Village of **Croton-on-Hudson** New York

Greenhouse Gas Emissions Baseline Inventory

of

Municipal Facilities and Activities

in the Village of Croton-on-Hudson, New York

for calendar year 2007

Final Draft (version 2007.1)
December, 2009

This report uses the Clean Air and Climate Protection 2009 Software published by ICLEI Local Governments for Sustainability.

ICLEI Local Governments for Sustainability USA

CACP 2009 Clean Air & Climate Protection Software

www.crotononhudson-ny.gov

Table of Contents

An open letter to the Croton community ii
Executive Summary: Village's governmental emissions for 2007 iii
Top 20 Government Emission Sources (map) iv

Part 1 The method and the journey 1

1.1 How did we measure emissions? Our greenhouse gas inventory methodology 1
1.2 What have we done? The journey toward sustainability 2
Figure 1: Compost Bin Sale Flyer
Figure 2: Photovoltaic panels on the Grand Street Firehouse
1.3 What is next? From data to solutions 5
Figure 3: What is a smart grid?
Figure 4: US energy flowchart (as % of total use in 2004)

Part 2: Croton's governmental greenhouse gas emissions 8

2.1 Our governmental greenhouse gas emissions: an overview 8
Table 1: Executive Summary by Sector: 2007 Village government emissions, energy, and cost
Figure 5: 2007 Village government inventory by sector in % emissions and $ cost.
2.2 Croton's Greenhouse Gas Emissions: the Detailed Inventory 9
Table 2: 2007 Government greenhouse gas emissions: Details by facility and activity
Figure 6: 2007 Greenhouse gas emissions by village department (CO2e tonnes)
Table 3: Source report by fuel: costs, emissions, and energy consumed 2007

Part 3: What does this mean? A closer look at the numbers 16

3.1 How much do we consume and spend by sector? 16
Figure 7: 2007 Village energy consumption and costs by sector (MMBtu and $)
3.2 What does this mean to me as a citizen? 17
Figure 8: 2007 Village greenhouse gas emissions impact per resident (lbs, kWh, $)
Table 4: Per village resident share of 2007 greenhouse gas emissions (lbs, kWh, $)
3.3 Comparing cost, emissions, and energy contributions by fuel used 18
Table 5: 2007 Village energy cost by energy unit per fuel source ($/MMBtu)
Figure 9: 2007 Village costs, emissions, and energy consumed by fuel source (%)
Figure 10: Fuels by cost per unit of energy ($/MMBtu)
Table 6: Electrifying the fleet: an example of fuel cost savings
3.4 What pollutes and how much? 20
Table 7: US EPA government criteria air pollutants tracked by the 2009 CACP protocol
Table 8: 2007 Government criteria air pollutant emissions: By sector and type (pounds)
Figure 11: 2007 Village air pollutant emissions by sector and type (pounds)

Appendix A: Our data collection and conversion methods 24
Figure A1: Bar chart of detailed emission sources by village department
Table A1: Converting Employee Commutation and Travel to Emission Impacts
Table A2: Emissions conversion by fuel type
Table A3: Employee Commutation Questionnaire
Table A4: Converting fertilizer use to emission impacts
Table A5 Converting solvent volumes to emission impacts
Table A6: Converting office employee waste to emission impact

Appendix B: Greenhouse gas science in a few pictures 29
Figure B1: The Earth's greenhouse gas effect
Figure B2: Past: Atmospheric concentrations of greenhouse gases: 0-2000 AD
Figure B3: Now: Natural vs. human forces vs. actual atmospheric temperature: 1900-2000 AD
Figure B4: Future: Projected carbon dioxide emissions & global temperature disruption: 2000–2100 AD
Figure B5: US energy flow from use to greenhouse gas emission
Table B6: Relative Global Warming Potentials of Some Common Greenhouse Gases

Appendix C: Climate disruption impacts in New York 35
Figure C1: Future state migrations under greenhouse gas emission impacts: 2000-2100

Appendix D: About Croton-on-Hudson, New York 37
Figure D1: Village Revenue and Appropriations History
Figure D1: Croton's water use and precipitation history: 1991-2008

Appendix E: About ICLEI Local Governments for Sustainability 39

Appendix F: Online Resources 40

Appendix H: Units, acronyms and other alphabet soup 41

Appendix G: Acknowledgements 41

Village of **Croton-on-Hudson** New York

Stanley H. Kellerhouse Municipal Building
One Van Wyck Street
Croton-on-Hudson, NY 10520-2501

Tel: 914-271-4781
Fax: 914-271-2836
www.crotononhudson-ny.gov

Mayor
Leo A. W. Wiegman

Trustees
Ann H. Gallelli
Ian W. Murtaugh
Richard Olver
Demetra Restuccia

Manager
Abraham J. Zambrano

Assistant Manager
Janine King

Treasurer
Sandra Bullock

Clerk
Pauline DiSanto

Engineer
Daniel F. O'Connor, P.E.

December 21, 2009

An open letter to the Croton community

Dear friends and neighbors,

We face an unprecedented challenge that will have an extremely strong impact on the health, safety, and welfare of our children and children's children. The issue is human-driven climate disruption. More warming from the human release of greenhouse gases to the atmosphere alters the jet streams, which leads to more violent swings in weather patterns. Translation: the prospect of more severe storms, on a scale of a Hurricane Floyd, as more frequent events is very real. New York State has already warmed up by 2 degrees Fahrenheit since 1970.

The good news is that all around us government has become engaging in solving climate disruption with both action plans and dollar resources for those plans. At the national level, the new administration increased funding for energy efficiency, conservation, and renewables on a massive scale as both a jobs program and a vastly improved promotion of promising technologies and polices. At the state level, Governor Paterson started the Climate Smart Communities initiative and established a goal for New York State of reducing greenhouse gas emissions by 80 percent from 1990 levels by the year 2050 with a significant renewable energy and efficiency impact by 2015.

At the local level, Croton joined the Governor's initiative the first week it was launched. We were the first municipality in New York to purchase electricity from wind power. We joined an international consortium of municipalities to tap into the best practices for sustainability and signed onto the US Conference of Mayors Climate Pledge. We are a founding member of a Westchester-based consortium of towns and villages collaborating on innovative, cost-effective energy initiatives using off the shelf technology. We are a little village that can set an early example and will make a difference!

Pushing the "reset" button on the economy gives us a great opportunity. We need to rethink "business as usual"–such as our reliance of fossil fuel. As a people of great creativity and collaboration, we will learn what's good for the environment and our children's future is best for the economy too. As part of the Northern Westchester Energy Action Consortium, we will have good company on this journey toward a more sustainable village, region, and nation.

In closing, I ask that you get involved. Educate yourself. Reduce your carbon footprint. Most importantly, share your ideas. Join with us–your friends and neighbors–on this journey to a place just around the corner where we take only what we can replace and we leave ample resources for those who will come after us. Our coastline and our economy depend on how much we get done in the next few years. We can do this together!

If the Earth were an apple, all life would take place within a layer as thin as the apple's skin. We only have one Earth. It's thin skin provides us the essential materials of life: air, water, and soil. One Earth–one health.

Thank you for your attention. Don't hesitate to drop us a note with any ideas you think we should consider.

Sincerely,

Leo A. W. Wiegman, Mayor

lwiegman@crotononhudson-ny.gov

Executive Summary: Croton's governmental emissions for 2007

What we have done so far

- In 2003, Croton took climate disruption seriously by buying wind power and joining Energy $mart Communities, signing the U.S. Conference of Mayors Climate Protection Agreement in 2009, & joining the Climate Smart Community initiative in 2009.
- In 2008, Croton joined ICLEI, a widely respected non-governmental organization that helps local governments address climate impacts.
- In 2008-9, Croton started an energy audit of the Municipal Building, purchased some higher mileage vehicles, and installed photovoltaic panels on Grand Street Firehouse.
- In 2009, Croton used ICLEI procedures and other methods to calculate village government's climate impact, a.k.a "carbon footprint" or "greenhouse gas inventory."

Why?

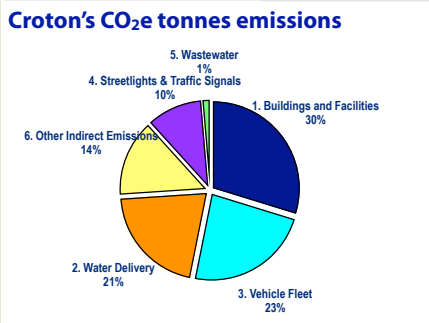
- To determine how and at what expense Village could reduce or eliminate any climate impacts resulting from its own governmental operations.
- Can the Village become a zero carbon emissions municipality?
- Should our government operations become carbon neutral?

What we found out

- Building operations, vehicle transportation, and drinking water delivery produce the greatest emission impacts.
- Electricity use is largest contributor to overall greenhouse gases indirectly through emissions at power plants that serve the Village's needs.
- Gas & diesel burned in Village vehicles is single largest local air pollution source among government operations.

By the numbers

- In 2007, the Village spent over a half million dollars on energy,
- bought almost 17.8 billion Btus of energy of all kinds, which
- caused over 1,770 tonnes of greenhouse gas emissions.



What does this mean?

The Village will find ways to reduce its direct and indirect emissions by

- seeking more efficient use of energy,
- generating or purchasing more renewable energy, and
- switching to cleaner fuels, and many other means.

Next steps! Develop Croton's climate action goals and plans

1. Analyze the energy, cost and emission reduction options (efficiency measures, renewables sources, fuel switching, etc).
2. Determine the lowest cost way to achieve them.
3. Demonstrate Village's commitment to a climate action plan, while safeguarding taxpayers.
4. Invite home & business owners to participate in community wide greenhouse gas inventory to include private sector buildings & operations.

Executive Summary Table by Sector: 2007 Village government emissions, energy, and cost*

Summary by Sector	Emissions (tonnes of CO_2e)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
1. Buildings and Facilities	528	29.8%	6,525	37%	$149,262	28%
2. Water Delivery Facilities	369	20.8%	3,583	20%	$149,560	29%
3. Vehicle Fleet	415	23.4%	5,701	32%	$126,894	24%
4. Streetlights & Traffic Signals	184	10.4%	1,699	10%	$88,791	17%
5. Wastewater Facilities	24	1.4%	252	1%	$9,269	2%
6. Indirect Emissions: Commuting, solvents, etc.	254	14.3%	0	0%	$8,430	0%
Totals	**1,774**	**100%**	**17,760**	**100%**	**$532,206**	**100%**

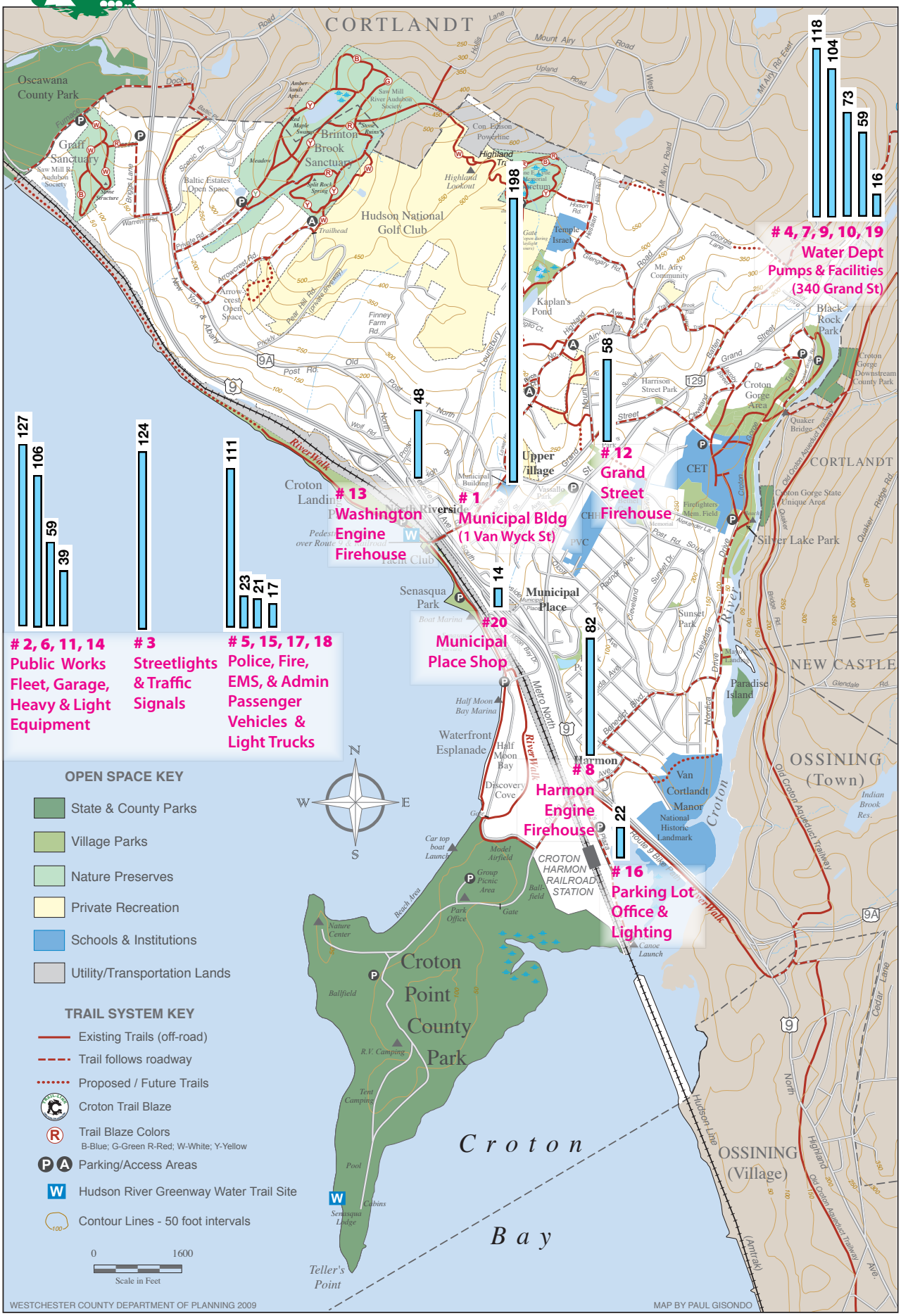
* For the Detailed Report, skip ahead to **Section 2.2. Croton's Greenhouse Gas Emissions: the Detailed Inventory (page 15)**

Village of Croton-on-Hudson New York

www.crotononhudson-ny.gov

Top 20 Government Emission Sources (2007)

metric tonnes of carbon dioxide equivalent (tCO_2e)



Part 1 The method and the journey

1.1 How did we measure emissions? Our greenhouse gas inventory methodology

> *"If you cannot measure it, you cannot improve it."*
> *— Lord Kelvin*

This first Greenhouse Gas Inventory creates a calendar year baseline of information about the energy consumption, costs, and resulting emissions from Village operations.

A climate impact inventory of local government operations identifies the amounts of electricity and fuel used in municipal buildings, traffic signals and streetlights, fleets and other local government operations. It also identifies other emission sources, such as employee commutation, travel, and waste generated, as well as, the village's use of fertilizer, lubricants, asphalt, paints, aerosols, and other solvents that are often overlooked in other municipal surveys. The data collected comes from the utility bills, fuel records, purchase invoices, and employee surveys. The data collected provides a baseline level of greenhouse gas emissions for which the government operations are responsible against which we can compare future performance. This baseline should provide the basis for an emissions reduction target and subsequent measures in a climate action plant to reduce greenhouse gas emissions and the costs associated with emissions.

An international non-profit, ICLEI-Local Governments for Sustainability developed the Clean Air and Climate Protection (CACP) software package to assist municipalities in conducting a greenhouse gas (GHG) emissions inventory (See www.icleiusa.org). After data is collected and entered into the software, the CACP software determines emissions using specific factors (or coefficients) according to the type of fuel or source used. The emissions analysis focuses on a few major greenhouse gases—carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). At the completion of the inventory, the quantity of emissions from the year establishes a baseline. The Village used CACP 2009 (version 2.0) released in April 2009 and its update (version 2.1) released in June 2009 to conduct this inventory. The ICLEI tools allow a municipality to inventory its own governmental sector operations, its residential sector, and its business sector.

The Village chose to restrict the scope in this first baseline inventory of emissions to its own governmental buildings, facilities, and activities for three simple reasons. First, the 2007 data on village's buildings and vehicles were good, available, reliable, and reasonably detailed. The ICLEI protocol requires we use a calendar year, not a fiscal year. The baseline year we chose is 2007 (January to December), because the quantity and quality of data we could retrieve for that period was superior to earlier years. Second, conducting a thorough inventory of our own municipal emissions would help us to gain in-house experience at manageable scale. It made good common sense to conduct a detailed examination of our own government operations, before undertaking inventories of the much larger emissions and energy consumption patterns in our residential and business sectors. Third, conducting estimates for Croton's residential and business sectors for 2007 would have involved too many "ballpark" estimates. For example, how would we determine the number of homes or businesses with oil heat versus other systems? The rougher residential and business sector data would have been far less useful in planning reduction tactics than the more precise numbers we did have for the governmental sector. We hope the practical specificity of this governmental baseline helps our residents and business owners see ways to lower future energy bills in the private sector.

In May 2009, the Village Manager's office asked a part-time staff person to assist with the data collection process for the baseline inventory. This person devoted approximately 100 hours over the summer learning the ICLEI CACP protocols, participating in the ICLEI webinars and, chiefly, researching Village records for the energy data to enter into the CACP software. In early fall of 2009, the Village Manager's office and Mayor presented the preliminary first draft to the village staff and the Sustainability Team. The staff and Team identified areas where the CACP protocol may be overlooking emission data, resulting in an undercount. A second wave of data collection in mid-fall relied on non-CACP methods and included: (1) Surveying village employee for commutation and business travel miles, (2) Researching the use of fertilizers on village fields, (3) Estimating the volume of various solvents or products used in maintaining the village's fleet and buildings (lubricants, R22 (freon replacement), asphalt, aerosols, etc), and (4) Estimating the impact of solid waste generated by municipal employees. The additional data of emission impacts raised the first draft of the village's "carbon tonnage" by over 14%, principally due to the 411,000 miles that village employees commuted to and from their village jobs in 2007. The first public version of this inventory report was a preliminary second draft released in early December that included these additional sources of greenhouse gas emissions. The final draft, issued in December, 21, 2009, incorporates a fuller description of the non-CACP methods

used for the second wave of data we analyzed. (The map in the Executive Summary omits the emissions from employee commutation. See Appendix A for more on our data collection and conversion methods.)

Some of the data we did have could not be incorporated into the ICLEI software and are not reflected in this first report: the village's long standing practice of purchasing a quarter of its electricity via wind power credits, on photovoltaic investments, and community projects such as encouraging residential use of compost bins and rain barrels. We have high confidence that we will be able to include both more complete energy and emission impact data and higher resolution data overall in later inventories. As thorough as this inventory appears to be for a village of our size, the volumes reported here represent reasonable estimates of our actual 2007 emissions. This year's collection exercise has already motivated the Village to track future expenses even more closely to allow easier retrieval and analysis in the future. Simply asking our staff to come up with data has fostered a wonderful, cooperative effort around uncovering more ways to save. The Sustainability Team has already been hard at work investigating reasonable approaches to energy emissions reduction and selecting a reduction target tailored to Croton's very specific situation.

1.2 What have we done? The journey toward sustainability

The Board of Trustees of the Village of Croton-on-Hudson has a made long term commitment to our becoming a more sustainable community that reduces consumption of our natural capital resources while exploiting the huge potential of our social capital resources. For help on this journey toward economic, and ultimately social sustainability, the Village joined ICLEI-Local Governments for Sustainability, an international association with national and regional offices that assists local governments in achieving local sustainable development objectives in 2008. In committing the village to advancing climate protection locally, the Village of Croton-on-Hudson has joined an international movement of more than 1000 local governments, including over 500 in the United States, that participate in ICLEI's Cities for Climate Protection (CCP) campaign.

As an ICLEI member, Croton has pledged to help reduce the negative impact of global warming and climate disruption by completing five milestones: (1) conducting a baseline emissions inventory, (2) setting an emissions reduction target, (3) developing an action plan to meet the target, (4) implementing actions in the plan, and (5) monitoring and verifying emissions reduction progress.

In completing these five milestones the Village of Croton-on-Hudson will be working to reduce local global warming, save money for our community, increase the energy efficiency of buildings and operations, and be part of a team that sets an example for the rest of the community in our efforts to protect our environment, economy, and the village. Joining ICLEI was only the first of many related steps by the Village.

> ***"The three questions that lay persons need to ask experts to be more literate in the environmental policy debates are (1) what can happen? (2) what are the odds? and (3) how do we know?"–***
> **Stephen Schneider (1997)**
> http://stephen schneider.stanford.edu

In 2003, Croton became the first municipal customer of wind power from Community Wind Energy's upstate Fenner Wind farm (www.fennerwind.com) and also joined the state's Energy $mart Communities initiative.

