Department of Technology, Management and Budget
Facilities & Business Services Administration
Design and Construction Division
For
Michigan Department of Corrections
Central Boiler Plant (Decentralization)
Technical Energy Assessment Audit
File No. 472/12168.DCS, Index No. 02550

February, 2013

*All cost and savings are +/- 10%.
TABLE OF CONTENTS

CENTRAL BOILER PLANT (DECENTRALIZATION)

Section 1—Existing Conditions ......................................................................................................................... 3
Section 2—Base Year Energy Usage.................................................................................................................. 8
  - Water & Sewer Utility Summary (p. 9)
  - Utility Cost Baseline & Summary (p. 10)
Section 3 - Energy Conservation Measures .................................................................................................... 11
  - Construction Cost Estimate - Boiler Decentralization (p. 17)
  - MTU Boiler Decentralization Cost Breakdown (p. 18)
  - ICF Boiler Decentralization Cost Breakdown (p. 119)
  - DORMITORY Boiler Decentralization Cost Breakdown (p. 20)
  - RMI Boiler Decentralization Cost Breakdown (p. 20)
  - Savings Calculations (p. 21-26)
  - Replace Existing Steam Boiler, Economizers, Controller, New Steam/Condensate Piping (p. 27)
  - Construction Cost Estimate - Replace Central Boiler/ Recommissioning (p. 29)
  - Steam Boiler Replacement Savings Calculations(p. 31)
  - Mechanical Boiler, Domestic Water Heater Specifications(p. 33)
  - Mechanical Decentralization Schematics
  - ICF Mechanical Recommissioning
  - MTU Mechanical Recommissioning

*All cost and savings are +/- 10%.
Section 1: Existing Conditions

1. The Central Plant has (3) 2000 hp boilers that are over 40 years old. The boilers provide steam to the reformatory, dormitory, ICF and MTU. The steam in each facility is used for heating, domestic hot water, kitchen equipment (kettles, combi oven, steamers) and clothes dryers.

2. During the summer, boiler #1 or 3 are operated with boiler #2 operated in the winter. A boiler is always kept on for standby.

3. Boiler #2 is the most efficient to operate in the winter but is oversized to operate efficiently in the summer due to the low load.

4. Boiler #2 has an economizer that heats the makeup water. The economizers for 1 and 3 do not work.

5. The boilers are manually controlled with no automatic control based on oxygen or combustion efficiency.

6. The feed water meter and condensate return meters do not work making it difficult to determine the amount of steam generated and the amount of water returned from each facility.

7. The boiler feed water is filtered, softened and de-alkalized. The dealkalizer is in need of replacement and requires frequent regeneration wasting water.

8. There is no back up fuel for the boilers; if natural gas is lost RMI, IBC, MTU, ICF and the Dormitory will have no heating, domestic hot water, kitchen steam kettles or dryers.

9. The steam and condensate piping for ICF and MTU are independent of each other with the dormitory steam connected to the ICF piping.

10. The piping for MTU is below ground with multiple steam pits. The steam piping is original but the condensate piping was replaced in 1979. The piping is in poor condition with leaks due to deteriorated piping, bad seals and traps. The steam pits show numerous leaks and drips that are a continuous source of maintenance. When the condensate piping at MTU was replaced, the drip legs from the steam piping were never connected to the new condensate returns discharging the condensate onto the ground wasting water. Natural gas that is needed to heat the makeup water and chemical that are needed to treat the makeup water.

11. ICF piping is above ground and easier to access and repair. The steam valve pipes for the ICF also show leaking steam and condensate.

12. The steam traps are surveyed regularly; the year 2012 report shows only a small amount of traps requiring maintenance. No ECM’s are recommended for the steam traps as it is a regular maintenance item.

<table>
<thead>
<tr>
<th>Facility</th>
<th>Total Traps</th>
<th>Traps requiring some maintenance based on 2012 testing</th>
<th>% to be repaired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorm</td>
<td>110</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>ICF</td>
<td>76</td>
<td>5</td>
<td>7%</td>
</tr>
<tr>
<td>Reformatory</td>
<td>686</td>
<td>33</td>
<td>5%</td>
</tr>
<tr>
<td>MTU</td>
<td>212</td>
<td>13</td>
<td>6%</td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.
13. Taking into consideration the age of the boiler, burner type, lack of boiler controls, the amount of leaks in the steam and condensate system, poor insulation in areas, and no drip leg condensate return we estimate the overall seasonal efficiency of the boilers to be 65% to 70% in the winter and 60% to 65% in the summer.

The redline shows the path of the steam and condensate piping that serves MTU, ICF and the Dormitory, which is connected to the piping going to ICF. The distance from the central power plant MTU is approximately 3,600 feet. Four pipes run from the boiler plant to MTU and ICF for a total of more than 14,000 feet of pipe (about 2.5 miles). The steam and condensate piping for MTU is buried and in poor condition with the steam piping being original (1954) and the original condensate replace in 1979. The piping to ICF dorm is above ground and was original installed in 1985 with the addition to the dorm in 2004.

All of the existing piping, steam vaults, steam traps and equipment would not be need under ECM #1 – Boiler Decentralization

ECM#1 is optional and based on 15 year financing.

Separate hi efficiency hot water boilers would be added to ICF and MTU.

*All cost and savings are +/- 10%. 
Diesel generator in central plant provides back up power to the reformatory and dormitory. The automatic start for the generator is based on (1) leg of (3) of the incoming power lines, the loss of the other (2) legs (brown out) will not start the generators. The generator must be manually shut down.

As part of **ECM #1 – Boiler Decentralization**

ECM #1 is optional and based on 15 year financing.

The generator controls would be revised to automatically start based on the loss of any power leg and automatically shut off.

Condensate from the drip trap is discharged on to the ground wasting water and natural gas. When the MTU condensate piping was replaced in 1979, the drip traps were not reconnected to the condensate piping.

**ECM #1 – Boiler Decentralization**

*All cost and savings are +/- 10%.*
Steam rises from one of the steam vaults indicating the loss of steam from the piping system. Under ECM #1 – Boiler Decentralization

ECM#1 is optional and based on 15 year financing.

The steam and condensate piping to MTU, ICF and the Dorm would be abandoned in place and hi efficiency boiler will be added to each facility.

Area of dead grass above the steam piping leading to MTU is an indication of heat loss. Under ECM #1 – Boiler Decentralization

ECM#1 is optional and based on 15 year financing.

The underground steam and condensate piping would abandoned in place. MTU would be converted to hot water heating with hi efficiency boilers savings natural gas, water and sewer costs, chemicals and regular maintenance on the underground piping.

*All cost and savings are +/- 10%.
The above are pictures of steam traps, heat exchangers, pressure reducing stations, condensate pumps and 2.5 miles of piping at ICF and MTU that will not be required and be removed (mechanical equipment) or abandoned in place (piping) as part of ECM #1 – Boiler Decentralization.

ECM #1 is optional and based on 15 year financing.

In total there is more than 14,000 feet of steam and condensate piping including all piping to each building and in each building that would not be needed, 288 steam trap will be eliminated, 23 condensate pumps would be eliminated, 31 hot water heat exchangers including pressure reducing and shut off valves will be eliminated, all steam coils will be replaced with new hot water coils, propane back up will be provided for both MTU and ICF (no current heating back up), replacement of 9 steam kettles with new gas fired kettles, replacement of 12 steam dryers with new gas fired dryers.

*All cost and savings are +/- 10%.
Section 2: Base Year Energy Usage

ELECTRICAL CONSUMPTION

The Central Plant provides power to RMI and Dorm in addition to the power requirements of the central plant.

The following usage table is the estimated electrical usage for the Central Boiler Plant based on comparing RMI and Dorm usage to the total.

<table>
<thead>
<tr>
<th>Usage Date</th>
<th>Total Elect Usage (Kwh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct-10</td>
<td>48,036</td>
</tr>
<tr>
<td>Nov-10</td>
<td>100,415</td>
</tr>
<tr>
<td>Dec-10</td>
<td>142,890</td>
</tr>
<tr>
<td>Jan-11</td>
<td>140,672</td>
</tr>
<tr>
<td>Feb-11</td>
<td>61,189</td>
</tr>
<tr>
<td>Mar-11</td>
<td>68,715</td>
</tr>
<tr>
<td>Apr-11</td>
<td>72,091</td>
</tr>
<tr>
<td>May-11</td>
<td>48,359</td>
</tr>
<tr>
<td>Jun-11</td>
<td>48,046</td>
</tr>
<tr>
<td>Jul-11</td>
<td>47,323</td>
</tr>
<tr>
<td>Aug-11</td>
<td>47,109</td>
</tr>
<tr>
<td>Sep-11</td>
<td>51,492</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>876,336</strong></td>
</tr>
</tbody>
</table>

NATURAL GAS UTILITY SUMMARY

Steam produced in the Central Boiler Plant is provided to the Dorm, ICF, MTU and Reformatory for space heating, domestic hot water, kitchen equipment and clothes dryers. The Central Plant actually uses very little steam for heating and will be ignored in this analysis. The DOC through the State of Michigan purchases gas through a broker or marketer and the gas is delivered to the facility by Consumers Energy. The price of natural gas due to recent drilling methods, a mild winter and economic recession is at an all-time low. We feel this will not continue and the cost of gas over the lifetime of the equipment will rise. A report from BP (British Petroleum) projects the gas costs to rise to by 61% over the next 5 years.

The following base line is based on the actual metered usage for the Central Boiler Plant.

*All cost and savings are +/- 10%.
WATER & SEWER UTILITY SUMMARY

Water is provided by the City of Ionia. There are (7) water meters which are currently read by the water company. (2) Meters use less than $10/year. Water from the remainder of the meters is provided to the Reformatory and Central Plant.

Sewer services are provided from the city of Ionia. Sewage for all of the facilities (Dorm, RMI, IBC, ICF, and MTU) is collected at single location (bar screen building) and metered with the utility charges based on this usage. The annual metered sewer usage is 1/3 more than the water usage for the individual buildings, the water and sewer should be equal or close. This indicates that other water is getting into the sanitary system i.e.: rainwater. Extensive engineering surveys and testing by the DOC indicates the Reformatory has “cross connections” of the storm sewer for rain/snow runoff discharging into the sanitary system. This was a common practice at one time, but the DOC is now being charged by the city for processing this water when it could be discharged to the nearest ditch or ponding system. The total base year metered sewer usage is 387,023 KGAL, the total base year metered water usage for all facilities is 264,277 KGAL leaving 122,746 KGAL (387.023 KGAL – 264,277 KGAL) of water that is not accounted for.

The meters that monitor the water usage for the boilers is not operating and the usage is estimated based on RMI $/inmate and square feet.

The estimated water usage for RMI is 65,800 KGAL based on inmates (see RMI Technical Energy Assessment, Base Year Energy Usage, Water & Sewer Utility Summary) The water usage for the central plant is 33,206 (99,006 KGAL total metered usage – 65,800KGAL estimated usage for RMI.) Some of this water is used for boiler make up, softener back flush, de alkalyzers, boiler blow down cool down.

Water and sewer costs have increased in the past (2) years from $5.72/KGAL to $8.06/KGAL with another water increase scheduled for 2018.

*All cost and savings are +/- 10%.
UTILITY COST BASELINE & SUMMARY

The following table summarizes the base line usage and cost that will be used for the analysis energy savings.

A base year of October 2010 to September 2011 was selected. The water and sewer costs are based on the 2012 water and sewer cost that are currently in place.

<table>
<thead>
<tr>
<th>Central Boiler Plant Steam Serving: RMI, ICF, MTU, Dorm</th>
<th>Base Year Utility</th>
<th>Base Year Utility Usage</th>
<th>Base Year Utility Cost ($/yr.)</th>
<th>Base Year Unit Cost</th>
<th>Unit Cost Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>248,838 MCF</td>
<td>$1,520,398</td>
<td>$6.11 $/Mcf</td>
<td>Estimated average natural gas cost over the term of the contract</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Central Boiler Plant</th>
<th>Base Year Utility</th>
<th>Base Year Utility Usage</th>
<th>Base Year Utility Cost ($/yr.)</th>
<th>Base Year Unit Cost</th>
<th>Unit Cost Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity (Estimated)</td>
<td>876,336 KWH</td>
<td>$ 77,465</td>
<td>$ 0.09 $/KWH</td>
<td>Actual blended $/KWH based on base year costs</td>
<td></td>
</tr>
<tr>
<td>Water (Estimated)</td>
<td>33,206 KGAL</td>
<td>$ 81,355</td>
<td>$ 2.45 $/KGAL</td>
<td>Actual cost of water that took effect in June 2012</td>
<td></td>
</tr>
<tr>
<td>Sewer (Estimated)</td>
<td>155,952 KGAL</td>
<td>$874,891</td>
<td>$ 5.61 $/KGAL</td>
<td>Actual cost of sewer that took effect in June 2013</td>
<td></td>
</tr>
</tbody>
</table>

Total | $2,554,108 |

*1 total sewer usage is base year central boiler plant usage (33,206 KGAL) + unaccounted for sewer usage.

<table>
<thead>
<tr>
<th>Sewer Base Year</th>
<th>Reading From</th>
<th>Reading To</th>
<th>Total Days</th>
<th>total $ Due</th>
<th>$/kGal</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/1/2010</td>
<td>12/31/2010</td>
<td>91</td>
<td>92947</td>
<td>$122,579.60</td>
<td>$1.43</td>
</tr>
<tr>
<td>1/1/2011</td>
<td>1/31/2011</td>
<td>30</td>
<td>28641</td>
<td>$42,555.30</td>
<td>$1.43</td>
</tr>
<tr>
<td>4/1/2011</td>
<td>6/30/2011</td>
<td>90</td>
<td>105667</td>
<td>$357,295.00</td>
<td>$3.40</td>
</tr>
<tr>
<td>7/1/2011</td>
<td>9/30/2011</td>
<td>91</td>
<td>95214</td>
<td>$323,727.00</td>
<td>$3.40</td>
</tr>
</tbody>
</table>

*All cost and savings are +/− 10%.
Section 3: Energy Conservation Measures

ECM #1 – Boiler Decentralization

ECM#1 is optional and based on 15 year financing.

Recommended Action

We recommend the installation of separate boiler systems at ICF, MTU, Dormitory and Reformatory. The ICF and MTU will be converted from steam to hot water heating with the addition of hi-efficiency hot water boilers. A separate steam boiler system will be added to the Dormitory. The RMI will remain steam but due to the reduced load requirement, new smaller capacity steam boilers will need to be added to the existing central boiler plant.

