhood Budgeting Program to Reduce Carbon Emissions, Build Community, Save Money and Reallocate Savings to New Green Project Initiatives

It is proposed that Carrboro create a new program that will identify projects to offer neighborhoods that will save the Town money and make the neighborhood's proportion of saved monies available to them to reallocate to new green project initiatives through a participatory democracy process.

Implementation Opportunities	• Enlists and engages neighborhoods in efforts to reduce CO_2 emissions in community-at-large • Builds community within neighborhoods • Neighborhood based economic development opportunities may spin-off • Possibility of creating a community scale "dashboard" that tracks energy use/emissions/savings • Recycling and composting successes translate into savings associated with less frequent trash pick-ups • Composting reduces trash headed for the landfill = cost savings + reduced methane gas • Neighborhood competitions awards program • Can boost initiatives such as Solarize; Energy Efficiency / Pete Street; Street Lights off for Climate t Project
Implementation Challenges	• Identification of mechanism for Town to allocate saved funds to neighborhoods • Development of participatory democracy process and criteria for new green project initiatives • Marketing for participation of neighborhoods • Availability for multi-family complexes?
Resources Needed (human and material)	• Full time person managing neighborhood portfolios and facilitating neighborhood efforts • Common spaces per neighborhood (i.e. for centralized neighborhood

	composting, solar panels, etc.) • Educational campaign on opportunities for greening ones neighborhood
Anticipated Cost	• Cost of full time person in charge of managing program • Marketing
Leadership	Neighborhood leaders
Partners	• Homeowner associations • Next Climate • Former Pete Street participants? • Town staff • Businesses Local building supply companies Solar installers Weatherization installers Local nurseries Local landscapers • Non-profits • Orange County Solid Waste Management – composting
Time Frame	Will depend on identification of leadership
Fit with Items	Many of the other recommendations
Next Step(s)	1. Presentations laying out town's CO_2 responsibilities as measured through social equity lens and the urgency of CO_2 reduction per the latest science • Town-wide initial presentation followed by • Presentations to neighborhoods that want to engage in green neighborhoods initiative 2. Create process for developing further program ideas and mechanism for neighborhoods to initiate • Set neighborhood CO_2 reduction goals in line with town's at large goal • Town recognizes savings achieved through existing green initiative successes and allocates these for neighborhoods to use proportional to neighborhood's impact in making the savings. (recurring) • Identify further potential programs and their contributions to reducing CO_2 for the neighborhood (ongoing) • Develop neighborhood green participatory democracy process and criteria for new green project initiatives • Develop way for town to allocate funds • Support and facilitate neighborhoods participation 3. Awards program for neighborhoods achieving biggest reductions per energy sector (Trash, Transportation, Housing) 4. On-street parking park and ride permits?
Evaluation Criteria	People reached. Energy saved. $ reallocated.

Community Integration Recommendation #4: Integrate Climate Action with Local Living Economy

Integrate Climate Action Implementation Opportunities identified in this Plan into the Update of the Local Living Economy Task Force Report

From 1990 to 2008 the rise in emissions from goods produced in developing countries but consumed in industrialized countries was six times greater than the emissions savings of industrialized countries. The international transportation of goods is not formally attributed to any nation and countries are not responsible for pollution produced by the manufacturing of goods that are shipped to their shores; those are attributed to the country where the goods were produced.

The Carrboro Local Living Economy Task Force Report enumerates many reasons why support of locally owned businesses is vital, including that locally owned businesses have less environmental impact. This recommendation identifies some of the means by which both locally owned businesses and a habitable climate can be simultaneously and further supported.

Implementation Opportunities	Integrate implementation opportunities into the update of the Local Living Economy Task Force report: 1) Include climate change mitigation in local living economy/locally owned marketing messaging 2) Encourage light manufacturing zone in Carrboro, 3) Set-up PACE program for commercial buildings to implement renewable energy.
Implementation Challenges	Time is running out to mitigate climate change!
Resources needed	Town staff
Anticipated cost	Cost of hiring staff
Leadership	• Town of Carrboro • Carrboro Business Alliance, • Town businesses
Partners	• Carrboro Economic Sustainability Commission, • Carrboro Economic Development department, • Carrboro Business Alliance, • County -- ¼ cent sales tax economic development monies
Time Frame	Some steps can be pursued immediately, others will take longer
Fits with items	• Local Living Economy Task Force report and update, • Implementation of locally owned first campaign, • Downtown geothermal heating district • Commercial energy improvement revolving loan fund
Next steps	Further develop each identified implementation opportunity
Evaluation criteria	The locally owned economy campaign is understood as also being a climate change mitigation strategy by the Carrboro community

Community Integration Recommendation #5: Expand Capacity

Expand Capacity to Pursue Community Sustainability Initiatives

Expanded capacity and prioritization and integration of climate action into community life are needed to implement this plan. The above recommendations (1-4) along with additional recommendations in the sections that follow in this plan will also support expanded community capacity. An online resource hub could also be created.

Implementation Opportunities	Additional capacity/initiative could facilitate non-profit/ business partnerships to improve energy efficiency in the community, publicly recognize successes, and more effectively pursue grants. A community grant program could be initiated.
Implementation Challenges	• Currently, Town has limited capacity to investigate and work with local partners to pursue these programs. • Ability of community advocates to organize • Community organizing requires dedicated volunteers; not clear if sufficient interest exists • Funding to help residents interested in retrofits • Staff capacity is currently limited to support a new advisory board/task force
Resources Needed (human and material)	Additional community volunteers and staff capacity
Anticipated Cost	Cost of staff and any operating budget.
Leadership	Board of Aldermen, Town staff, and community volunteers
Partners	None specific to this recommendation
Time Frame	As soon as possible
Fit with Items	Many of the other recommendations
Next Step(s)	Staff and Board of Aldermen to consider in development of operating budget and community champions to self-identify
Evaluation Criteria	Track adoption of measures facilitated/supported by the Town.

Community Integration Recommendation #6: Facilitate Low Cost Financing for Energy Efficiency and Renewable Energy Projects

Pursue Alternative/ Long Term/Low Cost Financing Approaches

Energy efficiency and renewable energy projects often require low cost/long term financing to be attractive since a short simple payback time can be hard to achieve; savings are realized over longer time frames. Two specific new financing approaches are suggested. The first is to utilize Qualified Energy Conservation Bonds (QECB), which may provide Carrboro and partners with access to low-cost financing that help projects become financially viable. The second is to make this low-cost financing available for community projects using a revolving loan fund or Property Assessed Clean Energy (PACE) financing.

Implementation Opportunities	Many of the recommendations listed in this report require low-cost financing. For example, QECBs could provide seed funding for • efficiency improvements to public buildings • a revolving loan fund for community projects • Property assessed clean energy (PACE), a program where the loan is paid using assessments on the property tax bill • low cost financing for home energy efficiency projects for community members who have difficulty qualifying for traditional financing
Implementation Challenges	• Reluctance to take on debt • Clarity about how to use the complex QECB mechanism to obtain state/federal approval • Capacity and expertise to issue bonds • Community financing via PACE or a revolving loan fund can have low community participation because (i) onerous loan application process requiring a lengthy municipal approval process, and (ii) maximum loan amounts that are set too low to fund an entire project with one loan.
Resources Needed	• Bond issuance process can be lengthy and the Town would need expertise • Would be coordinated with other programs that need financing
Anticipated Cost	The cost of low interest debt financing
Leadership	While QECBs have been used in municipalities outside of NC, within North Carolina these bonds have been limited to agricultural programs. There would be some learning required by the Town to get the bonds issued. Also, a PACE program has not yet been implemented by any NC municipality.
Partners	NC Clean Tech Center, UNC Environmental Finance Center, other local governments
Fit with Items	Many recommendations could benefit from low-cost financing
Time Frame	Exploration could begin immediately. For a higher probability of moving forward, either a Sustainability Coordinator or championing by the county or another entity will likely be needed.
Next Step(s)	Identify and/or recruit nonprofit organization/local champion to: • Identify project/revolving loan fund that could benefit from QECB • Pursue bond issuing process
Evaluation Criteria	• Life cycle costs and net present value

Community Integration Recommendation #7: Integrate Climate Action and Social/Equity Initiatives

Low income households spend 24% of their income on energy costs. To make housing affordable, we must do more than just lower mortgage payments/rent. We also need to take a look at how to lower

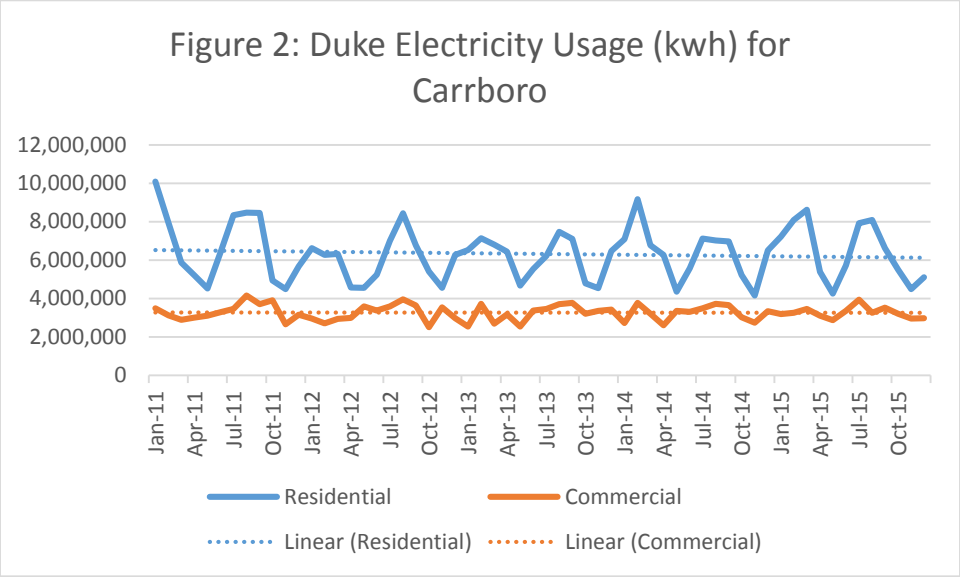
utility bills. The installation cost of solar has dropped precipitously in recent years and more and more middle and upper class households are taking advantage of this opportunity to both use clean energy and save money. However, the switch to solar is made easier by income tax credits and access to financing. Both of these are often not available for lower income/wealth households. The mechanisms to make energy more affordable are federal grants, community programs, and Town initiatives/ordinances.

Implementation Opportunities	• Grants: In July 2015, the federal government announced increased grant and loan guarantee funding for solar installations on "federally assisted housing". This includes HUD's rental housing portfolio (Public Housing, Multifamily Assisted) and USDA's Rural Development Multifamily Programs, as well as rental housing supported through the Low Income Housing Tax Credit (LIHTC). More information is available at the HUD exchange webpage: www.hudexchange.info • Community programs: Community programs have worked to improve energy efficiency and renewable energy access for low-income communities. One example is *Grid Alternatives,* a non-profit that develops solar for low-income, single family homes by deploying donated materials and simultaneously running a training program to complete the installation. The result is lower energy costs and a more skilled workforce. Another example is *Grid Free NC,* a solar company in Chatham County that has partnered with Habitat for Humanity to develop solar for low income families. • Town initiatives/ordinances: When assessing affordability, include the utility costs. Town-led initiatives that improve affordability and livability are preferred over bare-minimum construction. Efficiency improvements with little monetary benefit are not be preferred. For new development or substantial retrofits, the Town could offer leniency on other requirements in exchange for improvements to energy efficiency. For example, the Town could offer a density bonus or fewer required parking spaces in exchange for meeting a higher standard of energy efficiency.
Implementation Challenges	• Requirements and construction standards seek to improve the safety and longevity of buildings. However, such requirements should be crafted with care, as increases in cost of construction or delays in the approval process can make housing less affordable. • Federal grants only cover a small portion of affordable housing units.
Resources Needed	• Grant applications development • Facilitating community programs through seed or matching funding
Anticipated Cost	Variable, depending on Town commitment
Leadership	Town staff and community programs
Partners	Federal government, community programs, Triangle Green Building Council

Fit with Items	Works to address both affordable housing and climate change mitigation
Time Frame	Coordination with affordable housing focused efforts can be explored immediately. Significant traction is a long term proposition.
Next Step(s)	• Identify relevant federal grants • Develop partnerships with community programs • Investigate legal authority and cost-benefit analysis for Town ordinances
Evaluation Criteria	• life cycle costs and net present value

Building Energy Efficiency Measures

Residential and commercial buildings are the largest emissions sectors in Carrboro, accounting for 2/3 of all emissions. Duke Energy has been able to provide monthly electricity use data specifically for Carrboro beginning in January, 2011 through the end of 2015, broken out by residential and commercial accounts. An analysis of this data (Figure 2) indicates that residential electricity use declined by about 1% per annum during this time, while population increased by about 2% per annum. Commercial use remained very stable. The residential use also has a sharp seasonal pattern, with winter and summer peaks presumably associated with heating and cooling loads. This improved energy efficiency trend will need to be accelerated by 2-3 times to meet the 50% reduction by 2025 goal. Any ability to determine how representative the trend is of years prior to 2011 would also be beneficial to the monitoring of overall progress, but is difficult because of the lack of data.



Energy performance rating and auditing can inform interested parties on the overall energy efficiency of the building and provide transparency for market based decisions about property sales and rentals. By influencing a property's appeal to future renters and buyers, ratings can serve as an incentive for building owners to improve energy efficiency. This approach is being tested in cities such as Seattle, WA, Portland, OR, and Austin, TX. A website tracking different jurisdictions efforts for policies, improvements, and benchmarking in energy efficiency can be found at http://www.buildingrating.org/jurisdictions .

It is recommended that efforts be pursued so that the results of an energy audit and/or an energy performance rating (including one year of utility bills) are made available at the point of building sale or lease. This could be in the form of a written document and/or a numerical score such as a HERS rating or other recognized format. The information provided could include potential/recommended energy efficiency improvement measures. Carrboro would need to acquire statutory authority from the State to

make this a requirement. For new buildings and improvements requiring a building permit, pending the granting of a request for statutory authority, the Town could implement a section of the Building Code[17] with additional energy efficiency requirements that the Town does not currently have authority to implement. Alternatively, the Town could look into partnering with the Triangle Green Building Council to develop an optional checklist of efficiency performance/measures that, if implemented, would lead to special designation and public recognition.

Most Carrboro residents rent their homes; 33% of homes are owner occupied, compared to 59% renter occupied (the remaining 8% of homes are vacant)[18]. While some reductions can be achieved via low cost/no cost approaches, to achieve substantial (>10%) GHG reductions, retrofitting or including energy efficiency improvements during rehab work is typically necessary. For many rental properties, renters pay the utility bills and as a result, building owners/landlords may have little or no financial incentive to pursue this work. Conversely, renters have no financial incentive to make investments in a property they do not own. Accordingly, there is an underinvestment in energy efficiency improvements in rental units. Without aligning the landlord's costs for retrofits and the renter's benefit in lower energy bills, it will be difficult to voluntarily achieve GHG reductions in rental units. Addressing this issue requires engagement of a diverse set of stakeholders: affordable housing advocates, renters, landlords, new development planners, and energy efficiency contractors. It is recommended that the Town commission a Task Force to bring forward policy recommendations for how to align landlord and renter interests towards achieving energy efficiency in rental units. The Town could also create a voluntary registry or certification program that landlords could include in the advertisements of their properties. This could be in the form of a certification or a points system.

