Final Report

Physical Needs Assessment 2017

Prepared for

New York City Housing Authority

Prepared by

STV AECOM PNA – A Joint Venture

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ABOUT STV:

STV, the managing partner of the JV, is an award-winning professional firm consistently ranking among the country's top companies in the residential, education, corrections, highways, bridges, rail and mass transit sectors. In the past 10 years alone, STV has led the assessment of more than 4,000 buildings throughout New York and the Northeast, including the 2,400+ buildings of NYCHA and 1,400+ public schools throughout the Commonwealth of Massachusetts (Massachusetts School Building Authority 2016 School Survey). Founded more than 100 years ago, STV provides a complete range of planning, engineering, architectural, environmental, and construction management services to transportation, infrastructure, design-build, institutional, commercial, industrial, and military clients.

ABOUT AECOM:

AECOM is a global network of design, engineering, construction and management professionals partnering with its clients to imagine and deliver a better world. A fully integrated infrastructure firm ranked as Engineering News-Record's #1 design firm by revenue for eight consecutive years, AECOM employs 87,000 staff in over 150 countries on seven continents. AECOM became an independent company by the merger of five entities in 1990, with several of the predecessor firms having distinguished histories dating back more than 115 years. It is listed as No. 161 on the 2017 Fortune 500.

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Executive Summary

Preamble

The facts alone are staggering and impressive: 2,413 buildings in 325 developments over five boroughs; 769 facilities; 177,666 apartments; 404,000 residents – roughly five percent of the population of New York City. If NYCHA were a municipality, it would rank as the 47th largest among U.S. cities, just below Minneapolis, Minnesota. In fact, NYCHA houses more people than the populations of Cleveland or New Orleans – in a considerably smaller footprint.

The challenges are staggering as well: Federal budget allocations are projected to decline for the foreseeable future. The NYCHA portfolio continues to age, with 70 percent of NYCHA buildings built before 1969. And there's the burden of billions in unmet capital needs across the Authority's aging building stock: leaky roofs and exteriors, mold, faulty and unreliable heating systems, broken elevators, poor or nonexistent site lighting, and a host of other problems at any given time.

NYCHA's aggressive response to these challenges is *NextGeneration NYCHA*, defined in a joint letter by Mayor de Blasio and NYCHA CEO Shola Olatoye as "a long-term strategic plan that will guide us in changing the way we do business as a landlord …. . To do this, we must make difficult choices that change how NYCHA is **funded, operates, rebuilds, and engages** with residents." (Emphasis added.)

One of the four primary goals of *NextGeneration NYCHA* is **(Re)build, expand, and preserve public and affordable housing stock.** One of the necessary initial steps in addressing this goal is a sound and thorough understanding of the existing conditions of NYCHA buildings and grounds. This Executive Summary summarizes the findings of a Physical Needs Assessment of the NYCHA portfolio conducted in the period 2016-2017.

Introduction

In 2016, STV AECOM PNA – A Joint Venture, a joint venture (JV) of STV Incorporated (STV) and AECOM USA, Inc. (AECOM), was engaged by NYCHA to perform a Physical Needs Assessment (PNA) of the complete NYCHA portfolio of buildings.

Field inspections of the NYCHA properties were performed by teams totaling 140 inspectors over the 10-month period May 2016 – February 2017 covering all five boroughs. Inspectors surveyed all buildings, common areas, facilities and grounds at 325 developments, including a representative sampling (20,000+) of apartments, collecting data on the physical conditions of NYCHA infrastructure, identifying and quantifying components in need of repair or replacement, assigning a timeframe for addressing these components, and identifying hazardous conditions, e.g., leaking gas, a sagging structural element, frayed and exposed electrical wires, for immediate address by NYCHA maintenance personnel. The collected data were then evaluated through an intensive quality control/quality assurance process and costed using an expanded and updated Unit Cost Library.

Data Collection and Assessment Process

The PNA data were gathered in the field using a software application (**Mobile Validity®**) and iPads capable of gathering and reporting data on these and other parameters:

- **Borough**
- **Reporting Years**
  - Individual
  - Aggregated Years, e.g., Years 1-5, Years 1-20
- **Cost: aggregated costed actions**
- **Discipline**
  - Apartment
  - Architectural (Exterior and Interior)
  - Conveying
  - Electrical
  - Mechanical
  - Site – Architectural
  - Site – Electrical

  - Site – Mechanical
- **Condition Rating**
  - 1 Good
  - 2 Between Good and Fair
  - 3 Fair
  - 4 Between Fair and Poor
  - 5 Poor
- **Deficiency and quantity of deficiency**

  Deficiencies, such as cracked/spalling concrete, missing tile grout, mold, broken glass, vary by discipline. Similarly, units of measure and quantities of the deficiencies vary as well, e.g., number of damaged doors, linear feet of parapet to be repaired or replaced, square feet of ceramic tile to be regrouted or replaced, square feet of roof to be repaired or replaced, and so forth.
- **Potential Action**
  - Repair
  - Replace
  - Maintenance
  - No Action
- **Urgency of Action**
  - Immediate Action
  - Address within 12 months
  - Address within 5 years
- **Purpose of Action**
  - Life Safety
  - Structural
  - Security
  - Restore
  - Operations/Maintenance Savings

The above parameters can be viewed, sorted and grouped across any number of scenarios. For example, the projected costs of all bathrooms needing replacement can be sorted and totaled by individual building (e.g., Building 6, Smith Houses); by groups of buildings (Buildings 1, 3, 5, 6 and 8, Smith Houses); by development (all buildings, Smith Houses); by groups of developments (Smith Houses, Baruch Houses, 45 Allen Street); by borough (Manhattan); or by portfolio (all buildings in all five boroughs). Similarly, conditions of various building components can be identified and surveyed as well, such as all boilers with 5 Poor ratings in the Bronx, or the windows with 4 and 5 ratings in Stuyvesant Gardens II.

The costs below are based on the Unit Cost Library revised/expanded/updated through the 2017 PNA. These costs are applied to the deficiencies and deficiency quantities identified in the field to arrive at the costs for repairs and replacements.

Key Findings

The total projected cost of all needs – repair and replacement – over the next five years (Years 1-5) is **$31.8 billion** (2017 Dollars), and **$45.2 billion** (2017 Dollars) over 20 years (Years 1-20). The bulk of this need is due greatly to the aging NYCHA portfolio, where the average age of a NYCHA building is roughly 60 years and 70 percent of the portfolio was built prior to 1970.

- **No. 1 Need: Apartments, particularly bathrooms and kitchens**

NYCHA's largest need, estimated at **$12.6 billion** or roughly 40 percent of the total need, is in its portfolio of apartments (Tables ES-1 and ES-2, Figure ES-1). The bulk of these needs, $5.6 billion, are in bathrooms and kitchens, representing repairs to/replacement of bathtubs, toilets, tile surrounds, sinks, refrigerators, stoves, kitchen cabinets, and related appurtenances. Deteriorating conditions in bathrooms and kitchens are frequently linked to the aging piping systems in NYCHA buildings. Repairing/replacing hot/cold water piping and waste and sewage piping represent a projected cost of $0.44 billion. Another $0.22 billion ($220 million) is needed to repair walls and ceilings due to leaks from aging piping and the mold that ensues.

Leaks and the resulting damage to walls and ceilings and, increasingly, the presence of mold are recognized by NYCHA management and maintenance personnel as very serious and pressing issues. Addressing leaky roofs, windows and piping is a high priority of NYCHA management, as detailed in Strategy #9 in *NextGeneration NYCHA*.

Table ES-1. Total Costed Actions in First 5 Years by Discipline and Rank Order

Discipline	Cost[1] ($000,000)	Percentage	Included Components
Apartment	$12,579	39.6	Kitchen, Bathroom, Floor, Doors, etc.
Architectural	$10,711	33.7	Exterior (Roofing, Parapet, Entry Doors, etc.) and Interior (Common Areas, Interior Stairs, etc.)
Mechanical	$3,058	9.6	Boilers, piping, radiators, etc.
Conveying	$1,510	4.7	Elevators
Site - Architectural	$1,471	4.6	Fencing, playgrounds, sidewalks, etc.
Electrical	$1,358	4.3	Lighting, panelboards, generators, etc.
Site - Mechanical and Site - Electrical	$1,114	3.5	Site lighting, underground piping, etc.
Total	**$31,801**	**100.0**	

Note: 1. $000,000 = $ million. $12,759 in the table above = $12,759,000,000, or roughly $12.8 billion

Figure ES-1. Total Costed Actions in First 5 Years by Discipline

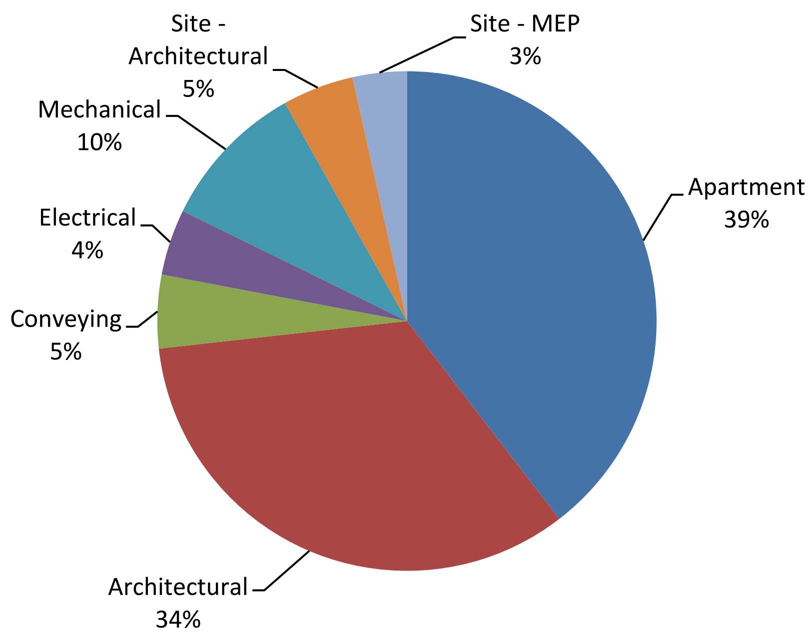


Table ES-2. Top 3 Highest Needs in Apartments by Borough ($000,000)

Component	Bronx	Brooklyn	Manhattan	Queens	Staten Island	Total[1]
Bathroom/ Kitchen	$1,395	$1,866	$1,697	$552	$121	$5,631
Floor	$774	$947	$869	$239	$70	$2,899
Doors	$343	$436	$409	$113	$32	$1,333
Total	$2,512	$3,249	$2,975	$904	$223	$9,863

Note: 1. $000,000 = $ million. $1,395 in the table above = $1,395,000,000, or roughly $1.4 billion

The distribution of the **$31.8 billion** in needs is presented in Table ES-3. The largest need is in Brooklyn ($10.9 billion), followed by Manhattan ($9.0 billion), the Bronx ($8.1 billion), Queens ($2.9 billion), and Staten Island ($833 million).

Table ES-3. Total Costed Actions in First 5 Years by Discipline and Borough ($000,000)

Discipline	Bronx	Brooklyn	Manhattan	Queens	Staten Island	Total[1]
Apartment	$3,250	$4,124	$3,750	$1,165	$289	$12,579
Architectural	$2,978	$3,619	$3,082	$768	$264	$10,711
Mechanical	$668	$1,091	$902	$329	$68	$3,058
Conveying	$285	$623	$371	$162	$68	$1,510
Site - Architectural	$369	$503	$383	$154	$62	$1,471
Electrical	$336	$554	$269	$153	$46	$1,358
Site - Mechanical	$241	$421	$236	$153	$35	$1,085
Site - Electrical	$9	$12	$4	$3	$1	$29
Total	$8,136	$10,947	$8,997	$2,887	$833	**$31,801**

Notes: 1. $000,000 = $ million. $3,250 in the table above = $3,250,000,000, or roughly $3.3 billion

▪ No. 2 Need: Architectural, representing exterior and interior building components

The second highest need lies in repairs to/replacement of exterior components (roofs, parapets, chimneys, windows, awnings, main front doors) and interior components (lobby and corridor floors, walls and ceilings; public area kitchens and bathrooms; mailboxes; a few gymnasiums and locker rooms) totaling **$10.7 billion** ($6.45 billion, exterior; $4.26 billion, interior). Given that the average age of a NYCHA building is roughly 60 years, and that many NYCHA buildings retain their original windows, it's not surprising that windows repair/replacement represents the largest need ($3.2 billion), followed by roof repair/replacement ($1.4 billion) and parapet/exterior wall repair and replacement ($1.3 billion) (Table ES-4). Strategy #9 in *NextGeneration NYCHA* specifically targets roofs, parapets and related components (roof drains, cornices, railing, insulation), and $1.3 billion in city funding is earmarked to complete repairs to/replacement of the worst roofs in the NYCHA portfolio.

