NYC School System's Clean Energy Transition

Presenter: Jeremy Shannon, AIA
NYC School Construction Authority

Climate Change Mitigation – NYC Public Schools

What NYC School Construction Authority has accomplished:

- Created the first Net Zero Public School in NY State in 2016.
- Added more than 25 Energy Conservation Measures (ECMs) to NYC's new Public School standards.
- More than 15 new schools designed to be Fossil Fuel Free clean energy buildings.
- Researching and implementing renewable Biofuel heating in existing schools.
- Installing Solar PV and green roof systems on more than a dozen new schools.

SCA

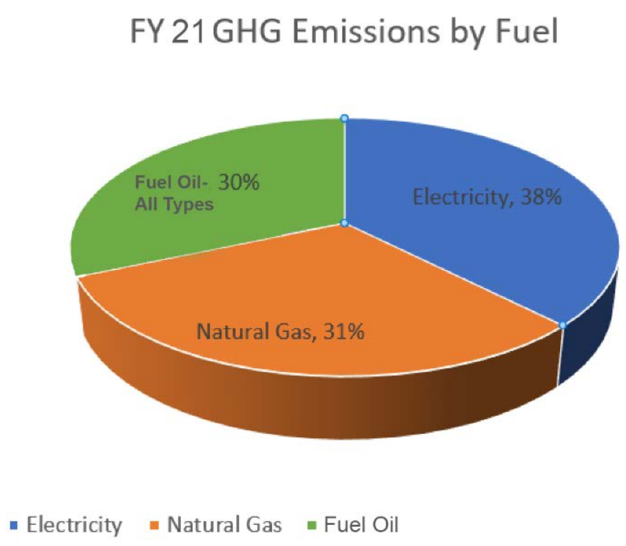
Mandates for NYC Public Schools - beyond Code

1. Plan NYC – enacted 2005.
2. LL86/2005 & LL32/2016 – LEED Certified or Equivalent for Schools
3. LL87/2009 – Energy Audits and Retro Commissioning (DSF)
4. LL88/2009 & LL132/16 & LL134/16 – Lighting/sub-metering (DSF)
5. LL130/2013 – Electric Charging Infrastructure
6. LL66/2014 - One City Built to Last – 80x50 goals.
7. LL06/2016 – Geothermal Feasibility
8. LL31/2016 – Low Energy Intensity Buildings
9. LL97/2017 – Green Infrastructure Feasibility
10. Executive Order #26 2017 – Paris Climate Agreement Goals
11. LL32/2018– Periodic Energy Stretch Code Adoption
12. LL33/2018 – Energy Efficiency Scores and Grades
13. LL94/2019 – Sustainable Roofing Zone
14. LL97/2019 – Carbon Emissions reduction Mandate
15. Climate Resiliency Design Guidelines

Sustainability Mandate Timeline

- 2019 – After July 1st LL31/LL32 of 2016 and LL97 of 2017 will be in full effect.
- 2025 – SCA and DOE to reduce portfolio GHGe 24% from 2005 totals.
  (~200,000 MTCO2e)
- 2025 – LL107/2018 – 100% of City Building electricity must be from Green Energy Sources.
- 2030 – LL31/2016 requires 38 Source EUI max for all new schools.
- 2030 – City Building Greenhouse Gas Emissions must be 50% less than 2005 baseline.
- 2050 – City Building Greenhouse Gas Emissions must be 80% less than 2005 baseline.
- 2050 – City Operations require 100% CO2 reduction from 2005 NYC baselines.

NYC Public Schools



~1,500 Schools
+155 Million SF
+1 Million Students & Teachers
37% of NYC municipal greenhouse gas emissions
1% of all annual NYC GHGe

