TECHNICAL GUIDE 13.0

Best Practice
Boiler Tuning Procedure

EECA BUSINESS™
PUTTING ENERGY TO WORK

1 Contents

Prepared for EECA by Emsol
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2 Introduction

In 2010 EECA reviewed the potential for improving efficiency of boilers operating in New Zealand. The potential for improvement is vast and this boiler tuning procedure is one of the main recommendations from EECA's review. The procedure is aimed at achieving three key objectives:

- Increase the frequency at which boilers are tuned in New Zealand
- Create a tuning procedure aimed specifically at increasing the efficiency of boilers
- Unify the standard to which boilers are tuned

Tuning tasks in this procedure have been limited to those that have a direct energy efficiency implication; whereas current tuning and boiler service practices have a large emphasis on combustion gas analysis only or routine maintenance and statutory safety compliance checks.

There is an overlap in the tasks of this procedure compared to traditional compliance checks, which is unavoidable. However, this overlap is minimised by integrating compliance checks with the boiler tuning scope on an 'as needed' basis.

Consideration has also been given to the available skill set of the average tuner to accomplish accurate and practical energy saving recommendations as part of the tune. This might include recommendations for Variable Speed Drives (VSD) or insulating steam manifolds and pipe work. At present there is a small group of highly skilled tuners available in New Zealand to meet demand. EECA and Emsol agreed to expect these tuners would be able to make such recommendations as a result of their many years of industry experience.

The frequency required for boiler tuning will depend on a number of variables, including and not limited to:

- Boiler water quality and water treatment practices
- Fuel type and quality
- Improvements from previous tunes
- Regularity and quality of maintenance being provided
- Type of boiler and size
- Existing human resources available on site, such as a full time boiler man
- Existing boiler monitoring and targeting practices that are in place
- Boiler operating loads and hours per year

This procedure was updated after using it in a pilot study (September 2011 to March 2012) and revised in June 2015 after using it in the field for three years. Its use by tuners has verified the methods and energy saving values published in this procedure. In particular, the factors listed in Table 2 are used in savings calculations to help achieve the objectives above. These factors are applicable in most situations and tuners may use different values where they recognise this from experience.

This procedure should also be read in conjunction with *Steam Efficiency – a systematic approach to reducing energy wastage* (EECA, Nov 2011).

3 Scope of boiler tune

This procedure is intended to cater for the majority of boiler systems installed across industrial, commercial and public sectors. This includes solid, liquid and gas fuelled boilers.

Figure 3.1 below depicts the three main stages of the boiler tune: Preliminaries, Maintenance and Gas Analyser Tuning.

“Boiler Tune” is defined to incorporate these three stages; Preliminaries, Maintenance and Gas Analyser Tuning. Flue gas analysis and combustion tuning only is referred to “Gas Analyser Tuning”.

Best practice boiler tuning is to concentrate on boiler systems located within the confines of the boiler house[1] and the immediate surroundings. It includes all related components such as feedwater and makeup tanks, deaerator, fuel handling areas, fans and the main steam or hot water line.

Particular emphasis has been placed on documenting observations and recommendations so as to give the boiler owner data that can be used to follow on from the tune and use in their organisation’s energy programme.

Figure 3.1 Scope of boiler tune

An indication of costs provided by various boiler tuners to apply this procedure for all three stages would be in the order of:

- $1,700 to $2,900 for a small boiler (0.5 – 1.1 MW)
- $2,600 to $5,000 for a medium sized boiler (1.2 – 2.9 MW)
- $3,000 to $7,000 for a large or complicated boiler system (3.0 – 14.0 MW)

Costs vary significantly between gas, liquid and solid fuel boiler types. The procedure proposed by this guide is significantly cheaper to carry out on gas and liquid fuel type boilers than solid fuel type.

[1] Or other immediate area where the boiler is located

Figure 3.2 (below) shows a typical fire tube boiler with many of the components that would be inspected as part of this procedure.

