# The Divergence Problem - Meeting "AIA 2030 Challenge" Standards with Existing Buildings: A New York City Tenant Case Study

*Steven Baumgartner and Julian Parsley, Buro Happold Consulting Engineers*


## ABSTRACT

Using a typical tenant-owner New York City case study, this paper shows the opportunities and challenges to providing a carbon neutral space in a New York City climate. The authors provide a framework and describe the steps to solving a divergence problem: the increasing intensity of energy use with the reduction of carbon targets.

In the goal to achieve carbon neutrality, the case study shows how a stepped process will provide opportunities to reduce carbon emissions by up to 86% below the baseline energy usage of 2007. This framework uses a combination of passive strategies, behavioral modifications, energy efficiencies, grid 'cleaning' and renewable resources; any purchasing of carbon credits will be solely to offset future growth of the carbon intensities.

Even with the most aggressive on-site strategies, the case study shows that energy will need to be provided by the public utility grid. Therefore, emphasis is placed on the 'cleaning' of the electric grid by 30%. The final step to achieving a carbon-neutral framework will be the implementation of radical (less economically viable) strategies combined with a level of reliance on unforeseen future technological advancements. It is concluded, that a viable goal for tenants is a 44% reduction of carbon emissions[1] over the next two decades compared to 2007 emissions.

In-depth financial analysis, and the economic barriers and incentives for these reductions are not discussed in this paper.


## Background

Architect Ed Mazria in his Architecture 2030 Challenge, which has been adopted by the American Institute of Architects (AIA), concludes that architects and designers can curb global warming to 1 deg. C by creating a stepped reduction in new building carbon emissions resulting in neutrality by 2030. The challenge also calls for, at a minimum, existing buildings (of an area equal to new construction) to be renovated annually to meet a fossil fuel, green house gas emitting, energy consumption performance standard of 50% of the regional average for that building type (AIA 2008).

## Divergence Problem Defined

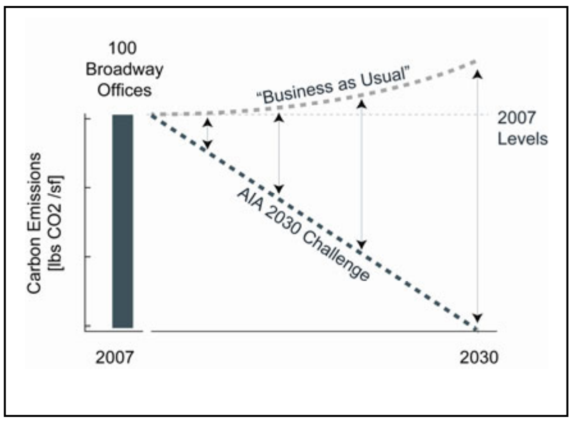
A divergence problem faces the design and construction industry: energy use intensities, and therefore carbon footprint intensities, are rising at the same time that our carbon reduction targets are becoming more and more stringent. Architects and engineers do not currently have a clear framework to reach often onerous carbon reduction goals in the context of site and program constraints.

[1] This includes 24% through tenant upgrades and an additional 20% from an improvement to the grid's carbon intensity.

Because of the restrictions imposed by infrastructure and the limitations of building systems and passive strategies that can be implemented in retrofit, reducing carbon emissions in existing buildings is often more challenging than designing carbon reductions into new buildings. The goals for reduction are further obstructed by barriers seen in many tenant leasing options, such as systems run for lowest base building energy use or mark-ups being made by landlords on tenant electrical use. This 'split incentive issue' also disincentives collaboration between landlords and tenants working together for $CO_2$ reductions, creating a separation of carbon scopes.

Population is growing, and individuals are using more energy. Gadgets are becoming more efficient, but people are buying more of them. Computer screens use less energy than they did previously, but many employees have two of them at their desks. "Green buildings", when occupied by professional service companies, are often being used by employees over longer daytime occupancy schedules with more weekend working; thus exceeding energy targets anticipated during their design. This is "Business as Usual" and is shown on many carbon forecasting graphs through 2030 as an ascending trend line, as it is in Figure 1.

**Figure 1. The Divergence Problem**




Currently 852 mayors from 50 states have committed to striving to meet or beat Kyoto protocol targets in their own communities (Mayors Climate Protection Center 2008). Many of these local jurisdictions, such as New York, have carbon reduction plans that echo the AIA 2030 challenge, using the year 2030 as a timeframe. Mayor Bloomberg's "plaNYC" has called for 30% reductions in carbon emissions in New York City by 2030, across all sectors: avoided sprawl, clean power, efficient buildings and sustainable transportation (The City of New York et al. 2007). Percentage reduction targets and a realistic framework for successfully reaching these goals have not been clearly defined for new buildings or existing buildings. Those who choose to adopt a 2030 carbon reduction framework must first establish realistic expectations, and then set forth a clear strategy and framework for achieving these goals.