NYC Public Schools –Carbon Emission Targets

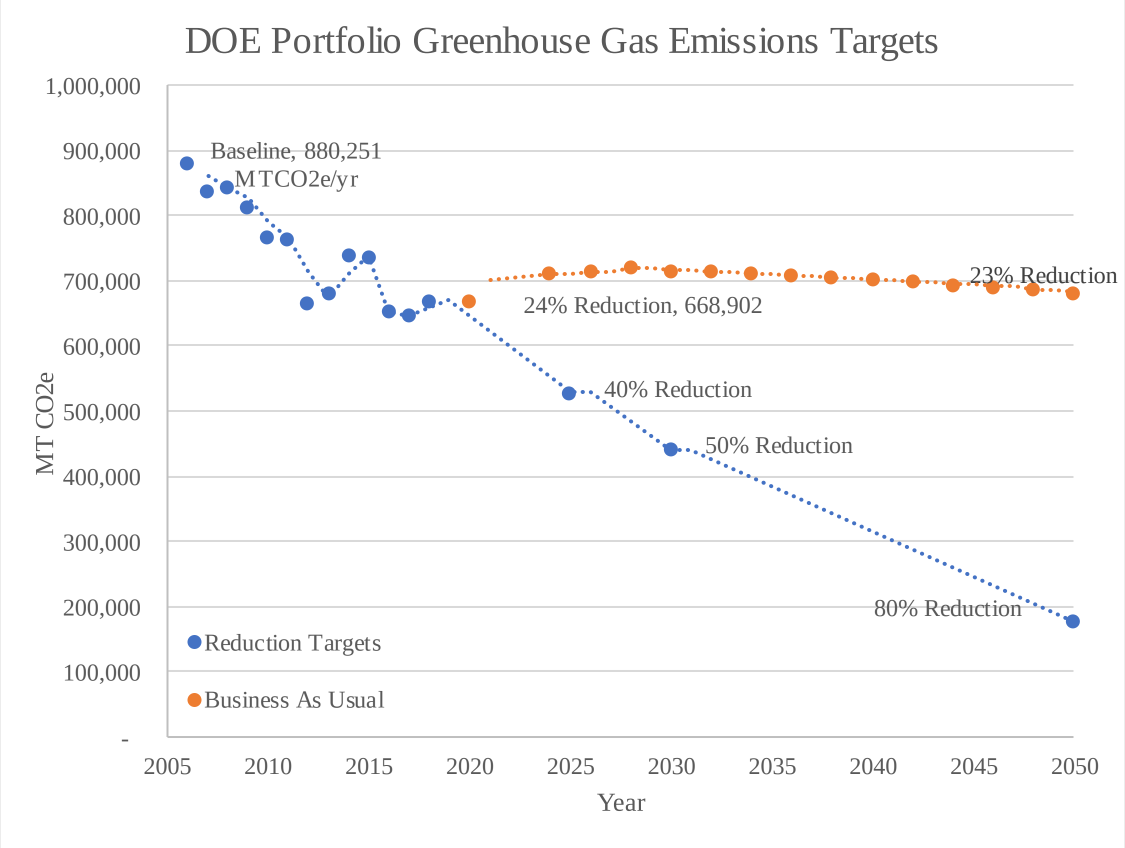


Table 1. Your Agency's Emissions Targets and Emissions Reductions from 2006 Baseline

	2006 Actual	2019 Actual	2025 Projected	2030 Projected
Agency emissions reductions - demand side (MTCO2e)			60,954	84,902
% of emissions reductions - demand side from a 2006			7%	10%
			-	-
Agency emissions reductions - supply side (MTCO2e)			23,276	282,612
% of emissions reduction - supply side from a 2006			3%	33%
Agency emissions target - total (MTCO2e)	858,811	740,129	655,898	372,614
% of emissions reductions from a 2006 baseline	0%	14%	24%	57%

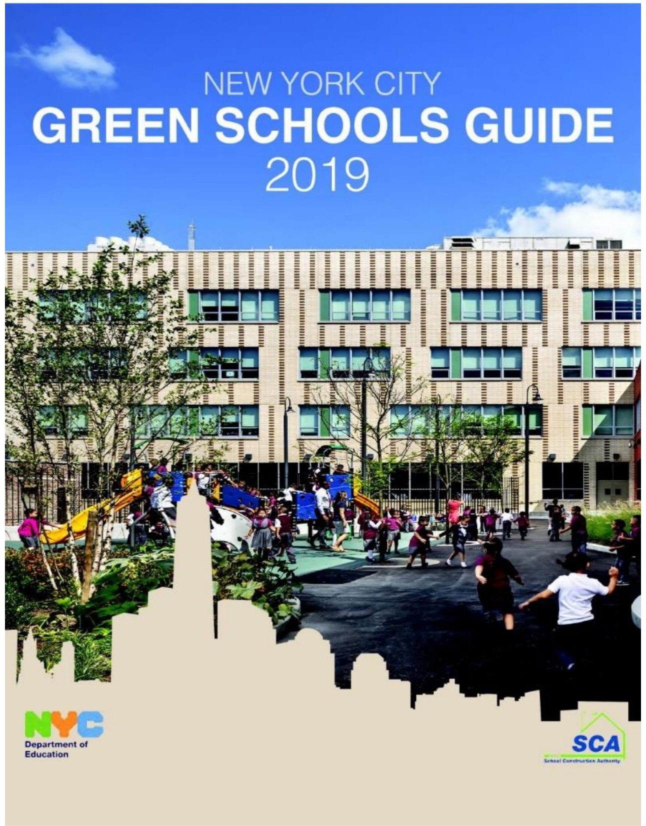
*Note: These demand-side emissions reductions are shown in Figure 1 below and represent demand-side reductions from SCA and DOE pathways.

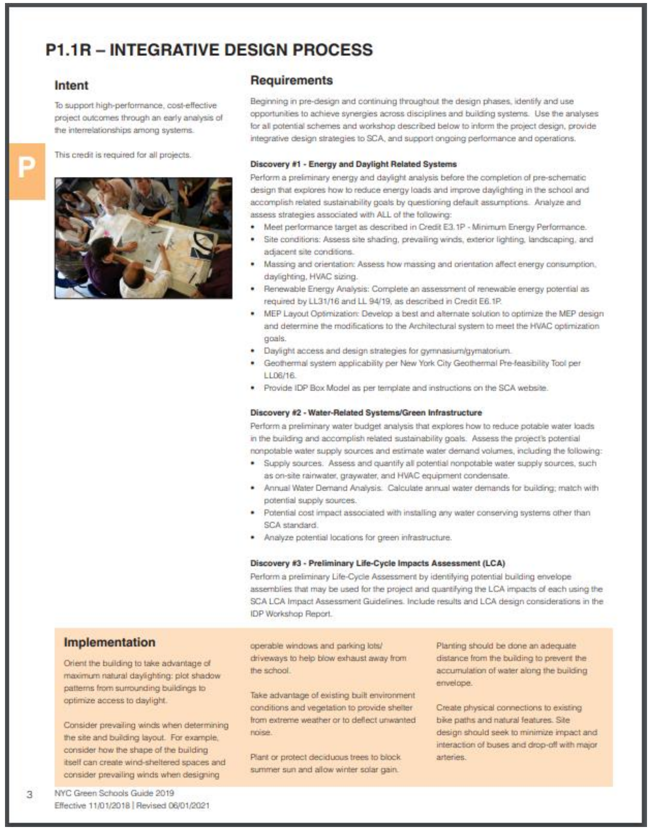
SCA

NYC School Construction Authority – Sustainable Design and Resiliency

NYC Green Schools Guide:

- No less stringent than LEED V4 Certified
- Includes all beyond code City, State, and Federal laws and regulations pertaining to Sustainability and Resiliency
- In effect since 2007 (15 years)
- 4 Major versions.
- Installing Solar PV and green roof systems on more than a dozen new schools.





