Considering District Energy Based on Residual Municipal Solid Waste Energy Plant

Case Study: Minneapolis North Loop Development

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Overview

Hennepin Energy Recovery Center
MSW Power Plant

Integrated District Energy Master Planning

Downtown Minneapolis North Loop

Existing WtE Plant - Downtown Minneapolis

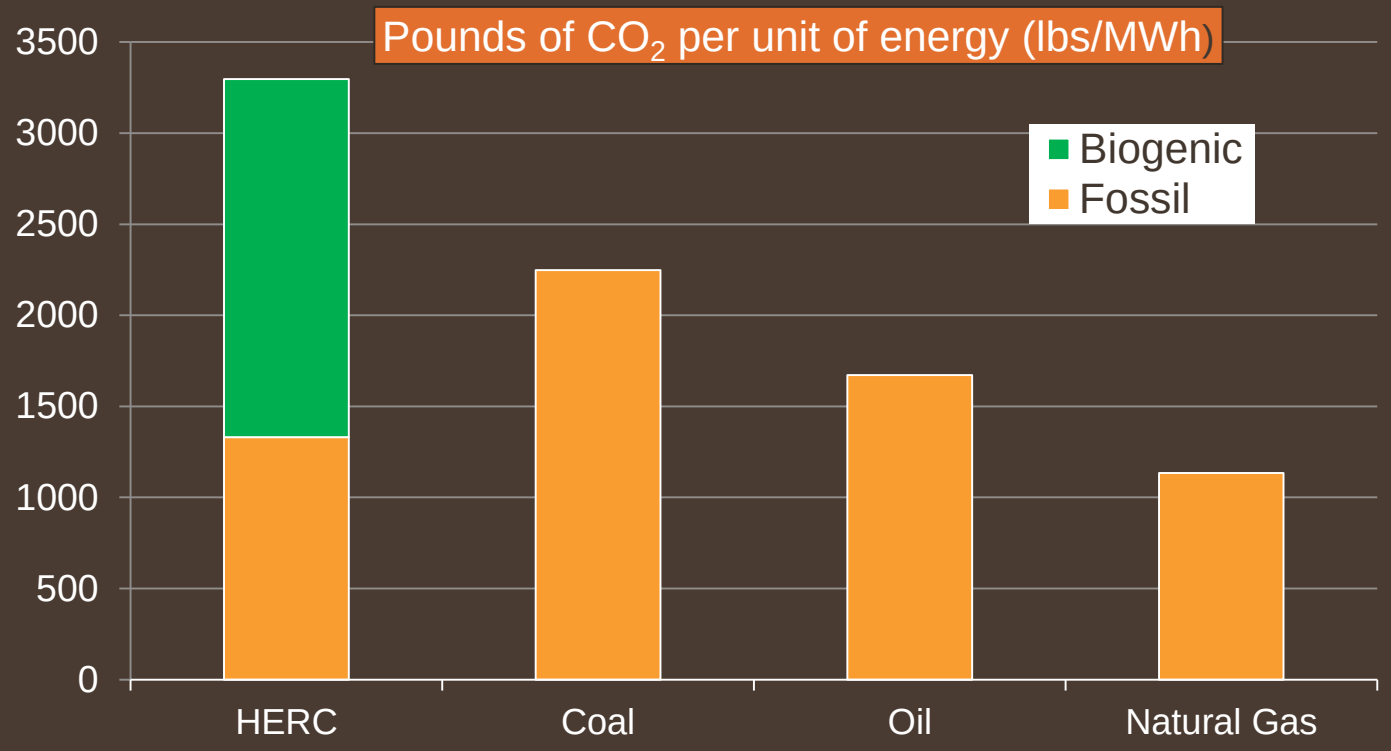
Hennepin Energy Recovery Center (HERC)

- 365,000 tons/year of MSW.
- Steam Turbine 38.7 MW at 350,000 lbm/hr.
- Benefit: The facility helps meet the state's renewable energy goal of 25 percent of energy from renewable sources by 2025.
- Reduce the release of GHG emissions by about 255,000 metric ton/year.
- Use some low grade heat for snow melting the public plaza area.
- Interconnects with NRG district steam system.

Existing Infrastructure

Existing Infrastructure

CO2e Emissions of MSW vs Fossil Fuel

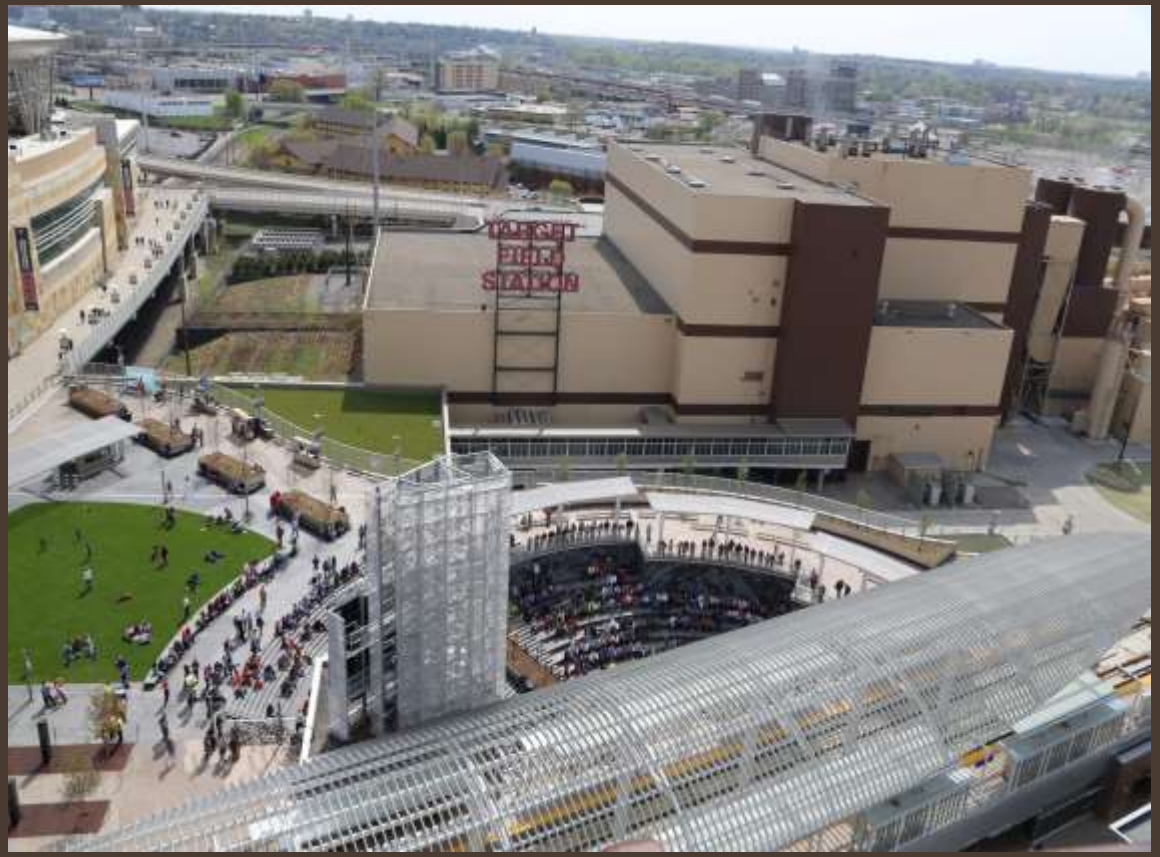


North Loop - Downtown Minneapolis

NORTH LOOP

Minneapolis' Fastest Growing Community:

- Target Field, Home of Minnesota Twins, and Timberwolves
- Planned Development for Commercial Office Buildings
- New and existing low rise apartments/condominiums



North Loop - Minneapolis

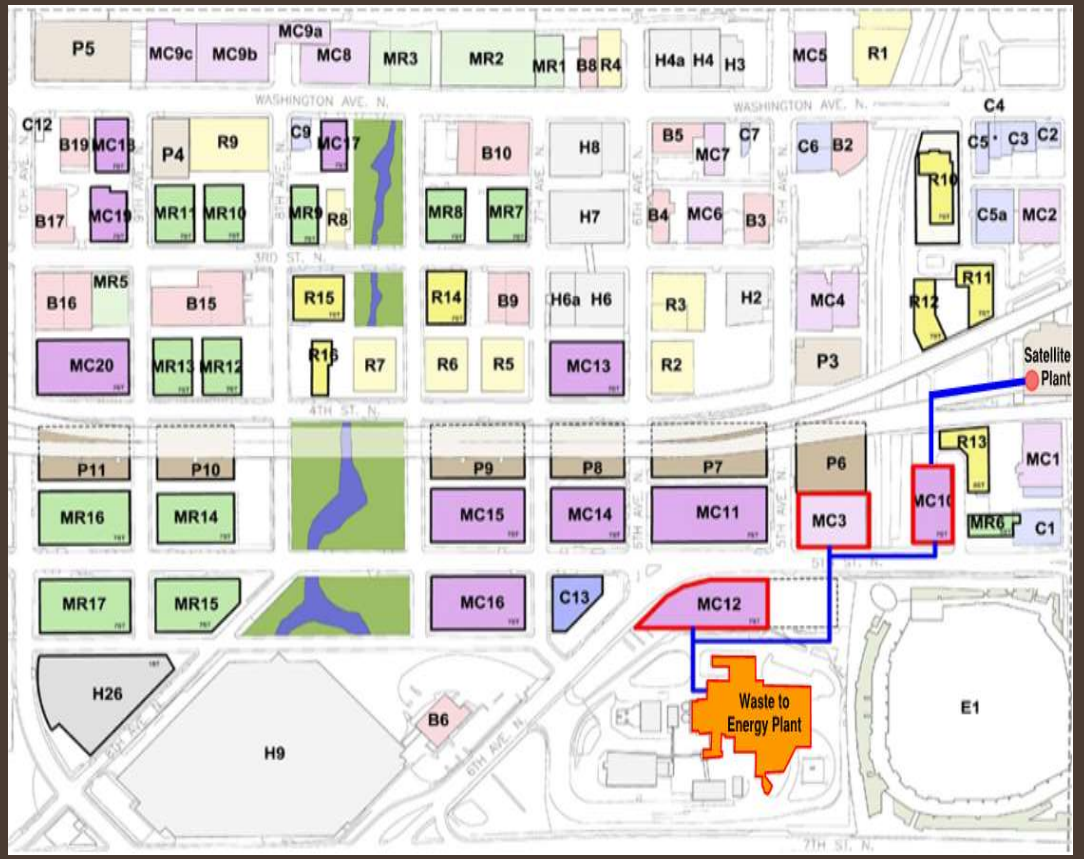
North Loop - Minneapolis

Aerial View Of The North Loop Area

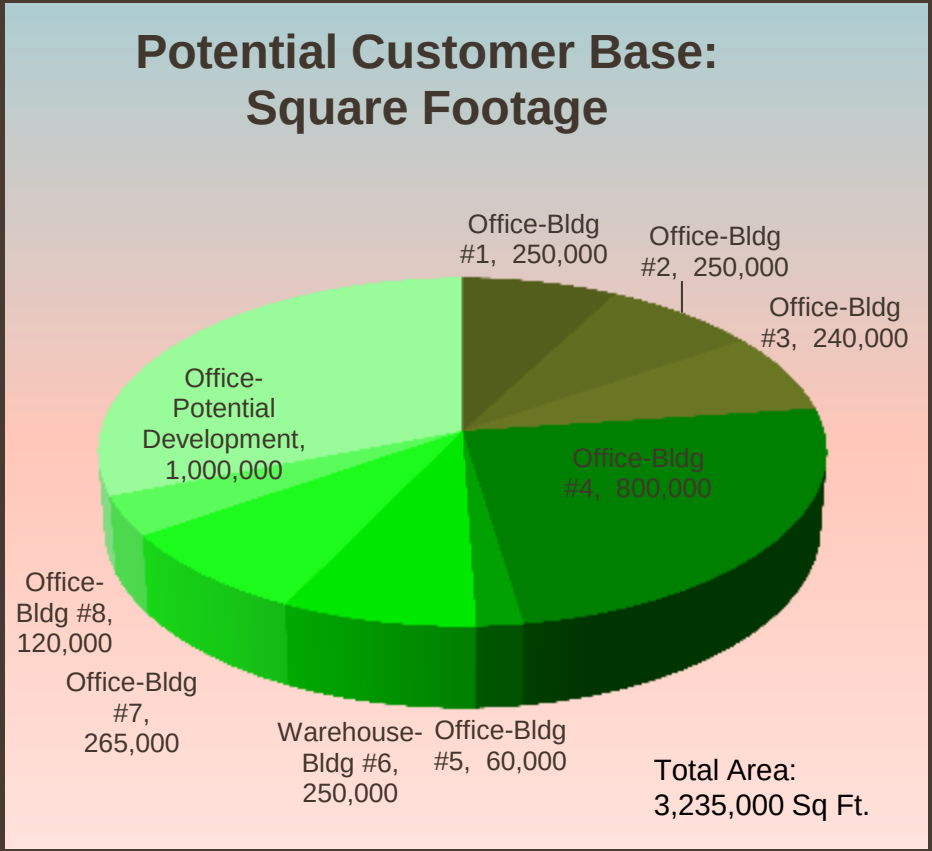
District Energy Master Planning

HGA Study

- MSW - Renewable Based Community District Energy
- Modern Low Temperature Hot Water Technology
- Cost Effective Phased Approach
- Phase 1 - Anchor Customers, 3-4 Buildings
- Phase 2 - Full Scale, 3 Million Square Feet
- Substantial CO2e Reduction
- Reliable, Efficient, and Resilient