Buildings Recommendation #1: 50% Challenge

Reduce Emissions Attributed to Carrboro Buildings by 50% by 2025

It is proposed that local leaders announce an emissions reduction challenge to reduce community-wide emissions by 50% by 2025. The challenge could include a component focused on buildings emissions in Carrboro.

Implementation Opportunities	Reduced electricity and gas use from more efficient building envelopes, appliances, HVAC systems, lighting. Healthier buildings; older buildings brought up to code; utility cost savings for building owners/occupants. More efficient buildings result in cost savings and support the green building sector. If the

[17] At the December 14, 2010 NC Building Code Council meeting, a 15% residential efficiency part of the code was not approved, instead this code was considered to be voluntary and included as Appendix 4 to the 2012 NC Energy Conservation Code. The Carrboro Board of Aldermen is seeking statutory authority to pilot making Appendix 4 mandatory. This request has not made it out of committee with the NC Legislature.

[18] UNC Capstone Team, 2015. 2012 Greenhouse Gas Emission Inventory for the Town of Carrboro, NC. http://nc-carrboro.civicplus.com/DocumentCenter/Home/View/2788

	private sector becomes engaged, the downtown area of Carrboro and Chapel Hill could evolve into a recognized "2030 District"[19]
Implementation Challenges	"Cost, complexity, inertia". High percentage of non-owner occupied buildings; financial challenges especially for lower income residents and renters.
Resources Needed (human and material)	A nonprofit organization to become a community champion. Neighborhood and business champions and grassroots/community organizing, outreach, and education. Broad support from community leaders, utilities, financiers, and contractors. Potentially, fiscal support for nonprofit and organizing/coordination support from Board and staff
Anticipated Cost	Time and potentially salary involved in organizing
Leadership	Potential leaders include: existing and/or new nonprofit(s); the Carrboro Business Alliance; Chamber of Commerce; Triangle Green Building Council
Partners	Potential partners include: existing and/or new nonprofit(s); the Carrboro Business Alliance; Chamber of Commerce; Triangle Green Building Council. Several programs have been developed in North Carolina to lower the barriers to energy efficiency adoption within a community. • The NC Banker's Association pools banks for the financing of low income tax credit apartment complexes. They are interested in partnering with nonprofits to start a small loan pool for energy retrofits.[20] • System Vision program, which partners Advanced Energy Corp, the Self-Help Credit Union, and the NC Housing Finance Authority to finance green home construction/retrofits.[21] • Transition Streets and Pete Street programs. [22] The State Energy Office and Cooperative Extension Service ran the E-Conservation Home Energy Improvements program, which expired in July, 2015. If it is not renewed, it is recommended that Carrboro discuss partnering with Chapel Hill, Orange County, and perhaps others to run a similar program. The State Energy Office has been pursuing this for several years and is a valuable resource for learning what works.
Time Frame	It is recommended that local leaders do this immediately.
Fit with Items	Renewable energy and transportation challenges

[19] http://www.2030districts.org/
[20] Contact is Michelle Lampert shellielampert@gmail.com
[21] http://www.nchfa.com/nonprofits/HPsystemvision.aspx
[22] In 2013 Carrboro and Chapel Hill contracted with Clean Energy Durham to pilot their "Pete Street" neighbor-to-neighbor energy retrofit program. The approach trains neighborhood volunteers who lead neighborhood workshops where small groups of resident learn simple energy savings projects and behaviors. Clean Energy Durham has recently closed.

Next Step(s)	Local elected officials/community leaders collaborate to initiate challenge
Evaluation Criteria	Reductions in energy use/GHG emissions from buildings. Updated community energy use/emissions inventories for 2016 and 2020

Buildings Recommendation #2: Energy Audit/Performance Rating

For Existing Buildings, an Energy Audit and/or Building Energy Performance Rating, Including Utility Bills from Past Year, Could be Conducted at Point of Sale or Lease.

An energy audit is a service that involves inspecting and analyzing energy use, efficiency, and conservation. Different types of audits can be pursued, from simple "walk through" audits to more involved audits that can use equipment (such as blower doors and infrared cameras). A building performance rating is the result of an analysis that rates a building on a standardized scale for buildings of the same type. For example, for homes, the Home Energy Rating System (HERS) is a national recognized rating system. EPA's Energy Star program similarly has created a system for rating and benchmarking different categories of buildings. The purpose of this recommendation is to create a level playing field using recognized standards of information about energy use and efficiency for people in the housing market.

Implementation Opportunities	· Healthier buildings (better air handling and moisture control) · Lower carbon emissions. · Lower utility bills for occupants. · Provides a service to those looking to buy or rent and reaches a demographic not reached with many incentive based efforts · Addresses the unique situation in Carrboro with a high percentage of non-owner occupied buildings · Heat loss audits could be automated for a neighborhood using thermal IR imagery · The Town's Energy Efficiency Revolving Loan Fund is available for recommended improvements to commercial buildings. · Can potentially support businesses performing energy ratings/audits
Implementation Challenges	· The Town does not have the authority to make this a requirement and would need special enabling legislation if this were to be a regulatory program. · Some building owners, especially those with less efficient buildings, will likely not be in favor of this for reasons of "over regulation" and/or the potential market implications.
Resources Needed (human and material)	Effort associated with outreach and education and crafting the details with stakeholders as well as monitoring for compliance.
Anticipated Cost	Significant costs are not anticipated but would need to be determined as part of implementation
Leadership	Board of Aldermen for policy direction, with support from the Economic Sustainability Commission, Town staff

Partners	Business Alliance, Chamber of Commerce, Board of Realtors, Triangle Green Building Council
Time Frame	Exploration could begin immediately. For a higher probability of moving forward, a champion will likely be needed.
Fit with Items	Rental Task Force; Rental Registry/Certification
Next Step(s)	To be determined
Evaluation Criteria	Reductions in metered utility energy usage and costs.

Buildings Recommendation #3: Demonstrate/Pursue Energy Performance Beyond Minimum Requirements for New Development

For New Developments and/or Individual New Buildings or Major Retrofits, Pursue Compliance with Voluntary Section of Building Code, or Request Specific Energy Performance Rating/Measures as Part of Land Use and/or Building Permit.

In 2010, a 15% residential efficiency part of the building code was not approved by the NC Building Council, instead this code was considered to be voluntary and included as Appendix 4 to the 2012 NC Energy Conservation Code. The Carrboro Board of Aldermen is seeking statutory authority to pilot making Appendix 4 mandatory. Other approaches could be followed to pursue energy efficiency in new buildings beyond the current minimum code requirements.

Implementation Opportunities	Healthier buildings (better air handling and moisture control) Lower carbon emissions. Lower utility bills for occupants.
Implementation Challenges	Additional Town staff time. Statutory authority, or voluntary compliance from developers/builders
Resources Needed (human and material)	Town staff to expand Building Code implementation and/or work with Triangle Green Building Council to develop checklist and form of recognition.
Anticipated Cost	No significant cost anticipated
Leadership	Town staff, potentially with support from Planning Board
Partners	Triangle Green Building Council
Time Frame	Exploration could begin immediately. Identifying a champion will likely be needed.
Fit with Items	Pursuing 50% reduction
Next Step(s)	TBD
Evaluation Criteria	Number of buildings affected. Reductions in metered utility energy usage and energy intensity (energy use per square foot)

Buildings Recommendation #4: Create Rental Property Task Force and Process

Create a Task Force to Pursue a Facilitative Process to Achieve Greenhouse Gas (GHG) Reductions in Rental Units

Most emissions in Carrboro come from buildings, a very high percentage of buildings are for housing and about two-thirds of housing in Carrboro is rental property. For progress towards Carrboro's Climate Action Goal, it is imperative that emissions reductions efforts address rental property. It is recommended that the Town commission a Task Force to bring forward policy recommendations for how to align landlord and renter interests towards improved energy efficiency in rental units. (This Task Force could be the same as identified below for renewable energy.)

Implementation Opportunities	• Energy efficiency reduces waste and saves money in the long term • Energy efficiency retrofits create local jobs
Implementation Challenges	• There is little precedent; organizing and coordinating will require significant effort. • Many rental property owners are not local. • Owners and renters financial incentives are not necessarily well aligned
Resources Needed (human and material)	The Town could partner with an outside organization to facilitate this Task Force.
Anticipated Cost	Staff time and/or contract support to help facilitate Task Force
Leadership	Town staff for giving the group a well-defined mission and keeping the group on track
Partners	Work with organization that facilitates stakeholder groups
Time Frame	Time frame to set up a Task Force depends on Board priority and staff/community capacity. Operating the resulting program would be a long term endeavor.
Fit with Items	50% reduction challenge; Rental Registry; Renewable Energy Task Force
Next Step(s)	1. Develop Task Force charge 2. Identify relevant stakeholders needed to agree to process in order to make impactful change 3. Identify outside organization to facilitate Task Force 4. Commission Task Force
Evaluation Criteria	Savings from lower energy bills could be put towards other projects. Keep energy dollars local. Reduces greenhouse gas emissions.

Buildings Recommendation #5: Create Rental Property Registry/Certification

Create a Certificate Program or Registry for the Energy Performance of Rental Housing

The basis for this recommendation is identical for the above building recommendations. The essence of this recommendation is that, as part of making rental properties more energy efficient, a program be created that makes it easy for those in the rental market to find energy efficient rental listings.

Implementation Opportunities	· Lower residential carbon emissions. · Lower utility bills for tenants. · Provides a service to those looking to rent and reaches a demographic not reached with many incentive based efforts · Addresses the unique situation in Carrboro with a high percentage of non-owner occupied housing · The Town could potentially support performing energy ratings/audits
Implementation Challenges	· The Town does not have the authority to make this a requirement. · The effectiveness of this program would be dependent on widespread adoption by Carrboro landlords. · It may require outreach to the landlords and research on the how to best communicate a potential rating system.
Resources Needed (human and material)	Town staff, or another entity, could run the program and set the program requirements.
Anticipated Cost	Costs would be primarily associated with staff time and marketing.
Leadership	Board of Aldermen for policy direction, Town staff
Partners	Triangle Green Building Council, potentially others
Time Frame	Time frame to set up depends on Board priority and staff/community capacity. Operating it would be a long term endeavor.
Fit with Items	Other buildings recommendations, especially the energy audit/performance rating
Next Step(s)	Outreach to determine interest and feasibility
Evaluation Criteria	Reductions in metered utility energy usage and costs.

Transportation Measures

Reducing emissions from transportation in Carrboro will rely on a coordinated, multifaceted effort involving infrastructure improvements, additional transit service, land use changes, outreach and engagement to affect transportation mode choices, and participation broadly with partners and across the community.

Availability of local bicycling and pedestrian infrastructure is strongly associated with overall levels of biking and walking, especially with trips to work, school, or shopping.[23] In September 2010, the League of American Bicyclists recognized Carrboro as a Bicycle Friendly Community at the "Silver" level. There is an aspiration to achieve the "Gold" level during the next review cycle. The Town has the support of the Carrboro Bike Coalition, Chapel Hill Carrboro City Schools and other Safe Routes to Schools partners, a high level of ridership relative to other jurisdictions, and comprehensive bicycling and greenway plans. In order to get even more people out of their cars and onto their feet and bikes, Carrboro must keep working on the gaps, continue to connect neighborhoods to schools, and expand bicycle and pedestrian infrastructure to connect all areas of Carrboro to downtown, surrounding greenways, and bike routes. Improvements such as signals and pavement markings can increase convenience and perceptions of safety, and provide official, visible recognition that bicyclists are legitimate users of the road.

Carrboro (and Chapel Hill and UNC) have sponsored Chapel Hill Transit for several decades, the only fare free transit system and the highest per capita use system in North Carolina. In combination with regional transit provided by GoTriangle, transit options, along with publically and privately supported rideshare/carpooling/vanpooling/car sharing options continue to increase. Nevertheless, for many users and trips, transit and other alternatives to single occupancy vehicle use is a difficult option because of the relative convenience and comparative time relative to single occupancy motor vehicle use. A number of initiatives are in place to help promote and expand use of alternatives to single occupancy vehicle use; suggestions for further pursuing these initiatives are provided. A final recommendation is to reduce vehicle idling in school loading zones.

[23] A Seattle study found that adults living within a half-mile of a bike path were 20 percent more likely to bicycle at least once a week. A Portland study found that cyclists went the furthest out of their way to use off-street bike paths, followed by bicycle boulevards (low speed streets that have been "optimized" for bicycle traffic) suggesting a general preference for facilities protected from motor vehicle traffic.

Transportation Recommendation #1: 50% Challenge

Reduce Greenhouse Gas Emissions from Motor Vehicle Use by 50% by 2025.

It is proposed that local leaders announce an emissions reduction challenge to reduce community-wide emissions by 50% by 2025. The challenge could include a component focused on transportation/motor vehicle emissions in Carrboro.

Implementation Opportunities	• Requirements and market for more fuel efficient/lower emission vehicles and pedestrian and bicycle infrastructure and transit system use continue to improve. • Land use planning is supporting mixed use, infill and redevelopment and community is proactive to further encourage non-vehicular modes.
Implementation Challenges	• High percentage of residents work outside Carrboro with significant challenges for using transit or commuting by bike or on foot. • Constraints such as topography/natural features, ownership, and grey infrastructure exist in some areas for further bicycle and pedestrian facility development. • Non-vehicular transportation options in some parts of Town are more limited. • Ability to monitor and track progress towards emissions reduction is currently quite limited methodologically and in terms of clarity of the responsible party for tracking.
Resources Needed (human and material)	There are no resource requirements associated with a recognized community-wide goal, although there will be resources needed for implementation of different actions.
Anticipated Cost	There are no specific costs associated with a recognized community-wide goal, although there will be resources needed for implementation of different actions.
Leadership	Local elected officials and community leaders could endorse this goal
Partners	Various public, private, nonprofit
Time Frame	It is recommended that local leaders do this immediately.
Fit with Items	Buildings and renewable energy challenges
Next Step(s)	Formal adoption/publicity for challenge
Evaluation Criteria	Ability to track emissions via VMT, fuel type, and vehicle efficiency. CAMPO model? Other methodology?

Transportation Recommendation #2: Enhance Transit Service

Improve/Extend Transit Service

While overall, Chapel Hill Transit is the most successful transit agency in North Carolina and GoTriangle is steadily increasing service, areas farther from downtown have more limited service.

Implementation Opportunities	• Transit service could be extended to new areas by adding more stops in Carrboro well connected to other transit, bike, and pedestrian access, and including more hours of service. • New Transit Oriented Development could be sited in the Northern Transition Area.
Implementation Challenges	• Fleet has many old and inefficient vehicles • Funding is currently stressed. • It is difficulty to site development of sufficient density in northern Carrboro to justify transit. • Service level makes it difficult for many commuters to use transit.
Resources Needed (human and material)	• Increased funding • Landowner, developer, and community support new mixed use/transit oriented development
Anticipated Cost	Improved local transit service costs will depend on different factors, and will be implemented by Chapel Hill Transit and GoTriangle.
Leadership	Board/Transit Partners, NTAAC, Transportation Advisory Board, Town staff for new development. Chapel Hill Transit for improved/expanded local transit service; GoTriangle for regional transit. Other partners below can also provide leadership.
Partners	Local business community, NTA neighbors
Time Frame	Transit development/improvement by nature is an ongoing and long term undertaking.
Fit with Items	See separate recommendation for steps to promote transit service.
Next Step(s)	• Work with GoTriangle and Chapel Hill Transit staff to provide additional feedback on plans for future service and ability to accelerate adding service. • Enhance transit access points along the 54/15-501 corridor from Chapel Hill/Carrboro to Durham and provide more frequent, reliable bus service.
Evaluation Criteria	Number of bus commuters/trips

Transportation Recommendation #3: Improve Vanpool/Carpool Options

Improve Vanpool/Carpool Options for Commuters

A considerable amount of transportation related emissions can be attributed to people commuting in and out of Carrboro for work. Vanpools and carpools can be an effective approach for reducing vehicle miles traveled and single occupancy vehicle trips, but existing park and ride areas could be more convenient for Carrboro commuters. Adding vanpool parking areas could reduce vehicle miles traveled and emissions.

