District of Columbia
Office of Planning

MEMORANDUM

TO: District of Columbia Zoning Commission

FROM: Jennifer Steingasser, Deputy Director for Development Review & Historic Preservation

DATE: November 5, 2012

SUBJECT: ZC 12-08 – Supplemental Report, Saint Elizabeths East Campus Proposed Zoning Text and Map Amendment from Unzoned to the Saint Elizabeths East (StE) District

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The following are the Office of Planning's responses to requests for additional information made by the Zoning Commission at the October 18, 2012 public hearing:

1. Intermittent streams in ravine.

During the review for the Transportation Environmental Assessment, an ecological survey identified areas on Parcels 13 and 16 as wetlands. However, the assessment did not identify a stream at the bottom of the ravine. More detailed assessments will be required for each new development along the ravine by District Department of the Environment (DDOE). In addition, land dispositions for each development parcel, particularly for ones adjacent to the ravine, will include stormwater management as an important goal, to minimize runoff impacts on the ravine.

2. Cross-section of Ravine

Attachment 1 shows a cross-section of 13th Street, Parcel 6, and ravine. The cross section includes a concept drawing of an approximately 90 foot tall building, showing that the slope of the ravine would result in approximately 25 to 30 feet of additional building face on the downhill side. The drawing also reflects some building sculpting as anticipated by the zoning. This sculpting from the ravine could be made a requirement of the zoning regulations, if the Zoning Commission feels this is appropriate.

3. Proposed Height of the FEMA Building on Parcel 2.

The *DHS Consolidation at St. Elizabeths, Master Plan Amendment: Federal Use Parcel of the East Campus*, March 30, 2012 shows the height of the proposed FEMA building wings would vary in relation to their context and the existing topography. The portion of the building that fronts on Martin Luther King Jr. Avenue would have a maximum height of four stories above existing grade, increasing towards the rear of the parcel, near the intersection of Pecan and 13th Street, to up to 9 stories. Cross sections of the building from Martin Luther King Jr. Avenue and Magnolia Street on Parcel 1 are shown on Attachment 2.

4. Building form on a sampling of lots

The Zoning Commission requested a sample of building forms on one of the parcels. OP is in the process of having these drawing prepared and will submit them to the Zoning Commission at or prior to the November 19 public meeting.

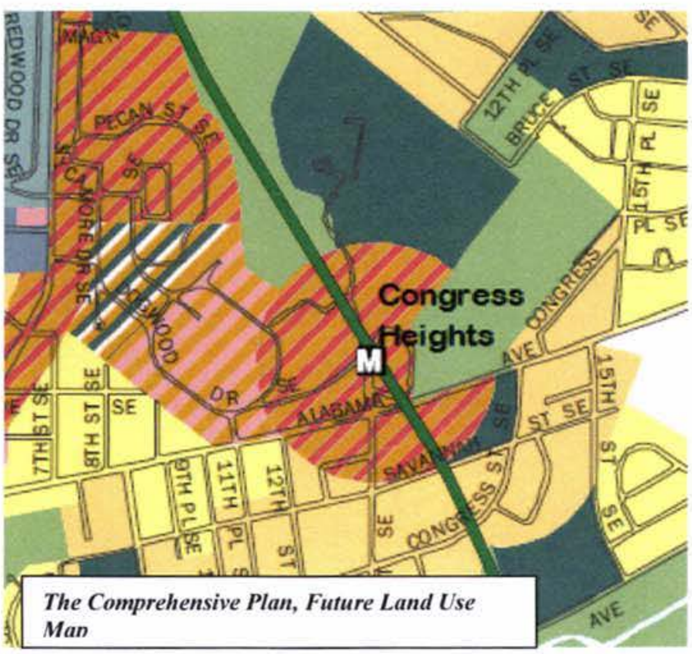
5. The chapel on Parcel 7. (Attachment 3)

The chapel was constructed in 1956 and, in addition to religious services, was used for review wide range of hospital activities and events. Diverse community activities were also held in the chapel. The chapel ceased to be used in approximately 2010, and the building was boarded up.

The chapel was evaluated as part of the St. Elizabeths Hospital National Historic Landmark East Campus Survey in March 2011and it was determined that the chapel is a non-contributing element of the St. Elizabeths Hospital National Historic Landmark as well as a non-contributing element of the local St. Elizabeths Hospital Historic District.

6. Height on Parcels 17 and 18, adjacent to the Congress Heights Metro Station

The zoning proposed for these sites would permit buildings of 70 feet on Parcel 17 and 90 feet on Parcel 18. In both cases, the FAR is considerably less than what might be expected for building of this height, to allow for the provision of open space, lower buildings, or building sculpting. At the hearing, there was some concern expressed about the proposed height on these parcels.



The Comprehensive Plan, Future Land Use Map

The Comprehensive Plan Future Land Use Map recommends a mixture of medium density residential and medium density commercial for the area around the Congress Heights Metro Station, including these two parcels (see map). Medium density residential generally anticipates buildings of between 4 and 7 stories while medium density commercial anticipates buildings up to 8 stories, although some variation in these height limits is possible.

The Far Southeast/Southwest Area Element in ***Policy FFS-2.2.4: Development Density*** **recommends** *". . . development densities on the site that are compatible with adjacent residential neighborhoods and that promote new economic development of the site, with moderate to medium densities residential and commercial on the site with the higher densities clustered in the area closest to the Martin Luther King Jr. Avenue and the Congress Heights Metrorail station. . . . Areas for high density should include . . . the area surrounding the ravine to take advantage of the steep topography to accommodate additional height and density without negatively impacting viewsheds."* Further, the Plan at Policy FSS-2.4.1: Congress Heights Metro

Station recommends the encouragement of mixed use medium density residential and commercial development at the Congress Heights Metro Station and that development be *"cognizant of the adjacent lower density neighborhood to the west and south."* The zoning attempted to balance these policy statements by permitting the anticipated height, but limiting permitted densities and lot occupancy to allow the siting and bulk of new buildings to better reflect the character of lower density areas.

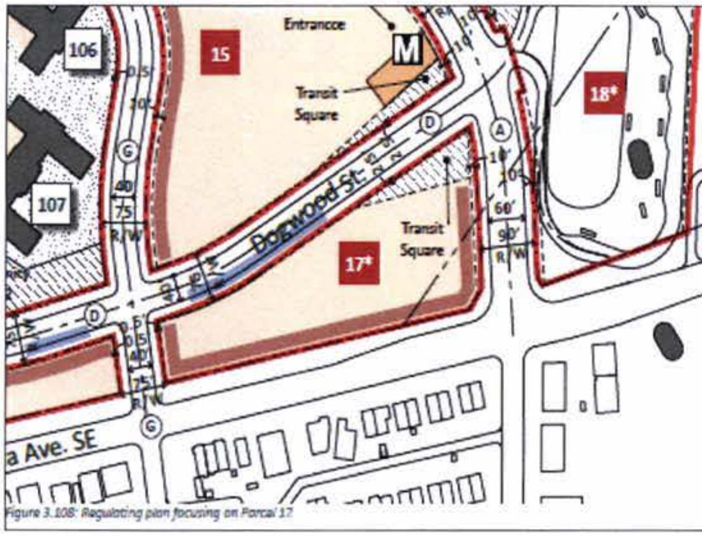


Figure 3.108: Regulating plan focusing on Parcel 17

The Saint Elizabeths Master Plan recommends maximum building heights of 6 stories on Parcel 17, or 70 feet as recommended for this parcel in zone StE-17. The Master Plan also includes recommended building step-backs, including along Alabama Avenue, to lessen visual impacts on the lower density residential area to the south. OP did not include these step-backs in the zoning regulations, as all developments on the site will have Historic Preservation Review which would assess any new building against its context. However, since building massing along Alabama is less of a HPRB issue and more of a zoning and neighborhood character issue, OP could draft proposed zoning regulations to establish such building step-backs along Alabama Avenue if requested to do so by the Zoning Commission.

For Parcel 18, the Metro Station, the Master Plan recommends that *"future development be guided by the zoning for the site"*. Development should reflect the recommendations for a mix of uses, public realm and placemaking, including a step-back along Alabama Avenue similar to that recommended for parcel 17. While the zoning would allow for a building of 90 feet, in accordance with the Comprehensive Plan and Master Plan, the relatively low permitted density and the lot occupancy limit of 75% are intended to provide for public realm space and building bulk sculpting opportunities.

Attachment 4 shows a crosssection of the Metro Station and the buildings across Alabama Avenue.