In the spring 2009, the Village signed on to Governor Paterson's Climate Smart Communities pledge, with its goal–among others–of reducing electricity use by 15 percent from projected levels no later than 2015.

In mid-2009, the Village signed on as a charter member of the new Northern Westchester Energy Action Consortium (NWEAC). Fourteen neighboring municipalities had joined at the time of this report. With a steering committee comprised of representatives from the municipalities elected officials and sustainability/energy panel volunteer committees, NWEAC acts as a consultant to its members on seeking grants and as a clearinghouse for a broad range of initiatives related to energy efficiency, conservation, and renewable, non-polluting energy sources. NWEAC has ongoing initiatives on energy retrofit financing for homeowners, organic waste stream studies, and smart grid demonstration projects (www.smartgridwestchester.org).

In June 2009, the Village conducted a very successful compost bin truck sale working closely with a vendor. Villagers purchased almost 200 "Earth Machines" on a single Saturday. Diverting organic kitchen or yard waste from the curbside collection to a back yard compost bin could save thousands of dollars, while sequestering carbon locally by turning organic waste into garden soil locally. The Village intends to repeat this truck sale in 2010, adding rain barrels to water a home owner's garden and conserve drinking water. (See Figure 1.)

Figure 1: Compost Bin Sale Flyer

Tipping costs are for Croton solid waste are $25 per ton. DPW staff time and hauling costs are probably another $25 per ton. So these 193 compost bins just saved (or avoided) $3,374–and that's per year! Shortly after the Compost Bin Sale Day, the vendor wrote the Village the following note: "Just so you know...if the Earth Machine composter is used properly, it can divert 700 lbs of organic waste from the waste stream (1/3 of a ton for an average 4 person household). Saturday we distributed 193 units capable of recycling 135,100 pounds of organic matter into useable soil per year. That's about 67.5 tons of matter avoided from the collection process." –Jeff Brown, President, www.ecopromo.com

Also in June 2009, the Village turned on the new photovoltaic panels on the Washington Engine Company Firehouse on Grand Street. Installed by Mercury Solar Systems of New Rochelle, New York, this 6.0 kW set of panels connects to the grid for net metering using a SunPower inverter and exports that data to the web via a Sunny Boy WebBox. A New York Power Authority grant paid for the system. In its first 70 days, the system generated about 2,480 kWh of electricity. This firehouse, one of three in Croton, used 179 million Btu (52,459 kWh) of electricity in 2007 at a cost to taxpayers of $5,988. The solar electric system's output is available online for anyone to observe (See Figure 2.)

Compost Bin Sale Day

Sponsored by the Village of Croton-on-Hudson

Saturday, June 20, 2009, 10 am–2 pm

Municipal Place Yard @ North Riverside Avenue, Croton-on-Hudson
(former Skatepark and current Wednesday Farmer's Market location)

Reserve by Wednesday, June 17, 4 pm, to make sure we have a bin for you!

Reserve your bin(s) to lock in the $48 sale day price.

Note: A FREE kitchen scrap bucket (a retail value of $2) will be given away with each bin reserved by Wednesday, June 17.

This is a rain or shine, cash or check only event. You must pick up your bin(s) on the day of the sale only.

$48 sale day price ($150 value)
Cash or check only

Don't delay, Reserve today! The Earth Machine is the number one selling composter in North America. The $48 "enclosed" bin features a locking lid, snap together assembly, a retrieval door, anchor pegs and a simple "how-to" book. The vendor will also offer an optional base, aerator, "Presto" bin, kitchen pail, and other seasonal accessories. The Village needs reservations for 100 bins by June 17 in order to secure this very good group discount price!

To reserve, send your name, phone number, email address, and quantity of bins desired to **jhannigan@crotononhudson-ny.gov** (use "compost bin" as subject line!), or fax this form to **914-271-2836**, or call **914-271-4781** with this information.

Yes, reserve an Earth Machine for me!

My Name _____

My Phone _____

My Email _____

I want to buy Earth Machine bin(s) at $48 each on June 20, 2009 (circle quantity): **1** , **2** , **3** , __.

Village of Croton-on-Hudson *where nature happens*
www.crotononhudson-ny.gov

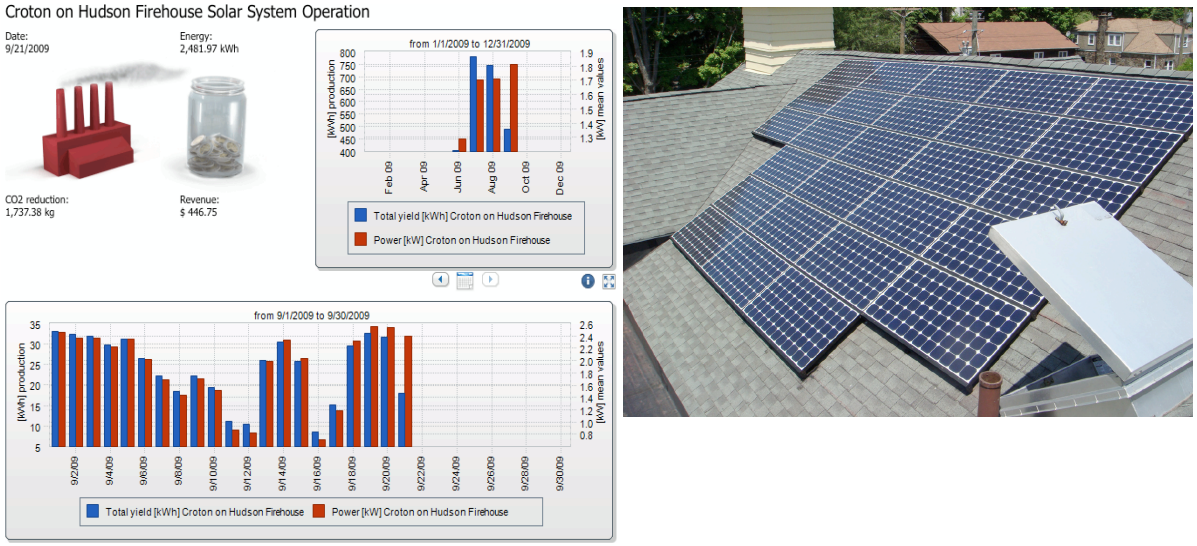


Figure 2: Photovoltaic panels on the Grand Street Firehouse

Watch the daily solar electric output of the panels on the roof of Croton's Grand Street Firehouse: http://bit.ly/Croton_Firehouse_SolarPanels (photos courtesy of Tex Dinkler and Dan O'Connor)]

In early fall 2009, the Village appointed a Sustainability Team to harness the talent, expertise, and ideas amply evident among Croton-area residents. The volunteer-run Sustainability Team is charged with helping guide the Village through the ICLEI Climate Protection milestones, as well as fostering other numerous other new efforts such as local community gardens. Specifically, the Team will be making recommendations to the Village on the ICLEI milestones that lie ahead.

In sum, we are doing quite a bit, but must do and are about to do much more.

1.3 What is next? From data to solutions

As noted earlier, the ICLEI process for its member municipalities is a cycle of data gathering, setting reduction targets, formulating action plans, and assessing whether those actions have the desired effect. This report is only the first step for the Village as Milestone 1, Conducting the Emissions Analysis. The next phase of work will begin immediately and involve setting a reasonable, achievable, and meaningful reduction goal for the tonnes of greenhouse gases that Village operations will emit in calendar 2010. The Village's Sustainability Team of local volunteers with relevant expertise, will be charged with delivering recommendations to the Village for a reduction target before the end of calendar 2009 for Milestone 2, Setting the Target.

> *"Doing nothing about climate change is far more expensive and risky than taking strong pro-active and immediate measures."*
> **–Sir Nicholas Stern (2007)**
> www.hm-treasury.gov.uk/sternreview_index.htm

Once a target is chosen, the Village must determine which particular recommendations from the Team and others to pursue toward achieving the overall strategy of reducing the greenhouse gases by Village operations and facilities. This Milestone 3, Developing the Climate Action Plan, is the heart of the process. We will include all actions our jurisdiction has already implemented since the base year and all measures our jurisdiction plans to implement in the future to meet its GHG emissions reduction target. We will consider what existing programs or policies are already reducing GHG emissions? A municipal building retrofit? Street lighting upgrades? A new residential composting program? Can these be expanded or enhanced to help meet our emissions reduction goals?

The good news is that the Village is already engaged in a host of reduction activities, many of which are not yet reflected in the 2007 data. The 2009 New York State Energy Plan provides further opportunities (www.nysenergyplan.com).

Any climate action plan is only as effective as the implementation. Once we have selected a reduction target and formed an action plan, we will immediately begin acting on that plan as Milestone 4: Implementing the Local Climate Action Plan. Given the timing, it may be possible for the reduction goal and subsequent action recommendations to help guide the budget preparations for the Village's next fiscal year 2010-2011 (which begins in June). The fifth and final step is Milestone 5, Monitoring Progress and Reporting Results, in which the Village revisits the original 2007 baseline in early 2011 as the data for calendar 2010 becomes available for analysis.

As the ICLEI guide for municipalities states, "*The Milestones can be undertaken concurrently, and the specific emissions reduction target and contents of the Climate Action Plan are up to your jurisdiction to determine.*"

Our challenge is clear: We need form a coherent, cohesive, coordinated plan for reducing energy cost, energy emissions, and energy consumption.

This journey we have embarked upon will affect every taxpayer in ways that mitigate future tax increases and exploit the opportunities ahead for participating in the energy-internet economy just around the corner. Before we delve into the numbers, let's take a brief look at what we will be hearing more about in 2010 and beyond.

Conservation and energy efficiency

Using less energy (conservation) and using appliances that consume less energy for the same output (efficiency) are two different but related concepts central to our efforts. Turning off unneeded lamps is conservation. Putting more efficiency bulbs into after making conservation steps is a next logical step. While the Village is studying how to use less energy throughout its operations, the same principles apply to homeowners and business proprietors. Many conservation measures can be undertaken at low or no cost (turning off what is not needed, from printers to fans and pumps etc). Many efficiency measures often require a modest investment (in better light bulbs or variable speed pump motors) and should be undertaken after

> *"There are three major ways to reduce greenhouse emissions: reducing energy use, replacing fossil fuels with renewables and increasing energy efficiency. Policy instruments are available for all of them."*
> **–Sonja Koeppel and Diana Ürge-Vorsatz (2007)** www.unepsbci.org

a life cycle cost benefit analysis helps to identify the energy payback period beyond which the efficiency expense has paid for itself. This payback is often relatively short (a matter of months or a few years) relative to the service life of the investment. For example, motion detector light switches for public bathrooms combined with high efficiency light fixtures might be a "conservation plus efficiency" investment with a favorable payback period, as the newer bulbs have service lives 3 to 5 times longer than the older, hotter and less efficient incandescent bulbs.

Energy and heat recovery ventilation

Although rare in the United States, the "passive house" is a reality in Europe, where tens of thousands have been built. The concept is also known as "low energy" or "zero energy building." These homes, office, and commercial buildings often use a simple, highly effective heat exchange system, combined with superb insulation. They take full advantage of the sun's path and daylighting. Stale air is vented to the outside, but not before all the useful heat (or cool) in it is extracted and transferred to fresh air that is drawn into the home. Ventilation upgrades for existing structures can include such technology to avoid having to bring the fresh air up or down to the desired comfort level and to avoid losing all the comfort in the stale air before it goes out the exhaust vent. (See www.nrel.gov/buildings/zero_energy.html, www.passivehouse.us, and greenfootstep.org.)

Smart grid integration and distributed generation

The nation's current electricity grid consists largely of a one-way flow of power from utilities to the consumers. If we marry internet communications technology to the existing copper wire transmission technology, we suddenly have the ability to send messages in both directions about power demand and supply from the generator and distributor to the end-user. If the grid operators know a peak in demand is coming, for example, in mid-afternoon on a scorching summer day, a smart grid could alert end-users to dial down their consumption a tiny bit and avoid having to turn on the very expensive peak power plants. The utility saves money. The consumer saves money. Smart grid technology is already well-developed and reaching the commercialization stage quite rapidly as we will see in the next two years. A smart grid with advanced metering capacities will help us spot opportunities to increase energy efficiency and reduce base loads. It will also greatly enhance our ability integrate new renewable energy sources into the power mix. A smarter grid raises the value of distributing power generation sites throughout the service areas closer to where the electricity is needed. Doing so cuts transmission line losses and provides regional stability to the grid's capacity. Distributed generation is likely to come from newer, cleaner energy sources from natural gas fired peaking plants to renewable energy installations of many kinds. (See Figure 3 below, and www.usea.org/Publications/USEA_Smart_Grid_Lunch_and_Learn.asp and www.oe.energy.gov/smartgrid, and "Combined heat and power" below.)

Figure 3: What is a smart grid?

A smart grid is an "energy internet" that marries our existing copper wire electricity infrastructure with the latest internet communication infrastructure. Because such instantaneous two-way communication allows the grid to know when power from renewables (solar, wind, etc) is available and how to ask consumers to shed demand during peak loads, the smart grid makes renewable even more viable financially and more valuable to the integrity of the entire transmission system.

Install new advanced meters to the existing grid.

+

Add monitoring feedback via internet for consumers.

+

Expand renewables to fit into the new demand response network.

=

healthier economy & planet

Renewable energy

> *"Climate is what you expect. Weather is what you get."*
> **–Mark Twain**

From hydro to solar and wind power, we have untapped potential for producing clean electricity here in the Empire State. Germany is less sunny than New York and has installed more than 430,000 solar electricity systems with a total nominal output of 3,800 MW (www.renewables-made-in-germany.com). The photovoltaic system on Croton's Grand Street Firehouse uses German technology (http://bit.ly/Croton_Firehouse_SolarPanels). The key to wide adoption of solar electricity is commercialization on a mass scale that will bring down the cost of photovoltaic panels. Two other sun-driven technologies are less costly than photovoltaics: Solar thermal walls heat the space inside a building by cleaver and simple movement of warmed air. Solar water heaters can drastically lower the fuel bill for domestic hot water heating. Both these technologies are at least 2,500 years old and quite cost-effective with today's newer, more durable materials.

Geothermal heat pumps and radiant heat and cooling

New geothermal heat pumps operate very efficiently in extracting heat from a deep local well and using that to produce a comfortable temperature in a new or renovated building. The new Ossining Public Library employ geothermal heating and cooling. Using radiant heat or cooling water loops in the floor (or walls) of a new or renovated structure is much more efficient than a traditional baseboard radiator or forced air system. Think how hot a radiator is to touch when the heat is on. By contrast, radiant heat operates well at a lower water temperature spread over a large surface area than a baseboard radiator and is the preferred method for distributing the heat from a geothermal heat pump. (See www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12640 and www.geoexchange.org.)

Energy co-ops

Some of us join a food co-operative to get better food at reasonable prices through the power of group purchases, regardless of where the food is actually grown. We can apply the same principle of co-operative investment and reward to renewable energy, If someone proposed that investors could earn a nice dividend for several years, and after reaching the payback period, see rapid growth in earnings, that might be attractive, If this investment entailed replacing old dirty energy sources with new cleaner ones, that might be even more attractive. Toronto's pioneering for profit WindShare Cooperative is such a venture (www.windshare.ca). Windshare produces income for its member from a major wind turbine on Toronto's waterfront. This same cooperative approach in Denmark has enabled that small nation to reduce its reliance on fossil fuels and increase wind power capacity dramatically. Today wind power provides 20% of Denmark's electricity, even though much of Denmark has only modest wind speeds. The wind power cooperative model in Europe has financed both small and large projects and can be replicated in the United States as well (www.windpowerworks.net).

Combined heat and power

Combined heat and power (CHP), also known as cogeneration, is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. Combined heat and power incorporate proven, reliable and cost-effective technologies that are already making an important contribution to meeting global heat and electricity demand. By enhancing energy supply efficiency and using waste heat and low-carbon renewable energy resources, CHP, particularly when complemented by district heating and cooling (DHC), is an important part emissions reductions strategy. The benefits stem from the fact that these applications produce energy where it is needed, avoid wasted heat, and reduce transmission and distribution network losses. (See Figure 1.6b.) Other benefits include cost savings for the energy consumer; lower CO_2 emissions; reduced reliance on imported fossil fuels; reduced investment in energy system infrastructure; enhanced electricity network stability through reduction in congestion and 'peak-shaving'; and beneficial use of local and surplus energy resources–particularly through the use of energy from waste, biomass, and geothermal resources in district heating/cooling systems.[10]

Carbon sequestration

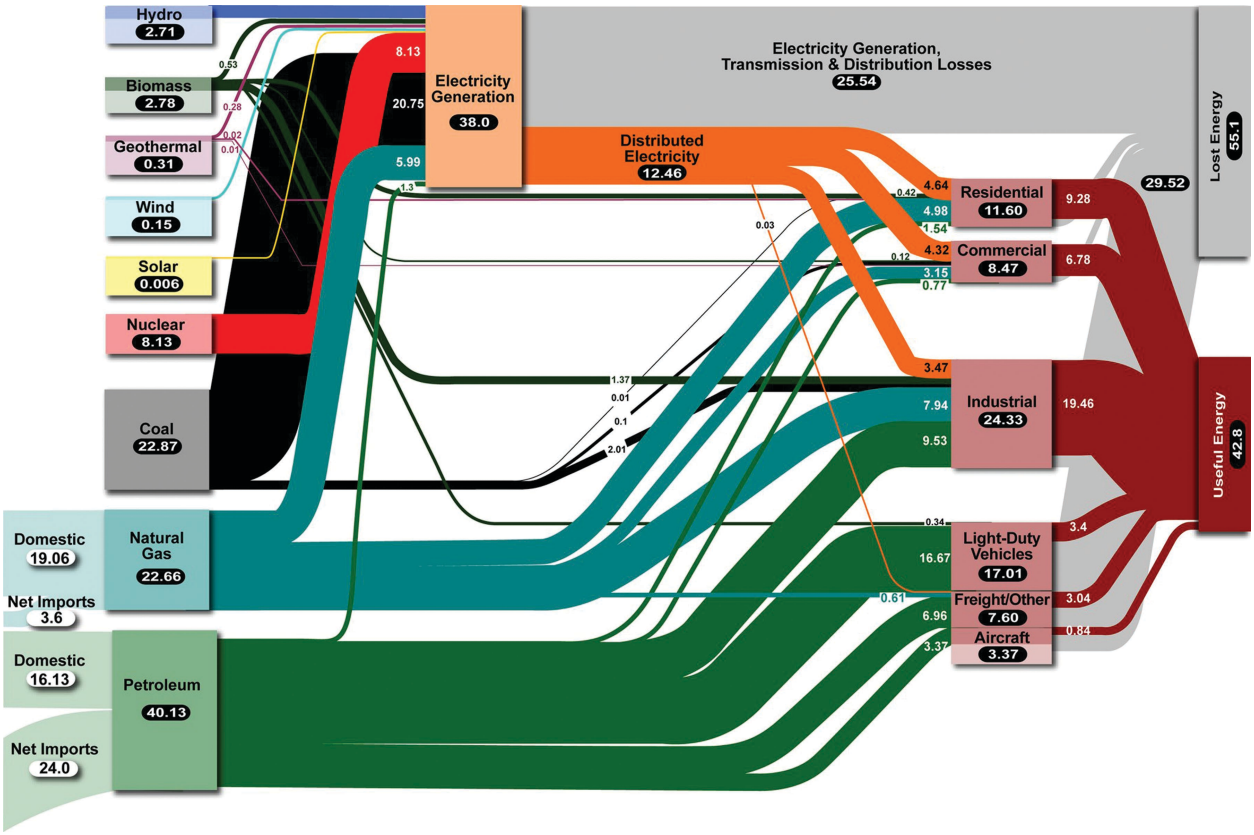
Burning fossil fuels emits carbon to the atmosphere. Planting a tree will take carbon out of the atmosphere and put it in the ground. Composting will do the same by reducing the distance we ship organic waste and putting it into the ground below our feet. Reducing overgrazing by deer in our forests will also cause better, denser plant growth and

sequester more carbon than those denuded woods do now. If just one in five Croton households compost 100% of their organic kitchen waste, that alone is a measurable positive impact in reducing emissions. Managing the Village's street tree program and its park spaces to maximize carbon capture through fostering a robust diversity of locally indigenous plant varieties can all help as well.

Finally, as a national context, let's examine energy flows throughout our national economy for 2004 (See Figure 4.). The transmission and distribution losses alone in our electricity system are staggering.

