Evaluation of Alternatives to Coal-Fired Steam at MCB Camp Lejeune

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Project Objectives

- Develop comprehensive Baseline Definition (Current Operation)
- Obtain concurrence on baseline
- Identify alternatives to current operation
- Economic Assessment of Alternatives
- Identify most cost effective means to supply comfort heat and hot water

Baseline definition

- Operating
- Maintenance
- Environmental
- Capital
- Life Expectancy

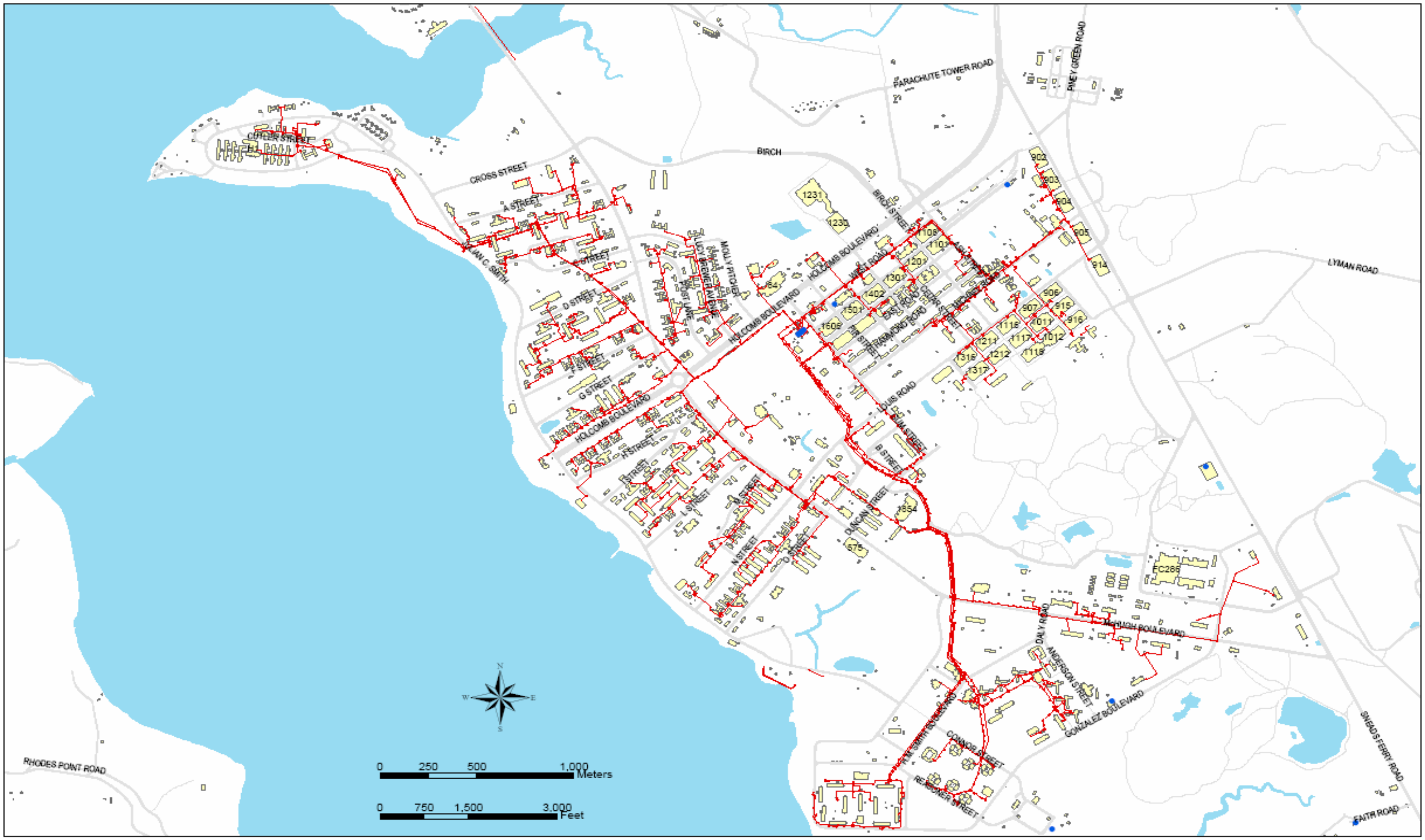
Current System Statistics

- Main Steam Plant (industrial area)
  - 4 coal-fired boilers @100,000 lb/hr steam each;
    1 oil/gas-fired boiler @ 80,000 lb/hr steam
- Steam Distribution System
  - ~343,000 feet of steam and condensate lines (65 miles) supply heat and hot water to ~300 buildings (10M sq ft)
- Current Operating Cost ~$10 million/year
  - $6M fuel, $1M capital, $3M O&M

Baseline Definition - Methodology

- Design specs for MSP and steam distribution system
- Daily, monthly, and annual fuel use and steam production records
- Fuel and electricity costs
- Operating, maintenance, and repair costs for the MSP and distribution systems
- GIS records

Steam Network



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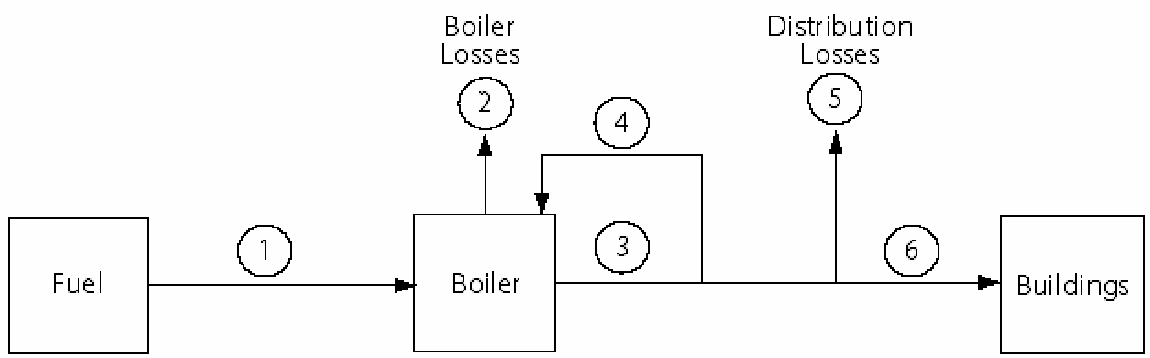
Baseline Definition - Conclusions

- Fuel Prices in mid-2005 significantly higher than in 2004
  - Coal and NG 100% higher than in 2004
