The Lazy Man's Guide to 80 x 50 in NYC

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ABSTRACT

The Lazy Man methodology was developed to help New York City establish its high level strategies for achieving 80% carbon reductions by 2050 -- including the degree of efficiency upgrades required for for new and existing buildings and the trade-offs between building efficiency, cleaning the grid, and electrification of transportation and buildings. Lazy Man begins by simplifying the problem: it divides the carbon sources into the four major urban categories (building energy, building fuel, transportation, and waste/ fugitive gases) and normalizes base year emissions to 100. It utilizes the simple waterfall format to present past changes and explore the future changes that would be required to achieve an 80% reduction. The possible future changes analyzed by Lazy Man are limited to the following 6 actions: BAU in all 4 categories through 2050, the impact of efficiency and waste reduction on the BAU, the impact of efficiency and waste reduction on the existing situation, the benefit of existing clean power, additional clean power as applied to building based electrical use, and the electrification of buildings and transportation with additional clean supply.

By simplifying the arithmetic, the carbon sources, and the possible actions, and presenting each scenario on a single page with clear graphics, the Lazy Man methodology enables policy makers to quickly grasp the results of their decisions and how each decision affects the rest. It also answers fundamental questions such as whether buildings need to be entirely electrified and the amount of clean power that will be necessary.

Introduction

More and more jurisdictions are setting the goal of reducing their carbon emissions by 80% by 2050. This is an enormously complex problem to understand and solve. There are many issues and variables to consider: the growth rate, the reductions that have already occurred, the reductions that will need to come from new buildings vs. existing buildings vs. transportation vs. waste, not to mention fuel switching, cleaning the grid and the electrification of both transportation and buildings. But to achieve their carbon goals efficiently and cost effectively, jurisdictions need to set reasonable targets for each broad strategy, such as how efficient new buildings will need to be. They also need to understand the tradeoffs between strategies.

The Lazy Man establishes a general methodology that any jurisdiction could use for answering these broad questions and establishing general targets, and presents it in a way that makes it easy to understand how the parts go together. In a graphic format of approximately 20 slides, it derives a scenario of 2050 outputs for New York City's transportation, building, and power sectors – how efficient new and existing buildings will need to be, how much fuel switching and electrification will need to occur, etc. It also shows what happens if one "dials the knobs", relaxing the efficiency requirements for new buildings, simultaneously increasing electrification, for example. This methodology allows policy teams to quickly establish their high level goals, and move to the much denser and thornier questions of how to achieve them.

Establishing the Baseline

The Lazy Man methodology was developed to facilitate high-level thinking about how the major parts of a city's greenhouse emissions strategy go together. Throughout the analysis, then, assumptions have been simplified in order to allow the big picture issues to emerge.

Step One: The Lazy Man methodology begins by documenting the carbon emissions from the city's base year and the most recent year and any gains or losses that have occurred during that time period. In NYC, the baseline year was 2005 and the most recent year was 2012. For mathematical simplicity, the total carbon emissions from the baseline year are normalized to 100, which makes it easy to see at a glance how much each intervention is contributing to the achieving the 80% reduction goal.

Step Two: Lazy Man divides the city's carbon emissions into 4 parts, ie. the carbon emissions in the city that come from the following sources, making certain simplifying assumptions:

- Building Fuel (ie. all carbon emitted from site-based from fuel use in all buildings)
- Building Electrical (ie. all carbon emitted from electrical fuel use in buildings[1] as per the local coefficients)
- Transportation[2]
- Waste and Fugitive: Emissions due to solid waste and fugitive gases, such as SF6, HCFC's, methane, etc.

Documenting Changes from the Baseline that have Occurred

Step Three: Lazy Man presents the reductions that have occurred from the baseline year to the most recent year, again normalizing against the baseline year, defined at 100. See in Figure 1 below a waterfall graph, which documents an 18.8% reduction in carbon emissions from 2005[3] to 2012[4], as per NYC's greenhouse gas emissions inventories. However the main reductions are in electrical, which is represented by the large blue box marked -10.3 – meaning that citywide emissions were reduced 10.3% off the 2005 baseline through reduced GHG emissions from building-based electrical use. This large decrease in emissions from electricity was mostly obtained by cleaning NYC's electrical grid, largely through new, more efficient power plants and fuel switching to natural gas.