Table ES-4. Top 5 Highest Needs in Architectural Exterior Components by Borough ($000,000)

Component	Bronx	Brooklyn	Manhattan	Queens	Staten Island	Total[1]
Windows	$856	$1,079	$987	$203	$88	$3,213
Roof	$447	$542	$352	$63	$15	$1,419
Parapets	$338	$290	$219	$63	$4	$914
Exterior Walls	$63	$102	$173	$27	$35	$400
Doors	$20	$22	$16	$7	$2	$67
Total	$1,724	$2,035	$1,747	$363	$144	$6,013

Note: 1. $000,000 = $ million. $856 in the table above = $856,000,000, or $856 million

▪ No. 3 Need: Mechanical

The third highest need is in Mechanical components at **$3.1 billion**. Mechanical components include heating plants and related components (boilers, burners, gauges, pumps and so forth); radiators; air conditioners; heating and ventilating fans; hot water heaters; potable water, drain, sewer and gas piping; among others. Many of the Mechanical needs are in heating plants, with repair/replacement projected at $1.33 billion. Over 744 boilers have a Remaining Useful Life (RUL) equal to or less than 5 years.

- **No. 4 Need: Conveying/Elevators**

Elevators, both passenger and freight, are vital and necessary components of NYCHA housing. Roughly 50 percent of NYCHA residential buildings are seven stories or more, and about nine percent are buildings of 17-31 stories. To state that working and reliable elevators are a necessity is an obvious misstatement; they are an essential component of NYCHA housing.

For the 2017 NYCHA PNA, specialized, experienced elevator inspectors were used to inspect elevators. In addition, the Conveying questionnaire was revamped and extended, adding 34 deficiency/action/unit cost combinations and yielding greater detail on the conditions of NYCHA elevators. Repairs to/replacement of elevators is projected at **$1.5 billion**.

- **No. 5 Need: Site-Architectural, Site-Mechanical, Site-Electrical**

These three disciplines define the sites and grounds inspected in the PNA. Site-Architectural components include parks and playgrounds within the development; parking lots; streets and sidewalks; landscaping; the occasional tennis court; fencing; among others. Site-Mechanical components include underground piping primarily, e.g., steam conduit; water, drainage, sewage, gas lines; catch basins; and so forth. Site-Electrical consists of one component: site lighting, a vital safety concern and one of much interest to residents.

Condition ratings of underground piping were heavily dependent on interviews with the development manager and superintendent. Detailed questions were asked relating to drainage or sewage back-ups, areas that flooded during light rainfall events (indicating a poorly-functioning drainage system); areas where steam appeared; and so forth. The answers were factored into the condition ratings.

Underground piping was generally installed during the construction of the development, and thus is as aged as each individual development. Given that the average age of a NYCHA building is 60 years, it's safe to state that the same holds true of underground piping as well. Underground piping has a useful life between 80-100 years or more, so there is a remaining useful life (RUL) in NYCHA's underground infrastructure. However, such infrastructure may increasingly fail in periods of "stress," for example, heavy rainfall events, high heating demand, and so forth.

Repair to/replacement of the three combined site components – Architectural, Mechanical, Electrical – total **$2.6 billion**.

Comparison of 2017 PNA with Previous Assessments

Table ES-5 compares the projected costs of three PNAs completed in 2006, 2011 and 2017. A direct comparison of the total costs is not accurate as each is listed in the dollar value at that particular point in time, e.g., the $6.9 billion in 2006 reflects 2006 Dollars; 2011, 2011 Dollars; and so forth. Inflation has eroded the dollar value over time: a 2017 Dollar buys less than a 2006 or 2011 Dollar. It takes more dollars in 2017 than in the past to pay for the same unit of work, which represents some of the increase over time.

Table ES-5. Total Costed Actions, 2017 PNA and Previous PNAs

Reporting Year	Repair ($000,000)	Replacement ($000,000)	Total[1] ($000,000)
2017			
Year 1	$2,727	$22,698	$25,425
Years 2-5	$110	$6,266	$6,376
Total	$2,837	$28,964	**$31,801**
2011			
Year 1	$1,258	$245	$1,503
Years 2-5	$205	$15,163	$15,368
Total	$1,463	$15,408	$16,871
2006			
Year 1	$1,512	$339	$1,851
Years 2-5	$233	$4,848	$5,081
Total	$1,745	$5,187	$6,932

Note: 1. $000,000 = $ million. $2,727 in the table above = $2,727,000,000, or roughly $2.7 billion

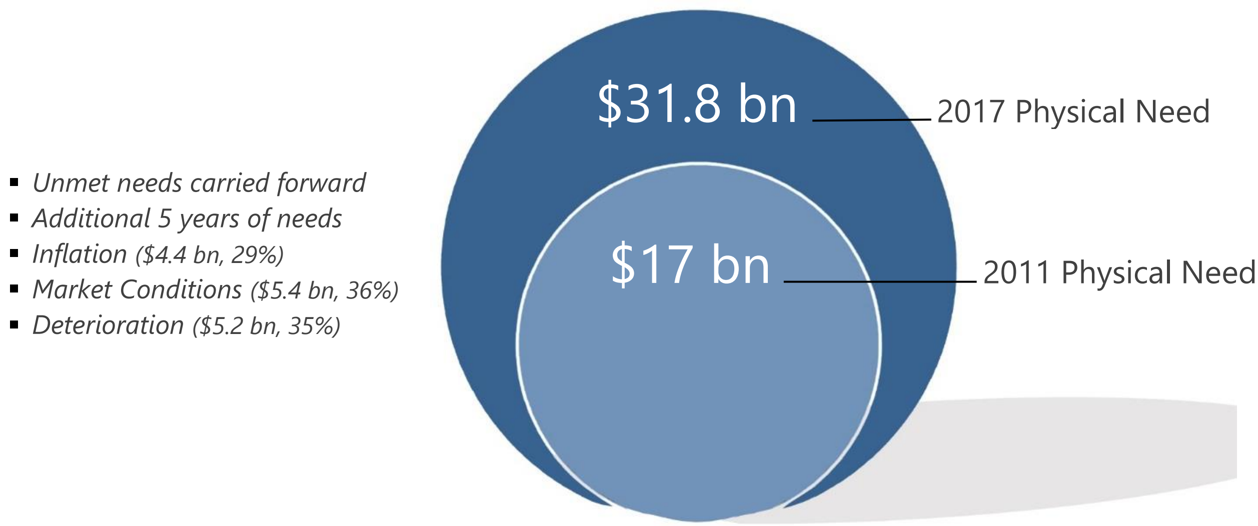
Other factors are at play as well. The needs identified in the 2011 PNA were not wholly met, and those unmet needs are carried forward into the 2017 PNA data and costs. The year 2011 marked a period when the national economy was emerging from the so-called Great Recession. Contractors were "hungry" for work and priced work very competitively. Today, there's a very pronounced building boom in New York City, and many contractors are very busy elsewhere. In such a market, NYCHA is competing with other developers and development projects for limited contractor resources. Since the PNA Unit Cost Library reflects the construction market in 2017, it is capturing these higher prices for units of work – prices which also apply to NYCHA, other city agencies/authorities and private entities as well.

Inflation ($4.4 billion, 29 percent) and market conditions ($5.4 billion, 36 percent) are estimated to account for approximately $9.8 billion, or 65 percent of the roughly $15 billion increase in the 2017 PNA compared to the 2011 PNA.

Also, the 2017 projected needs reflect the aging of the NYCHA portfolio. Buildings 60 years old on average simply require more repair/replacement than buildings, say, 20 years old. Additional deterioration of the portfolio is estimated to account for $5.2 billion, approximately 35 percent of the difference between the 2017 and 2011 PNAs.

Furthermore, the 2017 PNA reflects improvements in assessment methodology. Condition data on more building components were gathered in the most recent PNA, providing additional detail on the existing conditions of the NYCHA portfolio. Unit costs were developed as well, providing greater granularity in the costs of these conditions.

Figure ES-2. Increase in Costs from 2011 PNA to 2017 PNA



The Challenge Ahead

Addressing needs totaling **$31.8 billion in Years 1-5** (**$45.2 billion in Years 1-20**), particularly in a period when support for public housing and sustainable communities is diminishing at the federal level, is a daunting challenge to NYCHA, and one that will severely test its management and staff. Difficult choices are ahead.

In recent years, NYCHA management and maintenance personnel have invested heavily in roofs, parapets and exterior walls to weatherproof building exteriors. This is vital, necessary and should continue. Data from the 2017 PNA, however, suggest that another avenue of focus and investment should be apartment kitchens and bathrooms, whose conditions are frequently (and increasingly) related to the condition of the aging network of hot/cold water piping, waste and sewage piping, and related risers buried in the walls of NYCHA buildings. A holistic approach to future repairs/replacement is recommended, where aging piping networks are replaced along with kitchens and bathrooms.

1 Pre-field Activity

1.1 Program Background

The New York City Housing Authority (NYCHA) is a New York State chartered public benefit corporation established in 1934. NYCHA is the largest public housing authority in North America providing affordable public housing for over 400,000 authorized residents, roughly five percent of the population of New York City.

Maintaining a comprehensive database of building condition information is essential to NYCHA's effective operation. Federal regulations recommend NYCHA and other public housing authorities conduct a facility condition survey every 5 years for every residential and non-residential property within its portfolio. Accordingly, NYCHA completes a Physical Needs Assessment (PNA) to identify current facility conditions, which includes a comprehensive inspection of various site, building and utility components and their sub-components.

The aim of the PNA process is to identify, plan and begin the rehabilitation process for each of NYCHA's developments, seeking to bring those developments up to acceptable modernization and energy efficiency standards. Selected through a competitive selection process, STV AECOM PNA – A Joint Venture conducted facility condition assessments at all NYCHA developments across the five boroughs of New York City (Figure 1), and energy audits at 463 buildings representing the entire portfolio. The PNA process provides current facility condition data for 2,300+ buildings found on 325 properties (over 2,500 acres) citywide, as well as 766 non-residential facilities (offices, retail establishments, laundry rooms, and so forth), 176,000+ apartments, and over 3,300 elevators (Table 1), and projected annual cost savings from a wide variety of energy conservation measures.

Figure 1. NYCHA Developments in New York City

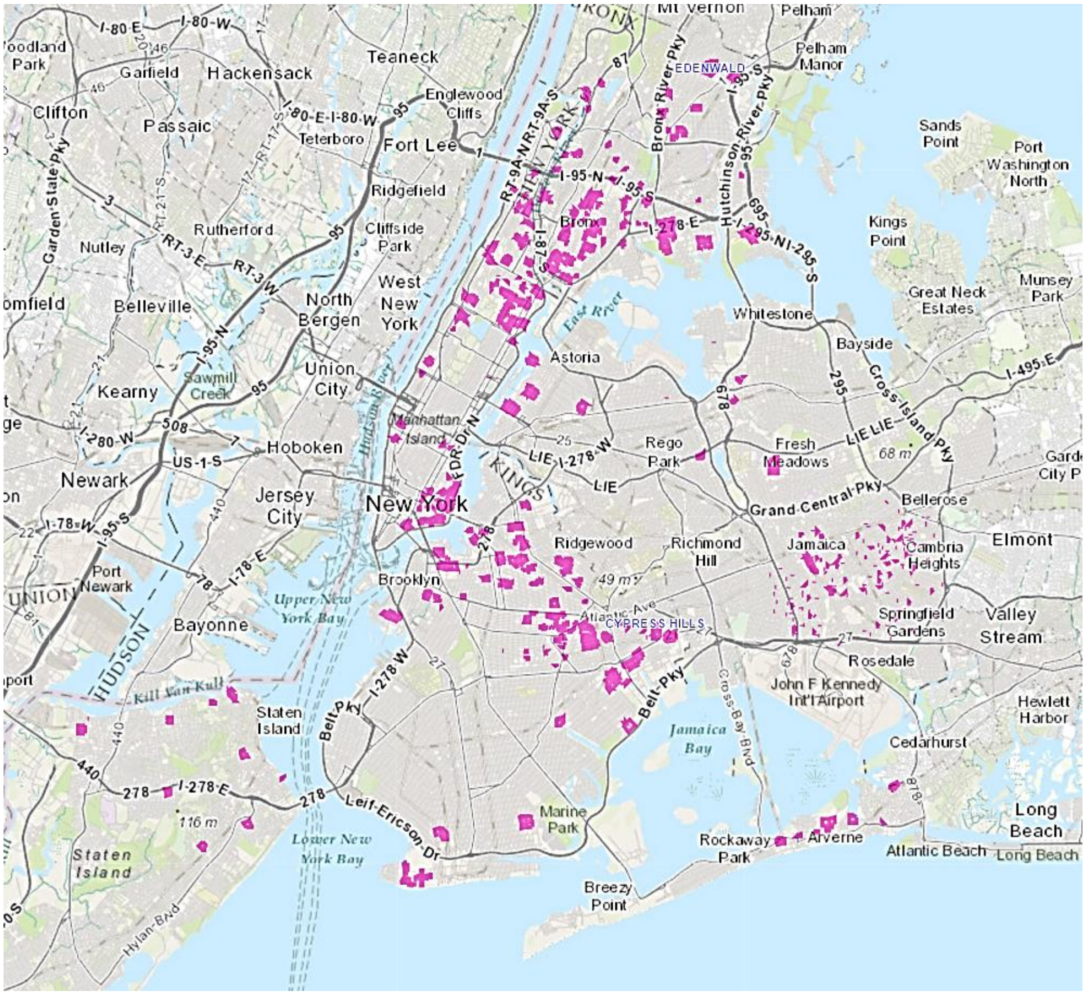


Table 1. NYCHA Portfolio Assessed in 2017 Physical Needs Assessment

Borough	Buildings	Developments	Facilities	Apartments[1]
Bronx	609	93	161	44,389
Brooklyn	891	99	249	58,592
Manhattan	566	101	263	53,189
Queens	226	22	70	15,778
Staten Island	83	10	23	4,510
Total	**2,375**	**325**	**766**	**176,458**