Building Space Projection

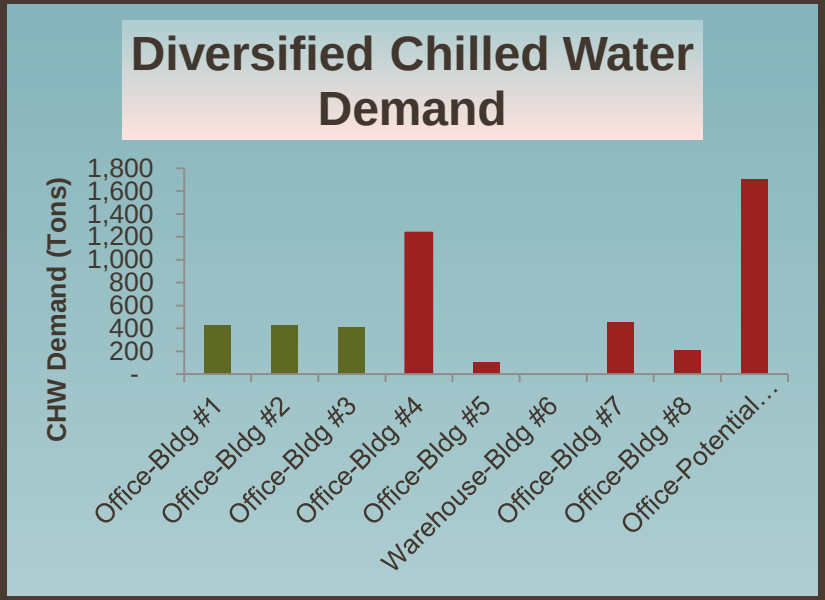


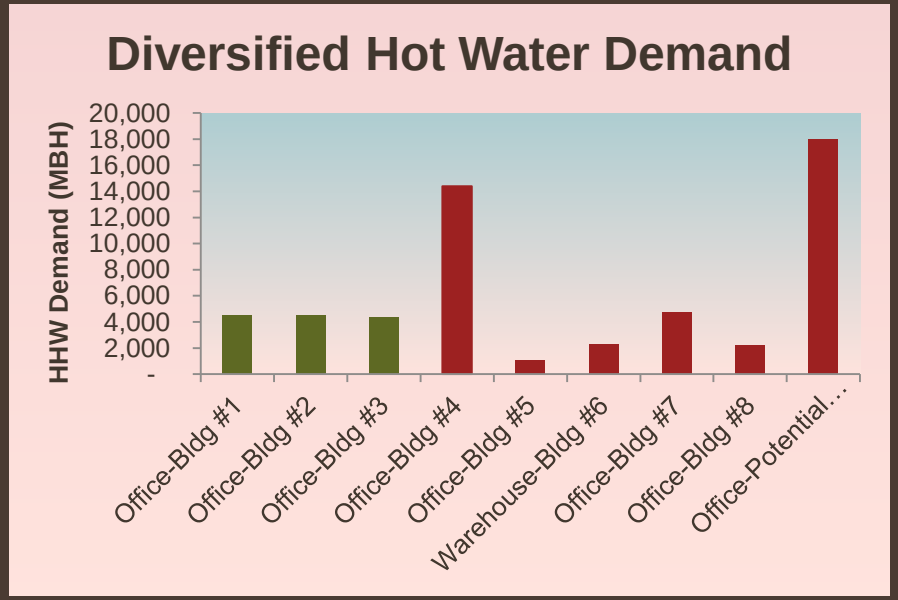
Building Type/Usage	Phase 1(SF)	Phase 2(SF)	Total Space (SF)
Office-Bldg #1	250,000	-	250,000
Office-Bldg #2	250,000	-	250,000
Office-Bldg #3	240,000	-	240,000
Office-Bldg #4		800,000	800,000
Office-Bldg #5	-	60,000	60,000
Warehouse-Bldg #6	-	250,000	250,000
Office-Bldg #7	-	265,000	265,000
Office-Bldg #8	-	120,000	120,000
Office-Potential Development	-	1,000,000	1,000,000
Total	740,000	2,495,000	3,235,000

Account building space projection

- By phased approach
- By building type - i.e. commercial, hotel, residential, office

Thermal Load Analysis

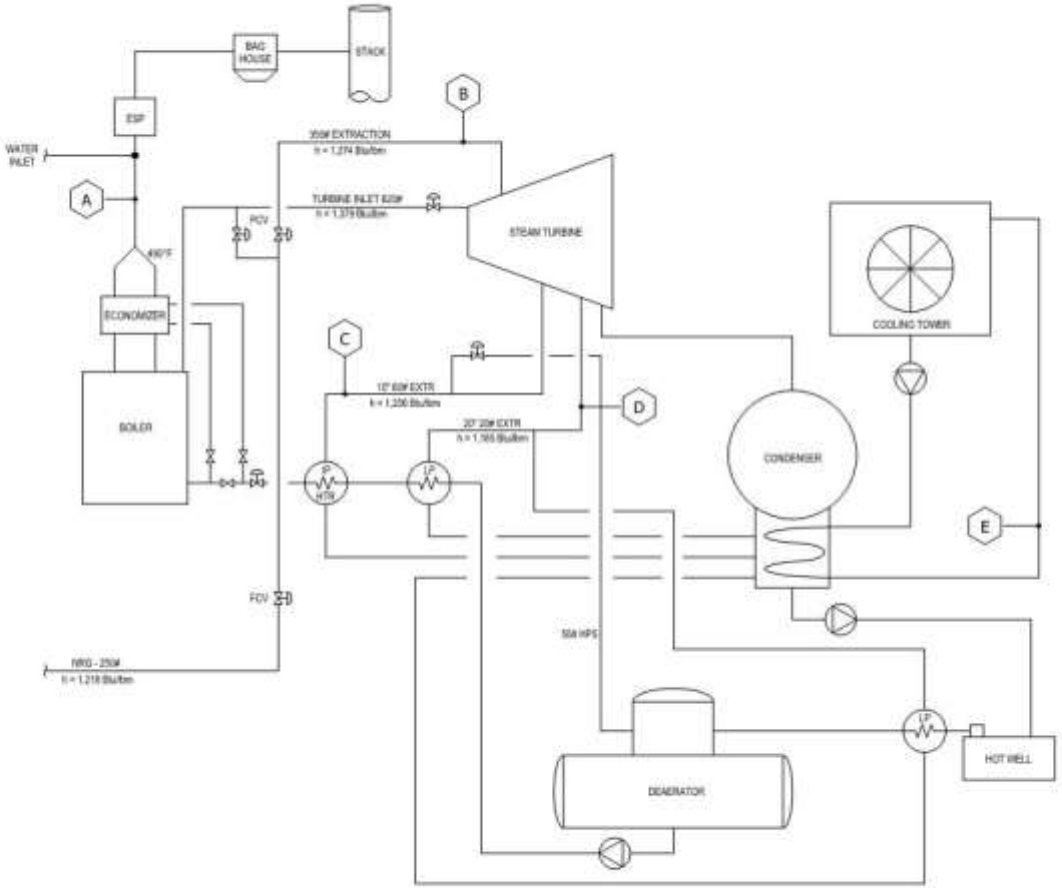




	Phase 1	Phase 2	Total
Diversified Hot Water Demand (MBH)	13,320	42,660	55,980
Diversified Chilled Water Demand (Tons)	1,258	3,693	4,951