[1] A small percentage of NYC's electrical use is used for public transportation and other uses, but for simplicity, all NYC electrical has been folded into "Buildings" in Lazy Man.
[2] For simplicity, transportation carbon emissions are assumed to be fuel-based cars and trucks.
[3] Inventory of New York City Greenhouse Gas Emissions, April 2007; http://www.nyc.gov/html/planyc/downloads/pdf/publications/greenhousegas_2007.pdf
[4] Inventory of New York City Greenhouse Gas Emissions, Dec. 2013; http://www.nyc.gov/html/planyc/downloads/pdf/publications/NYC_GHG_Inventory_2013.pdf

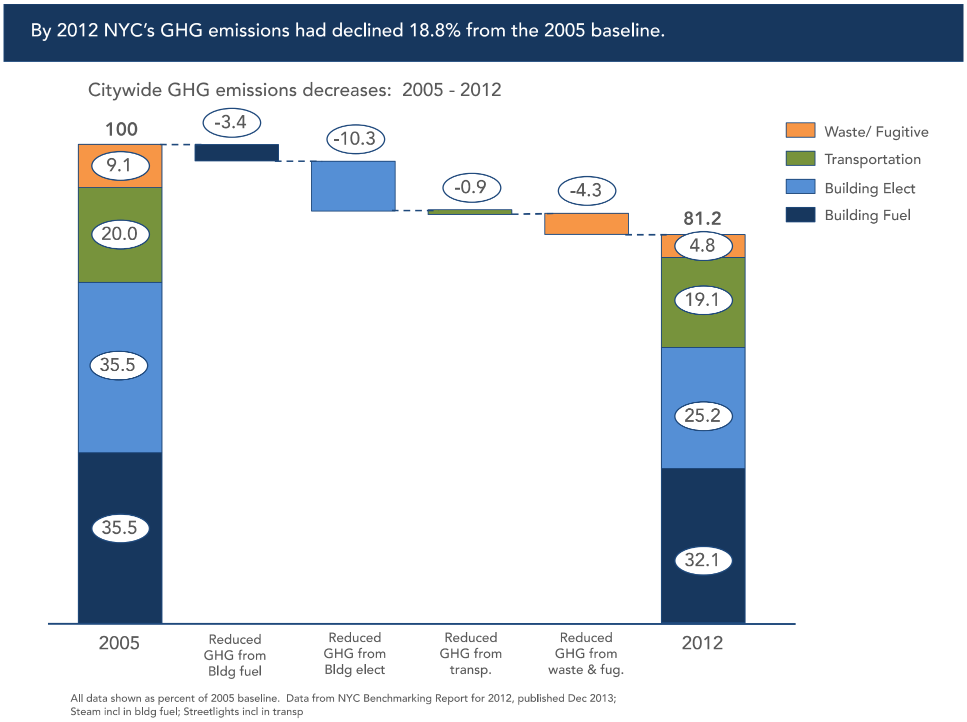

Figure 1: Waterfall Chart -- Reductions in NYC's Carbon Emissions, 2005 to 2012

Establish a Starting Scenario: Growth Rates and Efficiency

Step Four: Establish the Business as Usual (BAU) growth rate through 2050. In NYC, Lazy Man's growth rates were based on predictions from the NYC Department of City Planning of a 14% growth in population and a 29% commercial growth. This translated into a 19% average growth from 2012 to 2050. This 19% growth rate was applied equally to the BAU for all four categories of the 2012 carbon inventory – on the assumption that a 19% growth in combined population and commercial would result in approximately 19% more traffic, waste, and building energy use. This coarse assumption is then refined by Step 5 below, which considers how much efficiency each category of growth would reasonably achieve. So, for example, new buildings should be designed to use 65% less energy than existing ones, so the 19% becomes an "efficient BAU" of .19 x .35 or a BAU of 6.7% for building energy consumption through 2050.

Step Five: Develop a scenario of "Reasonable Reductions" as a starting point. In the NYC Scenario 1 analysis, the following assumptions were made, using fairly conservative assumptions for Waste and Transportation in order to concentrate on efficiency and clean power issues.

- Waste and Fugitive: 80% reductions for existing and for new (ie. the 19%). This was conservative given the City's projections of more than 100% reductions from waste[1].