Figure 4: US energy flowchart (as % of total use in 2004)

The left side of this chart shows, by percentage, the "input" sources of energy in the United States in 2004. That year total US energy consumption required about 96 quadrillion Btus or "quads." A quad is 10 to the 15th power Btus or a million billion Btus. The boxes in the middle of the chart show the percentages of "throughput," that is, what happens to the energy as it is converted for end use. Note that 38% of all our incoming energy is used for electricity generation. More startling, of the electricity we do generate, only one-third is actually distributed to the end user with the rest wasted in electrical generation, transmission, and distribution losses. The right side of this chart shows the total resulting lost energy from all sectors as more than 55% versus the actual useful delivered energy (about 43%). Source: Lawrence Livermore National Laboratory (2006) Energy and Environment Division. https://publicaffairs.llnl.gov/news/energy/content/energy/energy_archive/energy_flowchart_scenarios/ucrlTR204891.pdf



Part 2: Croton's governmental greenhouse gas emissions

This entire emissions report can be summed up in one (long!) sentence:

In calendar 2007, the Village government spent over a half million dollars buying almost 17.8 billion British thermal units (Btu) of energy to conduct Village business and provide Village services that caused over 1,774 metric tonnes of greenhouse gas emissions.

The CACP software converts all the different energy sources from gallons of diesel or gasoline to kilowatt-hours of electricity or therms or cubic feet of propane or natural gas into a single standard unit, British thermal units, a.k.a. Btus. Keep in mind that one metric tonne is 2,204 pounds, a long ton, and is larger than a short ton, which is 2,000 pounds. As this Part 2 of the report is all about the numbers, let's turn that the sentence above into a simple equation:

17.8 billion Btus = 5.2 million kiloWatt-hours (kWh) for one year
= enough to run an average house for 50 years
= $532,000 in energy expense
= 1,774 metric tonnes of emissions.

2.1 Our governmental greenhouse gas emissions: an overview

The ICLEI CACP protocol designates the typical purpose of energy use as "sectors," such as buildings (heating, cooling, ventilation), fleet (diesel, gasoline, compressed natural gas), water delivery (electrical), streetlights (electrical), and wastewater (electrical). Solutions to reducing emissions within a given sector, such as buildings, are typical related and similar, no matter what actual municipal department or function that building happens to serve.

In Table 1, Summary by Sector (shown in redacted form in the Executive Summary table), we see the results of the 2007 greenhouse gas emission inventory for the weight of emissions for the three key gases produced, the amount of energy consumed, and the cost of that energy, sorted by the key sectors within the village operations (buildings, vehicles, water delivery, streetlights, and wastewater).

The village's buildings and facilities produce the single largest set of emissions (~30%%) and with the next largest coming from the Village's fleet (~24%), and water delivery services (~21%) surprisingly close behind. (The data for Table 1 comes from the sector totals in the complete detailed report in Table 2, in descending tCO_2e order.)

Table 1: Executive Summary by Sector: 2007 Village government emissions, energy, and cost.

Summary by Sector	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
1. Buildings and Facilities	528	3	43	**528**	29.8%	**6,525**	36.7%	**$149,262**	28.0%
2. Vehicle Fleet	412	12	10	**415**	23.4%	**5,701**	32.1%	**$126,894**	23.8%
3. Water Delivery Facilities	368	3	20	**369**	20.8%	**3,583**	20.2%	**$149,560**	28.1%
6. Other Indirect Emissions (commutation, solvents, etc.)	-	-	-	**254**	14.3%	**0**	0.0%	**$8,430**	1.6%
4. Streetlights & Traffic Signals	184	1	8	**184**	10.4%	**1,699**	9.6%	**$88,791**	16.7%
5. Wastewater Facilities	23	0	2	**24**	1.4%	**252**	1.4%	**$9,269**	1.7%
Totals	1515	19	83	**1,774**	100%	**17,760**	100%	**$532,206**	**100.0%**

As mentioned, the CACP protocol estimates emissions by weight for prominent three greenhouse gases, carbon dioxide, nitrous oxide, and methane. The latter two are less comon than carbon dioxide, hence they are measured in kilograms (kg), not tonnes (t). While emitted in much smaller amounts than carbon dioxide, both nitrous oxide and methane have very powerful greenhouse gas effects, even in low doses. Due to the methane's chemical properties, one molecule of methane is 22 times more powerful in forcing atmospheric warming within one hundred years than one molecule of carbon dioxide. Likewise, one molecule of nitrogen dioxide in 298 times more powerful in forcing

warming within one hundred years than one molecule of carbon dioxide. Time does remove some of the global warming potential (GWP) of both nitrogen oxide and methane. But time has much less effect in reducing the carbon dioxide, a stable compound whose long-lasting molecules have an atmospheric lifetime of 1,000 years or more. The CACP protocol takes all this into account by converting the impacts of all the other gases plus carbon dioxide into a lump sum of "carbon dioxide equivalents" or "CO_2e" as we will label it here and throughout this report.

For comparison's sake, according to the research of the Global Footprint Network, the average North American citizen generates about 20 tonnes of CO_2e per year (tCO_2e/y)–five times more than the average global citizen (www.footprintstandards.org). By that estimation, Croton's 8,000 residents might generate collectively about 160,000 tCO_2e per year, with about half due to their home and half due to transportation. In other words, Croton's residential sector generates 100 times more greenhouse gas emissions than the village's government operations. We are placing our village government under a microscope in order to save taxpayers money, and to highlight one area where government can lead by example.

Before we get to the detailed findings in Table 2, it may help to look at the big results in visual, pie chart form. In Figure 1, the left hand pie chart shows the emission of CO_2e tonnes as a percent by sector from Table 1. The right hand pie chart shows the costs for each sector in dollars from Table 1. (See Figure 5.)

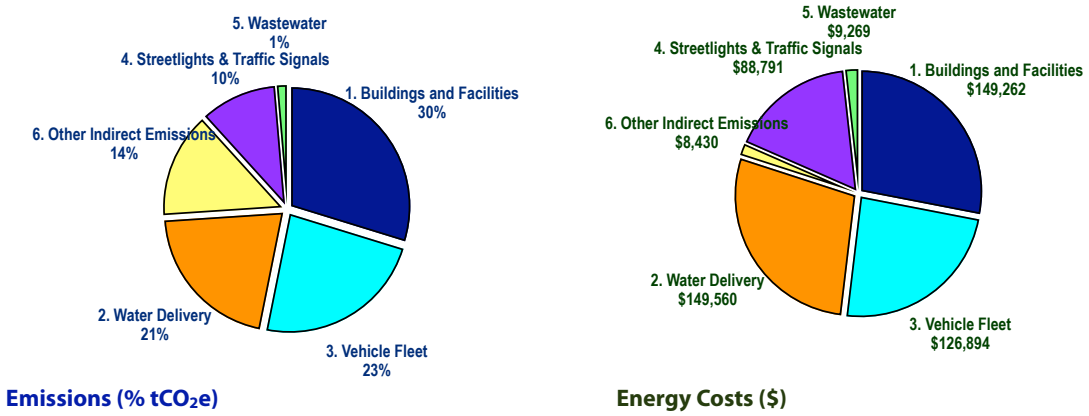


Figure 5: 2007 Village government inventory by sector in % emissions and $ cost.

The left pie chart in Figure 5 shows the emissions of tonnes of carbon dioxide equivalents (tCO_2e) in the blue column in Table 1 for each sector. The total cost of the energy consumed by each sector is in the right pie chart. We sorted these by largest to smallest emission source, with building and facilities as the #1 emitting sector. Notice that if we sort by largest to smallest cost, water delivery would be the most expensive sector, followed by buildings and facilities.

2.2. Croton's Greenhouse Gas Emissions: the Detailed Inventory

After this bird's eye view above, let's get to the heart of this baseline inventory! Table 2, "2007 Government greenhouse gas emissions: Details by facility and activity," displays all the details of each village service or facility that we could document caused a greenhouse gas emission in calendar 2007. To help readers visualize the location of these emission sources, we included as many street addresses or locations as possible. (A geographic display of Croton's "Top 20" emitters appears as the map in the Executive Summary at the front of this report.)

In 2007, a single building, the Village's Municipal Building, led all other facilities by a wide margin in producing greenhouse gas emissions : 198 tCO_2e (tonnes of carbon dioxide equivalent) in Line 1.1 of Table 2. The largest Village building, it operates around the clock housing Croton's Police Department. Myriad departments, volunteer committees, community organizations and nonprofits use the building on evenings and weekends for meetings. As the building in Croton that "never sleeps," the Municipal Building houses good opportunity for energy savings.

The combined emissions of Village's three firehouses, 187 tCO_2e, almost matches that of the Municipal Building, as seen in Lines 1.3, 1.4, 1.5 in Table 2. Providing clean, safe potable water from the Village's wellfields at 340 Grand Street also is a major contributor to emissions. The pumping required to lift 400 million gallons a year through the system to hilltop storage tanks relies on electricity and is responsible for 369 (Line 2.T of Table 2) of the total 383 tonnes of emission generated by the water department. (Due to rounding, in Table 2 some "0" values understate actuals.)

Table 2: 2007 Government greenhouse gas emissions: Details by facility and activity

Sector details by facility/activity	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
1. Buildings and Facilities									
1.1 Municipal Building (1 Van Wyck St.)									
Electricity	113	1	5	113	6.4%	1,038	5.8%	$ 36,227	6.8%
Fuel Oil (#2)	61	0	9	61	3.4%	832	4.7%	$ 18,000	3.4%
R22 (Freon replacement)	24	0	0	24	1.4%	-	0.0%	$ 533	0.1%
Subtotal	**198**	**1**	**14**	**198**	**11.2%**	**1,870**	**10.5%**	**$ 54,760**	**10.3%**
1.2 DPW Garage (Gateway Plaza Garage)									
Electricity	33	0	1	33	1.9%	306	1.7%	$ 11,129	2.1%
Fuel Oil (#2)	3	0	1	3	0.2%	46	0.3%	$ 648	0.1%
Natural Gas	69	0	6	69	3.9%	1,295	7.3%	$ 19,334	3.6%
Subtotal	**105**	**0**	**8**	**105**	**5.9%**	**1,647**	**9.3%**	**$ 31,111**	**5.8%**
1.3 Harmon Firehouse (30 Wayne St.)									
Electricity	41	0	2	41	2.3%	375	2.1%	$ 13,819	2.6%
Fuel Oil (#2)	-	0	0	0	0.0%	6	0.0%	$ 90	0.0%
Natural Gas	33	0	3	33	1.9%	618	3.5%	$ 8,547	1.6%
R22 (Freon replacement)	8	0	0	8	0.5%	-	0.0%	$ 177	0.0%
Subtotal	**82**	**0**	**5**	**82**	**4.6%**	**999**	**5.6%**	**$ 22,633**	**4.3%**
1.4 Washington Engine Firehouse (81 N. Riverside Ave.)									
Electricity	16	0	1	16	0.9%	149	0.8%	$ 5,871	1.1%
Fuel Oil (#2)	31	0	5	31	1.7%	427	2.4%	$ 7,477	1.4%
Natural Gas	1	0	0	1	0.1%	13	0.1%	$ 357	0.1%
Subtotal	**48**	**0**	**6**	**48**	**2.7%**	**589**	**3.3%**	**$ 13,705**	**2.6%**
1.5 Grand Street Firehouse (154 Grand St.)									
Electricity	19	0	1	19	1.1%	179	1.0%	$ 5,988	1.1%
Fuel Oil (#2)	-	0	0	0	0.0%	6	0.0%	$ 90	0.0%
Natural Gas	38	0	4	38	2.1%	712	4.0%	$ 3,178	0.6%
Subtotal	**57**	**0**	**5**	**57**	**3.2%**	**897**	5.1%	**$ 9,256**	**1.7%**
1.6 Water Dept Office (340 Grand Street)							0.0%		
Electricity	2	0	0	2	0.1%	16	0.1%	$ 895	0.2%
Propane	14	0	2	14	0.8%	222	1.3%	$ 6,131	1.2%
Subtotal	**16**	**0**	**2**	**16**	**0.9%**	**238**	1.3%	**$ 7,026**	**1.3%**
1.7 Municipal Place Shop							0.0%		
Electricity	5	0	0	5	0.3%	46	0.3%	$ 2,461	0.5%
Propane	9	0	2	9	0.5%	138	0.8%	$ 3,800	0.7%
Subtotal	**14**	**0**	**2**	**14**	**0.8%**	**184**	1.0%	**$ 6,261**	**1.2%**
1.8 Recreation Building (at Water Dept)							0.0%		
Electricity	2	0	0	2	0.1%	19	0.1%	$ 1,654	0.3%
Propane	4	0	1	4	0.2%	61	0.3%	$ 1,654	0.3%
Subtotal	**6**	**0**	**1**	**6**	**0.3%**	**80**	0.5%	**$ 3,308**	**0.6%**
1.9 Municipal Place Trailer							0.0%		
Electricity	2	0	0	2	0.1%	18	0.1%	$ 1,012	0.2%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**18**	**0.1%**	**$ 1,012**	**0.2%**
1.10 Silver Lake Park (Truesdale Drive)									
Electricity	-	0	0	0	0.0%	3	0.0%	$ 190	0.0%
Subtotal	**-**	**0**	**0**	**0**	**0.0%**	**3**	0.0%	**$ 190**	**0.0%**
Total Buildings and Facilities	**528**	**3**	**43**	**528**	**29.8%**	**6,525**	**36.7%**	**$ 149,262**	**28.0%**

Sector details by facility/activity	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
2. Water Delivery									
2.1 Meter pit heat & pump (119 Old Post Rd)									
Electricity	55	0	2	55	3.1%	509	2.9%	$44,483	8.4%
Fuel Oil (#2)	3	0	1	3	0.2%	46	0.3%	$648	0.1%
Subtotal	**58**	**0**	**3**	**59**	**3.3%**	**555**	**3.1%**	**$45,131**	**8.5%**
2.2 Pumphouse #4 (340 Grand Street)									
Electricity	113	1	5	113	6.4%	1,041	5.9%	$37,255	7.0%
Propane	5	0	1	5	0.3%	83	0.5%	$2,230	0.4%
Subtotal	**118**	**1**	**6**	**118**	**6.7%**	**1,124**	**6.3%**	**$39,485**	**7.4%**
2.3 Pumphouse #1 (340 Grand Street)									
Electricity	94	1	4	95	5.4%	870	4.9%	$30,232	5.7%
Propane	9	0	2	9	0.5%	149	0.8%	$4,016	0.8%
Subtotal	**104**	**1**	**6**	**104**	**5.9%**	**1,019**	**5.7%**	**$34,248**	**6.4%**
2.4 Pumphouse #3 (340 Grand Street)									
Electricity	68	0	3	69	3.9%	630	3.5%	$23,630	4.4%
Propane	4	0	1	4	0.2%	65	0.4%	$1,766	0.3%
Subtotal	**72**	**0**	**4**	**73**	**4.1%**	**695**	**3.9%**	**$25,396**	**4.8%**
2.5 Mt. Airy Pump (Hessian Hills tank)									
Electricity	6	0	0	6	0.3%	53	0.3%	$1,108	0.2%
Propane	3	0	0	3	0.2%	42	0.2%	$1,108	0.2%
Subtotal	**8**	**0**	**1**	**8**	**0.5%**	**95**	**0.5%**	**$2,216**	**0.4%**
2.6 Pump #2									
Propane	5	0	1	5	0.3%	76	0.4%	$2,015	0.4%
Subtotal	**5**	**0**	**1**	**5**	**0.3%**	**76**	**0.4%**	**$2,015**	**0.4%**
2.7 Bungalow Road Duck Pond									
Electricity	2	0	0	2	0.1%	19	0.1%	$1,068	0.2%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**19**	**0.1%**	**$1,068**	**0.2%**
2.8 Prickley Pear Golf Course Heat tape									
Electricity	-	0	0	0	0.0%	-	0.0%	$1	0.0%
Subtotal	**-**	**0**	**0**	**0**	**0.0%**	**-**	**0.0%**	**$1**	**0.0%**
2.T **Total Water Delivery Facilities**	**367**	**3**	**20**	**369**	**20.8%**	**3,583**	**20.2%**	**$149,560**	**28.1%**
3. Vehicle Fleet									
3.1 Police Passenger									
Gasoline	109	6	6	111	6.3%	1,535	8.6%	$36,326	6.8%
Subtotal	**109**	**6**	**6**	**111**	**6.3%**	**1,535**	**8.6%**	**$36,326**	**6.8%**
3.2 Public Works-Heavy Duty Trucks									
Diesel	126	0	0	127	7.2%	1,729	9.7%	$36,902	6.9%
Subtotal	**126**	**0**	**0**	**127**	**7.2%**	**1,729**	**9.7%**	**$36,902**	**6.9%**
3.3 Public Works Pickup Trucks									
Gasoline	57	4	3	59	3.3%	809	4.6%	$17,649	3.3%
Subtotal	**57**	**4**	**3**	**59**	**3.3%**	**809**	**4.6%**	**$17,649**	**3.3%**
3.4 Public Works--Equipment									
Diesel	14	0	0	14	0.8%	192	1.1%	$4,106	0.8%
Off road Diesel	23	0	0	23	1.3%	313	1.8%	$6,691	1.3%
Off road Gasoline	2	0	0	2	0.1%	25	0.1%	$594	0.1%
Subtotal	**39**	**0**	**0**	**39**	**2.2%**	**531**	**3.0%**	**$11,391**	**2.1%**
3.5 Fire Department Light Truck									

Sector details by facility/activity	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
Gasoline	21	0	0	21	1.2%	296	1.7%	$6,994	1.3%
Subtotal	**21**	**0**	**0**	**21**	**1.2%**	**296**	**1.7%**	**$6,994**	**1.3%**
3.6 Fire Department Heavy Duty Equipment									
Diesel	23	0	0	23	1.3%	311	1.8%	$6,642	1.2%
Subtotal	**23**	**0**	**0**	**23**	**1.3%**	**311**	**1.8%**	**$6,642**	**1.2%**
3.7 Administration Passenger									
Gasoline	17	1	0	17	1.0%	241	1.4%	$5,705	1.1%
Subtotal	**17**	**1**	**0**	**17**	**1.0%**	**241**	**1.4%**	**$5,705**	**1.1%**
3.8 Public Works- Gasoline Light trucks									
Diesel	9	0	0	9	0.5%	126	0.7%	$2,666	0.5%
Subtotal	**9**	**0**	**0**	**9**	**0.5%**	**126**	**0.7%**	**$2,666**	**0.5%**
3.9 Fire Department Diesel Light Truck									
Diesel	9	0	0	9	0.5%	123	0.7%	$2,619	0.5%
Subtotal	**9**	**0**	**0**	**9**	**0.5%**	**123**	**0.7%**	**$2,619**	**0.5%**
Subtotal Vehicle Fleet	**410**	**12**	**10**	**415**	**23.4%**	**5,701**	**32.1%**	**$126,894**	**23.8%**
4. Streetlights & Traffic Signals									
4.1 Streetlights (659 fixtures @ average 125 W)									
Electricity	124	1	5	124	7.0%	1,142	6.4%	$57,447	10.8%
Subtotal	**124**	**1**	**5**	**124**	**7.0%**	**1,142**	**6.4%**	**$57,447**	**10.8%**
4.2 Outdoor Lighting (Gateway Plaza Parking Lot/Office)									
Electricity	22	0	1	22	1.2%	207	1.2%	$8,203	1.5%
Subtotal	**22**	**0**	**1**	**22**	**1.2%**	**207**	**1.2%**	**$8,203**	**1.5%**
4.3 Alexander Lane Ballfields									
Electricity	2	0	0	2	0.1%	22	0.1%	$7,956	1.5%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**22**	**0.1%**	**$7,956**	**1.5%**
4.4 Outdoor Lighting (Salt Shed/Rear Parking Lot)									
Electricity	8	0	0	8	0.5%	73	0.4%	$3,743	0.7%
Subtotal	**8**	**0**	**0**	**8**	**0.5%**	**73**	**0.4%**	**$3,743**	**0.7%**
4.5 Senasqua Park (Elliott Way)									
Electricity	12	0	1	12	0.7%	111	0.6%	$3,501	0.7%
Subtotal	**12**	**0**	**1**	**12**	**0.7%**	**111**	**0.6%**	**$3,501**	**0.7%**
4.6 Outdoor Lighting (N. Riverside Footbridge)									
Electricity	6	0	0	6	0.3%	52	0.3%	$2,790	0.5%
Subtotal	**6**	**0**	**0**	**6**	**0.3%**	**52**	**0.3%**	**$2,790**	**0.5%**
4.7 Outdoor Lighting (Section A Parking Lot)									
Electricity	3	0	0	3	0.2%	24	0.1%	$1,362	0.3%
Subtotal	**3**	**0**	**0**	**3**	**0.2%**	**24**	**0.1%**	**$1,362**	**0.3%**
4.8 Park Lighting (Black Rock)									
Electricity	2	0	0	2	0.1%	19	0.1%	$1,116	0.2%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**19**	**0.1%**	**$1,116**	**0.2%**
4.9 Outdoor Lighting (Croton Dam Road)									
Electricity	2	0	0	2	0.1%	19	0.1%	$1,102	0.2%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**19**	**0.1%**	**$1,102**	**0.2%**
4.10 Traffic Signals									
Electricity	2	0	0	2	0.1%	18	0.1%	$832	0.2%
Subtotal	**2**	**0**	**0**	**2**	**0.1%**	**18**	**0.1%**	**$832**	**0.2%**
4.11 Outdoor Lighting (Holiday Lights Benedict Blvd)									
Electricity	1	0	0	1	0.1%	9	0.1%	$491	0.1%
Subtotal	**1**	**0**	**0**	**1**	**0.1%**	**9**	**0.1%**	**$491**	**0.1%**
4.12 Outdoor Lighting (Veterans Corner)									

