SOUTH STATION
EXPANSION

Appendix B - Greenhouse Gas Analysis Documentation

June 2016

massDOT
Massachusetts Department of Transportation

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1. Introduction

This appendix presents information that is used throughout Section 3.13, Greenhouse Gas Emissions Analysis, of the Final Environmental Impact Report (FEIR) for the South Station Expansion project (SSX). The information in this appendix is divided into the following four main components:

1.1. Building Modeling Outputs

The modeling outputs shown in Attachment A allow for a comparison to be made between baseline and proposed building energy use. This is also the source of the energy inputs for the Greenhouse Gas (GHG) analysis for stationary sources.

1.1. Potential Emissions Savings Analysis

This component analyzes the potential emissions savings if the project were to use the Veolia Energy System (steam), as shown in Attachment B. It is important to demonstrate a potential alternative that is still under consideration for the project based on its feasibility. This analysis provides the inputs and calculations used in the discussion of the Veolia Energy System alternative.

1.2. Combined Heat and Power (CHP) Sizing and Performance Estimate

This component analyzes the potential on-site CHP alternative and the resulting GHG impacts, as shown in Attachment C. The datasheets for a potential CHP unit are also provided in this component.

1.3. Plug-in GHG Estimate Calculations

These calculations, shown in Attachment D, demonstrate the emissions difference between idling on the diesel engine and the potential ground plug-in alternative. The data presented in this component is discussed in the transportation alternatives section for locomotive plug-ins.

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Attachment A – Building Modeling Outputs

Monthly Energy Consumption – Baseline
Monthly Energy Consumption – Proposed

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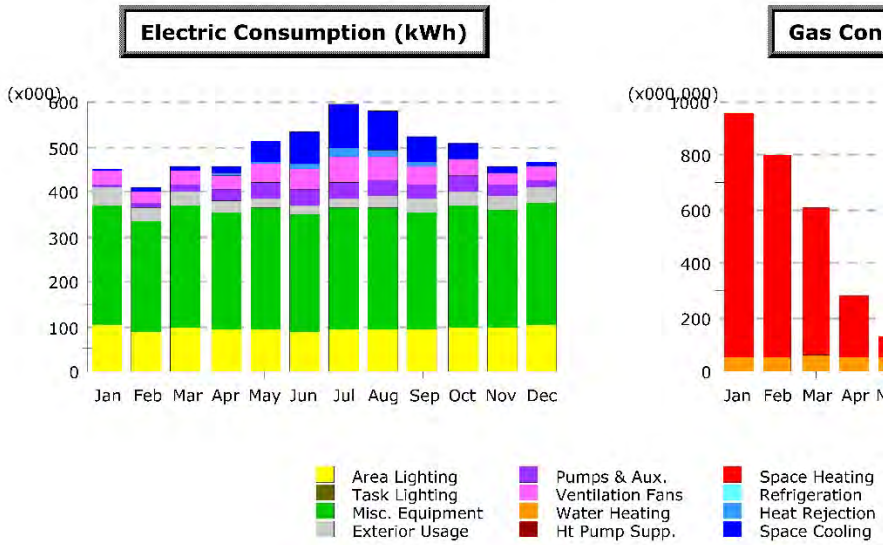