Note: 1. Unlike Buildings, Developments and Facilities, where 100 percent of the units within these categories were assessed, the Apartment category was sampled. Approximately 20,000 apartments were actually assessed, 10-15 percent within each building, and the results extrapolated to the entire apartment portfolio.

The 2017 PNA is a 5-year contract with an intensive Year 1 of development, assessment, analysis and training of NYCHA staff in use of the PNA database tool, and four years (Years 2-5) of follow-on technical assistance and hosting of the digital database. The entire contract consists of six parts as noted in Table 2. This report addresses Parts 1-4; activity in Parts 5 and 6 will be addressed in the future.

Table 2. 2017 PNA by Part

Part	Year	Description
Part 1	1	Facility Condition Assessments
Part 2	1	Infrared Thermography Roof Assessment
Part 3	1	Energy Audits and ECM Analysis
Part 4	1	PNA Database and User Interface (Software Application)
Part 5	1	Capital Planning Tool (Software Application)
Part 6	2-5	Application Hosting, Support and Enhancement Services

Key **ECM** Energy Conservation Measure **PNA** Physical Needs Assessment

1.2 Initial Steps

Four concurrent tasks began after STV AECOM PNA – A Joint Venture was selected through a competitive Request for Proposals process conducted by NYCHA. These tasks addressed:

- Internal organization and structure
- Refinement/extension of field assessment software
- Management and staffing
- Training

The first listed task – internal organization and structure – relates to the business aspects of the two firms in the joint venture, and is not a focus of this report. The remaining three tasks are discussed in turn below.

1.2.1 Refinement/Extension of Field Assessment Software

<u>1.2.1.1 Existing Software</u>

The team was provided with an earlier version of the field assessment software – **Mobile Validity** – used in the prior PNAs (2006 and 2011). This software application offered a pre-defined menu of data collection items organized along the lines of seven **questionnaires**, with each specifically addressing particular building component categories: **Apartment, Architecture, Electrical** and **Mechanical** – and site components: **Site-Architectural, Site-Electrical** and **Site-Mechanical**. Building components were defined in a **Physical Breakdown Structure** (**PBS**), a hierarchy that breaks down a building component into component and sub-component parts. Select examples of the PBS are presented in Table 3; the entire PBS is presented in Appendix B.

Table 3. Examples of Physical Breakdown Structure within Mobile Validity

Questionnaire	PBS1	PBS2	PBS3	PBS4	PBS5
Apartment	Architectural	Bathroom	Accessories		
			Bathtub		
			Door Saddle		
			Exhaust / Vent		
			Shower Head & Valve		
			Sink		
			Toilet		
			Vanity		
			Wall Finishes		
		Ceiling			
		Closet			
		Doors			
		Floor			
	Mechanical	Radiator / Convector / Baseboard			
		Terminal Unit Steam Trap			
		Thermostat			
Architectural	Exterior	Roof	Bulkhead Roof	Hatch	
			Low Roof	Hatch	
			Main Roof	Hatch	
			Low Roof	Cupola	
				Roofing	
				Skylight	
				Water Tank Enclosure	
Mechanical	Heating	Unit Heater			
	Heating Plant	Boiler System	Boiler, Hot Water	Boiler	
				Gas/Oil Burner	
			Boiler, Packaged Modular	Boiler	
				Gas/Oil Burner	
			Boiler, Steam	Boiler	
				Gas/Oil Burner	

In Table 3, the PBS for the Architectural (**PBS1**) elements within the Apartment Questionnaire shows five components within **PBS2**: Bathroom, Ceiling, Closet, Doors, and Floor. The Bathroom is further divided into nine **PBS3** sub-components: Accessories, Bathtub, Door Saddle, Exhaust/Vent, Shower Head & Valve, Sink, Toilet, Vanity, and Wall Finishes. In summary, the higher PBS number, the greater the level of detail and specificity.

Mobile Validity is configured to accept the following data inputs, among others:

- Condition Rating
  - 1 Good
  - 2 Between Good and Fair
  - 3 Fair
  - 4 Between Fair and Poor
  - 5 Poor
- Deficiency and quantity of deficiency
  - Deficiencies vary by questionnaire
  - Unit of measurement varies, e.g., each, linear feet (lf), square feet (sf)
- Potential Action
  - Repair
  - Replace
  - Maintenance
- Urgency of Action
  - Immediate Action
  - Address within 12 months
  - Address within 5 years
- Purpose of Action
  - Life Safety
  - Structural
  - Security
  - Restore
  - Operations/Maintenance Savings

1.2.1.1 Refinement/Extension of Mobile Validity

Over a two-month period – late February through late April 2016 – an intensive effort was undertaken by subject matter experts in the fields of architecture, electrical engineering, mechanical engineering and civil engineering to refine and extend the existing Mobile Validity software application. Great care was taken to ensure consistency among the various questionnaires. For example, the deficiencies encountered in a gypsum board ceiling in an apartment likely would be the same as those encountered in a lobby or corridor with a like ceiling. Accordingly, the deficiencies were made the same in each questionnaire. Numerous small adjustments to the titling of deficiencies and minor corrections and edits were made in this process.

Perhaps the most significant change in the software was in a reorganization of data collection using seven questionnaires to one using ten questionnaires, with the primary changes occurring in the 2011 Architectural and 2011 Mechanical questionnaires (Table 4).

Table 4. 2017 PNA vs. 2011 PNA Questionnaire Structure

2011 PNA	2017 PNA	2017 PNA Components Assessed (Select)
Apartment	Apartment	Architectural, Electrical and Mechanical components within the apartment interior
Architectural	Architecture (Exterior)	Roofs, parapets, cornices windows, primary and secondary doors, awnings
	Interior	Public area (generally first floor) ceilings/walls/floors of lobbies, corridors, community kitchens and public bathrooms
	Interior (Upper Floors)[1]	Ceilings/walls/floors of upper floor corridors, stairwells; heating elements, if any; lighting fixtures
Electrical	Electrical	All main electrical panels and circuits; lighting in first floor public areas; emergency/exit lighting; fire alarm systems
Mechanical	Mechanical	Boilers; HVAC; air conditioning units; chillers; roof ventilating fans
	Conveying	Passenger and freight elevator components
Site – Architectural	Site – Architectural	Grounds/landscaping; site fencing; playgrounds and playground equipment; parking lots; sidewalks
Site – Electrical	Site – Electrical	Site lighting
Site – Mechanical	Site – Mechanical	Underground utilities, e.g., drainage, sewerage, steam piping; catch basins; dry wells; exterior compactors

These changes were initiated primarily to reflect the staffing and logistics of the 2016-2017 field data collection effort. For instance, the 2017 PNA team employed specialized subconsultants to inspect NYCHA elevators; accordingly, the elevator data components were transferred from the 2011 Mechanical questionnaire to a separate, stand-alone 2017 questionnaire titled Conveying. Similarly, the 2011 Architectural questionnaire was divided into three 2017 questionnaires: Architecture (Exterior), Interior and Interior (Upper Floors) to reflect assignments to different team members and subconsultants. The 2017 Interior (Upper Floors) questionnaire was assigned to staff who inspected apartment interiors; it was deemed efficient to assign them the interior corridors and stairwells in the upper floors as well.

A select listing of other changes in Mobile Validity for the 2017 PNA are presented in Table 5.

Table 5. Select Changes in Mobile Validity in 2017 PNA

Questionnaire	Component	Change
Apartment, Interior, Interior (Upper Flrs)	Walls, Ceilings	Attempt to identify source of mold, where possible, in defining deficiency (ex.:) Ceramic Tile: Excessive Mold Ceramic Tile: Excessive Mold/Leaking Pipe Ceramic Tile: Excessive Mold/Leaking Roof
Architecture	Roofs (PBS3)	Expand Roof from one PBS3 listing (Roof) to three: Main Roof, Bulkhead Roof, Low Roof
Architecture	Main Doors (PBS2)	Expand to include two PBS3 components: Primary Door, Secondary Door
Electrical	Lighting	Add Lighting Fixture – LED to PBS2
Electrical	Exit Lighting, Emergency Lighting (PBS1)	Expand within PBS1 and PBS2 to offer greater detail and selection options in field
Interior	Specialties (PBS2)	Change the name "Specialties" to list the specific components: Mailboxes, Directories, Display Unit
Mechanical	Various	250 data options (component + deficiency + potential action) added to greatly expand the level of reporting detail in the Mechanical questionnaire

1.2.2 Management and Staff

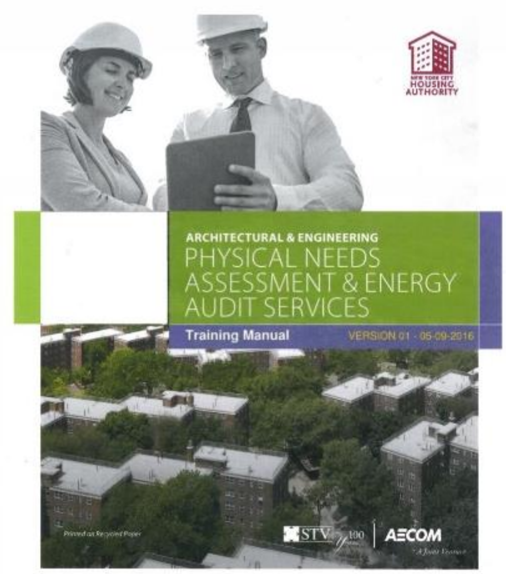
The structure and organization of the team performing all elements of the 2017 PNA are presented in Table 6.

Table 6. Structure of Consultant Team

Role	Position	Responsibilities
Management		
Executive	Directors (2)	Leadership, Oversight, Policy
Program Management	Program Manager Deputy Program Manager Assistant Program Manager (2)	Client Relations/Liaison, Policy Implementation, Program/Project Management, Schedule, Staffing, Budget
	Project Manager, Apartments Project Manager, Energy Project Manager, Roof Thermography Project Manager, Conveying	Project Management, Staffing, Quality Control
	Quality Assurance Manager (2)	Quality Assurance
Scheduling/Logistics	Scheduler Borough Coordinator (3)	Scheduling, Schedule Maintenance, Field Team Logistics
Technical		
Technical Lead	Discipline Lead (3) for Architecture, Mechanical, Electrical	Subject Matter Expert, Inspection Methods/Methodologies, Training, Quality Control/Quality Assurance
Technical Support	Super Team (4) for Architecture, Interior, Mechanical, Electrical	Liaison between Discipline Lead and Field Teams, Deputy to Discipline Lead, Quality Control
Inspection/Assessment	Teams of four consisting of inspectors responsible for Architecture, Interior, Mechanical and Electrical. One inspector, a registered professional engineer or architect, was designated Team Leader.	Field inspection and assessment
	Teams (multiple) consisting of inspectors responsible for Apartments and Interiors (Upper Floor), Elevators and Roofs associated with roof thermography	

1.2.3 Training

Development of a training program and manual began shortly after selection but accelerated as the 2016-2017 version of the Mobile Validity software application began to take shape. The formal training of the field inspectors involved both technical subject matter, e.g., what to inspect, how to assess a component and assign a condition rating, and so forth, and the Mobile Validity software application itself, e.g., how to select a particular building from the portfolio directory, how to enter data in the field, how to forward completed data reports to a centralized database in the cloud, and so forth.



