Presentation Overview:

- U.S. energy & environmental overview
- Overview of U.S. boiler inventory & opportunities for performance improvements in the context of energy & environmental factors
- Review of current & future boiler efficiency metrics
- Introduction to modular On-Demand boiler technology
- Review of boiler water treatment methods / support systems that optimize boiler performance
- First Steps: Boiler performance benchmarking
- Brief Overview of Local EE Rebates & Incentives
- Case Studies of successful projects
Global Impact:

- Global Sales ~ 143,000 Units (~ 12,000,000 BHP)
  - Asia ~ 140,500
  - North America ~ 2,500

- ~ 500 Trillion Btu Annual Energy Savings Worldwide
- ~ 180 Million Metric Tons of Annual CO₂ Reductions Worldwide
Miura – North America:

- North American operations established in Canada c.1990

- Current North American operations:
  - Sales and service network established in the U.S. & Canada via regional rep’s
  - New U.S. manufacturing facility operational in April 2009 (Rockmart, GA)
North American Inventory / Opportunity:

60,000,000 BHP

Energy / $ / Environmental Impact:

~ 6.2 Quadrillion Btu
~ $ 5 Billion
~ 300 MtCO$_2$

*1 Quad Btu = 40 - 1,000 MW Power Plants
Accounting for the Environment:

- The global environment & economies are on a crash course with each other that will in the end leave them inseparable

- CO$_2$ is the new currency of the “green” economy

- Energy efficiency is the “first fuel” for addressing environmental challenges
Sustainable Business Principles:

- “Triple Bottom Line”:
  - **Social Responsibility**
    - Extended Product Stewardship
    - Online Maintenance System
    - Safe & Easy Operation
  - **Environmental Stewardship**
    - Reduced Fossil Fuels Consumption
    - Reduced GHG Emissions
    - Reduced Water Consumption
  - **Economic Prosperity**
    - Reduced Fuel Costs
    - Reduced Operation Costs
    - Increased Operational Efficiency
U.S. Energy Inventory:

- **U.S. Energy Flow – 2006 (Quadrillion Btu’s*)**:  
  - Commercial + Industrial Sectors - 50.75 Quads of Energy OR 50% of all energy use  
  - Fossil Fuels – 86.25 Quads or 85% of all energy consumption (C/I boilers account for as much as 40% of energy consumption)

*1 Quad Btu = 40 - 1,000 MW Power Plants
U.S. Boiler Market Survey: Energy Consumption

- U.S. Commercial Boilers – Energy Consumption (2005): ~ 1.6 Qbtu / yr or nearly 30% of all energy in commercial facilities

- CO₂ Emissions - Commercial Boilers: ~ 120+ MtCO₂ / yr
U. S. Boiler Inventory: Distribution by Region

- U.S. Commercial Boilers – Breakdown by Region (2005):
  - West Coast: Total Capacity ~ 140 Billion Btu/hr
- U.S. Industrial Boilers – Energy Consumption (2005): ~ 6.5 Qbtu / yr or up to 40% of all energy at industrial facilities

- CO₂ Emissions - Industrial Boilers: ~ 500+ MtCO₂ / yr
U.S. Boiler Inventory: Distribution by Region

- U.S. Industrial Boilers – Breakdown by Region (2005):

- West Coast:
  
  Total Capacity ~ 130 Billion Btu / hr
U. S. Boiler Market Survey:
Age Distribution

- U.S. Boilers – Age Distribution of Boilers > 10 MMBtu/hr (2005):
- C/I Boiler Inventory – 163,000 units w/ capacity of 2.7 Trillion Btu/hr

- 47% of existing inventory – 40+ yrs. old
- 76% of existing inventory – 30+ yrs. Old
Unlocking U.S. Energy Efficiency

Bang for Buck – Commercial Sector

- 2009 McKinsey EE Report for DOE / EPA:

~ 6.5 Quadrillion Btu’s at an avg. capital investment of ~ $12 / MMBtu
Unlocking U.S. Energy Efficiency
Bang for Buck – Industrial Sector

- 2009 McKinsey EE Report for DOE / EPA:

- Waste Heat Recovery
  Energy Mgmt for E/I Processes
  ~ 13 Quadrillion Btu’s at an avg. capital investment of ~ $7 / MMBtu
FEMP Guidelines: Boiler Selection Criteria

- **FEMP = Energy Star for larger energy-using equipment**
- **Minimum boiler efficiency guidelines**
- **Boiler system selection & sizing guidelines**

“If building loads are highly variable, as is common in commercial buildings, designers should consider installing multiple small (modular) boilers.”

“Modular systems are more efficient because they allow each boiler to operate at or close to full rated load most of the time, with reduced standby losses.”
U.S. GHG Emissions: NOx

- Map of ozone non-attainment areas in the U.S.:
- Ground level ozone pollution is the primary driver of NOx emissions regulation in the U.S.

Nonattainment areas are indicated by color. When only a portion of a county is shown in color, it indicates that only that part of the county is within a nonattainment area boundary.
NOx is produced when oxygen & nitrogen in air combined at high temperatures during combustion.