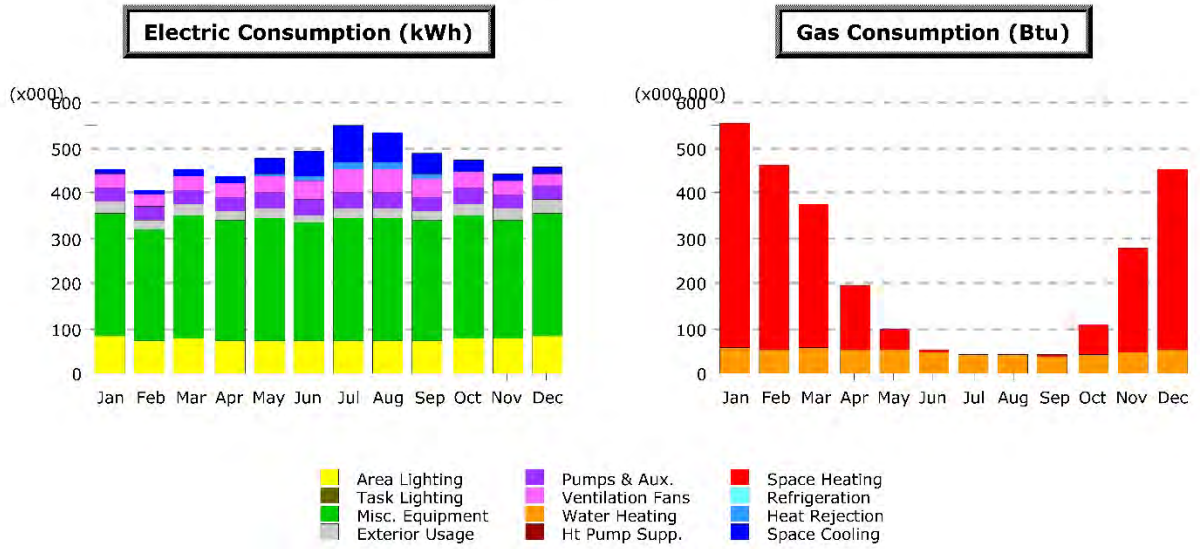
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	5.6	6.6	9.8	19.2	45.1	68.8	97.2	84.1	57.0	32.0	14.4	10.0	449.9
Heat Reject.	0.1	0.1	0.2	0.7	4.7	10.1	18.0	14.5	7.6	2.2	0.5	0.2	58.7
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	28.0	26.1	30.1	30.9	43.0	48.3	56.3	54.3	44.2	37.4	28.3	28.9	456.1
Pumps & Aux.	10.2	11.5	17.1	27.0	32.4	33.5	36.2	35.3	32.2	31.4	22.7	16.8	306.3
Ext. Usage	36.1	30.2	30.1	25.7	23.6	21.3	22.6	25.3	27.8	32.2	34.1	36.9	345.7
Misc. Equip.	270.1	244.5	271.5	264.0	271.5	262.6	271.6	271.5	262.6	271.6	259.4	271.6	3,192.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	101.5	89.0	96.9	90.3	92.1	86.7	90.6	92.0	92.1	98.7	97.8	102.1	1,129.8
Total	451.6	408.0	455.7	457.9	512.3	531.2	592.4	576.9	523.6	505.5	457.3	466.5	5,939.0

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	900.8	751.2	547.8	228.7	75.1	9.7	-	1.5	8.5	107.7	387.3	722.8	3,741.2
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	53.9	51.0	56.8	52.1	50.7	43.7	40.8	39.0	37.0	40.2	45.3	48.8	559.2
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	954.7	802.2	604.6	280.8	125.7	53.4	40.8	40.5	45.5	147.9	432.6	771.7	4,300.4

Terminal Expansion Proposed | Run Date/Time: 06/26/14 @ 15:47



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	12.1	11.4	14.2	18.5	36.0	55.1	80.7	69.4	45.8	26.4	15.7	14.0	399.3
Heat Reject.	0.3	0.3	0.4	1.0	4.9	9.8	17.4	14.0	7.8	2.6	0.8	0.5	59.8
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.2	1.0	0.9	0.5	0.2	0.0	0.0	0.0	0.0	0.2	0.7	1.0	5.7
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	27.7	25.6	29.3	30.0	40.7	45.6	52.8	51.0	41.4	35.6	27.6	28.3	435.5
Pumps & Aux.	31.0	28.1	31.6	31.3	33.4	33.2	35.8	34.8	32.7	33.0	31.0	30.8	386.7
Ext. Usage	28.9	24.2	24.1	20.6	18.9	17.0	18.1	20.2	22.2	25.7	27.3	29.5	276.8
Misc. Equip.	270.1	244.5	271.5	264.0	271.5	262.6	271.6	271.5	262.6	271.6	259.4	271.6	3,192.5
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	81.2	71.2	77.6	72.2	73.7	69.4	72.5	73.6	73.7	79.0	78.2	81.7	903.9
Total	452.5	406.2	449.6	438.1	479.2	492.7	548.9	534.5	486.2	474.2	440.8	457.3	5,660.2

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	500.3	412.0	315.3	142.0	49.2	6.2	1.7	1.6	6.2	66.8	229.6	402.5	2,133.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	53.9	51.0	56.8	52.1	50.7	43.7	40.8	39.0	37.0	40.2	45.4	48.8	559.3
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	554.2	463.0	372.1	194.0	99.9	49.9	42.5	40.6	43.2	107.0	274.9	451.3	2,692.6

Attachment B – Potential Emissions Savings Analysis

Veolia Steam Greenhouse Gas (GHG) Calculations

This attachment provides backup documentation for the Veolia Steam Greenhouse Gas analysis described in FEIR Section 3.13, Greenhouse Gas Emissions. The assumptions and methodologies for this analysis, as described in FEIR Section 3.13, were developed in accordance with guidance from the Department of Energy Resources (DOER) and input from Veolia.