## Case Study of Buro Happold's 100 Broadway New York Office

A steel frame curtain wall construction, 100 Broadway was built between 1894 and 1896 (Hiro Real Estate Co. 2008). The building was modified in 1922 with the addition of the 23rd and 24th floor penthouse, which Buro Happold (BH) has occupied since the start of 2006. BH has a ‘net lease’ lease agreement with the property manager. BH as the tenant is responsible for all three of the usual operating costs: building insurance, maintenance and property taxes. This arrangement is known as a triple net lease. BH pays electric charges directly to ConEdison. Maintenance, including base building heating, insurance and taxes are pro-rated by the square footage leased by BH and the charges are included in the monthly rent.

At BH’s 100 Broadway Office, there are several incentives to build green:

- Practicing what it preaches: as a Sustainability Consultancy, the office needs to reflect that commitment;
- Broadening its knowledge of the benefits of green technologies such as user comfort, increased productivity and worker retention;
- Ability to attract a young, knowledgeable staff; and
- General environmental stewardship.
- As part of ISO 14001 Certification, BH is creating an Energy Management System

However, there are several barriers:

- The incentives for implementing energy efficiency measures are often split between the building owner and tenant;
- The owner specifies which architects and contractors will be hired, which is not only cost ineffective, but often leads to inefficient tenant designs that are copied from floor to floor;
- High construction costs, specifically electrical installation;
- Quality of space and space planning optimization is a primary driver and efficiency is not;
- Energy costs are near 1/100 of staff costs; and
- Occupants expect a certain level of automation with comfort conditions provided on demand (potentially 24 hours/day) with no waiting time.

## 100 Broadway Building & System Description

The building systems of 100 Broadway are outlined in Table 1, broken down by base-building and tenant. This represents a typical tenant lease structure, where the tenant can only influence some services.

Commercial spaces in New York City represent nearly 25% of the city’s carbon emissions (The City of New York et al. 2007). 100 Broadway is a fairly typical tenant leasing model in New York City, so a framework for reducing carbon emissions in this sector can have a large impact on reducing the city’s overall carbon footprint. New York office spaces, like 100 Broadway, however, are unique to others found in different parts of the country. High occupancy densities and high energy consuming clients drive up the energy demand per square foot in most New York City buildings. The site density of lower Manhattan provides specific challenges for on-site renewable energy strategies, which are a critical step in reaching these carbon goals.

**Table 1.: 100 Broadway System Description**

| System | Base-building | Tenant |
|---|---|---|
| Heating | Gas fired boiler in basement | Heating coil in Air Handling Unit, Perimeter Fin Tube |
| Cooling | Cooling Tower and distributed condenser water | Floor Packaged Water Cooled unit, distributed to Variable Air Volume (VAV) boxes w/o reheat |
| Lighting | Main foyer, stairwells, exterior, Mech. Equip. rooms, elec and other back of house storage areas. | All tenant spaces, including floor elevator lobby and bathrooms |
| Domestic Hot water | Elec. Heater for toilet rooms only | Local elec. Domestic hot water heater. |
| Other | | General kitchen facilities, computer servers and small power items. These items were fully surveyed and are listed in the energy end use section. |

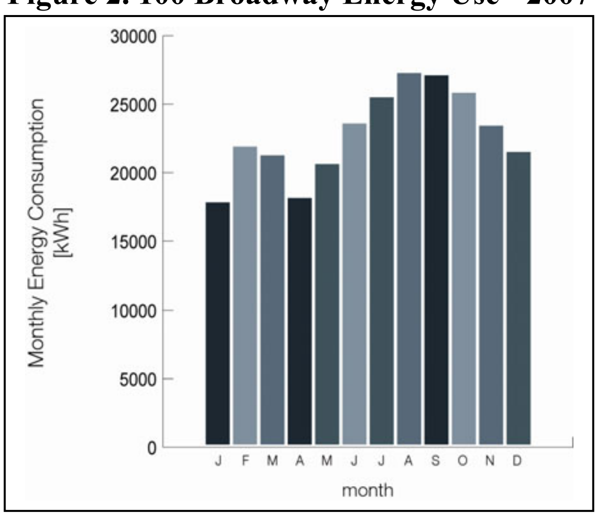
The building systems in Table 1 are thought to be fairly typical of recently renovated New York City buildings (within the last 10 years). An area where enhanced performance is particularly strong is lighting, where low power density, controls and switching off at night leads to lower than usual energy consumption.