Implementation Opportunities	Add GoTriangle vanpool/carpool parking in Carrboro (including downtown Carrboro and Northern Carrboro) and nearby in Chapel Hill.
Implementation Challenges	Requires partnership with GoTriangle and local businesses.
Resources Needed (human and material)	Signs to identify vanpool and carpool parking areas
Anticipated Cost	Signs to identify vanpool and carpool parking areas
Leadership	Board of Aldermen; Staff; GoTriangle
Partners	Chapel Hill Transit, GoTriangle; businesses with suitable parking
Time Frame	The main timing consideration is determining who can champion this.
Fit with Items	Reduce transportation emissions by 50% by 2025.
Next Step(s)	Work with GoTriangle to identify currently registered vanpools and carpools and use this info along with expected increase in use to establish carpool and vanpool parking areas, including downtown Carrboro and Northern Carrboro and nearby areas in Chapel Hill.
Evaluation Criteria	Number of vanpool and carpool commuters

Transportation Recommendation #4: Further Promote Walking, Biking, Transit

Take Additional Steps to Promote Walking, Biking, and Transit Use

Carrboro has a considerable base of bicycling, walking, and transit use to build on. In September 2010, the League of American Bicyclists named the Town of Carrboro a Bicycle Friendly Community at the "Silver" level, and there is an aspiration to achieve the "Gold" level during the next review. Carrboro has significant support from the Carrboro Bike Coalition and other partners and already participates in the Safe Routes to School program. Marketing and educational programs, as well as regulations, significantly affect levels of bicycling, walking, and transit use. Investments in infrastructure must be supported by outreach programs to be most effective.

Implementation Opportunities	More promotion/outreach for bicycling and walking
Implementation Challenges	● Challenge of changing set behaviors. ● Some greenway, bike route, and transit services are not yet complete. ● Transit services are spotty or non-existent in some areas ● Uncertain funding for new/renovated buses
Resources Needed	● Town Staff and partners support.
Anticipated Cost	TBD
Leadership	Town Transportation Planner, with support from Recreation and Parks staff, Transportation Advisory Board, Greenways Commission.
Partners	UNC, Chapel Hill Transit, GoTriangle, Carrboro Bike Coalition, Carrboro Business Alliance, Chapel Hill-Carrboro City Schools, Walk Bike NC
Fit with Items	Reduce Greenhouse Gas Emissions from Motor Vehicle Use by 50% by 2025; Improve and Extend Bicycling and Pedestrian Infrastructure; Improve and Extend Transit Services
Time Frame	This is ongoing. The main consideration for significantly accelerating efforts is identifying people with capacity.
Next Step(s)	● Continue, accelerate, and intensify efforts to: o Promote bike to work days; consider doing these weekly. Studies have reported long-term increases in bicycling following bike-to-work days. o Work with the Carrboro Bicycle Coalition to: put on and publicize on-going bicycle training; o Work with the Carrboro Bike Coalition to hold "Open Streets" days. o Work with Chapel Hill Transit and GoTriangle to develop and implement a marketing and educational program on carpooling, vanpooling, and transit use. Promote official car free, carpool, vanpool, and transit use days. o Support the *Safe Routes to Schools Program*. Work with the Carrboro-Chapel Hill City School System and local PTAs to promote bike and walk to school days; consider doing these weekly. o Pursue efforts to implement land use and development policies that help ensure destinations for daily needs, such as school, work, and shopping, are within convenient bicycling distance from home. Encourage developers to promote multi-modal transportation options. ● Promote "park and stroll" programs at schools, where students are dropped off at a remote location and walk or bike the rest of the way to school. ● Research and implement a bike sharing system downtown. ● Explore new policies that make driving more expensive and less convenient (e.g. reduced parking supply, increased parking fees, and reduced road speeds). Lower speed limits for vehicles make bicycling safer and more attractive. One study conducted in Germany found that reducing general speed limits led to a significant increase in bicycling.
Evaluation Criteria	● Number of students biking or walking to school. ● Number of residents biking, walking, or using transit, carpooling or vanpooling to commute to work. ● Increased transit ridership.

Transportation Recommendation #5: Limit Idling in School Loading Zones

Limit Idling in School Loading Zones

Avoiding idling time has a multitude of benefits including: savings in fuel and maintenance costs, extending vehicle life, and reducing damaging emissions. It is especially appropriate to look at school loading zones because they are focal points in Carrboro for vehicle idling, expose a sensitive population to air pollution, and meaningful reductions could be achievable through simple behavior change. Outreach resources are available at http://daq.state.nc.us/motor/idle/idle_campaign.shtml.

Implementation Opportunities	This is a simple effort that will reduce air pollution and GHG emissions.
Implementation Challenges	Parental resistance, especially at elementary schools, and outreach/enforcement.
Resources Needed	School system employee time. Consider recruiting student and parent volunteers to help with education/outreach.
Anticipated Cost	Costs associated with staff time
Leadership	Board of Aldermen, CHCCS School Board, staff
Partners	PTA; individual school teams;
Time Frame	If the policy direction exists, this could be pursued immediately.
Fit with Items	Community integration and emission reduction recommendations
Next Step(s)	Coordinate with CHCCS
Evaluation Criteria	Monitoring of idling activity

Renewable Energy Measures

Carrboro's Climate Action Goal can be pursued by generating more energy from renewable sources and improving energy efficiency. This section provides recommendations for how to increase renewable energy from two sources, solar and geothermal. Solar panels convert light from the sun into electricity. Geothermal heating and cooling employs pumps and wells to take advantage of the near constant temperatures below the Earth's surface. This can be used to reduce the costs to heat buildings in the winter and cool them during the summer. Both of these approaches require considerable initial costs to install the equipment. However these technologies have low maintenance costs and a lifetime of more than 25 years, which creates considerable energy savings over time. Homeowners and businesses that can shoulder the upfront costs have been switching to renewable energy. The focus of these recommendations is to help speed the transition to renewable energy, especially addressing the barrier of initial costs.

The first recommendation is to develop a community solar project for Carrboro. Solar panels can provide low-cost energy without environmental impacts. Many home and business owners are realizing lower energy costs by investing in solar. However, most Carrboro residents either rent or own homes that are shaded by trees, and cannot benefit from solar at their home. A community solar project would allow people across Carrboro to invest in solar, lower electricity bills, and help bring about a clean energy future for our Town. However, the electric utilities that service Carrboro restrict most forms of community ownership. Legislation currently under discussion in the NC General Assembly would allow a third-party, such as a community entity, to sell electricity directly to power consumers. Under this change, a community group could own a solar installation and sell the energy to a large buyer, such as the Town of Carrboro. The agreement could set the electricity price to a rate that is beneficial to both the Town and the community investment group.

The second recommendation is to explore and encourage geothermal heating and cooling, especially in downtown. The Carrboro Century Center has considerable heating and cooling costs that could be reduced by switching to geothermal. Developing geothermal heating and cooling for the Century Center could reveal economies of scale, where neighboring buildings could be added to the system at lower cost. If it is legally and technically feasible and cost-effective, the opportunity could be extended to explore the formation of a geothermal heating and cooling utility to provide low-cost, sustainably sourced heating and cooling to downtown buildings that is easy for property owners to join.

The third recommendation is to convene an action group to develop policy opportunities to create incentives for renewable energy and energy efficiency upgrades in rental properties (see Buildings Recommendation #3). The majority of Carrboro residents are renters and do not directly have control over their energy efficiency and energy generation. Because renters pay the utility bills, landlords have less financial incentive to invest in energy savings. Lowering electricity costs makes housing more affordable, but the incentives are not aligned to encourage this change. This action group will be charged with finding policy opportunities to better align renter and landlord incentives towards lowering electricity costs. This action group should include advocates from renter, property owner, affordable housing, and green building organizations.

When taken together, these recommendations provide opportunities for Carrboro residents and businesses to further participate in and benefit from the switch to renewable energy.

Renewable Energy Recommendation #1: Pursue Community Solar Projects

Pursue Community Solar Projects

Solar panels can provide low-cost energy without environmental impacts. Many home and business owners are realizing lower energy costs by investing in solar. However, most Carrboro residents have homes that are shaded by trees, and cannot benefit from solar at their home. A community solar project would allow people across Carrboro to invest in solar, lower electricity bills, and help bring about a clean energy future for our Town. However, the electric utilities that service Carrboro restricts most forms of community ownership. Legislation currently under discussion in the NC General Assembly would allow a third-party, such as a community entity, to sell electricity directly to consumers. Under this change, a community group could own a solar installation and sell the energy to a large buyer, such as the Town of Carrboro. The agreement could set the electricity price to a rate that is beneficial to both the Town and the community investment group.

Implementation Opportunities	• Broadly share solar investment benefits, including keeping dollars local • Town of Carrboro buildings could be first adopters, but this approach could be deployed on other buildings • The community investment group could pay the upfront costs to develop solar
Implementation Challenges	• Requires considerable effort to organize support and investment • The loss of the NC Renewable Energy Tax Credit and the absence of third-party sales of electricity significantly limit the market.
Resources Needed (human and material)	This will likely require collaboration between Town staff and one or more outside organizations.
Anticipated Cost	There are options depending on how the electricity purchasing agreement with the community group is defined
Leadership	Town staff for considering Town property; economic development groups for development of community infrastructure
Partners	Work with organization that coordinates community investment group
Time Frame	Projects could take months or more to develop and would have benefits for many decades
Fit with Items	Community Integration recommendations
Next Step(s)	Develop program with community investment group
Evaluation Criteria	Savings from lower energy bills could be put towards other projects. Keep energy dollars local. Reduces greenhouse gas emissions.

Renewable Energy Recommendation #2: Pursue Downtown Geothermal Heating and Cooling

Pursue Geothermal Heating/Cooling, Especially in Downtown

Geothermal heating and cooling employs pumps and wells to take advantage of the near constant temperatures below the Earth's surface. This can be used to reduce the costs to heat buildings in the winter and cool them during the summer.

Implementation Opportunities	• Lower costs of heating and cooling • Century Center or Town Hall/Town Commons could be candidate for first adopter • If marginal costs of adding adjacent community/commercial buildings to the heating and cooling network are low, then a municipal utility could be an effective way to provide services at low cost • A community geothermal utility would make it easier to adopt geothermal broadly by lowering costs and simplifying construction. • Savings from lower energy bills could be put towards other projects
Implementation Challenges	• Unknown technical feasibility • Large upfront costs; requires low-cost financing • New for Carrboro. Orange County buildings in Hillsborough have implemented geothermal in HVAC and are realizing substantial savings
Resources Needed (human and material)	Effort to: explore feasibility; develop engineering design; and policy development towards an approach for other community buildings.
Anticipated Cost	Upfront costs are large but design lifetime of equipment is approximately 50 years. Geothermal systems (on average) reduce heating and cooling costs by 50%. The actual installation costs and benefits depend on the building.
Leadership	Town staff for development for Town buildings, business community for development of community infrastructure
Partners	Technical assistance from Orange County, contractor(s), and investors
Time Frame	An initial assessment of technical feasibility could be pursued quickly. Project development would likely take several years, depending on the scope, with benefits for many decades
Fit with Items	Pursue Partnerships; 50% Reduction Goal for Buildings
Next Step(s)	1. Examine completed projects in Orange County 2. Solicit contracting support for feasibility study 3. If deemed feasible, develop preliminary design for Town of Carrboro buildings including financial assessment and environmental benefits. 4. Explore opportunities to develop a municipal utility 5. Explore ways to encourage developers to install geothermal
Evaluation Criteria	• Reduced energy bills. • Reduced greenhouse gas emissions. • More comfortable work environment for Town staff.

Renewable Energy Recommendation #3: Create Rental Property Task Force and Process

Create a Task Force to Pursue a Facilitative Process to Achieve Greenhouse Gas (GHG) Reductions in Rental Units

It is recommended that the Town commission a Task Force to bring forward policy recommendations for how to align landlord and renter interests towards achieving renewable energy in rental units. (This Task Force could be the same as identified above for building energy efficiency.)

Implementation Opportunities	• Renewable energy is clean energy and create local jobs
Implementation Challenges	• The policy options to address this issue also have an impact on Town planning and affordable housing
Resources Needed (human and material)	Town staff could partner with an outside organization to facilitate this Task Force.
Anticipated Cost	Staff time and/or contract support to help facilitate Task Force
Leadership	Town staff for giving the group a well-defined mission and keeping the group on track
Partners	Work with organization that facilitates stakeholder groups
Time Frame	Time frame to set up a Task Force depends on Board priority and staff/community capacity. Operating the resulting program would be a long term endeavor.
Fit with Items	Task Force/Facilitative Process for Buildings
Next Step(s)	1. Develop Task Force charge 2. Identify relevant stakeholders needed to agree to process in order to make impactful change 3. Identify outside organization to facilitate Task Force 4. Commission Task Force
Evaluation Criteria	Savings from lower energy bills could be put towards other projects. Keep energy dollars local. Reduces greenhouse gas emissions.

Ecosystem Protection and Enhancement

The ecosystems that Carrboro is located within are being affected by a warming planet, but they also offer opportunities for combating climate change. This section of the plan includes recommendations to improve ecosystem health and resilience by reducing stormwater impacts, increasing tree canopy and biodiversity, better management of invasive plants and encouragement of native plants, managing organic waste and improving soil quality. In addition, there is a need for better information about the impact of climate change as well as herbivory on the health of the community forest. These focus areas are discussed separately, but are highly interwoven. The following is a brief overview of each area to provide context for the recommendations.

Climate change is likely to increase the frequency and intensity of storms and droughts in Carrboro, which will in turn increase the negative impacts of stormwater runoff that include erosion, flooding, nonpoint source pollution (including nitrogen and phosphorus delivery to surface waters), and altered hydrology[24]. Many methods and opportunities exist to aid in curbing stormwater runoff (permeable paving, rain gardens, and green roofs to name just a few), but often landowner interest and available resources are not in place to pursue these projects[25]. Creating a stormwater utility or joining Chapel Hill's utility could ensure a dedicated funding source for stormwater projects that is not subject to discretionary spending in annual budget cycles. Doing so would provide the financial stability and predictability needed for such projects. A utility could also support public education, helping citizens understand the causes and consequences of stormwater runoff and the ways in which individuals can limit the runoff and pollution leaving their property.

Despite climate and land use changes, forests in the southeastern USA will likely continue to provide a sink of atmospheric carbon dioxide (CO_2). There is potential for mitigating $C0_2$ emissions through carbon sequestration in soils and plant biomass. Protection of these natural carbon sinks in the face of development pressures is an important issue for climate change mitigation. The potential savannafication of the southeast, in which forests are converted into more open woodlands due to a combination of hotter and drier conditions, is one of the most significant potential climate change impacts in the USA. [26]A healthy forest, and in particular a healthy riparian forest, is integrally related to healthy creeks and downstream waters. For example, these ecosystems not only store macronutrients in their biomass, but they are also responsible for stabilizing and building soils with rich microbiological processes that recycle nutrients such as nitrogen and phosphorus. In doing so, creeks are protected from being overloaded and over fertilized with sediment and nutrients. Riparian forests shade creeks and help regulate the water temperature, and the creeks and creek valleys create important microclimates.