Sector details by facility/activity	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)
Electricity	-	0	0	0	0.0%	3	0.0%	$248	0.0%
Subtotal	**-**	**0**	**0**	**0**	**0.0%**	**3**	**0.0%**	**$248**	**0.0%**
4.T **Total Streetlights**	**184**	**1**	**8**	**184**	**10.4%**	**1,699**	**9.6%**	**$88,791**	**16.7%**
5. Wastewater									
5.1 Skyview pump									
Electricity	7	0	0	7	0.4%	63	0.4%	$2,678	0.5%
Subtotal	**7**	**0**	**0**	**7**	**0.4%**	**63**	**0.4%**	**$2,678**	**0.5%**
5.2 Nordica Drive Pump									
Electricity	7	0	0	7	0.4%	60	0.3%	$2,586	0.5%
Subtotal	**7**	**0**	**0**	**7**	**0.4%**	**60**	**0.3%**	**$2,586**	**0.5%**
5.3 1 Arrowcrest Drive									
Electricity	3	0	0	3	0.2%	28	0.2%	$1,953	0.4%
Natural Gas	4	0	0	4	0.2%	74	0.4%	$537	0.1%
Subtotal	**7**	**0**	**1**	**7**	**0.4%**	**102**	**0.6%**	**$2,490**	**0.5%**
5.4 Half Moon Bay River Club pump									
Electricity	3	0	0	3	0.2%	27	0.2%	$1,515	0.3%
Subtotal	**3**	**0**	**0**	**3**	**0.2%**	**27**	**0.2%**	**$1,515**	**0.3%**
5.T **Total Wastewater Facilities**	**24**	**0**	**2**	**24**	**1.4%**	**252**	**1.4%**	**$9,269**	**1.7%**
1-5T **Subtotal (sectors 1-5)**	**1,513**	**19**	**83**	**1,520**	**85.67%**	**17,760**	**100.0%**	**$523,776**	**98.4%**
6. Other Indirect Emissions									
6.1 **Employee Commute and Business Travel**									
a. Passenger car (412,966 miles)				181.84	10.2%	-		-	
b. Passenger rail (1,150 miles)				0.09	0.0%	-		-	
c. Air travel (850 miles)				0.83	0.0%	-		-	
Subtotal				**182.62**	**10.3%**	-		-	
6.2 **Groundskeeping**									
Fertilizer use (2,350 pounds)				9.79	0.6%	-		-	
Subtotal				**9.79**	**0.6%**	-		-	
6.3 **Maintenance Solvents**									
a. Lubricants (600 gallons)				48.59	2.7%	-		-	
b. Asphalt (300 short tons)				13.88	0.8%	-		-	
c. Aerosols (5,000 fluid ounces)				0.90	0.1%	-		-	
d. Paints (105 gallons)				0.39	0.0%	-		-	
Subtotal				**63.76**	**3.6%**	-		-	
6.4 **Solid Waste**									
Employee (17.21 short tons)				-1.89	-0.1%	-		$ 430	0.1%
Subtotal				**-1.89**	**-0.1%**	-		**$ 430**	1.5%
6.5 **Wind Power**									
Renewable energy credits (not included in CACP 2.0)				na		na		**$ 8,000**	**1.5%**
6.T **Total Other indirect emissions**	na	na	na	**254**	**14.3%**	na		**$ 8,430**	**1.6%**
Grand totals (sectors 1-6)	**1,513**	**19**	**83**	**1,774**	**100%**	**17,760**	**100%**	**$532,206**	**100%**
na= not available	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	(%)	Energy (MMBtu)	(%)	Cost ($)	(%)

The data in Table 1 and Figure 1 may be interesting. But it does not help us figure out what each department might do, until we resort all the energy and costs inputs by the Village department that incurred them. Figure 6 shows what each department (or budget category) contributes to the overall emission output. (See Figure 6; For a more detailed look at the composition of emission sources within each department, see Appendix A, Figure A1.)

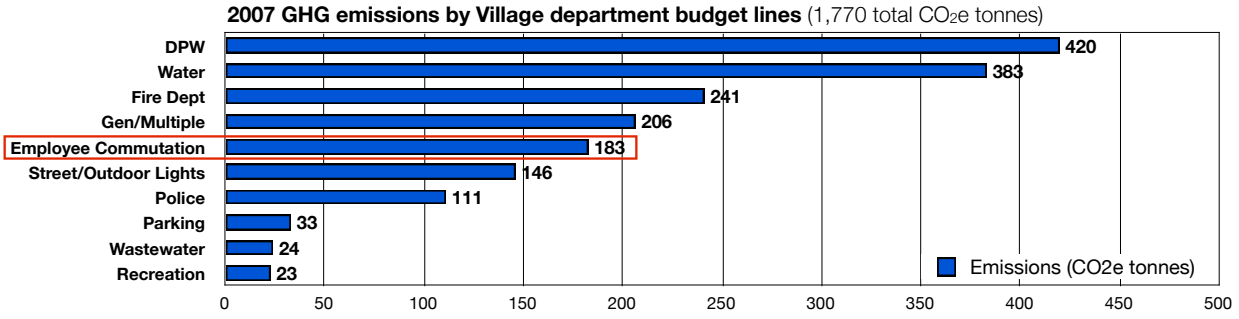


Figure 6: 2007 Greenhouse gas emissions by village department (CO_2e tonnes)

The DPW and Water service areas as the most emission intensive, when we arrange the 2007 greenhouse gas emissions as a bar chart for distinct budget areas within the Village's annual appropriations plans. If impact of employee commuting (in the red box) were a budgeted department, it would rank as the fifth largest emission source. (See Figure C1 in the Appendix C for a breakdown for each department.)

It can be helpful to examine this same data by type of energy or emission source across all sectors or departments. In Table 3, the cumulative contributions of each energy is listed by the same categories as in Table 2: emission volume, energy value, and cost. The energy emission types are arranged here in descending order of cost.

Table 3: Source report by fuel: costs, emissions, and energy consumed 2007

Emission Sources by energy type purchased	CO_2 (tonnes)	N_2O (kg)	CH_4 (kg)	CO_2e (tonnes)	CO_2e (%)	Energy (MMBtu)	Cost* ($)
Electricity	775	4	31	777	*43.80%*	7,148	$314,546
Gasoline	204	11	9	208	*11.72%*	2,881	$66,674
Diesel	181	0	0	182	*10.26%*	2,481	$52,935
Natural Gas	145	0	13	145	*8.17%*	2,712	$31,953
Fuel Oil (#2)	98	0	16	98	*5.52%*	1,363	$26,953
Propane	53	0	10	53	*2.99%*	836	$22,720
Offroad Diesel	23	0	0	23	*1.30%*	313	$6,691
R22/Freon replacement	32	0	0	32	*1.80%*	0	$710
Offroad Gasoline	2	0	0	2	*0.11%*	25	$594
Total purchased energy	**1,513**	**15**	**79**	**1,520**	***85.67%***	**17,759**	**$523,776**
Indirect emissions: commuting, solvents, etc				254	*14.3%*	na	$8,430
Grand total	**1,513**	**15**	**79**	**1,774**	***100%***	**17,759**	**$532,206**

Notes on compiling emissions by sector and department data *(Tables 2 & 3, Figures 5 & 6)*

In 2007, the Village's ten buildings and numerous other structured facilities–from the Municipal Building to the DPW garage–accounted for 35% of our emissions. The building represent about 60,000 square feet of conditioned space, that is, interior space heated in winter and cooled in summer. The village's fleet of cars, trucks, backhoes, tractors, and lawnmowers are the second largest source at 27%. Our municipally-owned and operated water delivery system is just behind that at 24%. The Village pumps about 400 million gallons of water a year from its wells in the Croton River Gorge up to storage and distribution tanks that then use gravity to send water to your faucet. Water is heavy; 1 US Gallon of water = approximately 8.35 pounds (3.78 kilograms). Electric pumps at the several pump houses between the well field and the hilltop tank do all that work. Streetlights are the most significant portion of the 12% of emissions that come from lighting and traffic signals. The wastewater facilities contribute 2% of the Village's overall emissions and reflect the pumping of wastewater from the Village up to the County's main lines that lead to treatment facilities. This 2% does not include the Village's pro-rated share of the energy used to run the County's water treatment plant as that data was not readily accessible. It is interesting to compare this pie chart (where the emissions come from) to the village budget pie chart on the preceding pages (where the money goes).

As Croton does not operate a bus fleet, this pie chart combines all vehicle data in the ICLEI CACP worksheets (Transit Fleet and Vehicle Fleet) into one data set (Vehicle Fleet) for the purposes of these snapshots. The data for each major sector are derived from the "Subtotals" for each sector (See Table 2).

CACP sums the emissions of CO_2, N_2O, and CH_4 in metric tonnes as "Equivalent CO_2"for the report. Note that we label these values more specifically in metric tonnes (t) as in "tCO_2e." rather than the the ICLEI label for the purposes of this report. One metric tonne = 2,204 US pounds. ICLEI uses international metric untis (metric tonnes, kilograms) rather than "British" units (pounds, tons). All of the scientific research in the US and rest of the world that forms the methodological basis for ICLEI"s Clean Air Climate Protection model uses the metric units. The equivalent carbon dioxide values for each village facility or activity come from the line item subtotals in Table 2. The equivalent carbon dioxide values for each village facility or activity used throughout this report derive from the line item subtotals in Table 2.

Sector 1, Lines 1.1 and 1.3 (R22): Regarding R22 (freon replacement) for numerous air conditioners in 2007, the Municipal Building Trane unit had 14 pounds replaced, jury room unit 6 pounds, and Historical Society unit 1.25 pounds, and the Harmon Firehouse had 10 pounds. replaced, each at a price of $25.00 per pound. A unit of R22 has a global warming potential (GWP) 1,780 times greater than the same unit of CO2. So for Mun Bldg the CO_2e in metric tonnes is: (14 + 6 + 1.25) lbs x 1,780 GWP= 37,825 lbs. Divide by 37,825 lbs by 2,204lb/t =17.2 tCO_2e. The 10 lbs of R22 for the Harmon Firehouse yields: 10 lbs x 1780 GWP= 17,800 lbs. Therefore, 17,800/2,204lb/t =8 tCO_2e.

Sector 6, Other Indirect Emissions: Had the Village stopped short of examining emission impacts of indirect activities (such as employee commutation, use of solvents, waste stream volume and management enumerated in sector 6 of Table 2), this report would have missed almost 1 in 6 of the tonnes of actual emissions (14.3%) that operating our village services and facilities produce.

Table 3 gathers all the purchased fuel data from Table 2 and aggregates them by type of fuel, arranged here in descending order of cost, which happens to coincide with emissions order.

Part 3: What does this mean? A closer look at the numbers

3.1 How much do we consume and spend by sector?

Let's ignore emissions for a moment. They are, after all, results caused by other activities. Let's look at the principal driver, energy consumption, and the cost of those energy choices. The energy consumption produces both a dollar cost result as well as an emission result. Numbers are just data ciphers until we see meaning in them that turns them into information we can use. Notice the close correlation between energy and costs for the first, second and fifth sectors, compared with large "gap" between the energy and cost for the third and fourth sectors. (See Figure 7.)

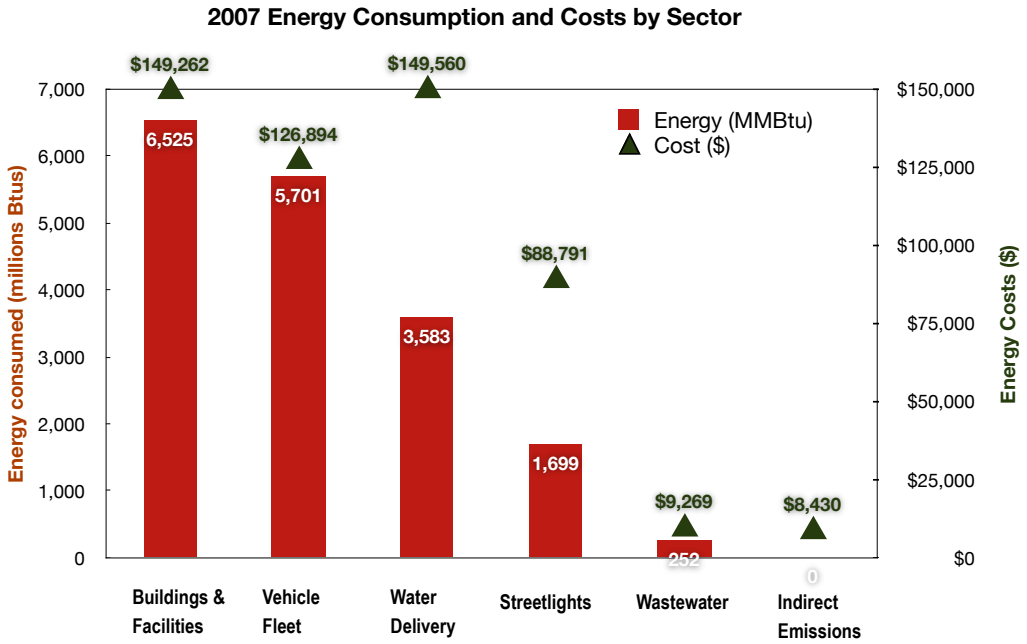


Figure 7: 2007 Village energy consumption and costs by sector (MMBtu and $)

The total energy consumed in 2007 by our major municipal sectors appears in the red bar and scale on the left in millions of British thermal units (0 to 7,000 MMBtus). The cost in 2007 dollars to taxpayers for that energy by sector is displayed by the green triangle and the dollar unit scale in the right ($0 to $160,000). This information comes from the two columns to the far right of the Table 1 (with energy data in red and cost in green).

At least two aspects of this energy versus cost information are noteworthy. First, we spend more energy dollars on our delivering water to the village's over 2,000 water customers ($149,560) than we spent on operating our 10 municipal buildings ($148,552), due largely to relying on electrically driven pumps for distributing municipal water combined with the relatively high cost of electricity per unit of energy. While the Village's per unit energy prices are lower than the retail prices that residents pay, these prices too are subject to inflation. For example, the Village's total energy expenses represented 3.5% of the total Village budget in 2007. Since then, electricity costs have climbed steeply due to rising transmission and distribution charges. Even if the Village managed to cap its demand for electricity, this inflation alone might add 30% to the village's electricity bill of circa $300,000 (in 2007), already the largest and most expensive portion of the Village's fuel energy mix. Second, as with water delivery, the energy cost for street lighting ($88,791) is disproportionally higher than the energy costs associated with vehicles or buildings, again due to the relatively high cost of electricity per unit of energy purchased.

Note on comparing consumption and cost (Figure 7)

The total 2007 greenhouse gas emissions for Village buildings and activities are 1,774 tonnes or 3,911,000 pounds. (A metric tonne is 2,204 pounds, slightly larger than a US "short" ton.) That translates into 488 pounds of greenhouse gas for each Croton resident that year. (See Section 3.3, " What does this mean to me as a citizen?") Carbon dioxide (CO_2) accounts for 99.5% our total emissions, as the first data column in Table 1 shows. (Note that the Village's total energy expense in 2007 ($532,000) represented about 3.3% of the total annual municipal budget that year of $16.05 million. By 2009-2010, with energy costs rising and total village appropriations lower than in 2007, energy costs rose to become a relatively bigger slice of the expense pie.) To examine the energy consumed versus cost for energy by sector, we sorted the CACP Summary Report output by the "Energy (MMBtu)" column (Table 1). We combined all CACP vehicle emissions data (vehicle and transit) into one data set ("vehicle fleet") for the purposes of this report, as the village has no real transit vehicle service.

3.2 What does this mean to me as a citizen?

The Village government's consumption of energy per resident in 2007 translates roughly as follows. In 2007, each Village resident's share of the energy bill was just over $66 ($532,000/8,000). Each resident's share of the energy consumed was just over 2.2 million Btus or 652 kilowatt-hours (1770 million Btu/8,000). The village operations resulted in just under 490 pounds of greenhouse gas emissions for each resident (1,500 metric tonnes/8,000). Each resident's share of village energy of circa 652 kWh ($66) per year is just a bit below what the typical modest family home might consume in an average month of between 800 and 1,000 kWh. (See Figure 8.)

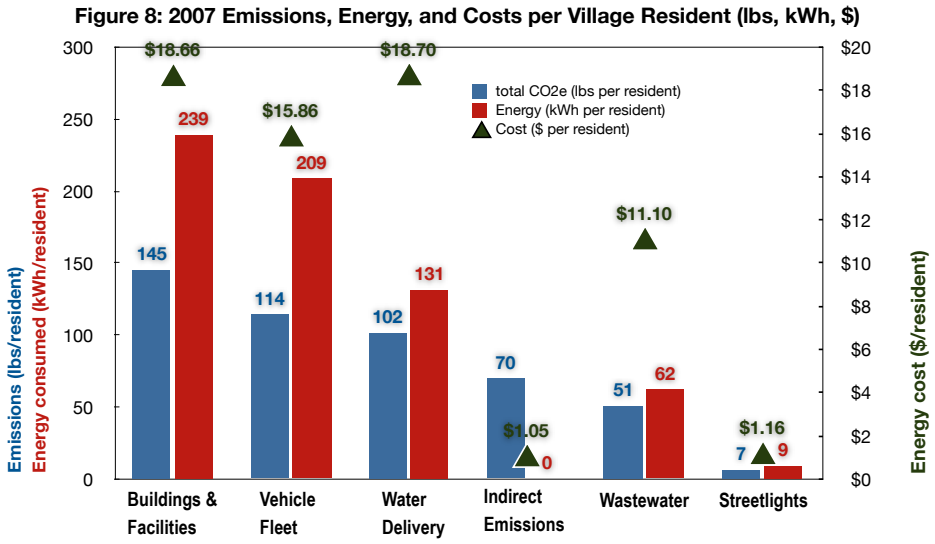


Figure 8: 2007 Emissions, Energy, and Costs per Village Resident (lbs, kWh, $)

Expanding on Figure 7, Figure 8 shows each Village resident's share of the costs, emissions, and energy consumed for each sector of village facilities and activities. The vertical bars on the left show the emissions volume in pounds and energy amount in kilowatt-hours for each major sector of village activity, respectively. The units on the vertical axis on the left (0 to 300) reflect identical scales in pounds and kilowatt-hours to make comparison easier. The dark triangles show the cost of the energy for each sector with the vertical axis on the right depicting the energy cost scale in dollars ($0 to $20).

Table 4: 2007 emissions, energy & costs per resident (lbs, kWh, $)

	Emissions* (CO_2e lbs per resident)	Energy** (kWh per resident)	Cost*** ($ per resident)	
1. Buildings and Facilities	**145**	**239**	$	18.66
3. Water Delivery	102	131	**$**	**18.70**
2. Vehicle Fleet	114	209	$	15.86
4. Streetlights & Traffic Signals	51	62	$	11.10
5. Wastewater	7	9	$	1.16
6. Other Indirect Emissions (Commuting, solvents, fertilizer, etc)	70	0	$	1.05
Total	489	650	$	66.53

* 1 (metric) tonne = 2,204 pounds
** 1 MMBtu = 1 million Btu = 293 kilowatt-hour
*** Croton resident population rounded to 8,000.

Notes on calculating the cost, energy, and emissions per resident *(Table 4 & Figure 8)*

To facilitate comparisons with other municipalities, we have rounded the Village's population to 8,000. To calculate per resident amounts, we combined both Transit Fleet and Vehicle Fleet from Table 2 under a single Fleet sector. Because kWh and pounds may be more familiar units to area residents that the units used throughout the ICLEI protocol (MMBtus and metric tonnes), we added columns to convert Btus to kWh, and metric tonnes to pounds (Croton resident population rounded to 8,000; 1 (metric) tonne = 2,204 pounds; and 1 MMBtu = 1 million Btu = 293 kilowatt-hours). We then calculated per resident quantitIes for total emissions of all gases, energy, and costs based on the the totals for each sector (See Table 2), which we then converted to Figure 8 above. The top value in each column is indicated in bold in Table 4 above, which is sorted in descending order of per resident costs.

3.3 Comparing cost, emissions, and energy contributions by fuel used

How do different fuels compare in cost, emissions, and energy contribution? Electricity is the largest source of greenhouse gas emissions in the Village, the largest fuel cost (60%) and largest source of energy consumed. equivalent to 51% of greenhouse gases emitted–and is also the fuel source that produces the most emissions (40%). As shown in the Table 5 below, we can examine the relative percent of costs, emissions, and energy consumed that each fuel type represents.