Account realistic building consumer load assessment

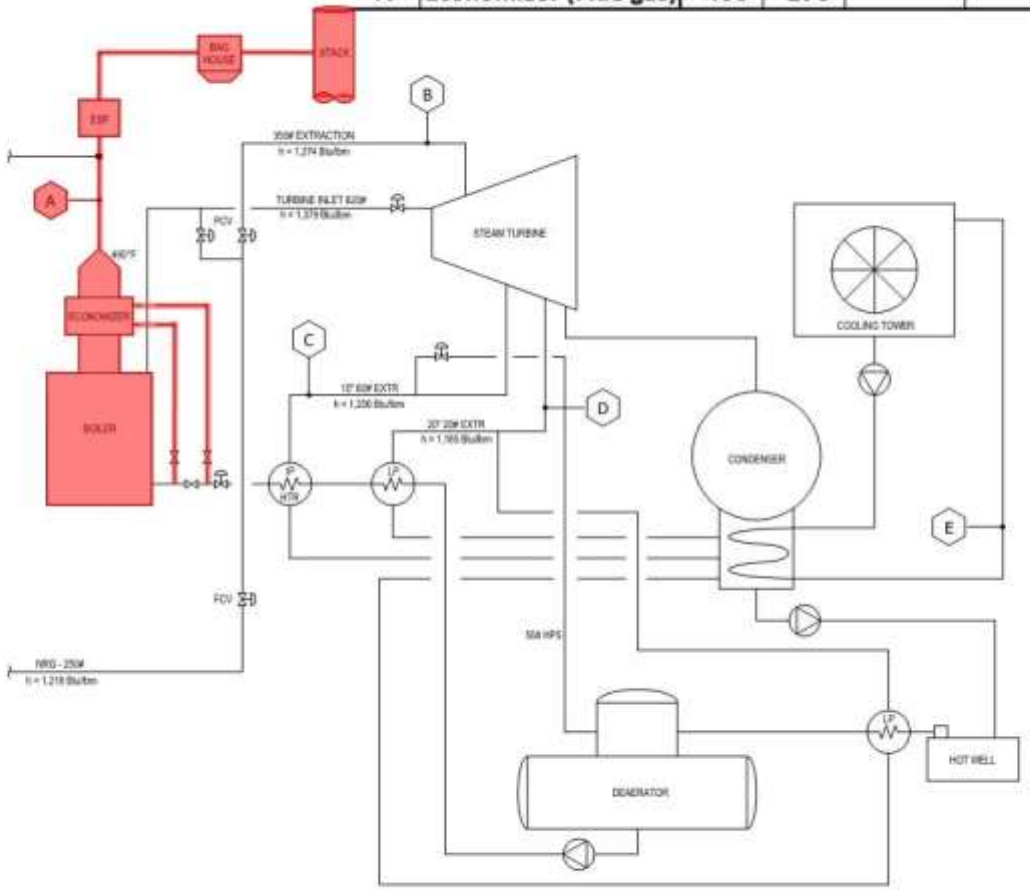
- Account for diversification


BAG HOUSE
STACK
ESP
WATER INLET
A
B
350# EXTRACTION
h = 1,274 Btu/lbm
TURBINE INLET 625#
h = 1,379 Btu/lbm
PCV
STEAM TURBINE
COOLING TOWER
ECONOMIZER
BOILER
C
12" 63# EXTR
h = 1,256 Btu/lbm
D
20" 20# EXTR
h = 1,165 Btu/lbm
CONDENSER
E
FCV
50# HPS
HRG - 25#
h = 1,218 Btu/lbm
DEAERATOR
HOT WELL

Recovery Point		Temperature (°F)		Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/H Available
A	Economizer (Flue gas)	400	270		456,000	19.0

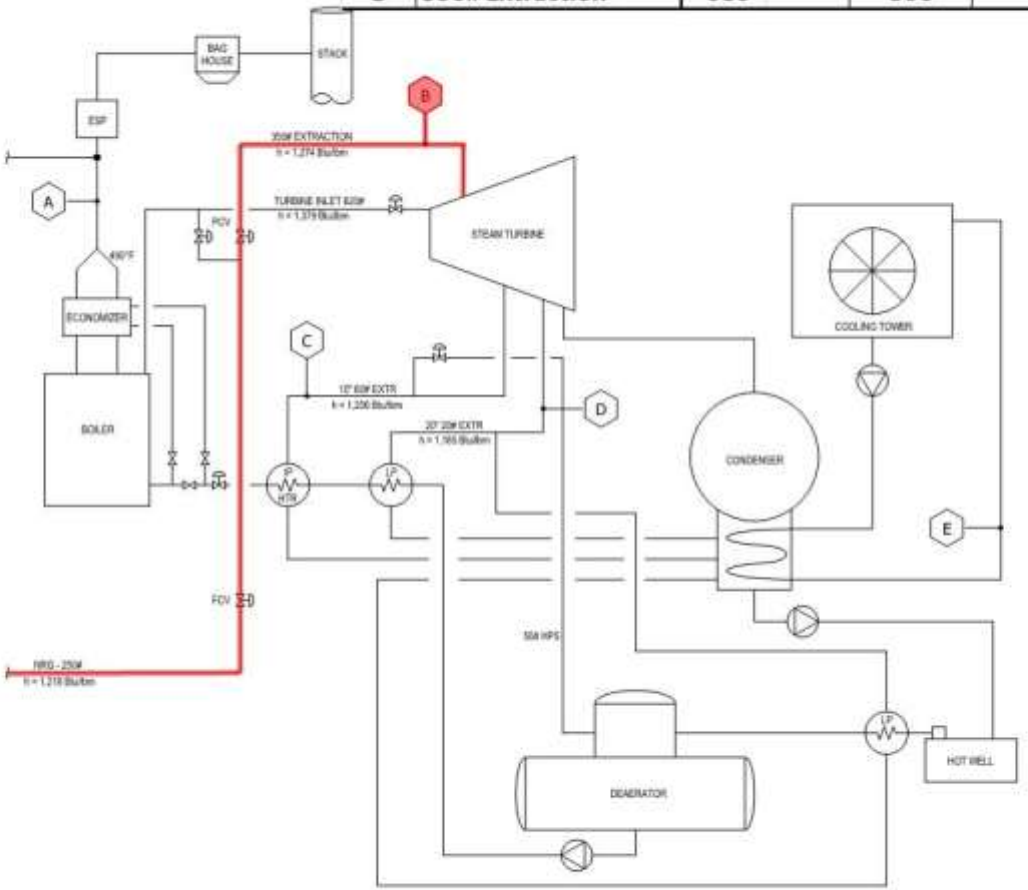
- Waste Heat
- Reduces water Use
- Available Space in Breeching and Plant