P1.1R – INTEGRATIVE DESIGN PROCESS

Intent

To support high-performance, cost-effective project outcomes through an early analysis of the interrelationships among systems.

This credit is required for all projects.

P

Requirements

Beginning in pre-design and continuing throughout the design phases, identify and use opportunities to achieve synergies across disciplines and building systems. Use the analyses for all potential schemes and workshop described below to inform the project design, provide integrative design strategies to SCA, and support ongoing performance and operations.

Discovery #1 - Energy and Daylight Related Systems

Perform a preliminary energy and daylight analysis before the completion of pre-schematic design that explores how to reduce energy loads and improve daylighting in the school and accomplish related sustainability goals by questioning default assumptions. Analyze and assess strategies associated with ALL of the following:

- Meet performance target as described in Credit E3.1P - Minimum Energy Performance.
- Site conditions: Assess site shading, prevailing winds, exterior lighting, landscaping, and adjacent site conditions.
- Massing and orientation: Assess how massing and orientation affect energy consumption, daylighting, HVAC sizing.
- Renewable Energy Analysis: Complete an assessment of renewable energy potential as required by LL31/16 and LL 94/19, as described in Credit E6.1P.
- MEP Layout Optimization: Develop a best and alternate solution to optimize the MEP design and determine the modifications to the Architectural system to meet the HVAC optimization goals.
- Daylight access and design strategies for gymnasium/gymatorium.
- Geothermal system applicability per New York City Geothermal Pre-feasibility Tool per LL06/16.
- Provide IDP Box Model as per template and instructions on the SCA website.

Discovery #2 - Water-Related Systems/Green Infrastructure

Perform a preliminary water budget analysis that explores how to reduce potable water loads in the building and accomplish related sustainability goals. Assess the project's potential nonpotable water supply sources and estimate water demand volumes, including the following:

- Supply sources. Assess and quantify all potential nonpotable water supply sources, such as on-site rainwater, graywater, and HVAC equipment condensate.
- Annual Water Demand Analysis. Calculate annual water demands for building; match with potential supply sources.
- Potential cost impact associated with installing any water conserving systems other than SCA standard.
- Analyze potential locations for green infrastructure.

Discovery #3 - Preliminary Life-Cycle Impacts Assessment (LCA)

Perform a preliminary Life-Cycle Assessment by identifying potential building envelope assemblies that may be used for the project and quantifying the LCA impacts of each using the SCA LCA Impact Assessment Guidelines. Include results and LCA design considerations in the IDP Workshop Report.

Implementation

Orient the building to take advantage of maximum natural daylighting: plot shadow patterns from surrounding buildings to optimize access to daylight.

Consider prevailing winds when determining the site and building layout. For example, consider how the shape of the building itself can create wind-sheltered spaces and consider prevailing winds when designing operable windows and parking lots/ driveways to help blow exhaust away from the school.

Take advantage of existing built environment conditions and vegetation to provide shelter from extreme weather or to deflect unwanted noise.

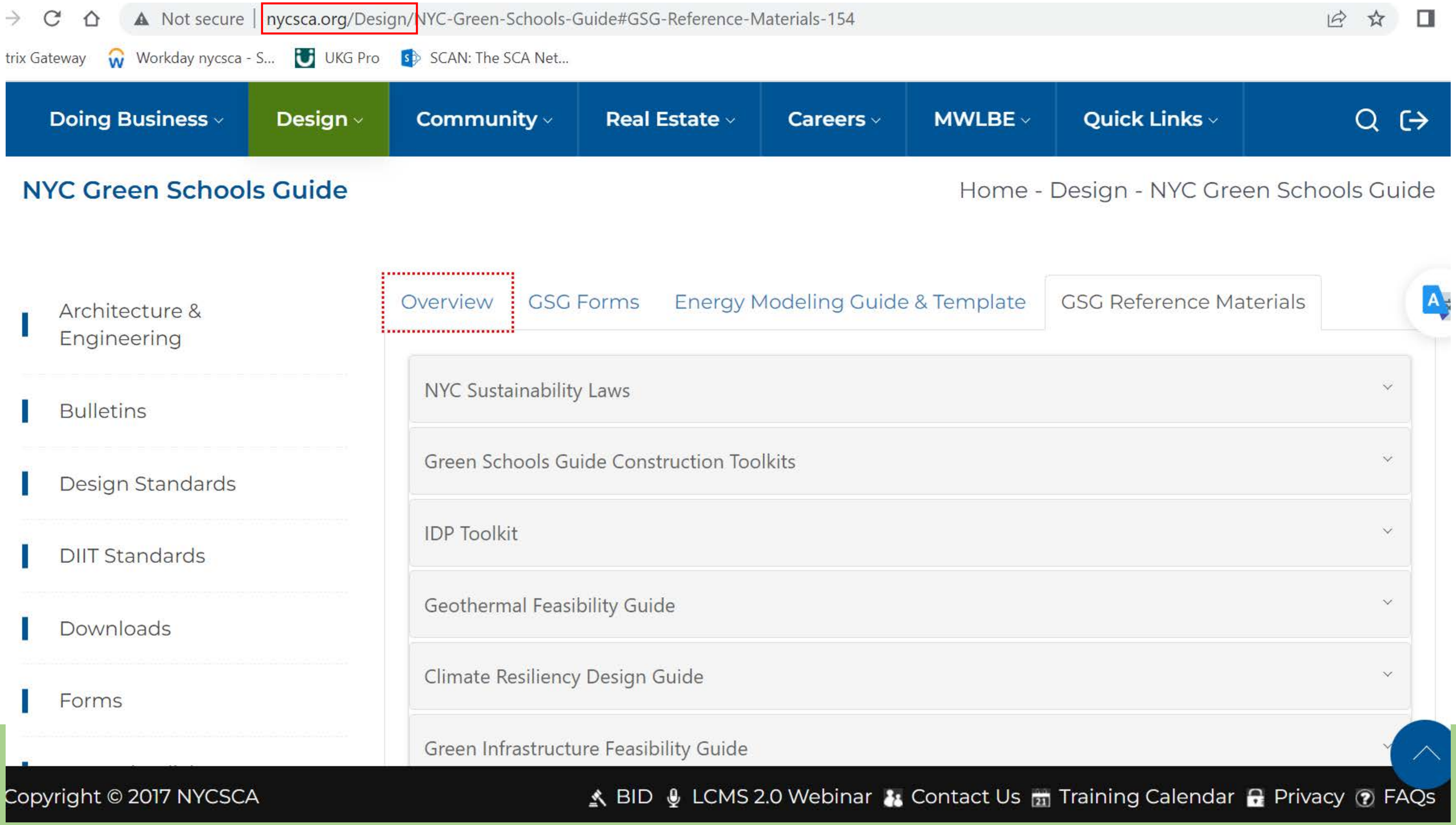
Plant or protect deciduous trees to block summer sun and allow winter solar gain.