[1] *One New York*, April 2105, p. 175ff; http://www.nyc.gov/html/onenyc/downloads/pdf/publications/OneNYC.pdf

- Transportation: 60% reductions for existing and for new. This is fairly conservative. Given the 50% reductions in CAFÉ standards for new cars sold by 2025 compared to ones on the road in 2005, an additional 10% reduction over the next 25 years does not seem far fetched.
- Buildings – both electrical and site-based fuel. For new construction, assume that, on average, new buildings will quickly become dramatically more efficient, using only 65% less energy per unit area than the current average energy for buildings of their type. And assume that, on average, existing buildings will cut their energy use in half. (Note that existing buildings are held to a lower standard than new construction, since it is assumed that making existing buildings more efficient will be more difficult tactically and technically than for new construction.)

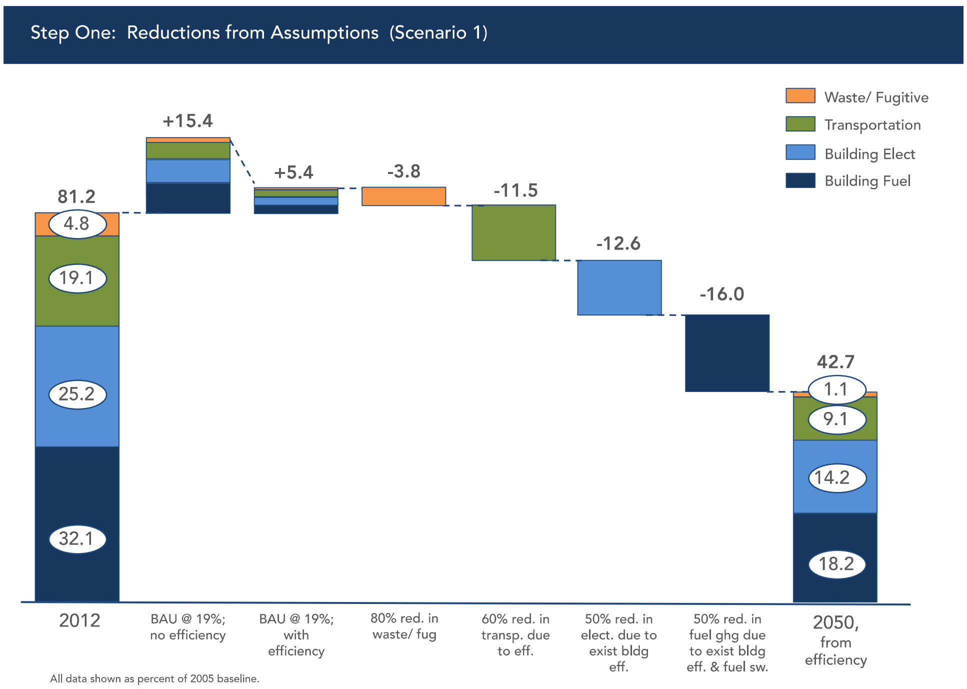

Figure 2: Waterfall Chart – Impacts of Efficient Growth and Efficiency

As can be seen in Figure 2, radical efficiency alone will not deliver 80 x 50 by 2050. After efficiency alone, we are left with 42.7% of our baseline – much more than 20%. Most of this 42.7% comes from fuel use and electricity in buildings and from transportation.

The Secret Sauce: Accruing the Benefit of Shrinking the Grid

Step Six: But wait! It turns out that reducing electrical use has an additional benefit that needs to be accrued in the accounting. In NYC[1], 37% of the electricity delivered annually is from clean power – mostly nuclear. Figure 3 shows NYC's load curve; the orange area

[1] May 6., 2106 email from Jon Dickinson

represents the amount supplied by fuel-based power and the blue are represents the amount supplied by carbon neutral power.

Figure 4 shows what happens after electricity consumption has been reduced through radical efficiency in new construction and across the existing building stock. Note that there have been a few simplifying assumptions.