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Convert Site gas consumption to site district steam consumption

Note (1): DS Losses = 12%; Assumed gas boiler efficiency = 93% therefore DS load = Site gas *.93* 1.12 = 1.04 Site gas.

2,712	Terminal Expansion GHG Mitigated Case, Gas Use for heating (MMBtu/year) site path
2,820	Terminal Expansion GHG Mitigated Case, Steam supplied by Veolia for heating (MMBtu/year)
1,974	Terminal Expansion GHG Mitigated Case, Steam supplied by Kendall for heating (MMBtu/year)
846	Terminal Expansion GHG Mitigated Case, Steam supplied by Kneeland for heating (MMBtu/year)

Convert all or a portion of the project as-proposed site path grid cooling electric use to steam use using the COP of the as-proposed absorption chillers.

1,363	Terminal Expansion GHG Mitigated Case, Electric Use for cooling (MMBtu/year) site path
100%	portion of cooling potentially provided by absorption chillers (preliminary for calculation purposes)
5.00	COP of electric chillers, assumed for this calculation
1.00	COP of absorption chillers, assumed for this calculation
273	Terminal Expansion GHG Mitigated Case, Steam Use for cooling (MMBtu/year) site path
245.34	Terminal Expansion GHG Mitigated Case, Steam Use for cooling (MMBtu/year) site path from Kendall
27.26	Terminal Expansion GHG Mitigated Case, Steam Use for cooling (MMBtu/year) site path from Kneeland

Subtract the site cooling transferred to the absorption chillers from the site path as-proposed grid electicity use

19,299	Terminal Expansion GHG Mitigated Case, Electric Use for all uses (MMBtu/year) site path
1,363	Terminal Expansion GHG Mitigated Case, Electric Use transferred to absorption chillers (MMBtu/year) site path
17,936	Terminal Expansion GHG Mitigated Case, Remaining Electric Use (MMBtu/year) site path

Multiply the MMBtu steam supplied to the absorption chillers by 1.12[1] and add to the steam supplied for heating.

Note (1): To account for the 12% DS distribution system losses.

245.34	Terminal Expansion GHG Mitigated Case, Steam Use for cooling (MMBtu/year) site path for Kendall
12%	District steam distribution system losses
275	Terminal Expansion GHG Mitigated Case, Steam supplied by Kendall for cooling (MMBtu/year)
1,974	Terminal Expansion GHG Mitigated Case, Steam supplied by Kendall for heating (MMBtu/year)
2,249	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall (MMBtu/year)
27.26	Terminal Expansion GHG Mitigated Case, Steam Use for cooling (MMBtu/year) site path for Kneeland
12%	District steam distribution system losses
31	Terminal Expansion GHG Mitigated Case, Steam supplied by Kneeland for cooling (MMBtu/year)
846	Terminal Expansion GHG Mitigated Case, Steam supplied by Kneeland for heating (MMBtu/year)
877	Terminal Expansion GHG Mitigated Case, total steam supplied by Kneeland (MMBtu/year)

Multiply the total steam supplied by Kendall by 1.37 (the electricity cogenerated per unit steam generated) to quantify the amount of grid energy displaced by the Kendall generation of combined heat & power district steam.

2,249	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall (MMBtu/year)
1.37	Electricity generated at Kendall Station per unit district steam generated (Mmbtu/Mmbtu)
3,081	Electricity generated at Kendall Station while generating the steam to support the Terminal Expansion GHG Mitigated case, MMBtu/year

Subtract the amount of grid energy displaced by the Kendall generation of combined heat & power district steam from the site electricity.