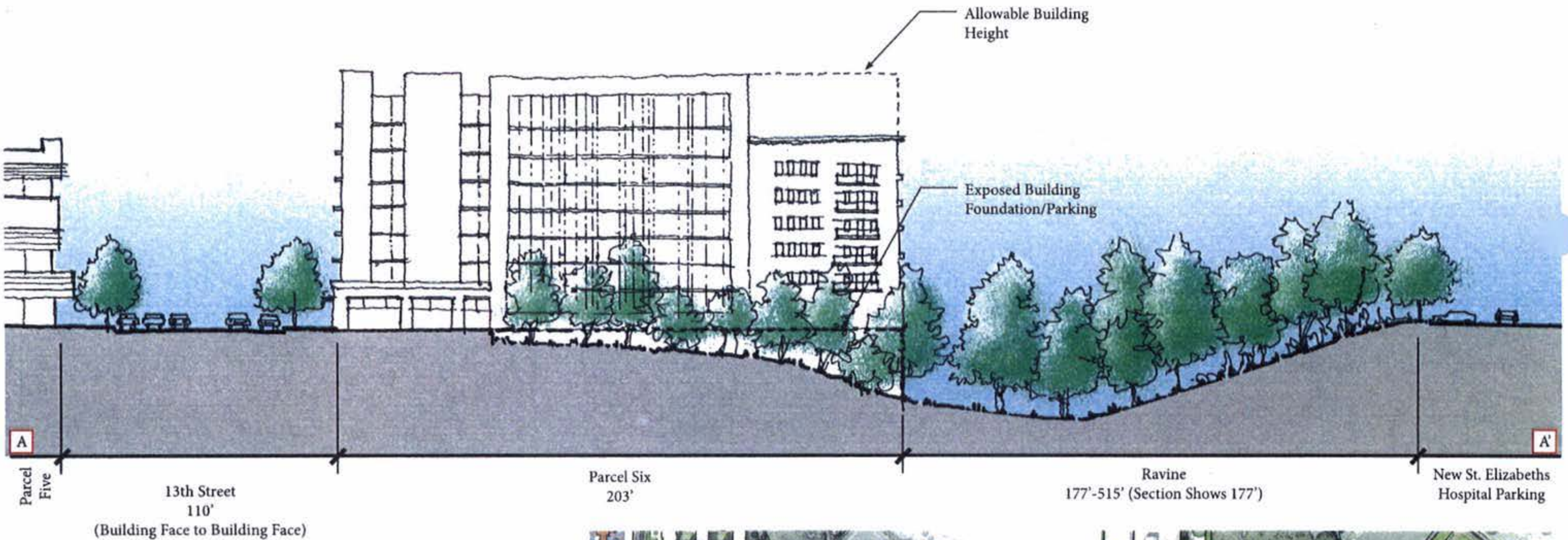
7. <u>Engineering Report on Co-generation</u>

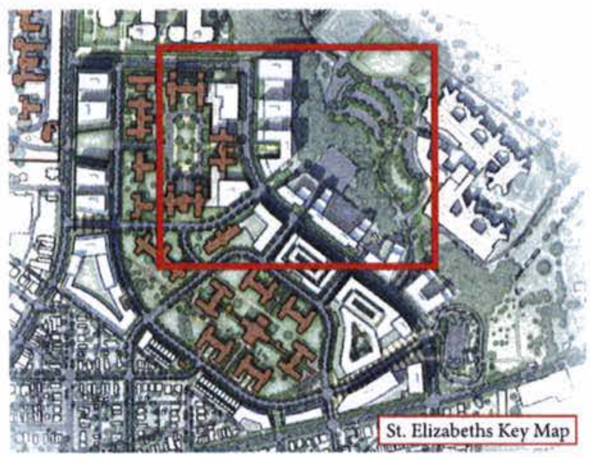
Attachment 5 is a copy of the draft St Elizabeths East Campus District Energy Concept Feasibility Study.

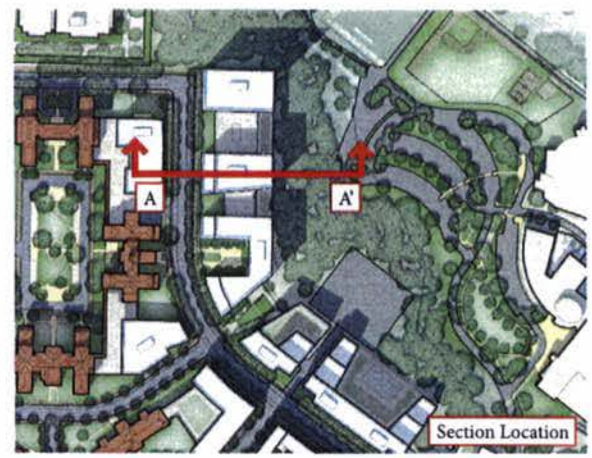
8. <u>Limitations on § 3303.7 (Emergency Shelters for five to15 persons and Community Based Institutional Facilities for seven to 15 persons)</u>

Section § 3303.7 of the proposed zoning recommends special exception review of any proposed emergency shelter for five to15 persons and community based institutional facilities for seven to 15 persons subject to the requirements of § 305. This provision is similar to those provisions in the R-

2 to R-4 zones which among the most restrictive zones. The Fair Housing Act also limits local jurisdiction ability to prohibit such uses. § 305.3 has limitations such that there shall be no other property with a similar facility within the same square/parcel and that no other property containing a community-based residential facility for seven (7) or more persons shall be within a radius of five hundred feet (500 ft.) from any portion of the property. The BZA is also given the discretion to waive these requirements subject to the facilities not having adverse impacts on the neighborhood because of traffic, noise, operations, or the number of similar facilities in the area. Further, all land disposition agreements and proposed uses on the site by DMPED will be subject to review by the ANC.