VOLUME I - GENERAL

The training manual consisted of five volumes: one general (Volume I) and four technical volumes (Volumes II-V). The general volume covered project overview; organizational structure and management; personal conduct, safety and awareness; and an introduction to the Mobile Validity software application.

The four technical volumes – Architecture (II), Mechanical (III), Electrical (IV) and Conveying/Energy Audit /Quality Control (V) – addressed components, methodologies, deficiencies, and so forth specific to that discipline. The training manuals were loaded onto each iPad for ready access in the field.

Training began on Monday, May 9, 2016, and concluded Friday, May 20, 2016. While the bulk of the training involved classroom work, three days were allotted to field visits to Smith and Fulton Houses where the Discipline Leads and Super Team members walked the field inspectors through an actual field inspection. The first field inspection day was Monday, May 23, 2016.

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2 Field Activity

After a brief shake-out period, where the field teams, scheduler and borough coordinators, and program managers tested and refined communications protocols, field inspections began to fall into a routine.

2.1 Scheduling and Coordination with NYCHA

One of the keys to the success of the 2017 PNA field work is the open and constant communication maintained throughout the project. The more formal of the various means of communication employed was the **Bi-weekly Report** prepared by the Deputy Program Manager for the NYCHA Program Manager. This report provided backward and forward views: backward by reporting the field inspections occurring in the prior two-week period, forward by listing the field inspections scheduled for the next two weeks. The NYCHA Program Manager used the former to report progress to NYCHA senior management and the latter to notify the NYCHA development managers and maintenance foremen of upcoming inspections.

2.2 Field Inspections

Field inspectors traveled to the developments primarily via NYC Transit, although some team members drove; a few were able to walk to their field assignments on occasion.

Once assembled, the Team Leader called a borough coordinator and reported in. If this was the first inspection day at a new development, the inspection began with an all-hands interview with the development manager, the maintenance foreman and sometimes other senior development staff as well. The interview posed a prescribed series of questions to the development manager and staff, many of which were intended to elicit information on current conditions, e.g., whether, say, any new boilers or windows were installed within the last five years, or whether any particular area of the grounds flooded in light rainfalls, signaling a clogged drainage system. The development managers and staff across the entire portfolio proved to be a tremendous wealth of information, and NYCHA is to be complimented on their professionalism and pride in their developments.

The field inspection of a building began with all hands on the roof, where the Architecture inspector, assisted by the Interior inspector, examined the roof, roof drains, fencing around the roof, parapet, cornices, bulkhead walls, and so forth. The Mechanical inspector examined roof-mounted mechanical equipment, mainly ventilation fans but the occasional chiller as well. The Electrical inspector inspected any roof-mounted lights.

The inspectors then proceeded to the basement, where the bulk of the Mechanical and Electrical components, e.g., boilers, hot water heaters and storage tanks, pumps, trash compactors, main electrical panels and circuits, were generally located. The Architecture inspector examined basement walls/floors/ceilings for any signs of structural issues, and assessed the overall condition of these components.

The team then generally disbursed to inspect other areas: the Architecture inspector proceeded outside to examine the exterior walls, windows, balconies, main and secondary doors, and so forth. The Interior, Mechanical and Electrical inspectors proceeded to the first floor to examine lobby and corridor walls/floors/ceilings, community kitchens, public bathrooms, any management offices, gymnasiums, community centers and the like.

The grounds were inspected as well. The Mechanical and Electrical inspectors completed the relevant site questionnaire, while the Interior inspector was assigned the Site-Architectural questionnaire.

Individual teams developed their own work habits and work flows, and what is described above is the general flow of the field inspection. Given the work load of the Architectural inspector, one or more of the other inspectors may assist by counting windows or missing window guards. Some teams inspected the grounds in one continuous inspection; others inspected the grounds in increments, generally some loosely-defined area around each particular building, and accumulated these data over time in notebooks, inputting data totals into the final report.

The inspectors used the Mobile Validity software application loaded on small, portable iPads to organize and gather the data. Once a report was complete and checked using built-in checks and balances, inspectors were encouraged to "synch" their report as soon as possible, both to ensure the integrity of the data and to kick-start the QA/QC process back in the office.

The inspection day ended with a telephone call by the Team Leader to a borough coordinator to report on inspections completed and the schedule for the following day.

Periodic reports reporting preliminary findings were submitted at points where inspections were 25, 50, 75 and 100 percent complete. The dates of these submittals and the number of inspected developments included in each is noted below (Table 7).

Table 7. Periodic Reports Issued

Period (Percent Complete)	Date of Issue	No. Developments
25	December 2016	31
50	February 2017	48
75	April 2017	103
100	October 2017	145

At peak period, **80+ inspectors** were in the field on a daily basis. All totaled, **2,375 buildings, 325 development grounds, 766 facilities, 3,300+ elevators,** and some **20,000+ apartments** were inspected in the 2017 PNA. Field inspections began May 23, 2016, and concluded the week of January 23, 2017, a period of only eight months. Specific inspection end dates by borough are denoted in Table 8; a detailed listing of inspection dates is provided in Appendix C.

Table 8. Field Inspection Completion Dates by Borough

Borough	Week of
Staten Island	July 18, 2016
Queens	October 3, 2016
Manhattan	January 2, 2017
Bronx	January 9, 2017
Brooklyn	January 23, 2017

2.3 Hazardous Conditions

A contract term required all hazardous conditions in building systems or components encountered during field inspections be documented and reported to NYCHA within 24 hours. NYCHA defines a hazardous condition as a “life-threatening safety condition that needs to be corrected immediately, including, but not limited to: a non-operational fire alarm; missing handrail; and non-operational emergency lighting.”

Accordingly, a hazardous conditions report standard form was developed covering Architecture, Mechanical and Electrical components. The report was included on the iPad the field inspectors took into the field, and Mobile Validity allowed a photograph(s) to be attached to the hazardous conditions report. Inspectors were trained in the identification of hazardous conditions, and frequently consulted with the Discipline Leads when suspect conditions were encountered. Inspectors were instructed to complete and file such reports as quickly as possible.

A similar form was used to gather structural conditions of a hazardous nature.

As hazardous and structural conditions were encountered and verified, they were reported to NYCHA and the appropriate development staff to be resolved. A summary of the hazardous conditions encountered is presented in Table 9.

Table 9. Hazardous Conditions Encountered During Field Inspections

Hazardous Conditions	Description
Gas Leaks	Gas leaks in boiler rooms and gas meter rooms
Clogged Water Conditions	Sewage, stormwater and clogged drainage water conditions in basement boiler rooms, tank rooms and/or electric service rooms
Metal & Steel Ladders	Loose and defective bolt connections and support members
Site Work	Missing and defective handrails, fencing, benches and areaway gratings. Also included are tripping hazards associated with exterior pavements, sidewalks and stairs.
Windows	Broken and defective window glass, window units and child guards. Also included are window AC units not properly supported.
Back Flow Prevention Devices	Back flow preventers or double check valves not installed on utility service lines
Fire/Sprinkler Systems	Defective and nonfunctional fire/sprinkler devices and trouble alarms at control panels
Fire Doors	Missing and nonfunctional fire doors and hardware at building stairs, lobbies, corridors and mechanical rooms
Apartments, Stairs and Corridors	Active leaks, mold conditions and hazards associated with walls, ceilings, floors, lighting, electrical outlets, panels, smoke detectors and plumbing at building interior apartments, corridors and stairs
DOT Sidewalks	Heaving on the DOT sidewalks
Water Towers	Identifying poor conditions and leaking roof top water tanks at Brevoort Houses, Tompkins Houses, Gaylord White Houses, Howard Houses, Murphy Houses, Clinton Houses and Drew Hamilton Houses. Continuous leaks contributed to extreme ponding of water at the base of the water towers and vegetation conditions at surrounding roof areas.

3 Post-field Activity

Post-field activity included an intensive QA/QC effort; completion of an update of the Unit Cost Library; analyses of the data; and refinement to the interface used to view and sort/organize the collected data.

3.1 Quality Assurance/Quality Control

An intensive QA/QC effort continued after completion of the field activity. Several field teams were brought into the office to "scrub" the completed reports, and automated queries were established to check the overall database for potential errors. For example, for a component to be rated a 5, a deficiency must be identified. The database was queried to identify all reports where a component was rated a 5 but no deficiencies were identified. All such reports were corrected; in a number of instances, a reinspection of the component in question was required. Specific queries were tailored to each of the questionnaires.

Considerable attention was paid to entering correct total quantities, particular in regards to roof areas and apartment floor areas. Digital copies of architectural plans of all NYCHA buildings where such plans existed were assembled and roof areas and typical apartment floor areas were measured. In some instances, a scaled aerial photograph was used to take-off roof areas. A database of roof areas was developed and used to check roof areas reported in roof field inspector reports, and the entries were corrected where appropriate.

The checking and scrubbing of reports constituted the quality control component of the QA/QC program. The quality assurance component was overseen by two senior staff, one from each member of the joint venture. Working in concert, both ensured that the proper procedures, methodologies and protocols were in place and were being followed. Final quality assurance certifications, stipulating that all required quality control measures were properly implemented, were received on July 20, 2017.

3.2 Unit Cost Library

A review and update of the Unit Cost Library (UCL), which began while field inspections were underway, was concluded in post-field activity, yielding current 2017 prices for all deficiencies noted in the 2017 Mobile Validity software application. In total, the Unit Cost Library consists of 4,390 combinations of component/deficiency/quantity/action/cost.

The team's approach to the development of the 2017 UCL, as detailed below, utilized industry standard practices, protocols, procedures, methodologies and sources commonly used in cost estimating. An internal team of licensed and experienced professionals performed the analyses and work described herein. These cost estimators are highly skilled individuals whose day-to-day job roles require the provision of cost estimating services for major programs in the NY Metro region, and most have been involved with work in support of ongoing NYCHA rehabilitation and construction projects.

Our cost estimating methodology included the following steps:

1. **Review and Comparison: 2011 UCL, 2011 PBS, and 2017 PBS.** The process began by reviewing the 2011 Unit Cost Library for accuracy, then comparing the 2011 Physical Breakdown Structure (PBS) with the 2017 PBS. The Discipline Leaders and supporting team members compared node-to-node relationships due to modifications of the PBS during the 2017 PNA program development process. Where corresponding 2011 PBS nodes existed, costs were reviewed for accuracy for use as Base Unit Costs. Where there were no corresponding node-to-node relationships between 2011 and 2017 PBS nodes, new Base Unit Costs were developed. Within three key disciplines, 246 new Base Unit Costs were developed in the Electrical discipline, 164 in Architecture and 68 in Mechanical.

2. **Cost Escalation.** Based on NY metro area construction costs, escalated increases were accounted for between 2011 and 2017 at three percent per year (compounded). This escalation factor was only applied to 2011 costs deemed accurate and where corresponding 2017 PBS nodes existed. Inaccurate costs were disregarded and new Base Unit Costs developed.

3. **New 2017 Base Unit Costs.** Due to modifications of the PBS during the 2017 PNA process, new Base Unit Costs were developed for 2017 PBS nodes identified without a corresponding 2011 PBS node. New costs (478 in the Electrical, Architecture and Mechanical disciplines alone) were developed using a combination of the following methods:

   - RS Means costing data for New York City
   - Costing/pricing books and data published by the National Electrical Contractors Association (NECA) and other professional organizations
   - Vendor's quotes and data

- Internal STV and AECOM databases
- Experience with and knowledge of the New York City construction market within the STV and AECOM cost estimators

4. 2017 Hard Costs and Unit Soft Costs.