Planting should be done an adequate distance from the building to prevent the accumulation of water along the building envelope.

Create physical connections to existing bike paths and natural features. Site design should seek to minimize impact and interaction of buses and drop-off with major arteries.

3 NYC Green Schools Guide 2019
Effective 11/01/2018 | Revised 06/01/2021

NYC SCA – Website and References



How we got here!

Studies, Pilots, & Standards

NYC School Construction Authority's Climate Mitigation Playbook:

- Develop a rigorous study of new technologies in Sustainability and Resiliency.
- Apply appropriate technology to new and existing pilot schools.
- Analyze constructability, costs, and KPI for new technology once installed.
- Seek funding where necessary and adjust design standards to include successful technologies.

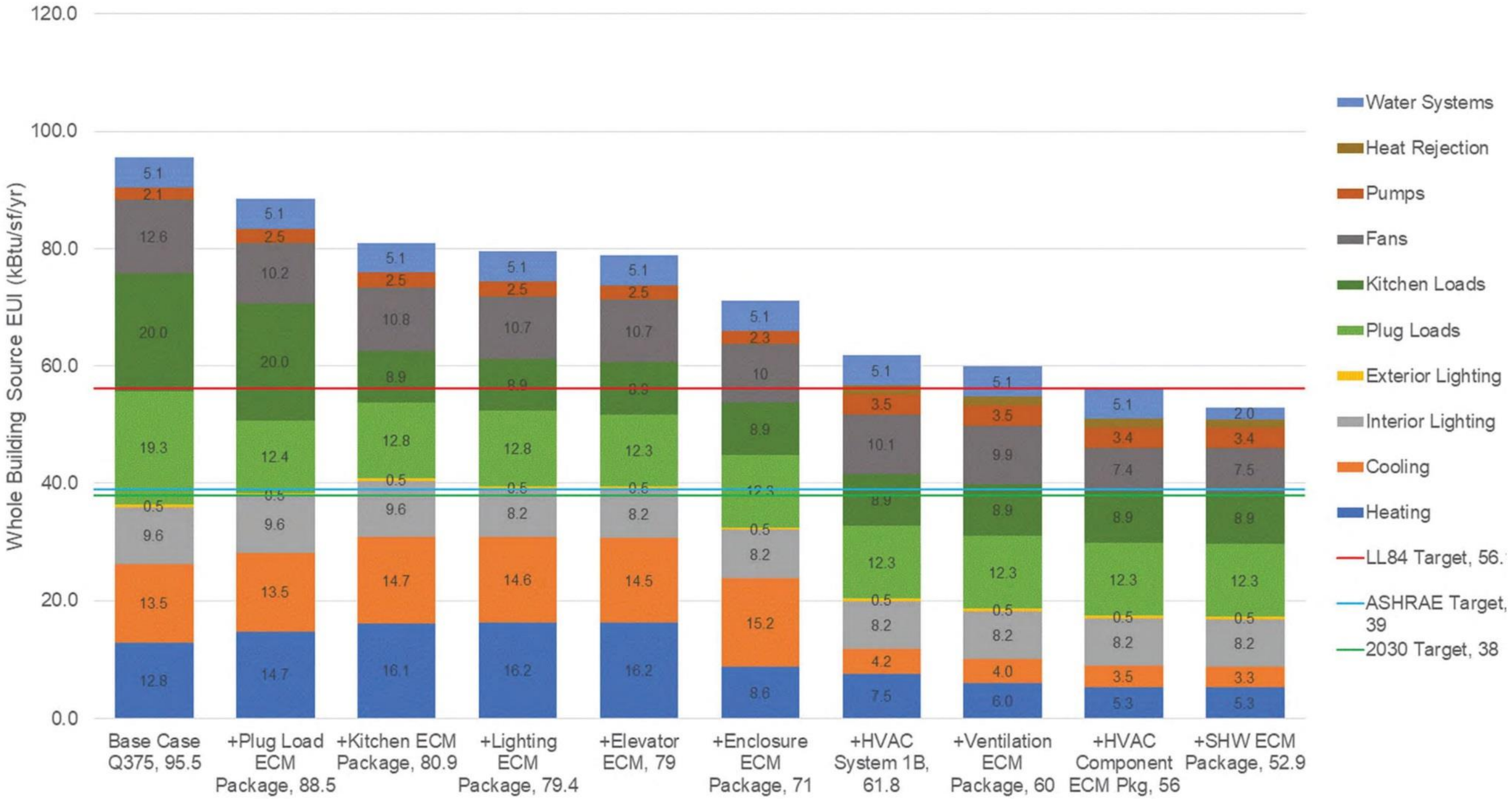
Low Energy Intensity Schools (LL31) Feasibility Study