SECTION ONE: RAVINE

Attachment 1

ATTACHMENT 2

Proposed Heights of FEMA Buildings

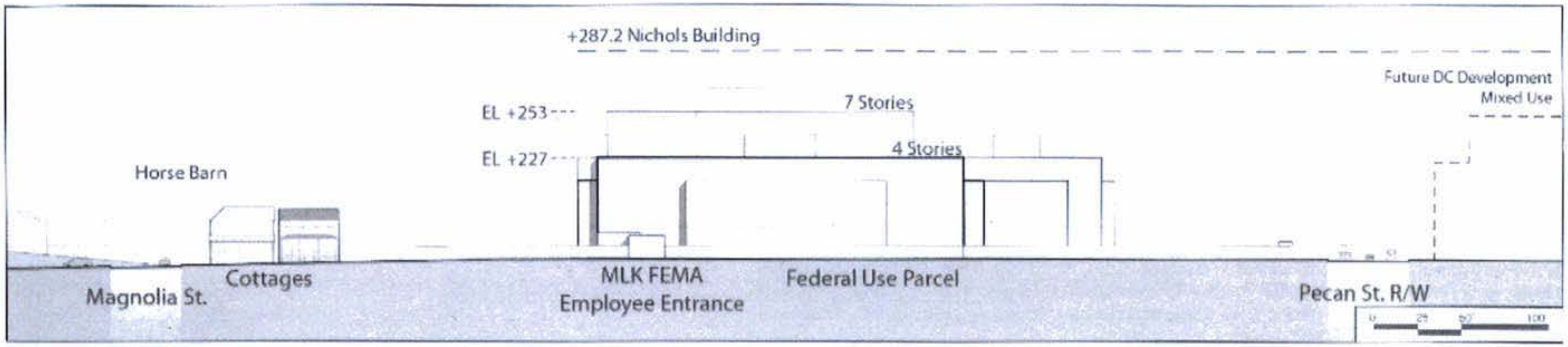


Figure 6.16 – Elevation Study 2 – View East Along MLK Avenue

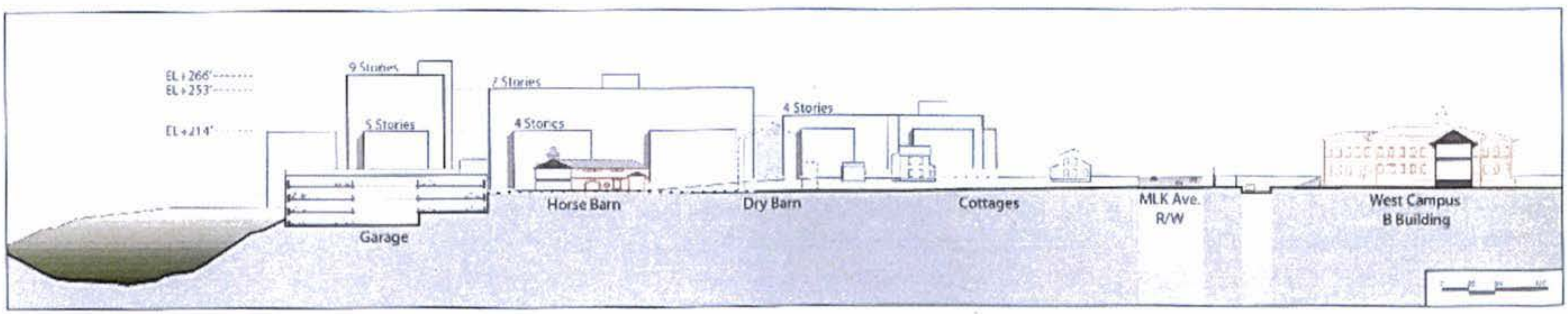


Figure 6.18 – Elevation Study 4 – View South Along Magnolia Street

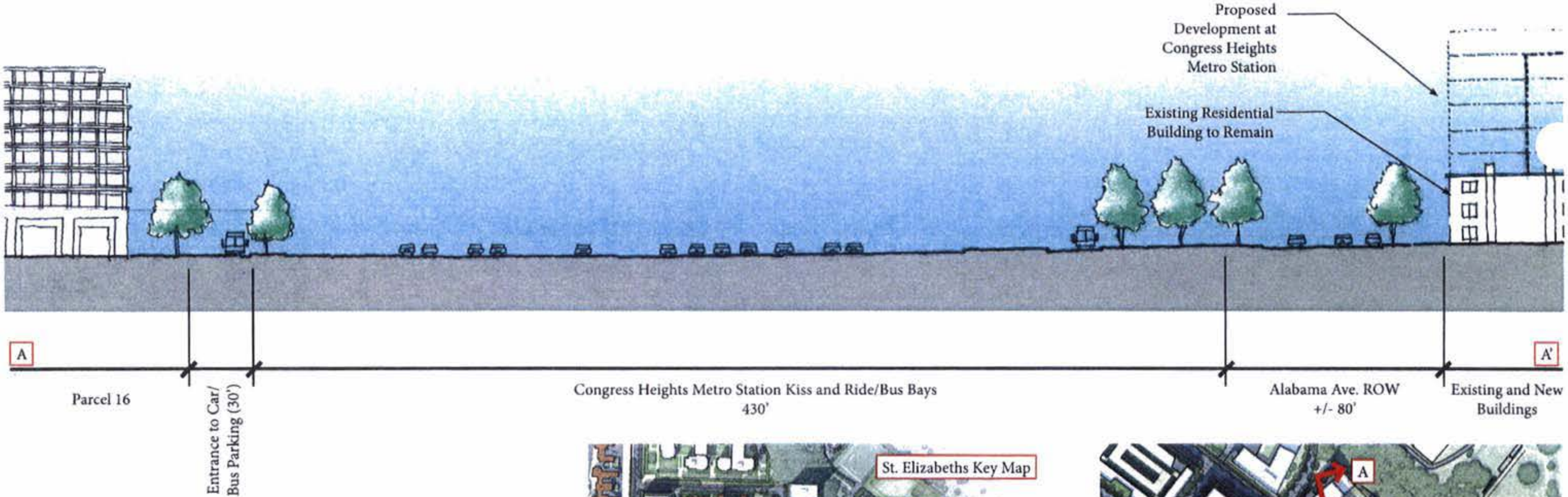
ATTACHMENT 3
Photographs of the Chapel

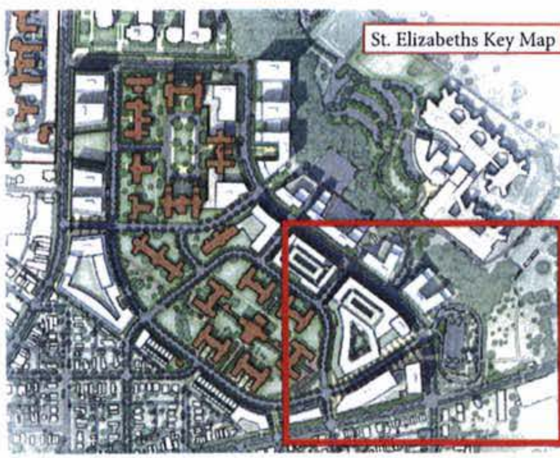
North Elevation

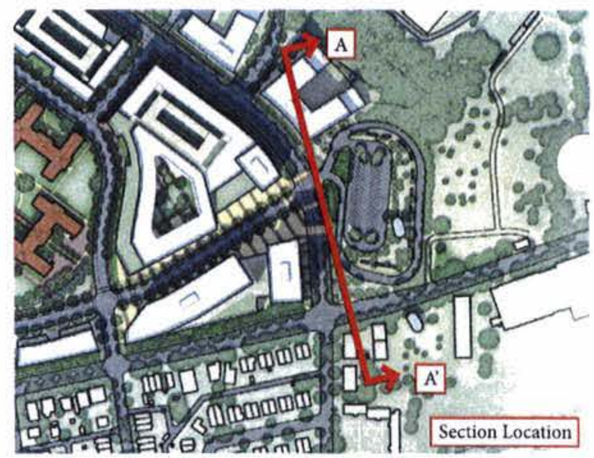
East Elevation

South Elevation

West Elevation







SECTION TWO: METRO SITE

St. Elizabeths East Campus Master Plan

Attachment 4

Technical Memorandum

ARUP

To	Feras Qumseya, Office of the Deputy Mayor for Planning and Economic Development Geraldine Gardner, District of Columbia Office of Planning	Date	15 August 2012
Copies	Neil Sullivan, Ayers Saint Gross	Reference number	219824-00
From	Cameron Thomson and Alan Glynn, Arup	File reference	REP/219824/M001
Subject	St Elizabeths East Campus District Energy Concept Feasibility Study		

Executive Summary

At the request of the District of Columbia Office of Planning and Office of the Deputy Mayor for Planning and Economic Development (the District), Arup performed a concept-level feasibility study for the viability of a centralized District Energy (DE) system to serve the proposed St Elizabeths East Campus development (East Campus). The objectives of the study were to: (1) determine the technical viability of potential DE scenarios, including heating, cooling, and power generation, and (2) make a recommendation so that a subsequent commercial assessment could be completed in support of a go/no-go decision to pursue DE on East Campus.

Using building-energy-simulation software, a preliminary energy-demand profile was developed for each of the proposed parcels at East Campus based on a LEED® Silver performance standard. Once established, these demands were used to evaluate the different ways of providing heating and cooling for the site.

Energy Scenarios Evaluated

The scenarios evaluated during this feasibility study include:

- **Baseline**
    - Traditional building-by-building heating and cooling systems
- **District heating and cooling *with* tri-generation (tri-gen)**
    - Central plant incorporating gas-fired co-generation, gas-fired boilers, absorption chillers, and electrical centrifugal chillers
- **District heating only *with* co-generation (co-gen)**
    - Central plant incorporating gas-fired co-generation, gas-fired boilers (also referred to as combined heat and power (CHP))
- **District heating only *without* co-generation**
    - Central plant incorporating gas-fired boilers and no co-generation

These scenarios were evaluated for the full site build-out as well as for the proposed Phase 1 build-out.

Findings:

1. Not Enough Load in Phase 1

From a technical point of view the full site build-out proposed for East Campus has a good energy demand and is comparable in density and space-usage to many successful DE schemes globally. However, the

relatively low energy demands associated with the proposed Phase 1 of the development (as indicated in Figure 10) do not lend themselves well to providing the startup loads.

A review of likely anchor load connection options revealed no viable options due to either their demand-density-to-distance ratio (meaning the demand was too far from the possible DE plant location) or because they had existing energy systems that have undergone relatively recent upgrade or overhaul (i.e., St Elizabeths hospital complex).

When the District has reason to develop some or all of the proposed land uses with intensive thermal demands, such as the the proposed hotel or conference center, the project may still have an opportunity to develop a DE system in future phases.

2. Strong Sustainability Benefits

Given the District of Columbia is served by relatively fossil-fuel-intensive grid electricity, onsite power generation, even using natural gas, can help offset a significant quantity of greenhouse gas emissions. The relatively modestly-sized generating systems modelled for the tri-gen and co-gen-only scenarios could yield reductions of up to 14 percent and 7 percent, respectively, from the baseline (see Figure 8).

3. District Cooling Unlikely Due to Large Possible Residential Build Out

The viability of centralized cooling is unlikely due to the relatively low and inconsistent demands associated with the large proportion of residential land uses in the proposed building mix. These inconsistent (or "peaky") loads that occur in the morning and evening hours must be balanced with strong daytime loads (for example, commercial, retail, or hotel uses) to create more consistent load, thereby enabling much greater efficiency for the central plant.

4. Generation and Sale of Power Needs Further Investigation

Combined heat and power (CHP) could help offset a significant quantity of East Campus greenhouse gas emissions as well as reduce the cost of the heating services. However, further economic analysis is needed on: (1) the relative cost of producing electricity with CHP technology versus the cost of grid power and (2) the impact of standby charges and other utility fees, to determine if CHP is commercially viable.

5. Thresholds for Further Analysis

Third party service providers Arup spoke to about the project would like to see at least 1 MW of serviceable on-site co-generated power (and in some cases 2-3 MW) in order to justify a more detailed consideration of developing a DE project on East Campus.

Best design practices for efficient cost-effective sizing of co-generation DE systems typically require over 80% availability. In other words, the equipment should have a need to run for at least 80% of total possible running hours. This figure can vary depending on the relative value of the power and heat being produced.

The co-generation DE systems modelled for this analysis assumed a power-to-waste-heat output ratio of around 50:50. This ratio can vary somewhat with differing co-generation systems and configurations to help the system better fit the site heat demand profiles and help maximize either heat or power output – whichever is more valuable.