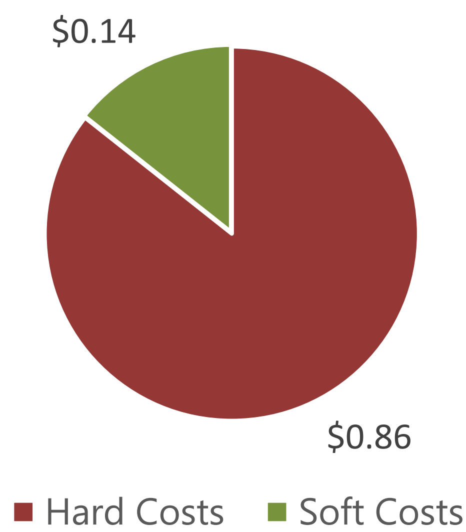
All unit prices reflect i) 2017 prevailing wage rates in New York City, ii) work to be performed in confined spaces and iii) mid- and high-rise construction. Architecture/Engineering Services reflect the complexity of NYCHA projects and include allowances for field surveys and hazardous materials surveys and tests. Construction Management Services include allowances for materials testing, laboratory analyses, air quality monitoring and so forth. In effect, 86¢ of every dollar spent on NYCHA construction is for "hard" costs like labor and materials, general conditions, overhead and profit, insurance, bonds, permits, and other; the remaining 14¢ is for "soft" costs, e.g., architecture, engineering and construction management services. Table 10 and Figure 2 illustrate this.

Table 10. Unit Cost Breakdown

Cost Types	Applied Percentages		NYCHA Project Dollar
"Hard" Costs (Construction-related)			
Labor and Materials	NA		$0.62
General Conditions and Construction-related Costs			
General Conditions ▪ Mobilization/Demobilization ▪ Temporary Protection (Sidewalk Bridges, etc.) ▪ Site Safety, Site Security ▪ Field Office/Utilities ▪ Clean-up ▪ Permits	12.5	.08	
Overhead & Profit	12.5	.08	
Insurance	2	.01	
Bonds	2	.01	
Contingency	10	.06	
Subtotal, General Conditions and Const-related Costs	39	0.24	$0.24
Subtotal, Hard Costs			$0.86
"Soft" Costs (A/E- and CM-related)			
Architectural/Engineering (A/E) Services	10	.07	
Construction Management (CM) Services	12	.07	
Subtotal, Soft Costs	22	0.14	$0.14
Total Costs			**$1.00**

The mark-ups for general conditions and construction-related costs (39 percent) and architecture, engineering and construction managements services (22 percent) track reasonably well with those used in other large institutions, agencies and authorities in the Greater New York area.

Figure 2. Breakdown of NYCHA Project Dollar



5. **One cost per PBS Node.** The 2017 UCL takes into account only one cost per PBS node. Variable-size components such as boilers, air conditioning units, piping, electrical switches, transformers, and elevators were provided with an average or mid-line quantity for estimating purposes. Quantities for such are listed in Table 11.

Table 11. Quantities used for Estimating Select Cost Items

Discipline	PBS1	PBS2	PBS3	Capacity
Mechanical	Air Compressor			10 HP
Mechanical	Air Conditioning	Central Station Air Handler		12.5 HP
Mechanical	Air Conditioning	Chilled Water System	Chiller - Packaged	30 tons
Mechanical	Air Conditioning	Chilled Water System	Chiller, Air Cooled	30 tons
Mechanical	Air Conditioning	Chilled Water System	Chiller, Water Cooled	30 tons
Mechanical	Air Conditioning	Cooling Tower	Cooling Tower	45 tons
Mechanical	Air Conditioning	Packaged / Rooftop Unit		15 tons & 3 HP
Mechanical	Air Conditioning	Packaged Terminal Air Conditioning		4 tons

Discipline	PBS1	PBS2	PBS3	Capacity
Mechanical	Domestic Water System	Electric Water Heater		20 kW
Mechanical	Domestic Water System	Distribution Piping		4" insulated
Mechanical	Domestic Water System	Domestic Water Heat Exchanger - Tank Type		5000 gallons
Mechanical	Domestic Water System	Gas Fired Water Heater		500 MBH
Mechanical	Domestic Water System	Gravity System	Roof Tank	20,000 gallons
Mechanical	Domestic Water System	Gravity System	Supply Pump	25 HP
Mechanical	Domestic Water System	Pressure Booster System		7.5 HP duplex
Mechanical	Drainage / Sewage System	Building Storm Piping		8 inches
Mechanical	Drainage / Sewage System	Sewage / Waste Piping		8 inches
Mechanical	Drainage / Sewage System	Sewage Ejector Pump		3 HP
Mechanical	Drainage / Sewage System	Sump Pump		1.5 HP
Mechanical	Forced Air Heating	Gas Fired Furnace		250 MBH
Mechanical	Gas Service	Distribution Piping		6 inches diameter
Mechanical	Heating Plant	Boiler System	Boiler, Hot Water	75 BHp
Mechanical	Heating Plant	Boiler System	Boiler, Packaged Modular	630 MBH
Mechanical	Heating Plant	Boiler System	Boiler, Steam	300 BHP
Mechanical	Heating Plant	Oil / Water Separation System		150 gallons per hr
Mechanical	Interior Compactor			15 HP
Mechanical	Sprinkler System	Booster Pump/Motor		7.5 HP
Mechanical	Sprinkler System	Piping		3 inches diameter
Mechanical	Standpipe System	Piping		4 inches diameter
Electrical	Emergency Generator Set	Automatic Transfer Switch (ATS)		60 Amps
Electrical	Emergency Generator Set	Emergency Generator Set	Diesel	400 kW

Discipline	PBS1	PBS2	PBS3	Capacity
Electrical	Emergency Generator Set	Emergency Generator Set	Natural Gas	400 kW
Electrical	Panelboard	Fused Disconnect Switch		225 Amps
Electrical	Panelboard	Fused Toggle Switch		225 Amps
Electrical	Panelboard	Molded Case Circuit Breakers		225 Amps
Electrical	Service Switch			4000 Amps
Electrical	Switchboard	Air Circuit Breaker		3000 Amps
Electrical	Switchboard	Fused Disconnect Switch		3000 Amps
Electrical	Switchboard	Fused Knife Switch		3000 Amps
Electrical	Switchboard	Molded Case Circuit Breaker		3000 Amps
Electrical	Fire Alarm System	Main Panel	F A C P (Electronic)	6 Zones
Electrical	Fire Alarm System	Main Panel	F A C P (Standard)	4 Circuits
Electrical	Fire Alarm System	Sub-Panel	Electronic	4 Zones
Electrical	Fire Alarm System	Sub-Panel	Standard	4 Circuits
Electrical	Transformer	Dry Type		3000 Amps
Electrical	Transformer	Liquid Type		3000 Amps
Conveying	Traction Elevator			# of floors: 8 # of entrances: 1 capacity: 6-8 people speed: slow to mod
Conveying	Hydraulic Elevator			# of floors: 8 # of entrances: 1 capacity: 6-8 people speed: slow to mod
Apartment	Electrical	Electrical Panel Board		60 Amps

6. **2017 Prices for Key Components.** Key components designated by the Discipline Leads and supporting team members were identified. The team's cost estimators reviewed these nodes and in some cases provided new 2017 Base Unit Costs in addition to escalated 2011 Base Unit Costs. In some instances, Base Unit Costs were reexamined for quality control purposes and accuracy.

7. **Final Review and Selection of 2017 Unit Costs.** Final reviews were conducted during a number of workshops attended by senior NYCHA staff, Discipline Leaders, supporting team members, and the cost estimators. All Unit Costs were reviewed, vetted for quality, and approved. Approved Unit Costs are represented within the three (3) Unit Cost Library (UCL) documents provided to NYCHA. The same approved costs are utilized by the PNA Database Application and Capital Planning Tool.

3.3 Interface with PNA Database

A software application ("PNA Database Application" or "Application") for querying/sorting/assembling data within the PNA database was developed and implemented. It is the interface between NYCHA managers and the PNA data. Building on an earlier, existing version of the Application, the software and its capabilities are as follows:

1. **Menu and dashboard.** The Application is menu-driven using a dashboard interface.

2. **Geographical maps.** The Application is capable of displaying the PNA data on a geocoded map-based system with digital photographic images and statistics documenting conditions at each NYCHA development by location.

3. **Reporting capability.** The Application is able to produce various types of reports in different formats (e.g., grid, pivot and formal reports), allowing NYCHA staff to produce multiple summary and detail reports at the building level, development level and the entire portfolio level. Reports can be generated by sorting and filtering the data in multiple ways including, but not limited to:

   - Asset-based filters
     - geographical location, borough and electoral district
     - development size
     - buildings count
     - floors and unit count
     - building component
     - year built
     - construction type
   - Needs-based filters
     - deficiency type
     - urgency of action year
     - historical project completion data

- overall and individual component condition rating
- recommended corrective action
- Remaining Useful Life (RUL)

4. Ability to prioritize needs. The Application is capable of assigning a priority rating to each deficiency and producing reports based on these priority ratings by development or across the entire portfolio. The priority ratings can be used by NYCHA to establish the relative importance of recommended actions over a 20-year planning period. The Application considers the following in assigning priority rankings:

- history of the completed projects and cost per development
- overall and individual component condition rating
- type of action required to satisfy needs (e.g., repair, replace, maintain)
- reason for action
- urgency of action year
- Remaining Useful Life (RUL)

5. Long-term planning ability. The Application accommodates long-term planning by incorporating the expected useful life of the building systems and components.

6. Unit Cost Library. The Application incorporates the Unit Cost Library described above.

7. Data Exchange Tool. The Application includes a tool for retiring deficiencies from the database once addressed. For example, after replacing obsolescent windows at Smith Houses, the exchange tool allows for those obsolescent windows to be removed from the needs database as the need has been met. The tool is capable of retiring the needs for "in progress" and "completed" projects on an annual or intermittent basis. The tool allows NYCHA staff to run updated reports after removing the addressed needs.

8. GPNA interface and mapping tool. The Application provides an interface to map the needs, unit costs and quantities from the NYCHA database into the GPNA database maintained by the U.S. Department of Housing and Urban Development. It is also capable of generating HUD GPNA reports and submissions annually or more frequently, as needed.

9. Condition-based ratings system. The Application has the ability to roll up an overall rating to the building, facility, development and entire portfolio level.

10. **Updated conditions ratings.** Over time, unrepaired deficiencies will continue to deteriorate. To account for this, the Application includes a function that estimates changes in conditions over time, and updates condition ratings annually for every building system and component.

11. **Compatibility with NYCHA systems.** The Application is compatible with the financial management system and project management system maintained by NYCHA.

A training manual and training program of NYCHA staff will accompany full deployment of the Application. The initial training session with NYCHA staff was held on Monday, March 19, 2018.

3.4 Capital Planning Tool

Currently underway at the time of this report is the development of a **Capital Planning Tool** that will enhance and extend many of the features of the Application and provide some new capabilities as well. It, too, will be menu-driven with a dashboard interface and fully capable of generating both pre-programmed and custom reports. It will include a scenario manager, which will allow NYCHA staff to choose multiple options for the Capital Plan and evaluate the revised needs affected by these different options. It will be able to integrate data from the Application and NYCHA's existing systems including, but not limited to, the Oracle financial management system, the project management system, and the Maximo asset management system.

One of the tool's most useful capabilities will be its capacity to allow NYCHA managers to compare various capital plan scenarios. For instance, Scenario 1 may call for windows in one development to be replaced in Years 1-5 and roofs in Years 6-10. A second scenario, Scenario 2, may consider the reverse: roofs replaced in Years 1-5 and windows in Years 6-10. Roofs and windows degrade at different rates over time, and built-in algorithms will capture these different rates. Developing and running the two scenarios through the tool will allow the costs of the two to be compared. Additional tweaks to the scenarios can be made to refine the analysis. In the end, NYCHA managers will have an extensive array of data and analyses upon which to compile a capital plan that will maximize available capital funds.

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4 Energy Audits

4.1 Overview

For the first time NYCHA included an energy audit in a Physical Needs Assessment. The purpose of an energy audit is to collect data pertaining to building components, such as those in the heating, cooling, ventilation, building envelope and lighting systems, to establish energy usage and baseline energy consumption. Once the baseline consumption is determined, Energy Conservation Measures (ECMs), basically any type of project conducted, or technology implemented, to reduce the consumption of energy in a building, are integrated with the PNA database, offering green alternatives to repair and replacement choices.