NOx negative impacts on the environment include:
- Reacts w/ airborne VOC’s in sunlight to form smog
- Reacts w/ water vapor to create acid rain
- Contributes to global warming - nearly 300X the GWP of CO₂

NOx regulations established & enforced via local AQMD’s (Air Quality Management Districts).

NOx regulations have shown a steady reduction in allowable concentrations via fuel-burning equipment.

California’s SCAQMD regulations require maximum NOx levels for most stationary equipment to be set at 9 PPM by January 1, 2013.
California Emissions: AQMD’s

- California NOx emissions regulated via 15 Air Basins & 35 Air Quality Management District’s
- AQMD’s set emissions regulations to meet state State Implementation Plan (SIP) that in turn meets federal EPA limits
- Local emissions limits vary by local environmental conditions & AQMD compliance priorities
- Recent EPA reductions in ozone emissions limits resulting in reductions to allowable NOx emissions
U.S. GHG Emissions:

- **U. S. GHG Emissions Flow – 2005 (total mtCO2e):**
  - Commercial + Industrial Sectors ~ 1.4 Billion mtCO\textsubscript{2}e, as much as 20% of all U.S. GHG emissions

7.2 Billion mtCO\textsubscript{2}e
Total U.S. GHG Emissions
California GHG Emissions: 
**Impact by Composition**

- $\text{CO}_2$ from Fossil Fuel Combustion $\sim 80\%$ of all CA GHG emissions:
U.S. CO$_2$ Emissions:

- U.S. CO$_2$ Emissions Intensity (2005):
- State of California ~ 480 MtCO$_2$ (7% of U.S. GHG’s) (BAU increase by 25% to 600 MtCO$_2$ by 2020)
Comparison of carbon content of major fuels:

- Coal ~ twice the carbon content of natural gas

### CO₂ Equivalents (lbs/MMBtu)

- Natural Gas – 117 lbs
- Propane – 139 lbs
- Distillate Fuels – 162 lbs
- Residual Fuels – 174 lbs
- Coal (BC) – 205 lbs
- Coal (AC) – 227 lbs

### Accounting for the Environment: Global Warming Potential

- **Global Warming Potential (GWP):** Major greenhouse gases
- **GWP =** Ability of specific GHG’s to trap heat in the atmosphere
- **CO\textsubscript{2} = 1 GWP** (All other gases factored as CO\textsubscript{2} equivalent (CO\textsubscript{2}e))

<table>
<thead>
<tr>
<th>Name</th>
<th>Pre-industrial concentration (ppmv *)</th>
<th>Concentration in 1998 (ppmv)</th>
<th>Atmospheric lifetime (years)</th>
<th>Main human activity source</th>
<th>GWP **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water vapour</td>
<td>1 to 3</td>
<td>1 to 3</td>
<td>a few days</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Carbon dioxide (CO\textsubscript{2})</td>
<td>260</td>
<td>365</td>
<td>variable</td>
<td>fossil fuels, cement production, land use change</td>
<td>1</td>
</tr>
<tr>
<td>Methane (CH\textsubscript{4})</td>
<td>0,7</td>
<td>1,75</td>
<td>12</td>
<td>fossil fuels, rice paddles, waste dumps, livestock</td>
<td>23</td>
</tr>
<tr>
<td>Nitrous oxide (N\textsubscript{2}O)</td>
<td>0,27</td>
<td>0,31</td>
<td>114</td>
<td>fertilizers, combustion, industrial processes</td>
<td>296</td>
</tr>
<tr>
<td>HFC 23 (CHF\textsubscript{3})</td>
<td>0</td>
<td>0,000014</td>
<td>250</td>
<td>electronics, refrigerants</td>
<td>12 000</td>
</tr>
<tr>
<td>HFC 134 a (CF\textsubscript{3}CH\textsubscript{2}F)</td>
<td>0</td>
<td>0,0000075</td>
<td>13,8</td>
<td>refrigerants</td>
<td>1 300</td>
</tr>
<tr>
<td>HFC 152 a (CH\textsubscript{3}CHF\textsubscript{2})</td>
<td>0</td>
<td>0,0000005</td>
<td>1,4</td>
<td>industrial processes</td>
<td>120</td>
</tr>
<tr>
<td>Perfluoromethane (CF\textsubscript{4})</td>
<td>0,00004</td>
<td>0,00008</td>
<td>&gt;50 000</td>
<td>aluminium production</td>
<td>5 700</td>
</tr>
<tr>
<td>Perfluoroethane (C\textsubscript{2}F\textsubscript{6})</td>
<td>0</td>
<td>0,000003</td>
<td>10 000</td>
<td>aluminium production</td>
<td>11 900</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF\textsubscript{6})</td>
<td>0</td>
<td>0,0000042</td>
<td>3 200</td>
<td>dielectric fluid</td>
<td>22 200</td>
</tr>
</tbody>
</table>

- CO\textsubscript{2} emissions = 116.41 lbs CO\textsubscript{2} / MMBtu (HHV)
- CH\textsubscript{4} emissions = 0.046 lbs CO\textsubscript{2}e / MMBtu (HHV)
- N\textsubscript{2}O emissions = 0.068 lbs CO\textsubscript{2}e / MMBtu (HHV)