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[24] http://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1131&context=scwrc

[25] http://www.nrdc.org/water/pollution/storm/chap4.asp

[26] Ingram, K., K. Dow, L.Carter, J. Anderson (eds). Climate of the Southeast United States: Variability, Change, Impacts, and Vulnerability. Washington, D.C. Island Press, 2013.
NRC (National Research Council), 2010. Adapting to the Impacts of Climate Change. Washington, D.C. National Academies Press.

Overgrazing by deer could adversely affect the health of the forest by causing a decrease in plant diversity and aiding in the spread of exotic species. Soil studies have shown that the seed stores in areas with deer overpopulation can shift from native wildflowers and woody plants to invasive plants and grasses. This could threaten the ability of our forests to regenerate in a healthy way and continue to serve as diverse ecosystems and significant carbon sinks.

Trees, whether lining a city street or part of a forest, are an important tool in addressing climate change. Carrboro's urban forest provides innumerable ecosystem services[27] (not just limited to climate protection/resilience and energy management). Trees act as carbon sinks, reduce the heat island effect in urban areas, and reduce the energy used to cool and heat buildings. Trees stabilize and improve soil, reducing erosion and improving stormwater management through infiltration and evapotranspiration. Trees have been shown to increase property values and help to create a sense of community and economic vitality[28]. Trees absorb air pollutants, reducing exposure of dangerous chemicals to people and wildlife. And, of course, trees offer habitat for wildlife such as pollinators and migratory birds. A recent study has shown that Carrboro lost about 4% of its tree canopy between 2002 and 2010[29]. A "Tree Coalition" could be formed to promote the preservation and health of trees and the community forest in Carrboro and be a resource for citizens who have questions about trees on their property.

Unfortunately, native plant species are being threatened by invasive plant species (categorized by the US government as non-native species that are economically and environmentally devastating). Recent studies have shown that as climate change lengthens growing seasons, invasive species are adjusting their flowering schedules more quickly than their native counterparts. This earlier bloom time can allow invasives to shade out natives and "capture a larger share of nutrients, water, or pollinators".[30] It can take decades to discover that a species is invasive, and such a discovery does not necessarily lead States to ban nursery sales of the species. Many people are unaware of the critical importance of native plants to food webs and biodiversity, and often fail to realize the impact that their own landscaping choices have on our local ecosystems. For example, because native plants serve as the host plants on which native insects lay their eggs -- and 96% of North American birds (excepting seabirds) rely on native insects to feed their young-- native plants are important both environmentally and economically. According to The White House, as of 2009, pollination of US crops by native insects was valued at more than nine billion dollars. It is recommended that the Town and community take a three-fold approach to this issue: 1) review and strengthen Town ordinances against invasive species and in favor of native species; 2) educate the community about the link between native species and ecosystem health; and 3) encourage invasive species removal projects that are carried out by citizens but led by a non-profit or task force.

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[27] See Nowak, D. et al., "Sustaining America's Urban Trees and Forests". USDA Forest Service, Northern Research Station. State and Private Forestry General Technical Report NRS-62. June 2010. http://www.fs.fed.us/openspace/fote/reports/nrs-62_sustaining_americas_urban.pdf

[28] Council of Tree and Landscape Appraisers, as reported by City of Raleigh
ICMA, as reported by City of Raleigh

[29] Shields, Shane. 2014. Modeling Carrboro's Tree Canopy Cover 2002 to 2010. Report completed as intern to Carrboro Planning Department.

[30] Niijhuis, Michelle. "How Climate Change is Helping Invasive Species Take Over." Smithsonian.com. Smithsonian Magazine, December 2013. http://www.smithsonianmag.com/science-nature/how-climate-change-is-helping-invasive-species-take-over-180947630/?no-ist

The Town should consider expansion of composting in studies of and plans for waste management for multiple reasons. According to NCDENR, "landfills are the largest human-made contributor of methane into the atmosphere. Methane, a greenhouse gas, is 72 times more potent than CO_2 over twenty years." The organic material buried in landfills is responsible for this methane, releasing the gas through anaerobic decomposition. Orange County has recently begun to utilize the methane in its landfill for energy production. At the same time, reducing future methane production at landfills is a positive climate mitigation measure. Composting is considered to be the most effective way to combat this production of methane[31]. Orange County Solid Waste Management is scheduled to begin offering onsite disposal of household organic waste (i.e. food scraps) at its Chapel Hill facility on Eubanks Road in 2016. This will be in addition to the composting facility offered at its Walnut Grove Church Road Convenience Center in Hillsborough. However, many residents do not utilize these convenience centers, instead throwing their food scraps into the trash. Cities and towns that have implemented curbside composting have been able to move to bi-weekly trash pickup, freeing up funds for commercial hauling and processing of compost. Seattle, Portland, and San Francisco have curbside composting programs that could offer examples for Carrboro[32].

Ecosystem Recommendation #1: Pursue Stormwater Utility

Create a Stormwater Utility in Carrboro, or Join Chapel Hill's Stormwater Utility.

The Town has taken steps to exceed minimum State requirements for stormwater volume control and water quality buffers for new development and instituted land use planning and policies that have to some extent reduced surface water impacts from new development and exceeded what many other jurisdictions have pursued. The Town has also actively worked with the Bolin Creek Watershed Restoration Team to restore the aquatic health of Bolin Creek. Nevertheless, monitoring of aquatic life continues to identify concerns for the health of Bolin Creek, and stormwater runoff is also known to impact Morgan Creek and other creeks in Carrboro. From the viewpoint of residents with properties regularly experience flooding impacts, however, the Town has not yet been able to comprehensively respond to these impacts. The reality of climate change means that it will likely become more difficult in the future to adequately safeguard the health of local streams and citizens properties. In addition, the Town is faced with both current and new future regulatory requirements related to stormwater runoff. The Town administers an NPDES Phase II stormwater permit, and also will be pursuing a multimillion dollar initiative in the next decade to comply with the Jordan Lake Existing Development Rules.

According to the UNC Environmental Finance Center, there are currently 55 utilities operating in North Carolina, including many utilities in small towns. There appears to be a solid foundation from the work

[31] Dennings, Kelly. (2010). The Link between Recycling and Climate Change [SlideShares]. retrieved from http://www.slideshare.net/NCDENR/the-link-between-recycling-climate-change

[32] Seattle composting program: http://www.seattle.gov/council/bagshaw/attachments/compost%20requirement%20QA.pdf
Portland composting program: http://www.portlandoregon.gov/bps/56513
San Francisco composting program: http://www.sfenvironment.org/zero-waste/recycling-and-composting

of all these communities that there is value in having dedicated, predictable and sufficient funding for stormwater management efforts. Chapel Hill has formed a stormwater utility that has significantly increased Chapel Hill's ability to more proactively manage stormwater. Hopefully, a majority of Carrboro residents would be willing to support a utility if the revenue is well managed, especially if provisions are included so that the fee structure not be burdensome to lower income residents.

Implementation Opportunities	• Fee structure can be set up for greater "environmental equity" (fees are based on actual runoff impact, not property value). • Emerging/innovative financing approaches exist for stormwater and green infrastructure. • Chapel Hill's stormwater utility offers: local lessons (what works well/what is difficult); staff with technical expertise in engineering, science, administration, outreach/education; potential for efficiencies/sharing of resources. • A utility would help address current limited fiscal and staff capacity to meet needs for flooding issues/property impacts, protecting and restoring surface water quality, requirements for federal/state stormwater permit, and planning for compliance with Jordan Lake rules. • Opportunities exist for incorporating incentives for implementation of on-site stormwater management. For example, offering subsidies to help homeowners and businesses pay for part of a project on their land as a way to incentive the implementation of BMPs on private property. • The City of Durham has found that it is less expensive overall to distribute stormwater-related expenses as a utility fee rather than by increasing property taxes.[33]
Implementation Challenges	• Carefully planning the utility's goals upfront. • Determining whether to create a new utility, join Chapel Hill's utility, or explore an alternative approach that protects the benefits of a utility. • Determining a pathway for helping low-income individuals (exemptions, reimbursements, etc.). • Creating a well-conceived and well-implemented public outreach campaign. This campaign is needed to get public buy-in, ensuring that citizens are understand the purpose of and need for the utility.
Resources Needed (human and material)	• Funds for stormwater management/financing study • Eventually, new staff position(s) • Partnering agreement if collaborating with Chapel Hill • Funds for an education campaign
Anticipated Cost	See footnote[34]

[33] See #7 on the City of Durham's Stormwater Utility Fee Frequently Asked Questions Page: http://durhamnc.gov/ich/op/pwd/GIS/Pages/FAQ.aspx

[34] The average residential fee across 55 utilities in NC is currently about $1/month/1000 sq. ft. of impervious surface. Chapel Hill's utility's fee is about twice the average rate. See http://www.efc.sog.unc.edu/reslib/item/nc-stormwater-utility-dashboard# for details on NC stormwater utility rates. http://www.efc.sog.unc.edu/project/innovative-financing-approaches-stormwater-and-green-infrastructure has information on innovative financing.

Leadership	• Policy leadership from Board of Aldermen. • Management, technical, and administrative leadership from staff. • Environmental Advisory Board may be able to provide support. • Chapel Hill and Durham stormwater may be able to provide advice based on their own experiences.
Partners	Potentially Chapel Hill, OWASA
Fit with Items	Creating a new revenue stream for the Town adds capacity (Community Integration Recommendation #5)
Time Frame	Deciding to look into a stormwater utility could happen immediately. Forming a utility or joining Chapel Hill's utility would likely take 1-2 years
Next Step(s)	1) Staff to look into both administrative and policy opportunities and challenges a) Contact nearby jurisdictions and Environmental Finance Center determine best fit for Carrboro in creating a utility. b) Determine whether or not to partner with Chapel Hill's stormwater utility. 2) Craft public outreach/education campaign about negative impacts of stormwater and economic/environmental benefits of a utility.
Evaluation Criteria	• Town can consider annual surveys and other means of measuring public awareness about stormwater impacts and management • Increased number of BMPs created and increased amount of area treated to control stormwater runoff* • Improved stream health as measured by aquatic insects • Changes in stream hydrology based on stream gage monitoring • Availability of harvested rainwater in times of drought • Utility is being funded by fees collected

Ecosystem Recommendation #2: Evaluate Extent to Which the Deer Population and Climate Change affect Native Plant Ecosystems.

Evaluate Extent to Which the Deer Population and Climate Change affect Native Plant Ecosystems.

It is recommended that Carrboro seek professional support to determine whether native plant ecosystem effects from the deer population and climate change are apparent in the community forest. The potential savannafication of the southeast, in which forests are converted into more open woodlands due to a combination of hotter and drier conditions, is one of the most significant potential climate change impacts in the USA. Overgrazing by deer has the potential to adversely affect the health of forests, causing a decrease in plant diversity and forest regeneration, and aiding in the spread of non-native, invasive species.

Implementation Opportunities	A better understanding of ecosystem impacts from climate change and herbivory would: • Provide a baseline of forest ecosystem conditions; • Identify if actions are needed to mitigate negative ecosystem impacts; • Yield action options more specific and more consistent with local conditions.
Implementation Challenges	An evaluation of forest ecosystem impacts would: • Require outside assistance from experts in forest/ecological/wildlife assessment; • Require coordination among owners of community forest.
Resources Needed (human and material)	• Administrative support from Town Staff with help from the Environmental Advisory Board. • Information/advice/guidance from organizations such as the NC Forest Service – Orange County, Humane Society of the United States, ecologists/botanists.
Leadership	Policy leadership by the Board of Alderman. Support from Town Staff and the Environmental Advisory Board.
Partners	Carolina North Forest Management, NC Forest Service – Orange County
Fit with Items	Tree Coalition, Invasive Plant Management
Time Frame	Further study could be pursued immediately.
Next Step(s)	1. Obtain professional assistance with evaluating impact of climate change and deer herbivory on forest health 2. Consider outcome of evaluation and identify response that meets needs of community.
Evaluation Criteria	Forest understory (increase in native flora, decrease in exotic species, and increase in plant and animal biodiversity).

Ecosystem Recommendation #3: Accelerate/Expand Organic Waste Collection/Composting

Accelerate Efforts to Study and Implement a Comprehensive Organics Collection and Composting Program.

The Solid Waste Advisory Group, along with local government staff, are actively looking at the future of solid waste in Orange County, including implementation of an organics program. Prioritization/acceleration of this effort is encouraged. Details are provided below.

Implementation Opportunities	• Improved soil quality by increasing soil organic content; • Improved water quality by improving infiltration; • Decreased carbon footprint by decreasing methane gas and decreasing the number of trips to the transfer station. • Potential to move to bi-weekly trash pickup, freeing up funds for commercial hauling and processing of compost. Funding for the program could come entirely from the reduction of trash hauling and tipping fees. • A backyard composting demonstration site(s) in a central location(s) could encourage people to participate in composting. • The Town could consider offering finished compost for sale to the community (currently done at the county level) or providing it for free to program participants.
Implementation Challenges	• Educating the public is critical, as contamination of waste streams remains problematic. Contamination is a big problem in composting due to packaging, utensils, and other plastics being discarded with organic matter. Any campaign would need to be multilingual, as Carrboro is home to many people who speak Spanish or Karen as their first (and sometimes only) language. • Residential composting is especially challenging for multi-family housing, which is more prevalent in Carrboro than other jurisdictions in Orange County. Future planning needs to be sensitive to this challenge. • It can be labor-intensive to get businesses on board. Orange County staff currently have to go back to a business two or three times to get the business to agree to participate. In addition, employees need to be retrained as new people are hired. • Questions remain about program financing. Will Pay-As-You-Throw be viable? Would residents be charged for composting services, or given a discount on trash/recycling services if they compost? Would they pay for the collection but then receive free compost in return?
Resources Needed (human and material)	• Potentially, further waste characterization studies • Composting equipment (bins, trucks). • A business to take the food waste if Carrboro isn't going to have its own composting site. • Utility or some way to process fees from participants. • Additional staff resources and/or partnerships with community groups

	and/or businesses to expand outreach and education. This could include encouragement of a local business to operate the curbside program (such as CompostNOW).
Anticipated Cost	The main cost is likely to be the educational campaign aimed at letting people know what can be composted and what still goes in the trash, along with bins. Once the program is running, it could fund itself through money that used to be spent hauling and disposing of trash in landfills.
Leadership	Policy: Solid Waste Advisory Group. Technical: Local government staff.
Partners	Local gardening organizations, environmental groups, local businesses, county staff.
Fit with Items	Community Integration recommendations
Time Frame	Carrboro has initiated a solid waste study. Current trajectory for Solid Waste Advisory Group (SWAG) to consider a residential composting program is three to four years.
Next Step(s)	1. The solid waste study can include lessons learned from other communities with successful curbside composting (e.g., San Francisco, Portland, Seattle, NYC) and locally successful programs (CHCCS, UNC, etc.) as well as how to collaborate with local contractors (Brooks, CompostNow, etc.).[35] 2. Budget for and choose area for pilot program that includes residential and multi-family units. 3. Expand program to entire town. • Future plans should consider adding a more central drop-off location downtown. • Future studies and plans should include curbside compost collection.
Evaluation Criteria	Set a goal of 30% reduction in organic material being hauled to the transfer station by 2020, then 70% by 2030.