  - Fuel oil 30% higher
  - Electricity 12% higher
- Steam demand varied significantly
  - Average: 104,000 lb/hr (120 MMBtu/hr)
  - Minimum: 75,000 lb/hr (87 MMBtu/hr) in summer
  - Maximum: 220,000 lb/hr (254 MMBtu/hr) at 10 ºF ambient

Baseline Definition - Conclusions

- Based on the annual average and minimum summer steam demands:
  - 23% of the annual fuel input is delivered to end users
  - 77% is associated with boiler losses, auxiliary steam use by the MSP, and distribution losses
- Flooding of steam tunnels during heavy rains increases steam demand by up to 100,000 lb/hr (one boiler)

MSP Energy Balance



Stream	Fuel	Boiler Losses	Steam Produced	Auxiliary Steam Usage	Steam Distribution Losses	Steam to End Users
ID	1	2	3	4	5	6
MMBtu/hr	133	13	120	11	78	31
Percent of Fuel	100	10	90	8	59	23
Percent of Steam			100	9	65	26

Baseline Definition – Conclusions

- Primary causes of steam distribution system heat losses:
  - Deterioration of insulation on steam lines
  - Condensate losses from leaking FRP pipe
  - High boiler water blowdown due to heat exhanger corrosion

Baseline Definition - Conclusions

- Based on calculated heat losses from steam distribution system:
  - Repair of insulation and replacement of FRP would reduce heat losses by ~50%
  - These repairs would reduce annual steam demand and fuel consumption by ~37%
  - Value of reduced fuel consumption is ~$2 million per year