100 BHP (3.35 MMBtu/hr) ~ 390 mtCO\textsubscript{2}e/hr (natural gas)

* ppmv = parts per million by volume, ** GWP = Global warming potential (for 100 year time horizon).
U.S. GHG Emissions:

- **U.S. CO₂ Emissions (Gigatons CO₂e) – 1990 - 2030:**
- **29% of GHG’s Traced to Site Emissions in the Commercial / Industrial Sectors**

### Overall GHG emissions – 1990-2030
Gigatons CO₂e

<table>
<thead>
<tr>
<th>Year</th>
<th>Emissions</th>
<th>Sinks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>5.4</td>
<td>-0.8</td>
</tr>
<tr>
<td>2005</td>
<td>6.1</td>
<td>-1.1</td>
</tr>
<tr>
<td>2030</td>
<td>9.7</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

### GHG emissions by sector – 2030
Percent

- **Transport:** 1.3%
- **Industry:** 18%
- **Residential buildings and appliances:** 13%
- **All buildings and appliances:** 2%
- **Commercial buildings and appliances:** 1.9%
- **Waste:** -0.1%
- **Agriculture:** 0.3%

U.S. GHG Reduction Potential: Distribution by Region

- U.S. Potential GHG Reductions by Region (2005):
  - West: Total GHG Reductions Potential ~ 600 MtCO$_2$e
U.S. State Climate Action Initiatives:

- Current States with Climate Action Plans / Legislation:
- Growing “grass roots” climate initiatives nationwide
Signed into law by the Governor in September 2006

Establishes comprehensive program of regulatory & market mechanisms to achieve cost-effective reductions of GHG’s:

Establishes California Air Resources Board (CARB) as lead agency responsible for monitoring & reducing state GHG emissions with regular progress milestones:
California GHG Emissions:

- **AB 32:** GHG emissions reductions – 2010 - 2050

- 25% Reduction in GHG by 2020
- 80% Reduction in GHG by 2050

1990 GHG Levels
California Assembly Bill 32
Global Warming Solutions Act 2006

- Provides mandated fixed limits on GHG’s from key sectors representing 85% of the state’s total GHG’s
- Targets GHG reductions to 1990 emissions levels by 2020 (~ 25% reduction from current GHG levels)
- Regulated GHG sources must show compliance with the GHG cap imposed via the number of allowances allocated to them at the end of the 3-year period
- Compliance period 1 (beginning Jan. 1, 2012) – regulates large GHG sources > 25,000 mtCO2e annual GHG’s
- Compliance period 2 (beginning Jan. 1, 2015) – all other sources of GHG’s to be regulated by the cap-and-trade program
Compliance with regulation can be achieved with “allowances” and/or “offsets”.

An *allowance* is a permit to emit 1 mtCO2e annually.

Total number of allowances in the state = the “cap” in the cap-and-trade program.

Total number of allowances to be reduced each compliance periods creating new GHG “budgets” at the start of each successive compliance period.

An *offset* is a credit that represents a reduction in GHG emissions (from approved offset sources).

Each offset is equal to 1 mtCO2e annual emissions.

The total number offsets that a regulated source can use for compliance is 8% of its total GHG emissions.

Regulated sources of emissions must turn in allowances + offsets = to their total GHG emissions.
Planned Reductions in Annual GHG Allowance Budgets (2012-2020):

<table>
<thead>
<tr>
<th>Compliance Period</th>
<th>Allowance Budget Year</th>
<th>Annual Allowance Budget (Millions of CA GHG Allowances)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Compliance Period</td>
<td>2012</td>
<td>165.8</td>
</tr>
<tr>
<td></td>
<td>2013</td>
<td>162.8</td>
</tr>
<tr>
<td></td>
<td>2014</td>
<td>159.7</td>
</tr>
<tr>
<td>2nd Compliance Period</td>
<td>2015^12</td>
<td>394.5</td>
</tr>
<tr>
<td></td>
<td>2016</td>
<td>382.4</td>
</tr>
<tr>
<td></td>
<td>2017</td>
<td>370.4</td>
</tr>
<tr>
<td>3rd Compliance Period</td>
<td>2018</td>
<td>358.3</td>
</tr>
<tr>
<td></td>
<td>2019</td>
<td>346.3</td>
</tr>
<tr>
<td></td>
<td>2020</td>
<td>334.2</td>
</tr>
</tbody>
</table>
Valuation of GHG allowances:

- Allowances will be auctioned in an open market
- CARB also establishes a cost containment allowance reserve with allowances for sale at three tier levels:
  - Tier 1 - $40 / mtCO$_2$e allowance price
  - Tier 2 - $45 / mtCO2e allowance price
  - Tier 3 - $50 / mtCO2e allowance price
- Reserve allowances are available for purchase from CARB 3 weeks after allowance auction
- Reserve allowance prices are to escalate at 5% + cost of inflation each year
- Reductions in available allowances each compliance period will drive increasing prices for allowances & thus encourage GHG reduction projects in first year
U. S. Boiler Market Survey:

- What are the roots of the boiler technology currently operating in the U.S.?