Recommendations:

- The District should not pursue a DE system in Phase 1 unless or until: (1) a hotel or conference center is programmed or (2) more commercial office and/or retail is programmed.
- The District should consider sizing a subsequent phase so the total heating demand of buildings to be developed in that phase can support the efficient running of co-generation plant with 1 MW of on-

site power generating capacity. Should this threshold be achievable, a co-generation DE system should be further analyzed for commercial and financial viability.

- The public right-of-way should include a thermal utility corridor for heating and cooling loops as the concept infrastructure plan is developed.
- Further conversations and analysis are needed on the potential to connect the New Hospital to DE system in subsequent phases.

1 Introduction

At the request of the District of Columbia Office of Planning (the District), Arup performed a concept-level feasibility study for the viability of a centralized District Energy (DE) system to serve the proposed St Elizabeths East Campus development (East Campus). The objectives of the study were to: (1) determine the technical viability of potential DE scenarios, including heating, cooling, and power generation, and (2) make a recommendation so that subsequent commercial assessment could be completed in support of a go/no-go decision to pursue DE on East Campus. This memorandum presents the results of the DE study.

2 Definition of Scope

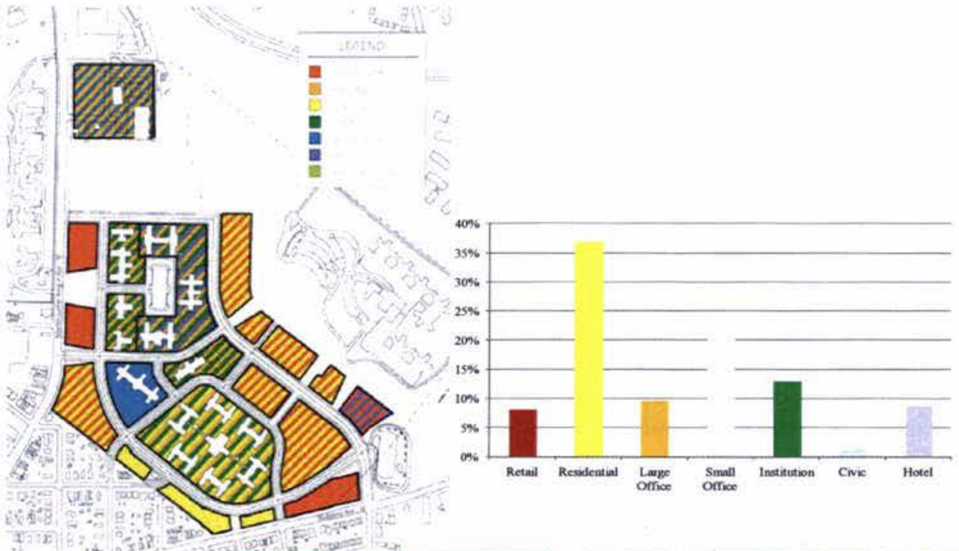
Arup's tasks for this analysis involved:

- Review opportunities and constraints of the existing site conditions.
- Review existing/adjacent energy distribution systems and identify potential synergies with adjacent land uses.
- Develop a high-level option analysis (matrix) of applicable/non-applicable infrastructure energy systems.
- Estimate an approximate order-of-magnitude energy demand for the development using the preliminary development program and efficiency design targets set forth in the sustainability framework.
- Determine the feasibility and applicability of District heating and cooling, co-generation (co-gen), and renewable energy technologies specific to the site conditions.

3 Project Site and Phasing

The energy-demand analysis was based on the proposed programming for Alternative 2, which is the preferred alternative being considered in the Draft Master Plan. The areas (in square feet) of each land use type in that program are summarized on Figure 1.

Technical Memorandum



	Retail	Residential	Large Office	Small Office	Institution	Civic	Hotel
	346,310	1,579,000	407,274	973,635	551,846	61,689	373,122
Total	4,292,876						

Figure 1 – Proposed Full-Site Program with Gross Square Feet

The large building density to the north of the campus is an approximately 800,000-square-foot site slated for the proposed FEMA headquarters and was not included as part of the energy analysis as it is slated to be served by the DE system being developed on the St. Elizabeths West Campus (West Campus).

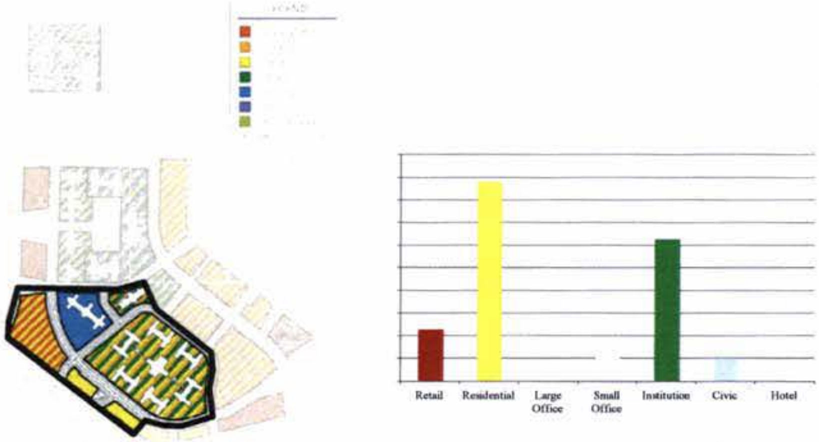
West Campus is a federal property undergoing major development by the General Services Administration (GSA) that will serve as future headquarters for the US Coast Guard and Department of Homeland Security. The West Campus will be served by a centralized DE system, with co-generation currently being developed by Washington Gas and its partners. GSA has invested significant effort and capital in creating an entirely independent infrastructure between the historically connected East and West campuses. As an exception to this effort, there is a tentative plan to provide thermal service from the West Campus central utility plant to the FEMA headquarters site on East Campus.[1]

The new St Elizabeths hospital complex neighbors East Campus to the east across a ravine and was not included in the analysis.

The proposed development is expected to occur in phases over the next several years.

The first phase of development (Phase 1) is illustrated below on Figure 2. As suggested by the District, only a small portion of the CT Oval will be readied for Phase 1.

[1] Arup phone conversation with William Willis and Gaftie Marlow Jr., GSA project managers for the West Campus Development, Thursday, January 12, 2012



	Retail	Residential	Large Office	Small Office	Institution	Civic	Hotel
	90,000	350,000	0	70,287	248,982	39,099	0
Total	798,368						

Figure 2 – Proposed Phase 1 Program with Gross Square Footages

The numbers and compositions of subsequent phases were uncertain at the time of this analysis.

4 Approach

The scenarios analyzed included full site build-out and Phase 1 build-out, as discussed in Sections 4.1 and 4.2 and summarized in Table 1.

4.1 Full Site Build-Out

The scenarios evaluated for full site build-out include:

- Baseline
- District heating and cooling *with* tri-generation (tri-gen)
- District heating only *with* co-generation
- District heating only *without* co-generation

These scenarios were examined to give an indication of the suitability of the final site build-out for a DE system to determine if it was appropriate to continue with the analysis and to create a performance benchmark for the potential preceding phases.

4.2 Phase 1 Build-Out

The scenarios evaluated for Phase 1 build-out include:

- Baseline
- District heating and cooling *with* tri-generation
- District heating only *with* co-generation

- District heating only *without* co-generation

These scenarios were examined to assess the performance of a DE system in Phase 1.

	Electricity	**Heating**	**Cooling**
Baseline	- All buildings served by independently metered electrical utility connections	- All buildings served by separate gas utility connection - All buildings' heating met by local 'in-house' gas-fired boilers	- All buildings' cooling met by local 'in-house' air conditioning systems (chillers and cooling towers)
District heating only *without* co-gen	- All buildings served by independently metered electrical utility connections - Electrical utility connection required by District Energy Centre (for district heating circulating pumps and other ancillary equipment)	- All buildings heating served by the District distributed hot water system heated with gas-fired boilers - Gas utility connection required by District Energy Centre - All central site heating plant (boilers, circulation pumps and ancillary equipment) located at District Energy Centre - Building connection points (heat exchangers and ancillary equipment) required for connecting each building or building cluster	- All buildings' cooling met by local 'in-house' air conditioning systems (chillers and cooling towers)
District heating only *with* co-gen	- All buildings served by independently metered electrical utility connections - Electrical utility connection required by District Energy Centre (for district heating circulating pumps and other ancillary equipment) - Electricity co-generated at District Energy Centre either sold back to grid and/or used to offset on-site grid-imported load (tbc)	- All buildings heating served by the District distributed hot water system heated with gas-fired boilers and waste co-generation heat - Gas utility connection required by District Energy Centre - All central site heating plant (boilers, circulation pumps and ancillary equipment) located at District Energy Centre - Building connection points (heat exchangers and ancillary equipment) required for connecting each building or building cluster	- All buildings' cooling met by local 'in-house' air conditioning systems (chillers and cooling towers)
District heating and cooling *with* tri-gen	- All buildings served by independently metered electrical utility connections	- All buildings heating served by the District distributed hot water system heated with gas-fired boilers and waste co-generation heat	- All buildings heating served by the District distributed chilled water system cooled with electrical centrifugal chillers and absorption chiller(s) powered by waste co-generation heat
District heating and cooling *with* tri-gen	- Electrical utility connection required by District Energy Centre (for district chilled water plant, hot & chilled water system circulation pumps and other	- Gas utility connection required by District Energy Centre	- All central site cooling plant (chillers, cooling towers, circulation pumps and ancillary equipment) located at District Energy Centre