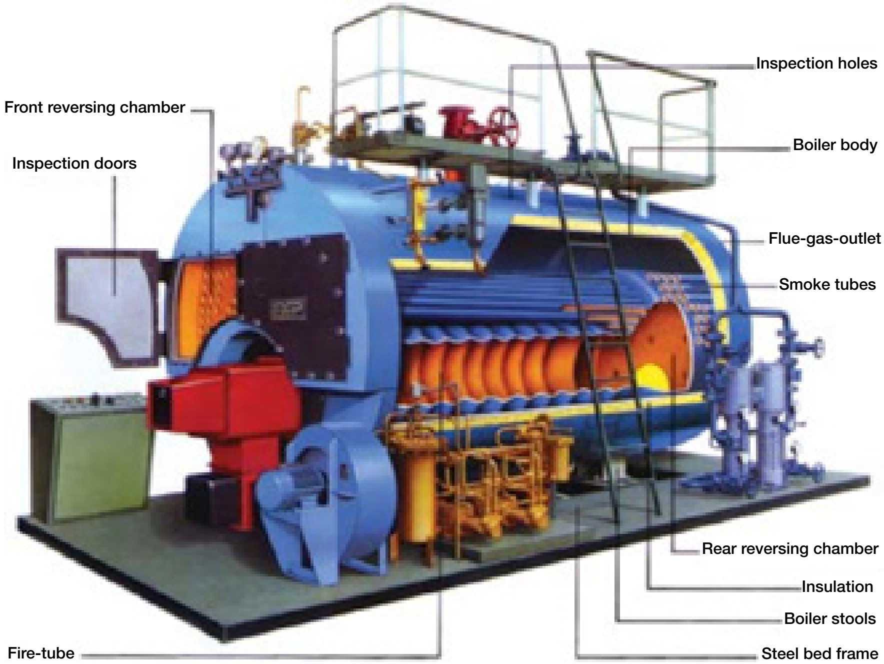


Figure 3.2 - Typical fire-tube boiler

Figure 3.3 (below) depicts a typical large industrial coal fired boiler and steam system, with many of the components that would be inspected as part of this procedure. Note, most boilers are in the region of 1.5 MW - 9 MW and would be simpler by nature to tune than the boiler shown below.

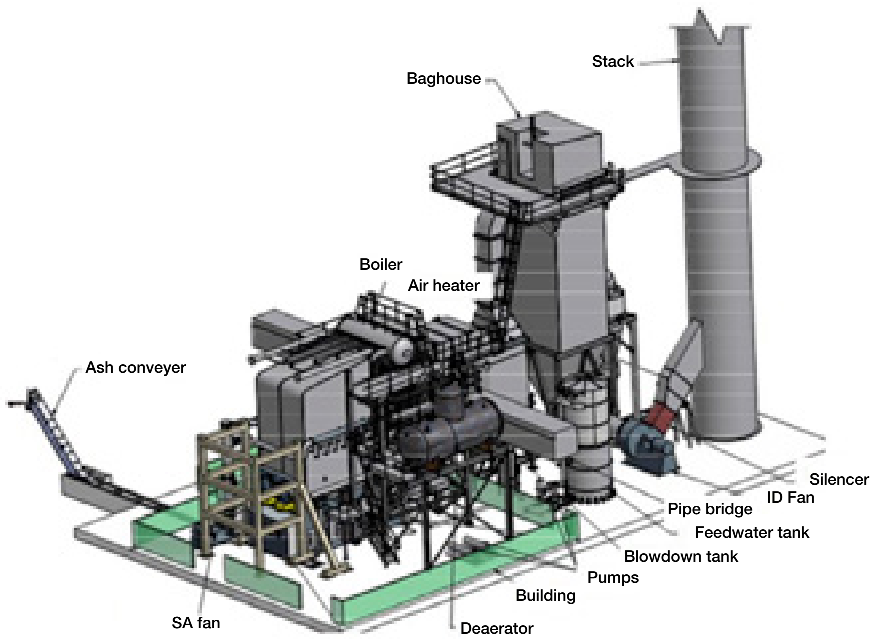


Figure 3.3 Typical large industrial coal fired boiler

4 Tuning Procedure - Tasks and Order of Events

Shown below are the individual tasks to be performed by the tuner during a best practice boiler tune (in their intended order of completion). Note, some of these tasks are already included in a boiler annual service; however they are listed here because they affect the energy efficiency of a boiler.

Stage One (Preliminaries) would normally be completed during the same visit as an annual boiler service, before the boiler is shut down. Stage Two (Maintenance) would normally be completed during the same visit as an annual boiler service. However, Stage One (Preliminaries) may also be completed during the same visit as completing Stage Three (Gas Analyser Tuning), after the annual service is complete and at other times during the year. It is important before the tuner visits the site that they discuss with the boiler operator the timing of Stage Three in order to obtain readings across a range of boiler operating loads.

Depending on the size and type of boiler the order of tasks may vary. Some boilers can be shut down more often than others, which also depend on production requirements and frequency of service.

It is recommended the tuner follows the order of events below unless the boiler cannot be shut down easily. If this is the case then some of the tasks in ‘Preliminaries’ and ‘Maintenance’ that require the boiler to be shutdown should be completed at the same time as an annual service. In addition, the most recent annual service report should be reviewed and energy efficiency opportunities calculated and reported accordingly (eg de-scaling boiler tubes). The remaining tasks may be carried out on a different frequency of two to four times a year.

The frequency of a best practice boiler tune should start at every six months unless prior experience demonstrates a different frequency should be used. When the cost of a best practice boiler tune exceeds the savings identified at each tune then the number of tunes per year should be reduced by one. Conversely, when the savings identified is more than double the cost of the boiler tune then the number of tunes per year should be increased by one.