17,936	Terminal Expansion GHG Mitigated Case, Remaining Electric Use (MMBtu/year) site path
3,081	Electricity generated at Kendall Station while generating the steam to support the Terminal Expansion GHG Mitigated case, MMBtu/year
14,855	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) site path

Multiply the site electricity remainder by 3.01, the Site to Source Conversion Factor for grid electricity.	
14,855	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) site path
3.01	Site to Source Conversion Factor for grid electricity
44,713	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) source path

Multiply the CHP DS by 1.59 (SSFCF for CHP DS).	
2,249	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall (MMBtu/year)
1.59	Site to Source Conversion Factor for Kendall district steam
3,576	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall (MMBtu/year) source path

Multiply the CHP DS by 1.45 (SSFCF for boiler DS).	
877	Terminal Expansion GHG Mitigated Case, total steam supplied by Kneeland (MMBtu/year)
1.45	Site to Source Conversion Factor for Kneeland district steam
1,271	Terminal Expansion GHG Mitigated Case, total steam supplied by Kneeland (MMBtu/year) source path

Step 10: Add values from steps 4 and 5 together to obtain the source fuel energy.	
44,713	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) source path
3,576	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall (MMBtu/year) source path
1,271	Terminal Expansion GHG Mitigated Case, total steam supplied by Kneeland (MMBtu/year) source path
49,560	Terminal Expansion GHG Mitigated Case, total energy use (MMBtu/year) source path

Evaluate source fuel energy usage for proposed case	
2,712	Proposed Terminal Expansion GHG Site Path Gas Energy Use
19,299	Proposed Terminal Expansion GHG Site Path Electric Energy Use
1.09	SSFCF for Natural Gas
3.01	SSFCF for Electricity
2,956	Proposed Terminal Expansion GHG Source Path Gas Energy Use
58,090	Proposed Terminal Expansion GHG Source Path Electric Energy Use
61,046	Total Proposed Source Path Energy Usage

Compare source fuel energy usage for Proposed and Mitigated Case Source Path	
61,046	Total Proposed Source Path Energy Usage
49,560	Terminal Expansion GHG Mitigated Case, total energy use (MMBtu/year) source path
-18.82%	Percent Reduction in Source Path Energy Usage

Convert to GHG for Mitigated Case Site Path	
14,855	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) site path
719	lb/MWh CO2 from ISO NE reports
211	lb/MMBtu CO2 (lb/MWh converted to lb/MMBtu)
1,565	tons of CO2 from electric generation
3,126	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall + Kneeland for Site Path (MMBtu/year)
117	lb/MMBtu CO2 for steam generation
183	tons of CO2 from steam generation
1,748	tons of CO2 total from GHG Mitigated Case

Convert to GHG for Proposed Case Site Path	
19,299	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) site path
719	lb/MWh CO2 from ISO NE reports
211	lb/MMBtu CO2 (lb/MWh converted to lb/MMBtu)
2,033	tons of CO2 from electric generation
2,712	Terminal Expansion GHG Mitigated Case, total steam supplied by Veolia (MMBtu/year) site path
117	lb/MMBtu CO2 for steam generation
159	tons of CO2 from steam generation
2,192	tons of CO2 total from GHG Mitigated Case

Compare GHG for Proposed and Mitigated Case Site Path	
1,748	tons of CO2 total from GHG Mitigated Case
2,192	tons of CO2 total from GHG Mitigated Case
-20.26%	Percent Reduction in Source Path CO2 Emissions

Convert to GHG for Mitigated Case Source Path	
44,713	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) source path
726	lb/MWh CO2 from ISO NE reports
213	lb/MMBtu CO2 (lb/MWh converted to lb/MMBtu)
4,757	tons of CO2 from electric generation
3,576	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall for Source Path (MMBtu/year)
1,271	Terminal Expansion GHG Mitigated Case, total steam supplied by Kneeland for Source Path (MMBtu/year)
4,847	Terminal Expansion GHG Mitigated Case, total steam supplied by Kendall + Kneeland for Source Path (MMBtu/year)
117	lb/MMBtu CO2 for steam generation
284	tons of CO2 from steam generation
5,041	tons of CO2 total from GHG Mitigated Case

Convert to GHG for Proposed Case Site Path	
58,090	Terminal Expansion GHG Mitigated Case, Electric Use minus electricity generated at Kendall Station while generating steam to support the Terminal expansion GHG mitigated case (MMBtu/year) source path
719	lb/MWh CO2 from ISO NE reports
211	lb/MMBtu CO2 (lb/MWh converted to lb/MMBtu)
6,121	tons of CO2 from electric generation
2,956	Terminal Expansion GHG Mitigated Case, total steam supplied by Veolia (MMBtu/year) source path
117	lb/MMBtu CO2 for steam generation
173	tons of CO2 from steam generation
6,293	tons of CO2 total from GHG Mitigated Case

Compare GHG for Proposed and Mitigated Case Site Path	
5,041	tons of CO2 total from GHG Mitigated Case
6,293	tons of CO2 total from GHG Mitigated Case
-19.91%	Percent Reduction in Source Path CO2 Emissions