Final Report

22 January 2021

WHOLE-BUILDING SCENARIO ENERGY MODELING UPDATES

Stacked ECM Packages, HVAC System 1B: 40.1 Total Source EUI Reduction



Low Hanging Fruit – ECMs (energy conservation measures)

MECHANICAL

- CO2 Demand Controlled Ventilation- CO2 sensor controlled DCV
- Nighttime air flush out.

LIGHTING

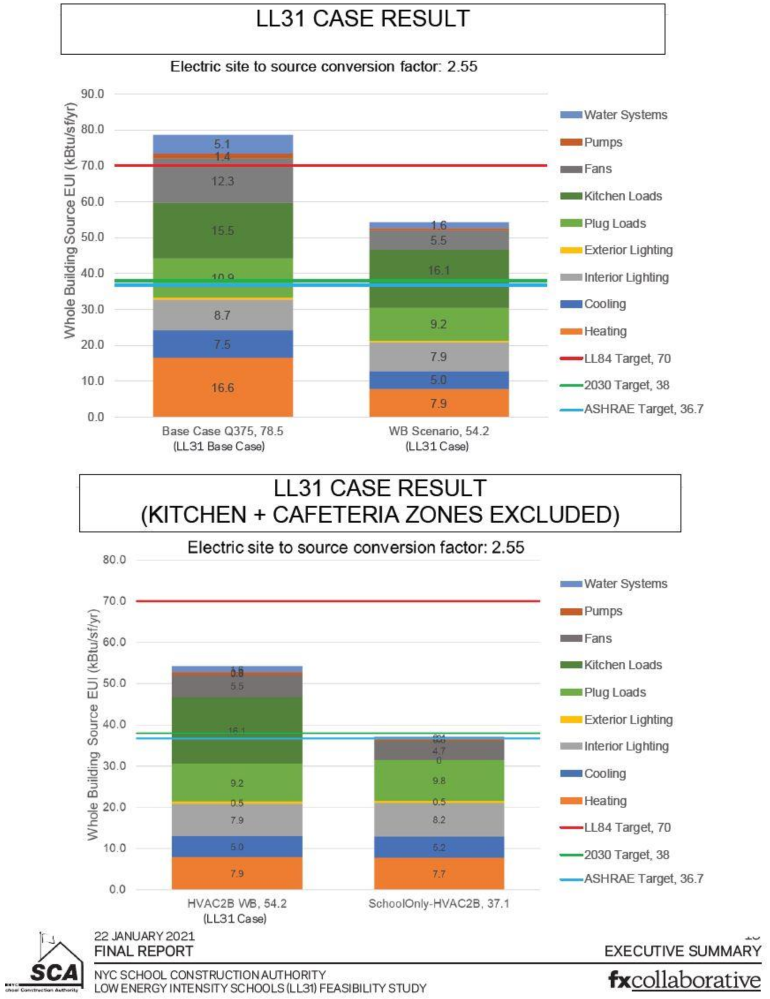
- Lower Lighting Levels - Lighting levels in offices and classrooms will be reduced to 28 Foot-candles (FC) and 35 FC, respectively, from 40 FC
- Shorter Lighting Turn-Down Time - reducing the lighting occupancy sensor turn down time from the standard 15 minute interval to 5 minutes

DOMESTIC HOT WATER

- Lower Bathroom Faucet Supply Temperatures to 90°F from 105°F.
- Faucets with Atomizing Aerators retrofit capability - faucets will be provided that can incorporate atomizing aerators (provided additional 5-7% building wide water reductions)

KITCHEN AND PLUG LOADS

- Demand Defrost in Freezers (new standard)
- Additional Walk-In Cooler Insulation- increased to 6" panels from 4" panels



New Construction: ECM Pilots

Project Facts
Building Addition: 52,349 SF
Source EUI: 56 kBtu/ft^2/yr

Project Facts
Building Addition: 49,975 SF
Source EUI: 69 kBtu/ft^2/yr

Project Facts
New High School: 308,819 SF
Source EUI: 51 kBtu/ft^2/yr

Project Facts
Building Annex: ±64,200 s.f
Source EUI: 55 kBtu/ft^2/yr
90 kW PV Array

Additional ECMs for all new Schools

ENVELOPE

- Roof Insulation = Upgrade to R40 roof insulation (standard was R30)
- Underslab Insulation = Upgrade to an R15 insulation under all regularly occupied spaces (standard was R10 insulation only under Kindergarten and Pre-k)
- Improved Air Sealing, Building Envelope Commissioning

MECHANICAL

- Double Pipe Insulation = 2 and 3 inches (standard was 1 and 1-1/2 respectively)
- Variable Speed Compressors on Chillers (standard was staged compressors)

DOMESTIC HOT WATER

- Domestic Water Heater to Central Heat Pump (standard was gas fired atmospheric boiler for DHW)

KITCHEN AND PLUGLOADS

- Electric Cooking (standard was gas for various main appliances) Expected EUI reduction: 0.4