Table 5: 2007 Village energy cost by energy unit per fuel source ($/MMBtu)

Fuel Source	Emissions (%CO_2e)	Energy (MMBtu)	Cost ($)	Cost/Energy ($/MMBtu)	Cost/Energy ratio, if electricity =$1
Electricity	51.1%	7,148	$314,546	$44.00	$1
Gasoline	13.7%	2,881	$66,674	$23.14	$0.53
Diesel	11.9%	2,481	$52,935	$21.34	$0.49
Natural Gas	9.5%	2,711	$31,953	$11.79	$0.27
Fuel Oil (#2)	6.6%	1,362	$26,953	$19.79	$0.45
Propane	3.5%	836	$22,720	$27.18	$0.62
Offroad Diesel	1.5%	313	$6,691	$21.38	$0.49
Offroad Gasoline	0.1%	25	$594	$23.76	$0.54
R22 Freon replacement	0%	0	$710	na	na
Sum:	**100%**	**17,757**	**$523,776**	**$24.05**	**Average**

The relative contributions toward costs, emissions, and energy consumed for each fuel type are depicted graphically in Figure 9. This chart helps show which fuels deliver more energy for less cost.

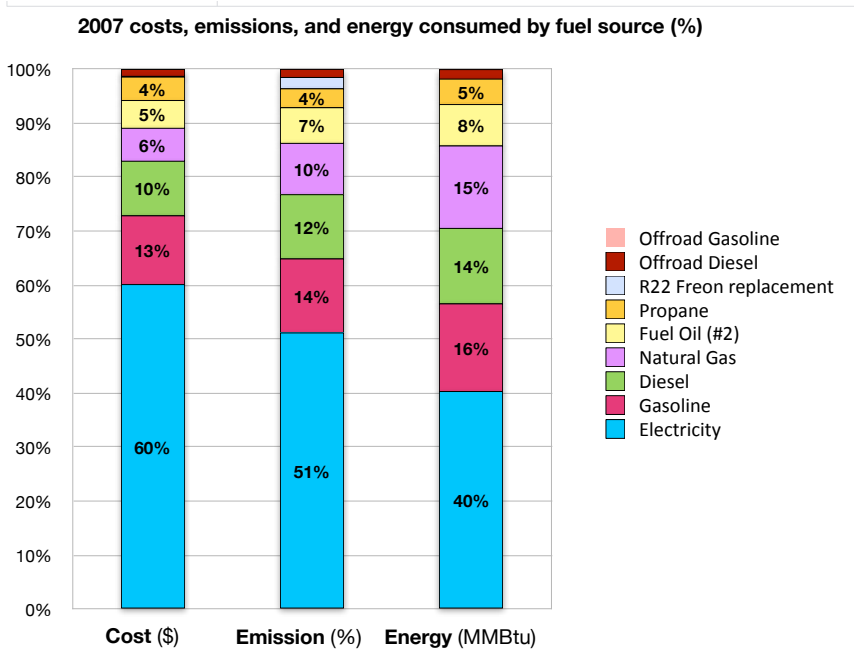


Figure 9: 2007 Village costs, emissions, and energy consumed by fuel source (%)

In 2007, electricity represented 60% of the village's energy costs, 51% of the resulting greenhouse gas emissions, and 40% of the total energy consumed. By contrast, natural gas was a relatively cheap fuel as only it was only 6% of the cost, but produced 15% of the energy we needed. Emissions is measured for all the gases as the equivalent in carbon dioxide (CO_2e).

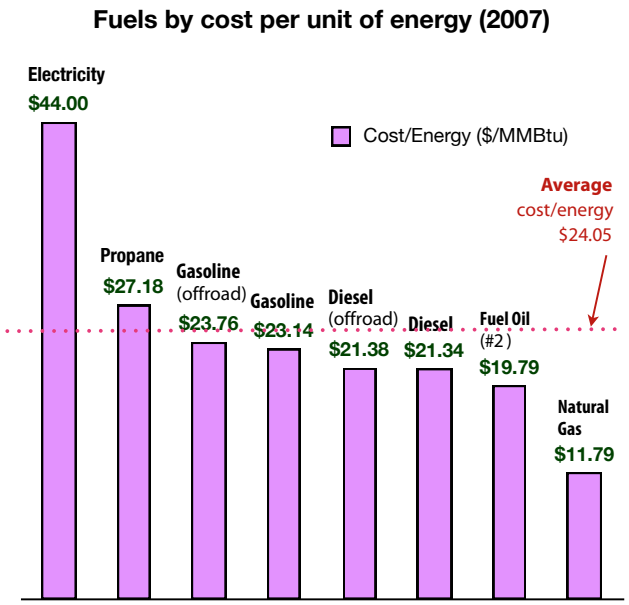
On a dollar per unit of energy basis, electricity is the most expensive fuel for the energy value we obtain from it. Each $1 we spent on electricity produced the same amount of energy (in Btus) as $0.27 spent on natural gas. (See Table 5 and Figure 10.)

Figure 10: Fuels by cost per unit of energy ($/MMBtu)

In the second bar chart on the right, we see the relative cost of each fuel per unit of energy for 2007, equalized on a $ per million Btu basis. The data for this chart may be found in Table 3.3a.

Of course, many activities are fuel specific. Our computers or streetlights cannot run on natural gas, at least not without a major conversion.

But some activities can be powered by fuels different from what we now use, often in the heating and cooling of buildings. For example, the heating plant in the Municipal Building basement might be a candidate for installing "dual fuel" capacity to allow us to switch to a lower emission fuel such as natural gas when that fuel is cheaper than fuel oil.



Electrifying our fleet might reduce gasoline emission and air pollution here in the Village. For example, if we had electrified half the village car fleet that ran on gasoline in 2007, our gasoline bill would have dropped significantly. But how much would our already large electricity bill have gone up to provide the equivalent energy for the passenger vehicles? As we see from the very rough scenario in Table 6, the village would save over $26,000 a year in fuel costs by electrifying fifty percent of the fleet's gasoline miles.

Table 6 Electrifying the fleet: an example of fuel cost savings

Steps		Assumptions
a) total gasoline costs	$66,674	From Table 3.3a above.
b) share being electrified	50%	Assume half the fleet vehicles (not police sedans) are electrified
c) gas cost being replaced with kWh	$33,337	**(a * b)**
d) price per gallon gas	$2.50	This gas cost may be lower than $2.50 for village via state contract
e) # gallons being replaced	13,335	**(c / d)**
f) MPG for that gas	20	Typical fleet average for non-police vehicles
g) miles that gas yielded	266,696	**(e / f)**
h) miles per kWh that e-car gets	5	Range is 4 to 6 miles per kWh, and is rising each year as is the battery storage, currently at about 10-12 kWh (yielding 55-60 miles per charge).
i) # kWh needed for equivalent miles	53,339	**(g / h)**
j) $ per kWh	$0.13	Vehicles likely to be charged at off peak, cheaper times (at night).
k) electricity costs	$6,934	**(i * j)**
l) difference	**$26,403**	Hypothetical net annual savings in fuel cost for electrifying 50% of village fleet's gasoline miles.

Every decision has consequences. This electricity for a new fleet has to be produced somewhere. Unless we produce that electricity by renewable or low emission means, higher electricity demand often means burning fossil fuel elsewhere or trapping heat from nuclear fission. Smog from tailpipe pollution tends to be produced locally and dissipate locally. But the greenhouse gases are very different. Once carbon is airborne, it remains aloft for hundreds of years spreading very widely in the windy layers of the atmosphere. In short, our carbon in New York is your carbon in California, and vice versa. We should consider electrifying our fleet, but all such choices need to be thought through carefully.

Notes on energy costs, amount and emissions by fuel *(Figure 6 & Table 5)*

To calculate the relative contributions to cost, emission, and energy that each fuel source represents (as a percent), we sorted the CACP Report by Source data for cost, equivalent CO_2 (CO_2e), and energy by cost. We divided the energy cost by the energy consumed for the cost per million British thermal units (MMBtu). See the complete details in Table 2). Table 5, which includes all the energy fuel costs except the renewable credit expense for wind power, $8,000, a factor not calculable in the current version of CACP.

3.4 What pollutes and how much?

In addition to greenhouse gases, the CACP protocol calculates the pollutants the result from energy sources. The Village of Croton-on-Hudson was also responsible for the release of air pollution in 2007. As defined by the federal government, pollutants are substances that are toxic, carcinogenic, or harmful in other direct ways to living organisms (See www.epa.gov/air/urbanair/). Under the U.S. Clean Air Act, certain pollutants, called "criteria air pollutants" are regulated. Sulfur compounds are linked to acid rain; nitrogen compounds are linked to smog. Like dust and particulate emissions, smog is a respiratory health hazard. The five major criteria air pollutants tracked by

the government are listed in Table 7 below. As with toxic emissions, the emission of category pollutants must become more stringent to offset the growing total volume of these emissions.

Table 7: US EPA government criteria air pollutants tracked by the 2009 CACP protocol

Compound:		Sources:
CO	carbon monoxide	Emission resulting from incomplete fossil fuel combustion
NO_x	oxides of nitrogen	Emission resulting from nitrogen and oxygen in the air combining at the high temperatures of combusting fuel
PM10	particulate matter	Particles (10 microns in size) that become airborne after fossil fuel combustion
PM2.5	particulate matter	Particles (2.5 microns in size) that become airborne after fossil fuel combustion
SO_x	sulfur oxide	Emission resulting from the sulfur found in fossil fuels
VOC	volatile organic compounds	Complex carbon-based compounds, often carcinogenic, resulting from industrial uses of fossil fuels.

The US government has set specific limits on the amount of emission allowed from certain emissions that pollute, that is, they are known as toxic, carcinogenic, or otherwise harmful to living organisms in large doses: carbon monoxide (CO), Nitrogen oxide (NO_x), sulfur oxide (SO_x) ,volatile organic compounds (VOC), and particulate matter of various sizes (PM10, PM2.5). For sectors calculated in the CACP protocol, Table 8 displays the results.

Table 8: 2007 Government criteria air pollutant emissions: By sector and type (pounds)

Pollutants by sector and type (pounds)	carbon monoxide (CO)	nitrogen oxide (NO_x)	sulfur oxide (SO_x)	volatile organic compounds (VOC)	particulate matter (PM10)	Total by sector
2. Vehicle Fleet	16,315	4,740	192	1,771	214	**23,232**
1. Buildings & Facilities	2,027	6,978	2,502	561	992	**13,060**
3. Water Delivery	1,002	1,233	3,067	125	841	**6,268**
4. Streetlights	516	526	1,661	58	449	**3,210**
5. Wastewater	57	67	174	7	47	**352**
Total by pollutant	**19,918**	**13,545**	**7,596**	**2,522**	**2,543**	**46,124**

These pollutants are byproducts of the industrial process and easier to reduce than greenhouse gases. For example, switching to low sulfur coal reduces the sulfur oxide released on combustion. First, vapors that leak from fossil fuels before combustion contribute to air pollution, so sealing tanks reduces that source. When we smell gasoline, our nose is detecting volatile organic compounds. Industrial use of fossil fuels produces volatile organic compounds (VOCs), either directly as products, e.g. gasoline, or indirectly as byproducts, e.g. the compounds found in smokestack. Methane (CH_4) is a VOC that–like carbon dioxide–occurs naturally, but has become far more prevalent due to human use of fossil fuels and agriculture. Second, some hazardous compounds such as the sulfur oxides (SO_x) result from sulphur present in the fossil fuel being released by burning. The sulfur compounds combine with water molecules in the atmosphere to become acid rain. Others, such as carbon monoxide (CO) and family of more complex, carcinogenic volatile organic compounds (VOCs) come from the incomplete combustion of fossil fuels. Better combustion and catalytic exhaust converters reduce those emissions. A third group, such as nitrogen

oxides, form when nitrogen from the atmosphere combines with oxygen during the burning of fossil fuels. Fourth, solid material present in the fuel that does not burn survives as particles that become airborne. These dust particles are often very small in size (less than 10 microns or one millionth of a meter) and can travel deep into our lungs when we breath.

We can deduce the fuel used for each sector based on the "pollution fingerprint" of that sector. The biggest pollutants by sectors reveal what kind of energy drives that sector the most. The left hand set of bar charts in Figure 11 clearly shows our vehicle fleet is the number polluter, largely due to the reliance on the internal combustion engine burning gasoline or diesel. Two thirds of the fleet's pollution (almost 16,000 pounds) is in the form of carbon monoxide. Note, that the sulfur oxide (SO_x) is negligible for the fleet, whereas it is the second biggest component for the buildings, water delivery, and lighting sectors. We use lots of coal to produce electricity, and a common impurity in coal is sulfur, which becomes the catalyzing component for acid rain when burned.

The right hand set of bar charts in Figure 11 on the right show that carbon monoxide leads this group of air pollutants in the Village, largely due to fleet miles. Buildings are the largest source of nitrogen oxide, a byproduct of the coal burned for electricity. Notice that the largest component of the sulfur oxide is the water delivery system. That is because the Village water system uses electricity to do virtually all its work of pumping water. Electricity is a smaller portion of the overall fuel picture for our buildings than it is for water or streetlights and traffic signals.

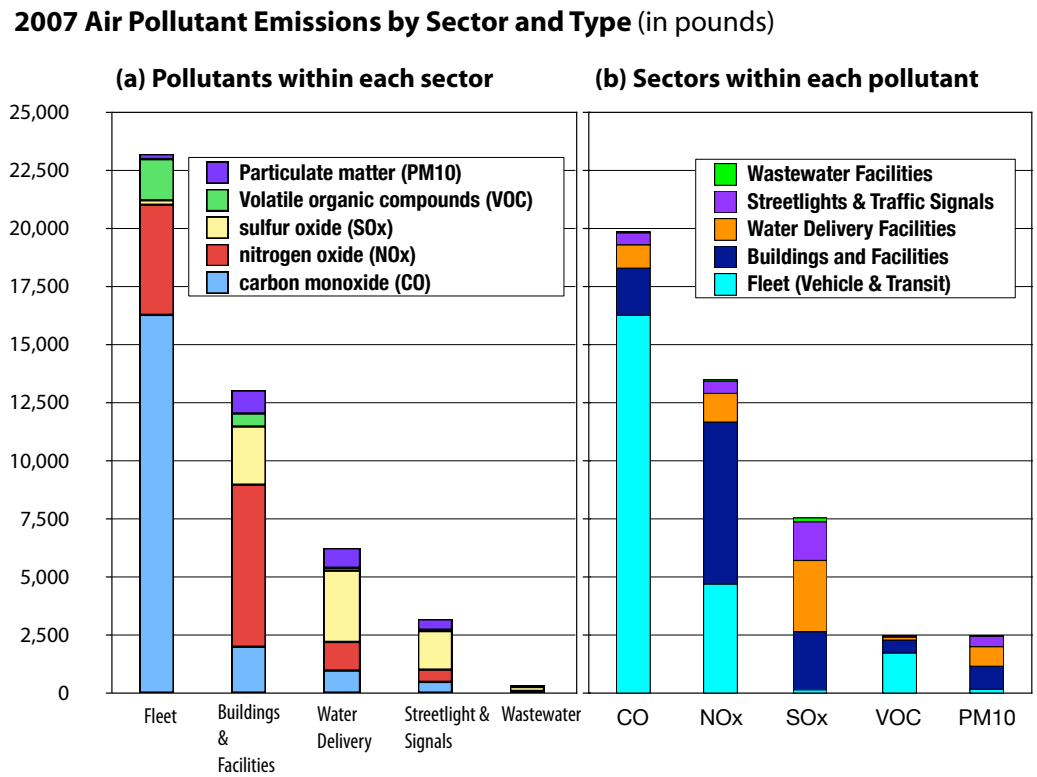


Figure 11: 2007 Village air pollutant emissions by sector and type (pounds)

Village operations caused the release of criteria air pollutants in 2007 totaling 46,124 pounds (or 21 metric tonnes) in addition to the greenhouse gas emissions of over 1,500 metric tonnes. Figure 11 shows two views, (a) and (b), of the same data listed in Table 2. The scale on the far left (0 to 25,000 pounds) is the same for both charts. The first bar chart (a) on the left shows the total volume of air pollutant emissions for each sector of village activity. The second (b), on the right, show the total volume of pollutants for each category of specific pollutants. Either way, adding up all the bar segments in (a) comes to 46,124 pounds as does adding up all the bar segments in (b). The data for these figures comes from Table 8. These figures do not include the pollution impact of the indirect emissions (commuting, solvents, fertilizers use), because the CACP model did not allow that calculation. The air pollution of the 412,000 commuting miles by employees alone is very considerable, but again, not shown here.

Notes on criteria air pollutant methodology *(Figure 11)*

We created bar charts based on CACP Air Pollution data table from the "Government Criteria Air Pollution" figures generated by the CACP protocols. We resorted this data to place the sector that emits the largest volume of all pollutants in the top row and first columns of the table for ease of reference (for right hand table) and the largest volume pollutant (CO) on top row and first column (for the left hand chart). For bar chart (a) we placed the sector data (Fleet, etc) on the bottom horizontal axis. For bar chart (b), we flipped the rows and columns to place the pollutant data (CO) on the bottom horizontal axis. As Croton does not operate a transit fleet, we combined all vehicles (Transit Fleet and Vehicle Fleet) into one data set (Fleet), even though CACP protocol suggests separating the two.

Appendix A: Our data collection and conversion methods

All the data in Table 2 for sectors 1 (Buildings and Facilities) through 5 (Wastewater Facilities) were calculated using the ICLEI CACP protocols. The data for sector 6, Other Indirect Emissions (including the greenhouse gas impact of village employee commutation and business travel, the village's use of solvents and fertilizer, and generation of solid waste) needed to be calculated using methods outside the CACP protocols. These non-CACP methods are explained briefly here. We welcome feedback toward improving the data collection and analysis tools.

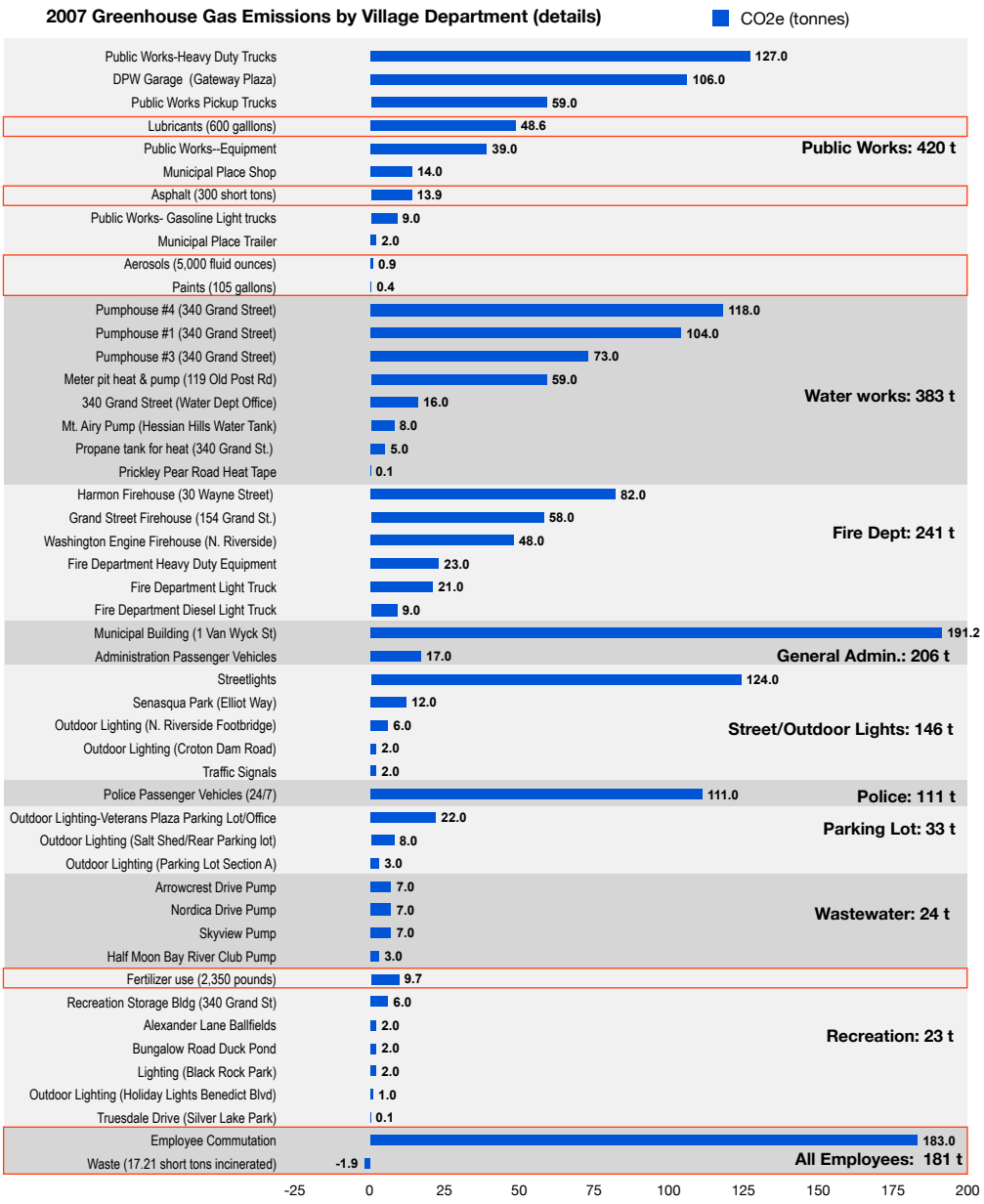


Figure A1: Bar chart of detailed emission sources by village department

The horizontal scale shows metric tonnes of CO_2e (tCO_2e) for each source within a village department. The departments are arranged in descending tonnage order and within departments by order of descending sources Emission inside a red box are indirect sources (See sector 6 in Table 2). The initial inventory yielded ~1,550 tCO_2e. These indirect sources added another ~250 tCO_2e, once they were identified and calculated. Had we limited our inventory to the direct sources available from our energy purchases, we would have underestimated the greenhouse gas emissions of village operations by over14%.