- Estimated Energy Savings = 42,053 MCF/yr.
- Estimated Energy Cost Savings = $256,945/yr.
- Estimated Water Savings = 26,565 KGAL/yr.
- Estimated Water Cost Savings = $65,084/yr.
- Estimated Sewer Savings = 61,000 KGAL/yr.
- Estimated Sewer Cost Savings = $342,210/yr.
- Implementation Cost = $21,031,348

Implementation costs includes design and engineering, project management, contingency, performance, overhead and profit. Estimated energy and cost savings are for year one only.

Estimated water savings based on reduction of steam loss from MTU, ICF and the Dorm. Additional savings will be from reduced softener regeneration, reduced dealkalizer usage, and reduced need to cool blow down.

Estimated sewer savings is based on reduction in sewer usage from disconnecting the existing storm sewer from the sanitary system.

*All cost and savings are +/- 10%.

Existing Conditions

The existing Central Plant provides steam to the Reformatory, ICF, Dormitory and MTU. The (4) steam and condensate piping are almost 2 ½ miles in total length and portions are in poor condition. This ECM proposes to reduce the load on the existing central plant by installing separate boiler plants at MTU, ICF, Dorm and Reformatory. The boiler plants at MTU and ICF would be 90% hi efficiency hot water boilers with the buildings being converted from steam to hot water. The dormitory would remain steam heating and a separate building will be built outside the fence to house the new boiler. The RMI would remain steam and (2) new smaller steam boilers will be installed in the Central Boiler Plant.

1. The existing boilers are over 40 years old.
2. The central boilers provide steam to the Reformatory, Dormitory, ICF and MTU.
3. The steam is used for heating, domestic hot water, steam kettles, vegetable steamers and clothes dryers.
4. (1) Boilers has been retubed
5. (1) economizer out of (3) works
6. The boilers burners are not low turn down, and do not operate efficiently in the summer.

*All cost and savings are +/- 10%.
7. The steam and condensate piping for MTU is underground. The steam piping is original and the original condensate piping was replaced in 1979. The drip legs from the steam piping are not installed to the condensate return as the original piping was and is discharged to the ground wasting water and natural gas. Every year, the system experiences leaks and a path can clearly be seen in the grass where the steam piping is buried.

8. The steam and condensate piping for ICF is above ground and was installed in 1985. This piping is in better condition than MTU and is accessible, but the piping has numerous leaks and drips in the valve pits.

9. The original steam and condensate piping for the Dorm was replaced in 2004. The piping was connected to the above ground piping to ICF.

10. The existing condensate pumps are in many cases original and in need of constant maintenance and repair.

11. The existing steam coils, heat exchangers and piping at MTU is over 50 years old and in poor condition; the useful service life for this equipment is 20 to 25 years.

12. Generators provide backup power to the reformatory and dormitory. The generators will only start when one of the (3) power legs is down.

**Proposed Systems**

This ECM proposes to remove the steam heating equipment at MTU and ICF and replace them with hi efficiency boilers and domestic water heaters. Hi efficiency condensing boilers can operate at up to 95% efficiency. Most of the existing hot water heating equipment will be reused limiting use of the full efficiency of the condensing boilers. The sizing of the equipment was based on a combination of DOE-2 load run, square feet, comparison to existing equipment size.

The existing steam to hot water heat exchangers used for domestic hot water will be replaced with hi efficiency condensing domestic water heaters that are rated up to 95% efficiency.

The dormitory would remain steam heating and a separate building will be built outside the fence to house the new boiler.

The RMI would remain steam and (2) new smaller steam boilers will be installed in the Central Boiler Plant.

Sizing for heating equipment is based on current inmate population, square feet and existing equipment.

Existing power in individual building is available for equipment listed from existing panels unless otherwise noted.

**General**

1. Condensing boiler to be Aerco or approved equal. Boiler must be of equal capacity.
2. Condensing Domestic hot water heaters to be Aerco or approved equal.
3. New steam boiler to be Cleaver Brooks or approved equal.
4. Pumps to be B&G or approved equal.
5. All condensing unit heaters to be Modine Effinity93 or approved equal.
6. Provide equipment information to DOC for review of approved equal.
7. All steam and condensate piping, condensate pumps, PRV, valves, relief vents, etc. in equipment or mechanical rooms to be removed to wall, roof or floor. Cap steam and condensate piping.
8. Steam piping, condensate piping, condensate tanks and accessories in tunnels or inaccessible areas to be abandoned in place.
9. Underground piping to be abandoned in place. Piping above ceilings to be abandoned in place.
10. All equipment to be disposed of off site. Owners dumpster not to be used.

*All cost and savings are +/- 10%.*
11. All piping to be insulated and labeled with contents and direction.
12. Each facility to have (1) utility gas meter for a total of (4) meters.
13. Provide all starters and disconnects for all equipment specified.
14. Provide all structural, concrete bases, electrical and plumbing as required for all equipment installed.
15. Provide all insurance as required to meet DTMC, DOC requirements.
16. All contractors and employees to be approved by DOC for work in the fenced/inmate area.
17. All installations to meet all local and state rules, regulations and standards regarding boiler rooms and accessibility.
18. All equipment locations, accesses, chases to be approved by ICF, DOC and DTMB before installation.
19. All work shall include all necessary engineering and/or architectural design services and drawings, material, labor, supplies, trucking, handling, clean-up, receiving and unloading of equipment, disposal of all trash and demolition materials, repair of any damaged surfaces to original condition etc.
20. Provide all equipment, material, labor, sheet metal, piping, insulation, concrete work, patching, permits, inspection fees and other work as needed for a complete installation.
21. This is a Performance Contract and is not subject to any change orders for any reasons, foreseeable or unforeseeable except for additional work specifically requested by the Owner. Quotations are to be all inclusive. Please make allowances in your quotations for all circumstances, as change orders are not permitted in a performance contract.
22. Any architectural or structural items needed for this mechanical work shall be included in your pricing, including any penetrations, painting of pipe in exposed areas, pipe labeling, general patch & paint, structural improvements, concrete bases, etc.
23. Provide all sheet metal, duct insulation, curbs, supports and piping required to meet the intent. Make all required openings in structures and complete framing and support of their mechanical work. Pipe-wall penetrations are cut and completely fireproofed by the contractor.
24. Provide all required power to equipment. Assume electric power is available and adequate for the equipment as specified. Provide power from nearest breaker or panel to new equipment. Provide all starters, disconnects, fuses as required.
25. Permits: The Contractor shall furnish and pay for all permits and inspections required for applicable work.
26. Codes: All work performed shall comply with all applicable codes and ordinances including all Building Codes, Mechanical Codes, Plumbing Codes, Electrical Codes and Fire Codes. If required by the local codes the building systems affected by this work shall be brought up to current code unless grandfathered under the code.
27. Equipment Sizing: All contractors are responsible for determining the appropriate equipment size. It is required that the contractor have a licensed professional engineer verify the equipment size before construction begins.
28. As much as possible to use local contractors and labor if available and meets the scope requirements including approval by DOC.
29. Subcontractor shall be responsible for proper disposal and off-site removal of all material and debris accumulated at the jobsite. Provide dumpster service for your work.
30. Subcontractor shall provide submittals in electronic format. Your pricing for each quote must stand alone, independent of the acceptance or rejection of the other quotes.
31. Demolition and construction CANNOT interfere with the operations of the Prison. Provisions must be made to work on equipment when not in use either seasonally or by shifts.
32. Provide performance and payment bond.

*All cost and savings are +/- 10%.
33. Include all applicable and special taxes that may be assessed locally on contract work such as a “Business Tax” or “Use Tax” for the privilege of doing business in the City, County or other Government jurisdiction.

**MTU**

1. Refer to drawings in this section for further information.
2. Remove the existing domestic hot water heat exchangers and storage tanks in the lower level of the maintenance building.
3. Remove existing condensate tank and all steam and condensate piping and accessories in lower level.
4. Remove steam and condensate piping in (10) mechanical rooms.
5. Remove all steam to hot water heat exchangers and accessories in each building. (typical 10)
6. Install (4) hi efficiency condensing boilers in the maintenance building lower level.
7. Install (3) 50 hp pumps with variable frequency drives.
8. Install new (5) hi efficiency domestic water heaters and storage tanks.
9. Existing domestic hot water piping to buildings to be reused.
10. Install new hot water and return water piping in tunnel system to each building.
11. Remove existing heat exchangers in each building and connect to new hot water piping.
12. Replace existing steam heating coils with new hot water coils.
13. Replace steam finned tube in field house with new hot water finned tube.
14. Remove existing unit heaters and install (25) how water unit heaters in school shop areas.
15. Instal hi efficiency rust, sediment filter for boiler.
16. Install new gas piping from Consumers to maintenance building.
17. Install new gas piping to each building in tunnel system.
18. Provide new power panel in Maintenance lower level for new equipment.
19. Provide and install variable frequency drives as listed below as manufactured by Danfoss, Toshiba, Square D or other approved equal. VFD to include filters and impedance devices to prevent interference with MCU security and electrical system.
20. Remove (6) existing steam clothes dryers. Provide and install (6) new gas 75 lb. clothes dryers with fire suppression, ducted make up air and prison package.
21. Remove (5) steam kettles. Provide and install new (5) 80 gallon gas steam kettles.
22. Remove existing steam to hot water heat exchanger for dishwasher. Provide gas fired dishwasher pre heater.
23. Provide and install (1) 30,000 gallon propane tank. The propane will serve both MTU and ICF. Furnish and install supports, fencing, vaporizer, piping, power, bulkhead, pumps, valves, reliefs, start up and training.

**ICF**

1. Refer to drawings in this section for further information.
2. Housing Units (typical 5): Remove existing steam to hot water heat exchangers in each housing unit and install (2) hi efficiency condensing boilers. Connect to existing hot water system.
3. Units 100, 200, 300 to share boiler system and pumps. Remove (3) existing steam to hot water heat exchangers and install (3) hi efficiency condensing boilers in building 300 mechanical room. Provide underground piping to building 200 and from building 200 to building 100. Provide (2) 15 hp pumps.
4. All flues and intakes to be run as high as possible with limited inmate accessibility. All access thru floors to be securely enclosed.
5. Install new gas underground piping from central gas piping near maintenance building to each new boiler room.

*All cost and savings are +/− 10%.*
6. MSI: remove existing steam to hot water heat exchanger and accessories, pump, (8) hot water unit heaters. Install (8) new condensing unit heaters.
7. Housing Units: Remove existing steam to domestic hot water heat exchanger, tank, and install (2) new hi efficiency domestic water heaters and storage tanks. Connect to existing hot water.
8. Housing Units and MSI: Remove (6) existing steam clothes dryers. Provide and install (6) new gas 75 lb. clothes dryers with fire suppression, ducted make up air and prison package.
9. Remove (4) steam kettles, (1) steam combi oven, (1) steamer. Provide and install (4) 80 gallon gas steam kettles, (1) 132,700 Btu gas combi oven and (1) 240,000 Btu gas steamer.
10. Remove existing steam to hot water heat exchanger for dishwasher. Provide gas fired dishwasher pre heater.

**Reformatory**
1. Refer to drawings in this section for further details.
2. Remove (2) existing boilers. (1) existing boiler to remain as back up.
3. Existing deaerator, condensate feed tanks and pumps, blow down, de alkalyzers, softeners to be reused.
4. Install (2) new smaller capacity boilers with low turndown, economizers and trim controls in the central plant.
5. Provide new feed water pumps.
6. Install automatic startup of generators based on the incoming power. Generator to automatically start if any of the 3 legs is lost. Generator to automatically shut down.

**Dormitory**
1. Refer to drawings in this section for further details.
2. Disconnect and abandon steam and condensate piping to the steam piping pit near dormitory.
3. Install new boiler building near steam piping.
4. Install (2) new steam boilers with controller and connect to existing steam piping in steam piping pit.
5. Install softener, feed pumps.

See below for sample specifications for hi efficiency boilers, hi efficiency domestic water heaters and pumps.

**Mechanical Recommissioning**
Due to the age and condition of the mechanical equipment at ICF and MTU ESG recommends that the mechanical equipment be rebuilt or replaced. See ICF and MTU **Mechanical Recommissioning** matrix. The following is a scope of equipment included:

- Replace supply fan bearings.
- Clean supply fan blower wheels
- Replace supply fan motors with new energy efficient
- Replace supply fan sheaves, flywheels, and belts. Replace shafts where required.
- Rebalance central air handler.
- Replace return air fan bearings
- Clean return air fan blower wheel
- Replace return air fan motors with new energy efficient
- Replace return air fan sheaves, flywheels, and belts. Replace shafts where required.

*All cost and savings are +/- 10%.
• Replace general exhaust fans (excluding kitchen, welding, wood, shop or other specialty exhaust fans)
• Replace outside air, return air, exhaust air and relief dampers.
• Replace multizone dampers
• Replace face and bypass dampers
• Replace existing hot water coils
• Replace hot water control valves
• Replace pipe mounted (including domestic hot water) and base mounted pumps. Rebalance at pump.
• Thorough cleaning of entire air handling unit (excluding ductwork)
• Clean fresh air intakes.
• Replace kitchen MUAU at ICF.
• Replace existing softener at ICF
• Replace existing softener at MTU.
• Labeling of all equipment.
• Existing hot water finned tube radiation, unit heaters, and cabinet unit heaters to be reused.
• Existing cabinet unit heaters and hot water unit heaters to be cleaned, coils and motors replaced as required.
• Existing shut off valves, balancing valves, dampers to be reused where possible. Include allocation for new shut off, balancing valves, thermometers, pressure reducing valves, strainers, triple duty valves, etc., as required.
• (1) Year parts and labor warranty for all new and existing equipment that will be reused.

*All cost and savings are +/- 10%.
### Construction Cost Estimate

<table>
<thead>
<tr>
<th>Client</th>
<th>MDOC and DTMB</th>
<th>Estimate/Rev. Date:</th>
<th>2-13-13</th>
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<tbody>
<tr>
<td>Project</td>
<td>Decentralization</td>
<td>Contract #:</td>
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<tr>
<td>Location</td>
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#### HEATING SYSTEM UPGRADE/MECHANICAL RE-COMMISSIONING

<table>
<thead>
<tr>
<th>Item Description</th>
<th>Qty.</th>
<th>Unit</th>
<th>Unit Cost</th>
<th>Total</th>
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<tr>
<td>See attached Construction cost estimate sheets for further breakdown</td>
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<tr>
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<tr>
<td>(8)</td>
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<td>(9) TOTAL HEATING SYSTEM UPGRADE/MECHANICAL RE-COMMISSIONING</td>
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*Estimates +/- 10% and are based on Means, past experience, vendor pricing and contractor review.*

The above is a summary of the estimated costs for the proposed ECM's. Further information can be found in the write up and description for each section. The above are for budgetary purposes only.