- Miura is focused on energy efficiency technology transfer to bring the U.S. boiler inventory into the 21st century...
Moving Boilers into the 21st Century: Engineering + Innovation

- Weaknesses in Conventional Boilers:
  - Physical Size / Footprint
  - Excessive Warm-up Cycle
  - Excessive Radiant Losses
  - Poor Response to Changing Loads
  - Poor System Turn-Down Capability
  - Sub-par Overall Operational Efficiency / Load Management Capabilities
  - Innate Safety Issues via Explosive Energy
  - Lack of Integrated NOx Emissions Control
  - Lack of Integrated Heat Recovery
  - Lack of Integrated Controls / Automation
  - Lack of Integrated 24/7 Online M+V / M+T
Reducing Boiler “Footprint”

- **Physical Footprint:**
  - Reduced space requirements
  - Reduced energy plant construction costs
  - Reduced boiler “hardware”

- **Energy Footprint:**
  - Reduced energy consumption / wasted energy
  - Reduced explosive energy
  - Reduced embodied energy

- **Environmental Footprint**
  - Reduced consumption of natural resources
  - Reduced harmful emissions
  - Reduced carbon footprint
Conventional boiler systems expend large amounts of energy to meet variable load conditions.

Design limitations of conventional boilers prevent them from efficiently responding to every-changing load demands.

Result: Significant wasted energy & emissions at load swings.
Managing Energy Load Variability:
Modular On-Demand Systems

- Modular on-demand boiler systems reduce energy consumption required to meet variable loads by dividing the output capacity among multiple small units (like gears in a transmission).
- Modular systems are designed specifically to meet varying load demands.
- Result: Significantly reduced energy & emissions at load swings.
Optimized Energy Management via **Modularity**

- Modular design concept:

  200HP TDR=1:3 Step(H,L)
  200HP TDR=1:3 Step(H,L)
  200HP TDR=1:3 Step(H,L)
  200HP TDR=1:3 Step(H,L)
  200HP TDR=1:3 Step(H,L)
Optimized Energy Management via 

Modularity

- Modular design concept:
- Each boiler unit acts like a single piston in the overall boiler system

1000HP boiler system
TDR=1:15
(15 steps of modulation)
Modular Capacity Range: Flexibility + Efficiency

- Boiler Types & General Capacity Ranges
- Modular – Point-of-Use to District Energy Capacities

Multiple Boiler Installation to Meet Specific Demand
(Multiple Boilers & Controllers)

Max. Multi-Unit Boiler Capacity w/ Single Controller
(+/- 150 MMBtu/hr or 150,000 lbs/hr)

Max. Individual Boiler Capacity
(+/- 10 MMBtu/hr or 10,350 lbs/hr)

Boiler Types & General Capacity Ranges

<table>
<thead>
<tr>
<th>Boiler Type</th>
<th>Capacity Range (MMBtu/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firetube Boilers</td>
<td>1,000</td>
</tr>
<tr>
<td>Small Watertube Boilers</td>
<td>100</td>
</tr>
<tr>
<td>MIURA Boilers</td>
<td>10,000</td>
</tr>
<tr>
<td>Large Watertube Boilers</td>
<td>1,000</td>
</tr>
<tr>
<td>Stoker Boilers</td>
<td>100</td>
</tr>
<tr>
<td>Fluidized Bed Boilers</td>
<td>1,000</td>
</tr>
<tr>
<td>Pulverized Coal Boilers</td>
<td>10,000</td>
</tr>
</tbody>
</table>
Understanding Boiler Efficiency: 
*In-Service Efficiency*

Boiler Efficiency = \( \frac{\text{Output Energy}}{\text{Input Energy}} \)

- **Input Energy**: Gas
- **Output Energy**: Steam / Hot Water
Understanding Boiler Efficiency:

“Combustion Efficiency” ($E_c$)
- The effectiveness of the burner to ignite the fuel
- Per ANSI Z21.13 test protocol

“Thermal Efficiency” ($E_t$)
- The effectiveness of heat transfer from the flame to the water
- Per the Hydronics Institute BTS-2000 test protocol
- Recognized by ASHRAE 90.1 standard

“Boiler Efficiency”
- Often substituted for combustion or thermal efficiency

“Fuel-to-Steam Efficiency” (A.K.A. Catalog Efficiency)
- The effectiveness of a boiler operating at maximum capacity and a steady state, with flue losses and radiation losses taken into account.
Understanding Boiler Efficiency:
ASHRAE Standard 155-P

- A more meaningful measure of boiler performance
- Applicable to steam & hot-water boilers with \( \geq 300,000 \text{ Btu/hr capacity} \)
- Applicable to individual, modular and/or multiple boilers

**Purpose of the standard:**

1. Provide a comprehensive measure of boiler system operating efficiency, including:
   - Steady-state thermal efficiency
   - Part-load efficiency
   - Through-flow loss rate
   - Idling-energy input rate of individual boilers

2. Provide a calculation to determine application-specific seasonal efficiency ratings for boilers
Application Seasonal Efficiency (ASE):