- Before Emission Controls
- Available Energy Fluctuates over Time



- **Largest Available Source**
- **Existing Export Contract**
- **Greatest impact on Electrical Generation**

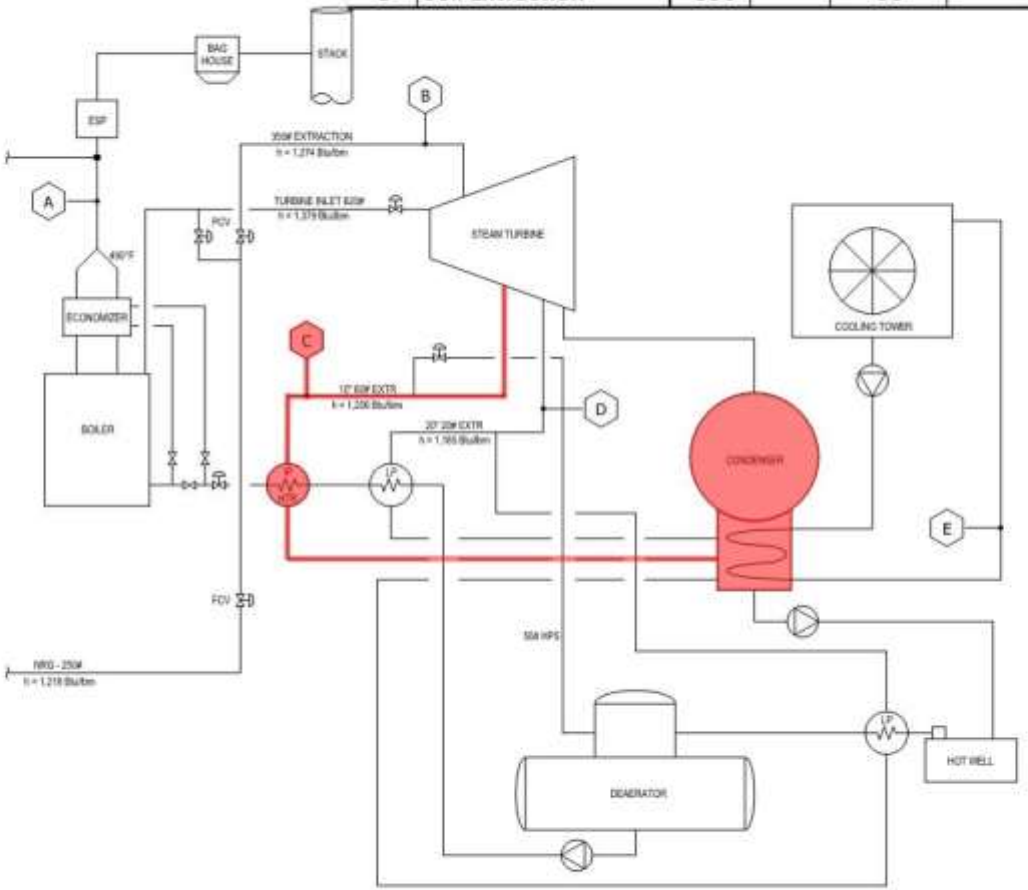
Recovery Point		Temperature (°F)	Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/H Available
B	350# Extraction	539	350	90,000	106.7



Recovery Point		Temperature (°F)	Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/Hr Available
C	60# Extraction	350	60	64,000	60.7

- Less Impact on Electrical Generation
- Existing port

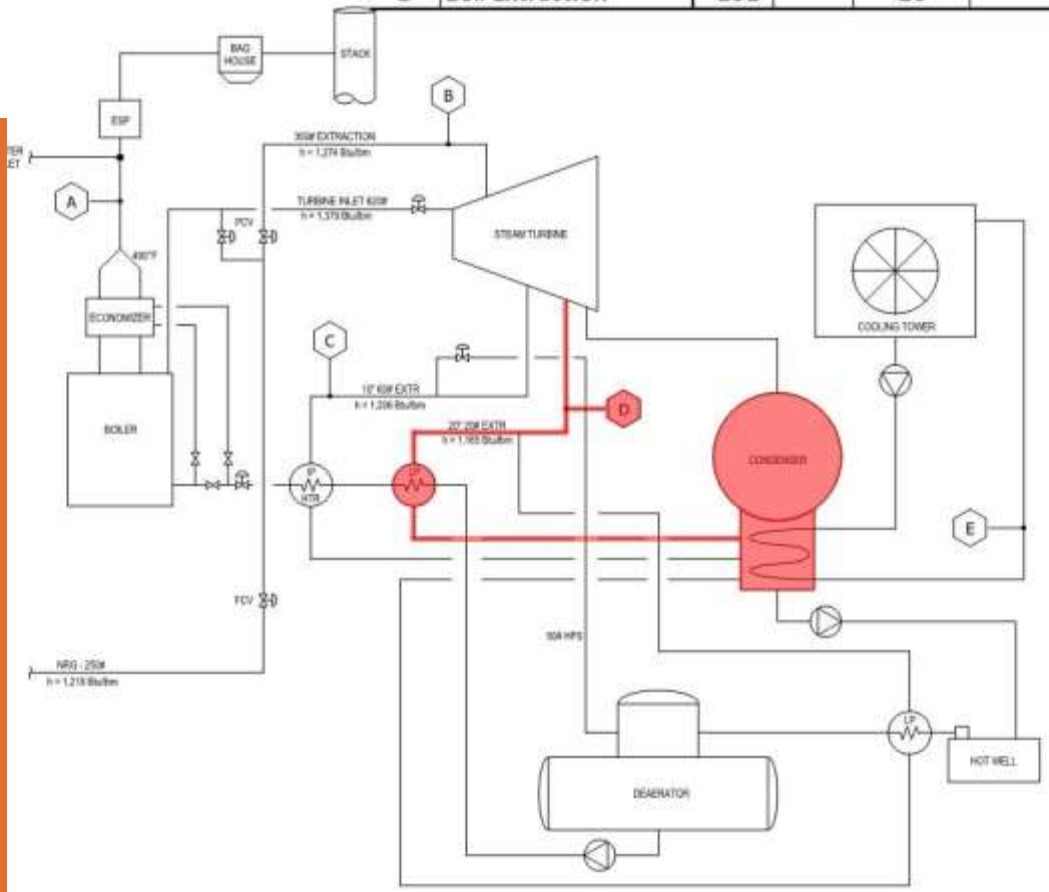
- Current Loads:
  - Feedwater Preheat
  - Deaerator



Recovery Point		Temperature (°F)	Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/Hr Available
D	20# Extraction	251	20	32,000	31.0