GENERAL

- Solar PV in addition to required Sustainable Roofing Zone LL94.
- Gearless Elevators

SCA

For Kitchen Equipment & Domestic Hot Water:

Electrification

Electric Combi Oven

Hybrid heat pump DHW 120 gallon unit

EXISTING BUILDING PILOTS

Built 1958, 78,000 SF
3 stories + cellar

Built 1972, 43,000 SF
3 stories + partial basement

Built 1958, 150,000 SF
3 stories + partial basement

- **ECM:** Roof Additional Insulation: + 2” for total R40 Insulation
- **ECM**: Add Structural Thermal Breaks to Parapets
- **ECM:** High Performance Rainscreens with R30 Insulation
- **ECM:** Improved Air Tightness
- **ECM:** Higher performance Windows (U factor 0.25)

Beneficial Electrification – Fossil fuel free schools

Study Results:

- Heat pump electrification is currently technologically feasible for all size public schools.
- Electrification of new buildings **cost less** than new gas equipment.
- Electric heat pump schools can be **lower in site and source energy**, and **lower in GHGe**.
- Technology can be applied to existing schools as well.
- Summer electrical peaks not affected, i.e. No short term Utility issues.

LARGE HIGH SCHOOL ELECTRIFICATION STUDY

OCTOBER 14, 2022

THE NEW YORK CITY
SCHOOL CONSTRUCTION AUTHORITY
Long Island City, NY

Report Prepared by

OLA CONSULTING ENGINEERS, PC

ADDITIONAL PROJECT TEAM MEMBERS:
LILKER ASSOCIATES CONSULTING ENGINEERS (DESIGN ENGINEER)
DI DOMENICO AND PARTNERS (ARCHITECT)
ELLANA CONSTRUCTION COST CONSULTANTS (COST ESTIMATOR)
EME GROUP CONSULTING ENGINEERS (PEER REVIEWER)
SCA SUSTAINABILITY AND RESILIENCY DESIGN TEAM
SCA CAPITAL PLANNING
SCA DESIGN & CONSTRUCTION INNOVATION MANAGEMENT

SCA

September 30, 2022 *Large High School Electrification Study* *Page 18 of 19*

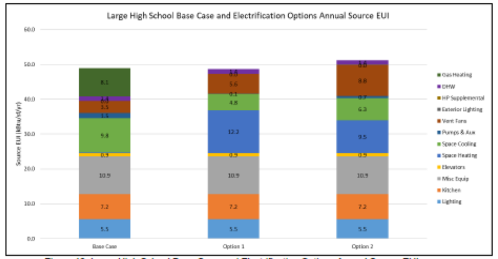


Figure 13. Large High School Base Case and Electrification Options Annual Source EUI

Figure 14 shows the annual cost breakdown by end use for the Base Case and the electrification options. It was noted that both the options have higher annual utility costs than the Base Case, due to higher electric demand and energy rates. Option 1 has the highest annual cost, due mainly to the large demand penalty associated with the large sized heat pump units and large quantity of electric resistance perimeter heat compared to Option 2.

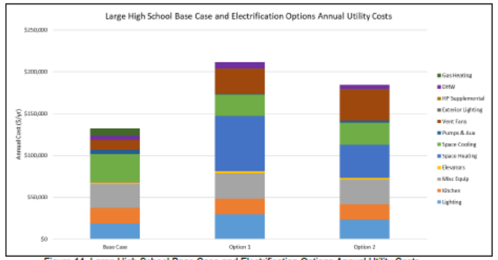


Figure 14. Large High School Base Case and Electrification Options Annual Utility Costs

For Public Assembly & Other Spaces:
Electrification of Heating and Ventilation

Roof Top VAV system
w/ Heat Pumps.

VRF ceiling mounted
Air Handling Unit (AHU)

Roof mounted VRF
Compressor

For Classrooms: Electrification of Heating, Cooling, and Ventilation

- Due to urban density and renovations during occupancy, individual classroom heat pumps with ventilation are an ideal choice for NYC existing schools.
- Individual units provide separate air systems between rooms w/ recirculation and outdoor air through Merv 13 filtration for optimal air quality.

All Electric New and Existing Public Schools

- In 2020, NYC SCA designed and is building 4 electric prototype schools based on electrification studies it performed.
- In 2022, NYC SCA is adopting our new building standard to be all electric. SCA builds roughly 12-15 new buildings per year.
- In 2022, SCA is finalizing the design of 3 existing schools to be all electric.
- SCA is starting ‘all electric’ design on an additional 6 existing schools.

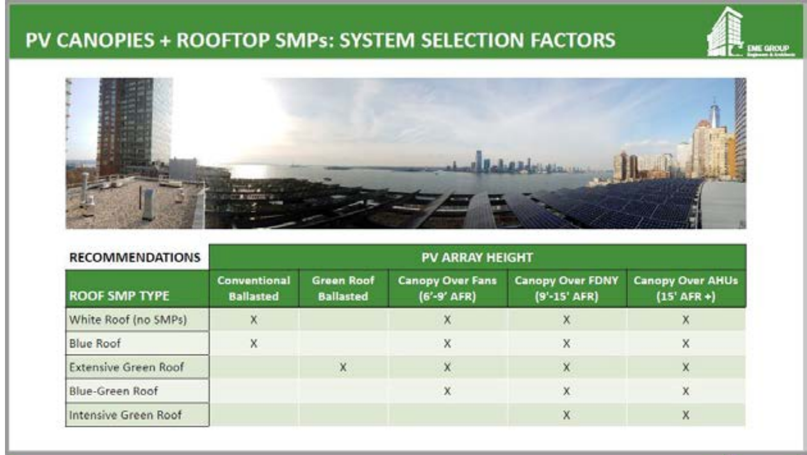
In one year by designing all electric schools instead of gas boilers in 12 buildings, SCA will annually have reduced 2,700 tons of GHGes (the equivalent annual emissions of 300 US homes).