## 100 Broadway Energy Use

With existing buildings, the challenge of creating a baseline energy model has been removed. It is clear what is used within the building: the utility bills give the metered usage, and simple energy audits can provide an understanding of the base building and tenant demarcation lines. Benchmarking can be the challenge, e.g. establishing an understanding of how the space is performing compared to similar spaces of comparable program and climate.

Electrical consumption dominates energy use in The BH office. The monthly electrical energy consumption is presented in Figure 2. It shows that, as would be expected in New York City, summer energy consumption is elevated due to cooling loads on the building. Also, the results show a small increase in the base electrical consumption due to an increase in office occupancy from 80 to 130 employees over the course of 2007. The two floors are now fully occupied, giving an occupant density of approximately 125 gross square feet (gsf) per person.

**Figure 2. 100 Broadway Energy Use - 2007**

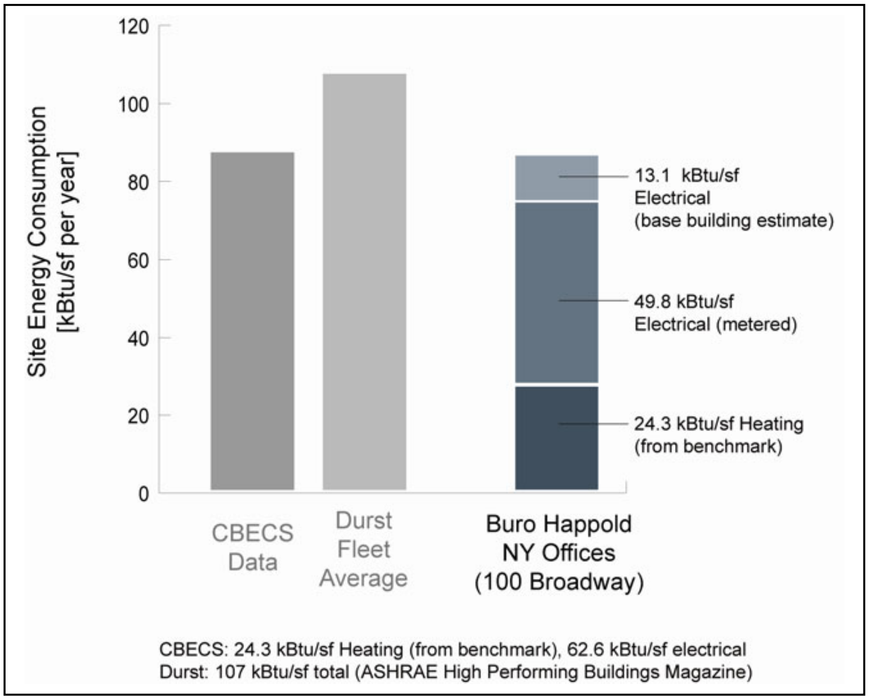


The office space loads are 1.1 Watts per square feet (W/sf) for lighting, 0.7 W/sf at 90 W/person for occupant load and small power equaling 0.6 W/sf (70 W per computer). The load for printers and servers was taken at 0.2 W/sf.

**Benchmarking Energy Consumption**

To indicate how the office space performs, the authors have analyzed a number of parameters. Electrical energy consumption for an office building from CBECS 2004 has been used to benchmark its energy performance (EIA 2006). For a similar type of space and climate, CBECS data shows 86.1 kBtu/sf. However, CBECS data is limited as it is only possible to sort it in terms of building use, size or location, but not all three. The building type of "office" was thought to offer the closest data comparison.

**Figure 3. Energy Benchmarking**




The total building energy consumption has been benchmarked against CBECS and the Durst Fleet, as shown in Figure 3. A new publication called "High Performing Buildings", published by ASHRAE, has included real energy performance from high performing buildings. The Durst Organization has shared their fleet's data in the first issue, Winter 2008 (Hinge & Winston 2008).

The BH office in New York consumes 74.1 kBtu/sf as measured from the meters and billed from ConEdison. This figure represents only tenant energy consumption, and has not included base-building energy consumption. The authors have estimated that this figure represents 85% of total site energy consumed. This assumption represents estimates for central elevators, base-building lighting and central plant energy. The total site energy is then 87.2 kBtu/sf, a level of energy consumption comparable to a typical office per CBECS and significantly lower than that of the Durst Fleet.