Seasonal “bin-based” calculation whereby hourly building loads are divided into 101 bins, 0-100

Each “bin” is a snapshot of the boiler system load factor percentage based on heating demand

In any bin, various boilers may be:

- Off and isolated (via modular, on-demand system)
- Off, but with through-flow from active boilers
- Operating at steady-state high fire
- Modulating
- Operating at steady-state low fire
- Cycling
- Idling
Understanding Boiler Efficiency:

- Fuel-to-Steam vs. In-Service Efficiency
- Understanding operating efficiency = tracking energy losses
Increasing Efficiency = Reducing Losses: 

Radiant Losses

- With energy efficiency, size matters...
- Increase efficiency via reduced boiler thermal footprint

200 BHP Firetube Boiler

200 BHP Modular Boiler

1,000+ Gallons VS 65+ Gallons

Smaller Boiler Surface Area = Significant Reduction in Radiant Losses
Increasing Efficiency = Reducing Losses: 

**Radiant Losses**

- **Radiant Losses:** 12 MMBtu/hr input at 100% output
- **Option A – Conventional System:**
  - Single 12 MMBtu/hr unit input
  - Rated at 2% radiant loss
  - 240,000 Btu/hr energy loss
- **Option B – Modular System:**
  - 3 x 4 MMBtu/hr unit input
  - Rated at 0.5% radiant loss
  - 3 x 20,000 Btu/hr losses = 60,000 Btu/hr energy loss
Increasing Efficiency = Reducing Losses:

Radiant Losses

- Radiant Losses: 12 MMBtu/hr input at 33% output
- Option A – Conventional System:
  - Single 12 MMBtu/hr unit at 33% = 4 MMBtu/hr input
  - 240,000 Btu/hr energy loss
  - Results in 6% total radiant loss
- Option B – Modular System:
  - 3 x 4 MMBtu/hr units (only 1 operating)
  - 1 x 20,000 Btu/hr losses = 20,000 Btu/hr energy loss
  - Only 0.5% total radiant loss
Space Savings – Addition by Subtraction:

- Small boiler footprint (good for point-of-use applications)
- No tube-pull space required
- **Double** the boiler output of a typical boiler room (existing facilities)
- Reduce required boiler room area by over **50%** (new construction)
Space Savings – Addition by Subtraction:

- The 21st century boiler plant…
- Take advantage of freed-up space to:
  - Increase capacity
  - Incorporate other functions (in lieu of costly new construction)
- Miura has received UL certification for zero side-clearance modular configuration
Increasing Efficiency = Reducing Losses:

- Utilize feed-water economizer for built-in waste heat recovery
- Feed-water economizers increase efficiency by capturing waste exhaust gases to preheat feed-water entering the boiler
- Boiler efficiency can be increased by 1% for every 40°F decrease in stack gas temperature

<table>
<thead>
<tr>
<th>Initial Stack Gas Temperature, °F</th>
<th>Recoverable Heat, MMBtu/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boiler Thermal Output, MMBtu/hr</td>
</tr>
<tr>
<td></td>
<td>25</td>
</tr>
<tr>
<td>400</td>
<td>1.3</td>
</tr>
<tr>
<td>500</td>
<td>2.3</td>
</tr>
<tr>
<td>600</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Based on natural gas fuel, 15% excess air, and a final stack temperature of 250°F.
Increasing Efficiency = Reducing Losses: **Start-up Losses**

- Thermal shock/stress is the **#1 cause** of fire-tube boiler damage & repair.

- Conventional boiler performance is limited by thermal stress resulting in inefficiency by requiring slow boiler start-up & perpetually idling operation.

- Firetube boilers typically require as much as 90 minutes for cold start-up & must remain idling when in stand-by mode resulting in significant wasted energy & emissions.
Increasing Efficiency = Reducing Losses: **Start-up Losses**

- Innovative “Floating Header” pressure vessel design eliminates thermal shock
- All welded tube to tube-sheet construction
- X-ray & dye-penetrant quality control with heat treatment for stress relief of steel
- Single-pass design for even temperature distribution
- No more “re-rolling tubes” or “tube popping”...
- Allows for steam production in 5 minutes from cold start
Increasing Efficiency = Reducing Losses: Blow-down Losses

- U.S. DOE steam systems BEST PRACTICES recommendation:
  
  “Improve boiler efficiency and reduce water consumption by utilizing automatic surface blow-down in lieu of continuous and/or manual blow-down.”

- Miura’s BL Controller boiler control system includes automatic blow-down for optimization of blow-down for highest efficiency operation.