- Least Impact on Electrical Generation
- Existing port
- Best Pressure

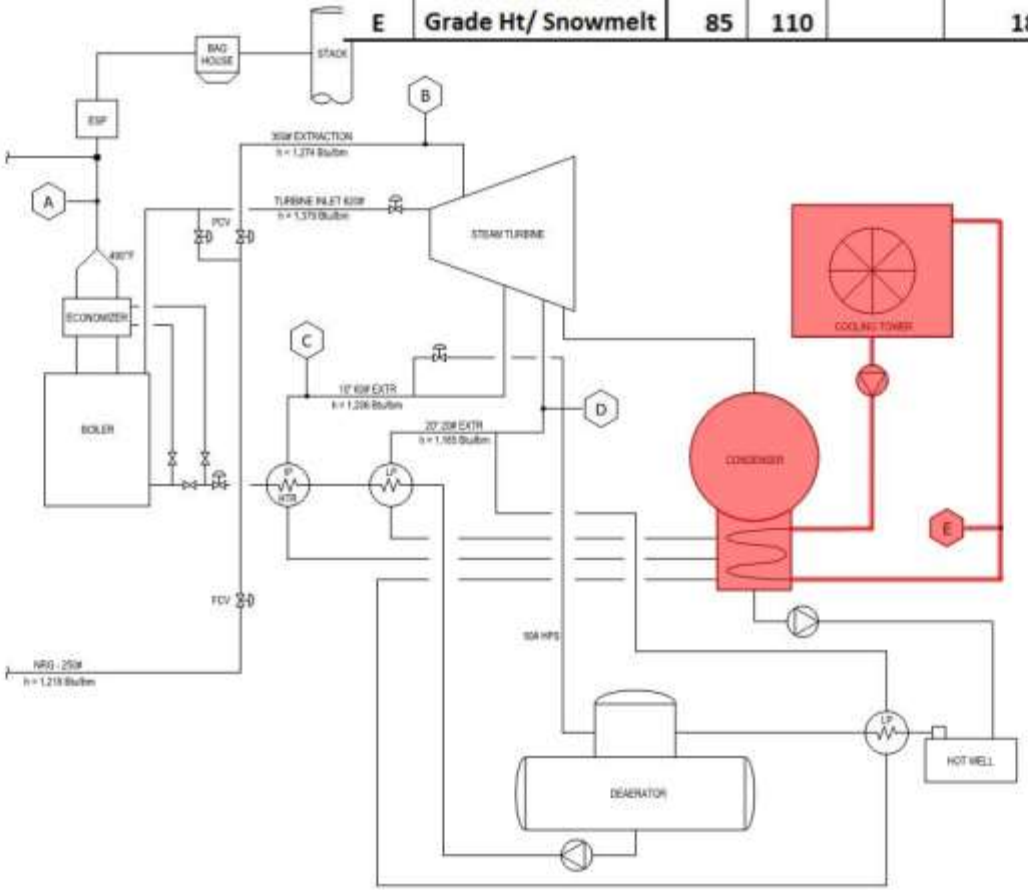
- Current Loads:
  - Feedwater Preheat
  - Air Preheat



	Recovery Point	Temperature (°F)		Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/Hr Available
E	Cond Water -Low Grade Ht/ Snowmelt	85	110		182,117	273.0

- Waste Heat- No Impact on Electric Generation
- Largest Source
- Good for Heat Pump Loop

- Low Grade Heat
- Largest Piping required for District Energy
- Current Loads:
  - Snowmelt



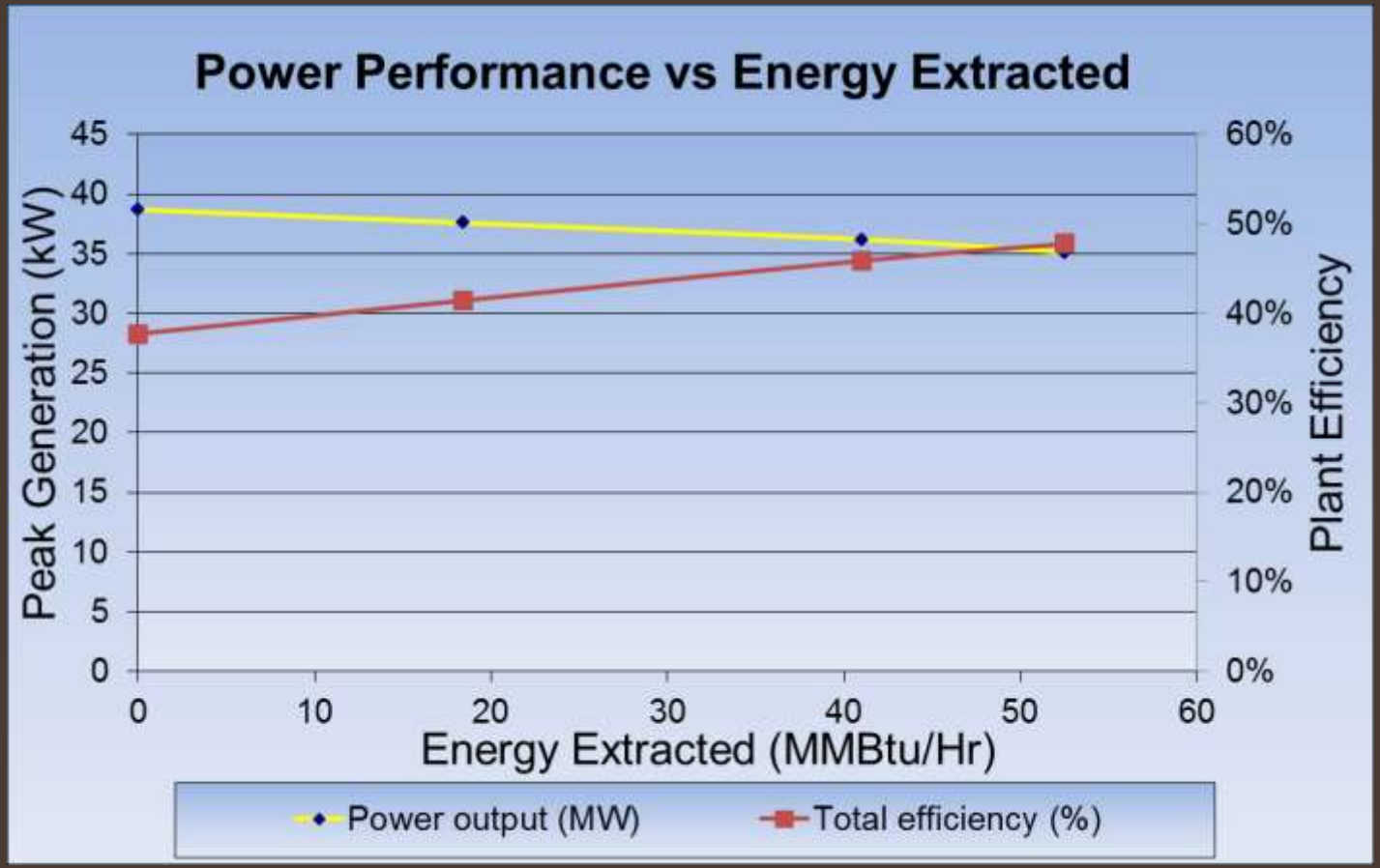
	Recovery Point	Temperature (°F)		Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/Hr Available	Existing Diversified Flow (lbm/hr)	Existing Diversified MMBtu /Hr Available
	Turbine Inlet	750		620	350,000	147.0	300,000	
A	Economizer (Flue gas)	400	270		456,000	19.0	390,857	6.9
B	350# Extraction	539		350	90,000	106.7	25,000	57.1
C	60# Extraction	350		60	64,000	60.7	53,500	1.4
D	20# Extraction	251		20	32,000	31.0	26,500	1.0
E	Cond Water -Low Grade Ht/ Snowmelt	85	110		182,117	273.0	-	258.0
F	Blowdown	180	110		7,000	0.5	6,000	0.4
							Total Available (MMBTU/HR)	324.8
							Extraction Energy Available (MMBTU/HR)	59.5