The energy audit process involved the following steps:

1. Develop audit protocols, data requests, and build software application for data collection
2. Train Energy and PNA teams on audit protocols
3. Conduct audits and collect required data
4. Establish energy model
5. Develop ECM recommendations
6. Integrate ECMs into PNA database

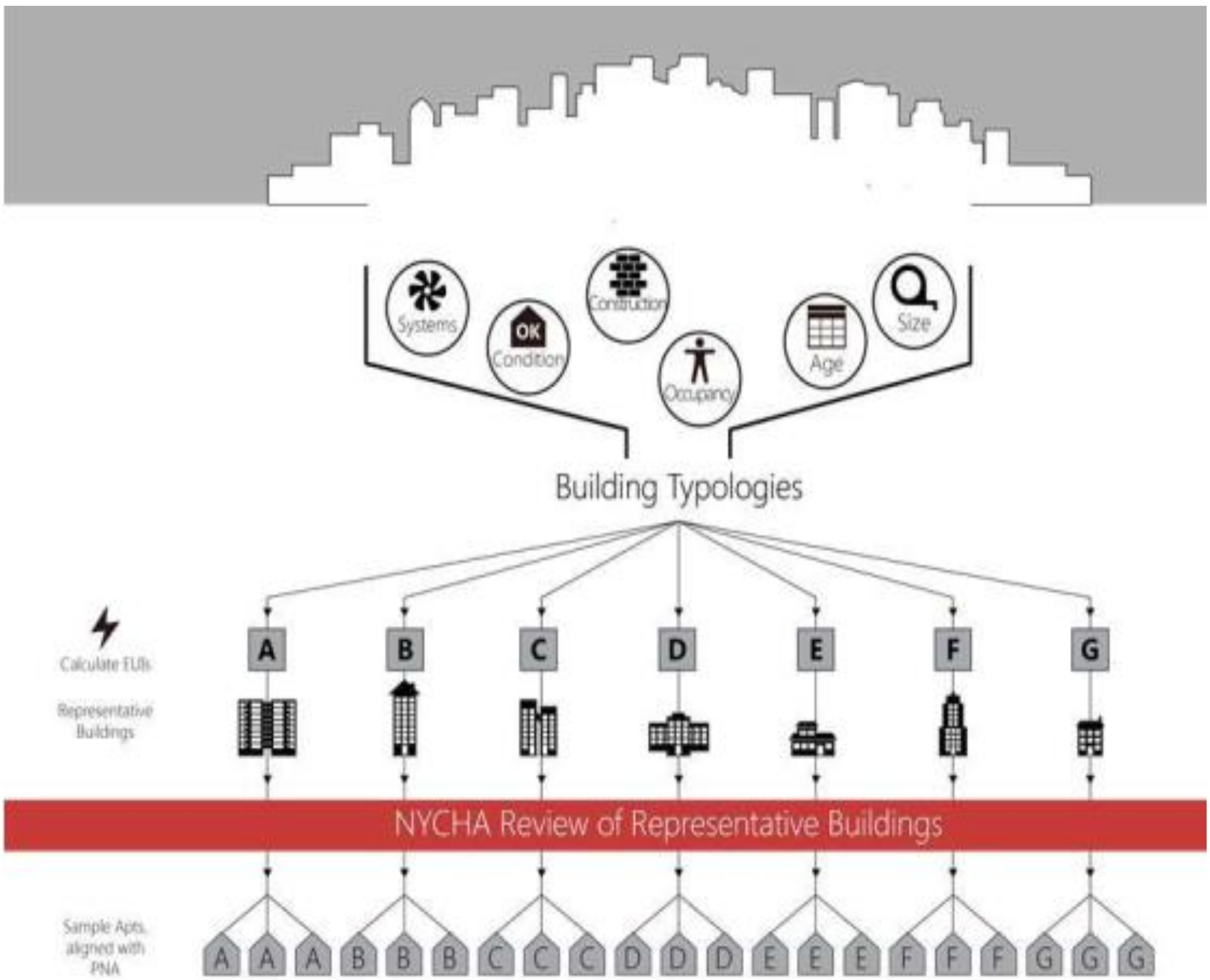
4.2 Pre-field Activity

4.2.1 Building Typologies

One of the critical initial steps was to assess the NYCHA portfolio and divide it into categories, called typologies, of like characteristics, e.g., size, age, layout, building systems, materials, and so forth. Twenty-six (26) data sets, encompassing building information as well as electric/fuel/water consumption data, were used to compile building lists with attributes necessary for typology breakdown. The most extensive building list included descriptive data on each of 2,469 NYCHA buildings. Of the 2,469 buildings, 2,346 had the complete necessary data from the typology parameters to identify their typology classification. The remaining 123 buildings were determined to be non-residential facilities.

In the end, 17 significant typologies of NYCHA buildings were developed. The process is illustrated in Figure 3.

Figure 3. Building Typology Definition Process



A typology code of four digits (**x.x.x.x**) is assigned to each unique typology. Table 12 defines what each digit in the code means. The 17 typologies and the number of NYCHA buildings within each typology are presented in Table 13.

Table 12. Definition of Typology Codes (x.x.x.x)

X.x.x.x	Building Height	**L**	Low Rise (0-4 stories)
		M	Mid Rise (5-8 stories)
		H	High Rise (9+ stories)
x.X.x.x	Building Age	**1**	Pre-1979 code (constructed before 1979)
		2	1979 code (constructed after 1979, before 1991)
		3	1991 code (constructed after 1991)
x.x.X.x	Heating System Supply	**1**	Central Plant (central boiler plant serving campus)
		2	Central Plant – City Steam (central reducing station connected to city steam serving campus)
		3	Individual Boilers (standalone building with boiler room)
x.x.x.X	Heating System Distribution	**1**	Heating Hot Water
		2	Low Pressure Steam
		3	Electric

Table 13. NYCHA Building Typologies

Typology Code	Typology Name	No. of NYCHA Buildings	No. of NYCHA Buildings Audited	No. of NYCHA Buildings after Redistribution[1]
L.1.1.1	Low Rise - Pre-1979 Code - Central Plant - Heating Hot Water	61	7	61
L.1.1.2	Low Rise - Pre-1979 Code - Central Plant - Low Pressure Steam	190	43	193
L.1.3.1	Low Rise - Pre-1979 Code - Individual Boilers - Heating Hot Water	19	13	29
L.1.3.2	Low Rise - Pre-1979 Code - Individual Boilers - Low Pressure Steam	102	16	103
L.2.1.1	Low Rise - 1979 Code - Central Plant - Heating Hot Water	149	29	149
L.3.1.1	Low Rise - 1991 Code - Central Plant - Heating Hot Water	29	6	30
M.1.1.1	Mid Rise - Pre-1979 Code - Central Plant - Heating Hot Water	36	7	36
M.1.1.2	Mid Rise - Pre-1979 Code - Central Plant - Low Pressure Steam	661	129	681
M.1.2.2	Mid Rise - Pre-1979 Code - Central Plant - City Steam - Low Pressure Steam	16	3	16
M.1.3.2	Mid Rise - Pre-1979 Code - Individual Boilers - Low Pressure Steam	203	43	206
M.2.1.1	Mid Rise - 1979 Code - Central Plant - Heating Hot Water	60	10	60
M.2.3.1	Mid Rise - 1979 Code - Individual Boilers - Heating Hot Water	11	4	25
M.3.1.1	Mid Rise - 1991 Code - Central Plant - Heating Hot Water	47	11	47
H.1.1.1	High Rise - Pre-1979 Code - Central Plant - Heating Hot Water	13	6	22
H.1.1.2	High Rise - Pre-1979 Code - Central Plant - Low Pressure Steam	448	88	452
H.1.2.2	High Rise - Pre-1979 Code - Central Plant - City Steam - Low Pressure Steam	18	3	20
H.1.3.2	High Rise - Pre-1979 Code - Individual Boilers - Low Pressure Steam	216	45	216
	TOTAL (>10 buildings in Typology)	2,279	463	2,346

Note: 1. Includes buildings within typologies considered not significant and thus not accounted for as a specific typology. Buildings within these insignificant typologies are assigned to the nearest matching typology for consideration of ECMs.

4.2.2 Software Application Development

An online data collection platform known as iForm was specifically configured to capture all energy-related field data. The software was loaded onto portable computers, and field data was entered directly into the software application by the inspector. The application provided a consistent platform in data collection and recording across all teams involved on the project.

The application was configured to collect data on site conditions, size, and quantities when applicable for the following:

- Windows and Doors
- Lighting for mechanical rooms, public lobby/stairway areas, building exterior and parking lot areas
- Centralized and de-centralized domestic hot water systems
- Boilers, burners, and control systems
- Pumps, VFD's, fans, and dampers
- Air conditioning systems for common areas
- Pipe and insulation
- Ductwork and insulation

The application was also configured to collect data in common areas including:

- CO_2 and CO levels
- Temperature
- Lighting levels

The application also incorporated a QA/QC check to improve the quality of data collected in the field. For instance, in those data fields where a number is to be entered, say, the size of a steam trap in inches, the application blocked the entry of other characters, such as letters or symbols (&, %, @, #), in the field.

4.3 Field Activity

After extensive training on the data collection process and on the iForm application, actual field audits began on May 23, 2016, and were concluded on November 18, 2016. Four field teams of two auditors per team were scheduled daily, while one office-based back-up team (also two members) organized the collected data for reporting and modeling purposes and provided on-site support as needed.

The energy audit's schedule followed the master PNA schedule, taking into consideration the efficiency, consistency and safety of the teams.

Specifically, 10 percent of buildings within each typology were chosen to be audited, and the data from this sampling represent the baseline energy consumption and energy conservation measures within each typology. The representative buildings were selected by identifying which buildings had an energy intensity within ±20 percent of the median energy intensity for that typology. Median energy intensity for each building was determined prior to the audits utilizing historical data, and served as the key identifying factor in the representative building selection process. In total, **463 buildings** were audited within the **17 typologies** (Table 13).

Progress reports were prepared and presented to NYCHA at milestones representing completion of 25 percent, 50 percent and 75 percent of the audits (Table 14). These reports included a summary of the audit progress and findings; building typologies; preliminary modeling methodology; ECMs; energy audit database; and photos.

Table 14. Audit Summary Table

Reporting Period	No. of Buildings Audited (Cumulative Total)	No. of Developments Visited (Cumulative Total)	No. of Typologies Represented	Total Area of Buildings Audited (000 sf)
25% Interim	116	31	13	5,057
50% Interim	232	55	15	13,645
75% Interim	348	103	15	25,694
Audit Completion	463	153	17	36,041

4.4 Post-field Activity

Post-field activity involved identification of energy conservation measures, energy modeling, an extensive QA/QC process, and analysis and assessment.

4.4.1 Energy Conservation Measures (ECMs)

The energy team developed a complete list of potential ECMs based on guidelines described in various publications of the U.S Department of Housing and Development (HUD) – Energy Conservation Handbook and the experience of the team from previous studies and projects (Table 15).[1] The main objective of recommending ECMs is to reduce

[1] Each ECM is described in detail in *NYCHA PNA and EA Energy Audit Report* dated October 19, 2017.

NYCHA's energy intensity and operating costs while also improving tenant safety, health, comfort level and resiliency of NYCHA building systems.

Table 15. Energy Conservation Measures Evaluated

Code	Name
1	Install replacement windows
3	Window sealing and caulking
4	Install new doors
5	Install weather-strip and door-sweep to exterior doors
6	Install/increase roof insulation
7	Install reflective roof coating
8	Replace boilers
9	Replace burner
10	Install boiler oxygen trim controls
15	Replace utility steam with natural gas-fired heating system
17	Install heat recovery
18	Insulate hot water or steam pipes
31	Install dedicated domestic hot water system/summertime unit
32	DHW system upgrade
34	Install water-efficient showerheads and faucets
35	Replace existing toilets with low gpf model
45	Replace old refrigerator with high-efficiency unit
46	Install thermostatic radiator valve (TRV)
48	Replace old window air conditioners with high-efficiency units
50	Replace bathroom fans
53	EMS/centralized boiler control with wireless temperature sensors (Advanced)
60	Lighting
96	Replace washers
97	Replace dryers

Key **DHW** domestic hot water **gpf** gallons per flush **EMS** Energy Management System

4.4.2 Energy Modeling

The Targeted Retrofit Energy Analysis Tool (TREAT) v3.5 was used to model the audited 463 buildings to estimate costs and potential savings from the identified energy conservation measures. TREAT is an energy modeling software for single and multifamily housing types. It works in conjunction with the hourly simulation engine, SUNREL, to carry out thermal calculations.

The overall modeling project effort included integrating PNA and energy audit information in TREAT. While developing the building model, information was entered under different sub-categories based on the type of asset. These energy models were then used to identify the most beneficial ECMs for the NYCHA portfolio of buildings.