## Energy End Use Breakdown

To understand the opportunities for energy conservation measures a complete energy end use breakdown has been conducted. All energy consuming items have been listed in Figure 4. A combination of benchmarks and calculations have been used to estimate the energy end use breakdown using a bottom up approach. All energy consuming items have been surveyed, along with behavioral surveys of 25% of staff. Annual energy consumption has been estimated from a mix of annual consumption benchmarks and power draw and hours of operation as stated in the calculation method below. The authors summarized percentages in Figure 5 to display the major sources of energy consumption.

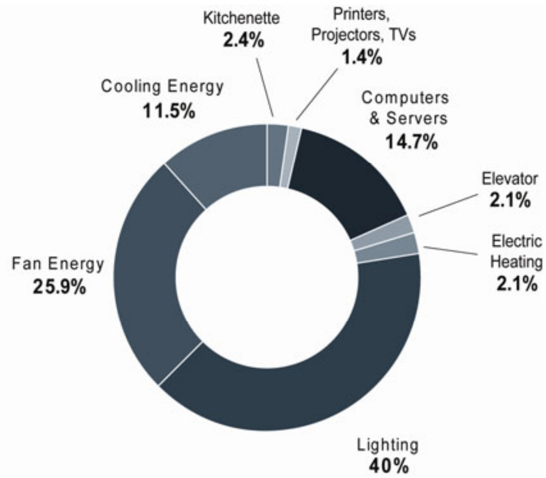
### Figure 4. Assumptions used for 100 Broadway Energy Breakdown

| Energy End Use | Estimated Annual Energy Consumption | | % Total | Assumptions & Calculation Method |
|---|---|---|---|---|
| **Kitchen Equipment** | | | **2.33%** | |
| Dishwasher | 801 | kWh/yr | 0.33% | 10 Cycles/wk, 1.54 kWh/cycle, from E.Star data. |
| Water Coolers | 827 | kWh/yr | 0.34% | 1 cold unit, 0.29 kWh/day, 2# H&C units, 2.19 kWh/day (E.Star) |
| Refrigerator | 1,000 | kWh/yr | 0.42% | DOE 2004 databook indicates 500 kWh/ unit per year |
| Microwave | 234 | kWh/yr | 0.10% | 1 unit, 900 W used for 1 hour per day, 5 days per week |
| Domestic HW Heater | 2,299 | kWh/yr | 0.96% | CBECS 2004 1% energy benchmark used on annual energy |
| Sump Pump | 437 | kWh/yr | 0.18% | Assumes 0.4 kW power draw for 3 hours per day, 7 days per week |
| **Office Equipment** | | | **18.03%** | |
| TVs | 191 | kWh/yr | 0.08% | 2#, 20 hrs on stand-by, 4 hrs on with 70W power consumption |
| Projectors | 281 | kWh/yr | 0.12% | 2 units, 900 W used 1 hour per day 3 days per week |
| Electric Heaters | 4,933 | kWh/yr | 2.06% | 7#, average 2.5 kW & 1973 hrs use/yr (from surveyed data) |
| Printers / Plotters | 2,912 | kWh/yr | 1.21% | 2# small, 2# large, 2# plottes, average 8hrs at 1.4 kW draw |
| Servers | 8,320 | kWh/yr | 3.47% | Assumes 2 kW draw during the day, 1 kW draw at night (16 hours) |
| Computers | 26,595 | kWh/yr | 11.09% | 70W/computer, 130# diversified, 90% 9 – 6pm, 20% across 5 hrs |
| **Elevator** | 5,000 | kWh/yr | **2.08%** | Adjusted benchmark from 15,000 kWh/yr for a typical elevator |
| **Lighting** | 95,267 | kWh/yr | **39.72%** | Assumes 1.1 W/sf across 8–11pm typical, 10-6pm Sat/Sun, 2 kW |
| **Fan Energy** | 61,560 | kWh/yr | **25.67%** | 2# 9kW operate 9hrs/day M-F (surveyed), 8hrs/day Sat/Sun for 30 |
| **Cooling Energy** | 27,334 | kWh/yr | **11.40%** | From a modeled load of 20 kBtu/sf/yr and a COP of 3.5 on |
| **Total Calculated Energy** | **237,992** | **kWh/yr** | | |
| **ConEd Meter total** | **239,840** | **kWh/yr** | | |

**Notes:**
1. Calculation method uses installed power and operating hours, energy star or CBECs benchmarks and energy model results as noted above.
2. M-F indicates Monday to Friday.