Figure A1 shows the major components of each department's emissions. Note that only one item, "Waste" under General Administration, offers a negative net emission value. Why? Because the village's solid waste is incinerated through the Westchester County facility in Peekskill, operated by Wheelabrator. Incineration to generate energy from waste avoids the methane release from landfill that same material. Hence the net reduction in greenhouse gas emission for this one item. (See Figure A1.)

The most significant indirect emission source is commutation by village employees. We used a survey completed by 57 out of 81 employees to determine commuting distances, modes, and the extent of any village-related business travel. The survey was made available to all employees in either paper or digital form. The digital form employed the free "basic"tool available at Surveymonkey.com. The survey analysis is summarized in Table A1. The text of the survey and number of responses per question is depicted in Table A3.

Table A1: Converting Employee Commutation and Travel to Emission Impacts

Employee Commute and Travel Data (2007)			
1	Average roundtrip commute	24.4	miles
2	Average number of days in 2007 commuted	208	days
3	Total commute miles reported by survey respondents	297,492	miles
4	Percent of commuters who drove automobile	100.0%	%
5	Percent of employees who responded to survey	70%	% (57 out of 81 employees)
6	Extrapolated commutation vehicle miles for all employees	**411,091**	miles
Employee Travel for Village business outside Westchester County			
7	Number of out of county trips	39	trips (in all modes of travel)
8	Percent of trips in which village employees carpooled	33%	trips (13 out of 39 total trips)
9	Total passenger vehicles miles for those trips	**1,875**	miles (22 solo and 13 carpool trips)
10	Total rail miles for travel	**1,150**	miles (3 trips)
11	Total airplane miles for travel.	**850**	miles (1 trip)
Cumulative Greenhouse Gas Emission Impacts from Employee Commutation and Travel			
		miles	**GHG impact (tCO_2e)**
6.1a. Total Village Employee Passenger Car miles (line 6+9)		**412,966**	**181.840**
6.1b. Total Village Employee Passenger Rail miles (line 10)		**1,150**	**0.082**
6.1c. Total Village Employee Air Travel miles (line 11)		**850**	**0.826**
			182.748

Notes on conversion of miles to emission impacts *(Table A1)*

6.1a. Employee passenger car miles: Assuming an automatic 4 cylinder (2.2 liter) 2003 model sedan using regular gasoline with average 20 miles per gallon emits 8.806 kg CO_2/gallon, over the 412,996 commutation and business travel miles in 2007 by village employees, the emission result is (412,966 miles/20 mpg) * (8.8 kg CO_2/gallon)/1000= **181.84 tCO_2e.**

6.1b Employee passenger rail miles: Assuming commuter rail diesel fuel efficiency of 134.43 passenger miles/gallon, and 9.987 kg CO_2/gallon, the 1,150 passenger rail miles by village employees in 2007, the emission result is: (1,150 miles/134.43 mpg) * (9.987 kg CO_2/gallon)/1000= **0.085 tCO_2e.**

6.1c. Employee air travel miles: Assuming air travel emission of 0.972 kg/CO_2 per passenger mile, the emission result is (0.972 kg/CO_2) * (850 miles)/1000= **0.826 tCO_2e.**

See conversion factors from Clean Air–Cool Planet below (in Table A2) www.cleanair-coolplanet.org .

Table A2: Emissions conversion by fuel type

	kg CO_2 / Gallon	MMBtu/passenger mile	kg CO_2/mile	kg CH_4/mile	kg N_2O/mile
Gasoline Fleet	8.806370549				
Diesel Fleet	9.987005662				
Air		0.004931815	0.971806514	0.00000953	0.000011
Train		0.002806075	0.225702106	0.0000036	0.00000353

[Source: Clear Air–Cool Planet www.cleanair-coolplanet.org]

Table A3: Employee Commutation Questionnaire

Q1. I worked for the village for some or all of period between January 1, 2007 and December 31, 2007.
[answered question; 58 of which 50 (86%) were employees in 2007; skipped question 0]

Q2. How far did you travel each trip to work in 2007? (Enter the number of miles in a typical round trip. For most people this is the distance between your home and place of work. Round off to the nearest mile.)
[answered question 57; skipped question 1]
Average distance 24.3 miles (range: 1 - 90 miles)

Q3. What was the most common way that you commuted to your village job during 2007? (check one)
[answered question 55 ; skipped question 3]

Walk	0%
Bicycle	0%
Passenger car	100%
Mass transit bus only	0%
Mass transit train only	0%
Mass transit combination of bus and train	0%

Q4. Did you drive to work alone or carpool in 2007? (check one) We want to know the most common pattern you followed. (54 responses)
[answered question 54 ; skipped question 4]

alone 53	
carpool	1

Q5. How many days per year do you travel to work? (fill in number) You would have commuted 250 days in a year, if you worked 5 days a week for the 50 weeks and took a 2 week vacation. A typical work year has 260 work days. (57 responses)
[answered question 57 ; skipped question 1]
Average # commuting days: 209

Q6. If you travelled outside Westchester County for village-related business during 2007, tell us about the trips by selecting the transportation mode and distance for each one (trip) below. If you repeated a trip on more than one occasion in 2007, indicate that in the third menu column below.
[answered question 20 ; skipped question 38]

# of Trips	Travel Mode	# of Trips	Roundtrip Distance
22 trips	Passenger car alone	22	< 100 miles
13	Passenger car carpool	7	between 100-200 miles
3	Train	1	between 201-300 miles
0	Bus	6	between 301-400 miles
1	Airplane	1	between 401-500 miles
0	Other	1	between 501-800 miles
39	total trips	1	more than 801 mile
		39	total trips

Q7. You can leave any other comments here in this text box. Thank you.
[answered question 7 with comment; skipped question 51]

The Village contracts with the turf maintenance firm for upkeep on its lawns and athletic fields. In 2007, this work deployed fertilizer four times between early April and late October for a total of 2,350 pounds of various fertilizer compounds. We estimate this volume to have released 9.67 tCO_2e. (See Table A4).

Table A4: Converting fertilizer use to emission impacts

Converting fertilizer use to emission		
6.2. Fertilizer Use		**units**
a) volume by weight	2,350	*pounds*
b) conversion factor	0.004166173	*tCO_2e/lb*
total (a*b)	**9.79**	***tCO_2e***

How did the Village address the use of solvents in this inventory? Based in invoices and expenditures for calendar 2007, the staff came up with the following usage estimates: 600 gallons of lubricants (motor oils, grease, transmission fluid); 5,000 fluid ounces of aerosol solvents; 300 tons of asphalt; and 105 gallons of paint. (See Table A5.)

Table A5: Converting solvent volumes to emission impacts

Solvent volume to emission conversion

6.3a. **Lubricants**		**units**
a) volume	**600**	***gallons***
b) CO_2 content in lb/gallons	7.5	*lb/gal*
c) CO_2 in lb per lb of oil	23.8	*lb/gal/lb oil*
d) GWP	1	*na*
e) subtotal	107,100	*CO_2e in lbs*
f) conversion to metric tonnes	0.00045372	*metric tonne/lbs*
total (a*b*c*d*e*f)	**0.00**	***tCO_2e***

6.3b. **Asphalt**		**units**
a) volume	**300**	***short tons***
b) CO_2 content in lb/gallons	7.5	*lb/gal*
c) fuel needed per ton of asphalt mix	2	*gallons/ton mix*
d) GWP	6.8	*$1/CO_2e$*
e) subtotal	30,600	*CO_2e in lbs*
f) conversion to metric tonnes	0.00045372	*metric tonne/lbs*
total (a*b*c*d*e*f)	**13.88**	***tCO_2e***

6.3c. **Aerosols**		**units**
a1) volume	**5,000**	***fluid ounces***
a2) volume conversion to gallons	128	*fluid ounces/ gallons*
b) CO_2 content in lb/gallons	7.5	*lb/gal*
c) fuel needed	1	*na*
d) GWP	6.8	*$1/CO_2e$*
e) subtotal	1,992	*CO_2e in lbs*
f) conversion to metric tonnes	0.00045372	*metric tonne/lbs*
total (a1*a2*b*c*d*e*f)	**0.00**	***tCO_2e***

6.3d. **Paint**		**units**
a1) volume	**105**	***gallons***
a2) volume conversion to gallons	0.1	*VOC evaporation rate*
b) CO_2 content in lb/gallons	12	*lb/gal*
c) fuel needed	1	na
d) GWP	6.8	*$1/CO_2e$*
e) subtotal	856.8	*CO_2e in lbs*
f) conversion to metric tonnes	0.00045372	*metric tonne/lbs*
total (a1*a2*b*c*d*e*f)	**0.39**	***tCO_2e***

What is the amount of trash per employee figure that a municipality should use? That depends on a number of factors: Is there active recycling of paper, plastics, metals at the workplace? How is the resulting solid waste handled downstream? Does the municipality measure the solid waste its own operations create? Is organic waste matter handled separately?

The Village offices do recycle. Organic waste principally in the form of yard waste is handled separately, but was not calculated for 2007 as the volume data was not readily available. The remaining solid waste is handled as part of the County's refuse district. This district uses the Charles Point Resource Recovery Facility in Peekskill, an energy from waste incineration plant, that is operated by Wheelabrator (For more, visit "Environmental Facilities Department" at www.westchestergov.com.). (See Table A6.)

Table A6: Converting office employee waste to emission impact

Converting office waste to emission		
6.4. **Waste**		**units**
a) estimated per employee day	1.7	*pounds*
b) # employees	81	
c) workdays/ year	250	
d) annual waste (a*b*c)	34425	***lbs/yr***
e) conversion to short tons (d/2000)	17.21	***short tons/yr***
f) conversion factor (incineration with energy from waste)	-0.11	*tCO_2e/ short ton*
total (e*f)	**-1.89**	***tCO_2e***

Notes on conversion of fertilizer to greenhouse gas emission impact (Table A4)

6.2 Fertilizer applications: In 2007, Turf managment records showed the following applications: April, Calvacade @ 400 lbs; May, Greenyard W&F @400 lbs; June, Greenyard W&F @ 500 lbs and Triplet @ 3 gallons; September, Bifenthrin@ 500 lbs; October, 18-24-12 fertilzer @ 500 lbs. We assumed worst case that these all comprised synthetic compounds that yield 0.004166173 tCO_2e/lb in a mix of CO2, N2O, and CH4, versus 0.004166173 tCO_2e/lb from organic fertilizers. [Source: Clear Air–Cool Planet www.cleanair-coolplanet.org]

Notes on conversion of solvent to greenhouse gas emission impact (Table A5)

6.3a Lubricants: We assumed 600 gallons of lubricants (motor oils, grease, transmission fluid) would have the emission impacts as as #2 oil. The big question is how it was disposed of. We made a worst case assumption, all of it was burned in a waste boiler, since that is common. The emission impact of burning #2 oil is 7.5 lb/gallon. For 600 gallons, this yields 7.5 lb/gal x 600 = 4500 lbs @ 23.8 lb CO_2 / lb of oil / 2204 lb per tonne = **48.59 tCO_2e**.

6.3b Asphalt: Assuming 2 gallons of fuel is consumed per ton of hot asphalt mix produced, this equates to about 50 lbs CO_2e per ton mix. Multiplying this by 300 tons of asphalt yields: 300 tons x 2 gal/ton x 7.5 lb/gal x 6.8 GWP = **13.88 tCO_2e**.

[Source http://www.hotmix.org/index.php?option=com_content&task=view&id=449&itemid=72]

6.3c Aerosols: Under the conservative assumption for aerosols that both the propellant and fluid content are comprised of volatile organic compounds of with emission content of 7.5 lbs CO_2e per gallon and GWP of 6.8 factor, 5000 fluid ounces at 128 ounces per gallon and 7.5 lb /gallon yields 5000/128 x 7.5 = 293 lb x 6.8 lb CO_2e/lb = **0.90 tCO_2e**.

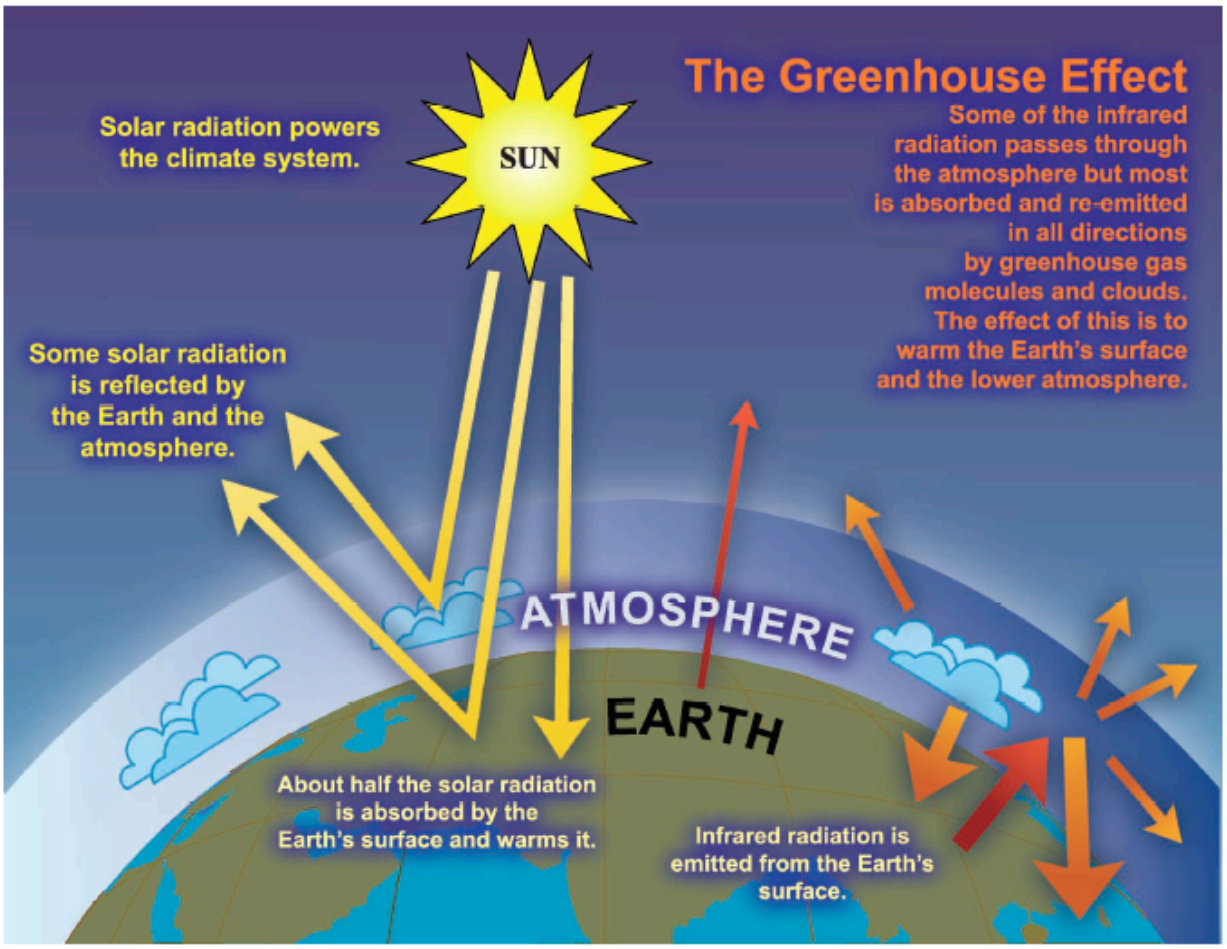
6.3d Paint: The paint volume–10 gallons for the Municipal Garage plus 25 gallons of primer and 50 gallons of paint for Municipal Building, plus 30 gallons for other miscellaneous work, bollards, fences, signs, outdoor recreation courts, etc. (assuming 300 square feet/gallon)–yields a total of 105 gallons. At 10% volatile organic compound (VOC) evaporation from the paint and an average global warming potential (GWP) in terms of CO_2e for VOC of 6.8, this yields 105 gal x .1 x 12 lb/gal x 6.8 = 856.8 lbs CO_2e/ 2204 lbs= **0.39 tCO_2e**.

Notes on conversion of village office waste to greenhouse gas emission impact (Table A6)

6.4 Solid Waste: The waste per village employee calculation relied on an average of the 1.7 pounds per workday per employee. For 81 people and 250 workdays/year, that yields 34,425 lb/yr, or 17.21 short tons per year. Incineration in energy from waste facilities eliminates any option for methane formation as would occur were the trash to be landfilled, but it also adds a component for the fuel used to burn the garbage. CACP rev. 6.4 shows a net credit for energy from waste incineration since it eliminates that methane formation: it subtracts 0.11 tCO_2e per short ton of trash. Multiplying that factor by the 17.21 short tons of office trash yields a credit of 1.89 tCO_2e. [Source: Keep America Beautiful Toolbox www.kabtoolbox.org/aboutus2.asp?id=389 :under Tools, click on Overview.]