Ecosystem Recommendation #4: Create a Tree Coalition

Help Community Members Form an Independent Tree Coalition to Support the Community and Advocate for the Community Forest

Most of Carrboro's community forest is owned and managed by private landowners. There is a rich community of local arborists, gardeners, landscapers, nurseries, botanists, and ecologists that can support the community in creating healthier and more beautiful yards and ultimately a more resilient and diverse community forest. However, the knowledge and skills are relatively dispersed. Landowners can benefit from a local resource to help with forest, landscape, and tree management and advocacy.

[35] http://dusp.mit.edu/sites/dusp.mit.edu/files/attachments/project/Municipal%20Curbside%20Compostables%20Collection%20%20What%20Works%20and%20Why.pdf

Implementation Opportunities	• Increase public awareness of the intrinsic value and beauty of trees. • Provide oversight for a community scale urban forestry program. • Educate citizens about proper tree selection, planting, and care. • Educate citizens about the health of the larger community forest, its importance for both human and environmental health, and ways in which they can support it. • Partner with local government and civic groups to improve and expand the Town's tree canopy.
Implementation Challenges	• Creating a new and sustainable organization or finding an existing organization to lead the coalition. • Connecting with the public.
Resources Needed (human and material)	• A nonprofit organization to become a community champion for education, outreach, and action. • Neighborhood and business champions. • Broad support from community leaders, utilities, and business partners to help fund and provide technical expertise (e.g., arborists, foresters, nurseries, landscapers, NC Botanical Gardens, NC Cooperative Extension Service, Carolina North staff, Duke Forest staff). • Fiscal/policy/staff support from Town, North Carolina Urban Forest Council.
Anticipated Cost	Costs associated with nonprofit establishment/management if an existing nonprofit doesn't offer to take on the task (though this may be unnecessary if a coalition, like the Carrboro Bike Coalition, is formed.)
Leadership	Nonprofit/community members pulled together by Town staff.
Partners	NC Botanical Garden, Arbor Day Foundation, National Wildlife Federation, possibly expanding to Chapel Hill, Hillsborough, and/or Orange County.
Fit with Items	Community forest; stormwater utility; invasive plant management
Time Frame	Depends on identifying leadership and ability to mobilize community
Next Step(s)	Establish goals for the coalition Recruit members Form partnerships with those who have technical expertise. Begin education/outreach campaign to community

Ecosystem Recommendation #5: Improve Regulations and Community Capacity to Discourage Invasive Plants and Encourage Native Plants

Pursue both Regulatory and Non-regulatory Approaches to Better Manage Invasive Plant Species and Increase Community Efforts to Improve Plant Communities

The spread of non-native and invasive plants is a threat to forest resilience and biodiversity. Ideas for approaches to reduce the spread of non-native/invasive plants are offered in this recommendation.

Implementation Opportunities	• Implement a campaign to educate people on the link between native plant species and ecosystem health, particularly for pollinators who face stress due to climate change and other factors. • Encourage naturalized landscaping instead of manicured lawns. These types of landscapes offer critical wildlife habitat, cause a decline in the use of petroleum-based fertilizers and pesticides, more effectively capture stormwater runoff, and reduce the heat island effect.[36] • Pursue invasive species removal projects, especially in Town parks and along greenways/bikeways/right-of-ways. Such projects would be carried out by citizens but perhaps spearheaded by a local non-profit or task force. Projects could initially focus on: 1. Vining invasives (Japanese wisteria, porcelain berry, kudzu, mile-a-minute, English ivy, Japanese honeysuckle, oriental bittersweet, Japanese euonymus) that threaten urban tree health; 2. Japanese stiltgrass and privet that alter soil pH and outcompete many native grasses and shrubs.
Implementation Challenges	• Many people can't distinguish between native and non-native/invasive plants, nor do they know that the plants they're choosing for their yard are invasive. • Many people don't understand the link between native plants and ecosystem health, choosing their plants based on cost or aesthetics. • Renters don't often have the option to choose what's planted outside their door. • Some landowners and HOAs are resistant to native species or more natural-looking landscapes. • Some developers may need outreach and education. • Large/big box nurseries often sell few (if any) native species • Some people need assistance learning about/accessing local nurseries that specialize in natives. • Deer tend to ignore non-native species and prefer native species.
Resources Needed (human and material)	• Town staff to examine/amend ordinances. • Someone(s) to head an educational campaign. • Someone(s) to lead invasive species removal projects.
Anticipated Cost	Money for an educational campaign and supplies for projects removing invasives (tools, leaf bags, etc.).
Leadership	Town staff, Environmental Advisory Board, a non-profit or task force to lead invasive removal projects
Partners	NC Botanical Garden, NC Native Plant Society, local nurseries, biologists, local bee keepers, landscapers knowledgeable about native/invasive species, HOAs, Friends of Bolin Creek, Morgan Valley Alliance
Fit with Items	Community forest; Tree Coalition
Time Frame	Town staff are currently looking at the LUO. An outreach campaign is a long

[36] See this book for more information on the benefits and approaches for more naturalized yards and landscapes: Tallamy, Doug. *Bringing Nature Home*. Portland: Timberpress, 2010. Print.

	term undertaking.
Next Step(s)	• Update the Land Use Ordinance invasive/native plant requirements. • Implement an educational campaign, maybe in partnership with the Botanical Gardens or others, to help citizens and businesses understand the importance of planting natives and avoiding invasives. This could be done in conjunction with the Town's newly established annual Pollinator Day. • Explore options for implementing invasive removal projects. • Develop and regularly update an inventory of areas with excessive invasive plant growth
Evaluation Criteria	• Stronger ordinance against invasive species and in favor of native species. • Decrease in the number of invasive species in Carrboro and an increase in the number of natives. • More knowledgeable citizenry concerning the importance of native species.

Implementation Recommendations

This plan identifies a number of recommendations that include elements of implementation, however it is beyond the scope of the plan to include a detailed implementation plan. The following suggestions are offered as a starting point for pursuing implementation, and focus on categorizing the recommendations into (somewhat arbitrary) timeframes for consideration. "Work has already begun" refers to recommendations which are currently being pursued, and the predominant need is for acceleration, mobilization, and/or additional resources. "Begin immediately" refers to recommendations that could be prioritized because they support other recommendations, can potentially be pursued with more limited partnering requirements, outside or new resources or statutory authority, and in general have a lower risk/higher reward. Those listed "Within one year" are likely to involve more effort/resources, rely more heavily on the creation of partnerships, the development of educational campaigns, and/or input from the community. Items listed under "Within two years" will likely require significant effort and reliance on potential partners and are subject to some uncertainties. Finally, a regulatory based approach to two recommendations is likely to be possible only through changes in state law. While this prioritization is offered to attempt to make the entire pallet of recommendations more manageable from an implementation perspective, considerable flexibility is needed, and reasons to adjust the priorities will no doubt arise as part of implementation. Additional suggestions on the time frame and next steps are included in the more detailed recommendations in previous sections of the plan.

<u>Work has already begun:</u>
Transportation Recommendation #3: Improve Vanpool/Carpool Options
Transportation Recommendation #4: Further Promote Walking, Biking, Transit
Ecosystem Recommendation #3: Accelerate/Expand Organic Waste Collection/Composting
Ecosystem Recommendation #5: Improve Regulations and Community Capacity to Discourage Invasive Plants and Encourage Native Plants

<u>Begin immediately:</u>
Community Integration Recommendation #4: Integrate Climate Action with Local Living Economy
Buildings Recommendation #1: 50% Challenge
Transportation Recommendation #1: 50% Challenge
Ecosystem Recommendation #1: Pursue Stormwater Utility

<u>Begin Within 1 Year:</u>
Community Integration Recommendation #1: Create Grass Roots Partnerships to Engage Community
Community Integration Recommendation #2: Expand Public Partnerships to More Explicitly Consider Climate Action
Community Integration Recommendation #3: Create Green Neighborhood Program
Community Integration Recommendation #5: Expand Capacity
Community Integration Recommendation #6: Facilitate Low Cost Financing for Energy Efficiency and Renewable Energy Projects

Community Integration Recommendation #7: Integrate Climate Action and Social/Equity Initiatives
Buildings Recommendation #4 and Renewable Energy Recommendation #3: Create Rental Property Task Force and Process
Buildings Recommendation #5: Create Rental Property Registry/Certification
Transportation Recommendation #5: Limit Idling in School Loading Zones
Renewable Energy Recommendation #1: Pursue Community Solar Projects
Ecosystem Recommendation #2: Evaluate Extent to Which the Deer Population and Climate Change affect Native Plant Ecosystems
Ecosystem Recommendation #4: Create a Tree Coalition

Begin Within 2 years:
Transportation Recommendation #2: Enhance Transit Service
Renewable Energy Recommendation #2: Create a Downtown Geothermal District

Statutory Authority May Be Needed to Pursue Recommendation as a Requirement:
Buildings Recommendation #2: Require Energy Audit/Performance Rating
Buildings Recommendation #3: Demonstrate/Pursue Energy Performance Beyond Minimum Requirements for New Development
(For these two recommendations, a non-regulatory approach is also offered in the recommendation for which statutory authority is not needed.)

Appendix 1

Boulder's Local Climate Action Plan and Climate Commitment

The Task Force recommends that Carrboro pay close attention to Boulder, Colorado, a community that is leading the pack with local climate action planning in the US[37]. For example, Boulder is:

1) A leader in energy efficiency according to the American Council for an Energy Efficient Economy. Boulder has distinguished itself through:
   a. excelling in improving access to energy usage information;
   b. implementing the SmartRegs program, which mandates baseline energy efficiency requirements for rental housing;
   c. receiving the highest rating from ACEEE by having staff dedicated to implementing community-wide efficiency goals and implementing programs to mitigate the urban heat island effect, including instituting an Urban Forestry program.
   d. Piloting Community Power Partnership, a program designed to help residents and businesses better understand their electricity use at a whole-building and circuit levels.
   e. Piloting Boulder Energy Challenge, a grant program launched in 2014 that has provided $300,000 funding for innovative solutions from the community to reduce emissions.
   f. Running EnergySmart, a program that offers energy efficiency assessments, advising services and rebates for residents and businesses. Since EnergySmart began in 2010, more than 7,500 housing units and 2,300 businesses have participated in the program, more than $3.4 million in rebates have been paid and over $18 million in private investments made.
2) Working to become a zero waste community that reuses, recycles and composts at least 85 percent of its waste stream by the year 2025.
3) Becoming a Platinum Bicycle Friendly Community (one of 4 in the US).
4) Pursuing owning and operating a local electric utility, a process known as municipalization. For the city, it's an opportunity to move away from getting electricity from a for-profit investor-owned utility with a carbon-intensive coal-powered energy supply.
5) Becoming a platinum-level Solar Friendly Community in 2014, with one of the highest per-capita solar installations in the country. Since 2007, Boulder residents, businesses and institutions have installed more than 15 megawatts of solar on more than 1,900 rooftops.
6) Supporting climate action initiatives by the Climate Action Plan (CAP) tax (since 2007). The tax funds city-funded programs and services designed to reduce local greenhouse gas emissions.
7) Pursuing a GHG reduction goal of 80% by 2050, having already made substantial progress.

[37] More information about what Boulder is doing is available at https://bouldercolorado.gov/climate and https://bouldercolorado.gov/climate/boulders-climate-commitment .

Appendix 2

How the Jones Household Goes Carbon Free in 10 Years

In July 2008, Al Gore challenged the country to generate all our electricity carbon free in just 10 years. He believes it's possible, and so do we. We also think it's possible for individual families to go carbon free in 10 years.

How the Jones Household Goes Carbon Free in 10 Years

HERE'S HOW YOU CAN DO IT ...

yes! magazine

Reprinted from
Issue 45
Spring 2008
CLIMATE SOLUTIONS
yes! magazine
Related articles at
www.yesmagazine.org/climatesolutions

Beyond Lightbulbs

The Jones Household Goes Carbon Free in 10 Years

START HERE

YEAR 1

A Big Difference from Small Changes

The family starts off with easy changes: They wash clothes in cold water and air dry them in the summer, replace incandescent bulbs with compact fluorescents (CFLs), turn off their computer when not in use. That's an instant, virtually free savings of 6,200 pounds of CO_2. They make one simple transportation change: One of the adults commutes by bus three days a week—enough to see whether it can be done, but keeping the second car just in case. That's worth another 2,200 pounds. They're down to 51,600 pounds and it hasn't cost them anything but the price of the CFLs and a clothesline. They're actually saving money.

YEAR 2

Home Improvement

They stop donating so much heat to the outdoors: attic and basement insulation, sealing and insulating heat ducts, and patching the large air leaks typical of standard construction saves them a whopping 7,100 pounds. These savings aren't free up front, but the savings in heating and cooling bills will repay the cost over time. Besides, Mrs. Jones is handy with home repair, and does a lot of this work herself. Down to 44,500 per year.

YEAR 3

House and Car

The bus commute's gone well, so Mr. Jones now buses to work all the time. They've worked on consolidating trips outside work, and find they can do without the second car altogether. That's 5,900 pounds gone. They finish weatherproofing their house: beefing up wall insulation, weatherizing doors and windows, and upgrading to high performance windows. Another 1,800 pounds disappear. They're at 36,800.

YEAR 4

Shed Carbon on Vacation

Instead of flying for their annual vacation, the Joneses take the train: a leisurely way to save 7,200 pounds every year. (If they took the bus, they'd save even more.) They're at 29,600 pounds per year—halfway there a year early.

YEAR 5

Car Upgrade

Time to replace the car. Thanks to consumer demand, electric cars have become widely available, and they buy one. Even charging on dirty power, they save 9,000 pounds. Household total is now 20,600.

60,000 lbs − 8,400 lbs = 51,600 lbs → 51,600 lbs − 7,100 lbs = 44,500 lbs → 44,500 lbs − 7,700 lbs = 36,800 lbs → 36,800 lbs − 7,200 lbs = 29,600 lbs → 29,600 lbs − 9,000 lbs = 20,600 lbs →

Brooke Jarvis and Doug Pibel

Meet the Joneses. They're your average U.S. energy consumers. They haven't yet upgraded to energy-efficient appliances, their house needs better insulation, and they keep the place as cool in the summer and warm in the winter as most Americans do. The two adults commute 30 miles each per day, in separate cars with average fuel efficiency, and every year they each drive an additional 4,500 miles running errands and taking their child to soccer games and violin practice. The family takes one vacation trip per year, flying to visit grandparents 1,350 miles away. How much CO_2 do their house and cars produce? We figure it at 60,000 pounds, or 10 tons for each family member.

Lately, though, the Joneses have been reading about climate change, and they're getting worried. Ecological crisis has never felt so urgent before. Even little Joey Jones is talking greenhouse gases—he learned at school that scientists are predicting a worldwide climate catastrophe that will change the rest of his life, unless we stop the worst effects by making big changes in the next ten years. The Joneses decide: change is necessary, and they're ready to do their part. But how much can they really do? A lot, it turns out.

In 10 years, without sacrificing their way of life, the Jones family eliminates the CO_2 emissions that their home and transportation used to create—the bulk of their carbon footprint.

Count Your Carbon

Want to keep up with the Joneses? Here are the numbers we used. Use them to find—then shrink—your own carbon footprint.