**Figure 5. Estimated 100 Broadway Energy Breakdown Summary**

| | | |
|---|---|---|
| Kitchenette | 5,598 | 2.4% |
| Printers, Projectors, TVs | 3,384 | 1.4% |
| Computers & Servers | 34,915 | 14.7% |
| Elevator (23rd/24th) | 5,000 | 2.1% |
| Electric Heating | 4,933 | 2.1% |
| Lighting | 95,267 | 40.0% |
| Fan Energy | 61,560 | 25.9% |
| Cooling Energy | 27,334 | 11.5% |
| **Total Calculated Energy** | **237992** | **kWh/yr** |
| **ConEd Meter total** | **239840** | **kWh/yr** |




## Carbon Emissions Benchmarking & Strategies

From the energy analysis conducted the office annual carbon emissions can be calculated. The carbon intensity used for the electrical grid and gas are 1.038 lbs$CO_2$ per kWh and 117.1 lbs$CO_2$ per kBtu respectively.

The carbon reduction strategy outlined below develops a series of behavioral changes, tenant improvements, major upgrades and renewable technologies in a series of strategies. The assumptions used to create this information are outlined in Figure 6.

## Figure 6. Strategy Assumptions

| Ref # | | | |
|---|---|---|---|
| | **Step 1: Passive Energy Efficiency Strategies** | | |
| | Strategies that can be easily implemented with existing controls | | |
| 1.1 | Office Equipment | Activate stand-by controls on remaining machines | 15% of 118 machines save 1.5 hours of use & 70 Watts, 5 days per week, 52 weeks per year |
| 1.2 | Office Equipment | Encourage complete turning off of equipment at night | 10% of 118 machines save 14 hours of use & 50 Watts, 5 days per week, 52 weeks per year |
| 1.3 | Lighting | Strict switching off meeting room lights when not in use | 2 hr/day of savings- 5 days/week in each meeting room are available through better switching, 16x32W fittings. |
| 1.4 | Lighting | Better use of dimming features & switching | lighting can be dimmed down using existing controls with education and a defined control strategy, 4 hrs of savings 7 days / wk across 50% of office with 50% savings in energy from level 2 dim setting. |
| | **Step 2: Tenant Upgrade Strategies** | | |
| | Strategies that require work such as electrical re-wiring with better controls, these are considered feasible only on a renovation | | |
| 2.1 | Lighting | Fix lighting controls (switches in 23rd/24th corner spaces) | 18# 18W fittings can be turned off for 11 hours per day, 7 days a week, when the light switches are fixed |
| 2.2 | Lighting | Fix occupancy sensors in the 24$^{th}$ flr store | 8 hours of savings for a single 32W fitting could be achieved if the occupancy sensor were installed as intended. |
| 2.3 | Lighting | Individual Switching per 3 fixtures (weeknight savings) | 3 hours of savings are achievable each day across 50% of the space with a 100% saving in energy only the reqd lights turned on. |
| 2.4 | Lighting | Individual Switching per 3 fixtures (weekend savings) | 6 hr/day of savings are achievable across 50% of the space with a 100% saving in energy consumption only the reqd lights being turned on. |
| 2.5 | Lighting | Turn off remaining 24 hour lights, leave main entrance only | 6# 18 W fittings are left on for night safety, could be minimized with only the lift foyer lights left on. 8 hours of savings per night would be achieved. |
| 2.6 | Water Heating | Heat pump hot water heater to replace electric resistive | A heat pump water heater could replace the electric resistive for the generation of hot water, the evaporator could be located in the IT closet for free cooling. A COP of 4 has been assumed, saving 75% of electrical energy consumption. |
| | **Step 3: Base Building Upgrade Strategies** | | |
| | Strategies considered here would only be possible on major renovation | | |
| 3.1 | HVAC | High efficiency compressor upgrade | It is assumed that the compressor efficiency could be improved from 3.5 to 4 with a high efficiency unit specified. |
| 3.2 | HVAC | Constant volume fan upgraded variable frequency drive | It has been estimated that 45% energy savings are achievable from the fan energy from conversion to VAV. |
| 3.3 | HVAC | Condenser water reset for improved efficiency | It is assumed that a 3% improvement in efficiency is achievable from maintaining the minimum condenser flow temperature to maximise compressor efficiency. |
| | **Step 4: Renewable Energy Strategies** | | |
| | Renewable strategies applicable for 24flr only. | | |
| 4.1 | Photovoltaic Installation | 40 kW South facing rooftop array | It is assumed that a 4000 sf PV array could be located on the roof, optimized for maximum performance, tilted and South facing. |
| 4.2 | Rooftop Microturbines | 8 # 6kW Rooftop turbines | Rough estimate of .2 Capacity factor, .6 Wind Factor |
| 4.3 | Heating | Biomass Boiler Installation | It is assumed that a biomass boiler could be installed to supply carbon nuetral heating. |
| | **Strategy 5: Radical Strategies** | | |
| | Strategies included here are not given feasible given expectations on quality of service | | |
| 5.1 | General | Remove the cold water coolers | Cold water could be provided directly from taps with no cooling. This energy use would be removed. |
| 5.2 | General | Remove sump pump | On major renovation the layout could be altered to allow gravity drainage or draining through the floor below and connecting into the gravity system. This energy use would be removed. |
| 5.3 | HVAC | HVAC System Upgrade (Chilled Beams/Underfloor Air) | The VAV system could be replaced with either an underfloor air system which would provide fan energy savings, or a chilled beam system. |
| 5.4 | General | Savings from banning local heaters if HVAC upgraded | If the HVAC system was improved to provide better thermal comfort then supplemental heaters could be banned from use within the office. A 30% saving in fan energy has been assumed. |
| 5.5 | General | Transformer Efficiency Improvement for Computers | It is assumed that over the next 15 years that computers will become more efficient resulting in a 5% improvement in transformer efficiency. |