Appendix B: Greenhouse gas science in a few pictures

Figure B1: The Earth's greenhouse gas effect

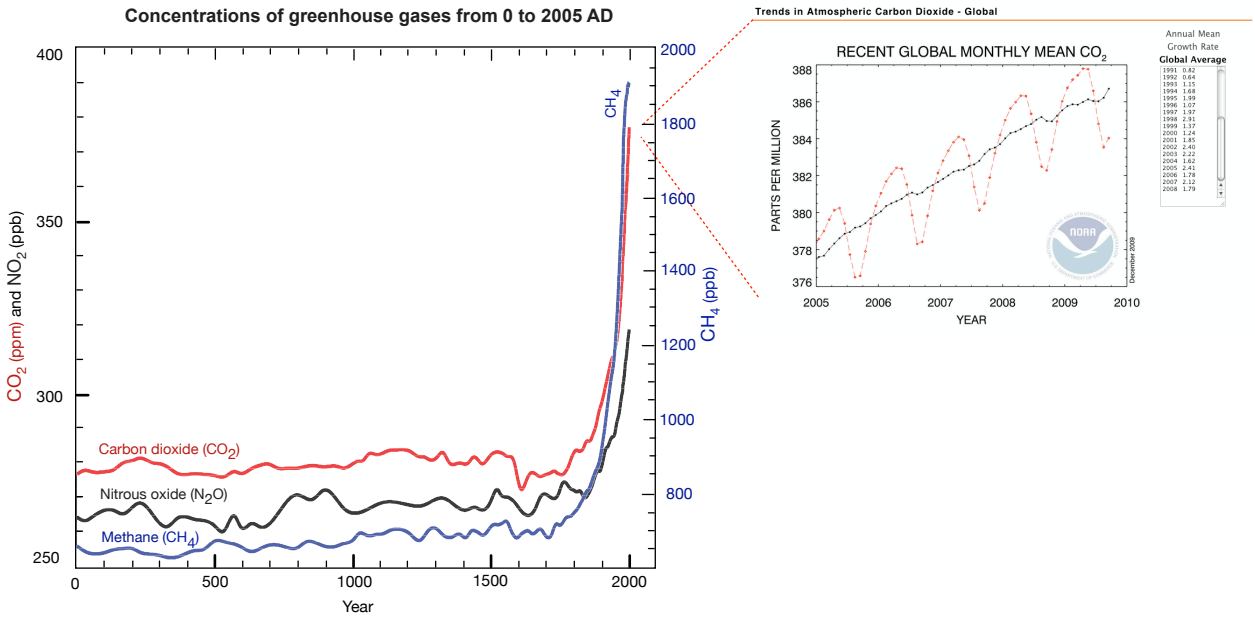


FAQ 1.3, Figure 1. *An idealised model of the natural greenhouse effect. See text for explanation.*

This figure shows an idealized and simplified of model how sunlight and the atmosphere interact to provide a life zone habitable for our species. The magic of our planet is that water, essential for life, if present simultaneously in all three of its states, as gaseos vapor (clouds), as liquid in our oceans and lakes, and as a solid (as ice and snow). About one-third of the Sun's energy that reaches the top of Earth's atmosphere is reflected directly back to space. The remaining two-thirds is absorbed by the land, ocean, and atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. But energy emitted from the Earth's surface radiates at much longer wavelengths, primarily in the infrared part of the spectrum. These wavelength are largely absorbed in the atmosphere by greenhouse gases, including water vapor and water droplets in clouds, and are reradiated back to Earth. This is called the greenhouse effect. [Source: FAQ 1.3 in IPCC (2007) FAQ (WG1) (in Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (eds Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL) AR4-WG1_FAQ-Brochure_HiRes.pdf: www.ipcc.ch]

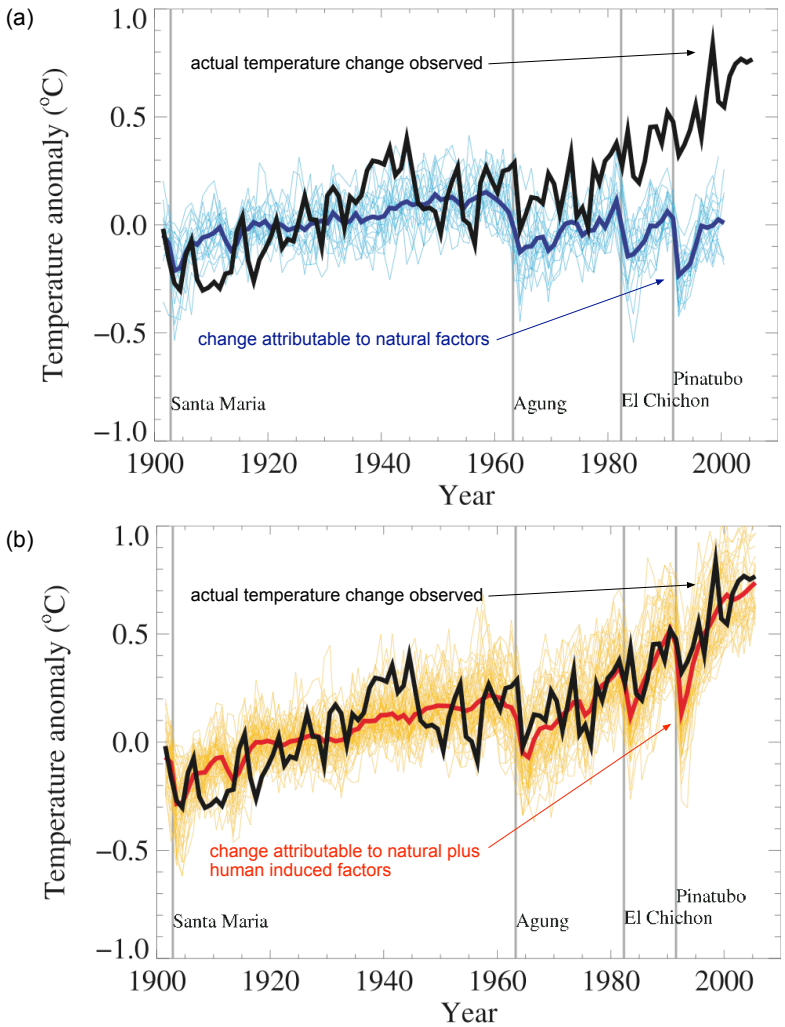
Figure B2: Past: Atmospheric concentrations of greenhouse gases: 0-2000 AD

Since about 1750, increases in atmospheric concentrations of important long-lived greenhouse gases are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample. You might notice the dip in the red CO2 curve (and the other curves) in the late 1500s and early 1600s. This period coincides with the Black Death pandemic that was especially severe in Italy and Spain and recurring outbreaks during the Thirty Years War in the German states and the Low Countries. Europe lost 11,000,000 people in these episodes of famine and disease as the plaque often often killed 10% of a community in less than a year, but as many as 30% or more in some communities. These massive population drops curtailed economic activity and probably account for the dips in emissions levels in these centuries. In any case in the past century, we have witnessed only steady increases in atmospheric concentrations of greenhouse gases.



As the inset chart shows, the concentrations in the past decade, as recorded at the peak of Hawaii's Mauna Lo, have steadily pushed to new highs. [Source: FAQ 2.1 in IPCC (2007) FAQ (WG1). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) file name: AR4-WG1_FAQ-Brochure_HiRes.pdf: www.ipcc.ch; Source (inset): Earth System Reserach Laboratory, NOAA, www.esrl.noaa.gov/gmd/ccgg/trends/]

Figure B3: Today: Natural vs.human forces vs.actual atmospheric temperature: 1900-2000 AD

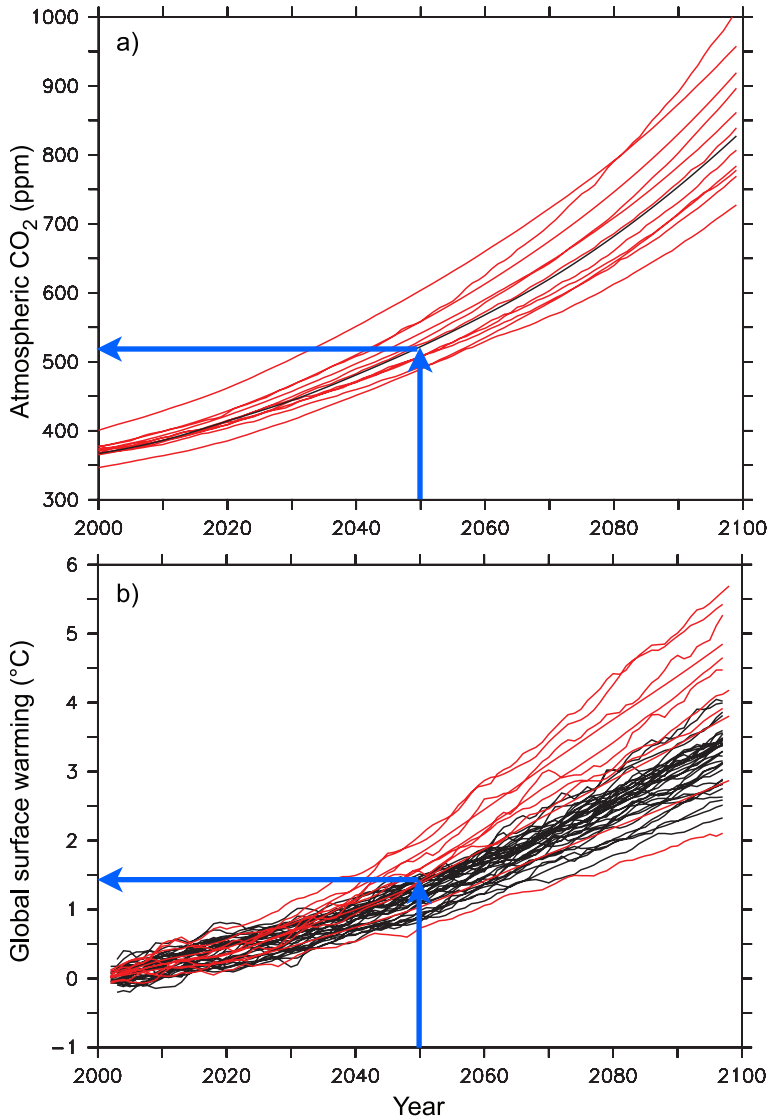


The heavy black line in both charts (a) and (b) here show the observed actual temperature changes for the past century with AD 1900 as 0 degrees of anomaly.

(a) In the top chart, the likely amount of temperature forced up or down by all natural causes is shown in blue, with the lighter blue shading showing the range for each year. Clearly, the natural causes do not match the actual temperature changes. Major volcanic eruptions are followed by global temperature decreases, due to the ejection of volcanic dust into the upper atmosphere, which blocks sunlight from reaching the Earth. Mount Pinatubo's colossal eruption of 1991 dropped Global temperatures dropped by about 0.5 °C.

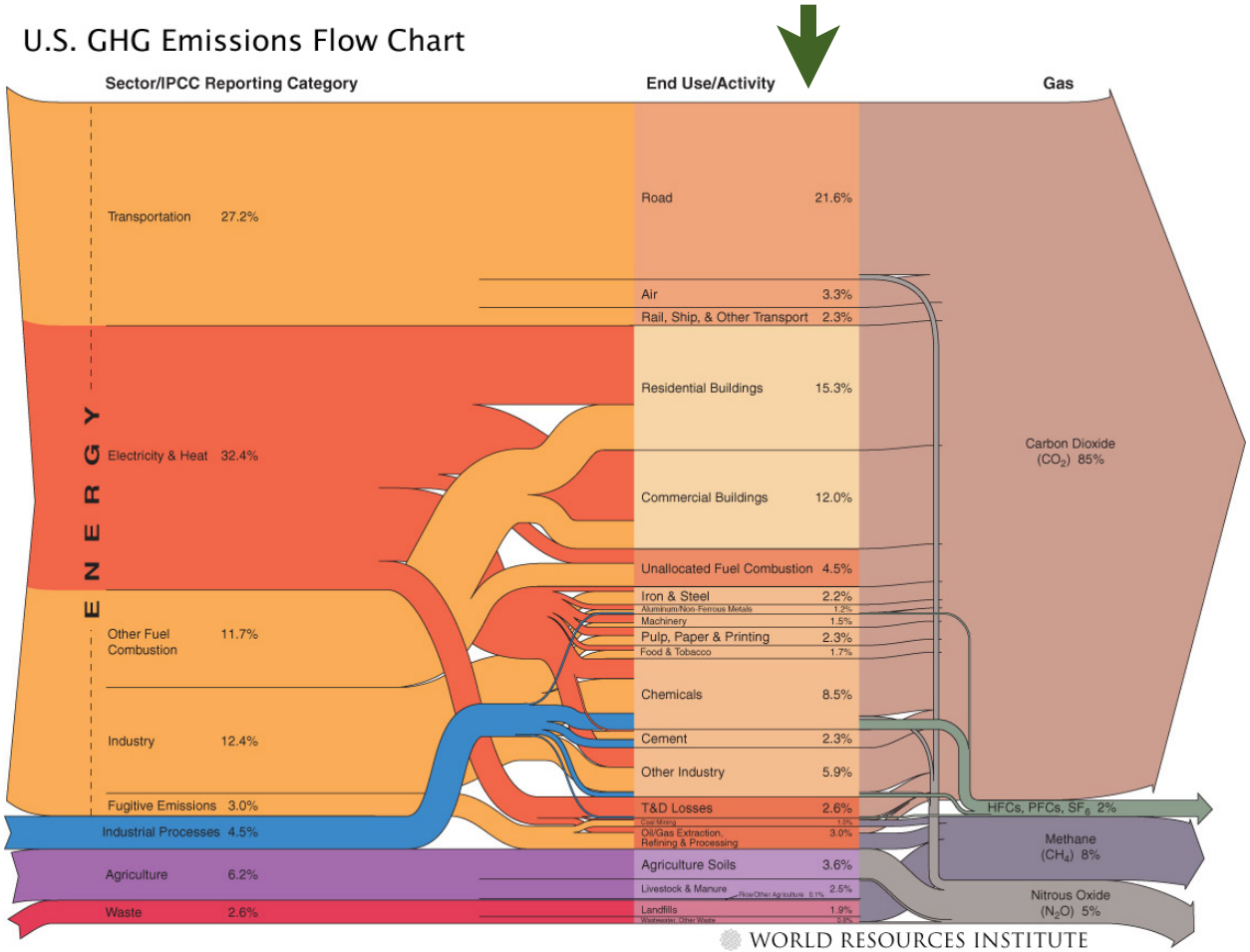
(b) The bottom chart shows the predicted impact on temperature of natural forcings combined with all the human-caused forcings in red, with the lighter red shading showing the range for each year. Adding the human impact to the underlying natural variations lifts the predicted natural temperature fluctuation to mirrors the actual rise almost perfectly. [Source: Figure 9.5 in Hegerl GC, et al (2007) Understanding and Attributing Climate Change. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) file name: ar4-wg1-chapter9.pdf: www.ipcc.ch]

Figure B4: Future: Projected carbon dioxide emissions & global temperature disruption: 2000–2100 AD



The year AD 2050, a time at which many readers of this report will still be alive and active, is shown here by the vertical blue arrow. In the top chart, the average projection atmospheric carbon dioxide in 2050 is about 520 ppm, a massive increase over today's already very high levels of circa 385 ppm. By 2050 at least two things will happen: (1) carbon dioxide reaches almost double the level prior to the industrial age (before 1850) and (2) atmospheric carbon forces the average global surface temperature to rise at least another degree Celsius (2 degrees Fahrenheit), if not more. The models used by scientists for these projections of atmospheric carbon dioxide assume that we will make some attempts to reduce human causes of climate disruption, but that the large differences present now across the world will remain as barriers to pervasive, uniform action. [Source: Adapted from Figure 10.20 in Meehl GA, et al. (2007) Global Climate Projections. (Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, (IPCC, 2007) document name: ar4-wg1-chapter10.pdf: www.ipcc.ch]

Figure B5: US energy flow from use to greenhouse gas emission



This diagram shows the flow of US energy from its use to the resulting greenhouse gas emissions. This flow reflects the complexity of our diverse society and the energy pathways it uses. All the end user activities located in the center under the dark arrow represent opportunities for higher efficiency, shift to cleaner power sources, or sequestration of the currently resulting emissions. [Source: Baumert K, Herzog T, Pershing J (2005) Navigating the Numbers: Greenhouse Gas Data and International Climate Policy, (World Resources Institute) www.wri.org/chart/us-greenhouse-gas-emissions-flow-chart]

Table B1: Relative Global Warming Potentials of Some Common Greenhouse Gases

Gas	Atmospheric lifetime (years)	Global warming potential (relative to CO_2) time frames			Concentration levels (parts per billion (ppb) by volume)		Main human activity source
		20 years	100 years	500 years	Preindustrial (ppb)	2007 levels (ppb)	
Water (H_2O)	(A few days)	(NA)	(NA)	(NA)	1,000 to 3,000	1,000 to 3,000	(NA)
Carbon dioxide (CO_2)	About 1,000	1	1	1	280,000	387,000	Fossil fuel, cement production, land use change
Methane (CH_4)	12	72	23	8	250	1774	Fossil fuel, rice paddies, waste dumps, livestock
Nitrous oxide (N_2O)	114	289	298	153	270	319	Fertilizers, combustion, industrial processes
HCFC-22 (R22)	12	5,160	1,780	549	0	0.169	Refrigeration, industrial processes

Most human activities emit more than one greenhouse gas. Burning coal produces carbon dioxide but also nitrous oxide and sulfur oxide gases. Our "carbon" footprint actually includes the impact of the many greenhouse gases combined. The global warming potential of each gas depends on the atomic structure of its molecules and how it interacts to sunlight and how it mixes with other gases. Methane is powerful in the short term, but its lifetime in the atmosphere is relatively brief (10–12 years) compared with some other greenhouse gases such as carbon dioxide, nitrous oxide, or the synthetic fluorocarbons (e.g., R22). The warming potential of a given mass of methane declines strongly over the long term as it breaks down in the atmosphere. Carbon dioxide, on the other hand, is more stable molecule. Carbon dioxide concentrations drop rapidly too, at first, but significant carbon dioxide remains in the atmosphere after 1,000 years, because natural processes recycle it. To make these comparisons easier to study, researchers use carbon dioxide, the most common and long-lived greenhouse gas, as the standard unit for global warming potential. Since the warming potential varies over time at different rates for each gas, it is common to use a 100 year time frame as the GWP value, unless otherwise noted. Due to the nuances among the factors that go into calculating GWP for a given gas under given conditions, readers may find GWP values differ slightly among published sources.

Table Sources: Adapted from realclimate.org and www.esrl.noaa.gov/gmd/ccgg/trends ,

Appendix C: Climate disruption impacts in New York

The Union of Concerned Scientists published the key findings summarized below in 2007 as the Northeast Climate Impacts Assessment study. If we continue business-as-usual, we can expect the following impacts from climate disruption in New York and the Northeast. These impacts are arranged below by category of human activity or necessity they most directly affect. This information was prepared in 2006. The bad news is that atmospheric carbon growth has actually accelerated more rapidly since then than the data trend upon which these projections were based. In short, unless we act strongly and immediately, we will be locking our kids and grandkids into a higher (worse) emission scenario described below, with very little chance of avoiding the most severe impacts.

"The Northeast is already experiencing changes consistent with global warming: rising temperatures, decreasing snow cover, and earlier arrival of spring. Due to emissions in the recent past, average temperatures across the Northeast are projected to rise another 2.5 to 4 degrees Fahrenheit (°F) in winter and 1.5°F to 3.5°F in summer above historic levels over the next several decades. The extent and severity of climate change beyond mid-century, however, will be determined by emissions choices we make now—in the Northeast and around the world." –Peter C. Frumhoff and others (2007 NECIA study) www.climatechoices.org/ne

Climate disruptions

By late this century, under the higher-emissions scenario:

• Winters in the Northeast could warm by 8°F to 12°F and summers by 6°F to 14°F above historic levels.

• The length of the winter snow season could be cut in half across northern New York, Vermont, New Hampshire, and Maine, and reduced to a week or two in southern parts of the region.

• Cities across the Northeast, which today experience few days above 100°F each summer, could average 20 such days per summer, and more southern cities such as Hartford and Philadelphia could average nearly 30 days.

• Short-term (one- to three-month) droughts could occur as frequently as once each summer in the area of the Catskills and the Adirondacks, and across the New England states.

• Hot summer conditions could arrive three weeks earlier and last three weeks longer into the fall.

• New York City is projected to face flooding equivalent to today's 100-year flood once every decade on average under the higher-emissions scenario and once every two decades under the lower-emissions scenario by century's end.

Water changes

Global warming in the Northeast will alter the timing and amount of stream flow, which would:

• Create more high-flow events in winter, particularly under the higher-emissions scenario, with an associated risk of winter flooding;

• Release earlier peak flows in spring—roughly two weeks earlier under the higher-emissions scenario and 10 days earlier under the lower-emissions scenario; and extended low-flow periods in summer—nearly a month longer by late-century under the higher emissions scenario, with little change under the lower-emissions scenario.

• Increase winter precipitation (much of which is expected to fall as rain) 20 to 30 percent by late-century under either emissions scenario.

• Reduce snowpack and shorten the snow season in the typically snowy northern states—up to 50 percent by late-century under the higher-emissions scenario and more than 25 percent under the lower-emissions scenario.

• Increase the frequency of short-term (one- to three-month) droughts by late-century from an average of once every two to three years to once every year across the Adirondacks, Catskills, and most of New England under the higher-emissions scenario, with little change under the lower-emissions scenario.

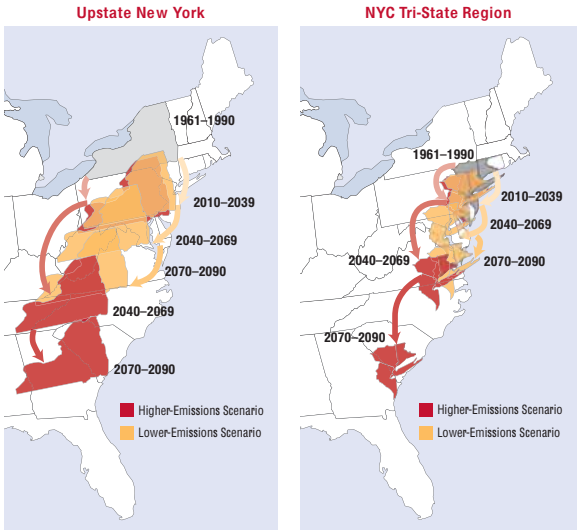
• Increase the frequency of extremely hot days (which can increase water demand) roughly five-fold under the higher-emissions scenario and two- to three-fold under the lower-emissions scenario.

• Amplify the likelihood and severity of damaging rainstorms under both scenarios.

• Raise sea levels between 10 and 23 inches under the higher-emissions scenario and 7 and 14 inches under the lower-emissions scenario, increasing the risk of saltwater intrusion into coastal aquifers.

Figure C1: Future state migrations under greenhouse gas emission impacts: 2000-2100

The maps in Figure C show two different outcomes under a lower (more preferable) and higher (less desirable) emissions outcomes. If we continue business-as-usual, the New York metropolitan area can expect climate like that of Atlanta or Savannah today. A longer golf season sounds great. But our region will undergo severe negative impacts on health, safety and welfare, including less reliable drinking water supplies, disrupted food growing capacity, and more frequent and more severe storms, as well as coastal flooding from sea-level rise. [Source: Frumhoff (2007) www.climatechoices.org/ne/]



Food changes

Our food supply will become harder to maintain:

• Weed problems and pest-related damage are likely to escalate, increasing pressures on farmers to use more herbicides and pesticides.