*All cost and savings are +/- 10%.*
### MTU - Boiler Decentralization Cost Breakdown

<table>
<thead>
<tr>
<th>Building</th>
<th>Type</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor (1.2 for work in fence)</th>
<th>Total Adjusted Cost</th>
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<td>$407,040</td>
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<td>$21,200</td>
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<td>$159,000</td>
<td>1</td>
<td>$159,000</td>
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<td>$21,200</td>
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<tr>
<td>24</td>
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<td>$954</td>
<td>$10,494</td>
<td>1.2</td>
<td>$12,593</td>
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<tr>
<td>25</td>
<td>Coil piping/ preheat pump</td>
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<td>$4,240</td>
<td>$46,640</td>
<td>1.2</td>
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<tr>
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<td>$12,593</td>
</tr>
<tr>
<td>31</td>
<td>Coil piping/preheat pumps</td>
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<td>$4,240</td>
<td>$46,640</td>
<td>1.2</td>
<td>$55,968</td>
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<td>34</td>
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<td>$31,800</td>
<td>1.2</td>
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<tr>
<td>35</td>
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<td>$13,250</td>
<td>1.2</td>
<td>$15,900</td>
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<td>36</td>
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<td>$502,664</td>
<td>$502,664</td>
<td>1</td>
<td>$502,664</td>
</tr>
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</table>

**TOTAL**                                                                                                         | $5,751,867

Above costs based on Means, Vendor pricing, contractor review and past experience

*All cost and savings are +/- 10%.
ICF - Boiler Decentralization Cost Breakdown

<table>
<thead>
<tr>
<th>Building</th>
<th>Type</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor (1.2 for work in fence)</th>
<th>Total Adjusted Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Demolition</td>
<td>1</td>
<td>$106,500</td>
<td>$106,500</td>
<td>1.2</td>
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<td>$319,500</td>
<td>1.2</td>
<td>$383,400</td>
</tr>
<tr>
<td>4</td>
<td>Vent Chase</td>
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<td>$106,500</td>
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<tr>
<td>5</td>
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<td>$63,900</td>
</tr>
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Above costs based on Means, Vendor pricing, contractor review and past experience

*All cost and savings are +/- 10%.
Dormitory - Boiler Decentralization Cost Breakdown

<table>
<thead>
<tr>
<th>Building</th>
<th>Type</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor (1.2 for work in fence)</th>
<th>Total Adjusted Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Demolition (piping)</td>
<td>1</td>
<td>$16,125</td>
<td>$16,125</td>
<td>1.2</td>
<td>$19,350</td>
</tr>
<tr>
<td>2</td>
<td>4115 MBH Steam Boilers (equipment)</td>
<td>2</td>
<td>$75,250</td>
<td>$150,500</td>
<td>1</td>
<td>$150,500</td>
</tr>
<tr>
<td>3</td>
<td>Install Boilers</td>
<td>2</td>
<td>$75,250</td>
<td>$150,500</td>
<td>1</td>
<td>$150,500</td>
</tr>
<tr>
<td>4</td>
<td>Blowdown separator</td>
<td>1</td>
<td>$5,375</td>
<td>$5,375</td>
<td>1</td>
<td>$5,375</td>
</tr>
<tr>
<td>5</td>
<td>Boiler feed system</td>
<td>1</td>
<td>$26,875</td>
<td>$26,875</td>
<td>1</td>
<td>$26,875</td>
</tr>
<tr>
<td>6</td>
<td>Stacks</td>
<td>2</td>
<td>$5,375</td>
<td>$10,750</td>
<td>1</td>
<td>$10,750</td>
</tr>
<tr>
<td>7</td>
<td>Piping (steam and domestic)</td>
<td>200</td>
<td>$133</td>
<td>$26,660</td>
<td>1.2</td>
<td>$31,992</td>
</tr>
<tr>
<td>8</td>
<td>3&quot; Gas piping</td>
<td>720</td>
<td>$11</td>
<td>$8,166</td>
<td>1</td>
<td>$8,166</td>
</tr>
<tr>
<td>9</td>
<td>Gas piping excavation and backfill</td>
<td>720</td>
<td>$3</td>
<td>$2,245</td>
<td>1</td>
<td>$2,245</td>
</tr>
<tr>
<td>10</td>
<td>Build boiler room</td>
<td>1008</td>
<td>$97</td>
<td>$97,524</td>
<td>1</td>
<td>$97,524</td>
</tr>
<tr>
<td>11</td>
<td>Replace PRV</td>
<td>1</td>
<td>$5,375</td>
<td>$5,375</td>
<td>1</td>
<td>$5,375</td>
</tr>
<tr>
<td>12</td>
<td>Softener</td>
<td>1</td>
<td>$32,250</td>
<td>$32,250</td>
<td>1</td>
<td>$32,250</td>
</tr>
<tr>
<td>13</td>
<td>Electrical Boilers and accessories</td>
<td>2</td>
<td>$8,063</td>
<td>$16,125</td>
<td>1</td>
<td>$16,125</td>
</tr>
<tr>
<td>14</td>
<td>Boiler room</td>
<td>400</td>
<td>$12</td>
<td>$4,730</td>
<td>1</td>
<td>$4,730</td>
</tr>
<tr>
<td>15</td>
<td>Misc expenses (10%)</td>
<td>1</td>
<td>$54,241</td>
<td>$54,241</td>
<td>1</td>
<td>$54,241</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$615,997</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Above costs based on Means, Vendor pricing, contractor review and past experience

RMI - Boiler Decentralization Cost Breakdown

<table>
<thead>
<tr>
<th>Building</th>
<th>Type</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor</th>
<th>total adjusted cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Demolition (2) Boilers</td>
<td>1</td>
<td>$188,479</td>
<td>$188,479</td>
<td>1</td>
<td>$188,479</td>
</tr>
<tr>
<td>2</td>
<td>Demo (2) economizers</td>
<td>2</td>
<td>$21,578</td>
<td>$43,156</td>
<td>1</td>
<td>$43,156</td>
</tr>
<tr>
<td>3</td>
<td>30,000#/hr boilers w/ economizers</td>
<td>2</td>
<td>$308,404</td>
<td>$776,808</td>
<td>1</td>
<td>$776,808</td>
</tr>
<tr>
<td>4</td>
<td>Install Boilers</td>
<td>2</td>
<td>$194,202</td>
<td>$388,404</td>
<td>1</td>
<td>$388,404</td>
</tr>
<tr>
<td>5</td>
<td>Install economizers (30,000#/hr)</td>
<td>2</td>
<td>$43,156</td>
<td>$86,312</td>
<td>1</td>
<td>$86,312</td>
</tr>
<tr>
<td>6</td>
<td>Boiler piping, valves, and specialties</td>
<td>1</td>
<td>$194,202</td>
<td>$194,202</td>
<td>1</td>
<td>$194,202</td>
</tr>
<tr>
<td>7</td>
<td>Boiler feed pumps</td>
<td>2</td>
<td>$60,958</td>
<td>$121,916</td>
<td>1</td>
<td>$121,916</td>
</tr>
<tr>
<td>8</td>
<td>Condensate and water meters</td>
<td>4</td>
<td>$5,395</td>
<td>$21,578</td>
<td>1</td>
<td>$21,578</td>
</tr>
<tr>
<td>9</td>
<td>PRV replacement</td>
<td>5</td>
<td>$10,789</td>
<td>$53,945</td>
<td>1</td>
<td>$53,945</td>
</tr>
<tr>
<td>10</td>
<td>Back up generator modifications</td>
<td>1</td>
<td>$25,132</td>
<td>$25,132</td>
<td>1</td>
<td>$25,132</td>
</tr>
<tr>
<td>11</td>
<td>Boiler stack modifications</td>
<td>2</td>
<td>$21,578</td>
<td>$43,156</td>
<td>1</td>
<td>$43,156</td>
</tr>
<tr>
<td>12</td>
<td>Misc expenses (10%)</td>
<td>1</td>
<td>$175,461</td>
<td>$175,461</td>
<td>1</td>
<td>$175,461</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>$2,118,549</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Above costs based on Means, Vendor pricing, contractor review and past experience

*All cost and savings are +/- 10%.
SAVING CALCULATIONS

**Hi Efficiency Hot Water Boiler Retrofit at MTU and ICF**

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Gas Heating Savings [MCF]</th>
<th>Natural gas $/MCF</th>
<th>Natural gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>9,750 $ 6,110 59,571</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTU</td>
<td>16,652 $ 6,110 101,742</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>26,401 $ 6,110 161,313</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The central boiler plant provides the heating, domestic hot water, steam to steam kettles, steamers and clothes dryers. The existing steam boiler are over 40 years old, one has been retubed, only one economizer is working and there are no controls for maintaining the best efficiency.

In the summer a single boiler operates to provide steam for domestic hot water, steam kettles, food steamers and steam dryers. Due to the low load and limited turn down capability the boilers do not operate efficiently.

This ECM proposes to replace the heating at MTU and ICF with hi efficiency hot water boilers, hi efficiency domestic water heater and gas fired dryers and kitchen equipment.

**Savings Calculations**

- **Hot Water Reset Schedule**
  - Reset schedule of new hot water temperatures based on the OA temp. The HWR temperature differential is the difference between the hot water supply and return temperature at the hot water supply temperature of the system. This is based heat needed at a h

- **Condensing Boiler Efficiency**
  - The chart sets the range of efficiency that the condensing boiler will operate based on the hot water return temperature. The efficiency of the boiler is based on AERCO boilers (see Condensing Boiler Efficiency Graph.)

- **Existing Boiler Efficiency**
  - Estimated efficiency of the existing steam boilers. The boiler will operate more efficiently at lower outside air temperatures. Losses are due to burner efficiencies, shell losses, blow down, etc... and have been estimated to be 6% based on the age and operation.

- **Existing Usage**
  - The central boiler plant provides steam to MTU, ICF, RMI and the Dormitory. The usage is estimated for MTU and ICF based on total steam usage, square feet and inmate population.
  - The % of gas used for domestic is based on summer usage, inmate population and square footage of the facility.
  - The % gas used by other is the estimated usage of steam kitchen equipment (steamers, kettles) and dryers. The usage is estimated.

**Hot Water Reset Schedule**

<table>
<thead>
<tr>
<th>Outside air temperature</th>
<th>HWS at OA</th>
<th>HWR temp diff. At OA</th>
<th>HWR</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>110</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>25</td>
<td>100</td>
</tr>
</tbody>
</table>

**Condensing Boiler Efficiency**

<table>
<thead>
<tr>
<th>Proposed Efficiency at 90 F HWR at 25% load</th>
<th>Distribution and shell losses, blow down, boiler degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposed Efficiency at 140 F HWR at 100% load</td>
<td>%</td>
</tr>
<tr>
<td>95%</td>
<td>87%</td>
</tr>
<tr>
<td>86%</td>
<td>75%</td>
</tr>
</tbody>
</table>

**Existing Boiler Efficiency**

<table>
<thead>
<tr>
<th>Building</th>
<th>Estimated efficiency at full load</th>
<th>Estimated Efficiency at Low load</th>
<th>% Distribution and shell losses, blow down, boiler degradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>76%</td>
<td>73%</td>
<td>3%</td>
</tr>
<tr>
<td>MTU</td>
<td>76%</td>
<td>73%</td>
<td>3%</td>
</tr>
</tbody>
</table>

**Existing Usage**

<table>
<thead>
<tr>
<th>Building</th>
<th>Gas Usage (Estimated based on steam usage from the central boiler plant)</th>
<th>% of gas used for domestic water heating</th>
<th>% of gas used for other (dryers, kitchen)</th>
<th>Net existing heating usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>53,251</td>
<td>27%</td>
<td>4%</td>
<td>51,678</td>
</tr>
<tr>
<td>MTU</td>
<td>89,582</td>
<td>29%</td>
<td>4%</td>
<td>86,020</td>
</tr>
<tr>
<td>TOTAL</td>
<td>142,833</td>
<td>28%</td>
<td>4%</td>
<td>95,698</td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.*
Efficiency of Heating System Based on OA Temperature and Hot Water Return Temperature

This chart is used to calculate the efficiency of the boiler based on the hot water return temperature. Condensing boilers can operate up to 95% but this efficiency is based on a low return water temperature. The design of heating system is based on a hot water supply temperature of 180 F. Most of the existing hot water heating equipment will remain reducing maximum efficiency of the condensing boilers.

The following chart calculates the efficiency of the condensing boiler based on the outside air temperature and estimated hot water return temperatures.

<table>
<thead>
<tr>
<th>OA Temp</th>
<th>52</th>
<th>48</th>
<th>44</th>
<th>40</th>
<th>36</th>
<th>32</th>
<th>28</th>
<th>24</th>
<th>20</th>
<th>16</th>
<th>12</th>
<th>8</th>
<th>4 F below</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours at OA Temp</td>
<td>504</td>
<td>625</td>
<td>472</td>
<td>418</td>
<td>412</td>
<td>811</td>
<td>456</td>
<td>301</td>
<td>302</td>
<td>226</td>
<td>180</td>
<td>97</td>
<td>49</td>
</tr>
<tr>
<td>% boiler operation at this OA</td>
<td>10%</td>
<td>12%</td>
<td>9%</td>
<td>8%</td>
<td>12%</td>
<td>16%</td>
<td>9%</td>
<td>6%</td>
<td>6%</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>HWs at OA Temp</td>
<td>110</td>
<td>116</td>
<td>123</td>
<td>129</td>
<td>135</td>
<td>142</td>
<td>148</td>
<td>155</td>
<td>161</td>
<td>167</td>
<td>174</td>
<td>180</td>
<td>185</td>
</tr>
<tr>
<td>HWr at OA Temp</td>
<td>105</td>
<td>110</td>
<td>115</td>
<td>120</td>
<td>125</td>
<td>130</td>
<td>135</td>
<td>140</td>
<td>145</td>
<td>150</td>
<td>155</td>
<td>160</td>
<td>160</td>
</tr>
<tr>
<td>Condensing boiler efficiency</td>
<td>91.6%</td>
<td>90.8%</td>
<td>90.0%</td>
<td>89.2%</td>
<td>88.4%</td>
<td>87.6%</td>
<td>86.8%</td>
<td>86.0%</td>
<td>86.0%</td>
<td>86.0%</td>
<td>86.0%</td>
<td>86.0%</td>
<td>86.0%</td>
</tr>
<tr>
<td>Estimated Existing Boiler Efficiency</td>
<td>72.0%</td>
<td>72.1%</td>
<td>72.2%</td>
<td>72.2%</td>
<td>72.3%</td>
<td>72.4%</td>
<td>72.4%</td>
<td>72.5%</td>
<td>72.5%</td>
<td>72.6%</td>
<td>72.6%</td>
<td>73.0%</td>
<td>73.0%</td>
</tr>
</tbody>
</table>

Gas Usage (MCF) at OA temperature

The following estimates the heating required at the facility based on the outside air temperature.