Solar PV Generation & Green Roofs

Studies, Pilots, & Standards

NYC SCA's work:

- 1 Megawatt designed last two years
- Added new standards on our website for PV system design.
- Studying Combination of PV and green roofs to increase production and biodiversity.
- Have implemented both ballasted and canopy PV systems.
- Renovating more than a dozen existing roofs per year to be PV ready for DOE installation.



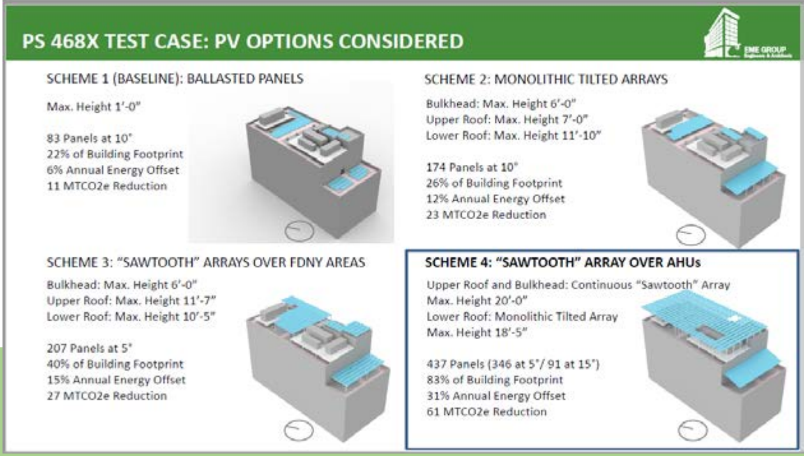
RECOMMENDATIONS	PV ARRAY HEIGHT				
ROOF SMP TYPE	Conventional Ballasted	Green Roof Ballasted	Canopy Over Fans (6'-9' AFR)	Canopy Over FDNY (9'-15' AFR)	Canopy Over AHUs (15' AFR +)
White Roof (no SMPs)	X		X	X	X
Blue Roof	X		X	X	X
Extensive Green Roof		X	X	X	X
Blue-Green Roof			X	X	X
Intensive Green Roof				X	X

Current SCA Standard	Recommended for Pilot Projects to Increase SW Detention and Plant Longevity
Green or blue roofs	Blue-green roofs with wicking
Built-in-place or fully modular green roofs	Hybrid modular green roofs with removable side panels
4" growing substrate depth	6" growing substrate depth
Inorganic substrate	5%-10% organic content in substrate
Sedum mix	Sedum, grasses, and perennials

Sedum Mix on 4" Substrate

Grass/Perennial Mix on 6" Substrate

PS 041M with LiveRoof Hybrid Green Roof System (Standard 4.25" Modules and Deep 6" Modules)



SCA

NYC School Construction Authority

SOCOTEC

SCA NEW TECHNOLOGY R+D BIOFUEL IN BUILDING HEATING APPLICATIONS

OCTOBER 19TH, 2022

IN CONSULTATION WITH:

- NYCSCA SUSTAINABLE DESIGN AND RESILIENCY (SDR)
- DOE DIVISION OF SCHOOL FACILITIES (DSF)
- NATIONAL OILHEAT RESEARCH ALLIANCE (NORA)
- BROOKHAVEN NATIONAL LABORATORY (BNL)
- DR. THOMAS BUTCHER, RESEARCH ENGINEER AT BNL AND DIRECTOR OF NORA LABORATORY
- RENEWABLE ENERGY GROUP
- SPRAGUE ENERGY
- PREFERRED UTILITIES MANUFACTURING CORPORATION
- WEBSTER COMBUSTION
- WEISHAUPT
- CLEAVER BROOKS
- CLEAN FUELS ALLIANCE AMERICA

OVERVIEW OF BIOFUELS

Biodiesel

- It is a renewable form of diesel fuel produced from refined organic matter
- Examples of feedstocks:
  > Soybean Oil
  > Animal Fats
  > Waste Vegetable Oil
  > Algae
- Biodiesel can be blended with other fuels
- Biodiesel is produced through transesterification
  > Lipids react with alcohol in the presence of a strong catalyst to form fatty acid methyl esters (FAME)
  > FAME is the chemical term for biodiesel
- Terminology:
  > B# refers to a fuel that is # biodiesel by volume:
    o B100 is pure 100% biodiesel, B20 is 20% biodiesel by volume, etc.
    o B99.9 typically refers to a blend with 99-100% biodiesel by volume
    o 2B10 refers to a blend of No. 2 oil that is 10% biodiesel by volume

Soybean Plants

Source: https://www.britannica.com/plant/soybean

Algae

Source: https://en.wikipedia.org/wiki/Algae_fuel

EMISSION FACTORS

SO_2 emissions for biodiesel blends are dependent on the manufacturer, since sulfur content can vary between 0 -15 ppm

Biodiesel has a lower emission factor because it emits biogenic carbon that gets sequestered by plants used for biodiesel feedstocks.