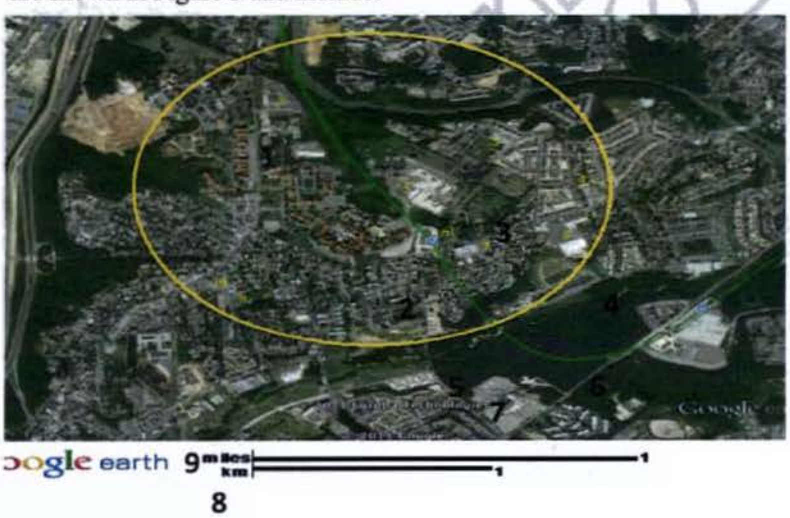
	Electricity	Heating	Cooling
(continued)	ancillary equipment)		
	- Electricity co-generated at District Energy Centre either sold back to grid and/or used to offset on-site grid-imported load (tbc)	- All central site heating plant (boilers, circulation pumps and ancillary equipment) located at District Energy Centre - Building connection points (heat exchangers and ancillary equipment) required for connecting each building or building cluster	- Building connection points (heat exchangers and ancillary equipment) required for connecting each building or building cluster

Table 1 Summary of implications for site electricity, heating and cooling provision and infrastructure of analyzed DE scenarios

Initial analysis revealed that the heating and cooling loads for Phase 1 are not large enough in magnitude or consistent enough to justify developing a DE system. Without a sufficient "anchor load" on Campus in Phase 1, we explored the possibility of serving adjacent or nearby loads in addition to East Campus energy loads.

Representatives from the adjacent large land uses were consulted to investigate the possibility of serving their energy demands with those of the new Campus development.

These sites (located within a 1-kilometer radius of the proposed location of a potential Campus DE center) are shown in Figure 3 and include:



1. DC Unified Communications Center
2. St Elizabeths New Hospital
3. Johnson Middle School
4. Turner Elementary School
5. Congress Heights Metrorail Station
6. Shops at Park Village (Giant)
7. Malcolm X Elementary School
8. King Elementary School
9. Congress Heights School

Figure 3 – Potential Anchor Load Energy Users within 1-Kilometer Radius of Site

Arup spoke to GSA and Washington Gas about West Campus to learn more about the strategies employed there and issues that have arisen through the design, permitting, and early construction of its DE system.

Most sites either had a demand-density-to-distance ratio from East Campus that would not make them viable candidates for connection, intermittent loads that would make DE service challenging (for example, most of the schools), or their energy systems have undergone relatively recent upgrade or overhaul.

The nearest and strongest source of potential demand is the new 500,000-square-foot St Elizabeths hospital, built to provide 24-hour care to 300 psychiatric patients; however, the hospital's hot and chilled water systems are less than 2 years old.

With no availability of a nearby anchor load, the analysis focused on the potential viability of a DE system serving the programmed uses within East Campus.

5 Energy Analysis

5.1 Estimating Energy Demand

Preliminary energy profiles of the buildings that could potentially connect to a DE scheme were modelled. This was done using eQUEST® building energy simulation software.

There are seven major building activity use categories that are assumed in the energy models:

- Residential
- Retail
- Large Office
- Small Office
- Hotel
- Institution (education)
- Civic

A set of virtual buildings were created to represent each of the building types in the above categories. For each building, a model was developed that assumed a geometry—size, shape, and orientation—that was representative of a similar building as currently outlined for the proposed site. The appropriate equipment loads and occupancy schedules were attributed to each of the models.

Characteristics, including the building envelope, window-to-wall ratio, lighting power/control, mechanical plant room design and efficiencies, domestic hot water loads, and elevator loads, are also attributed to each model in order to simulate a LEED® Silver energy performance standard.

Output from each building model was fed into the overall site energy model to give hourly annual electrical, heating, and cooling profiles for East Campus.

The modelled building energy loads and overall assumed energy consumption were calibrated to be consistent with ASHRAE load benchmarks and Commercial and Residential Building Energy Consumption Survey benchmark consumption data published by the Department of Energy.

Figure 4 illustrates the annual hourly heating (red), which included domestic hot water and cooling (blue) demands for the full site build-out.

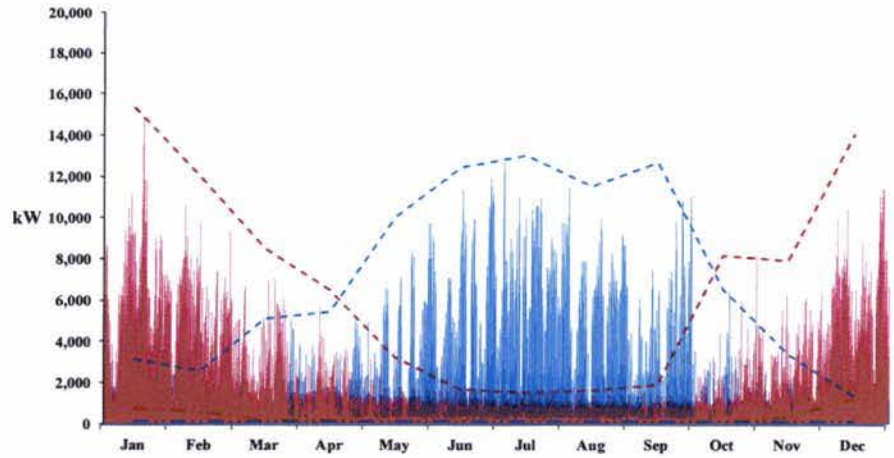


Figure 4 – Full Site Build-Out Annual Hourly Heating (red) and Cooling (blue) Loads

Figure 5 illustrates the annual hourly electricity demands (including the electricity needed for air conditioning) accounting for the full site build-out. For the district cooling systems analyzed, the electrical loads associated with air conditioning the buildings were separated.

Figure 5 – Full Site Build-Out Annual Hourly Electricity Load

For the baseline scenario, each building was assumed to house all the required heating and cooling equipment—in the form of conventional gas-fired boilers and centrifugal chillers—needed to serve peak heating and cooling loads within the building independent of its neighbors. No onsite power generation was assumed, and the plant and control strategies were modelled using a LEED® Silver standard.

The gas and electricity consumption values and peak plant loads for the baseline scenario were then compared against the various DE scenarios.

For the assumptions used in the energy demand analysis, please refer to Appendix A.

6 Results of Scenario Analysis

For the full site build-out and Phase 1, the energy performances of their respective energy systems (i.e. electricity, natural gas, and CO2 emissions) were compared for each scenario.

6.1 Full Site Build-Out

Figure 6 compares the site net annual electricity consumption for the full site between the baseline and each of the DE scenarios. For the scenarios with co-gen, the total electricity generated at the central plant has been indicated to illustrate the value of a relatively modestly sized co-gen system for each case. The generation capacity in the tri-gen system is larger than the co-gen-only scenario because of an absorption chiller providing additional cooling from waste-heat during the summer months.

This analysis did not estimate the dollar value of the electricity produced by co-gen or tri-gen as it could be sold back to the grid or used to offset energy demands of the DE system itself. However, the net consumption of electricity by East Campus at full build-out would be reduced as a result of it being produced onsite.