• An increasing number of storms producing heavy rainfall may delay spring planting and damage crops and soils, while more frequent droughts during the growing season—particularly under the higher-emissions scenario—could make irrigation essential for most high-value crops.

• Global warming may affect maple syrup production in this and other syrup-producing states in two important ways. First, warmer temperatures diminish the quantity and quality of sap flow and cause the tapping season to begin earlier and last less long. Second, climate change may cause a decline in habitat suitability for sugar maple trees.

Health changes

Global warming could worsen air pollution in the Northeast, creating more days when national air-quality standards cannot be met (particularly under the higher-emissions scenario):

• Deteriorating air quality would exacerbate the risk of respiratory, cardiovascular, and other ailments in states such as Massachusetts, which already has the highest rate of adult asthma in the United States.

• In the Philadelphia metropolitan region, for example, the number of days failing to meet the federal ozone standard is expected to at least quadruple by late-century under the higher emissions scenario if local vehicle and industrial emissions of ozone-forming pollutants are not reduced.

• Rising temperature and CO 2 levels could worsen pollen-based allergies across the Northeast, particularly under the higher-emissions scenario.

• Hotter, longer, drier summers punctuated by heavy rainstorms may create favorable conditions for more frequent outbreaks of mosquito-borne diseases such as West Nile virus.

Recreation changes

The character of the Northeast's forests may change dramatically over the coming century as the center of suitable habitat for most of the region's tree species shifts northward:

• Only western Maine is projected to retain a reliable ski season.

• The hemlock stands that shade and cool many of the Northeast's streams could be lost—much like the American elm—to a pest that thrives in warmer weather, further threatening native brook trout in the Adirondacks and elsewhere.

• Climate conditions suitable for maple/beech/birch forests are projected to shift dramatically northward, while conditions suitable for spruce/fir forests would all but disappear from the region.

As their forest habitat changes, many migratory songbirds such as the Baltimore oriole, American goldfinch, and song sparrow are expected to become less abundant, due to rising temperatures, shifting distribution of suitable habitat, or declining habitat quality.

[Source: Frumhoff PC, McCarthy JJ, Melillo JM, Moser SC, Wuebbles DJ (2007) Climate Change in the U.S. Northeast: A report of the Northeast Climate Impacts Assessment (NECIA), Union of Concerned Scientists www.climatechoices.org/ne/

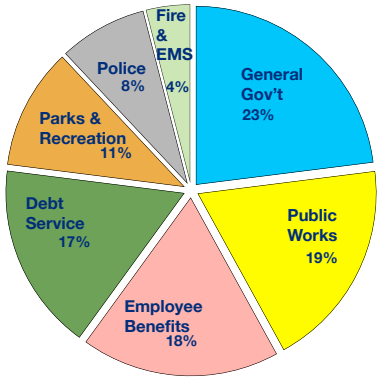
Appendix D: About Croton-on-Hudson, New York

The Village of Croton-on-Hudson is located in Westchester County, in the lower Hudson Valley, approximately 35 miles (50 kilometers) north of midtown Manhattan. The Village encompasses just under five square miles of land area and just over six square miles of water surface. The Hudson River and her tributary, the Croton River, meet at Croton, forming the Village's boundaries to the south and west. The Village's topography includes shoreline along the Hudson River west of Route 9, the forested Croton River Gorge, and a plateau at the Village's northern boundary that reaches elevations up to 600 feet within a mile of the Hudson. The Village offers both sweeping views of the Hudson River and Valley as well as more trails along wooded paths.

The suite of services provided to residents and business owners ranges from garbage collection to street and highway maintenance, and building codes and inspection, to police and emergency services, fire protection (through our excellent volunteer Fire Department), park and creation programs, tax assessments, village court and justice services, drinking water from our well field, sanitary sewer service, and parking lots for commuters and residents in several locations, most notably at the Croton-Harmon Station.

Croton-on-Hudson—as are all 553 villages in New York—is required to adopt a balanced budget each year before the start of the new fiscal year. For most villages, revenue is very heavily dependent on the property tax levied on local property owners. In Croton, sixty percent of the total budget is raised through the property tax levy, fifteen percent from the village-owned train station commuter parking lot, and the rest from other smaller non-tax levy revenues.

Croton's Typical Annual Budget Expenses



Very brief history

• The Village was incorporated in 1898 and currently has a population of just under 8,000 residents.

• The Village has a Council-Manager form of government. The five member elected Village Board of Trustees makes policy and functions on behalf of the citizens. The mayor acts as a member and the presiding officer of the board and is not a full-time position. The Board of Trustees hires a full-time Village Manager who handles the day to day activities in the Village and reports to the Board of Trustees.

• The Village's budget for 2009-2010 is circa $16 million, including a full service police department and a water delivery system based on a village-owned well field in the Croton River gorge. The Village has just over 80 full-time employees, roughly one employee for every 100 residents, or one employee for every $200,000 in the total budget. (See Figure D1.)

• The Village became a Tree City USA in 1984. The Hudson River Valley Greenway designated the Village as Greenway Model Community in 1993. The Village received the 2004 Visions in Planning Award for the development of the riverfront River Walk trail.

• The Village is home to the Croton-Harmon Train Station with frequent rail service to New York's Grand Central terminal via Metro-North and Penn Station via Amtrak.

The Local Government Public Access Television is Channel 78. Board of Trustee Meetings broadcast live, every other Monday, and again on the following Wednesday at 8:00 pm. Trustee Meetings are also available as on-demand web streams through the Village website: www.crotononhudson-ny.gov

Village Revenue Streams & Total Appropriations 1998-2010 ($millions)

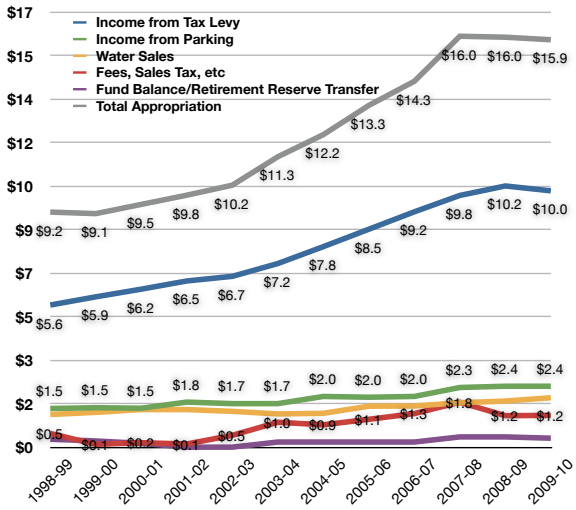


Figure D1: Village Revenue and Appropriations History

A decade of revenue sources and total budget appropriations are presented here and drawn from the Village"s annual budget books.

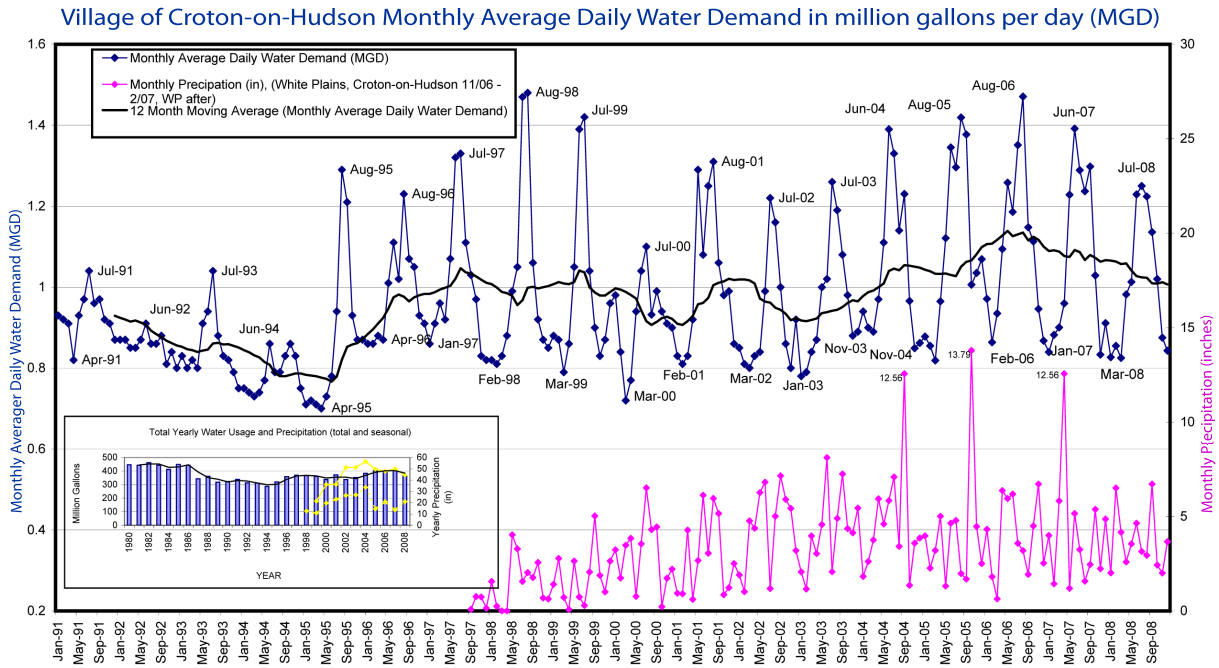


Figure D2: Croton's water use and precipitation history: 1991-2008

With water such a vital part of village services, this figure depicts annual water demand (in million gallons per day) as well as precipitation. The drop in demand from 1991 to 1995 is attributable to a vigorous leak detection program. The rise in 2004-2006 is attributable in part to the build out of residential homes and condominiums. Almost all customers now enjoy a Village-installed radio transmitter water meter which boosted accuracy of readings and improved leak detection and usage anomalies. (Source: Village Engineer's Office, 2009)

Water features prominently in this report is worth a brief look: The Village water utility bills or most customer are based on radio telemetry meter readings for accuracy and convenience. The water rate most homeowners and small businesses paid in 2007 was $4.307 per 100 cubic feet. Each "cube" of water is the equivalent of 748 gallons and weighs 6246 pounds (or 2.83 metric tonnes). Water sales revenue in 2007 was $1.73 million from delivery circa 400 million gallons to customers. (See inset in Figure D2.)

Some Croton-on-Hudson numbers	
Number of residents (2007 estimates)	c. 7,900
Number of village employees	82
Number of village buildings (heated)	10
Building space heated/cooled for village operations	60,000 square feet
Number of village police officers	22
Percent of Hudson River shoreline accessible to the public	100%
Number of public parks	13
Parking spaces at the municipally owned train station lot	c. 2,000
Year during which village first began buying wind power	2003
Village government's average electricity cost (2007)	$0.15/kWh
Square miles of surface area	4.8 sq mi. (land) & 6.1 sq. mi. (water)
Gallons of water pumped from village well fields (typical year)	400 million gallons
Marked walking trails	15 miles

Appendix E: About ICLEI Local Governments for Sustainability

ICLEI is an international membership association of local governments dedicated to climate protection and sustainable development. The organization was established in 1990 when more than 200 local governments from 43 countries convened at the World Congress of Local Governments for a Sustainable Future, at the United Nations in New York. Established as the International Council for Local Environmental Initiatives, the official name is now ICLEI-Local Governments for Sustainability.

ICLEI USA was launched in 1995 and has grown from a handful of local governments participating in a pilot project to a solid network of more than 500 cities, towns and counties actively striving to achieve tangible reductions in greenhouse gas emissions and create more sustainable communities. ICLEI USA is the domestic leader on climate protection and adaptation, and sustainable development at the local government level.

ICLEI's Communities for Climate Protection (CCP) methodology assists local governments to systematically track energy and waste related activities in the community, and to calculate the relative quantities of greenhouse gases produced by each activity and sector. The inventory methodology involves performing two assessments: a community-wide assessment and a separate inventory of government facilities and activities. The government inventory is a subset of the community inventory. Once completed, these inventories provide the basis for the creation of an emissions forecast, and allow for the quantification of emissions reductions associated with proposed measures.

The CCP campaign provides a framework for local communities to identify and reduce greenhouse gas emissions, organized along five milestones:

(1) Conduct an inventory of local greenhouse gas emissions;

(2) Establish a greenhouse gas emissions reduction target;

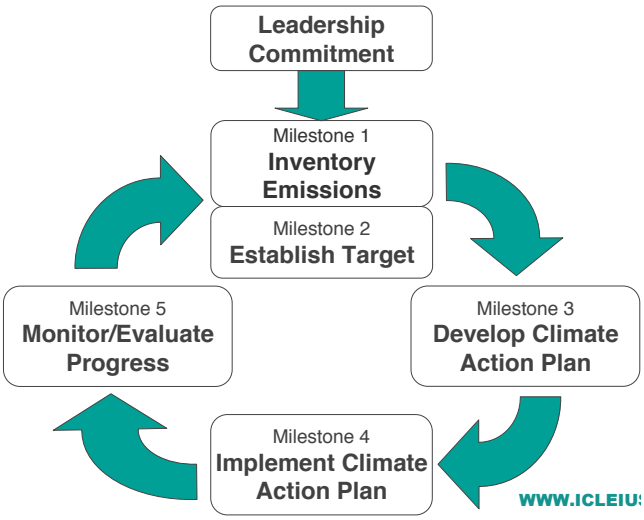
(3) Develop an action plan for achieving the emissions reduction target;

(4) Implement the action plan; and,

(5) Monitor and report on progress.

This report represents the completion of the first CCP milestone's governmental survey, and provides a foundation for future work to reduce greenhouse gas emissions in the Village of Croton-on-Hudson.

www.icleiusa.org



Appendix F: Online Resources

[See also ICLEI's Climate Change Outreach and Communications Guide www.icleiusa.org]

Local Government Websites

Environmental Consortium of Hudson Valley Colleges and Universities environmentalconsortium.org
Maricopa County (CA) Clean Air Campaign www.cleanairmakemore.com
Nashua Green Team (NH) www.nashuagreenteam.org
New York State Climate Smart Communities www.dec.ny.gov/energy/44992.html
New York State Energy Plan www.nysenergyplan.com
New York State Energy Research and Development Authority www.nyserda.org
New York State Get Energy Smart Programs www.getenergysmart.org
Northeast Climate Impacts Assessment www.climatechoices.org/ne/
Pace Global Warming Central www.law.pace.edu/env/energy/globalwarming.html
Sustainable Bedford (NY) www.bedfordny.info/html/green.htm
Sustainable Hudson Valley www.sustainhv.org
Sustainable Long Island www.sustainableli.org
Sustainable Portland (OR) www.sustainableportland.org
Westchester County (NY) Global Warming Task Force www.westchestergov.com/environment_globalwarming.htm

Climate Change Educational Information

Clean Air Cool Planet www.cleanair-coolplanet.org
Environmental Defense Fund - Understanding the Forecast www.edf.org/pubs/Brochures/globalwarming
IEA Greenhouse Gas Research & Development www.ieagreen.org.uk
Intergovernmental Panel on Climate Change www.ipcc.ch
National Council on Science and the Environment Climate Solutions http://ncseonline.org/climatesolutions
Natural Resources Defense Council Global Warming Solutions www.nrdc.org/globalwarming/solutions
New Scientist Global Warming Explanation www.newscientist.com/nsplus/insight/global/faq.html
Pew Center on Global Climate Change www.pewclimate.org
Union of Concerned Scientist, Global Warming Science www.ucsusa.org/global_warming/science
United Nations Framework Convention on Climate Change www.unfccc.org
US Climate Change Science Program www.climatescience.gov
US Energy Information Administration www.eia.doe.gov
US Environmental Protection Agency Regional Impacts of Global Warming www.epa.gov/climatechange/
US NOAA Global Warming FAQ www.ncdc.noaa.gov/ol/climate/globalwarming.html
World Climate Report www.greeningearthsociety.org/climate
World Wildlife Fund Climate Change Campaign www.panda.org/climate

Appendix G: Units, acronyms and other alphabet soup

A helpful Glossary of Acronyms used in local government work on sustainability and climate change may be found at http://www.icleiusa.org/action-center/general-resources/glossary.

The terms and abbreviations used in this report are listed below for the reader's convenience:

1 (metric) tonne = 1 t = 1,000 kilograms= 2,204 pounds (US) = 1.102 short tons (US)
Btu = British thermal unit of energy = 0.293 Watt-hours = 0.000293 kiloWatt-hours (KWh)
1,000 kWh = 1MegaWatt-hour (MWh) = 3,412,141.6 Btus
1 million Btus = 1MMBtus = 293 kWh = 0.293 MWh
1 quad = 1 quadrillion Btus = 1 million billion (10^15) Btus
(A quad is the unit is used by the U.S. Department of Energy in discussing world and national energy budgets. The global primary energy production in 2004 was 446 quad. See Figure 1.6b on US energy flows.)
CH_4 methane
CHP combined heat and power
CO monoxide
CO_2 carbon dioxide
CO_2e carbon dioxide equivalents (as measured in weight)
tCO_2e metric tonnes of CO_2 equivalents
tCO_2e/y = metric tonnes of CO_2e per year
GHG greenhouse gas (emissions), used in this report as the combined impact of numerous gases as carbon dioxide equivalents.
GWP global warming potential of one unit of carbon dioxide for a given period of time. Other compounds cause more warming per mass than carbon dioxide.
IPCC Intergovernmental Panel on Climate Change
kg kilogram(s)
kWh kilowatt-hour(s)
lb(s) pound(s)
MWh megawatt-hour(s)
N_2O nitrous oxide
NO_x oxides of nitrogen

We also recommend the search engine at the Encyclopedia of Earth for reliable explanations of energy concepts and terms: http://eoearth.org. The US Department of Energy's "Energy Calculator" is helpful for converting energy units: http://tonto.eia.doe.gov/kids/energy.cfm?page=about_home-basics

Appendix H: Acknowledgements

The Village would to acknowledge the leadership and initiative taken by several key staff in compiling this report and in learning the Clean Air Climate Protection protocols through ICLEI–Local Governments for Sustainability workshops and webinars. Specifically, Ronnie Rose, part-time assistant to the Village Manager's office, devoted about ten hours a week over a period of about two and one half months as the project's lead researcher. This work included training on the CACP toolkit, and researching and inputting the data that this inaugural baseline greenhouse gas inventory required. Janine King, Assistant Village Manager, worked closely with Ms Rose and also participated in the ICLEI training. Village Engineer Dan O'Connor and Tex Dinkler of the Fire Department also assisted with this report. Our department heads were all very helpful in answering the myriad questions not obvious from our utility bills alone. Our NYPA representatives and ICLEI's support staff were very helpful as well. The Village's Sustainability Team has been instrumental in vetting the early drafts to identify both data gaps and ways to close them as well ways to make the report more accessible to the general public. The Team includes Susan Lunden (Chair), Lindsay Audin, Carl Grimm, Niall Kelleher, Lee Streisfeld Leitner, Matthew Rubenstein, and Taylor Vogt. This group of volunteers have been invaluable and indefatigable. http://www.crotononhudson-ny.gov/Public_Documents/CrotonHudsonNY_BComm/sustainable

A Holiday Example: 40% saved!

In 2001, then Village clerk Peggy Keesler generously donated a 30 foot fir tree to the Village to be replanted from her yard to the parkway on Benedict Boulevard at South Riverside Drive. Every year our Village staff decorates this tree with seasonal holiday lights. The string of incandescent bulbs took a beating from the elements and required repair and numerous replacement bulbs. In fall 2009, Croton's public works foreman, Thomas Giglio, set out to find better looking lights to replace the old strings. Mr Giglio discovered the village could purchase 1,800 light emitting diode (LED) lights for $1,700. Of the total, 1,600 are used on the tree with 200 as spare light in reserve. Mr. Giglio ordered a special mix of colored bulbs that added white lights to the traditional red, green, and blue. These LED lights have more durable housings, do not use fragile bulbs, and consume a tiny fraction of the electricity of the incandescent bulbs. The parkway has two power outlets. Due to LED efficiency, all the new light strings could be plugged into a single outlet, leaving the second one open for a menorah. Mr Giglio notes, "A typical C7 incandescent lamp uses 5 watts for a total of 8000 watts of power as opposed to the new L.E.D. lights, which only use 1.4 watts per bulb for a total of 2100 watts of power." Therefore, in 2009, the village staff was able to decorate the tree with more lights and include a menorah, all while cutting costs for this one activity by over 40% since last year.

photo courtesy of C. Romedenne

Outdoor Lighting (Holiday Lights Benedict Blvd.)	
2007 (energy cost from line 4.11 on Table 2)	$491
2008 (estimated cost of electricity)	**$500**
Cost of new LED lights	$1700
Annualized cost of LED light (10 year lifespan)	$170
2009 (estimated electric bill of 1,600 new LED lights)	$125
New annual cost	**$295**
Savings (each year)	$205
	41%