- First, it is assumed that the load curve retains its basic shape; it merely shrinks because, to the first order of magnitude, energy efficiency will act roughly equally on all energy use at all times.   In other words, more efficient fans or more efficient lights will be more efficient independent of the day of the year and what time of day they are running.
- Second, it is assumed that the unused electricity will preferentially be fuel-based. In the diagram this is accomplished by putting the fuel-based energy above the carbon neutral so that as demand shrinks it drops off first. This assumption, which is known as "calculating on the margin", is reasonable in NYC because fuel-base consumption costs more to use incrementally (since you have to pay for the fuel), whereas the carbon neutral supply is incrementally free (since you will not turn off the nuclear plants which supply 97% of NYC's clean power). However, this may not pertain everywhere, because coal is sometimes used for base load, and hydro plants are often turned off. Hydro and coal, however, form a negligible part of NYC's power mix.
- Third, it is assumed that all fuel-based electricity can be lumped together, whereas some is dirtier than others. (This assumption results in a conservative assessment of the impact of shrinking since, in general the dirtiest supply would drop off first, since these result in the most expensive supply, since they are the least efficient users of fuel.)

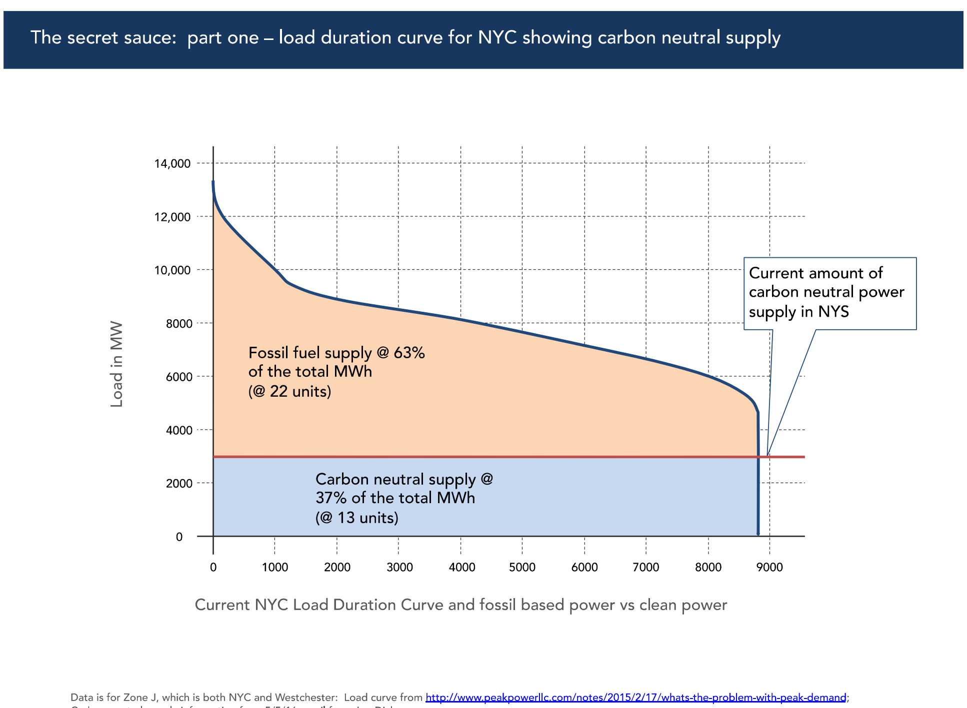

Figure 3: NYC's Current Load Curve and Supply Mix

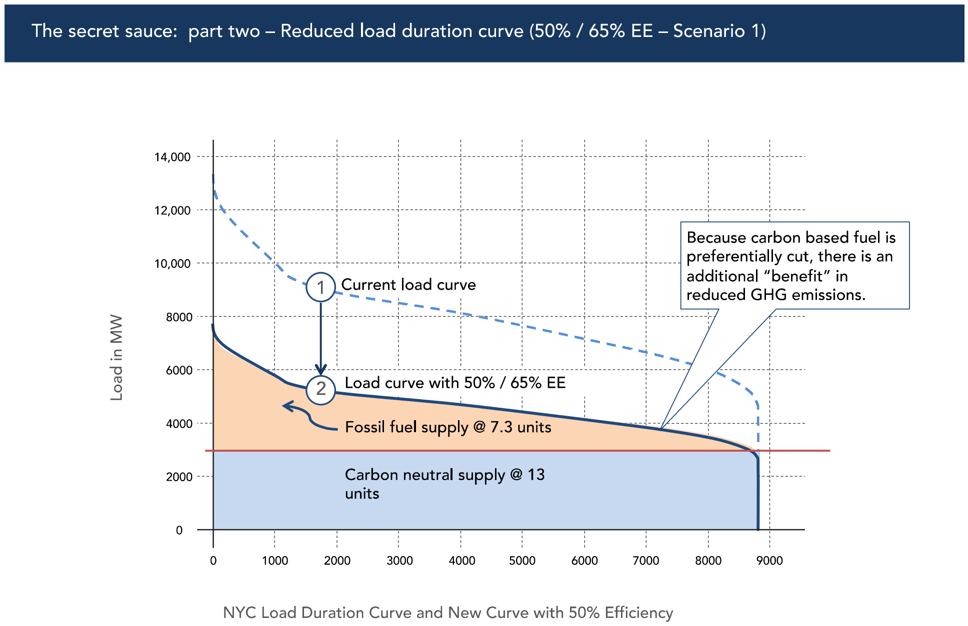

Figure 4: NYC's Load Curve and Supply Mix Under Scenario 1