	CO_2 output, in pounds
Gallon of gas	**19.36**
Gallon of fuel oil or diesel	**22.38**
Kilowatt hour of electricity (national average)	**1.43**
Therm of natural gas	**11.71**
Gallon of propane	**12.67**
Per passenger:	
Airplane mile	**1.28**
Train mile	**0.42**
Long-distance bus mile	**0.18**
Local mass transit mile	**0.50**
Electric bike mile	**0.02**

The Rest of the Story

The Joneses only changed their housing and transport habits. How can you go further?

Eat meatless. For every day of the week you skip meat, you'll save 215 lbs. per year.

Buy local. Most food eaten in the U.S. has traveled 1,500 miles to your plate.

Be a low-impact consumer. Choose local products, reduce the stuff you buy, and save embedded energy by buying used.

Reduce waste. Stop junk mail, reduce packaging, and reduce the 2,020 lbs. each American's waste produces annually.

Avoid the McMansion. A smaller house saves a lot of carbon: on average, 11.4 lbs. of CO_2 per square foot per year.

YEAR 6

Hot and Cold

They improve their water system, including insulating their hot water heater and their pipes, and also lower the temperature of their water heater: 1,000 pounds down. When the old refrigerator kicks the bucket, the Joneses buy a new energy-efficient one and finally unplug a second fridge in the garage, knocking off another 1,300. Total remaining: 18,300.

YEAR 7

Close to Home

Grandma and Grandpa retire and move nearby. The Joneses now vacation within the range of their electric car, saving 3,300 pounds of CO_2 each year. The city converts its bus fleet to clean electricity, which saves another 1,200 pounds. They're down to 13,800.

YEAR 8

A Few More Things Around the House

An efficient clothes washer saves carbon on its own, and saves dryer time. With all the money they're saving, they decide it's time to invest in a solar hot water system. Total: 2,000. Leaving 11,800.

YEAR 9

Electric Bikes

While the Joneses have been on this journey, their town has responded to citizen pressure and gone bike friendly. The new bike paths make it easy for both to ride to work. To ease the hills, they buy electric bikes. There are four months of the year when they can't bike, so they continue their usual commute patterns then. Savings: 3,500. Total remaining: 8,300.

YEAR 10

Green Power

The Joneses' furnace has been groaning and working overtime. They replace it with an electric heat pump, which also cools the house in summer. They also buy certified green, renewable power from their electric company, and the switch from coal plants eliminates the remaining 8,300 pounds of CO_2 produced by the electricity for their house and car.

20,600 lbs − 2,300 lbs = 18,300 lbs → 18,300 lbs − 4,500 lbs = 13,800 lbs → 13,800 lbs − 2,000 lbs = 11,800 lbs → 11,800 lbs − 3,500 lbs = 8,300 lbs → 8,300 lbs − 8,300 lbs = 0 lbs

Sources: Rocky Mountain Institute, Bureau of Transportation Statistics, Environmental Protection Agency, Department of Energy, University of Chicago.
Illustration by Kayann Legg / I-S

Appendix 3

10 Things You Want to Know about Human Nature if you're Fighting Climate Change

By Lisa Bennett, posted at http://grist.org/climate-energy/10-things-you-want-to-know-about-human-nature-if-youre-fighting-climate-change/ June 10, 2015.

I've spent nearly a decade thinking about why people get stuck on climate change: stuck in debates, denial, what looks like indifference, and the awful discomfort that comes with the question "But what can I do?" In search of answers, I've interviewed dozens of experts in psychology, neuroscience, sociology, economics, political science, and other fields — and many more Americans across a broad spectrum of political affiliations, income brackets, and ages. I've also read widely to tap the thinking of those who were once more commonly looked to for insights into human nature, such as poets, philosophers, and spiritual leaders. What I've come up with is my own climate-centric version of Robert Fulghum's *All I Really Need to Know I Learned in Kindergarten.* Climate change has been my window into learning about human nature — or, at least, about what we humans do when faced with a challenge much greater than ourselves. The experience has also persuaded me that a better understanding of our own nature can help inspire a more effective response to what is happening to the natural world.

Here then are 10 things I've learned, along with some ideas about how these insights might be applied by those working on climate change:

1. We are overly optimistic about the future — *our* future, that is. Neuroscientist Tali Sharot has observed that when newlyweds are asked about their chances of getting divorced, they tend to say zero, despite the widely known fact that the odds are 50-50. We instinctively overestimate the probability of positive events and underestimate the probability of negative events in our own lives, she writes in *The Optimism Bias*, for two reasons: We think we have more control over our lives than we actually do, and we tend to see ourselves as better than average.

Applied to climate change, this means that I might think that you — and surely those poor Pacific Islanders — might be negatively affected but I'll be OK. The problem, of course, is that this reflects a bias grounded in delusion. But don't try to tell me or anyone else that. You'll have a better chance of engaging others in climate action, experts like Sharot say, if you keep a laser-like focus on how climate change is affecting people now.

2. We can be blasé about the most important issues in the world because the global perspective is way beyond ordinary human scale. "Trying to convince people of the magnitude of the climate problem through large-scale statistics is essentially useless," says Scott Huettel, chair of the Department of Psychology and Neuroscience at Duke University. "The iconic global warming image of the polar bear on the iceberg is evocative precisely because it is one polar bear. Thousands of polar bears on a glacier that is receding would be irrelevant. Our brains cannot process it."

Put another way, climate change seems like an abstraction because it is so much bigger than us. Humans relate to human-sized stories — the kind that speak to a family living in a home like ours, having dreams and struggles like ours, and maybe discovering one day that their home is on a map of places expected to soon be under water.

3. We are wired to refute imperatives. "If you say I have to act now on climate change, my first reaction will be, 'No, I don't,'" says Huettel. The reason, he explains, is that our brains are very well designed to come up with counterarguments. So no matter how good the reasons to switch to solar energy or demand that government take bolder action on climate change, people can always come up with reasons why they don't need to do anything, such as: "If I don't act right now, the world will basically be the same."

Passing a law that requires people to change their behavior (especially if those changes are relatively easy to make) is one effective way around this. But short of that — just as in other aspects of human relationships — efforts to attract people to a cause are much more likely to yield a positive response than those that threaten or make demands.

4. We are vulnerable to peer pressure, especially about things that confuse us. We can watch the news, see photos of melting glaciers, even experience changing weather patterns. But if our neighbors aren't doing anything about climate change, we're unlikely to do anything either because, as much as we hate to admit it, we are herd animals who use social cues to adapt to our environment, according to Robert Cialdini, author of *Influence*: *The Psychology of Persuasion.* And if you doubt how powerful this instinct is, consider the experiment Cialdini conducted in which his team hung four different kinds of flyers on people's doorknobs in San Diego, with the goal of inspiring residents to reduce their energy consumption. Three of the flyers directly asked them to reduce their energy use, offering three different motivations: save money, save the environment, and benefit future generations. But none of these appeals made a significant difference. Only the fourth flyer did, which read simply: "The majority of your neighbors are undertaking energy-saving actions every day." The lesson: Don't be afraid to appeal to our instinct to fit in.

5. We shy away from topics that remind us of our mortality but can be motivated to take action on behalf of beings more vulnerable than us. Janis L. Dickinson, a professor of natural resources at Cornell University, conducted an experiment a few years ago in which she asked 3,546 people (largely birders) if they would be willing to reduce their energy consumption after learning that climate change was, among other things, a threat to people or to birds, and then she compared the results. It turned out that people were left unmoved by considering the threat to humans, but envisioning the threat to birds was another story. One possible reason, Dickinson says, is that considering climate change as a threat to humans may trigger thoughts of death (which we also tend to deny) whereas we like to think of ourselves as helping cute little creatures that seem to need us. This suggests that emphasizing the threat climate change poses to beloved animals could be an effective way of motivating people.

6. We perceive and respond to risks only when we feel them. While riding a roller coaster with my children one day, my youngest son took his hands off the bar and raised them in the air. The amusement park, I was sure, anticipated antics like this and did not expect people to remain in their seats by the strength of their grip. Still, I screamed, insisting he hold on because I was scared and, for the moment,

that made the risk I imagined feel real. This, says Columbia University professor of psychology Elke Weber, is how we perceive and respond to risk: through our emotions more than an analysis of the facts.

When it comes to climate change, this means that no matter how much scientific and journalistic evidence we are presented with, we will not be moved to action unless something makes us feel the risk. As a result, it may be more effective to tell a short, detailed story that can evoke people's feelings — for example, about an individual or family encountering some specific impact of climate change — than present yet more scientific evidence about the global or even national implications of a warming planet.

7. We are motivated more by hope than fear, at least in matters of social change. While research shows that fear is a more powerful motivator than hope when it comes to behaviors such as diet and fitness, inspiring social change seems to depend more on a positive vision of the future, according to the social movement, political science, and neuroscience experts with whom I spoke. "This rhetoric about we only have a certain amount of time is a killer. It doesn't make people engaged, it makes them give up," says David Meyer, professor of sociology at U.C. Irvine and author of *The Politics of Protest: Social Movements in America*. Sharot confirmed this, saying: "Our studies show that people don't process information — they don't pay attention — when what is being communicated is how things will get worse." In a widely shared opinion, Meyer said the implication was clear: "You have to be hopeful."

8. We are more likely to take action when we know precisely what we can influence. It would take a fantastic and deluded leap of the imagination to think that, as individuals, we can control rising seas, melting glaciers, or heat waves. As a result, when people hear messages that encourage them to broadly act on climate, it can strike them as unrealistic and trigger what psychologist Martin Seligman called learned helplessness — specifically because it appears so far outside their sphere of influence. But, as Seligman and others have also found, it is possible to cut through learned helplessness (or apparent indifference) by appealing to what people think they can control, such as their own attitudes and behavior. For this reason, Huettel recommends emphasizing how people will feel about themselves, for example, after they take some realistic action, such as riding a bike or buying a hybrid.

9. We need to believe our actions will make a difference. "We have to have some sense of efficacy to motivate us to make changes in our lifestyle that are beneficial to the planet," says Paul Slovic, a professor of psychology at the University of Oregon and expert in decision making around risk. But when it comes to big issues like genocide or climate change, his research suggests that people can be demotivated by a sense of inefficacy as well as what he calls "pseudo-inefficacy" or the illusion of inefficacy. For example, Slovic explained, some people fail to do anything because they think their action will be just a drop in the bucket, even though that drop is important. This finding suggests that it could be useful to explicitly speak to people's suspicion that individual actions don't matter and creatively show them how such drops add up.

10. We will continue to behave the same way we always have — even after we know it is problematic — until there is a realistic alternative. It is a safe bet that if you are reading this, you know that fossil fuels contribute to climate change and yet you continue, either directly or indirectly, to rely upon them, as most of us do.

But the reason for this, I have firmly come to believe, is not because most people don't care, don't get it, or have been duped by climate denial propaganda. I find a more believable reason in the words of Thomas Kuhn, widely considered one of the most influential philosophers of science of the 20th century. "People are unlikely to jettison an unworkable paradigm, despite many indications it is not functioning properly," Kuhn said, "until a better paradigm can be presented." While individual behavior changes are essential, in other words, many of them remain dependent on systemic public- and private-sector changes. To fully succeed, we need a "moon shot"-style rapid transition to a clean energy economy, like the one proposed by a group of scientists and economists led by the U.K.'s former chief scientist, Sir David King.

But in the end, even the best of plans depends on understanding, communicating, and acting with a fuller appreciation not just of the state of the natural world but of our own nature, which means bringing today's global climate story down to a human scale. The good news is that doing so requires that we engage some of the best aspects of human nature, including our ability to be present in the here and now, to care more about people than facts, to be drawn to hope more than fear, to be willing to defend those weaker than us, and to focus our actions on things that are in our control — all the while being capable of believing in, even being thrilled by, the vision of a moon shot.

Lisa Bennett, coauthor of Ecoliterate*, is a writer and communications strategist focused on climate change and what helps people rise to challenges great and small. She blogs at lisabennett.org/blog, and is on Twitter at @LisaPBennett.*

Appendix 4

Energy in the 21st Century: Excerpts from Post Carbon Institute's Energy Primer[38]

We are now facing a transformational moment in our energy story. As we leave the age of seemingly cheap and plentiful fossil fuels and enter an era of extreme energy, the ever-rising financial, social, and environmental costs of fossil fuels can no longer be ignored. The essential problem is not just that we are tapping the wrong energy sources (though we are), or that we are wasteful and inefficient (though we are), but that we are overpowered, and we are overpowering nature.

– Richard Heinberg, from the Introduction to ENERGY: Overdevelopment and the Delusion of Endless Growth

The Energy Picture

In order to make the right choices and investments, we must have a more comprehensive understanding of our energy predicament, including:

- The true costs, potential benefits, and limitations of all energy options, including renewables;
- The impact of each form of energy production on human societies and nature; and
- The true relationship between energy, our economic system, and the environment.

It's tempting to take the micro-view and look for ways to target each of our energy problems with a technical fix. Can't we improve the energy efficiency of vehicles, insulate our buildings, and develop renewable energy sources? Yes, of course. Can't we regulate the fossil fuel industry better, and allow the vast, recently unlocked North American reserves of shale gas and shale oil to be produced responsibly? Possibly. We could do all of those things, and many more besides, to lessen the current energy economy's impacts on natural and human communities—and still there would remain serious obstacles ahead. Why? Let's move out from the details of our dilemma and take in the big picture.

What is Energy?

Though we cannot hold a jar of pure energy in our hands or describe its shape or color, it is nevertheless the basis of everything. Without energy, nothing could happen; matter itself could not exist in any meaningful sense. But because energy as such is so elusive, physicists and engineers define it not in terms of what it is, but what it does—as "the ability to do work," or "the capacity to move or change matter."

[38] http://energy-reality.org/primer/

In traditional societies, most useful energy came from the sunlight annually captured by food crops and forests; people exerted energy through muscle power and obtained heat from firewood. Modern industrial societies obtain enormously greater amounts of energy from fossil fuels, nuclear power, and hydroelectric dams, and they exert energy through a vast array of machinery. Industrial energy production is essential to every aspect of modern life, but no matter how far our technology for capturing or using energy advances, energy itself always remains the same.

In the nineteenth century, physicists formulated two fundamental laws of energy that appear to be true for all times and places. These are known as the First and Second Laws of Thermodynamics. The First Law is known as the law of conservation. It states that energy cannot be created or destroyed, only transformed. Think of energy as a singular reality that manifests itself in various forms—nuclear, mechanical, chemical, thermal, electromagnetic, and gravitational—and that can be converted from one form to another.

The Second Law states that in every energy conversion, some energy is dissipated (typically as heat). When the gas gauge in a car moves from "full" to "empty," it may appear that the energy that is chemically stored in gasoline is being consumed. But all the energy that was originally present in the gasoline still exists. In reality, the stored energy is merely being released and doing some work as it moves from a condition of higher concentration to one of lower concentration. It is converted from chemical storage (via the atomic electromagnetic bonds within hydrocarbon molecules) to mechanical motion and heat (as combustion within the engine's cylinders pushes the car forward and also increases the rate of motion of molecules in the cylinder and the surrounding environment).

We might be able to get some work out of the "wasted" heat being given off by the burning of gasoline in the car engine; but heat tends to radiate quickly into the general environment, so we would have to use that heat both immediately and close to the engine. If we could gather up all the heat and mechanical energy that was released by burning the tankful of gasoline, it could do just as much work for us yet again; but the act of re-concentrating and storing it would require more energy than we could regather. Thus, in effect, available energy is always being lost.