Summary	
Source Path Energy Comparison	
61,046	Total Proposed Source Path Energy Usage
49,560	Terminal Expansion GHG Mitigated Case, total energy use (MMBtu/year) source path
-18.82%	Percent Reduction in Source Path Energy Usage
Site Path CO2 Comparison	
2,192	tons of CO2 total from Proposed Case Site Path
1,748	tons of CO2 total from GHG Mitigated Case Site Path
-20.26%	Percent Reduction in Site Path CO2 Emissions
Source Path CO2 Comparison	
5,041	tons of CO2 total from GHG Mitigated Case
6,293	tons of CO2 total from GHG Mitigated Case
-19.91%	Percent Reduction in Source Path CO2 Emissions

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Attachment C –
Combined Heat and Power (CHP) Sizing and Performance Estimate

CHP Sizing and Performance Estimate
Potential CHP Unit Datasheets

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CHP Sizing and Performance Estimate				
SITE ENERGY USE	From eQUEST Monthly Energy Consumption in Figure 3-2			
DWH	Min.monthly Ave	41 MMBtu (July)		0.05 MMBtu/hr
CHP		The Yanmar CP10WN Micro CHP Unit is slightly oversized for this application: http://sonicchp.com/themes/sonicchp/docs/10kw-yanmar-data-sheet.pdf		
PERFORMANCE (per unit)				
	Engine output	10 kWe		Yanmar CP10WN Micro CHP Unit
	Heat input	0.12 MMBtu/hr HHV		Yanmar CP10WN Micro CHP Unit
	Thermal output	0.06 MMBtu/hr		Yanmar CP10WN Micro CHP Unit
	Heat rate	11,922 Btu/kWh HHV		calculated from above
ANNUAL ENERGY (1 unit)				
	Ann. capacity factor	90%		estimated, allows for scheduled and forced outages and some part-load operation
	Heat utilization factor	80%		estimated, allows for engine capacity factor and some thermal losses
	Grid elect. displaced	78.84 MWh/yr		
		269 MMBtu/yr		
	Fuel consumption	940 MMBtu/yr		
	Waste heat utilized	402 MMBtu/yr		
	Natural gas displaced @ 90% boiler efficiency	446 MMBtu/yr		
OVERALL THERMAL EFFICIENCY				
		MMBtu/yr		
	Fuel use	940		
	as electricity	269	29%	
	utilized heat	402	43%	
	Overall thermal efficiency		71%	accounts for heat utilization factor above
GHG EMISSIONS				
Emission Factors	Grid Electricity	726 lbs CO2/MWh		
	Natural Gas	117 lbs CO2/MMBtu		
	Fuel burned	55 tons GHG/yr		
	Grid electricity avoided	-29		
	Natural gas use avoided	-26		
	Reduction	0.3 tons GHG/yr		

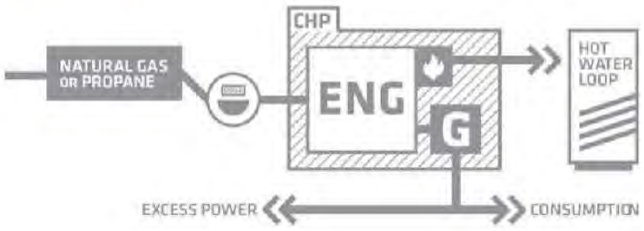
CP10WN Micro CHP Unit

The CP10WN micro CHP provides 10 kW electrical output along with recovered heat for generating hot water at rated temperature of 158 degrees (f). That output, along with a total efficiency as high as 88%, makes the CP10WN suitable for applications like nursing homes, fitness centers, health clubs, restaurants, hotels, multifamily housing units and even larger residences.

CP10WN FACTS

- High-performance, YANMAR durable gas engine
- Self Contained Radiator Package
- Quietest in its class at 54 dB(A) at 3.3 ft.
- Electrical and Thermal Outputs
- Maintenance Interval of 10,000 hours, 24/7 operation, 13 months and 3 weeks
- Black start and off grid operation capabilities
- Net metering where available
- Charmingly rectangular at 70.5"H x 57.9"W x 31.5"D
- Natural gas and Propane models available
- UL2200 Listed

CP10WN HOW



Using natural gas or propane, the CP10WN's high efficiency generator (G) provides 10kW of electrical power. The engine's thermal energy is captured and heats water at a rated temperature of 158 degrees (f) for immediate use or storage in an insulated tank. Excess electricity production can be sold back onto the grid in certain states, creating a credit.