The following steps were taken in aiming for carbon-neutrality:

- Steps 1: Passive Energy Strategies, or passive measures that could be implemented now to provide energy savings. This also includes no-cost energy reduction measures.
- Steps 2: Viable Tenant Upgrades that require moderate to major renovations to justify.[2]
- Steps 3: Base Building Upgrades that can only occur on a major renovation.
- Steps 4: Renewable Technologies that are currently available technologies.
- Steps 5: Radical Strategies which includes giving up certain luxuries, radical changes to service strategies, and unknown future technologies and renewable strategies.

Figure 7 shows the energy savings and $CO_2$ emission reductions associated with each strategy. Strategies listed have associated upfront costs, potential maintenance and operating costs, and hidden costs such as temporary relocation of tenant space and production downtime. As mentioned, the financial feasibility, incentives and drivers are not discussed in detail in this paper.

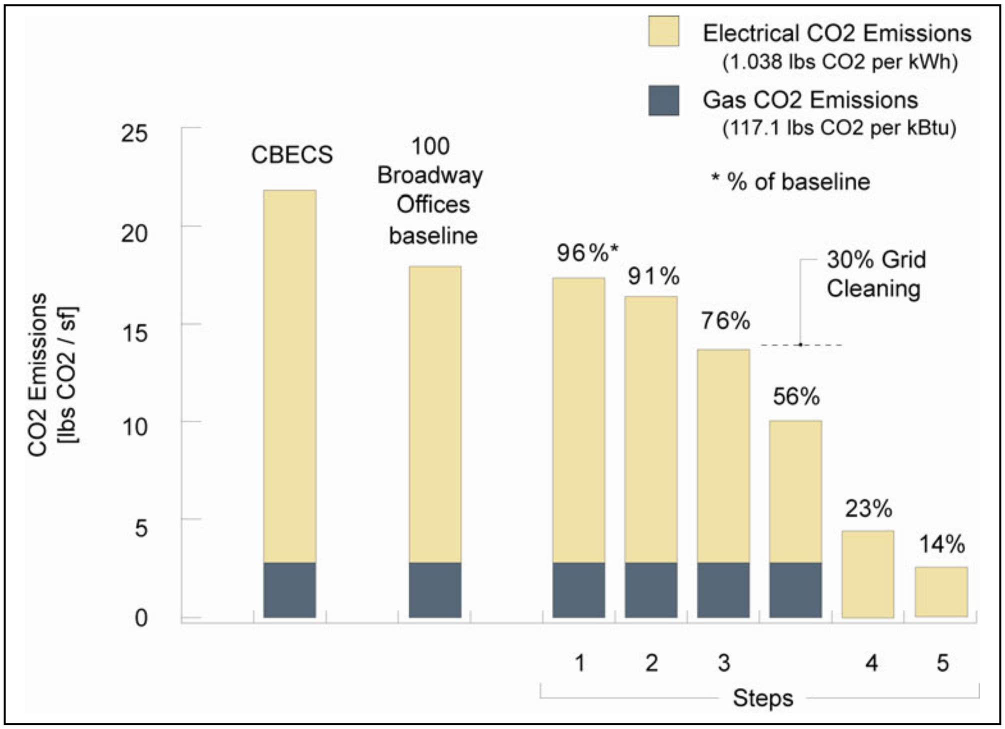
**Figure 7. Carbon Reduction Strategies**