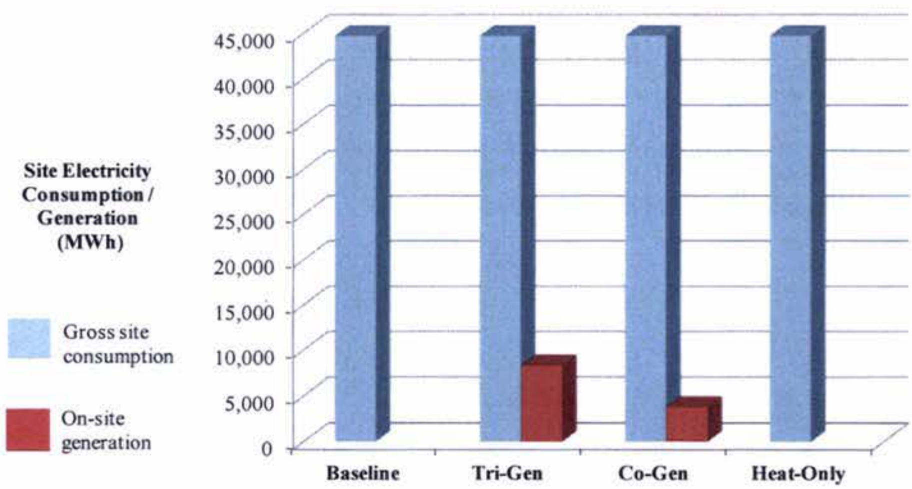


Figure 6 – Full Site Build-Out Scenarios, Electricity Consumption with Potential from Onsite Generation

Figure 7 illustrates the gas consumed between the different scenarios. The consumption rates of the two scenarios with gas-fired co-gen units are higher than the baseline and district-heat-only scenarios due to their gas-fuelled on-site production of electricity.

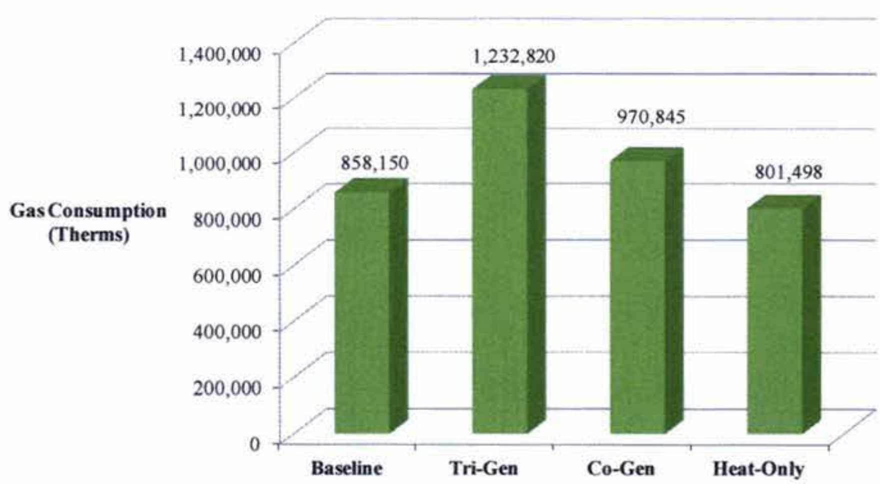


Figure 7 – Full Site Build-Out Scenarios, Gas Consumption

The heat-only scenario (without co-gen) is better than the baseline because a central plant can be more efficient and more responsive than individual building boilers—one of the primary benefits of DE.

Figure 8 illustrates the impact of the different district energy strategies on carbon dioxide (CO_2) emissions. The main reason for the emissions reduction between the baseline and the tri-gen and co-gen systems is the displacement of CO_2-intensive grid electricity (e.g. from coal-fired power plants) by on-site natural gas-fired generation.

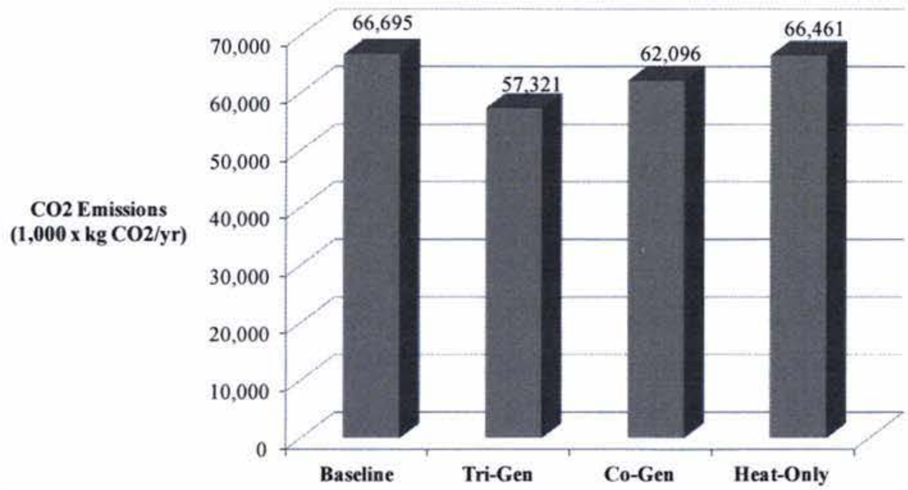


Figure 8 – Full Site Build-Out Scenarios, CO_2 Emissions

6.2 Phase 1

For the Phase 1 energy scenarios, the magnitudes of the values illustrated in Figure 6, Figure 7, and Figure 8 are proportionally less than for the full site build-out but the trends are replicated. Figure 10 illustrates the difference in scale of the site heating demands associated with the proposed Phase 1 of the development and those of the final full-site build-out.

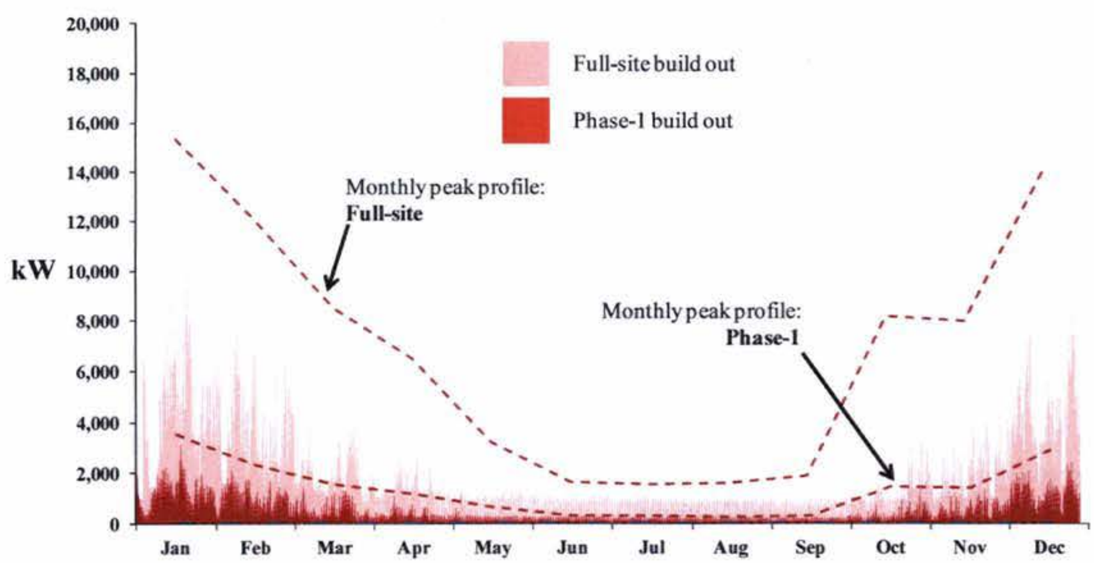


Figure 9 - Comparison of hourly annual heating demand profile for the Full-site versus Phase 1 build-outs

Figure 11 illustrates the difference in the order of magnitude between the annual site electricity loads for the full site build-out and the Phase 1development.

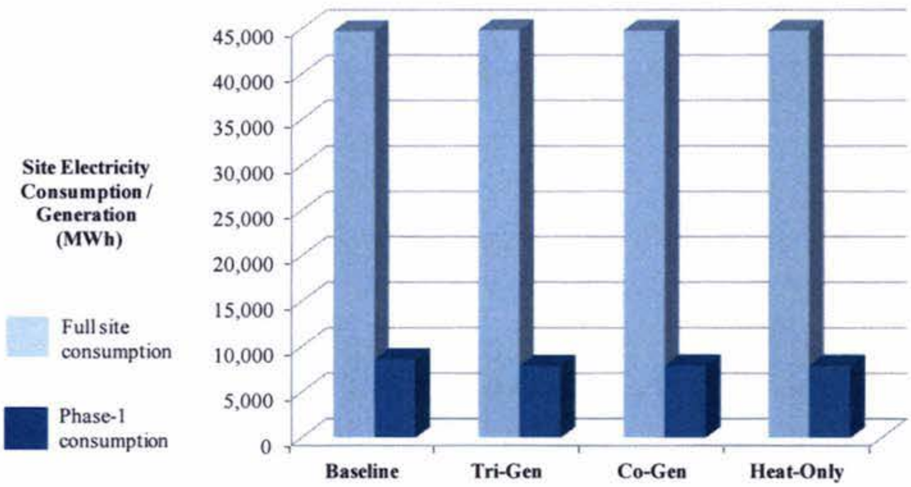


Figure 10 – Full Site versus Phase 1 Build-Out Scenarios, Electricity Consumption

Likewise, Figure 12 illustrates the difference in the order of magnitude between the annual site gas loads for the full site build-out and the Phase 1 development.