CP10WN SPECIFICATIONS

SPECIFICATIONS				UNITS	CP10WN-SN	CP10WN-SPB
POWER	Output	Rated output [1]		kW	10.0	
		Voltage		ACV	240/120 @ 60 Hz	
		Phases/wires		-	Single phase, 3 wire	
		Power factor		%	Above 97	
	Input (Parasitic load)	Consumption	Radiator fan stopped	kW	0.39	
			Radiator fan opening	kW	0.71	
			Heater for cold region	kW	0.70	
		Voltage		ACV	240	
FUEL	Gas type			-	Natural Gas	Propane
	Consumption [5]			BTU/hr (kW)	107,500 (31.5)	112,970 (33.1)
				volume	1.08 therms/hr	1.33 gal/hr
HEAT RECOVERY [2]	Recovered Heat			BTU/hr (kW)	57,300 (16.8)	65,180 (19.1)
	Hot water temp	Inlet		°F (°C)	149 (65)	
		Outlet		°F (°C)	158 (70) Max. 172 (78)	
	Hot water flow rate [3]			gal/min (L/min)	12.7 (48.2)	
EFFICIENCY [2]	Overall efficiency			%	85.0	88.0
	Electrical generation efficiency			%	31.5	30.0
	Exhaust heat recovery ratio			%	53.5	58.0
SOUND LEVEL	For rated load [4]		Radiator fan stopped	dB(A)	54	
			Radiator fan operating	dB(A)	56	
DIMENSIONS	Width			in. (mm)	57.9 (1,470)	
	Depth [6]			in. (mm)	31.5 (800)	
	Height			in. (mm)	70.5 (1,790)	
	Net weight [7]			lb (kg)	1664 (756)	

1 Parasitic loads are included.
2 The heat recovery and efficiency values are those for rated output in standard atmospheric conditions.
3 Maximum of 5%: 13.3 gal/min (50.6 L/min)
4 The sound levels are maximum values measured in four directions at a distances of 3.3 ft (1.0 m).
5 The amount of fuel consumption based on lower calorific values.
6 Depth 35.4 in. (900mm) including protrusions.
7 Including coolant and engine oil.

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Attachment D – Plug-in GHG Estimate Calculations

Plug-in GHG Estimate Calculations

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Mobile source emissions analysis revision to account for indirect electrical use associated with the proposed plug-in facilities at South Station and the layover sites.

Draft
Epsilon 11/24/2015

Factors:

14.3 kW average power load of fleet average coach in layover mode

39.8 kW electrical load for a typical locomotive in layover mode (totaled from individual loads)
From Keolis Annual Engineering Service Plan, 5/1/2015, Section 9.12.5

726 lb CO2/MWhr annual average system emission rate
From DRAFT 2014 ISO New England Electric Generator Air Emissions Report, Table 1-1

39.6 gallon/hour fuel consumption rate
From Emission Factors for Locomotives, Office of Transportation and Air Quality, 2009. EPA-420-F09-025 PAGE 5 (Consistent with calculations in SSX DEIR Appendix 12 Attachment E)

10,217 g CO2/gallon fuel
Consistent with SSX DEIR Appendix 12 Attachment E - Layover Locomotives CO2 Emissions

Inputs:

304 Number of coaches in layover mode per day
Based on 38 trains/day per SSX DEIR Appendix 12 Attachment E, 8 coaches per train

38 Number of locomotives in layover mode per day
Consistent with calculations in SSX DEIR Appendix 12 Attachment E for Widett & Readville 2 net

3.5 Hours per day in layover mode
Note: actual layover is 4.5 hours but 1 hour is spent idling on oil regardless of plug in so there is no difference for that hour

365 Days/year
Consistent with calculations in SSX DEIR Appendix 12 Attachment E
Note: that this is a high estimate of all 365 days being equal, in reality weekend service will be reduced

Outputs:

5,554 MWhr/year electric load from coaches plugged in at ground power receptacles

1,932 MWhr/year electric load from locomotives plugged in at ground power receptacles

7,486 MWhr/year electric load total plugged in at ground power receptacles

2,717 Tons CO2/year indirect emissions from electric use associated with trains plugged in at ground power receptacles

1,922,382 gallons fuel/year from baseline case train idling

21,650 Tons CO2/year baseline case direct emissions from diesel use associated with trains idling

18,933 Tons CO2/year improvement from electric use associated with trains plugged in at ground power receptacles

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