The following Tasks in Sections 4.1 to 4.5 should be used as a site visit check sheet. Note, some of these Tasks will not apply to all boiler types such as for gas boilers and small boilers. If this is the case then Not Applicable (NA) should be reported.

4.1 Preliminaries

Meet with boiler owner, discuss boiler performance and review boiler log book. Tuner to document events that affect performance and operation costs:

Boiler ‘Lockouts’
Fuel consumption
Reliability
Operational Costs
Maintenance
Boiler suitability

1. Observe boiler, document relevant readings and set points such as:

- Pressure [bar]
- Firing Rate [%]
- Steam Rate [kg/hour] (encourage owners to install accumulating steam meters)
- TDS [ppm]

2. Perform a walkthrough inspection of boiler house, document opportunities for improvement of insulation, heat recovery, condensate return, steam, water leaks and other similar sources of energy loss. Opportunities for insulation are found typically on:

- High pressure valves
- Manifolds
- Steam traps
- Pipes
- Planar Surfaces

The temperature and approximate surface area of surfaces that could be insulated is to be documented. Note, areas that should not be insulated such as those subject to internal overheating or those adjacent to flue exhaust

3. View fuel invoices, or if applicable fuel test certificates and comment on suitability of fuel quality.
4. Inspect fuel storage and handling procedures and comment if they are appropriate
5. Document water treatment procedures and comment on suitability and effects to long term boiler efficiency
6. Check combustion chamber/firebox for ingress or leaks
7. Observe and document combustion (flame quality, fuel distribution)
8. Record maximum attainable boiler output (if possible) – Steam rate [kg/hour]
9. Check and document fuel delivery pressure (liquid and gas)
10. Observe blowdown procedures and document TDS set point
11. Identify and document blowdown heat recovery opportunities
12. Measure and document deaerator water and surface temperature
13. Check soot blower operation
14. Measure and document feed tank temperature and insulation level, note any excessive quantities of steam returning to feed tank that would indicate steam trap failure
15. Check and document any occurrences of leaking safety or pressure relief valves
16. For coal boilers, check coal bed depth and rate of through put matches manufacturer’s requirement for efficient operation; comment on completeness of coal combustion
17. Check and document the amount of combustibles in the bottom ash and fly ash of solid fuel boilers

4.2 Maintenance – Fuel Handling

18. Check and service dampers, linkages and valves
19. Replace filters and nozzles for liquid boilers if not already completed in annual service
20. Service conveyors, augers and elevator buckets if not already completed in annual service

4.3 Maintenance – Heat Transfer

21. Inspect and if needed de-scale both fire and water sides of boiler tubes. Document existence of any scale deposits; take a sample of deposits for future analysis. If needed, clean site glass
22. Inspect and ask the operator when the boiler last had an acid clean; report appropriately on recommended frequency of acid cleaning.

4.4 Maintenance – Flue, Multiclone and stack

23. Check and service ID, FD and other fan drives as fitted. Document any opportunities to fit VSD's if not already completed in annual service.
24. Check multiclones and bag house. Document the occurrence of any compressed air leaks if not already completed in annual service. Check the length of pulse and/or pulsing frequency is not excessive.

4.5 Gas Analyser

25. Document existing draft/boiler pressure. Adjust airflow until a satisfactory draft/boiler pressure has been obtained.
26. Check ignition system and ease of starting. Document any difficulties in starting boiler
27. Obtain a uniform fuel bed (solid fuel). Document any signs of excessive clinker formation.

Begin tuning boiler at 100% firing rate - minimising CO and excess air. Repeat at 75%, 50% and 25% firing rates for modulating boilers and at high (100%) and low (25%) firing rates for two stage boilers.

For each firing rate document the parameters shown below.

Firing Rate	100%	75%	50%	25%
CO [%]				
O_2 [%]				
H_2O [%]				
CO_2 [%]				
Combustion Temperature (furnace)[°C]				
Steam Rate/Water flow[2] rate [kg/hr]				
Flue Gas Temperature [°C]				
Combustion Efficiency [%]				
Comment on fuel distribution on bed (if applicable)				
Comment on appropriateness of primary and secondary air flow rates				

If a steam or hot water meter is not available then the tuner should recommend in their report to install a meter on the main supply line leaving the boiler. It is expected a meter used in an energy monitoring and reporting programme will contribute to energy savings of 5% or more than otherwise would be achieved.

[2] Encourage owners to install an accumulating steam meter or water flow meter with inlet and outlet temperature readings

Report Template

Client's Organisation – **Tuning Report**

Boiler Make:	Add here
Boiler Type:	Add here
Operating pressure:	Add here
Fuel:	Add here
Boiler size:	Add here
Date installed:	Add here
Date last tuned:	Add here
Site address:	Add here
Boiler contact per:	Add here

Summary

Declaration that the tune has been carried out in accordance to EECA's 'Best Practice Boiler Tuning Procedure'.

