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.)

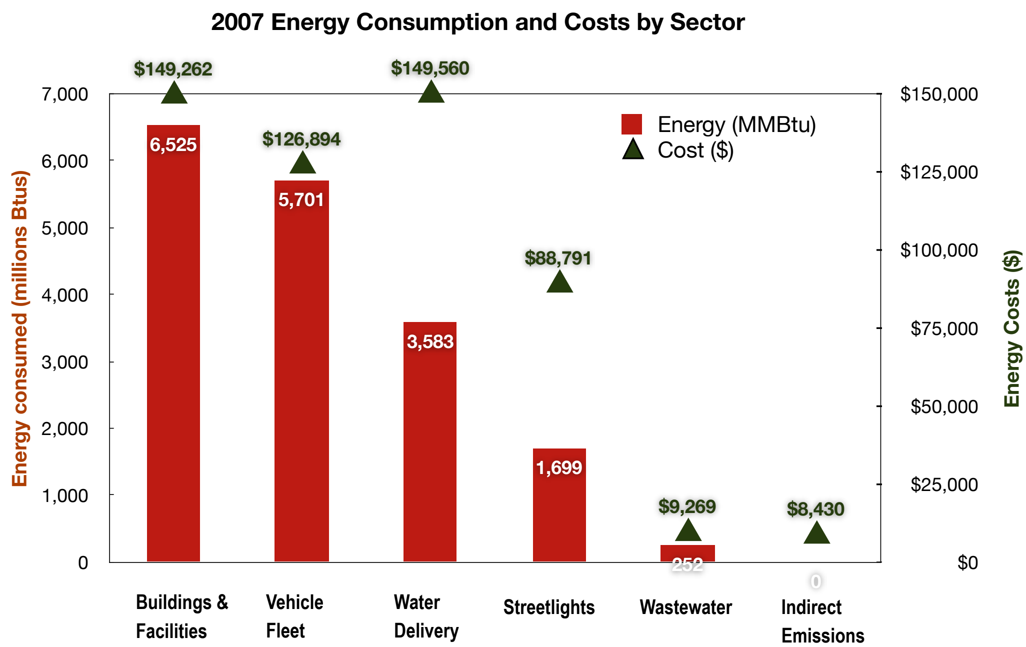


Figure 7: 2007 Village energy consumption and costs by sector (MMBtu and $)

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.)

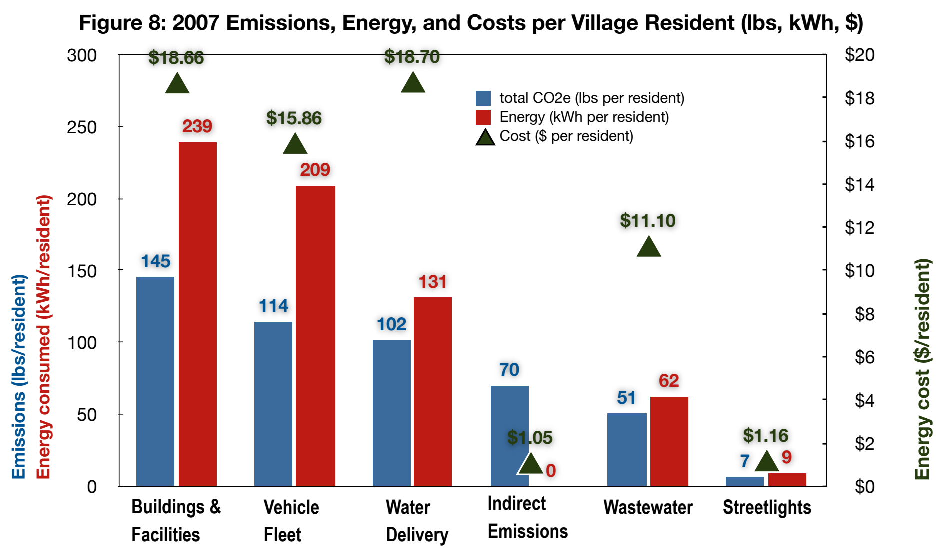


Figure 8: 2007 Emissions, Energy, and Costs per Village Resident (lbs, kWh, $)

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.