- Automatic blow-down is managed by the BL Controller via a proportional flow system & back-up conductivity probe that monitor TDS to maximize boiler performance and efficiency.
Increasing Efficiency = Reducing Losses: *Pre- & Post-Purge Losses*

- Utilize a control system that includes an intelligent purge system to optimize boiler performance
- “Purge Cancel” function interrupts post purge when fast restart is required, eliminating heat loss and improving response time
- Optimized response time (w/in 10 seconds) = increased efficiency + reduced emissions
Increasing Efficiency = Reducing Losses: 

**Losses at High Turn-down**

- Modular boiler system:

  ![Diagram of modular boiler system with MT1, MP1, Twisted pair cable, MI-Controller, and Steamp Header]

1. High-Fire
2. High-Fire
3. Low-Fire
4. Low-Fire
Optimized Energy Management with **Modularity**

- Multiple modular boilers act as one large, high efficiency, high turndown boiler
- Boilers react in 30 seconds or less.
- Shut off boilers in low load conditions
- In the event of a fault, backup boilers come online in 30 seconds
Boiler Scale Detection & Prevention: *Heat Transfer Losses - Scale*

- An eggshell thickness of scale can reduce boiler efficiency as much as 10%* (25% for 1/8” thickness, 40% for 1/4” thickness)

*Just 1/32” of scale thickness multiplied times each industrial boiler in the U.S. inventory ~

- Over $7 billion in wasted energy / yr (@ $1.00/therm)
- Over 50 million metric tons of CO$_2$ emissions / yr
Boiler Scale Detection & Prevention: Water Hardness Monitoring

- Installed between water softener & feed water tank
- Colormetry “sips” feed water every 30 minutes
- Detects water hardness below 1 ppm
- Automatically increases surface blow-down when water hardness is detected
- Interfaces with BL Controller & M.O.M. System
- Easily replaceable cartridges
Boiler Scale Detection & Prevention: Integrated Water Softener System

- “Smart” water softener system
- Enhanced performance / reduced salt usage by ~30% via split-flow regeneration
- Automatically alternates between primary / regeneration tanks for optimized performance
- Monitors brine tank level & alarms thru BL Controller
- Interfaces with Colormetry, BL Controller & Online Monitoring System

NEW

Miura Boilers
ML2 Panel
MW
CMU-H
Boiler Tube Protection:
Enhanced Chemical Water Treatment

- Eco-friendly Silicate-based water treatment
- Eliminates need for high temperature feed-water (i.e., DA tank) to activate chemical treatment
- Provides increased boiler efficiency by +1-2% via reduced blow-down & low temperature feed-water
- Reduces boiler chemical treatment costs due to more effective tube protection & computer controlled chemical feed system
- Reduces maintenance issues related to constant monitoring & adjustment of boiler water chemistry
- Reduces boiler performance issues such as feed-water pump cavitation, increasing pump efficiency by +10-20%
Boiler Tube Protection:
Enhanced Chemical Water Treatment

- Silicate filer water treatment feed is modulated via an interface with the MI Controller
- Chemical feed is based on steam demand measured by the steam pressure sensor
Online Monitoring / Management: Online “Energy Dashboard” Systems

- Utilize online monitoring system that interfaces with boiler control system as thermal energy management “dashboard”
- Provides 24/7 online M&T/ M&V online maintenance system
- Real-time 24/7 operation, fuel/water consumption, efficiency & emissions tracking capabilities
- Communicates with operations staff via workstation interface, PDA, email alerts
- Provides monthly reports
Online Monitoring / Management: 
**ER System “Energy Dashboard”**

- 24/7 Real-time Operational Parameters: LX Series Interface
  - Firing Rate
  - Steam Pressure
  - Scale Monitor
  - High Limit
  - Flue Gas Temp
  - Feedwater Temp
  - Flame Voltage
  - Next Blow-down
  - Surface B/down
  - Conductivity
  - Date / Time
Boiler Systems - Introduction:

- Available Models:
  - LX Series
  - EX Series

Miura Gas-Fired/Low Nox LX Series
High Pressure Steam Boiler

Miura Gas/Oil-Fired
EX Series
High Pressure Steam Boiler

LX Series
EX Series
Boiler Model Summary: 
**LX Series**

- Gas Only – Natural Gas / Propane
- 50, 100, 150, 200, 300 BHP Models
- Steam in 5 min. from Cold Start
- Low NOx Design (as low as 9ppm)
- Horizontal Flame Path
- 70-150 PSI Standard Operating Pressure (low and high pressure options available)
- Also Available in Hot Water Version
Boiler Model Summary: Combustion

**LX Series**

- **Patented Self-Quenching / Cooling Burner Design:** Flame Temp ~ 2,200 °F
- **Flame in Direct Contact w/ Water Tubes (No Furnace)**
- **Low NOx Leader:** 20 ppm standard (12 & 9 ppm models available)
Boiler Model Summary: *EX Series*

- Duel Fuel – Natural Gas/Propane & Oil
- 100, 150, 200, 250, 300 BHP Models
- Steam in 5mins From Cold Start
- Vertical Flame Path (top down)
- 70-150 PSI Standard Operating Pressure (high pressure option available)
- Also Available in Hot Water version
Boiler Model Summary: Combustion

EX Series

- Vertical Flame Path:

Floating Header Design – Side View

Combustion Path – Top View

Unlike other watertube boilers constructed inside an insulated box, the Miura boiler is constructed entirely of boiler tubes. The tubes form the inner and outer walls of the flue gas path.

Upper Header connected to Lower header only by schedule 40 water tubes. No external shell holds the headers together because the entire body of the boiler is constructed of boiler tubes.