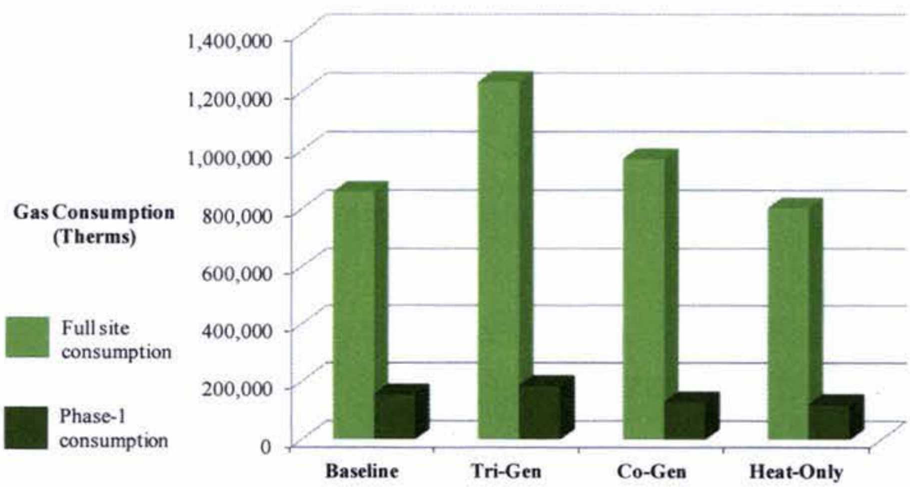


Figure 11 – Full Site versus Phase 1 Build-Out Scenarios, Gas Consumption

CO2 emissions for Phase 1 would follow the same trend as shown for the full site build-out.

7 Findings

1. Not Enough Load in Phase 1

From a technical point of view the full site build-out proposed for East Campus has a good energy demand and is comparable in density and space-usage to many successful DE schemes globally. However, the relatively low energy demands associated with the proposed Phase 1 (as indicated in Figure 10) do not lend themselves well to providing the start-up loads required to make an initial investment in a district energy system.

A review of likely anchor load connection options revealed no viable options due to either their low demand-density to high-distance ratio or because they had existing energy systems that have undergone relatively recent upgrade or overhaul (i.e. St Elizabeths hospital complex).

Should market forces enable the development of some or all of the proposed land uses with intensive thermal demands, the project may still have an opportunity to develop a DE system in future phases.

2. Strong Sustainability Benefits

Given the District of Columbia is served by relatively fossil-fuel-intensive grid electricity, onsite power generation, even using natural gas, can help offset a significant quantity of greenhouse gas emissions. The relatively modestly-sized generating systems modelled for the tri-gen and co-gen-only scenarios could yield reductions of up to 14 percent and 7 percent, respectively, from the baseline (see Figure 8).

3. District Cooling Unlikely Due to Large Possible Residential Build Out

The viability of centralized cooling is unlikely due to the relatively low and inconsistent demands associated with the large proportion of residential land uses in the proposed building mix. These inconsistent (or "peaky") loads that occur in the morning and evening hours must be balanced with strong daytime loads (for example, commercial, retail, or hotel uses) to create more consistent load, thereby enabling much greater efficiency for the central plant.

4. Generation and Sale of Power Needs Further Investigation

Co-generating combined heat and power (CHP) could help offset a significant quantity of East Campus greenhouse gas emissions as well as reduce the cost of the thermal services. However, further economic analysis is needed on: (1) the relative cost of producing electricity with CHP technology versus the cost of grid power and (2) the impact of standby charges and other utility fees, to determine if CHP is commercially viable.

5. Thresholds for Further Analysis

Third party service providers Arup spoke to about the project would like to see at least 1 MW of serviceable on-site co-generated power (and in some cases 2-3 MW) in order to justify a more detailed consideration of developing a project on East Campus.

Best design practices for efficient cost-effective sizing of co-generation systems typically require over 80% availability (proportion of actual annual operational running hours to total possible running hours). However, this figure can vary depending on the relative value of the power and heat being produced.

The co-generation systems modelled for this analysis assumed a power to waste-heat output ratio of around 50:50. This ratio can vary somewhat with differing co-generation systems and configurations to help the system better fit the site heat demand profiles and help maximize either heat or power output – whichever is more valuable.

8 Recommendations

- The District should not pursue a DE system in Phase 1 unless or until: (1) a hotel or conference center is programmed or (2) more commercial office and/or retail is programmed.
- The District should consider sizing a subsequent phase so the total heating demand of buildings to be developed in that phase can support the efficient running of co-generation plant with 1 MW of on-

site power generating capacity. Should this threshold be achievable, a co-generation DE system should be further analyzed for commercial and financial viability.

- The public right-of-way should include a thermal utility corridor for heating (and possibly cooling) loops as the concept infrastructure plan is developed.
- Further conversations and analysis are needed on the potential to connect the New Hospital to DE system in subsequent phases.

Appendix 1: Energy Analysis Assumptions

For heat generation and distribution systems, the lower the required heating temperature, the more inherently efficient the system can be. For the current analysis, no specific applications for high-grade heat in the form of steam were identified – only requirements for space heating and domestic hot water production. Therefore, the analysis was performed on the basis of a low-temperature hot water distribution system and a traditional chilled water distribution system for cooling. In addition, the cost of infrastructure and maintenance is significantly lower for low-temperature systems.

A number of large-scale DE projects that incorporate hot-water generation and distribution systems are either in current development or recently finished in the vicinity, which may imply greater local technical resources for this type of system.

Hot Water

- Flow: 200 degrees Fahrenheit (°F); Return: 140 °F
- Estimated arterial pipe size for full site build-out: 12 inches (300 millimeters)

Chilled Water

- Flow: 43 °F; Return: 54 °F
- Estimated arterial pipe size for full site build-out: 20 inches (500 millimeters)

For plant characteristics, the following system values were assumed:

- Gas-fired boilers (~80 percent seasonal efficiency)
- Gas-fired reciprocating combined heat and power (CHP) engines
  - 80 percent overall peak efficiency
  - 1.0 to 0.87 heat-to-electricity output ratio
  - Sized for ~90 percent annual full-load availability
- Single-effect absorption chillers (0.7 efficiency)
- Electric centrifugal water-cooled chillers
- Evaporative cooling towers

To estimate the size of co-gen and tri-gen plants to run against the site energy demands, a number of assumptions were made:

- Co-gen operates as 'base' boiler and in heat load-following mode.
- Annual availability is 88 percent (percent of total possible annual running hours), including scheduled and unscheduled shutdowns.
- No heat is "dumped."
- Absorption chiller (for tri-gen scenario) is sized to match co-gen waste heat when site heating demand is lowest.
- Absorption chiller only operates off available co-gen waste heat.

Based on the sizing assumptions and parameters above, an engine with 500 kilowatts (kW) of electrical output was sized for the co-gen scenario, and two 500-kW engines were assumed for the tri-gen scenario.

The rest of the site's heating and cooling demands were modelled to be picked up by banks of gas-fired boilers and electrical centrifugal chillers.

Plant spaces in the DE center were calculated to house this required plant with spare capacity and all ancillary plant items.

Figure A1.1 gives an illustrated breakdown of how this plant sizing strategy compares against the annual hourly site heating demands for the tri-gen scenario and the annual energy load breakdown between the different plant types.

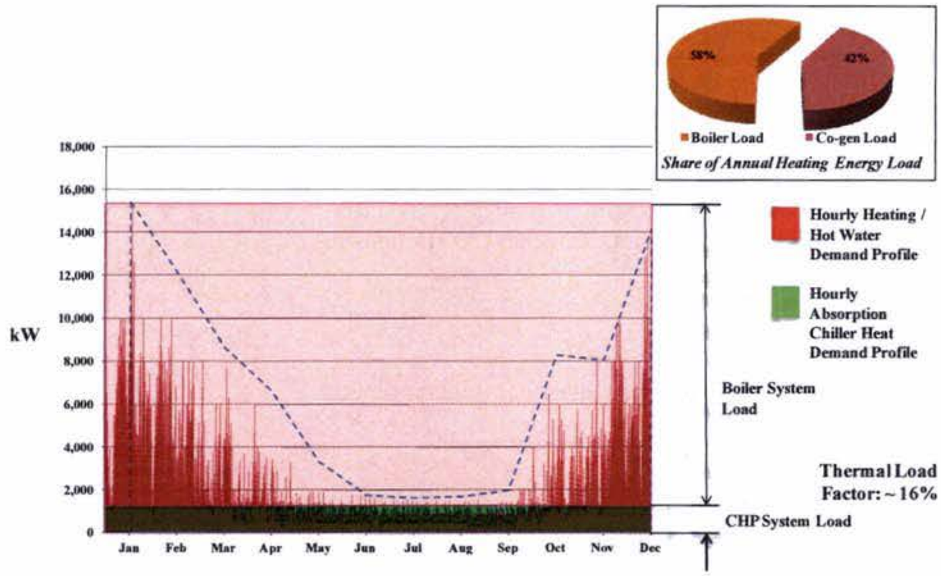


Figure 12.1 – Full Site Build-Out Tri-Generation Plant Heating Demand and Energy Breakdown

Similarly, Figure A1.2 illustrates how the site cooling demand is shared between the chiller types, along with the breakdown of annual air conditioning load.