<table>
<thead>
<tr>
<th>OA Temp</th>
<th>52</th>
<th>48</th>
<th>44</th>
<th>40</th>
<th>36</th>
<th>32</th>
<th>28</th>
<th>24</th>
<th>20</th>
<th>16</th>
<th>12</th>
<th>8</th>
<th>4 F below</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>3,466</td>
<td>4,298</td>
<td>3,246</td>
<td>2,075</td>
<td>4,209</td>
<td>5,577</td>
<td>3,136</td>
<td>2,875</td>
<td>4,209</td>
<td>5,577</td>
<td>3,136</td>
<td>2,875</td>
<td>1,554</td>
</tr>
<tr>
<td>MTU</td>
<td>5,831</td>
<td>7,231</td>
<td>5,461</td>
<td>4,836</td>
<td>7,080</td>
<td>9,382</td>
<td>5,275</td>
<td>3,482</td>
<td>3,494</td>
<td>2,615</td>
<td>2,082</td>
<td>1,122</td>
<td>567</td>
</tr>
</tbody>
</table>

Heating Savings (MCF)

The savings is based on the use of the more efficient condensing boilers versus the existing steam boilers.

Savings = MCF usage at OA Temp (see above) x (Condensing Boiler Efficiency - Estimated Existing Boiler Efficiency) / Condensing Boiler Efficiency

<table>
<thead>
<tr>
<th>Facility</th>
<th>Existing % eff</th>
<th>Condensing Domestic Water Heater Average Efficiency</th>
<th>Estimated Domestic Gas Usage (MCF)</th>
<th>Savings (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>72%</td>
<td>90%</td>
<td>3,443</td>
<td>0.089</td>
</tr>
<tr>
<td>MTU</td>
<td>72%</td>
<td>90%</td>
<td>25,979</td>
<td>5,196</td>
</tr>
</tbody>
</table>

Domestic Water Heating

All of the domestic hot water at MTU is from central boiler plant steam through heat exchangers, at ICF a majority of the water is provided from the central boiler plant. As part of the conversion from steam to hot water the existing steam to hot water heat exchangers will be replaced with hi efficiency condensing gas water heaters.

The domestic gas usage is estimated based utility bill summer usage, building modeling, inmate population and square feet. The condensing water heater efficiency can range as high as 95% or more but for calculation purposes an average of 90% will be used.

Savings = Estimated Domestic Gas Usage (MCF) x (Condensing Domestic Water Heater Average Efficiency - Existing % Efficiency) / Condensing Domestic Water Heater Average Efficiency

<table>
<thead>
<tr>
<th>Facility</th>
<th>Existing % eff</th>
<th>Condensing Domestic Water Heater Average Efficiency</th>
<th>Estimated Domestic Gas Usage (MCF)</th>
<th>Savings (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>72%</td>
<td>90%</td>
<td>15,443</td>
<td>1,089</td>
</tr>
<tr>
<td>MTU</td>
<td>72%</td>
<td>90%</td>
<td>25,979</td>
<td>5,196</td>
</tr>
</tbody>
</table>

Kitchen steamers and equipment

The central boiler plant provides steam to steamers and kettles in the kitchen and clothes dryers. As part of the conversion from steam to hot water the existing steam kitchen equipment and dryers will be replaced with gas fire equipment.

Savings = Estimated Existing Other Gas Usage (MCF) x (Average Efficiency of gas equipment - Existing % Efficiency) / Average Efficiency of gas equipment

<table>
<thead>
<tr>
<th>Facility</th>
<th>Existing % eff</th>
<th>Average Efficiency of gas equipment</th>
<th>Estimated Existing Other Gas Usage (MCF)</th>
<th>Savings (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICF</td>
<td>72%</td>
<td>80%</td>
<td>2,130</td>
<td>213</td>
</tr>
<tr>
<td>MTU</td>
<td>72%</td>
<td>80%</td>
<td>3,581</td>
<td>358</td>
</tr>
</tbody>
</table>
RMI and Dorm Steam Boilers

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Gas Heating Savings (MCF)</th>
<th>Natural gas $/MCF</th>
<th>Natural gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reformatory</td>
<td>5,733</td>
<td>6.11</td>
<td>$35,027</td>
</tr>
<tr>
<td>Dormitory</td>
<td>1,172</td>
<td>6.11</td>
<td>$7,159</td>
</tr>
<tr>
<td></td>
<td>6,904</td>
<td></td>
<td>$42,186</td>
</tr>
</tbody>
</table>

The existing steam boilers are over 40 years old, one has been retubed, only one economizer is working and there are no controls for maintaining the best efficiency.

The central boiler plant provides the heating, domestic hot water, steam to steam kettles, steamers and clothes dryers.

In the summer a single boiler operates to provide steam for domestic hot water, steam kettles, food steamers and steam dryers.

Due to the low load and limit turn down capability the boilers do not operate efficiently in the summer.

At RMI (2) existing steam boiler will be replaced with (2) reduced capacity boilers with high efficiency/low turn down burners, economizers to preheat the make up water and controls to automatically adjust the burner for maximum efficiency.

At the dorm new steam boilers will be added to a new boiler room outside the fence. The new boilers will have high efficiency/low turn down burners, economizers to preheat the make up water and controls to automatically adjust the burner for maximum efficiency.

**Savings Calculations**

- **Existing usage** Therms: Total annual gas consumption for 2011. facility usage is estimated.
- **Existing boiler efficiency (est.)**: Estimated existing efficiency based on age, no economizers, inefficient burners and no automatic combustion controls.
- **% boiler losses due to leaks, insulation, etc. (est.)**: Estimated losses due to leaking piping, missing insulation, bad steam traps, etc.
- **Existing Net efficiency**: Efficiency with new boilers, economizers, low turn down burners and automatic controls.
- **Proposed boiler efficiency (est.)**: Efficiency with new boilers, economizers, low turn down burners and automatic controls.
- **% boiler losses due to leaks, insulation, etc. (est.)**: Estimated losses due to leaking piping, missing insulation, bad steam traps, etc.
- **Proposed Net Boiler Efficiency** = Proposed efficiency - % distribution losses
- **Savings (MCF)** = Exist Usage x (future new efficiency - existing net efficiency) / Future net efficiency

<table>
<thead>
<tr>
<th>Building</th>
<th>Existing usage Therms</th>
<th>Existing boiler efficiency (est.)</th>
<th>% boiler losses due to leaks, insulation, etc. (est.)</th>
<th>Existing Net efficiency</th>
<th>Proposed boiler efficiency (est.)</th>
<th>% boiler losses due to leaks, insulation, etc. (est.)</th>
<th>Proposed Net Boiler Efficiency</th>
<th>Savings (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>15,428</td>
<td>76%</td>
<td>3%</td>
<td>73%</td>
<td>82%</td>
<td>3%</td>
<td>79%</td>
<td>1,172</td>
</tr>
<tr>
<td>Reformatory</td>
<td>90,577</td>
<td>77%</td>
<td>3%</td>
<td>74%</td>
<td>82%</td>
<td>3%</td>
<td>79%</td>
<td>5,733</td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.*
Steam and Condensate Heat Loss

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Gas Heating Savings (MCF)</th>
<th>Natural gas $/MCF</th>
<th>Natural gas Savings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam and Condensate Heat Loss</td>
<td>7,167</td>
<td>$ 6.11</td>
<td>$ 43,793</td>
</tr>
</tbody>
</table>

The central boiler plant provides steam to MTU, ICF and the Dormitory. The steam and condensate piping for MTU is over 20 years old and buried and in overall poor condition with numerous leaks and bad insulation. Steam and condensate piping to ICF is above ground and in fair condition with leaks in valve pits.

Steam and condensate piping for the Dorm is above ground and connects to the piping to the ICF. Insulation slow the loss of heat but does not eliminate it. Over time insulation, especially buried insulation, degrades.

This ECM proposes to install separate boilers at MTU, ICF and the Dorm eliminating the need for the steam and condensate piping.

**Savings Calculations**

**Piping**
- Piping for ICF and the Dorm is insulated and above grade. MTU is insulated and buried
- Wind speed used to calculate heat loss from above grade piping.

**PSIG**
- Pressure of the steam in the piping. Used to calculate the piping surface temperature. The pressure is between 80 and 100 psig with an average of 90 psi used for the analysis

**Pipe Temperature**
- Temperature of the piping. It is assumed the temperature of the piping will be the same temperature of the steam or condensate.

**Surrounding Temperature**
- Temperature of the area surrounding the piping. The average annual temperature in Michigan is approximately 55 F and this will be used for above grade piping. The below grade temperature varies with the depth. Piping buried less than 10 feet will experience a swing in temperature based on the surface air temperature but at a much slow rate. For calculations we have assumed the buried piping is at a constant 60 F (with no wind). The buried piping also assumes dry soil.

**Length**
- Length of associated piping

**Insulation thickness**
- Thickness of the covering the insulation. The insulation is assumed to be in good condition. 3" of insulation will be used for steam piping and 2" will be used for condensate piping.

**R Value**
- R value of the insulation. The actual R value is dependent on the average temperature. The value shown is for reference.

**Heat Loss (BTUH/ft)**
- Value used in the calculations is based on the 3plus Insulation Thickness Program by NAIMA (North American Insulation Manufacturers Association) and is available free on line. Sample output is included below.

**Heat Loss (MBTUH)**
- = length x Heat loss (BTUH/ft) / 1000 BTUH/MBH

---

<table>
<thead>
<tr>
<th>Facility</th>
<th>Piping</th>
<th>Wind (MPH)</th>
<th>Diameter (in)</th>
<th>PSIG</th>
<th>Pipe Temperature (F)</th>
<th>Surrounding Temp(F)</th>
<th>Length (ft)</th>
<th>Insulation Thickness (in)</th>
<th>R Value</th>
<th>Heat Loss (MBTUH)</th>
<th>Heat Loss (MBTUH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>Above Grade Condensate Return</td>
<td>5-2</td>
<td>0</td>
<td>180</td>
<td>8</td>
<td>380</td>
<td>2</td>
<td>8.00</td>
<td>15</td>
<td>6</td>
<td></td>
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<tr>
<td>MTU</td>
<td>Buried Condensate</td>
<td>3-3</td>
<td>0</td>
<td>180</td>
<td>8</td>
<td>3500</td>
<td>2</td>
<td>8.00</td>
<td>20</td>
<td>70</td>
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</tr>
<tr>
<td>ICF</td>
<td>Above Grade Condensate</td>
<td>5-1/2</td>
<td>0</td>
<td>180</td>
<td>8</td>
<td>3500</td>
<td>2</td>
<td>8.00</td>
<td>24</td>
<td>84</td>
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<tr>
<td>MTU</td>
<td>Buried Steam</td>
<td>6-5</td>
<td>0</td>
<td>180</td>
<td>8</td>
<td>3500</td>
<td>3</td>
<td>12.00</td>
<td>66</td>
<td>283</td>
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<tr>
<td>ICF</td>
<td>Above Grade Steam</td>
<td>5-8</td>
<td>0</td>
<td>331</td>
<td>54</td>
<td>3500</td>
<td>3</td>
<td>12.00</td>
<td>81</td>
<td>284</td>
<td></td>
</tr>
</tbody>
</table>

Total Heat Loss (MBTUH) 691

Estimated % heating system efficiency of steam boilers = 70%

Total Heat loss (MBTUH) / % boiler efficiency = 969

Bolilers provide steam to Facilities continuously

MBTUH x Hours = 8760

Heat Loss M BTU = 7,963,762

Heat Loss MBTU / Performance Factor = 90%

Adjusted M BTU = 7,167,386

Adjusted M BTU / 1000 M BTU/MCF = HEAT LOSS MCF 7,167

---

*All cost and savings are +/- 10%.
NAIMA 3EPplus V4.1

ESG
2701 dakota dr
caton rapids , mi
517-898-0211

Item ID = 1
Item Description =
System Application = Pipe - Horizontal
Dimensional Standard = ASTM C 585 Rigid
Calculation Type = Heat Loss Per Hour Report
Process Temperature = 331
Ambient Temperature = 55
Wind Speed = 5
Nominal Pipe Size = 8
Bare Metal = Steel
Bare Surface Emittance = 0.8
Insulation Layer 1 = 850F Mineral Fiber PIPE, Type I, C547-11
Outer Jacket Material = All Service Jacket
Outer Surface Emittance = 0.9

<table>
<thead>
<tr>
<th>Variable Insulation Thickness</th>
<th>Surface Temp (°F)</th>
<th>Heat Loss (BTU/hr/ft)</th>
<th>Efficiency (%)</th>
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</thead>
<tbody>
<tr>
<td>Bare</td>
<td>330.1</td>
<td>2325.00</td>
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<tr>
<td>0.5</td>
<td>105.3</td>
<td>389.10</td>
<td>83.25</td>
</tr>
<tr>
<td>1.0</td>
<td>79.4</td>
<td>200.60</td>
<td>91.37</td>
</tr>
<tr>
<td>1.5</td>
<td>71.6</td>
<td>144.40</td>
<td>93.78</td>
</tr>
<tr>
<td>2.0</td>
<td>67.5</td>
<td>114.90</td>
<td>95.06</td>
</tr>
<tr>
<td>2.5</td>
<td>64.4</td>
<td>93.03</td>
<td>96.00</td>
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<tr>
<td>3.0</td>
<td>62.9</td>
<td>81.58</td>
<td>96.49</td>
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<tr>
<td>3.5</td>
<td>61.7</td>
<td>73.16</td>
<td>96.85</td>
</tr>
<tr>
<td>4.0</td>
<td>60.9</td>
<td>66.69</td>
<td>97.13</td>
</tr>
<tr>
<td>4.5</td>
<td>60.2</td>
<td>61.55</td>
<td>97.35</td>
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<tr>
<td>5.0</td>
<td>59.6</td>
<td>57.37</td>
<td>97.53</td>
</tr>
<tr>
<td>5.5</td>
<td>59.2</td>
<td>53.90</td>
<td>97.68</td>
</tr>
<tr>
<td>6.0</td>
<td>58.8</td>
<td>50.96</td>
<td>97.81</td>
</tr>
<tr>
<td>6.5</td>
<td>58.5</td>
<td>48.45</td>
<td>97.91</td>
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<tr>
<td>7.0</td>
<td>58.2</td>
<td>46.26</td>
<td>98.01</td>
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<td>7.5</td>
<td>58.0</td>
<td>44.35</td>
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</tr>
<tr>
<td>8.0</td>
<td>57.8</td>
<td>42.66</td>
<td>98.16</td>
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<tr>
<td>8.5</td>
<td>57.6</td>
<td>41.15</td>
<td>98.23</td>
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<tr>
<td>9.0</td>
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<td>9.5</td>
<td>57.3</td>
<td>38.57</td>
<td>98.34</td>
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<tr>
<td>10.0</td>
<td>57.2</td>
<td>37.45</td>
<td>98.39</td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.
The central boiler plant provides steam to MTU, ICF and the Dormitory.
The steam and condensate piping for MTU is over 20 years old, buried and in overall poor condition with numerous leaks.
ICF has leaks in the steam valve pits.
The water and condensate meters in the central boiler plant do not operate.