By comparing the amount of fuel-based electricity used currently against the amount that will be used once demand shrinks (ie the two areas of orange in the charts), we see that the carbon impacts of electrical consumption is reduced by roughly 2/3 – somewhat more than our straight line accounting in Fig. 2. Figure 5A includes the savings accrued by "shrinking the grid". It cuts the distance from our goal by an additional 5.8%: we are now at 36.8%, but still not at 20%. What to do?

The Final Step: Electrification and Clean Power

Step Seven: Of the remaining carbon emissions (36.8%), the majority (27.3%) comes from fuel use in transportation and buildings, which has already been made efficient. If we could switch enough of that to electricity and provide only carbon-neutral power for that electricity usage, we could achieve the goal of 20%. Lazy Man assumes that transportation and buildings are equally "electrified". If we electrify 62% of transportation and fuel based energy use in buildings and provide carbon neutral electricity to them, we can reduce carbon emissions by 27.3 x .62, or 16.9%. Since 36.8% - 16.9% = 19.9%, we have slightly exceeded our goal of 20%. (In practical terms, this means changing from boilers and furnaces to heat pumps and mini-split systems.) Figure 5A shows how these remaining steps result in 19.9% of NYC's 2005 baseline in 2050.

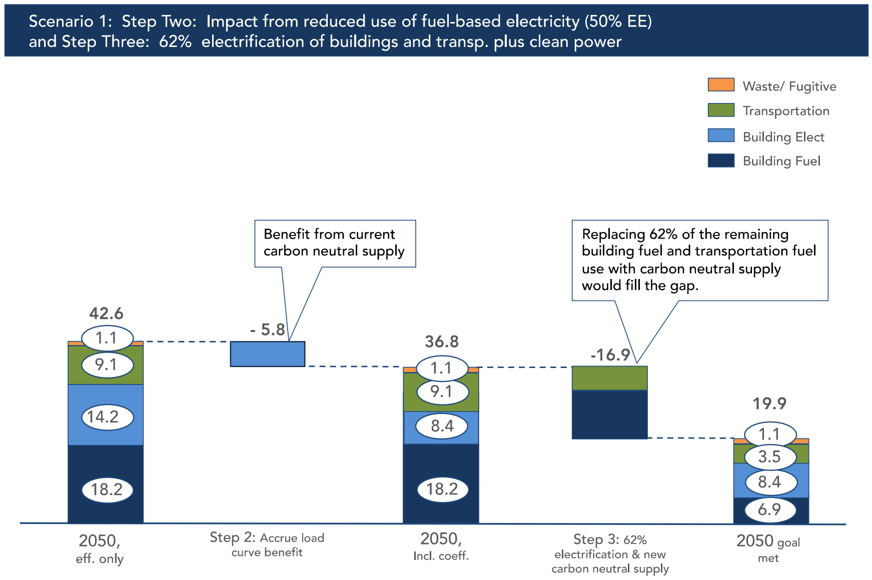

Figure 5A: Getting to 20% by accruing the benefit from the grid and electrifying 62% of transportation and building based fuels.

However, electrifying 62% of all heating and hot water and transportation could be logistically difficult, since it would entail intrusive transformations of building systems. Figure 5B looks at another approach where more carbon neutral supply is added to the grid, decreasing the carbon impact of the electrical portion of the building based electrical usage. In this scenario, only 45% of all heating, hot water and transportation would need to be electrified – a potentially more doable approach.