Sample Paragraph: *Tuner's Organisation* has tuned *Client's Organisation* boiler type boiler in accordance with EECA's 'Best Practice Boiler Tuning Procedure'.

The first paragraph states the estimated cost savings as a result of this tune.

Sample Paragraph: Total energy savings attributable to this tune have been estimated at **$** over the next 12 months if these efficiency improvements are maintained. This represents an approximate reduction in fuel consumption of **x%**.

The second paragraph states the measured increase in the combustion efficiency and its resulting energy and cost savings.

Sample Paragraph: Combustion efficiency has increased from **x%** to **y%** and is estimated to save **kWh**[3] (equal to $ at current fuel prices) over the next 12 months if this efficiency is maintained.

The third paragraph states the most significant gain in efficiency outside of the combustion efficiency. Efficiency gains are in line with EECA guidelines, cost savings are estimated from the total yearly fuel spend.

Sample Paragraph: Scale deposits approximately 3mm thick were found on the waterside heat transfer surfaces. These were removed during the tune in the presence of *Client's Organisation's* water treatment provider who suggested a review of the current dosing practices. *Tuner's Organisation* has estimated a further **z%**[4] increase in the gross boiler efficiency from removing these deposits, saving **kWh ($)** over the next 12 months if this is maintained.

The fourth paragraph states the second most significant gain in efficiency outside of the combustion efficiency. Efficiency gains are in line with EECA guidelines, cost savings are estimated from the total yearly fuel spend.

Sample Paragraph: *Client's Organisation* continuously blows down its boiler in order to control Total Dissolved Solid (TDS) levels. *Tuner's Organisation* has recommended *Client's Organisation* install an automatic TDS control system to reduce unnecessary losses and has indicated that this will cost in the region of $ and $ installed. A further **1%** saving in fuel costs (**$/yr**) can be realised by adopting this recommendation, giving a simple payback period of less than 12 months.

[3] Calculated as shown in sample calculation

The fifth paragraph should state the most attractive technology implementation recommendation, and refer the client to a list of consultants at the end of the report who can aid with determining its feasibility.

Sample Paragraph: Additionally, *Tuner's Organisation* recommends *Client's Organisation* seek consultation with regards to recovering this blowdown energy for use heating feedwater. A list of suitable consultants is attached as an appendix to this report.

The final paragraph should state the next recommended tune in accordance with EECA's guidelines for the boiler type in question.

Sample Paragraph: *Client's Organisation* should retune its boiler in six months time in order to maintain efficiency gains found during this report.

Preliminaries

Discussions with *Client's Organisation* boiler manager revealed the following information that would affect energy efficiency of the boiler:

- *Information point 1*
- *Information point 2*
- *Information point 3*
- *Information point 4, add all relevant information in this manner.*

The following target set points were noted prior to tuning:

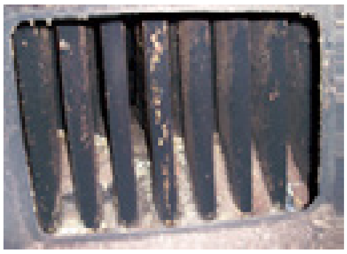
Pressure [bar]	
Firing Rate [%]	
Steam Rate [kg/hour] / Water temperature out	
TDS [ppm]	
Comments: • *Bullet point energy saving opportunities noted during the walk through of the boiler house and surrounding areas in this area*	

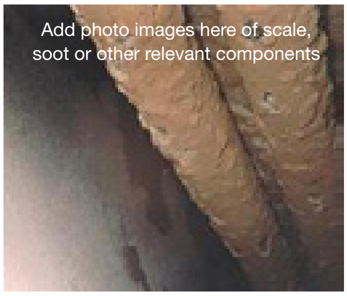
[4] Calculated as shown in sample calculation

Maintenance

Whilst conducting maintenance and repairs as part of this tune the following observations were noted:

- *Bullet point observations noted during the maintenance inspections and repairs*





Gas Analyser Tuning

Add a comment on the suitability of the boiler to the load. For liquid and gas burners the turndown ratio should be stated and comment given to its suitability over the majority of loads met by the boiler.

Client's Organisation uses a modulating burner in its boiler with a 4:1 turndown ratio. After conversing with boiler operators this was deemed suitable for the majority of operating conditions. The boiler typically operates at a firing rate of between 75% – 100%.