The energy modeling process was iterative as it included calibration with the actual energy usage data for both gas and electricity. The calibration threshold for accuracy was set at 15 percent, implying that the modeled energy use had to be within 15 percent of the energy use calculated from the utility bills.

Once that calibration was complete, ECMs applicable to each building were applied to determine the estimated energy savings for that particular building. A specific code number was assigned to each ECM to facilitate easier data extraction from the models, which would then be used for extrapolation of the results across the entire building portfolio of NYCHA. Each ECM also had an associated cost that was entered in the model.

Documentation of all modeling inputs were captured through a tracking document developed using a central spreadsheet accessible by the energy modeling team. This tracker was used for quality control checks in addition to tracking the progress of the modeling efforts on a weekly basis.

The outputs from each TREAT model include those listed below. Key findings of the TREAT modeling exercise and analysis/assessment are included in Section 4.5 Key Findings below.

- ECM per building type
- Cost of measure
- Annual savings (MMBtu)
- Annual savings ($)
- Payback years
- Cash flow ($/year)
- Improvement Life Years
- Savings-to-investment ratio (SIR) in package

4.4.3 Quality Assurance/Quality Control

During the modeling exercise, a Quality Assurance/Quality Control (QA/QC) Plan was developed. The plan included recommendations and procedures for project teams to follow to foster a consistent approach towards developing TREAT models and supporting documentation.

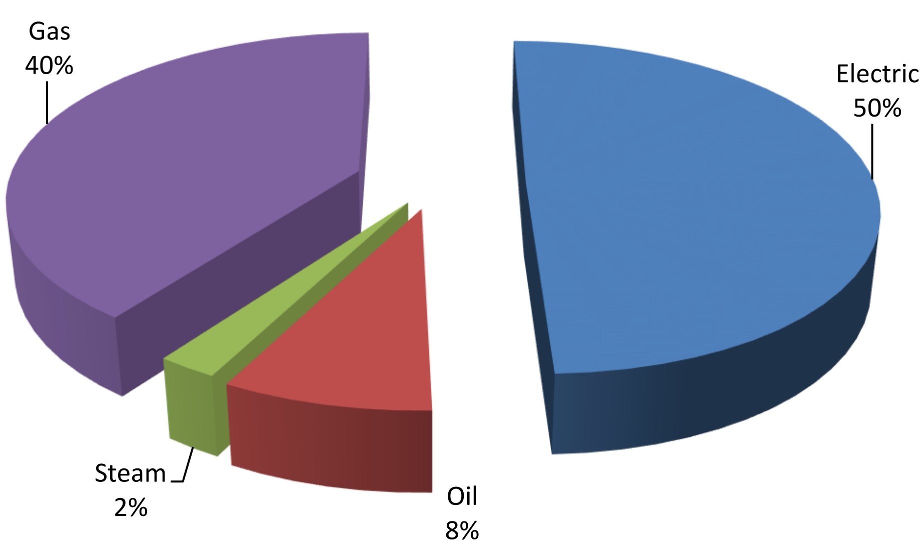
A multi-level approach was followed. The first level, implemented by TREAT modelers, occurred at the time the model was being calibrated, and focused on minimizing basic errors such as inputting incorrect data or not entering data in required fields. A second higher level check was carried out by an independent reviewer. Buildings were selected, one from each development, using a random sampling approach. A total of 163 buildings were reviewed in this second level of QC, representing about a third of the total number of buildings modeled in TREAT. All typologies were covered.

4.5 Key Findings

4.5.1 Existing Conditions

Within the 463 representative buildings audited, NYCHA's utilities include electricity, natural gas, fuel oil and steam. Utility consumption and cost data for the three-year period 2013-2015 have been collected and analyzed to provide an overview of NYCHA's current utility cost and consumption. As indicated in Figure 4, electricity and natural gas account for 90 percent of utility costs.

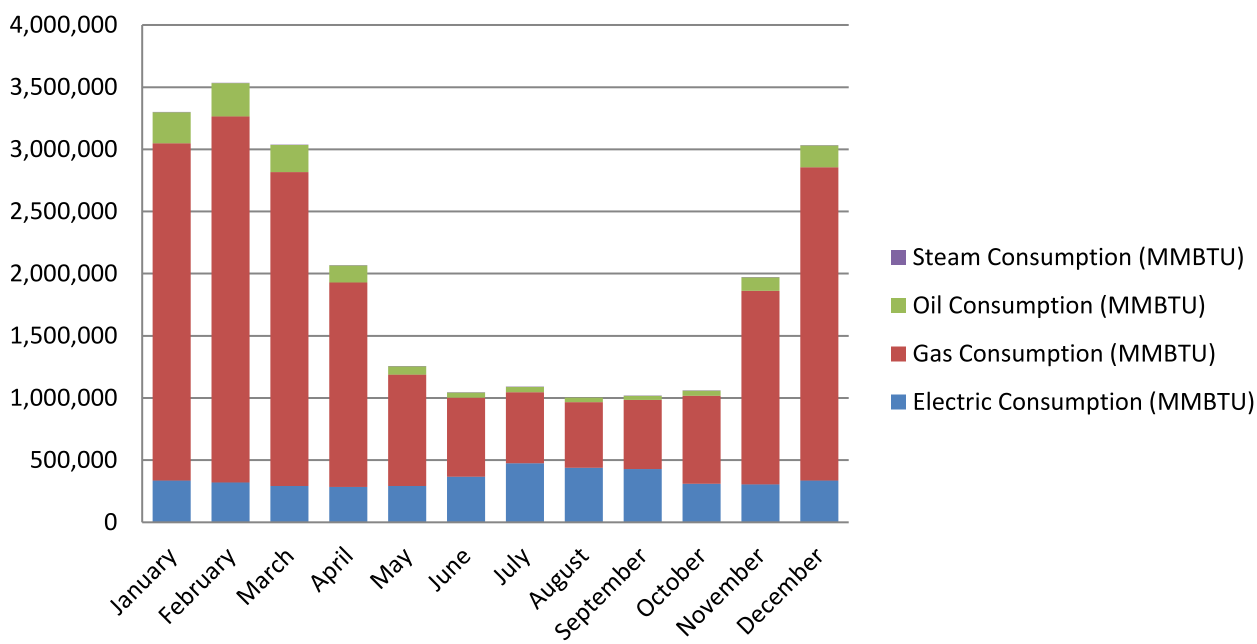
Figure 4. Utility Cost Allocation, 2013-2015



Source: NYCHA

Monthly utility costs hover around $40 million per month during the peak heating winter months of January, February and March, and drop to around $20 million per month in the period May-October. In the May-October period, the cost drop is due overwhelmingly to the reduced quantities of natural gas consumed (for heating purposes), although there is a slight uptick in electricity costs for comfort cooling. Figure 5 shows the average MMBtu (million British thermal units) consumed per month across all utilities.

Figure 5. Monthly MMBtu Consumed in the NYCHA Portfolio



Key **MMBtu** Million British thermal units

Source: NYCHA

4.5.2 Potential Energy Savings

NYCHA management has long recognized energy conservation as a desirable goal, one that not only saves increasingly scarce funds but also increases tenant comfort and improves the environment by reducing greenhouse gases. One of the four primary goals of *NextGeneration NYCHA* is to **operate as an efficient and effective landlord** (Goal #2). In pursuit of that goal, NYCHA management will **pursue a comprehensive sustainability agenda aimed at reducing NYCHA's carbon footprint** (Strategy #7). To that end, NYCHA released a four-goal Sustainability Agenda in April 2016, which begins with the sentence "A safe, clean, and healthy home is the right of every individual regardless of zip code."

NextGeneration NYCHA and the Sustainability Agenda are also informed by Mayor de Blasio's **One City: Built to Last**, a comprehensive energy efficiency and emission reduction plan for City buildings. Released in September 2014, this plan commits to an 80 percent reduction in the City's greenhouse gas emissions by 2050. *NextGeneration NYCHA* is also a part of **OneNYC**, the Mayor's plan for growth, sustainability, resiliency and equity released in April 2015. In summary, in regards to energy conservation, *NextGeneration NYCHA* and the Sustainability Agenda provide strategies for NYCHA to become more sustainable and resilient, to prepare for a changing climate, and to mitigate greenhouse gas emissions.

Given that the average age of a NYCHA building is roughly 60 years, much of the infrastructure and building systems are outdated and the materials and technology of the past, conditions which led to more than a doubling of utility costs in recent years, from $268 million in 2002 to $577 million in 2014. NYCHA has implemented sustainability initiatives over the past two decades, including an energy efficient refrigerator replacement program, conversion of boilers from heavy heating fuels to natural gas, energy efficiency lighting retrofits, an instantaneous hot water heater program, installation of apartment temperature sensors, and automated heating systems that allow remote monitoring of boilers and building controls. These sustainability initiatives have saved NYCHA tens of millions of dollars in utility costs, but much more can be done, as evidenced by the data in Table 16.

Table 16. Potential Annual Savings with Energy Conservation Measures

ECM Code	ECM Description	Energy Savings (MMBtu/year)	Energy Savings ($000/year)
60	Lighting	153,822	$15,539
45	Replace Old Refrigerator with High-Efficiency Unit	122,823	$14,064
18	Insulate Hot Water or Steam Pipes	1,206,614	$9,519
8	Replace Boilers	1,083,335	$9,038
1	Install Replacement Windows	914,051	$6,898
53	EMS/Centralized Boiler Control with wireless temperature sensors (Advanced)	932,162	$6,356
32	Convert from storage tank system to instantaneous hot water system	486,804	$4,470
48	Replace Old Window Air Conditioners with High-Efficiency Unit	56,449	$2,816
6	Install/Increase Roof Insulation	95,018	$663
5	Install Weather-Strip and Door-Sweep to Exterior Doors	73,162	$549
4	Install New Doors	4,893	$33

Based on the findings of the energy audit component of this PNA, two ECMs alone could generate roughly $30 million in annual savings. NYCHA could benefit significantly by taking advantage of recent advances in lighting technology, especially in LED technology, with potential annual savings of $15.5 million. A LED lighting system is almost 90 percent more efficient than an incandescent system, and 50 to 60 percent more efficient than fluorescent technology. In addition, LED lights last much longer than incandescent and fluorescent ones, resulting in significantly lower maintenance and replacement costs.

The data also verify the potential energy savings ($14 million annually) of NYCHA’s energy efficient refrigerator replacement program, and that program should continue.

And in late January 2018, the Office of the Mayor announced $200 million will be invested over three years to install 39 new efficient boilers at 10 developments and upgrade heating systems at 10 others; to modernize hot water systems at 12 developments by separating hot water from the heating boilers to reduce the strain on boilers; and to install new heating controls at 15 developments to regulate boiler temperature. The latter will help NYCHA monitor performance more closely, detect possible faults earlier, reduce the strain on boilers, provide more consistent heat to tenants, and save money on operating costs.

These are sound investments and supported by the energy audit data. Modernizing/ repairing mechanical systems, including insulating hot water or steam pipes ($9.5 million); replacing outdated boilers with new, high-efficiency ones ($9 million); installing EMS/centralized boiler controls with wireless temperature sensors ($6.4 million); and converting from storage tank systems to instantaneous hot water systems ($4.5 million) could greatly reduce NYCHA energy costs over time, freeing monies for investment in the portfolio elsewhere.

5 Roof Thermography Imaging

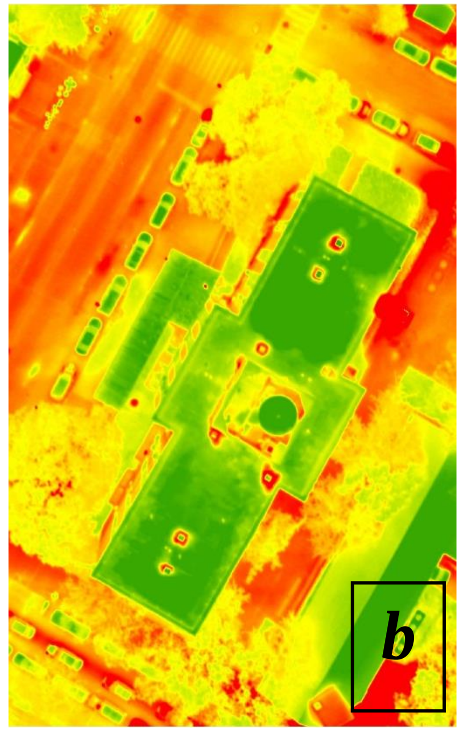
For the first time NYCHA included roof thermography imaging as a component of a physical need assessment. Since infrared radiation is emitted by practically all objects, thermography makes it possible to "see" with or without illumination. Thermal imaging cameras detect variations in temperature: warm objects stand out well against cooler backgrounds. Since humans and other warm-blooded animals become easily visible against the environment, day or night, thermography is particularly useful in military and surveillance settings. The phrase "night vision," frequently used in the military, employs night vision goggles that are essentially thermal imaging cameras.