| Ref # | | | Energy Savings (kWh/yr) | CO2 Emissions per year (lbs/gsf) | Cummulative % Savings over Baseline | Annual Payback ($) |
|---|---|---|---|---|---|---|
| | **Step 1: Passive Energy Efficiency Strategies** | | | | | |
| 1.1 | Office Equipment | Activate stand-by controls on remaining machines | 483 | 0.03 | | 111 |
| 1.2 | Office Equipment | Encourage complete turning off of equipment at night | 2,148 | 0.14 | | 494 |
| 1.3 | Lighting | Strict switching off meeting room lights when not in use | 266 | 0.02 | | 61 |
| 1.4 | Lighting | Better use of dimming features & switching | 6,537 | 0.41 | | 1503 |
| | | | **9,434** | **0.60** | **3.6%** | **2,170** |
| | **Step 2: Tenant Upgrade Strategies** | | | | | |
| 2.1 | Lighting | Fix lighting controls (switches in 23rd/24th corner spaces) | 1,301 | 0.08 | | 299 |
| 2.2 | Lighting | Fix occupancy sensors in the 24th flr store | 93 | 0.01 | | 21 |
| 2.3 | Lighting | Individual Switching per 3 fixtures (weeknight savings) | 7,004 | 0.44 | | 1611 |
| 2.4 | Lighting | Individual Switching per 3 fixtures (weekend savings) | 5,603 | 0.35 | | 1289 |
| 2.5 | Lighting | Turn off remaining 24 hour lights, leave main entrance only | 315 | 0.02 | | 73 |
| 2.6 | Water Heating | Heat pump hot water heater to replace electric resistive | 575 | 0.04 | | 132 |
| | | | **14,891** | **0.94** | **8.8%** | **3,425** |
| | **Step 3: Base Building Upgrade Strategies** | | | | | |
| 3.1 | HVAC | High efficiency compressor upgrade | 3,417 | 0.22 | | 786 |
| 3.2 | HVAC | Constant volume fan upgraded variable frequency drive | 36,936 | 2.33 | | 8495 |
| 3.3 | HVAC | Condenser water reset for improved efficiency | 2,500 | 0.16 | | 575 |
| | | | **42,853** | **2.70** | **23.8%** | **9,856** |
| | **30% Cleaning of the Grid** | | **N/A** | **3.60** | **44.0%** | |
| | **Step 4: Renewable Energy Strategies** | | | | | |
| 4.1 | Photovoltaic Installation | 40 kW South facing rooftop array | 48,800 | 3.08 | | 11224 |
| 4.2 | Rooftop Microturbines | 8 # 6kW Rooftop turbines | 50,000 | 3.15 | | 11500 |
| 4.3 | Heating | Biomass Boiler Installation | - | - | | - |
| | | | **98,800** | **3.08** | **76.7%** | **22,724** |
| | **Strategy 5: Radical Strategies** | | | | | |
| 5.1 | General | Remove the cold water coolers | 211 | 0.01 | | 48 |
| 5.2 | General | Remove sump pump | 437 | 0.03 | | 100 |
| 5.3 | HVAC | HVAC System Upgrade (Chilled Beams/Underfloor Air) | 17,237 | 1.09 | | 3964 |
| 5.4 | General | Savings from banning local heaters if HVAC upgraded | 4,933 | 0.31 | | 1135 |
| 5.5 | General | Transformer Efficiency Improvement for Computers | 1,330 | 0.08 | | 306 |
| 5.6 | General | Ban elevator use for single trips | 2,500 | 0.16 | | 575 |
| | | | **26,648** | **1.68** | **86.1%** | **6,129** |

[2] In BH's case, strategies 2.3 -2.6 are deemed major renovations due to extensive rewiring of space to implement these measures.

Figure 8 shows the $CO_2$ emissions of 100 Broadway offices at 2008 compared to CBECS data, as well as the stepped strategies to achieve carbon neutrality. The step between 3 and 4 shows a "cleaning of the grid" by 30%.

**Figure 8. Carbon Reduction Results**




A full range of measures have been assessed, and many were rejected as they did not apply to the specific nature of the space. Measures such as the addition of skylights, external shading, automatic internal blinds and free night cooling were not implemented in this study, but may be more applicable in other buildings.

The base building energy efficiency has not been fully addressed within this case study. Base building energy efficiency improvements such as variable volume pumping, variable volume cooling towers and lobby and core lighting improvements have been assumed as base building upgrades to be carried out over the next 25 years.