The intention of this ECM is to eliminate install separate boiler systems in or near MTU, ICF and the dorm. MTU and ICF will be converted to hot water eliminating most of the make up water. the dorm will remain steam but the reduce piping length and ne

### Savings Calculations

**Make up Water Temperature**
Temperature of the water entering the boiler. This assumes the water is preheated in the economizer or blow down heat recovery

**Pressure**
Boiler operating pressure

**Temp at pressure**
Associated temperature at the pressure

**Estimated Make up water gallons/day**
This is estimated from conversations with the boiler operators, observations of the system including steam pits and tunnels. See below for estimated usage of boiler plant.

**Pounds of water per day**
Conversion of gallons to pounds of water

**Energy required to heat water from 180 F to 100 PSI**
1,038 BTU/lb. = 158 BTU/lb. of water to raise the water from 180 F to 338 F + 888 BTU/lb. to raise the water rom 338 F/0 psi to 100 psi

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Gas Heating Savings (MCF)</th>
<th>Natural gas $/MCF</th>
<th>Natural gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU, ICF, Dorm</td>
<td>1,580</td>
<td>6.11</td>
<td>9,653</td>
</tr>
</tbody>
</table>

RMI and the central boiler plant are on the same meter making it difficult to determine the water requirements of the boiler plant alone.

**Base Year Water Usage from Dec -10 to Sep -11**
99,006 KGAL

**Number of Inmates**
1,338

**Estimated KGAL/inmate**
Estimated based other facilities
50

**RMI Water usage**
KGAL/inmate x number of inmates = 66,900

**Other usage**
Base year usage - RMI water Usage = 32,106

**Usage per day**
Other usage / 365 days = 88

The boiler plant make up a large part of this usage for make up water, dealkalyzers, softeners, blow down, etc...
We estimate the make up water per day to be 500 gallons per day or 182 KGAL/yr.

<table>
<thead>
<tr>
<th>Water and Sewer</th>
<th>Square feet</th>
<th>Inmates</th>
<th>Water Kgal</th>
<th>Kgal/(1000 sq.ft)</th>
<th>Kgal/inmate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC</td>
<td>400,807</td>
<td>1881</td>
<td>57,614</td>
<td>143.7</td>
<td>31</td>
</tr>
<tr>
<td>ICF and MTU</td>
<td>613,861</td>
<td>2001</td>
<td>100,416</td>
<td>163.6</td>
<td>50</td>
</tr>
<tr>
<td>MTU</td>
<td>480,041</td>
<td>1316</td>
<td>99,006</td>
<td>206.2</td>
<td>75</td>
</tr>
<tr>
<td>RMI Central Plant</td>
<td>480,041</td>
<td>120</td>
<td>7,241</td>
<td>160.6</td>
<td>60</td>
</tr>
<tr>
<td>Dormitory</td>
<td>45,100</td>
<td>120</td>
<td>264,277</td>
<td>171.6</td>
<td>50</td>
</tr>
</tbody>
</table>

**Total**
1,539,809

**Water Usage from bills**

<table>
<thead>
<tr>
<th></th>
<th>Dec-09</th>
<th>Dec-10</th>
<th>Dec-11</th>
<th>Dec-12</th>
<th>Dec-13</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBC</td>
<td>24,763</td>
<td>23,318</td>
<td>23,318</td>
<td>24,988</td>
<td></td>
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<tr>
<td>ICF and MTU</td>
<td>22,920</td>
<td>23,482</td>
<td>24,730</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF</td>
<td>23,283</td>
<td>23,128</td>
<td>24,826</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF</td>
<td>23,128</td>
<td>25,910</td>
<td>No data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>94,094</td>
<td>99,006</td>
<td>74,544</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.
REPLACE EXISTING STEAM BOILERS, ECONOMIZERS, CONTROLLER, NEW STEAM AND CONDENSATE PIPING

RECOMMENDED ACTION

Replace the existing steam boilers with (2) new steam boilers with economizers, boiler controls.

- Estimated Energy Savings = 23,531 MCF/yr.
- Estimated Energy Cost Savings = $143,773/yr.
- Estimated Water Savings = 26,565 KGA/yr.
- Estimated Water Cost Savings = $65,084/yr.
- Estimated Sewer Savings = 61,000 KGA/yr.
- Estimated Sewer Cost Savings = $342,210/yr.
- Implementation Cost = $18,935,335

Implementation costs includes design and engineering, project management, contingency, performance, overhead and profit. Estimated energy and cost savings are for year one only.

*All cost and savings are +/- 10%

Existing Conditions

Existing Conditions

The existing Central Plant provides steam to the Reformatory, ICF, Dormitory and MTU. The steam and condensate piping to get to ICF, Dorm and MTU is almost 2 ½ miles and portions are in poor condition. This ECM proposes to reduce the load on the existing central plant by installing separate boiler plants at MTU, ICF, Dorm and Reformatory. The boiler plants at MTU and ICF would be 90% hi efficiency hot water boilers with the buildings being converted from steam to hot water. The dormitory would remain steam heating and a separate building will be built outside the fence to house the new boiler. The RMI would remain steam and (2) new smaller steam boilers will be installed in the Central Boiler Plant.

1. The existing boilers are over 40 years old.
2. The central boilers provide steam to the Reformatory, Dormitory, ICF and MTU.
3. The steam is used for heating, domestic hot water, steam kettles, vegetable steamers and clothes dryers.
4. (1) Boilers has been retubed
5. (1) economizer out of (3) works
6. The boilers burners are not low turn down, and do not operate efficiently in the summer.
7. The steam and condensate piping for MTU is underground. The steam piping is original and the original condensate piping was replaced in 1979. The drip legs from the steam piping are not installed to the condensate return as the original piping was and is discharged to the ground wasting water and natural gas. Every year, the system experiences leaks and a path can clearly be seen in the grass where the steam piping is buried.
8. The steam and condensate piping for ICF is above ground and was installed in 1985. This piping is in better condition than MTU and is accessible, but the piping has numerous leaks and drips in the valve pits.
9. The original steam and condensate piping for the Dorm was replaced in 2004. The piping was connected to the above ground piping to ICF.
10. The existing condensate pumps are in many cases original and in need of constant maintenance and repair.

*All cost and savings are +/ - 10%.
11. The existing steam coils, heat exchangers and piping at MTU is over 50 years old and in poor condition; the useful service life for this equipment is 20 to 25 years.

12. Generators provide backup power to the reformatory and dormitory. The generators will only start when one of the (3) power legs is down.

**Proposed Systems**

1. Replace (2) of the existing boilers with new boilers.
2. (1) Boiler to be reduced capacity for use in the summer.
3. New boilers will have 8 to 1 burner turn down ratio.
4. (1) Existing boiler to be reused as back up.
5. Install new economizers on the (2) new boilers to heat the makeup water.
6. Install boiler control system for all (3) boilers.
7. Install meters on the makeup water and condensate returns from the Reformatory, ICF and MTU.
8. Install new 12” steam piping and 10” condensate piping serving MTU, ICF and the Dorm (existing piping from dorm to new piping to be reused.) New piping to be above ground similar to the existing piping to ICF. Existing buried piping to be abandoned in place.
10. Recommission existing systems at MTU and ICF.
   a. See Mechanical Re-commissioning above under Decentralization.
   b. Replace all steam coils.
   c. Replace all steam valves
   d. Replace all steam to hot water heat exchangers including domestic hot water.

*All cost and savings are +/- 10%.*
### Construction Cost Estimate

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>REPLACED CENTRAL BOILERS AND RECOMMISSIONING</td>
<td>$13,086,071</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>REPLACED CENTRAL BOILERS AND RECOMMISSIONING</td>
<td>$13,086,071</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Total Direct Cost</td>
<td>$13,086,071</td>
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</tr>
<tr>
<td>4</td>
<td>Project Management</td>
<td>5.0%</td>
<td>$654,304</td>
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<tr>
<td>5</td>
<td>Performance Bond</td>
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<td>6</td>
<td>Contingency</td>
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</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>Sub total $15,179,842</td>
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<td>Overhead</td>
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<td>11</td>
<td>Profit</td>
<td>5.0%</td>
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<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Project Total With Overhead and Profit</td>
<td></td>
<td>$17,532,718</td>
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</table>

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<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tr>
<td>1</td>
<td>REPLACED CENTRAL BOILERS AND RECOMMISSIONING</td>
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<td>2</td>
<td>Central Boiler Replacement</td>
<td>1</td>
<td>LS</td>
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<tr>
<td>3</td>
<td>Steam Piping Replacement - consolidating MTU, ICF and Dorm piping</td>
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<td>LS</td>
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<tr>
<td>4</td>
<td>Mechanical Recommissioning</td>
<td>326,800 sq. ft.</td>
<td>8.7</td>
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<tr>
<td>5</td>
<td>Back Up Generator Auto Start/Stop for RMI, Dorm, Central Boiler Plant</td>
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<td>LS</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7</td>
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<tr>
<td>12</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td>TOTAL REPLACED CENTRAL BOILERS AND RECOMMISSIONING</td>
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<td>$13,086,071</td>
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</tbody>
</table>

*All cost and savings are +/- 10%.*
Boiler Replacement

<table>
<thead>
<tr>
<th>Facility</th>
<th>Type Description</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor (1.2 for work in fence)</th>
<th>Total Adjusted Cost</th>
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</thead>
<tbody>
<tr>
<td>Central Boiler Plant</td>
<td>Demolish (3) boilers, piping, controls, asbest.</td>
<td>1</td>
<td>$235,000</td>
<td>$235,000</td>
<td>1</td>
<td>$235,000</td>
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<tr>
<td>(1) new 70,000 #/hr boilers</td>
<td>1 $185,000</td>
<td>1 $185,000</td>
<td>1</td>
<td>$185,000</td>
<td>1 $185,000</td>
<td>$185,000</td>
</tr>
<tr>
<td>(1) new 30,000 #/hr boiler</td>
<td>1 $370,000</td>
<td>1 $370,000</td>
<td>1</td>
<td>$370,000</td>
<td>1 $370,000</td>
<td>$370,000</td>
</tr>
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<td>Boiler Installation</td>
<td>1 $1,075,000</td>
<td>1</td>
<td>$1,075,000</td>
<td>$1,075,000</td>
<td>1 $1,075,000</td>
<td>$1,075,000</td>
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<tr>
<td>Demo (3) economizers</td>
<td>1 $52,000</td>
<td>1</td>
<td>$52,000</td>
<td>$52,000</td>
<td>1 $52,000</td>
<td>$52,000</td>
</tr>
<tr>
<td>Economizers (70,000 #/hr)</td>
<td>1 $24,000</td>
<td>1</td>
<td>$24,000</td>
<td>$24,000</td>
<td>1 $24,000</td>
<td>$24,000</td>
</tr>
<tr>
<td>Economizers (30,000 #/hr)</td>
<td>1 $50,000</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
<td>1 $50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Install economizers (70,000 #/hr)</td>
<td>1 $40,000</td>
<td>1</td>
<td>$40,000</td>
<td>$40,000</td>
<td>1 $40,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Install economizers (30,000 #/hr)</td>
<td>1 $50,000</td>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
<td>1 $50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>Boiler piping valves, and specialties</td>
<td>1 $260,000</td>
<td>1</td>
<td>$260,000</td>
<td>$260,000</td>
<td>1 $260,000</td>
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<tr>
<td>Boiler stack modifications</td>
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<td>$90,000</td>
<td>$90,000</td>
<td>1 $90,000</td>
<td>$90,000</td>
</tr>
<tr>
<td>Roof, wall, catwalk cut and patch</td>
<td>1 $302,000</td>
<td>1</td>
<td>$302,000</td>
<td>$302,000</td>
<td>1 $302,000</td>
<td>$302,000</td>
</tr>
<tr>
<td>Controls and wiring</td>
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<td>1</td>
<td>$150,000</td>
<td>$150,000</td>
<td>1 $150,000</td>
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<tr>
<td>Condensate and water meters</td>
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<td>1</td>
<td>$5,000</td>
<td>$5,000</td>
<td>1 $5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>Misc expenses (10%)</td>
<td>1 $379,400</td>
<td>1</td>
<td>$379,400</td>
<td>$379,400</td>
<td>1 $379,400</td>
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<td></td>
<td></td>
<td>$4,173,400</td>
<td>1 $4,173,400</td>
<td>$4,173,400</td>
</tr>
</tbody>
</table>