Options Assessment Methodology

- Energy Demand
  - Used 2010 for planning horizon
  - Estimated fuel requirements based on end-user heating & hot water (HHW) demand and delivery efficiency
  - Assumed 2010 HHW demand similar to 2004-05 level
  - Assumed no change in MSP operation or auxiliary loads
  - Calculated conduction heat loss to estimate heat losses from “design” distribution system

Energy Requirements

Stream	Design (MMBtu/hr)	Current (MMBtu/hr)
Fuel	83	133
Steam Generation	75	120
Auxiliaries	7	11
Distribution Losses	37	78
End Use	31	31

Options Assessment Methodology

- Fuel Costs
  - Coal: $3.70/MMBtu ($100/ton)
  - #2 Fuel Oil: $12.50/MMBtu ($1.75/gallon)
  - Natural Gas: $16.00/MMBtu ($1.6/therm)
  - Electricity: $14.65/MMBtu ($0.05/kWh)
- Capital Costs
  - PO data for similar MSP projects at CLJ
  - RSMeans Building Construction (retrofit factor = 1.5)
  - $1 million/yr for system upgrades

Options Assessment Methodology

- O&M Costs
  - Labor
    - Labor hours estimated based on fuel and equipment type
    - Units above 50 psig require 24-hr manning
  - Maintenance materials
    - Based on Public Works data for similar work
  - Chemicals for make-up water
    - Annual costs provided by Public Works
    - Water and sewer charges not included

Options Assessment Methodology

- Annualized and Life Cycle Costs
  - Constant 2005 dollars
  - Economic life 15 yrs (25 yrs for boilers)
  - Discount Rate of 5%
  - Life-cycle cost (LCC) calculated as Net Present Value of annualized cost for 15-yr period
- Environmental Impacts
  - SO_2 – based on fuel sulfur content
  - NOx & CO – based on AP-42 factors
  - PM – based on test data for MSP boilers
  - Solid Waste – based on fuel ash content

Options Description

- 1: Continue Current Operation (Baseline)
- 2: Repair Steam Distribution System
- 3: Convert MSP to Natural Gas
- 4: Repair Distribution System & Convert to Gas
- 5: Install Gas Boiler at French Creek to Satisfy Low-season (Spring – Fall) Demand
- 6: Install 2 Gas Boilers at French Creek to Satisfy Year-round Demand
- 7: Install 25-MMBtu/hr Boilers at Distribution Nodes
- 8: Install 5-MMBtu/hr Boilers Near End Users
- 9: Cogenerate Electricity at MSP
- 10: Convert to Electric Space & Hot Water Heating

Example Cost Summary

Energy Requirements			Avg MMBtu/hr (steam)	Avg MMBtu/hr (fuel)		Btu/yr (bil)				
Energy Demand			31			270				
Plant Auxiliaries &. Distribution System Losses			44			385				
Total Energy Requirements			75	83		655				
Energy Distribution	UOM	Usage	MMBtu/UOM	$/UOM	Conversion Efficiency	Distribution	$/MMBtu	Btu/yr (bil)		Annual Cost
Coal	ton	23,813	27	100	0.90	0.88	3.70	643		2,381,336
#2 Fuel Oil	kgal	621	140	1,750	0.88	0.12	12.50	87		1,086,982
Natural Gas	mcf	0	1.025	16.40	0.83	0.00	16.00	0		0
Electricity	MWh	2,725	3.412	50	0.95		14.65	9		136,252
Total						1.00		739		3,604,571
Capital Costs	Unit	# of Units	$/Unit	Cap $ (mil)		Discount Rate	Econ Life			Annualized Cost
Steam Generation	each	0	0	6.9		0.05	15			661,293
Replace insulation	ft	100,000	20	2.0		0.05	15			192,685
Replace condensate lines	ft	55,000	135	7.4		0.05	15			715,341
Replace heating elements	each	200	1,500	0.3		0.05	15			28,903
Total				16.6						1,598,222
Operating & Maintenance Costs	Unit	# of Units	$/Unit							Annual Cost
Op labor-MSP	hr	40,000	27.00							1,080,000
Op labor-Distribution	hr	29,333	27.00							792,000
Maintenance Labor	hr	16,240	27.00							438,467
Maintenance Materials	$	507,947	1.00							507,947
Chemicals	kgal water	13,530	1.70							23,000
Total										2,841,413
Total Annual Cost (incl Annualized Capital)										**8,044,206**
Life Cycle Costs										**83,496,110**
Environmental Tradeoffs	SO2 EF	SO2 tpy	NOx EF	NOx tpy	PM EF	PM tpy	CO EF	CO tpy	SW EF	SW tpy
Coal	1.58	506.7	0.815	261.9	0.200	64.3	0.019	6.0	6.7	2,143
#2 Fuel Oil	0.51	22.1	0.143	6.2	0.014	0.6	0.036	1.6	1.0	44
Natural Gas	0.00059	0.0	0.098	0.0	0.0074	0.0	0.082	0.0	0.0	0
Total Emissions (tons per year)		529		268		65		8		2,187
(All EF values are in lb/MMBtu)										