The Second Law is known as the law of entropy (entropy is a measure of the amount of energy no longer practically capable of conversion into work). The Second Law tells us that the entropy within an isolated system inevitably increases over time. Energy that is sufficiently concentrated (relative to background energy levels) so that it can do work for us is called a source. There are two kinds of energy sources: flows (examples include sunlight, winds, and rivers) and stocks (a word that in this context refers to energy chemically stored in substances such as wood or fossil fuels). Flows tend to be variable, whereas stocks deplete.

Energy-fueled Population Growth

Humanity's current population explosion is an aberration. During the vast majority of human history, population levels were low and quite stable. Demographer Joel Cohen estimates that from the time our species emerged until roughly twelve thousand years ago, when local agriculture appeared, the

population growth rate was less than 1/500th of 1 percent. After the widespread adoption of farming the growth rate ticked up by a factor of ten or more, but for thousands of years thereafter remained at around 1/50th of 1 percent. It took all of human history until the early eighteen hundreds for global population to reach one billion. Then the population doubled—a second billon was added—in just a century or so. Adding the next billion humans to the planet took only thirty years. The next billion, fourteen years. The next, twelve years. After another dozen years, in 1999, world population reached six billion, and the seven billion mark was passed in 2011.

When charted graphically, the human demographic explosion takes the familiar "hockey stick" shape of a classic exponential growth curve. Many factors contributed to demographic expansion, including: the global agricultural revolution in the sixteen hundreds when new foods were shared between continents; the dispersal of scientific and public health knowledge; and increasing urbanization. But central to the runaway population growth of the past two centuries is the incredible windfall of energy that fossil fuels presented to humanity. The ability to command energy, especially highly energy-dense fuels like coal, precipitated the Industrial Revolution and allowed its descendant, the techno-industrial growth culture, to flourish. Food could now be produced in far larger quantities, and local scarcity could be overcome through global transport networks.

Leading ecologists agree that humanity has already surpassed Earth's ecological carrying capacity. Exploiting the onetime reserve of fossil energy has allowed us to temporarily escape the constraints that kept early human population levels in check. Today's global extinction crisis, massive poverty and malnutrition, rising social inequity, and unraveling ecosystems around the globe suggest that the age of abundance is nearly over. As economist Lisi Krall tells her students, "The defining fact of this historical moment is the reality of exponential growth. With exponential growth, if you do the same things as your parents, you'll get entirely different results." Confronting the population problem is the preeminent challenge of our time.

Net Energy

A business may have high gross receipts and still go broke; it is the net, the profit after costs are subtracted, that determines viability. For any potential energy resource, the fundamentals are the same. How much energy is available after subtracting the energy costs to extract, process, and deliver the resource? To know how much energy from a particular source can actually be deployed by society, we must factor in both the production costs and the system costs—that is, the energy required to make energy available to the end user. With gasoline, for instance, this calculation would include energy costs related to oil exploration, drilling, refining, transportation, and the infrastructure that supports each step of the process. With coal-derived electricity, the calculation would include the life cycle from mine to power plant to electric grid.

Experts who study this use the terms "net energy ratio" or "energy returned on energy invested" (EROEI). Decades ago when the most accessible reserves were drilled, an oil company might produce 100 barrels of oil or more for each barrel's worth of energy invested. Declining oil field productivity has

brought the average net energy ratio for conventional oil down to approximately 20:1 globally, with more remote or hard-to-refine oil significantly worse. For fossil energy generally, the trend is downward despite technological advances in exploration and drilling. For biofuels, the net energy ratio is lower still. Some studies suggest that corn-derived ethanol actually has a negative net energy ratio—that is, more energy than a gallon of ethanol can deliver is used to produce a gallon of ethanol. Sugarcane-based ethanol has a superior net energy ratio, but it is still low compared to fossil fuels.

Any produced energy resource can be analyzed for its net energy ratio, although the process raises a difficult question: What are the boundaries of consideration? For example, when tallying the energy required to build a solar photovoltaic panel, what should be included in the accounting? The energy needed to mine the bauxite for the aluminum frame? The energy needed to manufacture the heavy equipment that did the mining? The energy needed to construct the factory that produced the panel? Where the boundaries are drawn affects the final net energy ratios.

A society that depends on inexpensive energy to maintain a high standard of living and constant growth faces a predicament—it cannot maintain itself over the long run without high net energy fuels. Oil, natural gas, and coal have provided a huge, high-quality energy subsidy to the modern world. That subsidy, which has enabled human population and wealth to grow exponentially, is based on finite resources and cannot continue indefinitely. Renewable energy sources, excluding hydropower, are generally more diffuse and have lower net energy ratios than fossil fuels. If high net energy sources are in decline, and no reasonable replacements are available, the result may be a painful restructuring as society rearranges economic activity to fit a diminishing energy supply.

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Energy-fueled Economic Growth

World economic activity has historically grown slowly. From the Middle Ages to until the early eighteen hundreds, average per capita income rose only about 50 percent. But since the advent of the Industrial Revolution the pace has picked up, with global per capita income rising more than eightfold in just the last two hundred years.

Energy consumption has also risen dramatically, from under 20 gigajoules (GJ)[39] per person per year in the pre-industrial era to over 75 GJ per person today (and more than 300 GJ per person in the United

[39] One joule is defined as the work required to produce one watt of power for one second. A gigajoule is a billion joules

States). During this period, energy consumption and economic activity have stoked each other in a self-reinforcing feedback loop. Once the fossil fuel tap was opened for the modern world in eighteenth-century Britain, the high-energy content of coal (and, later, oil) enabled unprecedented productivity—spurring more consumption, more demand for energy, and better technology to get at yet more fossil fuels.

Despite the clear link between energy and economic growth, economists have interpreted and normalized growth as resulting from factors such as "market efficiency" and "labor productivity," which (it is assumed) can be counted upon to produce more and more growth, ad infinitum. Policy makers have therefore built dependence on growth into the design of our economic system. Investors demand constant growth and high rates of return. Future growth is assumed to wipe away the debts taken on today by governments, businesses, and households. Most Americans are even betting their retirement savings, sitting in mutual funds on Wall Street, on continued growth.

As the global bonanza of cheap fossil fuels winds down, what will happen to economic growth? Certainly it's possible to get more benefit per joule through smarter use of energy, but using energy efficiency to "decouple" economic growth from energy consumption can only go so far. After the easy efficiencies are found, further efficiency measures often require greater cost for less benefit; and while greater efficiency may reduce costs at first, it can have the effect of spurring yet more consumption.

It's intuitively clear that it takes energy to do things, and modern civilization has exploited high-energy-content fossil fuels to dramatically reshape the living conditions and experiences of billions of people. (Altering the climate and destroying natural ecosystems around the globe were unintended consequences.) In the future, humanity will need to cope with both more expensive energy and less energy available per capita. Maintaining an acceptable level of productivity—let alone growth—may constitute one of society's foremost social, political, technical, and economic challenges.

Energy Density

Different fuels contain more or less potential energy per unit of weight or volume, and even within fuel types, such as wood or coal, the heat value varies. Anthracite packs more energy than bituminous coal, and putting oak rather than pine in the woodstove before bedtime makes a big difference in how warm the house will feel on a winter morning. The fossil fuel age has been such a bonanza because oil and coal are extremely energy-dense fuels. They have benefited from the long work of geological processes to concentrate the carbon molecules from ancient plant and animal matter.

On average, coal has approximately twice the energy density of wood. Liquid fuels refined from petroleum including gasoline, kerosene, diesel, and heating oil all contain more than three times the energy value of wood. It is no accident that when human societies have had the opportunity to transition from locally harvested biomass to concentrated fossil energy fuels, they have chosen to do so.

The miraculous quality of fossil fuel energy density is easy to understand if one imagines trying to push an automobile for twenty miles. Given enough time, and some help from athletic friends, it would be

possible to push a 3,000-pound car that distance. But it would require a tremendous amount of effort. And yet a mere gallon of gasoline (which, despite recent price increases, still costs far less in the United States than an equivalent amount of good coffee) can easily power a car that far in the time it takes to drink a mocha latte. The fact that renewable energy is, in general, more diffuse than fossil fuel presents the primary challenge to transitioning from the current energy economy to a renewables-powered future.

Peak Oil and Resource Depletion

Every individual gas or oil well, every oil field, and every oil-producing country experiences a similar lifecycle. After a well is drilled, extraction ramps up to its maximum sustained output and eventually begins to decline as the reservoir is depleted. Then we search for the next well, which is generally a little harder to find, a little more expensive to produce. The price of any fossil energy determines what reserves are economically recoverable, and technological innovations can temporarily reverse the decline or extend well life. But as with any finite, nonrenewable resource—coal, natural gas, uranium, etc.—depletion is inevitable at some point.

In recent years, a large body of literature has begun exploring the many ramifications of "peak oil"—the moment when aggregate global oil production reaches its apex. The late American geologist M. King Hubbert predicted in the mid-1950s that U.S. oil production would reach the top of its production curve around 1970 and then begin to decline. That assessment was remarkably prescient: America's production of crude did peak in 1970 and has been generally declining since, despite the addition of new sources on the Alaska North Slope and in the Gulf of Mexico. The United States, the first great power of the oil age, was also the first nation to explore, exploit, and begin to deplete its conventional oil reserves.

Oil of course is a global commodity. From a global perspective, reaching Hubbert's peak means that roughly half of the world's total oil resources are still in the ground, waiting to be tapped. Practically, however, the second half of the global oil resource is more difficult to access, making it less profitable (in terms of net energy) and more environmentally destructive than the earlier-exploited reserves.

The exact timing of the global oil production peak will only be recognizable in hindsight. Some energy experts predict that the peak will occur sometime during the first two decades of the twenty-first century. Others project continued growth in oil extraction through 2050. Based on data published by the International Energy Agency, global conventional oil production has been essentially flat since 2004, despite record-high prices, and likely peaked in 2006. Increased production of unconventional oil (deepwater oil, tar sands, oil shale, and shale oil) is officially projected to help meet growth in demand in the near future, but some energy experts insist that new production from these sources will be unable to make up for accelerating declines in production from conventional oil fields. Whether peak oil has occurred, is imminent, or remains years or decades off makes little difference to the salient fact: the era of abundant, inexpensive oil is closing, and all the systems for modern life designed around that earlier reality are bound to be affected.

Embodied Energy

Every material artifact—a carrot bought at the grocery store, the cooler where it was displayed, the supermarket building, the car driven there, and the road network it travels—requires a certain amount of energy in its manufacture, maintenance, and eventual disposal. The methods used to analyze the total embodied energy of manufactured objects vary, but in general, studies over the decades have used life-cycle analysis to quantify embodied energy in computers, household appliances, automobiles, and other common products.

The embodied energy in our physical infrastructure—from water mains and buildings to superhighways and airports—is immense, and thus infrastructure is one of the most important areas where energy use (and associated greenhouse gas pollution) could be reduced. In addition to building smaller, or building less, we can also build differently. Wood, for example, has the lowest embodied energy of common building materials; plastic has approximately six times as much embodied energy by weight, glass 16 times as much, steel 24 times as much, and aluminum a whopping 126 times as much embodied energy as wood. Erecting the scaffolding of civilization took a great deal of energy, and maintaining and expanding it takes more all the time. This vast amount of embodied energy, along with psychological and financial investments in the current energy distribution system, is a key obstacle to fundamental changes in that system.

Another useful metaphor that communicates the idea of embodied energy across a product's life cycle is the "energy train." Take for example that ubiquitous artifact of modern civilization, the mobile phone. To its owner, a cell phone is simply a handy gadget that offers convenience and a feeling of connection. But the phone does not exist in isolation—it isn't a single locomotive chugging down the tracks; rather, it pulls a train of cars behind it, all of which have ecological and energetic costs. Those metaphorical railroad cars are filled with packaging to ship the phone; an advertising industry to inculcate desire for it; a retail store to sell it; a communications network that allows it to function; an assembly plant to build it; factories to manufacture plastic cases and computer chips and other components; mines where copper, silver, and rare earth elements are dug from the ground; the transportation infrastructure to move raw materials; and of course the energy system (oil wells, coal mines, power plants, hydroelectric dams, etc.) that support the entire operation. It is a very long train, and every car being pulled along must be in place for even one mobile phone to make its first call.

Energy Sprawl

The foremost criterion by which to judge any existing or potential energy source is its systemic ecological impact. A key subset of this analysis is its physical footprint. The useful term "energy sprawl" refers to the ever-increasing area—on land and offshore—that is devoted to energy production. Quantifying the area affected by different energy sources raises challenging methodological questions. It's obvious, for instance, to take into account the drilling pad when considering the energy sprawl impact of oil and gas development. But one should also include the land affected by pipelines, access roads, refining facilities, and other related infrastructure in the calculation. Nuclear power plants occupy

a small area relative to their electrical generation output, the smallest physical footprint of any major energy source. That energy sprawl impact grows considerably, however, when one factors in uranium prospecting, mining, processing, nuclear waste disposal, and any new power lines needed for an expanded nuclear industry. Moreover, as past accidents have demonstrated, when nuclear power plants fail, a large area can be contaminated.

Because of their high energy densities, coal, oil, and natural gas have a medium-size footprint if judged on an energy-output-per-acre ratio; but in practice these extractive industries affect a huge and growing area because they dominate energy production, and because of the enormous quantities of energy being consumed. Oil shale development in the American West is a potential area of fossil fuel exploitation that would create massive energy sprawl. Renewables, which harness the diffuse energy sources of wind and solar power, can have a large physical footprint relative to energy produced; they constitute such a small part of the current energy mix in North America that their aggregate energy sprawl impact at present is modest but growing. Because wind turbines require minimum spacing distances to maximize wind energy capture, the physical footprint of wind power is extensive but can be mitigated, whereas decapitated mountains in Appalachia sacrificed for surface coal mining will never grow back. Siting wind turbines in existing agricultural landscapes need not fragment any additional wildlife habitat. Putting solar arrays on rooftops, parking lots, and urban brownfields need not contribute to energy sprawl at all while generating significant energy close to where it is needed, eliminating the sprawl precipitated by new transmission lines.

Devoting land to growing feedstock for liquid biofuels, or growing biomass for generating electricity, augurs the greatest potential energy sprawl of the major energy alternatives under discussion. The energy density of these fuels is low and the amount of land that must be effectively industrialized, even for relatively small quantities of biofuels or biomass-derived electricity, is massive. In the end, the most effective strategy for fighting energy sprawl is to reduce energy consumption.

Energy Slaves

During the vast majority of our species' history, work was done by human muscles (sometimes the muscles of human beings enslaved by others). After people learned to domesticate wild creatures, beasts of burden such as oxen and horses added to our ability to harness the Sun's energy—captured by plants and channeled into the muscles of work animals. (This relationship between domestic animals and the machines we use today is enshrined in the "horsepower" rating of modern engines.) More recently, people began using wind and waterpower to amplify human labor. But with the dawn of the fossil fuel age, the average person was able to command amounts of energy previously available only to kings and commanders of armies.

Where people or work animals formerly toiled in the fields, the petroleum-powered machines of industrial agriculture now do the work of growing food. Need to be on the other side of the planet tomorrow? Jet travel can get you there. Want to sit in the sunshine, gamble, and overeat with a few thousand strangers in a gigantic floating hotel? The cruise "industry" can make your dreams come true.

Energy-dense fossil fuels make the seemingly impossible or ridiculously extravagant whims of people a reality.

In effect, the modern energy economy provides power equivalent to that of vast numbers of human or animal servants. That is the idea behind the concept of "energy slaves." Although top athletes can do far better, a typical adult male at sustained labor is estimated to produce 75 to 100 watts of power. Calculate the total energy use of an average American and it seems that there are the energetic equivalent of more than 100 energy slaves working around the clock to prop up the easy lifestyle offered by modern civilization.