Steam Piping Replacement - consolidating MTU, ICF and Dorm piping

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Type Description</th>
<th>Qty.</th>
<th>Cost per unit</th>
<th>Total Cost</th>
<th>Work Factor (1.2 for work in fence)</th>
<th>Total Adjusted Cost</th>
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<tr>
<td>8”</td>
<td>Demolition</td>
<td>3500</td>
<td>$20</td>
<td>$70,000</td>
<td>1</td>
<td>$70,000</td>
</tr>
<tr>
<td>12”</td>
<td>New 100 PSI steam buried</td>
<td>500</td>
<td>$580</td>
<td>$290,000</td>
<td>1</td>
<td>$290,000</td>
</tr>
<tr>
<td>12”</td>
<td>New 100 PSI steam overhead</td>
<td>3000</td>
<td>$580</td>
<td>$1,740,000</td>
<td>1</td>
<td>$1,740,000</td>
</tr>
<tr>
<td>12”</td>
<td>Expansion compensation</td>
<td>11</td>
<td>$12,245</td>
<td>$134,695</td>
<td>1</td>
<td>$134,695</td>
</tr>
<tr>
<td>12”</td>
<td>supports</td>
<td>250</td>
<td>$210</td>
<td>$52,500</td>
<td>1</td>
<td>$52,500</td>
</tr>
<tr>
<td>12”</td>
<td>trenching</td>
<td>500</td>
<td>$50</td>
<td>$25,000</td>
<td>1</td>
<td>$25,000</td>
</tr>
<tr>
<td>All piping</td>
<td>Misc (grading, coring, temp, sidewalk, permit)</td>
<td>1</td>
<td>$16,500</td>
<td>$16,500</td>
<td>1</td>
<td>$16,500</td>
</tr>
<tr>
<td>12”</td>
<td>3” Mineral Fiber Insulation w/Stainless steel jacket</td>
<td>3500</td>
<td>$38</td>
<td>$133,000</td>
<td>1</td>
<td>$133,000</td>
</tr>
<tr>
<td>6”</td>
<td>Demolition</td>
<td>3500</td>
<td>$20</td>
<td>$70,000</td>
<td>1</td>
<td>$70,000</td>
</tr>
<tr>
<td>10”</td>
<td>New 100 PSI steam buried</td>
<td>500</td>
<td>$330</td>
<td>$165,000</td>
<td>1</td>
<td>$165,000</td>
</tr>
<tr>
<td>10”</td>
<td>New 100 PSI steam overhead</td>
<td>3000</td>
<td>$330</td>
<td>$990,000</td>
<td>1</td>
<td>$990,000</td>
</tr>
<tr>
<td>10”</td>
<td>Expansion compensation</td>
<td>11</td>
<td>$12,245</td>
<td>$134,695</td>
<td>1</td>
<td>$134,695</td>
</tr>
<tr>
<td>10”</td>
<td>supports</td>
<td>250</td>
<td>$210</td>
<td>$52,500</td>
<td>1</td>
<td>$52,500</td>
</tr>
<tr>
<td>10”</td>
<td>trenching</td>
<td>500</td>
<td>$50</td>
<td>$25,000</td>
<td>1</td>
<td>$25,000</td>
</tr>
<tr>
<td>10”</td>
<td>3” Mineral Fiber Insulation w/Stainless steel jacket</td>
<td>3500</td>
<td>$38</td>
<td>$133,000</td>
<td>1</td>
<td>$133,000</td>
</tr>
<tr>
<td>All Piping</td>
<td>Steam Main Drip Assemblies</td>
<td>5</td>
<td>$600</td>
<td>$3,000</td>
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<tr>
<td>All piping</td>
<td>supports for parallel system</td>
<td>292</td>
<td>$5,000</td>
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<tr>
<td>Misc expenses (10%)</td>
<td>10%</td>
<td>1</td>
<td>$549,489</td>
<td>1 $549,489</td>
<td>1 $549,489</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>$6,044,379</td>
<td>1 $6,044,379</td>
<td>$6,044,379</td>
</tr>
</tbody>
</table>

Above costs based on Means, Vendor pricing, contractor review and past experience

*All cost and savings are +/- 10%.
Steam Boiler Replacement

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural Gas Heating Savings (MCF)</th>
<th>Natural gas $/MCF based on gas cost over the 12 years of the performance contract</th>
<th>Natural gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Boiler Plant</td>
<td>21,773</td>
<td>$6.11</td>
<td>$133,035</td>
</tr>
</tbody>
</table>

The existing steam boiler are over 40 years old, one has been retubed, only one economizer is working and there are no controls for maintaining the best efficiency.

The central boiler plant provides the heating, domestic hot water, steam to steam kettles, steamers and clothes dryers.

In the summer a single boiler operates to provide steam for domestic hot water, steam kettles, food steamers and steam dryers. Due to the low load and limit turn down capability the boilers do not operate efficiently.

This ECM proposes to replace (2) existing boilers with new boiler with low turn down burners, economizers and controllers. (1) boiler will have a smaller capacity for summer or low load use.

**Savings Calculations**

- **Existing usage MCF**
- **Existing boiler efficiency (est.)**
- **% loss due to burner efficiency, leaks, etc.**
- **Existing Net efficiency**
- **Proposed boiler efficiency (est.)**
- **% loss due to burner efficiency, leaks, etc..**
- **Proposed Net Boiler Efficiency**
- **Savings (MCF)**

<table>
<thead>
<tr>
<th>Building</th>
<th>Existing usage MCF</th>
<th>Existing boiler efficiency (est.)</th>
<th>% loss due to burner efficiency, leaks, etc.</th>
<th>Existing Net efficiency</th>
<th>Proposed boiler efficiency (est.)</th>
<th>% loss due to burner efficiency, leaks, etc.</th>
<th>Proposed Net Boiler Efficiency</th>
<th>Savings (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Boiler Plant</td>
<td>248,838</td>
<td>76%</td>
<td>3%</td>
<td>73%</td>
<td>82%</td>
<td>2%</td>
<td>80%</td>
<td>21,773</td>
</tr>
</tbody>
</table>

*All cost and savings are +/- 10%.*
Steam and Condensate Piping Heat Loss

<table>
<thead>
<tr>
<th>Facility</th>
<th>Natural gas Heating Savings</th>
<th>Natural gas Savings $/MCF</th>
<th>Natural gas Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam and Condensate Heat Loss</td>
<td>1,758</td>
<td>$ 6.11</td>
<td>$ 10,738</td>
</tr>
</tbody>
</table>

The central boiler plant provides steam to MTU, ICF and the Dormitory.
The steam and condensate piping for MTU is over 20 years old and buried and in overall poor condition with numerous leaks and bad insulation.
Steam and condensate piping for ICF is above ground and in fair condition with leaks in valve pits.
Steam and condensate piping for the Dormitory is above ground and connects to the piping to the ICF.
Insulation slows the loss of heat but does not eliminate it. Overtime insulation, especially buried insulation, degrades.

This ECM proposes to install new steam and condensate piping for ICF and MTU. Both facilities will be combined into a single set of steam and condensate lines versus the current separate piping for each facility (4 pipes to 2 larger pipes.) The piping to the dormitory will be reused.

Savings Calculations

### Piping

- **Piping for ICF and the Dormitory is insulated and above grade. MTU is insulated and buried.**
- **Wind**:
  - Wind speed used to calculate heat loss from above grade piping.
- **PSIG**:
  - Pressure of the steam in the piping. Used to calculate the piping surface temperature. The pressure is between 80 and 100 psi and is used for the analysis.
- **Pipe Temperature**:
  - Temperature of the piping. It is assumed the temperature of the piping will be the same as the temperature of the steam or condensate.
- **Surrounding Temperature**:
  - Temperature of the area surrounding the piping. The average annual temperature in Michigan is approximately 55°F and this will be used for above grade piping. The below grade temperature varies with the depth. Piping buried less than 10 feet will experience a swing in temperature based on the surface air temperature but at a much slower rate. For calculations we have assumed the buried piping is at a constant 60°F (with no wind.) The buried piping also assumes dry soil.
- **Length**:
  - Length of associated piping.
- **Insulation thickness**:
  - Thickness of the covering the insulation. The insulation is assumed to be in good condition. 3” of insulation will be used for steam piping and 2” will be used for condensate piping.
- **R Value**:
  - R value of the insulation. The actual R value is dependent on the average temperature. The value shown is for reference.
- **Heat Loss (BTUh/ft)**:
  - Value used in the calculations is based on the 3Eplus Insulation Thickness Program by NAIMA (North American Insulation Manufacturers Association) and is available free online. The line compares the heat loss from 4 pipes versus 2. The values in black will be removed as part of the piping replacement. Values in Red will be added to the project.

### Heat Loss (MBTUh)

\[ \text{Heat Loss (MBTUh)} = \text{length} \times \text{Heat Loss (BTUh/ft)} \times 1000 \text{ BTUh/MBH} \]

---

<table>
<thead>
<tr>
<th>Facility</th>
<th>Piping</th>
<th>Wind (MPH)</th>
<th>Diameter (In.)</th>
<th>PSIG</th>
<th>Pipe Temperature (F)</th>
<th>Surrounding Temp (F)</th>
<th>Length (Ft.)</th>
<th>Insulation Thickness (in.)</th>
<th>R Value</th>
<th>Heat Loss (BTUh/ft)</th>
<th>Heat Loss (MBTUh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTU  Buried Condensate</td>
<td>2</td>
<td>1780</td>
<td>6</td>
<td>180</td>
<td>6</td>
<td>1480</td>
<td>2</td>
<td>8.00</td>
<td>15</td>
<td>6</td>
<td>105</td>
</tr>
<tr>
<td>ICF  Above Grade Condensate</td>
<td>3</td>
<td>1780</td>
<td>6</td>
<td>180</td>
<td>6</td>
<td>1480</td>
<td>2</td>
<td>8.00</td>
<td>20</td>
<td>70</td>
<td>1400</td>
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<tr>
<td>MTU  Buried Steam</td>
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<td>331</td>
<td>6</td>
<td>3540</td>
<td>3</td>
<td>3240</td>
<td>3</td>
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<td>231</td>
<td>2816</td>
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<tr>
<td>ICF  Above Grade Steam</td>
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<td>331</td>
<td>6</td>
<td>3540</td>
<td>3</td>
<td>3240</td>
<td>3</td>
<td>12.00</td>
<td>81</td>
<td>284</td>
<td>2240</td>
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<tr>
<td>NEW MTU, ICF, Dorm combined</td>
<td>4</td>
<td>331</td>
<td>6</td>
<td>3100.0</td>
<td>2</td>
<td>3100.0</td>
<td>3</td>
<td>12.00</td>
<td>133</td>
<td>573</td>
<td>7560</td>
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<tr>
<td>NEW MTU, ICF, Dorm combined</td>
<td>3</td>
<td>331</td>
<td>6</td>
<td>3100.0</td>
<td>3</td>
<td>3100.0</td>
<td>2</td>
<td>12.00</td>
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<tr>
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<td>331</td>
<td>6</td>
<td>3540</td>
<td>3</td>
<td>3240</td>
<td>3</td>
<td>12.00</td>
<td>133</td>
<td>573</td>
<td>7560</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>331</td>
<td>6</td>
<td>331</td>
<td>3540</td>
<td>3</td>
<td>3240</td>
<td>2</td>
<td>12.00</td>
<td>113</td>
<td>136</td>
<td>1470</td>
</tr>
<tr>
<td>6</td>
<td>331</td>
<td>6</td>
<td>3540</td>
<td>3</td>
<td>3240</td>
<td>2</td>
<td>12.00</td>
<td>113</td>
<td>136</td>
<td>1470</td>
<td></td>
</tr>
<tr>
<td><strong>Total Heat Loss (MBTUh)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>149</td>
<td></td>
<td>149</td>
</tr>
</tbody>
</table>

Estimated % heating system efficiency of steam boilers:

\[ \% \text{ Heating system Eff.} = \text{MBTUh} \times \% \text{ boiler efficiency} \]

Boilers provide steam to Facilities continuously for a total of **760 hours** of operation:

\[ \text{MBTUh x Hours} = \frac{3100.0 \times 760}{1000} = 2,378 \]

Heat Loss MBTU/MBTUh x Performance Factor:

\[ \text{Adjusted MBTU} / 1000 \text{ MBTU/MCF} = \frac{1,952,788}{1,757,510} = 1,758 \]

*All cost and savings are +/- 10%.*
CONDENSING BOILERS

PART 1 - GENERAL

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim and accessories for generating hot water.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.
   - Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length and footprint for each submitted boiler.

B. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 50% and 7% input firing rates at incoming water temperatures ranging from 80°F to 160°F.

C. Pressure Drop Curve. Submit pressure drop curve for flows ranging from 0 GPM to 750 gpm
   - If submitted material is different from that of the design basis, boiler manufacture shall incur all costs associated with reselection of necessary pumps. Possible differences include, but are not limited to, the pump type, pump pad size, electrical characteristics and piping changes.

D. Shop Drawings: For boilers, boiler trim and accessories include:
   - Plans, elevations, sections, details and attachments to other work
   - Wiring Diagrams for power, signal and control wiring

E. Source Quality Control Test Reports: Reports shall be included in submittals.

F. Field Quality Control Test Reports: Reports shall be included in submittals.

G. Operation and Maintenance Data: Data to be included in boiler emergency, operation and maintenance manuals.

H. Warranty: Standard warranty specified in this Section

I. Other Informational Submittals:
   1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Boilers must be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. I=B=R Performance Compliance: Condensing boilers must be rated in accordance with applicable federal testing methods and verified by AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

*All cost and savings are +/- 10%.
C. ASME Compliance: Condensing boilers must be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section IV "Heating Boilers".

D. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."


F. UL Compliance: Boilers must be tested for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

Boiler must be UL listed to certify that it can withstand a delayed ignition. If alternate listing is used, manufacturer must provide test data showing that the product was tested and certified to withstand a delayed ignition.

G. NOx Emission Standards: When installed and operated in accordance with manufacturer’s instructions, condensing boilers shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.1; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, and Rule 117.465.

1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 03.

1.6 WARRANTY

A. Standard Warranty: Boilers shall include manufacturer’s standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Boilers
   a. The pressure vessel/heat exchanger shall carry a 10-year from shipment, prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects or workmanship.
   b. Manufacturer labeled control panels are conditionally warranted against failure for (2) two years from shipment.
   c. All other components, with the exception of the igniter and flame detector, are conditionally guaranteed against any failure for 18 months from shipment.

PART 2 - PRODUCTS

1.1 MANUFACTURERS

C. Basis-of-Design Product: Subject to compliance with requirements, provide AERCO International, BMK 6000 or a comparable product as approved by Engineer.

1.2 CONSTRUCTION

A. Description: Boiler shall be natural gas fired, fully condensing, and fire tube design. Power burner shall have full modulation and discharge into a positive pressure vent. Boiler efficiency shall increase with decreasing load (output), while maintaining set point. Boiler shall be factory-fabricated, factory-assembled and factory-tested, fire-tube condensing
boiler with heat exchanger sealed pressure-tight, built on a steel base, including insulated jacket, flue-gas vent, combustion-air intake connections, water supply, return and condensate drain connections, and controls. Overall dimensions of the fully packaged boiler (with sheet metal panels) not to exceed 79” height x 34” width x 106” depth so as to fit through a 36” doorway without disassembly.

B. Heat Exchanger: The heat exchanger shall be constructed of 439 stainless steel fire tubes and tube sheets, with a one-pass combustion gas flow design. The fire tubes shall be 5/8” OD, with no less than 0.049” wall thickness. The upper and lower stainless steel tube sheet shall be no less than 0.25” thick. The pressure vessel/heat exchanger shall be welded construction. The heat exchanger shall be ASME stamped for a working pressure not less than 80 psig. Access to the tube sheets and heat exchanger shall be available by burner and exhaust manifold removal. Minimum access opening shall be no less than 14-inch diameter.

C. Pressure Vessel: The pressure vessel shall have a maximum water volume of 100 gallons. The boiler water pressure drop shall not exceed 4 psig at 570 gpm. The boiler water connections shall be 6-inch Victaulic connection. The pressure vessel shall be constructed of SA53 carbon steel, with a 0.25-inch thick wall. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The vessel shall be designed so that the thermal efficiency increases as the boiler firing rate decreases.