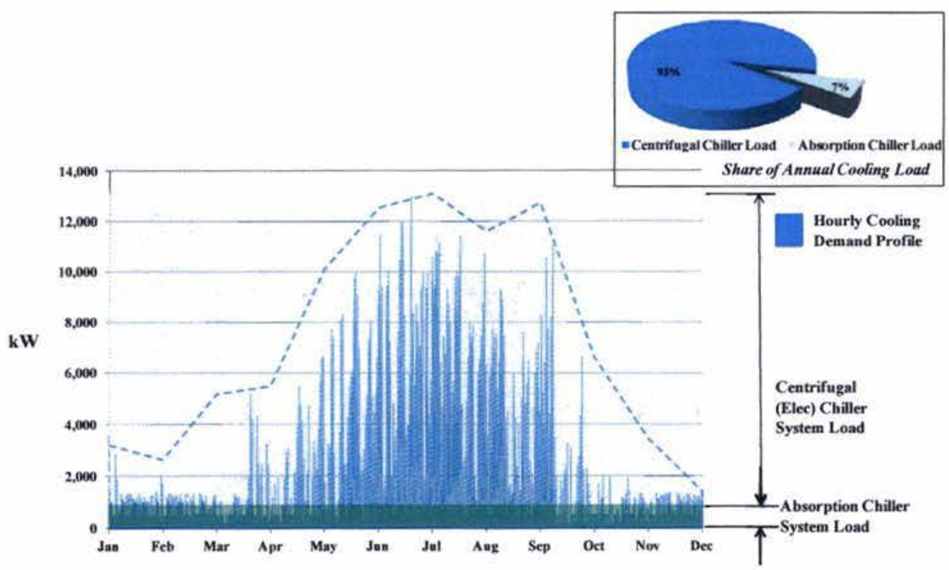


Figure A1.2 – Full Site Build-Out Tri-Generation Plant Cooling Demand and Energy Breakdown

Appendix 2: Components and Costs of District Energy

Capital Costs

- District heating and cooling distribution infrastructure
  - Pipework infrastructure
  - Building connection systems (including heat exchangers)
  - Pumps/lifts
- Central DE plant and infrastructure
  - Central gas-fired boilers
  - CHP system
  - Absorption chiller system
  - Centrifugal chiller system
  - Cooling towers
  - Chilled water and hot water pumping systems and controls
  - Electrical switchgear
  - Energy Center Building
- Fuel (gas) and power (electricity) interconnection infrastructure
- Soft design and construction costs
  - Preliminary engineering
  - Final design
  - Project management – design and construction
  - Construction administration management
  - Professional liability and other non-construction insurance
  - Legal permits, environmental review fees, testing, surveys, inspection, startup

Operational Costs

- Plant operations
- Routine maintenance
- Major maintenance and replacement
- Fuel costs
- Power costs
- Utility fees/tariffs
- Heat exchanger maintenance (cost usually borne by customers of the DE system)

Capital Savings

- Building plant avoided costs
    - Avoided costs of boilers in buildings
    - Avoided costs of chillers in buildings
    - Avoided costs of cooling towers in buildings

Operational Savings

- Avoided boiler and chiller maintenance in buildings
- Capital and/or running cost funding opportunities
    - State or federal incentive funding
    - Installed capacity payments from independent system operators
- Avoided heating fuel to buildings
- Either:
    - Revenue generated selling CHP electricity to utility for feed-in-tariff

    or

    - Avoided electricity costs by using CHP power directly onsite or via net metering

Figure A2.1 – Typical District Energy Distribution Pipework and Building Heat Exchanger Interface

Sources of Costs

A number of various sources were consulted in order to compile a first estimate of the capital costs, running costs, and CO_2 emissions for the DE and baseline scenarios. These included:

- RS means

- Recent Arup projects in the northeastern United States
- US Energy Information Administration
- eGRID

For the purpose of this study, the options examined have had their economic performance assessed without the aid of other capital or running cost funding incentives.

According to discussions with Michael Yambrach, Energy Program Manager for the District Department of General Services (DGS), electricity generated by the co-gen plant would be required to be exported to the grid for a negotiated tariff and would not be able to be used to offset the metered imported electricity required by the site, either by direct usage or net metering.

Table A2.1 shows a summary of the line items and associated cost estimates for the full-site build-out scenario incorporating a tri-generation system.

Table A2.1 - Summary of estimated capital costs for full-site tri-generation scenario

30 (°C/K) Assumed Heating Water System Delta T
6 (°C/K) Assumed Cooling Water System Delta T
4.0 (kW) Assumed typical Heating System Pump motor power
150 (gpm) Assumed typical Heating System Pump flow
4.0 (kW) Assumed typical Cooling System Pump motor power
150 (gpm) Assumed typical Cooling System Pump flow
1,941 †GPM Assumed Peak Hot Water Flowrate
8,263 ††GPM Assumed Peak Chilled Water Flowrate
*Rate Incl. 10% Controls
**Quantity Incl. 50% Spare Capacity and Rate Incl. 10% Controls
***Quantity Incl. 20% Spare Capacity and Rate Incl. 10% Controls
****See Energy Centre plant space build-up calculation

Line Item	District Items	Quantity Used	Init Use	Rate Used		Initial Cost	Portion of Subtotal	% of Initial Cost Overhauled after: (for payback graph) 10 Years	20 Years	50 Years
1	CHP Plant*	1,075	kW	$1,028.50	/kWe	$1,105,280	7%	20%	100%	100%
2	District Boilers**	21,240	kW	$45.70	/kW thermal	$970,644	6%	0%	75%	100%
3	Absorption Chillers*	745	kW	$359.98	/kW cooling	$268,184	2%	40%	100%	100%
4	Centrifugal Chillers**	19,339	kW	$98.69	/kW cooling	$1,908,554	12%	30%	100%	100%
5	Cooling Towers***	15,733	kW	$88.83	/kW cooling	$1,397,502	9%	30%	100%	100%
6	Ice Storage**	0		$0.00		$0	0%	0%	0%	0%
7	District Heating Pumps**	19	No. Pur	$1,009.80	/kW pump power	$78,381	0%	40%	100%	100%
8	District Cooling Pumps**	83	No. Pur	$1,009.80	/kW pump power	$333,763	2%	40%	100%	100%
9	District Building Heating Interconnections (est)***	24	Buildin	$18,700.00	/ connection	$448,800	3%	15%	100%	100%
10	District Cooling Building Interconnections (est)***	24	Buildin	$18,700.00	/ connection	$448,800	3%	15%	100%	100%
11	District Heat Exchangers***	2,329	†GPM t	$93.50	/ GPM through HEX	$217,725	1%	15%	100%	100%
12	District Cooling Exchangers***	9,916	††GPM t	$74.80	/ GPM through HEX	$741,696	5%	15%	100%	100%
13	District Heating Pipework (flow & return) estimate	3,810	m	$297.50	/m	$1,133,475	7%	0%	40%	100%
14	District Cooling Pipework (flow & return) estimate	3,810	m	$739.50	/m	$2,817,495	18%	0%	40%	100%
15	Electrical Connection Fault Mitigation Cost (estimate)	0		0		$0	0%			
16	Gas Connections	2	numbe	2550	per connection	$5,100	0%			
17	Energy Centre Building****	3,047	m2	$1,372.75	/m2	$4,182,527	26%			

Sub-Total	$16,057,923

*Soft Costs:

Preliminary Engineering	4%
Final Design	8%
Project management - Design & Construction	12%
Construction Admin & Management	10%
Professional Liability & Other Non-Construction Insurance	5%
Legal; Permits; Review Fees; Surveys; testing; Inspection; Start-up	1%
Sub -Total	40%

Contractor Indirects, OH & P %	20%
Sub-Total	$19,269,508
Soft Costs %*	40%
Sub-Total	$26,977,311
Contingency %	35%
Gross District System Capital Costs	$36,419,370

*Quantity incl. 50% Spare Capacity
**Quantity incl. 20% Spare Capacity

Line Item	Building Avoided Items (75% diversity for non-chiller buildings)	Quantity Used	Init Use	Rate Used	Initial Cost	% of Initial Cost Overhauled after: 10 Years	20 Years	50 Years
18	Building Boilers Avoided*	23,092	kW	$57.85 /kW thermal	$1,335,934	0%	100%	100%
19	Building Chillers Avoided*	14,750	kW	$96.63 /kW cooling	$1,425,304	30%	100%	100%
20	Building Generators Avoided	0	kW	$0.00 /kW	$0	0%	0%	0%
21	Building Cooling Towers Avoided**	11,800	kW	$80.75 /kW cooling	$952,842	30%	100%	100%

Building Systems Avoided Capital Costs	$3,714,079
Net District System Capital Costs	$32,705,290

Appendix 3: Baseline Parcel-by-Parcel Site Energy Results

[illegible]