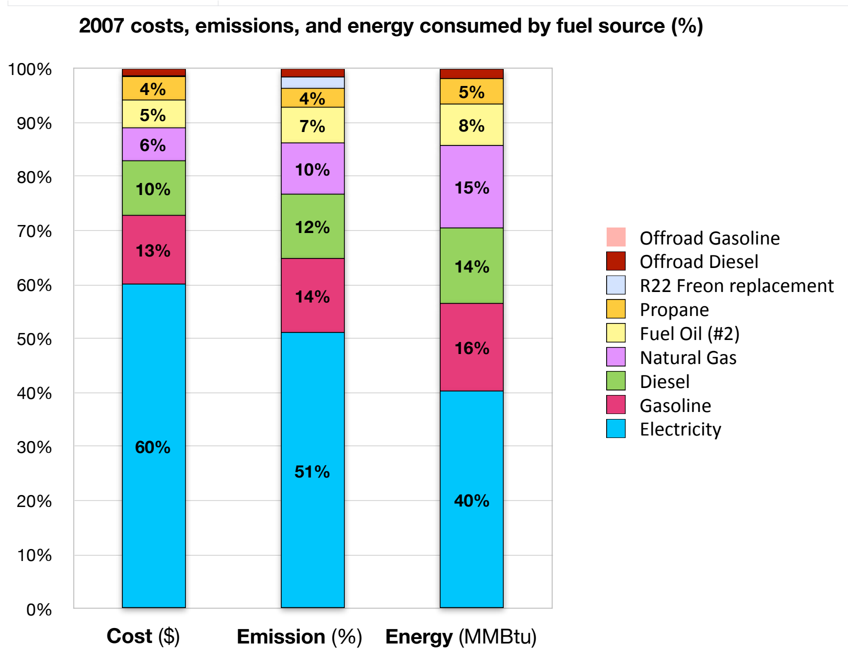


Figure 9: 2007 Village costs, emissions, and energy consumed by fuel source (%)

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).

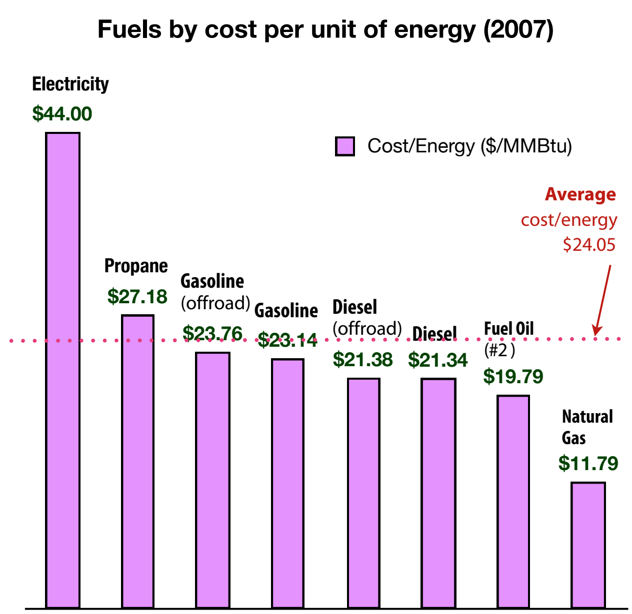
On a dollar per unit of energy basis, electricity is the most expensive fuel for the energy value we obtain from it. Each $1 we spent on electricity produced the same amount of energy (in Btus) as $0.27 spent on natural gas. (See Table 5 and Figure 10.)

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.

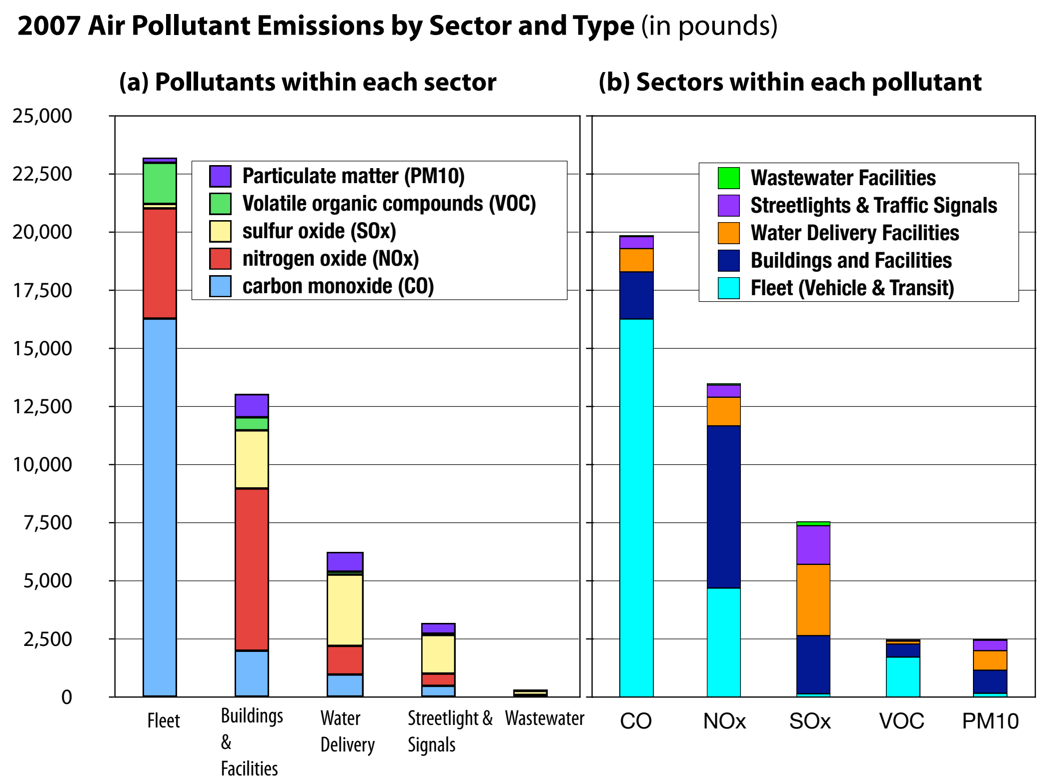


Figure 11: 2007 Village air pollutant emissions by sector and type (pounds)

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.