Heat Transfer Zone:
Only this middle section of the tubes receives heat. This is the area of thermal expansion. As the tubes expand and contract, the upper header moves independently of the lower header, relieving stress without tube bends.

External Level Control

Lower Header

Castable Refractory
Protects the tube sheet welds
Benchmarking to Save Energy: 
First Steps

- Why benchmark?...
  
  You are not managing what you do not measure...

- Benchmarking thermal energy systems first and foremost confirms that existing systems are sized appropriately for current load demands

- Benchmarking assesses energy performance of existing systems in comparison with the current “state of the shelf” in available technology

- Benchmarking allows facilities to better evaluate the carbon intensity of their operations

- Benchmarking data can be used to identify opportunities for energy savings & reduced emissions via systems upgrades

- Benchmarking data can be used as the basis of capital planning and/or award for energy efficiency rebates / grants
Miura’s **Data Logger** records metered usage to benchmark existing efficiency:

- Tank
- Radiant Losses
- Water Meter
- Gas Meter
- Gas
- Water
- Blow-down
- Existing Boiler
- Steam Demand
- Steam
- Miura Data Logger

---

**In-Service Efficiency Analysis: Benchmarking Tools**
Boiler In-Service Efficiency: Tracking Results

- Benchmarked energy efficiency of 25 boilers via ISE data:
- Average In-Service Efficiency = 66% at 33% average load factor

**Example Steam Load Profile**

<table>
<thead>
<tr>
<th>Company</th>
<th>Industry</th>
<th>Manufacture</th>
<th>HP</th>
<th>Year</th>
<th>Ave. Load</th>
<th>ISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>17%</td>
<td>70.8%</td>
</tr>
<tr>
<td>2</td>
<td>Foods</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>70.6%</td>
</tr>
<tr>
<td>3</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>19%</td>
<td>70.3%</td>
</tr>
<tr>
<td>4</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>69.9%</td>
</tr>
<tr>
<td>5</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>69.2%</td>
</tr>
<tr>
<td>6</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>68.8%</td>
</tr>
<tr>
<td>7</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>67.7%</td>
</tr>
<tr>
<td>8</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>66.9%</td>
</tr>
<tr>
<td>9</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>66.4%</td>
</tr>
<tr>
<td>10</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>65.7%</td>
</tr>
<tr>
<td>11</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>65.0%</td>
</tr>
<tr>
<td>12</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>13</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.8%</td>
</tr>
<tr>
<td>14</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.3%</td>
</tr>
<tr>
<td>15</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.3%</td>
</tr>
<tr>
<td>16</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>17</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>18</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>19</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>20</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>21</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>22</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>23</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>24</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
<tr>
<td>25</td>
<td>Chemical</td>
<td>CB</td>
<td>1500</td>
<td>1978</td>
<td>18%</td>
<td>64.9%</td>
</tr>
</tbody>
</table>

Average: 365 33% 66.0%
In-Service Efficiency by Boiler Type:

Miura’s modular systems provide increased energy efficiency at around 85% consistently from low to high load factors.
Steam Cost Calculator:  
**TCO (Total Cost of Operation) Analysis**

- **Fuel Cost**
- **Water Cost**
- **Sewer Cost**
- **Electricity Costs**
- **Chemical Costs**
- **Service Contract**
- **O&M Costs**
- **Future CO₂ Costs**
- **Projected Lifecycle Costs**

### Customer's name: Example 1

<table>
<thead>
<tr>
<th>Usage</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler HP</td>
<td>400 HP</td>
</tr>
<tr>
<td>Number of boilers</td>
<td>2 boilers</td>
</tr>
<tr>
<td>Average load</td>
<td>25 %</td>
</tr>
<tr>
<td>Operation time</td>
<td>12 hours/day</td>
</tr>
<tr>
<td></td>
<td>300 days/year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Price for customer</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water (supply + sewer)</td>
<td>5.8 $/kgal</td>
</tr>
<tr>
<td>Fuel gas (oil)</td>
<td>0.8 $/therm</td>
</tr>
<tr>
<td>Electricity</td>
<td>7 C/kWh</td>
</tr>
<tr>
<td>Chemical</td>
<td>0.80 $/100 HP</td>
</tr>
<tr>
<td>Labor charge</td>
<td>2,500 $/month</td>
</tr>
<tr>
<td>Maintenance contract</td>
<td>10,000 $/boiler</td>
</tr>
<tr>
<td>Carbon tax</td>
<td>0 $/ton CO₂</td>
</tr>
</tbody>
</table>

### System information:

<table>
<thead>
<tr>
<th>Reference</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam pressure</td>
<td>130 PSI</td>
</tr>
<tr>
<td>Steam enthalpy</td>
<td>1193.5 btu/lb</td>
</tr>
<tr>
<td>Blow down ratio</td>
<td>5 %</td>
</tr>
<tr>
<td>Feed water temp</td>
<td>190 °F</td>
</tr>
<tr>
<td>In service Efficiency</td>
<td>73 %</td>
</tr>
<tr>
<td>Condensation return</td>
<td>30 %</td>
</tr>
</tbody>
</table>