D. Modulating Air/Fuel Valve and Burner: The boiler burner shall be capable of a 15-to-1 turndown ratio of the firing rate without loss of combustion efficiency or staging of gas valves. The burner shall produce less than 20 ppm of NOx corrected to 3% excess oxygen. The burner shall be metal-fiber mesh covering a stainless steel body with pilot ignition system and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input via a “characterized” gas plate engineered by the boiler manufacturer specifically for that product. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable frequency drive (VFD), controlled cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

The boiler must be capable of at least 15:1 turndown and must accomplish this via a single Air-Fuel delivery system which consists of a single blower and single gas train to deliver the modulated air and gas supply to the burner. Staging of multiple air-fuel delivery systems to accomplish this turndown is unacceptable. If an alternative product is selected and cannot deliver at least 15:1 turndown without staging of multiple air-fuel delivery systems; the manufacturer or manufacturer’s representative must provide data to the building owner or operator, showing the added electrical consumption of their boiler, overall efficiency impact, and also an estimated replacement cost for the additional components that comprise the product.”

*All cost and savings are +/- 10%.
E. Minimum boiler efficiencies shall be as follows at a 20 degree delta-T:

<table>
<thead>
<tr>
<th>EWT</th>
<th>100% Fire</th>
<th>50% Fire</th>
<th>7% Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>160°F</td>
<td>87%</td>
<td>87%</td>
<td>87%</td>
</tr>
<tr>
<td>140°F</td>
<td>88%</td>
<td>88%</td>
<td>88%</td>
</tr>
<tr>
<td>120°F</td>
<td>89%</td>
<td>90%</td>
<td>90.5%</td>
</tr>
<tr>
<td>100°F</td>
<td>93.7%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>80°F</td>
<td>96%</td>
<td>98%</td>
<td>98.6%</td>
</tr>
</tbody>
</table>

F. Exhaust Manifold: The exhaust manifold shall be of corrosion resistant cast aluminum or 316 stainless steel with a 14-inch diameter flue connection. The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

G. Blower: The boiler shall include a VFD controlled fan to operate during the burner firing sequence and pre-purge the combustion chamber.
   - Motors: Blower motors shall comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
     a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require a motor to operate in the service factor range above 1.0.

H. Ignition: Ignition shall be via spark ignition with 100 percent main-valve shutoff and electronic flame supervision.

I. The boiler's manufacturer recommended annual replacement parts shall cost no more than $400 to the end customer.

J. The boiler shall be designed such that the combustion air is drawn from the inside of the boiler enclosure, decoupling it from the combustion air supply and preheating the air to increase efficiency. The combustion air must pass through an air filter before entering the combustion chamber. This air filter must be included as a standard part of the boiler packaging. Filter must meet performance capabilities of K&N filter.

K. Enclosure: The sheet metal enclosure shall be fully removable, allowing for easy access during servicing.

1.3 CONTROLS

A. The boiler control system shall be segregated into three components: “C-More” Control Panel, Power Box and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.

B. The control panel shall consist of six individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:
   - A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module for all message enunciation

*All cost and savings are +/- 10%.
• A CPU board housing all control functions
• An electric low-water cutoff board with test and manual reset functions
• A power supply board
• An ignition /stepper board incorporating flame safeguard control
• A connector board
• Each board shall be individually field replaceable.

C. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

D. The control panel hardware shall support both RS-232 and RS-485 remote communications.

E. The controls shall annunciate boiler and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 34 separate fault messages.

F. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:
   • Set point High Limit: Set point high limit allows for a selectable maximum boiler outlet temperature and acts as temperature limiting governor. Set point limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum boiler outlet temperature.
   • Set point Low Limit: Allow for a selectable minimum operating temperature.
   • Failsafe Mode: Failsafe mode allows the boiler to switch its mode to operate from an internal set point if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

G. The boiler control system shall incorporate the following additional features for enhanced external system interface:
   • System start temperature feature
   • Pump delay timer
   • Auxiliary start delay timer
   • Auxiliary temperature sensor
   • Analog output feature to enable simple monitoring of temperature set point, outlet temperature or fire rate
   • Remote interlock circuit
   • Delayed interlock circuit
   • Fault relay for remote fault alarm

*All cost and savings are +/- 10%. 
H. Each boiler shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each boiler shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

I. Each boiler shall have an oxygen monitoring system that will measure the oxygen content of the exhaust gasses in real-time. Output of O2 information shall be displayed on the C-More control panel. Optional O2 trim control available upon request.

J. Boiler Management System (BMS): The Boiler Manufacturer shall supply as an additional option, an integrated Boiler Management System Programmer to control all operation and energy input of the multiple boiler heating plant. The Boiler Management System shall be comprised of a microprocessor based control utilizing the MODBUS protocol to communicate with the Boilers via the RS-485 port. The BMS controller shall have the ability to operate up to 32 boilers per BMS panel.

The controller shall have the ability to vary the firing rate and energy input of each individual boiler throughout its full modulating range to maximize the condensing capability and thermal efficiency output of the entire heating plant. The BMS shall control the boiler outlet header temperature within +4ºF. The controller shall be a PID type controller and uses Ramp Up/Ramp Down control algorithm for accurate temperature control with excellent variable load response. The BMS controller shall provide contact closure for auxiliary equipment such as system pumps and combustion air inlet dampers based upon outdoor air temperature.

When set on Internal Set point Mode, temperature control set point on the BMS shall be fully field adjustable from 50°F to 190°F in operation. When set on Indoor/Outdoor Reset Mode, the BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. When set on 4ma to 20ma Temperature Control Mode, the BMS will operate the plant to vary header temperature set point linearly as an externally applied 4-20 ma signal is supplied.

When set on MODBUS Temperature Control Mode, the BMS will operate the plant to vary header temperature set point as an external communication utilizing the MODBUS protocol is supplied via the RS-232 port. The BMS controller shall have a vacuum fluorescent display for monitoring of all sensors and interlocks. Non-volatile memory backup of all control parameters shall be internally provided as standard. The controller will automatically balance the sequence of operating time on each boiler by a first-on first-off mode and provide for setback and remote alarm contacts. Connection between central BMS system and individual boilers shall be twisted pair low voltage wiring, with the boilers ‘daisy-chained’ for ease of installation.

1.4 ELECTRICAL POWER

A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the boiler.

C. Electrical Characteristics:

*All cost and savings are +/- 10%.
Option 1

- Voltage: 208 – 230 V
- Phase: Three
- Frequency: 60 Hz
- Full-Load Current 16.0 Amps

1.5 VENTING

A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with operating temperatures up to 230°F, condensing flue gas service. UL-listed vents Al 29-4C stainless steel must be used with boilers.

B. The minimum exhaust vent duct size for each boiler is fourteen-inch diameter.

C. Combustion-Air Intake: Boilers shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the boiler and the outdoors.

D. Common vent and common combustion air must be an available option for boiler installation. Consult manufacturer for common vent and combustion air sizing.

E. Follow guidelines specified in manufacturer's venting guide.

1.6 Gas Supply

A. Minimum Gas Pressure of 20" w.c.; Max Gas Pressure of 2 psig.

B. Boiler must be supplied required CFH at full capacity.

C. Gas piping should be sized in accordance with the tables in the Standard National Gas Code or by other engineering methods approved by local Authority Having Jurisdiction. The piping should be sized for the proper volumetric flow rate of the gas to the boilers and any other devices utilizing a common source.

1.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.

B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code. This testing includes combustion calibration, checking of boiler safeties, and performance, including boiler turndown – Each Boiler must be certified to a minimum of 15:1 turndown during the factory testing to assure performance.

1. If boilers are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.

C. Allow Owner access to source quality-control testing of boilers. Notify Architect fourteen days in advance of testing.

PART 3 - EXECUTION

1.1 EXAMINATION

A. Before boiler installation examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations and piping and electrical connections to verify actual locations, sizes and other conditions affecting boiler performance, maintenance and operations.

*All cost and savings are +/- 10%.
1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.2 BOILER INSTALLATION
A. Install boilers level on concrete bases as required.
B. Install gas-fired boilers according to NFPA 54.
C. Assemble and install boiler trim.
D. Install electrical devices furnished with boiler but not specified to be factory mounted.
E. Install control wiring to field-mounted electrical devices.

1.3 CONNECTIONS
A. Install piping adjacent to boiler to permit service and maintenance.
B. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
C. Install condensate piping from the drain on the exhaust manifold to the factory supplied condensate trap and optional condensate neutralizer and then pipe to a floor drain. The piping should be either PVC or Polypropylene; copper should not be used.
D. Connect gas piping to boiler gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required.
E. Connect hot-water piping to supply and return boiler tappings with shutoff valve and union or flange at each connection.
F. Install piping from safety relief valves to nearest floor drain.
G. Boiler Venting
   • Install flue venting kit and combustion-air intake.
   • Connect venting full size to boiler connections.

1.4 FIELD QUALITY CONTROL
A. Perform tests and inspections and prepare test reports.
   1. Manufacturer’s Field Service: Engage a factory-authorized service representative to inspect components, assemblies and equipment installations, including connections, and to assist in testing.
B. Tests and Inspections
   1. Perform installation and startup checks according to manufacturer’s written instructions.
   2. Perform hydrostatic test. Repair leaks and retest until no leaks exist.
   3. Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
C. Remove and replace malfunctioning units and retest as specified above.
D. Within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
E. Performance Tests:
   The boiler manufacturer is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the boiler manufacturer to complete the following performance tests:
   
   • Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
   • Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
   • Perform field performance tests to determine capacity and efficiency of boilers.
     a. Test for full capacity.
     b. Test for boiler efficiency at [low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20] percent of full capacity. Determine efficiency at each test point.
   • Repeat tests until results comply with requirements indicated.
   • Provide analysis equipment required to determine performance.
   • Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
   • Notify Engineer in advance of test dates.
   • Document test results in a report and submit to Engineer.

*All cost and savings are +/- 10%.
High Efficiency Gas Domestic Water Heaters

PART 4 - GENERAL

1.1 SUMMARY
A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, high efficiency condensing domestic water heaters, trim and accessories for generating hot potable water.

1.2 SUBMITTALS
A. Product Data: Include performance data, operating characteristics, furnished specialties and accessories.
   1. Prior to flue vent installation, engineered calculations and drawings must be submitted to Architect/Engineer to thoroughly demonstrate that size and configuration conform to recommended size, length and footprint for each submitted water heater.

B. Efficiency Curves: At a minimum, submit efficiency curves for 100%, 80%, 60%, 40%, 20% and the lowest input firing rates at incoming water temperatures ranging from 70°F to 140°F. Test protocols shall conform to AERCO’s AE-1 standard.

C. Pressure Drop Curve: Submit pressure drop curve for flows ranging from 0 GPM to maximum value of water heater.

D. Shop Drawings: For water heaters, water heater trim and accessories, include:
   1. Plans, elevations, sections, details and attachments to other work
   2. Wiring Diagrams for power, signal and control wiring

E. Source Quality Control Test Reports: Reports shall be included in submittals.

F. Field Quality Control Test Reports: Reports shall be included in submittals.

G. Operation and Maintenance Data: Data to be included in water heater emergency, operation and maintenance manuals.

H. Warranty: Standard warranty specified in this Section.

I. Other Informational Submittals.
   1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to water heater.

1.3 QUALITY ASSURANCE
A. Electrical Components, Devices and Accessories: Condensing water heaters must be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Performance Compliance: Condensing water heaters must be rated in accordance with ASHRAE 118.1 testing methods and verified by UL or AHRI as capable of achieving the energy efficiency and performance ratings as tested within prescribed tolerances.

C. ASME Compliance: Condensing water heaters must be constructed in accordance with ASME Water heater and Pressure Vessel Code, Section IV (HLW) Potable Water Heaters.

*All cost and savings are +/- 10%.
D. ASHRAE/IESNA 90.1 Compliance: Condensing water heaters shall have minimum efficiency according to "Gas and Oil Fired water heaters - Minimum Efficiency Requirements," when tested in accordance with Section G.1 "Method of Test for Measuring Thermal Efficiency" and G.2 "Method of Test for Measuring Standby Loss" of ANSI Z21.10.3

E. UL Compliance. Condensing water heaters must be tested for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Condensing water heaters shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

F. NOx Emission Standards. When installed and operated in accordance with manufacturer’s instructions, condensing water heaters shall comply with the NOx emission standards outlined in South Coast Air Quality Management District (SCAQMD), Rule 1146.2; and the Texas Commission on Environmental Quality (TCEQ), Title 30, Chapter 117, Rule 117.465.

G. Low Lead Compliance: Condensing water heaters must be third party classified to meet the requirements of ANSI/NSF 372, hence that the weighted average of the wetted surface area in contact with potable water must be no greater than 0.25% lead content.

1.4 COORDINATION
A. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 03.

1.5 WARRANTY
A. Standard Warranty: Water heaters shall include manufacturer’s standard form in which manufacturer agrees to repair or replace components of water heaters that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Fire-Tube Condensing Water heaters:
   d. The pressure vessel shall carry a 10-year from shipment, non-prorated, limited warranty against any failure due to waterside corrosion, mechanical defects, or workmanship. The heat exchanger shall carry a 10-year from shipment, prorated, limited warranty against any failure due to condensate corrosion, thermal stress, mechanical defects, or workmanship.
   e. Manufacturer labeled control panels are conditionally warranted against failure for two (2) years from shipment.
   f. All other components, with the exception of the igniter and flame detector, are conditionally guaranteed against any failure for 18 months from shipment.

PART 5 - PRODUCTS
1.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide AERCO INNOVATION or a comparable product as approved by Department of Corrections.

1.2 CONSTRUCTION
A. Each water heater shall be UL Listed; ASME Section IV (HLW) coded and stamped and shall incorporate a double block and bleed style -formerly IRI Gas train. Each unit shall
operate with a minimum ASHRAE 118.1 efficiency of 96% at full fire. System shall consist of a quantity of __ Water Heaters Model:

1. INN600 each with an input of 600 MBH, output of 578 MBH, 696 GPH, (11.6 GPM) at 40-140 °F when fired with natural gas, turndown ratio 14:1, NOx emissions of less than 9 ppm.)

2. INN800 each with an input of 800 MBH, output of 771 MBH, 924 GPH, (15.4 GPM) at 40-140 °F when fired with natural gas, turndown ratio 18:1, NOx emissions of less than 9 ppm.)

3. INN1060 each with an input of 1060 MBH, output of 1022 MBH, 1224 GPH, (20.4 GPM) at 40-140 °F when fired with natural gas, turndown ratio 24:1, NOx emissions of less than 12.5 ppm.)

4. INN1350 each with an input of 1350 MBH, output of 1300 MBH, 1560 GPH, (26 GPM) at 40-140 °F when fired with natural gas, turndown ratio 30:1, NOx emissions of less than 20 ppm.)