	Recovery Point	Temperature (°F)		Pressure (psig)	Maximum Mass Flow Rate (lbm/hr)	Design MMBtu/Hr Available	Existing Diversified Flow (lbm/hr)	Existing Diversified MMBtu /Hr Available
	Turbine Inlet	750		620	350,000	147.0	300,000	
A	Economizer (Flue gas)	400	270		456,000	19.0	390,857	6.9
B	350# Extraction	539		350	90,000	106.7	5,000	78.9
C	60# Extraction	350		60	64,000	60.7	40,200	15.2
D	20# Extraction	251		20	32,000	31.0	13,300	15.2
E	Cond Water -Low Grade Ht/ Snowmelt	85	110		182,117	273.0	-	258.0
F	Blowdown	180	110		7,000	0.5	6,000	0.4
							Total Available (MMBTU/HR)	374.6
							Extraction Energy Available (MMBTU/HR)	109.3

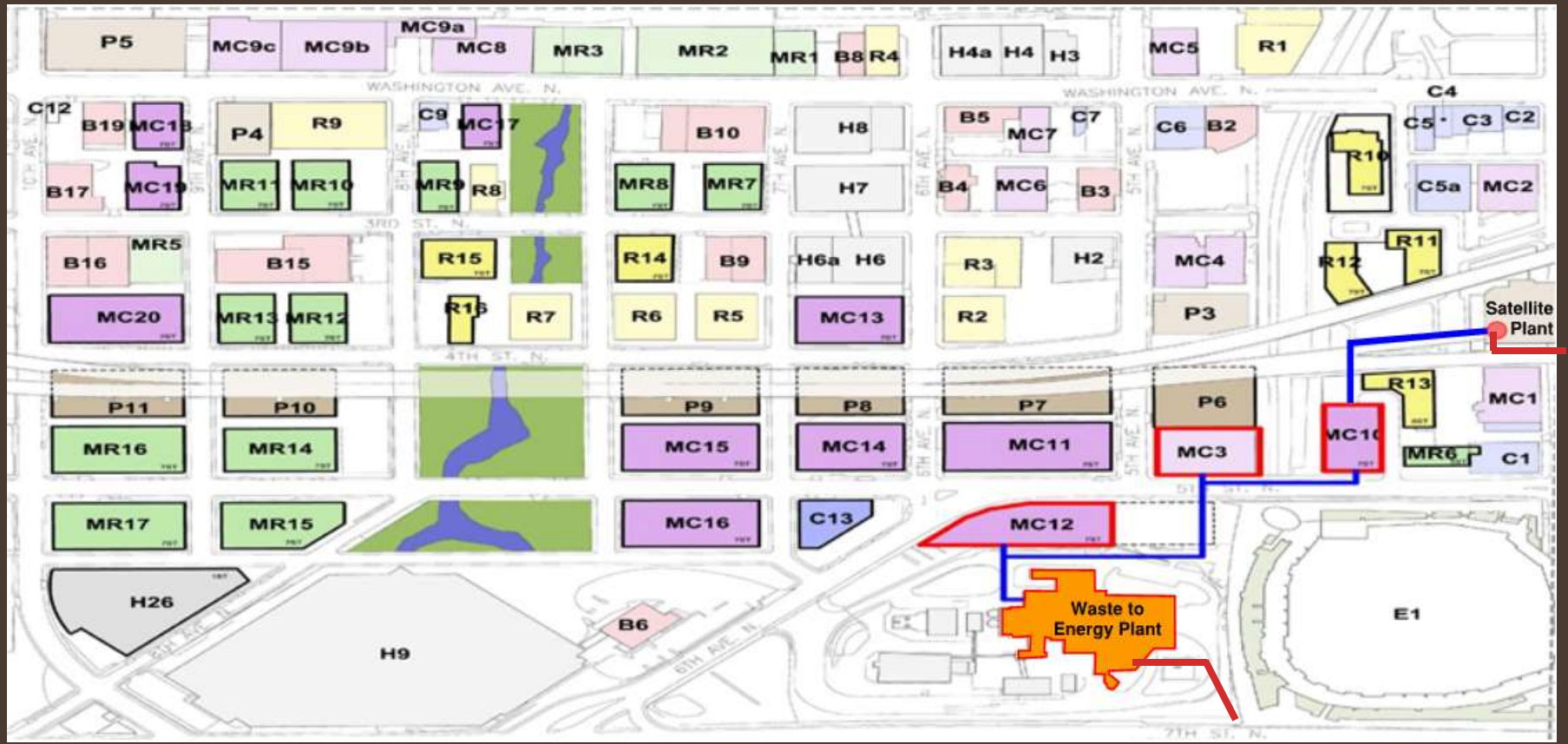
Plant Efficiency & Derate at Steam Extraction

Extraction (Mlbs/hr)	Extraction (MMBtu/hr)	Power output (MW)	Total efficiency (%)	Th Energy Cost ($/MMBtu) Based on Lost Electrical Revenue ($/MWH)	
-	-	38.70	38%	$ 30.00	$ 60.00
19.00	18.42	37.59	41%	$ 1.81	$ 3.62
42.80	41.00	36.20	46%	$ 1.83	$ 3.65
56.00	52.50	35.11	48%	$ 2.05	$ 4.10
99.80	90.65	38.70	54%	$ 2.39	$ 3.98
Waste Heat Recovery from Condenser Water					
-	52.50	38.70	51%	$ -	$ -