## Energy Efficiency Measures - Summary

Figure 7 shows the reduction summaries implemented in the four primary categories: passive strategies (including behavioral modifications), tenant upgrades, base-building upgrades and on-site renewable. These strategies result in a carbon savings of 56.9%. By 2030, achieving a carbon neutral office will not only have to depend on building upgrades, but on improvements to the quality of the energy on the grid. The authors are emphasizing the importance of a 30% carbon emission reduction based on increasing source energy efficiencies and improvements to transmission and distribution.

Due to site constraints of 100 Broadway, only one of the two on-site renewable strategies was included within the carbon reduction calculation. Because BH occupies the top floor, implementation of on-site renewables could be feasible with owner's permission. This is unlikely in many tenant-leasing agreements. As part of the carbon neutral scheme by 2030, further study would have to be done on the optimization of on-site renewable by the authors, as well as an improvement to the efficiencies of these systems.

Step 5 consists of a combination of radical strategies. These include, for example, less economically feasible solutions such as a chilled beam upgrade to the tenant space, giving up certain luxuries such as a refrigerator or single trip elevators, the improvements in the efficiency of technology such as computers, lighting and copiers, and the dependence on more efficient, viable and implementable renewable onsite energy strategies. A solution to carbon neutrality to many less urban tenants is “green power”. Reducing, or eliminating the carbon intensity of the source power to the site is an important factor which was not implemented in this case study. Factors associated with the carbon implications of “green power” contracts are not discussed within this paper.

## Reactions

The carbon reductions shown in Figure 7 do not account for any future growth and increases in energy use intensities per occupant. This is one half of the dilemma described within the divergence problem. The AIA’s 2030 Challenge allows up to 20% off-setting of carbon emissions through certified renewable energy credits.

The authors have established that if existing building tenants choose to rely on offsets, they should be used only to offset any growth in carbon emission intensities between now and 2030, with a maximum of 20%. This should be done on both a lbs$CO_2$/person as well as lbs$CO_2$/sf calculation, and then offset based on the larger value. Although minimal for this case-study, this strategy may prove to be a great incentive for behavioral change in companies that are seeing large energy intensity growth.

With the assumption that 2008 levels are the baseline between now and 2030, behavioral changes, efficiency improvements, and renewable strategies will result in 87.5% reduction from 2008 levels. Radical strategies, which can be defined as those that are not economically feasible and/or include technological advancements in efficiencies, will need to be used to make up the remaining 12.5% and achieve a carbon neutral office space by 2030.

Table 2 describes the AIA’s steps to accomplishing the 2030 carbon neutral goals, and the author’s strategic response.

**Table 2. Case Study Reactions to 2030 Steps**

| **Steps given by the AIA 2030 Challenge to accomplishing carbon reduction targets** (AIA 2008). | **Author’s Response to an existing tenant framework** |
|---|---|
| implementing innovative sustainable design strategies | Step 1 – Passive Strategies<br>Step 2 – Tenant Upgrades<br>Step 3 – Base-building Upgrades |
| generating on-site renewable power | Step 4 – Renewable Technologies |
| purchasing (20% maximum) renewable energy and/or certified renewable energy credits | Used only to offset any future growth to curb future increases in energy use intensities<br>(the “increasing” side of the divergence problem) |

## Conclusions

It can be concluded that a viable goal for tenants is a 24% reductions of carbon emissions over the next two decades. Carbon neutral tenant spaces can be achieved, however, and architects designers, building operators and occupants can continue to overcome the economic, social and technological barriers to reach this goal without the "crutch" of relying on the purchasing of carbon offsets. These offsets should be used only to curb future carbon growth within the organization.

Given the call for net zero energy buildings or carbon neutral buildings by jurisdictions, associations, and societies, it is important to understand what is achievable with current technology and when to look to future technological advances. Within the 100 Broadway context, a carbon neutral tenant space by 2030 will not come simply by implementation of aggressive energy conservation and renewable energy sources. There needs to be a combination of a commitment by the city to improve the efficiency of its infrastructure, technological advancements and a certain "changing of the tide". Behavioral changes resulting from a deeper commitment to energy awareness will result in a realization of the impact that each individual can have on contributing to the solution.

## References


[A2030] Architecture 2030. Architecture 2030. March 6, 2008 www.architecture2030.org/2030_challenge/index.html.

The City of New York. Mayor Michael R. Bloomberg. PLANYC: A Greener, Greater New York. April 2007: 9.

[EIA] The Energy Information Administration. Commercial Buildings Energy Consumption Survey. 2006.

Hinge, Adam, and Donald Winston. "The Proof is Performance." High Performing Buildings. Winter 2008: 32.

Hiro Real Estate Co. 2008. http://100broadway.com/history.html.

Mayors Climate Protection Center 2008. www.usmayors.org/climateprotection.