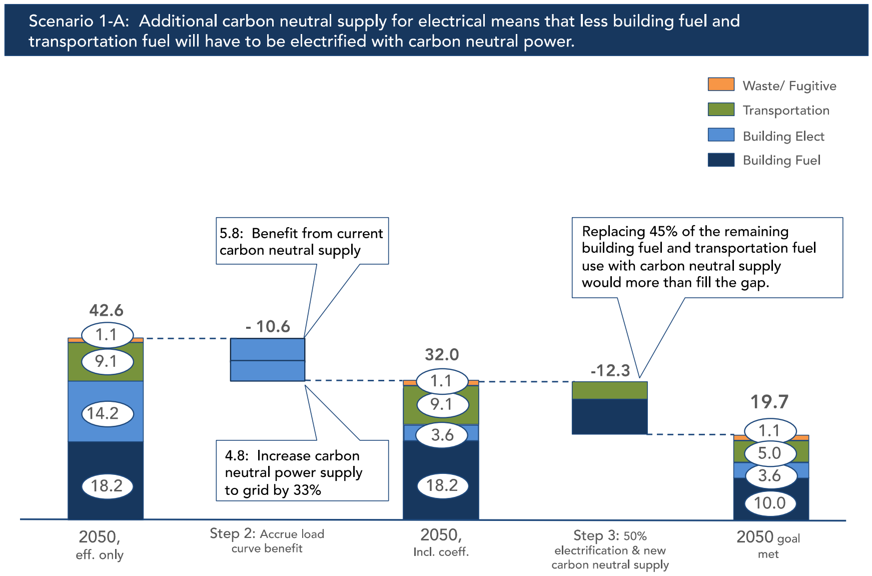

Figure 5B: Getting to 20% by accruing the grid benefit, adding 33% more clean power and electrifying 45% of transportation and building based fuels.

Impact on the Grid

As an additional exercise, let's assess what the 2050 grid would look like under the various scenarios. Let's look at Scenario 1, from Fig. 5A. Energy efficient BAU plus energy efficiency in existing buildings results, as we have seen, in shrinking the load curve. What happens to the grid when a fair percentage of transportation and fuel-based building energy use is electrified? The results are summarized in Fig. 6.

Note that Lazy Man assumes that the basic shape of the demand curve does not change appreciably – it just grows and shrinks proportionally. There are two reasons for making this assumption. First, for this broad brushed analysis, the exact shape of the demand curve is not critical; it is mostly useful as a tool to help visualize how decreases in demand remove the carbon-based power supply in preference to the carbon neutral power supply, amplifying the benefit of efficiency. And second, it's quite likely that the shape of the curves will not change much because two effects should tend to cancel each other out. The electrification of heating should result in more peakiness due to a new winter peak in addition to the summer peak. But the electrification of transportation might tend to flatten the curve, since charging would tend to occur at off-peak times; and more widespread use of batteries would do the same. So to a first order approximation, it seems safe to assume that the demand curve will have roughly the same shape in 2050 that it does now.