Tuner to note any key symptoms, faults etc that can be used for an explanation for lowering boiler efficiency

Whilst performing the gas analyser tuning the following observations were noted:

- *Bullet point observations noted during the gas analyser tuning in this area*

Tuner's Organisation recorded the following gas analyser readings before and after the tune:

Firing Rate	After 100%	Before 100%	After 75%	Before 75%	After 50%	Before 50%	After 25%	Before 25%
CO [ppm]								
O_2 [%]								
H_2O [%]								
CO_2 [%]								
Combustion Temperature [°C]								
Steam Rate/Water flow rate [kg/hr]								
Flue Gas Temperature [°C]								
Combustion Efficiency [%]								
Comment on fuel distribution on bed (if applicable)								
Comment on appropriateness of primary and secondary air flow rates								

Recommendations

Tuner to note in the report recommendations made during the site visit. These may include O_2 trim, VSDs on large fans and pumps etc.

During the course of this tune the following recommendations have been made to *Client's Organisation*. These recommendations (listed in the table below) have been in order of the benefit to the client once actioned.

Description	Estimate Cost	Energy reductions [kWh]	Net savings [$/year]	Capital Cost	Payback [years]

Actions

- *List energy efficiency recommendations made to the client here. Recommendations ordered from most appealing (low capital outlay and quick payback) and likely to succeed to those less appealing (longer payback and higher capital outlay).*

Appendices

Appendix 1: Suitable energy management consultants
Energy Management Association of New Zealand Ltd

http://www.emanz.org.nz

5 Calculating energy savings

Accurately determining energy and cost savings resulting from the boiler tune will provide boiler operators with confidence that capital spent in tuning and improving boiler efficiency meets the expected payback period.

Determining energy and cost savings requires an understanding of forecast energy use and previous 'business-as-usual' baseline energy use. Over-estimating future fuel consumption will inevitably create higher projected energy and cost savings, which are unlikely to be met.

Calculating energy and cost savings often requires knowledge of both engineering and financial modelling currently used by industry professionals. To achieve an accuracy of ±10% on a boiler efficiency opportunity, typically requires understanding of thermodynamics, heat transfer and fluid mechanics. Unfamiliarity with these could create a situation where boiler tuners are forced to make inappropriate assumptions or guess work.

EECA's Best Practice Combustion Tuning procedure uses EECA published 'expected energy saving potentials' for a variety of energy saving opportunities within the boiler house. Tuners are able to use these values with confidence, knowing that they have been derived from a reputable source. Additionally, tuners will stipulate energy and cost savings with little variation from one tuner to the next. These expected energy saving potentials are shown below in Table 1.

Table 1 - EECA published expected energy saving potentials

Technique/Method	Potential savings
Improved operation and maintenance of boilers	Up to 5%
Improved water treatment and boiler water conditioning	Up to 2%
Total dissolved solids (TDS) control and boiler blowdown	Up to 2%
Blowdown heat recovery	Up to 3%
Boiler and burner management systems, digital combustion controls and oxygen trim	Up to 5%
Flue gas shut-off dampers	Up to 1%
Economisers	Up to 5%
Combustion air preheating	Up to 2%

These values are absolute; they are relative to a boiler operating at 100% efficiency. The factors are applicable in most situations and tuners may recognise from experience that different values should be used in some situations. Refer also to Table 2 and the example in Section 5.2.

To convert the values shown in Table 1 into dollars saved per year, the tuner needs to use the current yearly consumption and spend on fuel. Proportional savings (quoted in a % of the yearly total) are estimated from these values.

Normally energy savings, such as heat loss savings shown in Figure 5.1, are calculated using a marginal cost of energy. For simplicity, the gross cost of energy is sufficient and should be used. This is calculated by dividing the total fuel spend (in units of cents) by the amount of fuel consumed (usually shown in units of kilowatt hours).

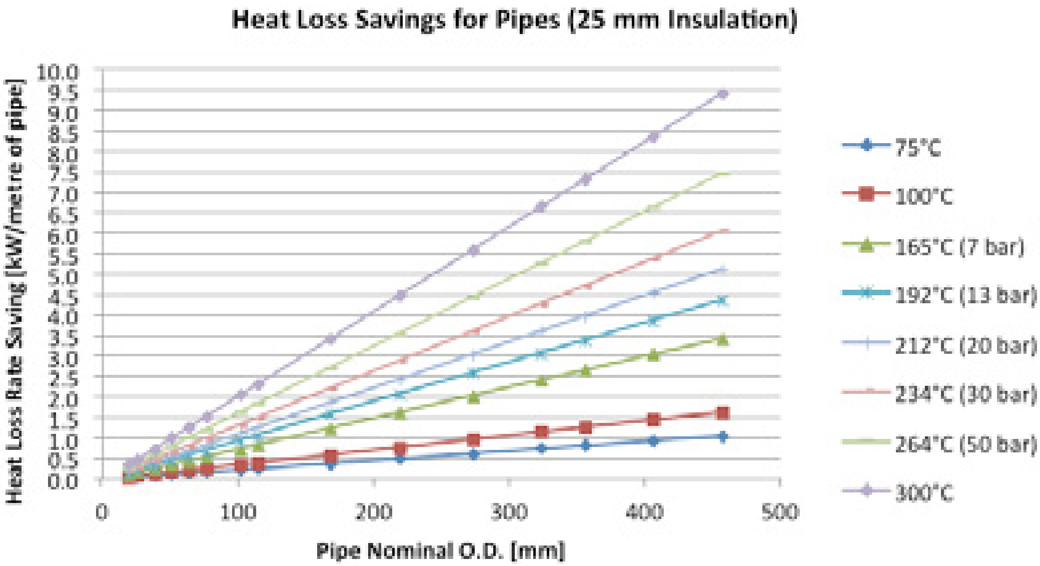


Figure 5.1 - Reductions in heat loss rate after installing 25mm insulation to pipes of various diameters and temperatures