Pollutant	No. 2 Fuel Oil	No. 4 Fuel Oil	Natural Gas	B20	B99.9
Carbon Dioxide CO_2 ($tCO_2e/MMBtu$)	0.07414	0.07617	0.05	0.05799	0.01118
Nitrogen Oxides NO_x (kg/MMBtu)	0.0783	0.172	0.0445	0.0674	0.0206
Sulfur Dioxide SO_2 (kg/MMBtu)	0.000695	0.1408	0.0002538	0.000563 - 0.000695	0 - 0.000695
Particulate Matter $PM_{2.5}$ (kg/MMBtu)	0.000027	0.1247	0.0008084	0.000027	0.000027

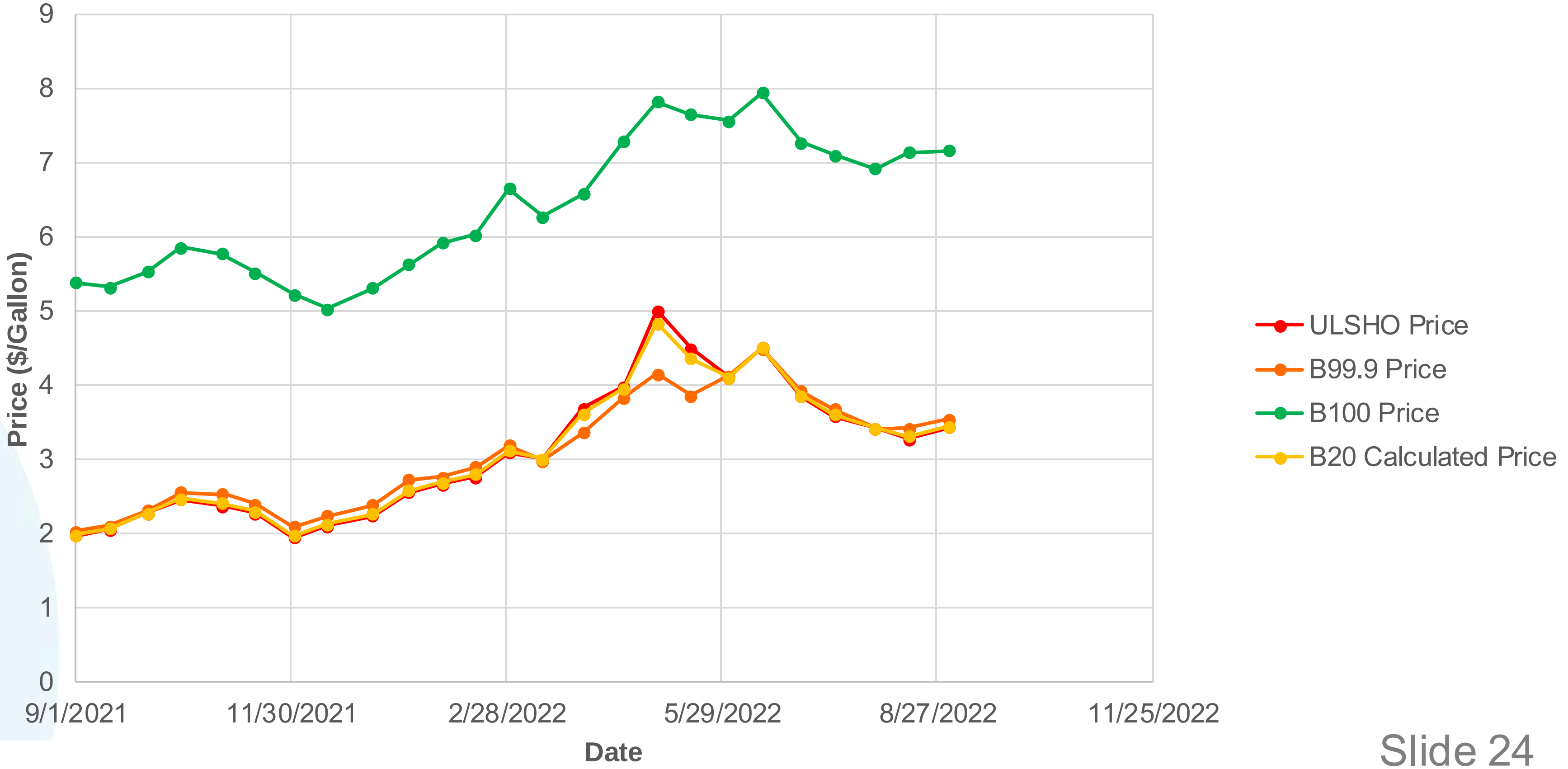
According to a research paper by Brookhaven National Laboratory, there is a strong correlation between $PM_{2.5}$ emissions and sulfur ppm in the fuel.

Dr. Tom Butcher, a researcher at the National Oilheat Research Alliance, has recommended using the same emission rates for No. 2 oil and blends of biodiesel, since their sulfur levels are similar.

FUEL COSTS

Sprague Energy provided the recent 12 months of New York Harbor fuel prices.

- B99.9 is less expensive than B100 due to IRS credit incentives.
- Biodiesel blenders may be eligible for a tax incentive for blending biodiesel with petroleum diesel to produce a mixture containing at least 0.1% diesel fuel.



Slide 24

Future Focused

- Increase study and implementation of Resiliency strategies.
- Study and implement Embodied Carbon reductions
- Implement energy saving equipment to reduce plug loads.
- R&D and Pilot Building Integrated Solar PV
- Continue Sustainability Master Planning to 2050

NYC Public Schools – Our Clean Energy Transition

In Summary:

- Created the first Net Zero Public School in NY State in 2016.
- Added more than 25 Energy Conservation Measures (ECMs) to NYC's new Public School standards.
- By 2022 more than 15 new schools designed to be Fossil Fuel Free clean energy buildings.
- Researching and implementing renewable Biofuel (B100) heating in existing schools.
- Installing Solar PV and green roof systems on more than a dozen new schools.

SCA

Questions? jshannon@nycsca.org