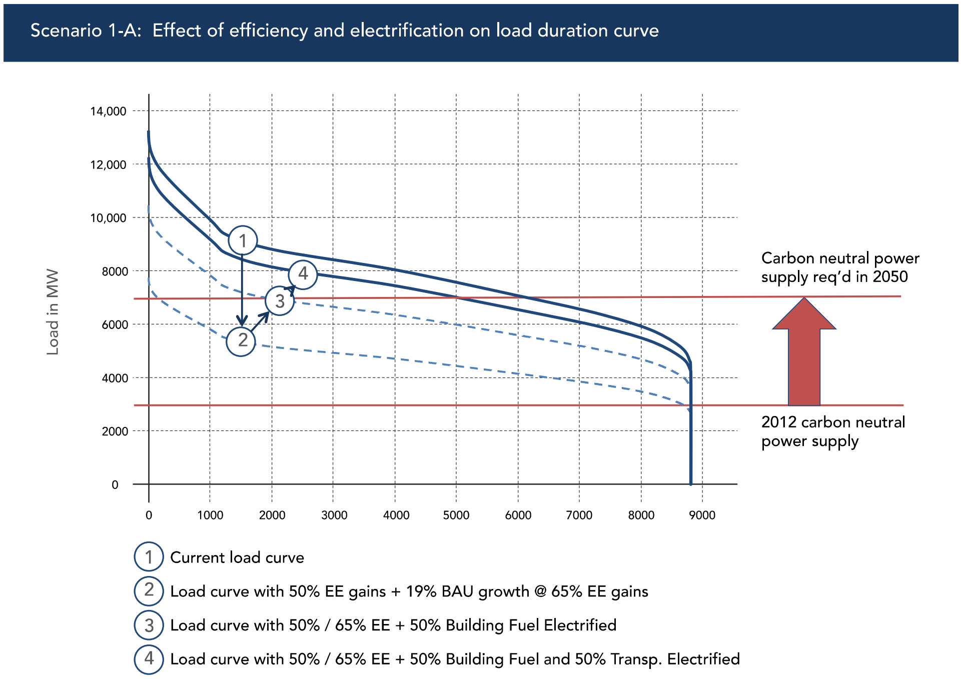

Figure 6: The Impact of Efficiency and Electrification on NYC's Grid

From Figure 6, two interesting high-level results emerge:

1. NYC's 2050 energy demand will be very much like NYC's current energy demand because the reductions due to building efficiency will be roughly cancelled out by increased electrical consumption due to electrification of building fuel and transportation.
2. The big change is in the amount of carbon neutral supply: NYC will need to more than double its carbon neutral supply.

Alternative Scenarios

Because Lazy Man is so high level, it enables one to "dial the knobs" on the various strategies. In other words, one can dial up more or less energy efficiency for new construction vs. energy efficiency in existing buildings vs. de-carbonization of the grid vs. electrification and clean power for building fuel vs. electrification and clean power for transportation

Consider the following scenarios from Figures 7, 5A, and 8, respectively:

- Scenario 2 requires the least average efficiency upgrades in existing buildings: 40%. To make up for this, the grid will need 33% more carbon neutral power, and 61% of building fuel and transportation will need to be electrified with more clean power.
- Scenario 1A requires 50% energy efficiency reductions in existing buildings. In addition, the grid will still need 33% more carbon neutral power, but just 45% of the building fuel and transportation will need to be electrified with more clean power.

- Scenario 3 requires the most dramatic efficiency upgrades in existing buildings: 60%. Here, the grid does not need more carbon neutral power, and just 37% of building fuel and transportation will need to be electrified with more clean power.