Insulation of 25mm thickness is generally adequate for most steam systems; with minimal benefits for specifying 50mm insulation. The decision of whether to use 50mm or 25mm insulation will depend on factors such as the marginal price of the fuel for the boiler and the temperature of the pipe to be insulated. Higher marginal fuel costs and higher pipe temperatures generally makes 50mm insulation more economically favourable than it is with relatively low fuel prices and pipe temperatures. Insulation providers and installers will be able to provide advice on appropriate choice of insulation thickness. It is recommended that boiler tuners consider both insulation options and leave the final decision to the client.

5.1 Example - Sample Calculation for Boiler Efficiency Improvement

Client's Organisation has had their boiler tuned by *Tuner's Organisation*. *Client's Organisation* informed *Tuner's Organisation* that they have consumed 589,258 litres of diesel in the last 12 months at an average invoiced cost of $1.44/litre.

Total annual fuel costs are:

$$589{,}258\text{l} \times \frac{\$}{\text{l}}1.44 = \$848{,}532$$

The Net Calorific Value (NCV) for diesel has been referenced as 35.7 MJ/litre (Garry Eng, 2008), therefore the total yearly energy consumption is:

$$589{,}258\text{l} \times 35.7\,\frac{\text{MJ}}{\text{l}} = 21{,}036{,}522\ \text{MJ}$$

Converting this to kWh:

$$\frac{21{,}036{,}522\ \text{MJ}}{3.6\ \text{MJ/kWh}} = 5{,}843{,}478\ \text{kWh}$$

The gross marginal cost of fuel energy can be evaluated at:

$$\frac{\$848{,}532}{5{,}843{,}478\ \text{kWh}} \times 100\,\frac{\text{c}}{\$} = 14.52\,\frac{\text{c}}{\text{kWh}}$$

Therefore *Client's Organisation* will save approximately 14.52 cents for every kWh saved through this tune.

As an example, 1.5% annual saving in fuel consumption from de-scaling will result in an energy cost saving of:

$$0.015 \times \$848{,}532 = \$12{,}728 \text{ per year}$$

Savings resulting from increasing combustion efficiency from 69% to 72%:

Energy consumption (η = 72%)

$$= \frac{\textit{(current energy consumption kWh} \times \textit{efficiency before tune)}}{\textit{(efficiency after tune)}}$$

$$\text{Energy consumption } (\eta = 72\%) = \frac{5{,}843{,}478 \ \frac{kWh}{year} \times 0.69}{0.72}$$

$$\text{Energy consumption } (\eta = 72\%) = 5{,}600{,}000 \ \frac{kWh}{year}$$

$$\text{Energy saved} = 5{,}843{,}478 \ kWh - 5{,}600{,}000 \ kWh$$

$$= 243{,}478 \ kWh/year$$

$$\text{Energy cost savings} = 243{,}478 \ \frac{kWh}{year} \times 14.52 \ \frac{c}{kWh}$$

$$= \$35{,}355 \ per\ year$$

5.2 Estimating savings for pipe insulation

Reducing the heat loss from a two meter section of eight inch diameter (219.1mm nominal O.D.) piping by installing 25mm of insulation can be calculated as follows:

Steam pressure: 13 bar

Steam temperature: 192°C

Heat loss model: Using Figure 5.1 for a 219.1mm nominal O.D. pipe at 192°C

$2\ m \times 2.1\ \text{kW}/m \times 18\ h/day \times 6\ days/week \times 48\ weeks/year = 22{,}000\ \text{kWh}/year$

Energy cost savings:

$$22{,}000 \ \frac{kWh}{year} \times 14.52 \ \frac{c}{kWh} \div 100 \ \frac{c}{\$} = \$3{,}200/year$$

It is acknowledged that this method of calculating savings could have varied results depending on the split between a boiler operators 'fixed' fuel charges and 'variable' fuel charges. Those boiler operators (typically smaller energy consumers) who have a higher proportion of fixed costs, will find that this method over estimates the saving potential, whilst larger energy consumers will find that this method provides a closer estimate.