Energy Future: A Positive Vision

Everyone engaged in combating human-caused climate change or specific elements of the current energy economy knows that the work is primarily oppositional. It could hardly be otherwise; for citizens who care about ecological integrity, a sustainable economy, and the health of nature and people, there is plenty to oppose—burgeoning biomass logging, mountaintop-removal coal mining, inadequately regulated natural gas and oil drilling, poorly sited solar and wind developments, river-killing megadams, and new nuclear and coal plants around the globe. These and many other fights against destructive energy projects are crucial, but they can be draining and tend to focus the conversation in negative terms. Sometimes it's useful to reframe the discourse about ecological limits and economic restructuring in positive terms, that is, in terms of what we're for. The following list is not comprehensive, but beauty and biodiversity are fundamentals that the energy economy must not diminish. And energy literacy, conservation, relocalization of economic systems, and family planning are necessary tools to achieve our vision of a day when resilient human communities are embedded in healthy ecosystems and all members of the land community have space enough to flourish. In short, what we're for is leaving behind the current energy economy, which is wasteful, polluting, and centralized; assumes perpetual growth; and is anchored by nonrenewable fuels. We envision a bold leap toward a future energy economy that fosters beauty and health; that is resilient because it emphasizes renewable, community-scale energy generation; that supports durable economies, not growth; and that is informed by nature's wisdom. Recognizing that all human economic activity is a subset of nature's economy and must not degrade its vitality is the starting point for systemic transformation of the energy system. While such a transition may seem daunting, reforms may be implemented incrementally, and the destination offers exciting possibilities for building vibrant human communities embedded in healthy ecosystems.

Energy Literacy

Energy is arguably the most decisive factor in both ecosystems and human economies. It is the fulcrum of history, the enabler of all that we do. Yet few people have more than the sketchiest understanding of how energy makes the world go around. Basic energy literacy consists of a familiarity with the laws of thermodynamics, and with the concepts of energy density and net energy (also known as energy return on energy invested, or EROEI). It requires a familiarity with the costs and benefits of our various energy sources—including oil, coal, gas, nuclear, wind, and solar. It also implies numeracy—the ability to

meaningfully compare numbers referring to quantities of energy and rates of use, so as to be able to evaluate matters of scale. Without energy literacy, citizens and policy makers are at the mercy of interest groups wanting to sell us their vision and products for the future energy economy. We hear from the fossil fuel industry, for example, that Canada's oil reserves (in the form of "tar sands") are second only to Saudi Arabia's, or that the United States has over one hundred years of natural gas thanks to newly tapped "shale gas" resources. And it's tempting to conclude (as many people do) that there are no real constraints to national fossil fuel supplies other than environmental regulations preventing the exploitation of our immense natural treasures. On the other end of the spectrum, we hear from technooptimists that, with the right mix of innovative energy generation and efficiency technologies, we can run the growth economy on wind, solar, hydropower, and biofuels. And it's tempting to conclude that we only need better government incentives and targeted regulatory reform to open the floodgates to a "green" high-tech sustainable future. Energy literacy arms us with the intellectual tools to ask the right questions: What is the energy density of these new fossil fuel resources? How much energy will have to be invested to produce each energy unit of synthetic crude oil from oil shale, or electricity from thin-film solar panels? How quickly can these energy sources be brought online, and at what rate can they realistically deliver energy to consumers? When we do ask such questions, the situation suddenly looks very different. We realize that the "new" fossil fuels are actually third-rate energy sources that require immense and risky investments and may never be produced at a significant scale. We find that renewable energy technologies face their own serious constraints in energy and material needs, and that transitioning to a majority-renewable energy economy would require a phenomenal retooling of our energy and transportation infrastructure. With energy literacy, citizens and policy makers have a basis for sound decisions. Householders can measure how much energy they use and strategize to obtain the most useful services from the smallest energy input. Cities, states, and nations can invest wisely in infrastructure to both produce and use energy with greatest efficiency and with minimal damage to the natural world. With energy literacy, we can undertake a serious, clear-eyed societal conversation about the policies and actions needed to reshape our energy system.

Conservation

The current energy economy is toxic not simply because of its dependence on climate-altering fossil fuels, but also because of its massive scale and wastefulness. A first step toward reducing its global impacts is simply using less energy, a goal readily accomplished through conservation practices that are widely available and cost-effective. Energy conservation consists of two distinct strategies: efficiency and curtailment. Energy efficiency means using less energy to produce a similar or better service. For example, we can exchange old incandescent lightbulbs for compact fluorescents or LEDs that use a fraction of the electricity and still enjoy satisfactory levels of indoor illumination. Curtailment means exactly what you'd think: cutting out a use of energy altogether. In our previous example of indoor lighting, this strategy might take the form of turning off the lights when we leave a room. Efficiency is typically more attractive to people because it doesn't require them to change their behavior. We want services that energy provides us, not energy per se, and if we can still have all the services we want,

then who cares if we're using less energy to get them? Much has been achieved with energy efficiency efforts over recent decades, but much more remains to be done: Nearly all existing buildings need to be better insulated, and most electric power plants are operating at comparatively dismal efficiencies, to mention just two examples. Unfortunately, increasing investments in energy efficiency typically yield diminishing returns. Initial improvements tend to be easy and cheap; later ones are more costly. Sometimes the energy costs of retooling or replacing equipment and infrastructure wipe out gains from efficiency. Nevertheless, the early steps toward efficiency are almost always rewarding. While curtailment of energy use is a less inviting idea, it offers clearer savings. By simply driving fewer miles we unequivocally save energy, whether our car is a more or less efficient model. We've gotten used to using electricity and fuels to do many things that can be done well enough with muscle power, or that don't need doing at all. Conservation helps us appreciate the energy we use. It fosters respect for resources, and for the energy and labor that are embodied in manufactured products. It reduces damage to already stressed ecosystems and helps us focus our attention on dimensions of life other than sheer consumption. During the latter decades of the twentieth century, most Americans achieved a standard of living that was lavish from both historical and cross-cultural perspectives. They were coaxed and cajoled from cradle to grave by advertising to consume as much as possible. Simply by reversing the message of this incessant propaganda, people might be persuaded to make do with less—as occurred during World War II—and be happier as well. Many social scientists claim that our consumptive lifestyle damages communities, families, and individual self-esteem. A national or global ethic of conservation could even be socially therapeutic.

Resilience

Resilience is "the capacity of a system to withstand disturbance while still retaining its fundamental structure, function, and internal feedbacks." Resilience contrasts with brittleness—the tendency to shatter and lose functionality when impacted or perturbed. Ecologists who study resilience in natural systems have noted that ecosystems tend to progress through a series of phases: growth, consolidation and conservation, release (or "collapse"), and reorganization. Each turning of this adaptive cycle provides opportunities for individual species and whole systems to innovate in response to external and internal change (i.e., disturbance). Resilient ecosystems (in the early growth phase) are characterized by species diversity; many of the organisms within such systems are flexible generalists, and the system as a whole contains multiple redundancies. In contrast, less resilient ecosystems tend to be more brittle, showing less diversity and greater specialization particularly in the consolidation phase. Resilience can be applied to human systems as well. Our economic systems, in particular, often face a trade-off between resilience and efficiency. Economic efficiency implies specialization and the elimination of both inventories and redundancy (which typically guarantee greater resilience). If a product can be made most cheaply in one region or nation, manufacturing is concentrated there, reducing costs to both producers and consumers. However, if that nation were to suddenly find it impossible to make or ship the product, that product would become unavailable everywhere. Maintaining dispersed production and local inventories promotes availability under crisis conditions, though at the sacrifice of economic efficiency (and profits) in "normal" times. From a resilience perspective one of the most vulnerable

human systems today is the American transportation system. For over seventy years we've spent trillions of dollars building transportation infrastructure that is completely dependent (i.e., "specialized") on affordable petroleum fuels, and we've removed or neglected most alternative methods of transport. As petroleum fuels become less affordable, the effects reverberate throughout the system. Resilience becomes more of a priority during periods of crisis and volatility, such as the world is experiencing today. Households, towns, and regions are better prepared to endure a natural disaster such as a flood or earthquake if they have stores of food and water on hand and if their members have a range of practical self-sufficiency skills. While the loss of economic efficiency implies trade-offs, resilience brings incidental benefits. With increased local self-sufficiency comes a shared sense of confidence in the community's ability to adapt and endure. For the foreseeable future, as global energy, finance, and transport systems become less reliable, the rebalancing of community priorities should generally weigh in favor of resilience.

Eco-Localism

A central strategy needed to increase societal resilience is localization—or, perhaps more accurately, relocalization. Most pre-industrial human societies produced basic necessities locally. Trade typically centered on easily transportable luxury goods. Crop failures and other disasters therefore tended to be limited in scope: If one town was devastated, others were spared because they had their own regional sources— and stores—of necessities. Economic globalization may have begun centuries ago with the European colonization of the rest of the world, but it really took hold during the past half century with the advent of satellite communications and container ships. The goal was to maximize economic growth by exploiting efficiency gains from local specialization and global transport. In addition to driving down labor costs and yielding profits for international corporations, globalization maximized resource depletion and pollution, simplified ecosystems, and eroded local systems resilience. As transport fuel becomes less affordable, a return to a more localized economic order is likely, if not inevitable. The market's methods of rebalancing economic organization, however, could well be brutal as global transport networks become less reliable, transport costs increase, and regions adapt to less access to goods now produced thousands of miles away. Government planning and leadership could result in a more organized and less chaotic path of adaptation. Nations can begin now to prioritize and create incentives for the local production of food, energy, and manufactured products, and the local development of currency, governance, and culture. Natural ecological boundaries—such as watersheds— bordered traditional societies. Bioregions defined by waterways and mountain ridges could thus become the basis for future relocalized economic and political organization. Deliberate efforts to relocalize economies will succeed best if the benefits of localism are touted and maximized. With decentralized political organization comes greater opportunity for participation in decision making. Regional economic organization offers a wide variety of productive local jobs. Society assumes a human scale in which individuals have a sense of being able to understand and influence the systems that govern their lives. People in locally organized societies see the immediate consequences of their production and waste disposal practices, and are therefore less likely to adopt an "out of sight, out of mind" attitude toward resource depletion and pollution. Local economic organization tends to yield art,

music, stories, and literature that reflect the ecological uniqueness of place—and local culture in turn binds together individuals, families, and communities, fostering a sense of responsibility to care for one another and for the land.

Beauty

Discussions about energy rarely focus on beauty. But the presence or absence of this ineffable quality offers us continual clues as to whether or not society is on a regenerative and sustainable path, or on the road to further degrading nature. From the time of the earliest cave paintings, human ideals of beauty have been drawn from the wild world. Animals, plants, rivers, oceans, and mountains all tend to trigger a psychological response describable as pleasure, awe, and wonder. The sight of a great tree or the song of a goldfinch can send poets and mystics into ecstasy, while the deep order inherent in nature inspires mathematicians and physicists. Nature achieves its aesthetic impact largely through anarchic means. Each part appears free to follow its own inner drives, exhibiting economy, balance, color, proportion, and symmetry in the process. And all of these self-actualizing parts appear to cooperate, with multiple balancing feedback loops maintaining homeostasis within constantly shifting population levels and environmental parameters. The result is beauty. Ugliness, by contrast, is our unpleasant aesthetic response to the perception that an underlying natural order has been corrupted and unbalanced—that something is dreadfully out of place. Beauty is a psychological and spiritual need. We seek it everywhere and wither without it. We need beauty not as an add-on feature to manufactured products, but as an integral aspect of our lives. With the gradual expansion of trade—a process that began millennia ago but that quickened dramatically during the past century—beauty has increasingly become a valuable commodity. Wealthy patrons pay fortunes for rare artworks, while music, fashion, architecture, and industrial design have become multibillion-dollar industries. Nature produces the most profound, magnificent, and nurturing examples of beauty in endless abundance, for free. Industrialism, resulting from high rates of energy use, tends to breed ugliness. Our ears are bombarded by the noise of automobiles and trucks to the point that we can scarcely hear birdsong. The visual blight of highways, strip malls, and box stores obscures natural vistas. With industrial-scale production of buildings, we have adopted standardized materials produced globally to substitute for local, natural materials that fit with their surroundings. But industrialism does not just replace and obscure natural beauty—it actively destroys it, gobbling up rivers and forests to provide resources for production and consumption. Large-scale energy production—whether from coal mines and power plants, oil derricks and refineries, or massive wind and solar installations—comes at a cost of beauty. While some energy sources are inherently uglier than others, even the most benign intrude, dominate, and deplete if scaled up to provide energy in the quantities currently used in highly industrialized nations. The aesthetic impact of industrial processes can be mitigated somewhat with better design practices. But the surest path to restoring the beauty of nature is to reduce the scale of human population and per capita production and consumption. Returning to a sustainable way of life need not be thought of as sacrifice; instead it can be seen as an opportunity to increase aesthetic pleasure and the spiritual nourishment that comes from living in the midst of incalculable beauty.

Biodiversity

The family of life on Earth is large: More than a million species have been identified and formally described by taxonomists, and estimates of the total number of species on the planet range from 3 million to 100 million. We humans depend for our very existence on this web of life of which we are a part. Indeed, it is part of us: Each human is inhabited by thousands of species of microbes that enable digestion and other basic functions. Yet through our species' appropriation and destruction of natural habitat we are shredding microbial, forest, prairie, oceanic, riparian, desert, and other ecosystems. Habitat loss, overharvesting, climate change, and other results of human numbers and behavior endanger untold numbers of species with extinction. Extinction is nothing new: It is an essential part of the process of evolution. Throughout the billions of years of life's history, life forms have appeared, persisted for thousands or millions of years, and vanished, usually individually but occasionally in convulsive mass events triggered by geological or astrophysical phenomena. There were five ancient extinction events so catastrophic that 50–95 percent of all species died out. Today humans are bringing about the sixth mass extinction in the history of life on Earth. While the normal rate of extinction is about one in a million species per year, the extinction rate today is roughly a thousand times that. According to recent studies, one in five plant species faces extinction as a result of climate change, deforestation, and urban growth. One of every eight bird species will likely be extinct by the end of this century, while one-third of amphibian and one-quarter of mammal species are threatened. As species disappear, we are only beginning to understand what we are losing. A recent United Nations study determined that businesses and insurance companies now see biodiversity loss as presenting a greater risk of financial loss than terrorism—a problem that governments currently spend hundreds of billions of dollars per year to contain or prevent. Nonhuman species perform ecosystem services that only indirectly benefit our kind, but in ways that often turn out to be crucial. Phytoplankton, for example, are not a direct food source for people, but comprise the base of oceanic food chains, in addition to supplying half of the oxygen produced each year by nature. The abundance of plankton in the world's oceans has declined 40 percent since 1950, according to a recent study, for reasons not entirely clear. This is one of the main explanations for a gradual decline in atmospheric oxygen levels recorded worldwide. Efforts to determine a price for the world's environmental assets have concluded that the annual destruction of rainforests alone entails an ultimate cost to society of $4.5 trillion—roughly $650 for each person on the planet. Many species have existing or potential economically significant uses, but the value of biodiversity transcends economics: The spiritual and psychological benefits to humans of interaction with other species are profound. Most fundamentally, however, nonhuman species have intrinsic value. Shaped by the same forces that produced humanity, our kin in the community of life exist for their own sake, not for the pleasure or profit of people. It is the greatest moral blot, the greatest shame on our species, for our actions to be driving other life forms into the endless night of extinction.