$8.0 million ÷ 270 bil Btu =
$30/MMBtu of steam to end users

Screening Assessment Results

Option	Energy (billion Btu/yr)	LCC (million $)			
		Energy	Cptl	O&M	Tot
1: Baseline	1,182	60	10	32	102
2: Repair Steam Distribution System	739	37	17	30	84
3: Convert MSP to Natural Gas	1,273	211	8	19	238
4: Repair Steam Line & Convert to Gas	795	132	14	17	162

Screening Assessment Results

Option	Energy (bil Btu/yr)	LCC (million $)			
		Energy	Cptl	O&M	Tot
5: Seasonal Boiler at French Creek	734	45	17	31	94
6: Year-round Boilers at French Creek	733	59	18	32	109
7: 25-MMBtu Boilers at Distribution Nodes	699	116	14	22	152
8: 5-MMBtu Boilers Near End Users	625	104	7	16	127

Screening Assessment Results

Option	Energy (bil Btu/yr)	LCC (million $)			
		Energy	Cptl	O&M	Tot
9: Electricity Cogeneration	1,991	138	21	-4	156
10: Electric Heat & Hot Water	298	23	36	11	71

8*: Distributed Boilers at $10 Gas	625	65	7	16	89
10*: Electricity at $0.08/kWh	298	37	36	11	84

Screening Assessment Results

- Attractiveness of options strongly influenced by fuel cost differential between coal, gas, and electricity
- Repair of steam distribution system economically attractive if MSP operation continued
- Use of natural gas unattractive unless fuel cost is ~$10/MMBtu or lower
- Conversion to electricity appears attractive, but depends on electricity price and conversion capital cost
- Environmental costs do not significantly alter relative attractiveness of options at current emission valuations

Lowest LCC Options

Option	Energy (bil Btu/ yr)	LCC (million $)			
		Energy	Cptl	O&M	Tot
1: Baseline	1,182	60	10	32	102
2: Repair Steam Distribution System	739	37	17	30	84
10: Electric Heat & Hot Water	298	23	36	11	71
8*: Distributed Boilers at $10 Gas	625	65	7	16	89
10*: Electricity at $0.08/kWh	298	37	36	11	84

Selection of Phase II Options

- Key Technical Issues
  - Future energy prices and rate structures
  - Adequacy of existing utility infrastructure
    - Cost of upgrading electrical and gas lines
  - Technology alternatives under Option 10
    - Assessment of existing building HVAC systems
    - Technical and economic tradeoffs with various electric technologies (heat pumps, boilers, HW heaters)
    - Retrofit of technologies to existing HVAC systems
- Base Concerns/Issues

Lessons Learned

- Sensitivity to inefficiencies
- BTU efficiency does not always equate to cost efficiency
- Plant-level buy-in is important; Command-level support is essential
- Project objectives and boundaries must be identified up-front!

Next Steps

- Further, more detailed evaluation of top 4 alternatives
- Identification of specific construction, installation, and demolition locations
- Development of final budgetary estimates
- Development of follow-on design or design-build project

QUESTIONS?