Heat loss rates are particularly sensitive to the ambient conditions surrounding the surface in question. For situations where hot surfaces are located outside and subject to high wind velocities or rain, a considerable divergence of heat transfer rates may occur than that shown in Figure 5.1, leading to higher than calculated losses. This creates a conservative result that if considered significant, should be referred for further analysis by a consulting engineer in the report.

Emphasis should be made to the client that these calculations have been made using approximate figures.

5.3 Estimating savings for other opportunities

The tuner can rely on savings calculated in Section 5.1 and 5.3 (above) to be within 10% accuracy; however other savings options can be affected by a large number of varying factors. In order to keep the time taken in calculating savings to a practical amount the tuner should use factors from Table 2 (below). These are used to help the Tuner calculate energy savings, which will keep the time and cost of the procedure to a minimum and be more accurate than simply using a mean value from the ranges listed in Table 1 EECA published expected energy saving potentials.

Note: the total amount of savings calculated should not exceed those values listed in Table 1.

Table 2 - Energy saving factors

Energy saving measure	Estimated saving
Improved operation and maintenance of boilers	**Up to 5%**
Clean soot/deposits from heat transfer surface	2% per 1mm thick soot
Stop one large steam/ hot water leak or more than two small leaks	2%
Improve performance of soot blowers	0.5%
Three to eight maintenance improvements not included below	1%
More than eight maintenance improvements not included below	3%
Improved water treatment and boiler water conditioning	**Up to 2%**
Clean scale deposits from heat transfer surface	0.5% per 0.1mm thick deposit
Reduce flue gas temperature to that recorded for cleaned boiler	1% per 22°C flue gas temperature reduction
Total dissolved solids (TDS) control and boiler blowdown	Up to 2%
Improve boiler blowdown from continuous to time control	1.5%
Improve boiler blowdown from continuous to TDS control	2%
Blowdown heat recovery	**Up to 3%**
Recover blowdown heat	2%
Boiler and burner management systems, digital combustion controls and oxygen trim	**Up to 5%**
Install oxygen trim	2%
Improve control of multiple boilers so that one is shut down, save standby losses	5%
Install variable speed drives (VSDs) for combustion air fans	1.5%
Economisers	**Up to 5%**
Install economiser	4%
Reduce flue gas temperature	1% per 22°C flue gas temperature reduction
Increase feed water temperature	1% per 6°C temperature increase

Following is an example energy saving calculation using results from tasks the Tuner completed in Section 4.

The Tuner identifies two steam leaks on the steam supply side of the boiler. One leak is large with a plume approximately 1,500mm long and one steam leak is small with a plume approximately 150mm long. The boiler is 1.8 MW coal fired and uses 3,150,000 kWh (480 tonne) coal a year. This costs $150,000 a year in coal.

Using Table 2: stopping one large and one small leak will save approximately 1% a year on energy use.

$2\% \times 3{,}150{,}000 \text{ kWh/year} = 63{,}000 \text{ kWh/year}$

Energy cost savings:

$$63{,}000 \, \frac{kWh}{year} \times 4.76 \, \frac{c}{kWh} \div 100 \, \frac{c}{\$} = \$3{,}000/year$$

It is acknowledged that this method of calculating savings will have varied results depending on the size of boiler, hours of operation and energy use per year. However it provides a practical indicator of whether a saving is in the order of $100 per year, $1,000 per year or $10,000 per year.

As a comparison, using thermodynamic principles two steam leaks of these sizes would save approximately 200,000 kWh ($9,500) a year for a boiler operating 24/7.

Although it results in a different value by a factor of three there will be ‘unders’ and ‘overs’ contributing to the total savings calculated. Using this approach will provide the client with the information needed to make a practical decision as to whether to stop the leak or not. It will also ensure there are consistent results irrespective of the person completing the boiler retuning procedure and increase the frequency at which boiler are being tuned.

6 Bibliography

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7 Appendices

7.1 Appendix B - Example Client Report

Example Report

Boiler Make:	Anderson
Boiler Type:	Firetube Sat Steam
Operating pressure:	10 bar
Fuel:	Diesel
Boiler size:	1.2 MW
Date installed:	01/05/96
Date last tuned:	01/05/2009
Site address:	Springs Road, ChCh
Boiler contact per:	Joe Blogs

Summary

Advanced Boiler Tuners (ABT) has tuned Best Practices Boiler Operator's (BPBO) Anderson diesel fired boiler in accordance with EECA's 'Best Practice Boiler Tuning Procedure'.

Total energy savings attributable to this tune have been estimated at **$48,000** over the next 12 months if these efficiency improvements are maintained.

Combustion efficiency has increased from **69%** to **72%** and is estimated to save **243,000 kWh** (equal to **$35,000** at current fuel prices) over the next 12 months if this efficiency is maintained.