B. Description: Water heater shall be direct fired, fully condensing, fire-tube design. Power burner shall have full modulation. The minimum firing rate shall not exceed 50,000 BTU/HR input. Water heaters that have an input greater than 50,000 BTU/Hr at minimum fire will not be considered equal. The water heater shall have the capability of discharging into a positive pressure vent. Water heater thermal efficiency shall increase with decreasing load (output), while maintaining set point. Water heater shall have an operational set point capability of 50 °F to 190 °F and shall maintain the outlet temperature within an accuracy of +/- 4 °F during load changes of up to 50% rated capacity. Heater shall operate quietly, less than 55 dba. Water heater shall be factory-fabricated, factory-assembled and factory-tested, fire-tube condensing water heater with heat exchanger sealed pressure-tight, built on a steel base, including a sealed insulated sheet metal enclosure that acts as combustion-air intake plenum, flue-gas vent, water supply, return and condensate drain connections, and controls. Each water heater shall have an ASME approved temperature/pressure relief valve with a setting of 150 psig and 210 °F.

C. Heat Exchanger: The heat exchanger shall be constructed with 316L stainless steel helical fire tubes, combustion chamber and dished tube sheet, with a two-pass combustion gas flow design. The heat exchanger shall be electro less nickel plated. The fire tubes shall be 3/4" OD, with no less than 0.035" wall thickness. The upper and lower stainless steel tube sheet shall be no less than 0.625" thick. The heat exchanger shall be welded and brazed construction. The heat exchanger shall be ASME Sect IV (HLW) stamped for a working pressure not less than 160 psig.

D. Shell Assembly Pressure Vessel: The shell assembly pressure vessel shall have a maximum water volume of 26 gallons. The water heater water pressure drop shall not exceed 2 psig at 30 gpm. The water heater water connections shall be 2-inch NPT male connections. The shell assembly pressure vessel shall be constructed of 304 stainless steel of 0.25-inch wall thickness. The shell assembly pressure vessel shall be electro less nickel plated. Inspection openings in the pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The shell assembly pressure vessel shall be ASME Sect IV (HLW) stamped for a working pressure not less than 160 psig.

E. Modulating Air/Fuel Valve and Burner: The water heater burner shall be capable rated turndown ratio of the firing rate without loss of combustion efficiency or staging of gas

*All cost and savings are +/- 10%.
valves. The burner shall produce less than 20 ppm of NOx corrected to 3% excess oxygen. The unit shall be certified by the South Coast Air Quality Management District (SCAQMD) as compliant with Rule 1146.2 for water heaters and water heaters less than or equal to 2 MBTUs, and the Texas Commission on Environmental Quality (TCEQ) as being compliant with Section 117.465 for water heaters and water heaters less than or equal to 2 MBTUs. The burner shall be metal-fiber mesh covering a stainless steel body with spark ignition and flame rectification. All burner material exposed to the combustion zone shall be of stainless steel construction. There shall be no moving parts within the burner itself. A modulating air/fuel valve shall meter the air and fuel input. The modulating motor must be linked to both the gas valve body and air valve body with a single linkage. The linkage shall not require any field adjustment. A variable frequency drive (VFD), controlled cast aluminum pre-mix blower shall be used to ensure the optimum mixing of air and fuel between the air/fuel valve and the burner.

F. Minimum water heater efficiencies shall be as follows at a 70 degree delta-T:

<table>
<thead>
<tr>
<th>EWT</th>
<th>100% Fire</th>
<th>80% Fire</th>
<th>60% Fire</th>
<th>40% Fire</th>
<th>20% Fire</th>
<th>&lt;10% Fire</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 °F</td>
<td>96%</td>
<td>97%</td>
<td>97.5%</td>
<td>98%</td>
<td>98.5%</td>
<td>99%</td>
</tr>
</tbody>
</table>

G. The exhaust manifold shall be of corrosion resistant cast aluminum with a 6-inch diameter flue connection. The exhaust manifold shall have a collecting reservoir and a gravity drain for the elimination of condensation.

H. Blower. The water heater shall include a variable-speed, DC centrifugal fan to operate during the burner firing sequence and pre-purge the combustion chamber.

1. Motors: Blower motors shall comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require a motor to operate in the service factor range above 1.0.

I. Ignition: Ignition shall be via spark ignition with 100 percent main-valve shutoff and electronic flame supervision.

1.3 CONTROLS

A. The water heater control system shall be segregated into three components: “C-More” Control Panel, Power Box and Input/Output Connection Box. The entire system shall be Underwriters Laboratories recognized.

B. The control panel shall consist of six individual circuit boards using state-of-the-art surface-mount technology in a single enclosure. These circuit boards shall include:

1. A display board incorporating LED display to indicate temperature and a vacuum fluorescent display module for all message enunciation
2. A CPU board housing all control functions
3. An electric low-water cutoff board with test and manual reset functions
4. A power supply board
5. An ignition /stepper board incorporating flame safeguard control
6. A connector board

*All cost and savings are +/- 10%.
Each board shall be individually field replaceable.

C. The combustion safeguard/flame monitoring system shall use spark ignition and a rectification-type flame sensor.

D. The control panel hardware shall support both RS-232 and RS-485 remote communications.

E. The controls shall annunciate water heater and sensor status and include extensive self-diagnostic capabilities that incorporate a minimum of eight separate status messages and 34 separate fault messages.

F. The control panel shall incorporate three self-governing features designed to enhance operation in modes where it receives an external control signal by eliminating nuisance faults due to over-temperature, improper external signal or loss of external signal. These features include:
   1. Set point High Limit: Set point high limit allows for a selectable maximum water heater outlet temperature and acts as temperature limiting governor. Set point limit is based on a PID function that automatically limits firing rate to maintain outlet temperature within a 0 to 10 degree selectable band from the desired maximum water heater outlet temperature.
   2. Set point Low Limit: Set point low limit allows for a selectable minimum operating temperature.
   3. Failsafe Mode: Failsafe mode allows the water heater to switch its mode to operate from an internal set point if its external control signal is lost, rather than shut off. This is a selectable mode, enabling the control can to shut off the unit upon loss of external signal, if so desired.

G. The water heater control system shall incorporate the following additional features for enhanced external system interface:
   1. System start temperature feature
   2. Pump delay timer
   3. Auxiliary start delay timer
   4. Auxiliary temperature sensor
   5. Analog output feature to enable simple monitoring of temperature set point, outlet temperature or fire rate
   6. Remote interlock circuit
   7. Delayed interlock circuit
   8. Fault relay for remote fault alarm

H. Water Heater Management: the water heater control system shall incorporate onboard multi-unit sequencing logic that would allow lead-lag functionality & sequencing between multiple water heaters operating in parallel and must have the following capabilities:
   1. Efficiently sequence 2 up to 8 units on the same system to meet the load requirement.
   2. Individual unit feed-forward logic will still be enabled for accurate temperature control equal to individual unit's specification.

*All cost and savings are +/- 10%.
3. Operate one motorized valve per unit as an element of the load sequencing. Valves shall close with decreased load as heaters turn off, minimum of must always stay open for recirculation.

4. Automatically rotate lead/lag amongst the units on the chain and monitor run hours per unit and balance load in an effort to equalize unit run hours.

5. Automatic bump-less transfer of master function to next unit on the chain in case of designated master unit failure; master/slave status should be shown on the individual unit displays.

6. Units will default to individual control upon failure of the communications chain.

7. Night temperature setback.

8. Designated master control, used to display and adjust key system parameters.

   I. Each water heater shall be supplied with a factory packaged and pre-wired motorized ball valve. This valve shall be controlled by the water heater control system as an element of the onboard water heater management.

   J. Each water heater shall include an electric, single-seated combination safety shutoff valve/regulator with proof of closure switch in its gas train. Each water heater shall incorporate dual over-temperature protection with manual reset, in accordance with ASME Section IV and CSD-1.

1.4 ELECTRICAL POWER

   A. Controllers, Electrical Devices and Wiring: Electrical devices and connections are specified in Division 26 sections.

   B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers and other electrical devices shall provide a single-point field power connection to the water heater.

   C. Electrical Characteristics:

      1. Voltage: 120 V
      2. Phase: Single
      3. Frequency: 60 Hz
      4. Full-Load Current: 9 Amps

1.5 CONDENSATE

   A. Low-profile condensate neutralizing tubes. Each tube shall be suitable for no less than 12 months continuous operation at full condensing rate. Tubes shall be refillable;

   B. Condensate traps, manufactured from only non-corrosive materials. In order to guarantee flue gasses cannot leak into the boiler room, the traps shall be float-type traps NO EXCEPTIONS.

1.6 VENTING

   A. The exhaust vent must be UL Listed for use with Category II, III and IV appliances and compatible with positive pressure, condensing flue gas service. UL-listed vents of PVC, CPVC, PP, or Al 29-4C stainless steel must be used with water heaters.

   B. The minimum exhaust vent duct size for each water heater is six-inch diameter.

*All cost and savings are +/- 10%.
C. Combustion-Air Intake: Water heaters shall be capable of drawing combustion air from the outdoors via a metal or PVC duct connected between the water heater and the outdoors.

D. The minimum sealed combustion air duct size for each water heater is six-inch diameter.

E. Common Vent and Common Combustion Air must be an available option for water heater installation. Consult manufacturer for common vent and combustion air sizing.

F. Follow guidelines specified in manufacturer's venting guide.

1.7 SOURCE QUALITY CONTROL

A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions and carbon monoxide in flue gas, and to achieve combustion efficiency. Perform hydrostatic testing.

B. Test and inspect factory-assembled water heaters, before shipping, according to ASME Boiler and Pressure Vessel Code.

1. If water heaters are not factory assembled and fire-tested, the local vendor is responsible for all field assembly and testing.

C. Allow Owner access to source quality-control testing of water heaters. Notify Architect fourteen days in advance of testing.

PART 6 - EXECUTION

1.1 EXAMINATION

A. Before water heater installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations. Examine piping and electrical connections to verify actual locations, sizes and other conditions affecting water heater performance, maintenance and operations.

1. Final water heater locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where water heaters will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

1.2 WATER HEATER INSTALLATION

A. Install water heaters level on concrete bases. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.

B. Install gas-fired water heaters in accordance with

1. Local, stats provincial, and national codes, laws, regulations, and ordinances.
5. Manufacturer’s installation instructions, including required service clearances and venting guidelines.

C. Assemble and install water heater trim.

*All cost and savings are +/- 10%. 
D. Install electrical devices furnished with water heater but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

1.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 sections. Drawings indicate general arrangement of piping, fittings and specialties.

B. Install piping adjacent to water heater to permit service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect gas piping to water heater gas-train inlet with unions. Piping shall be at least full size of gas train connection. Provide a reducer if required.

E. Connect hot-water piping to supply and return water heater tappings with shutoff valve and union or flange at each connection.

F. Multiple heaters shall be piped in reverse return or provided with balancing valves on hot water outlet. Each water heater shall have individual isolation valves for servicing and a hot water hose connection for start-up and field testing.

G. Install piping from safety relief valves to nearest floor drain.

H. Water heater Venting

1. Install flue venting kit and combustion-air intake.
2. Connect venting full size to water heater connections. [Comply with requirements in Division 23 Section "Breechings, Chimneys and Stacks.”]

1.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections

1. Installation and Startup Test: Perform installation and startup checks according to manufacturer’s written instructions.
2. Leak Test: Perform hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
   b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

*All cost and savings are +/- 10%.
D. Occupancy Adjustments: When requested within 2 months of date of Substantial Completion, provide on-site assistance adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests

The water heater manufacturer is expected to provide partial load thermal efficiency curves. These thermal efficiency curves must include at least three separate curves at various BTU input levels. If these curves are not available, it is the responsibility of the water heater manufacturer to complete the following performance tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.

2. Water heaters shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.

3. Perform field performance tests to determine capacity and efficiency of water heaters.
   a. Test for full capacity.
   b. Test for water heater efficiency at low fire, 20, 40, 60, 80, 100 and 80, 60, 40, 20% full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.

5. Provide analysis equipment required to determine performance.

6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.

7. Notify Engineer and in advance of test dates.

8. Document test results in a report and submit to Engineer.

*All cost and savings are +/- 10%.
**Base Mounted Hydronic Pumps**

1) Pumps shall be base-mounted, single stage, end suction design.
2) Pump volute shall be made of ductile iron with integrally cast pedestal support.
3) The impeller shall be cast bronze, enclosed type, statically and hydraulically balanced.
4) Impeller shall be keyed to the shaft and secured by a hex head impeller nut and washer.
5) Pumps shall be provided with a single inside unbalanced mechanical shaft seal for leak less operation.
6) A suitable arrangement shall be provided to furnish a portion of the pumped liquid to lubricate and cool the seal faces.
7) Pump shall be rated for a minimum of 175 psi working pressure.
8) Casings shall be provided with tapped and plugged holes for priming, vent, and drain.
9) Pump bearing housing shall have heavy duty regreasable ball bearings.
10) Baseplate shall be channel steel, sufficiently rigid to support the pump and driving motor.
11) A flexible-type coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor, and it shall be equipped with a suitable coupling guard as required.
12) Contractor to level and grout each unit according to manufacturer's instructions.
13) The motor shall be NEMA specifications and shall be the size, voltage and enclosure called for on the plans.
14) Pump and motor shall be factory aligned, and shall be realigned by contractor after installation.
15) Each pump shall be factory tested. It shall then be thoroughly cleaned and painted with at least one coat of high grade machinery enamel prior to shipment.
16) Each pump shall be checked by the contractor and regulated for proper differential pressure, voltage and amperage draw.
17) This data shall be noted on a permanent tag or label and fastened to the pump for owner's reference.
18) After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.
19) Pump series shall be "Series 1510 " as manufactured by ITT Bell & Gossett or approved equal.

**In line Hydronic Pump**

1) The pumps shall be of the horizontal, oil-lubricated type. Specifically designed and guaranteed for quiet operation.
2) Suitable for 125# (862 kPa) working pressure.
3) The pumps shall have a ground and polished steel shaft with a hardened integral thrust collar. The shaft shall be supported by two horizontal sleeve bearings designed to circulate oil or grease lubricated ball bearing design.
4) The pumps are to be equipped with a mechanical seal with carbon seal face rotating against a ceramic seat.
5) The motor shall be nonoverloading at any point on pump curve.
6) The motor shall be of the drip-proof, sleeve-bearing or ball bearing quiet operating, rubber-mounted construction.
7) Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping. Install with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
8) Single phase Motors shall have built-in thermal overload protectors.
9) All Units must be ITT Bell & Gossett Model No. 100 or approved equal.

*All cost and savings are +/- 10%.*