### Steam Price per 100 HP

1) Fuel Gas (oil) = $/therm x (3,348,000 / 100,000) x (100,000 / 100)
2) Water = $/kgal x (City water usage)
3) Electricity = C/kWh x (City usage)
4) Chemical = $/100 HP x (1 HP / 100 HP boilers)
5) Labor charge = $/month x (average load / hours)
6) Maintenance contract = $/year x (average load / hours)
7) Carbon tax cost = $/ton CO₂ x (3,348,000 / 100,000) x (100,000 / 100)

**Total price for a year**

1) Fuel Gas (oil) = 264,171
2) Water = 13,032
3) Electricity = 7,560
4) Chemical = 5,760
5) Labor charge = 30,000
6) Maintenance contract = 20,000
7) Carbon tax cost = 340,523

**Total** = $340,523
Energy Efficiency Incentives: Natural Gas Rebate Programs

- Utilize ISE Study data to satisfy incentives EE performance metrics
- Growing list of state & utilities sponsored rebate programs...

Refer to www.dsireusa.org
Case Studies: **Gekkeikan (California)**

- **Boiler System:** (2) 200 BHP, (1) 100 BHP LX Series units
- **Placed into service:** 1996, 1997, 2010
- **Process applications:** pasteurization, heating water, C.I.P.
- **LOW LOAD:** LX-100 (Low Fire)
- **MED LOAD 1:** LX-100 (Low/High Fire) + LX-200 (High Fire)
- **MED LOAD 2:** LX-100 (High Fire) + LX-200 (Low/High Fire) with LX-200 (Standby – Backup)
- **HIGH LOAD:** LX-100 (High Fire) + LX-200 (High Fire) + LX-200 (Low/High Fire as needed)
Case Studies: 
**Gulistan Carpet (North Carolina)**

- **Boiler Upgrade** – (6) 300 BHP units
- **Placed into service** – 2008
- **Estimated avg. operating cost savings** = $288,000 / yr. (270,000 therms / yr.)
- **Estimated avg. reduced CO₂ emissions** = 1,350 metric tons of CO₂ / yr.

- “We rely on steam for the dyeing process, and with previous steam boilers, we would have to wait at least two hours for steam to be produced. This resulted in labor inefficiencies and higher fuel costs. With the Miura boilers, we can have steam just a few minutes after startup. Since being installed, we estimate that we are saving an average of $24,000 each month on labor and fuel costs. The Miura boilers have significantly improved the efficiency of our facility.”
  – Jack Avant, Engineering Manager

- “The Miura boilers have performed very well. We contacted several boiler companies, and we did not find a single competitor that could meet our requirements. Miura’s efficiency is essential to meeting our performance needs and the fuel savings and the labor savings are very important to our bottom line.” – Avant
Case Study: University of Arkansas

- **Boiler Upgrade** – (6) 300 BHP units replaced (3) existing 600 BHP Kewanee firetube boilers

- **Summer “Peaking” Plant**

- **Placed into service – March 2008**

- **Reported energy savings = $280,000 / yr**

- **Reported reduced CO$_2$ emissions = 1.2 million lbs. of CO$_2$ / yr**

- “On-Demand Steam is a great asset as it allows us to be able to spool the boiler up very quickly, and then take it back down offline when the load dies down is really helpful. Another advantage of the Miura boilers is that if, by chance, we lose a boiler for some reason, we only lose a sixth of our production capacity. If you lose a large boiler, you can lose it all. That additional reliability factor of a multiple installation of Miura boilers is also something we liked.”

- With the installation of the six Miura LX-300 steam boilers, the University of Arkansas has not only upgraded its physical plant with the advantages of On-Demand Steam and a reduced environmental footprint, it has also saved money.
Case Studies:

Duke University (North Carolina)

- Boiler Upgrade – (15) 300 BHP units
- Replacement of Coal-burning Plant
- LEED-Gold Historic Building Restoration
- Placed into service – February 2010
- Estimated avg. reduced CO₂ emissions = over 50,000 metric tons of CO₂ / yr.

Miura’s technology provides a significant reduction in the energy losses associated with a typical start-up, purge, and warm-up cycle of a boiler.” - Russell Thompson, Duke University’s Director of Utilities and Engineering for Facilities Management

(referencing the on-demand steam capabilities of the university’s 15 new Miura LX-series natural-gas fired boilers, any one of which can be turned on or off as needed to meet the campus’ ever-changing steam-generation demands while optimizing performance for increased efficiency and reduced environmental impact.)
“Power-Plant-in-a-Box” Concept: Modular Micro-cogeneration System

- Partnership with Carrier Corporation
- Complete packaged heating, cooling & power generation

10 MMBtu/hr (heating)  
275 kW (elec)  
540 tons (cooling)

(A) Gas

(B) Carrier Micro-Steam (back-pressure turbine)

(C) Miura Boiler

(D) Condensate

(E) Carrier Micro-Steam

(F) Cooling water in / out

(G) Carrier Absorption Chiller

Steam @ high pressure

Steam @ low pressure

Chilled water in / out
Questions:

Jason Smith, LEED A.P.
(770) 916-1695 Office
(678) 939-7630 Cell
jason.smith@miuraboiler.com