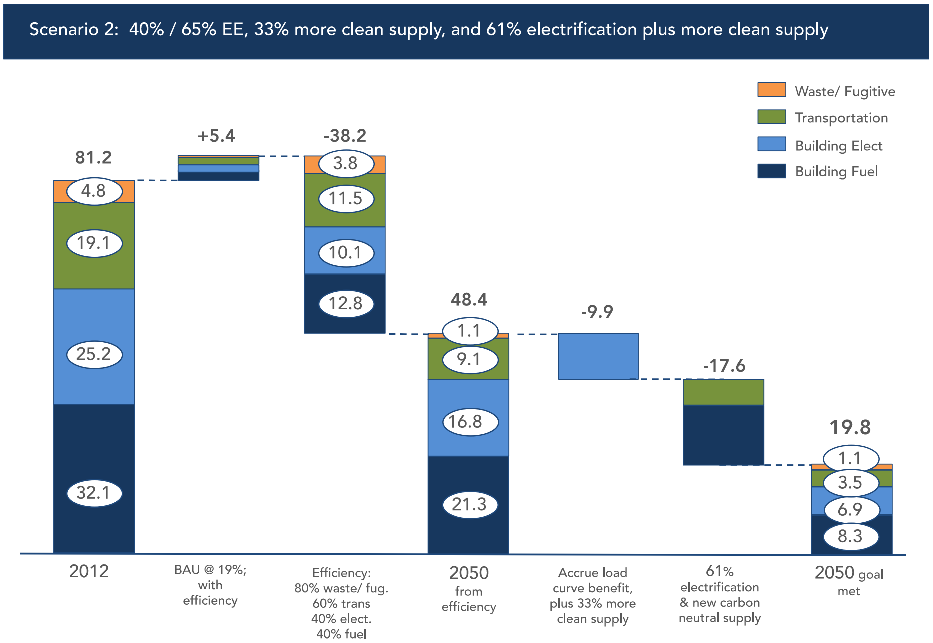

Figure 7: Scenario 2: 40% Energy Efficiency and 61% Electrification

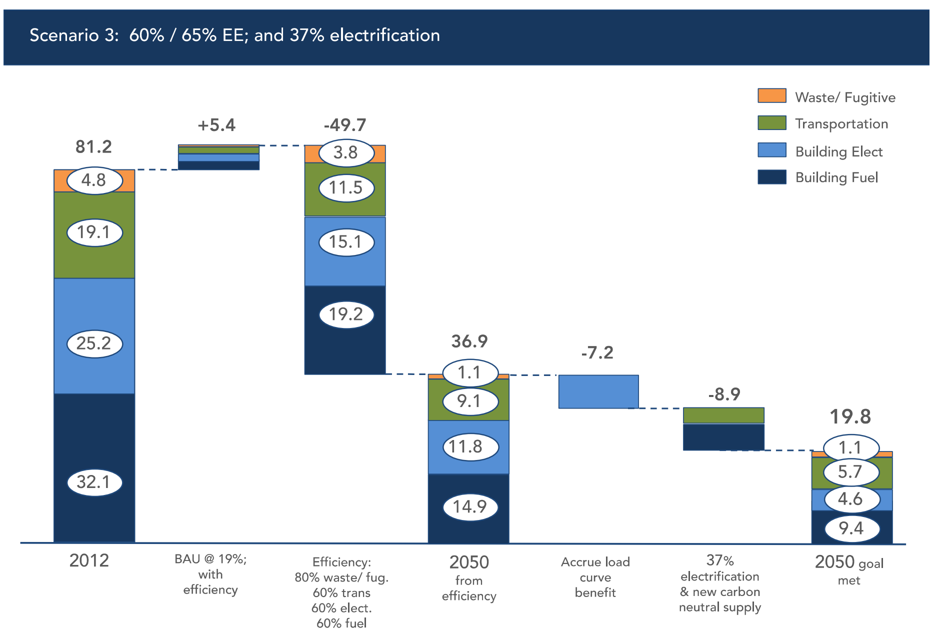

Figure 8: Scenario 3: 60% Energy Efficiency and 37% Electrification

Conclusions

A number of overarching conclusions for NYC flow from this exercise. They are probably applicable to other cities, especially those that have a major heating loads.

General Policy Conclusions

- Achieving 80 x 50 will require deep and serious efforts in *all* areas. Transportation and new and existing buildings will need to become significantly more efficient and waste will need to be dramatically reduced. But that will not be enough: in addition, there will need to be much more carbon neutral power and a significant amount of the transportation sector and building heating and hot water will need to be electrified and fed with carbon neutral supply.
- Achieving 80 x 50 *does not* necessarily require the widespread adoption of extreme efforts in any one area, such as net zero or full Passive House or a fully decarbonized grid – although such ambitious efforts will always be of value. It is likely that the most cost-effective solution will pull all the levers – from efficiency to electrification to carbon neutral supply – equally hard, but not to an extreme.
- Achieving 80 x 50 *does not* require full electrification. Fuel can still play a role, albeit much more minor, in the grid, buildings, and in transportation in 2050.
- There is not just one path to 80 x 50. Since there are multiple parameters, and none of them have to be pursued to the max, there is latitude for a certain amount of trade-off between strategies. This should enable policy makers to "dial the knobs" to develop the most cost-effective and/or most viable path.

Building Efficiency Policy and the 2050 Grid

- Existing buildings will, on average, need to reduce energy use by roughly 40% to 60%.
- New buildings will need to use roughly 60% to 70% less energy than the average for existing buildings of their type.
- Electrical demand will not change that much because the decreases due to efficiency will be roughly offset by increases from the electrification of transportation and buildings (heating and hot water). Consequently, the overall distribution system may not change appreciably.
- The big change is in the carbon neutral power supply, which will need to be more than doubled. That will likely have significant implications in terms of power generation and perhaps transmission.

Envisioning the Big Picture

- It is possible to sketch out the biggest moves of a city's carbon action plan in a single slide – see Figures 7 and 8 – so that one can see the relationships between all the parts. This can enable the big picture issues to emerge and more people to enter into this conversation, helping to detoxify this daunting and frightening problem.

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