Plant Efficiency & Derate at Steam Extraction

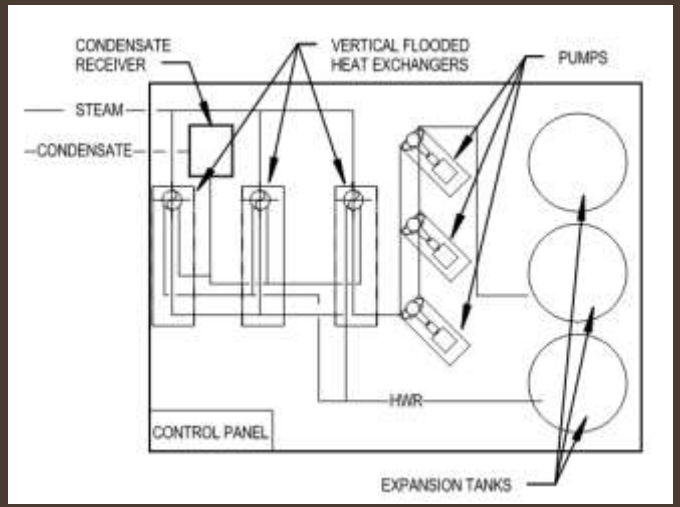


Thermal Piping Network - Anchor Customer-Phase 1



Thermal Piping Network - Full Build-out-Phase 2

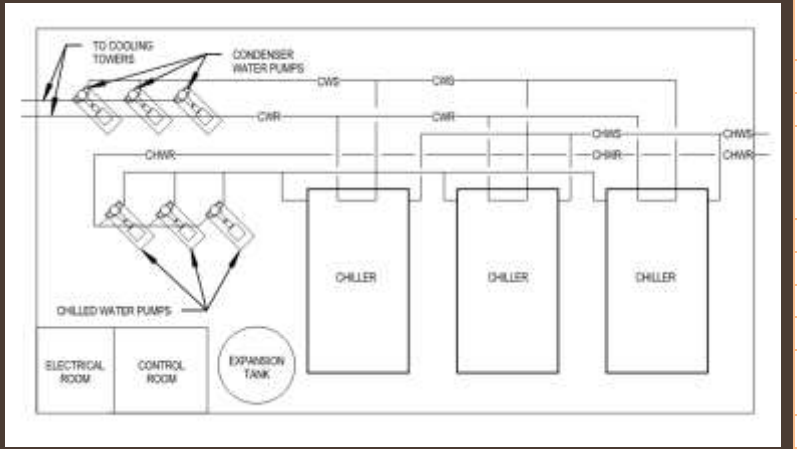
Capital Expenditure - Heating System



	Existing HERC Plant-Mech Room	Parking Ramp C	
Heating System	**Plant #1**	**Plant #2**	**Total**
New Heating Plant	$564,400	$564,400	$1,128,800
Plant piping	$250,000	$0	$250,000
Plant Building Site	$0	$300,000	$300,000
Contractors Gen. Cond.Fee/Bond/Insurance	$90,300	$224,700	$315,000
Est. Design Fee	$81,400	$98,000	$179,400
Contingency-15%	$147,915	$178,065	$325,980
SUBTOTAL Plant Cost	$1,134,015	$1,365,165	$2,499,180
Distribution Piping:			
Buried Steam Piping System	$0	$1,532,000	$1,532,000
Buried HHW piping	$235,500	$174,000	$409,500
SUBTOTAL Buried Piping	$235,500	$1,706,000	$1,941,500
GRAND TOTAL	**$1,369,515**	**$3,071,165**	**$4,440,680**
Building Interface*	$379,260	$193,500	$572,760

* To be negotiated with the potential customers

Capital Expenditure - Cooling System



Cooling System	Existing HERC Plant #1	Plant #2	Total
	Phase 1	**Phase 1**	
Cooling Plant	$1,820,600	$0	$1,820,600
Cooling Towers	$400,000	$0	$400,000
Electric Equipment, Wiring	$300,000	$0	$300,000
Plant Building Site	$0	$0	$0
Plant Piping	$350,000	$0	$350,000
Contractors Gen.Cond.-Fee/Bond/Insurance	$403,300	$0	$403,300
Design Fee	$294,700	$0	$294,700
Contingency-15%	$535,290	$0	$535,290
SUBTOTAL	$4,103,890	$0	$4,103,890
Distribution Piping:			
Buried Chilled Water Piping Network	$329,500	$914,500	$1,244,000
SUBTOTAL	$329,500	$914,500	$1,244,000
GRAND TOTAL	**$4,433,390**	**$914,500**	**$5,347,890**
Building Interface*	$624,750	$318,750	$943,500

Phase 1 Heating System Summary Cost

Heating Plant	$2,499,000
Distribution Piping	$1,941,000
Building Interconnection	$0
Subtotal	$4,440,000

Operating Assumption	
Heating Maintenance	$12,654
Incremental Labor	$30,000
Total Annual Admin	$7,500
Fuel Cost	$121,978
Capital Recovery	$368,558
Total Fixed Cost	$418,712
Variable Cost	$121,978

District Hot Water Heating Pricing Structure	
Connected Bldg Square Footage	740,000
Peak Diversified Demand (MMBtu/hr/Sqft)	18
Peak Diversified Heating Capacity (MMBtu/hr)	13.32
Equivalent Full Load Hours	1800
Annual Heating Consumption (MMBtu)	23,976
Demand Charge ($ per MMBtu/hour-month)	2620
Variable Charge ($ per MMBtu)	5.09
Availability	93%
Boiler Efficiency	80%
MSW Fuel ($/MMBtu)	4.00
Heating Unit Cost ($/MMBtu/hr)	21

Phase 1 Cooling System Summary Cost

District Cooling Pricing Structure	
Peak Cooling Demand (ton/sq.ft.)	575
Peak Cooling Capacity (ton)	1287
Equivalent Full Load Hours	900
Cooling Plant Efficiency (Kw/Ton)	0.70
Electrical Price ($/KWh)	0.08
Annual Cooling Consumption (ton-hr)	1,158,261
Demand Charge ($ per ton per month)	27
Variable charge ($ per ton-Hr)	0.09
Cooling unit cost ($/ton-hr)	0.45

Capital Cost	Phase 1	
Cooling Plant	$	4,103,000
Distribution Piping	$	1,244,000
Building	$	-
Subtotal	$	5,347,000

Operating Assumption	Cost($)
Capital Recovery	341,457
Electricity	64,863
Water and Sewer, Chemical	40,539
Subtotal Cooling Consumtion	105,402
Subtotal Cooling Demand	411,131

Financial Projection- Phase 1

Building Conventional System Pricing	
Average Heating+Cooling Cost ($/Sft)- 20	1.85
District Thermal Pricing	
Average Heating + Cooling Cost ($/SF)-	1.75
Returns	
IRR	5.01%
District Heating and Cooling Savings	
Average Over 20 yrs	4%
Cumulative	$ 1,805,000.00

Financing	
Equity	10%
Debt Amount (1000$)	10,049
Interest Rate	5.00%
Capital Recovery Factor	7.095%
Term	25

Financial Projections - Phase 1

Potential Changes to Revenues

- Reduced Direct Electric Revenue $72K-$158K
- Thermal Revenues $480K-$800K
- Additional O&M Costs $10-$30K
- Reduced Water Costs $22-$50K
- Other Potential Revenue streams
  - ,
  - Carbon Credits

Major Benefits & Opportunities

- Improved Plant Efficiency- improves with added customers.
- Reduced water use and discharge.
- Reduces fossil fuel use
- Renewable Energy.
- Lower City Carbon Footprint relative to conventional equipment.
- Current PPA expires in three years.
- Urban area with potential rapid development.
- Interconnect with NRG district steam system

Challenges

- Timing and uncertainty among the developers for the anchor customers.
  - New Building on Independent System.
  - Area development vs building development.
- Back-up sources - permitting for on-site heating generation.
- Rate structure between steam and hot water.