Scale deposits approximately 3mm thick were found on the waterside heat transfer surfaces. These were removed during the tune in the presence of BPBO's water treatment provider who suggested a review of the current dosing practices. ABT has estimated a further **1.5%** increase in the gross boiler efficiency from removing these deposits, saving **87,600 kWh** (**$12,700**) over the next 12 months if this is maintained.

BPBO continuously blows down its boiler in order to control Total Dissolved Solid (TDS) levels. ABT has recommended BPBO install an automatic TDS control system to reduce unnecessary losses and has indicated that this will cost in the region of $2,500 and $5,000 installed. A further **1%** saving in fuel costs (**$5,800/yr**) can be realised by adopting this recommendation, giving a simple payback period of less than 12 months.

Additionally, ABT recommends BPBO seek consultation with regards to recovering this blowdown energy for use heating feedwater. A list of suitable consultants is attached as an appendix to this report.

BPBO should retune its boiler in six months time in order to maintain efficiency gains found during this report.

Preliminaries

Discussions with BPBO boiler manager revealed the following information:

- Fuel consumption has steadily increased over the last nine months
- Boiler has failed to restart twice in the last month
- The boiler has generally proved reliable in operation
- Routine maintenance is only performed during yearly shutdown

The following set points were noted prior to tuning:

Pressure [bar]	9.8
Firing Rate [%]	85
Steam Rate [kg/hour] / Water temperature out	1,690
TDS [ppm]	1,800

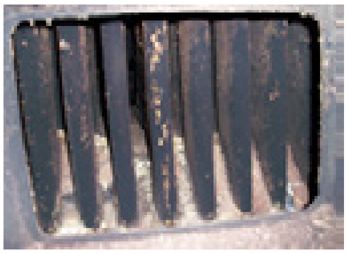
Comments:

- Main steam line uninsulated including two large valves (~2 m2)
- Inspection covers on boiler uninsulated, surface temperature of boiler ~ 70°C, recommend fitting additional insulation.
- Water treatment procedures have not been reviewed since commissioning of the boiler.
- 1.69 tonnes per hour was observed as the maximum rate of steam at 100% firing rate.
- Fuel pressure was observed to be 1000 kPa.
- Combustion appears to be asymmetric, possibly poor atomisation of fuel due to worn or partially blocked fuel nozzle.

Maintenance

Whilst conducting maintenance and repairs as part of this tune the following observations were noted:

- Minor soot deposits on fire side heat transfer surfaces
- Large deposits on water side of heat transfer surfaces – ~3mm thick
- Linkages and actuators serviced
- Forced draft fan in serviceable condition
- Flue and stack in good condition
- Fuel filters replaced, signs of waxing evident. Recommend bulk storage tank to be inspected and sterilised at next shut down
- Nozzles replaced, evidence of soot blockage present



Gas Analyser Tuning

BPBO uses a modulating burner in its boiler with a 4:1 turndown ratio. After conversing with boiler operators this turndown ratio was deemed suitable for the majority of operating conditions. The boiler typically operates at a firing rate of between 75% – 100%.

Whilst performing the gas analyser tuning the following observations were noted:

- Boiler emits visible black smoke upon initial start up, indicating incomplete combustion as a result of poor atomisation of fuel. Fuel nozzles were replaced which appear to have corrected this.

ABT recorded the following gas analyser readings before and after the tune:

Firing Rate	After 100%	Before 100%	After 75%	Before 75%	After 50%	Before 50%	After 25%	Before 25%
CO [ppm]	10	25	12	35	25	150	300	450
O_2 [%]	3.30	5.05	3.50	6.10	4.20	5.50	7.10	6.05
H_2O [%]	-	-	-	-	-	-	-	-
CO_2 [%]	12.40	2.50	11.75	1.95	8.50	1.50	5.50	1.05
Combustion Temperature [°C]	1580	1420	1475	1398	1420	1250	1395	1200
Steam Rate/Water flow rate [kg/hr]	1,690	1,480	1,270	1,100	850	780	420	350
Flue Gas Temperature [°C]	580	620	575	600	520	595	495	526
Combustion Efficiency [%]	72	69	71	64	65	59	59	53

Recommendations

During the course of this tune the following recommendations have been made to BPBO. These recommendations have been listed in order of the benefit to the client once actioned.

Actions

Savings Measure	Cost to implement ($)	Estimated Annual Savings ($/yr)
1. Fit insulation to inspection covers and end plate		
2. Insulate bare portions on the main steam line, valves and flanges		
3. Review current water treatment procedures in consultation with chemical suppliers		
4. Fit an insulation blanket to boiler body		
5. Continue to monitor fuel consumption and install a steam meter to allow monitoring of the gross boiler efficiency and steam to fuel ratio.		
6. Clean/sterilise diesel bulk storage tank at maintenance shutdown		

Appendices

Appendix 1: Suitable energy management consultants
Energy Management Association of New Zealand Ltd

http://www.emanz.org.nz

www.eecabusiness.govt.nz

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