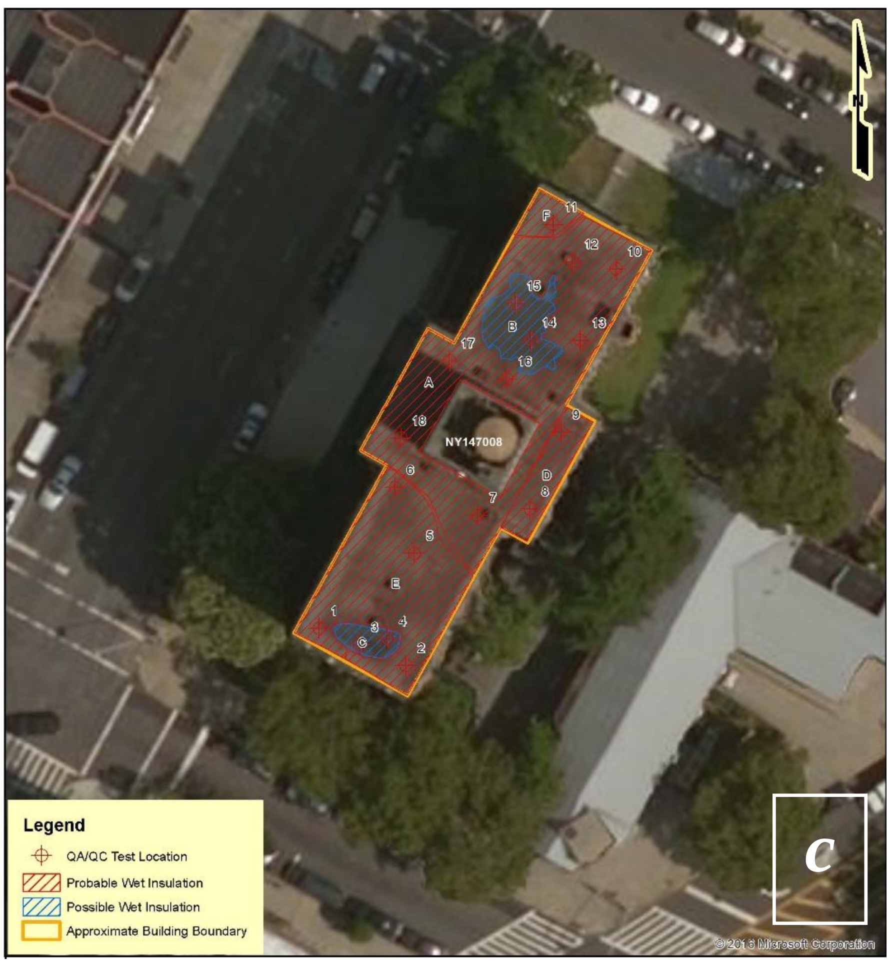
Thermography use has increased dramatically in commercial and industrial sectors in the past 50 years. Firefighters use thermography to see through smoke to find persons; maintenance technicians to locate overheating joints and sections of power lines, which are a sign of impending failure; and facility management staff look for thermal signatures indicating heat leaks from faulty thermal insulation, and use the results to improve the efficiency of heating and air-conditioning units.

5.1 Thermography in the NYCHA PNA

Because thermal imaging makes apparent temperature differences viewable, it is excellent at finding moisture and displaying/documenting problem areas unseen to field inspectors. The roof absorbs heat during the day and releases it when the temperature falls later. Wet areas release heat slower than dry areas. Because of this, the wet and dry areas are readily viewable in a thermal image (Figure 6), which displays apparent temperature differences as gradient colors.

Figure 6. “Typical” Roof Thermography Image and Analysis





Key

a Existing Conditions

b Roof thermography image

c Areas of damage

Cracks, poor seams, pinholes, and other damage to the outer roof membrane will cause water to be absorbed into sub-surface insulation layers. On the surface in a daylight inspection, these cracks and poor seams may not be readily apparent and go undetected. A thermal image will, however, and the value it adds to roof condition assessment cannot be underestimated. Left undetected and unaddressed, wet areas of roof insulation and other sub-surface layers can result in major structural damage or, at the very least, deterioration to any structure near the leak location.

The team included a consultant with prior experience in taking and evaluating roof thermal images. Roof thermal images of the NYCHA residential portfolio were obtained through the use of aerial thermography, that is, airplanes equipped with the appropriate thermal imaging cameras flew over all NYCHA residences and snapped thermal images of all NYCHA roof surfaces. In a number of instances, due to lack of access to a NYCHA roof in the field, these thermal images served as the only means of identifying roof condition. The consultant than assessed the condition of the roof; identified areas of probable damage, if any; and prepared a stand-alone report for each NYCHA building surveyed in the PNA. These reports and the thermal images in them are included in the PNA Database Application and accessible to NYCHA staff.

5.2 Reconciling Field Reports and Roof Thermography Reports

Given that field inspections and thermal imaging of NYCHA roofs took place simultaneously, field inspectors did not have access in the field to data provided by the thermal images. Accordingly, a reconciliation methodology was developed and implemented to combine the data from both sources: field inspection and aerial thermography. The methodology is described as follows:

Roof thermography reports to be coordinated with the **PNA field reports** by:

- Inputting deficiencies into PNA reports using “Leak – Severe” or “Leak – Local” for roofs identified as wet roof thermography reports. “Leak – Severe” and “Leak – Local” are existing deficiency types that are rarely used because field inspectors can’t see the leaks to identify them.
- Deficiency quantities will be revised to
  - i) equal the entire roof area if the wet area is greater than (>) 70 percent of the total roof area
  - ii) equal the wet area identified in the thermal imaging report if the wet area is less than (<) 70 percent of the total roof area
- A note will be added in the comment field of each modified field report to clarify that supplemental information from the thermal imaging reports was used in conjunction with the visual inspection data to determine the

rating for the roof. Specific language to be determined, standardized and approved by NYCHA.

METHODOLOGY NOTE 1 | LEAK – SEVERE

Wet areas greater than or equal to (≥) 30 percent of the total roof area will equate to a deficiency of **Leak – Severe**. This corresponds to a recommendation in the roof thermography reports of partial to total roof replacement.

- For wet areas of 70-100 percent of the total roof area, the condition rating will be modified to 5 (total replacement recommendation)
  - There are 430 reports with wet areas greater than 70 percent of total roof area.
- For wet areas between 30 percent and 70 percent of total roof area, the condition rating will be modified to 4 (partial replacement recom-mendation), unless additional deficiencies recorded make it a 5.
  - There are 529 reports with wet areas between 30 percent and 70 percent of total roof area. This will result in a combined increase of 531 roofs rated 4 or 5.

METHODOLOGY NOTE 2 | LEAK – LOCAL

Wet areas less than 30 percent of total roof area will equate to a deficiency of **Leak – Local**, corresponding to a recommendation in the roof thermography reports of limited roof repair.

- There are 703 reports with wet areas less than 30 percent of total roof area.
- The ratings for these roofs will be calculated based on the rating table.
- It is estimated that about half of the 703 buildings will receive a more severe condition rating.

6 Key Findings

Key findings for Years 1-5 are the focus of this report and are reported extensively in the Executive Summary. It is appropriate, however, that the years beyond Year 5 be examined in the context of long-range capital planning. Table 17 lists **$45.2 billion** (2017 Dollars) in total repair and replacement costs over a 20-year period identified as **Years 1-20**.

Table 17. Total Costed Actions in Years 1-20 by Discipline and Rank Order

Discipline	Cost[1] (000,000)	Percentage	Included Components
Apartment	$16,944	37.5	Kitchen, Bathroom, Floor, Doors, etc.
Architectural	$13,040	28.8	Exterior (Roofing, Parapet, Entry Doors, etc.) and Interior (Common Areas, Interior Stairs, etc.)
Mechanical	$6,876	15.2	Boilers, piping, radiators, etc.
Conveying	$2,604	5.8	Elevators
Electrical	$2,495	5.5	Lighting, panelboards, generators, etc.
Site - Mechanical and Site - Electrical	$1,763	3.9	Site lighting, underground piping, etc.
Site - Architectural	$1,511	3.3	Fencing, playgrounds, sidewalks, etc.
Total	**$45,233**	**100.0**	

Note: 1. $000,000 = $ million. $16,944 in the table above = $16,944,000,000, or roughly $16.9 billion

The first four disciplines in Table 17 are in the same rank order as they are when considering the repair and replacement costs for Years 1-5, while there are some changes in the remaining three disciplines. Site-Architectural drops to the lowest position in Years 1-20, while it ranked #5 in Years 1-5.

Figure 7 presents the Years 1-20 costs graphically. Apartment and Architectural needs together constitute 66 percent of the need; adding Mechanical needs increases that to approximately 82 percent of the total costed actions in Years 1-20.

Figure 7. Total Costed Actions in Years 1-20 by Discipline

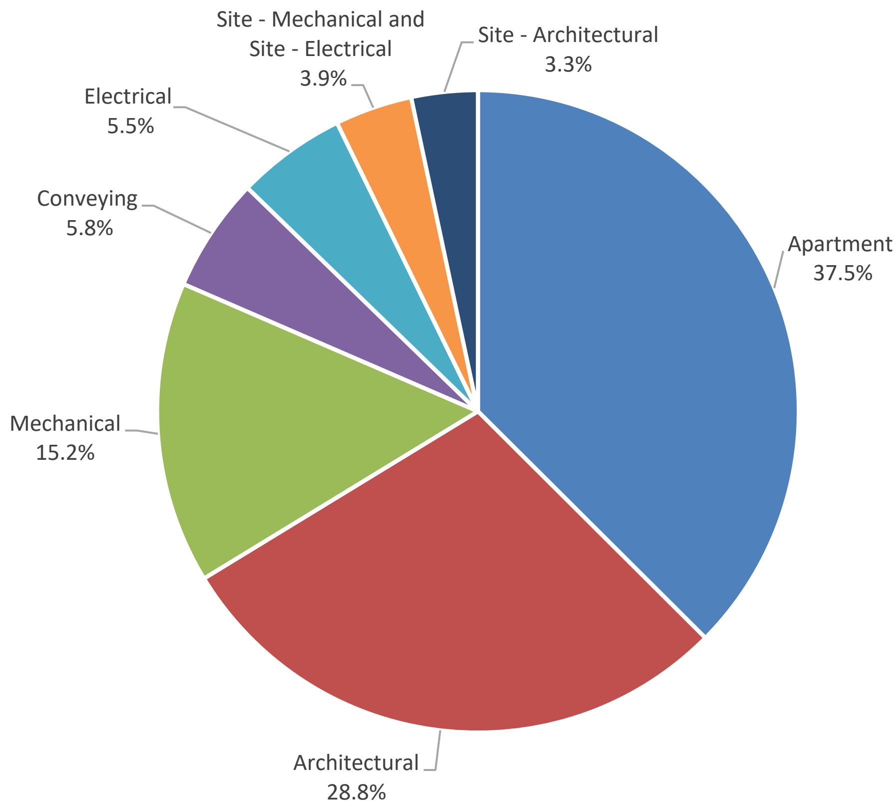


Table 18 illustrates the significant role total costed actions in Years 1-5 play in the 20-year capital planning timeframe. Years 1-5 needs, reflecting significant needs not addressed in the prior five years, total roughly 70 percent of the needs over the next 20 years, representing major needs for capital in the foreseeable future.

Table 18. Total Costed Actions in Years 1-5, 6-20 and 1-20 by Discipline

	Years 1-5	Years 6-20	Years 1-20
Discipline	**Cost[1] ($000,000)**	**Cost[1] ($000,000)**	**Cost[1] ($000,000)**
Apartment	$12,579	$4,365	$16,944
Architectural	$10,711	$2,329	$13,040
Mechanical	$3,058	$3,818	$6,876
Conveying	$1,510	$1,094	$2,604
Site - Architectural	$1,471	$40	$1,511
Electrical	$1,358	$1,137	$2,495
Site - Mechanical and Site - Electrical	$1,114	$649	$1,763
Total	$31,801	$13,432	$45,233
Percent of Years 1-20 Total	70.3	29.7	100.0

Note: 1. $000,000 = $ million. $16,944 in the table above = $16,944,000,000, or roughly $16.9 billion

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