Energy centre management
-key checks and measures -

If it’s **YOUR** energy budget—don’t risk second or third hand ‘guestimates’ of energy and emissions performance. Insist on **proven** operational data to support these key energy efficiency factors:

- efficient air flow
- turndown ratios
- direct digital combustion control
- motor speed control
- excess oxygen/excess air in combustion process
- flue gas analysis
- NOx and carbon emissions control

**DUNPHY**
Axial air flow is fundamental to ensuring:

- high combustion efficiency across a wide turndown range
- consistently lower fuel consumption
- truly low NOx
- noise levels below 65dBA without acoustic shrouds
- energy absorbing air vanes and splitters are not needed as extra add-ons.

The burner is the brain in the boiler house.

To save considerable project time and cost, always prepare a detailed specification for burner performance.

Compared with a new boiler, the burner fitted to the shell can be approximately half the capital cost BUT it’s the burner — not the boiler — that has the major impact on whole life efficiencies, costs and emissions.

Axial air flow burners are specifically designed to remove the air flow faults of gun type and rotary cup burners. Axial air flow produces uniform air distribution at all levels of firing — including at low fire operation.

Low fire status is often ignored by manufacturers who state efficiencies at full firing rate (typically less than 10% of burner operation.)

CHECK burner air flow design

CHECK turndown ratio

Turndown ratio is calculated by dividing the maximum system output at which safe, steady, controlled, efficient, pollution free combustion can be sustained by the minimum output.

A 10 : 1 turndown indicates that minimum efficient operating capacity is one tenth of maximum of operating capacity.

Insist on proven site data.

Target turndown ratios:

- Gas burners: 10:1
- Oil burners: 4:1
- Premix burners: 9:1

High turndown burners:

- save on fuel
- reduce maintenance costs
- reduce burner downtime

Annual fuel cost £

<table>
<thead>
<tr>
<th>Turndown ratio of the burner</th>
<th>21,000</th>
<th>20,500</th>
<th>20,000</th>
<th>19,500</th>
<th>19,000</th>
<th>18,500</th>
<th>18,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

www.dunphy.co.uk
Ratiotronic DDCC systems manage single and multi fuel burners so that they will consistently operate below $3\% \text{O}_2$ across **ALL** operating loads—and at less than **2\%** at **high fire**.

**Enhanced Capital Allowances**
To be eligible for ECAs, the burner must be on the approved Energy Technology List. Listing requires all gas and multi fuel burners rated above 400kW to have both DDCC and an inverter fitted to the forced draught fan.

**CHECK** the electricity savings made by fitting an inverter

Examples of the valuable **energy savings** which can be obtained from fitting a variable speed drive to a burner are shown on this graph.

A variable speed drive **saves energy and reduces noise** by reducing the speed of the burner to the level optimally required to match air or fuel flows.
Combustion efficiency can be measured by comparing percentage oxygen levels taken from flue gas readings. Typically, boilers will emit flue gas at approximately 250°C.

On comparative boilers, the difference in flue gas temperature may differ by (at most) 15°C. This will affect efficiency by less than 0.5%. **But the difference between excess oxygen levels can affect efficiency by as much as 10% and this does have a major impact on efficiency and the cost of fuel.**

Always check efficiency measurements at **low fire levels**. Low fire status is very often overlooked when air flow distribution is measured. Many burner manufacturers state efficiency at maximum capacity rate (full firing rate).

**Oxygen trim** is a means of managing combustion efficiency through fuel saving. It maintains optimum fuel to air ratios and maximises combustion efficiency by continually monitoring and automatically adjusting flue oxygen levels.

**A good oxygen trim system ‘learns’ the impact of every trim adjustment.**

This removes any time lag problem and allows full oxygen trim operation regardless of how often or how rapidly the firing changes.

**Flue gas losses: fuel to air ratios**

Efficient digital modulating burners consistently operate **at less than 2% excess air** at high fire.

The more efficient the burner, the lower the amount of excess air is used in combustion resulting in the least volumetric emission of CO₂ in flue gases. This graph shows typical carbon dioxide and oxygen analyses of flue gas when combustion is carried out at different levels of excess air and temperatures.
**CHECK how boiler efficiency is calculated**

Boiler efficiency results which are calculated ignoring the latent heat (i.e. using net CV) will always be greater than one where the latent heat is included (i.e. using gross CV).

Hence the popularity which exists among boiler manufacturers for quoting 'net efficiency'. A higher efficiency always looks better!

Nevertheless, boiler efficiency costs should be based on the total amount of energy (fuel) required.

Gross CV measures are, therefore, the more realistic measure.

Note: always check that like for like efficiency figures are being provided for burners and boiler plant.

**CHECK that carbon emissions are being minimised**

Critical elements which must be in place to reduce carbon emissions:

- Axial air flow burner design to deliver:
  - high combustion efficiency
  - high turndown ratio
  - low excess oxygen

True 3-pass boiler design with:

- large heat transfer surface
- low heat release rate
- low gas flue temperature
- high levels of insulation with low thermal conductivity

There is no single feature of a boiler or burner that can ensure a reduction in carbon emissions. Rather there is a number of key variables which must fit together like a jigsaw to ensure that CO₂ emissions are truly and consistently reduced.

The key to reducing carbon emissions is to reduce the amount of fuel used without compromising output.

And achieving high fuel efficiency depends on all the pieces of the jigsaw being in place.
CHECK how NO\textsubscript{x} emissions will be minimised

Burner design is critical in ensuring maximum efficiency and low NO\textsubscript{x}. **Crucial to the consistent reduction of NO\textsubscript{x}** is the principle of axial air flow which, when used in conjunction with a correctly dimensioned boiler, enables burners to be inherently low NO\textsubscript{x} emitters. **Air/fuel staging** is one of the most effective methods of reducing NO\textsubscript{x} and is achieved by separating the air and fuel into areas of sub stoichiometric and over stoichiometric conditions. The main aim of this technique is to divide the air into three distinct and separate patterns: primary, secondary and tertiary. Each of these patterns is controllable in its own right.

Axial air flow burners with ultra low NO\textsubscript{x} heads when fitted to a well designed boiler will easily achieve NO\textsubscript{x} emissions as follows:

- **Gas**
  - 70mg. per kW hour
- **Oil**
  - 165mg. per kW hour

Always ask for evidence of results from operating sites

The geometry of the boiler or furnace must be such that hotspots are eliminated, eddying currents are created to facilitate internal flue gas circulation and the design provides for a low and smooth transfer of heat.

In addition, because NO\textsubscript{x} is a thermally produced gas, its reduction is also dependent on the calorific value of gas.

**Caveat emptor:** without firm data on air flow, boiler geometry and the CV of gas, then boiler and burner suppliers cannot guarantee consistent levels of NO\textsubscript{x} emissions.

**TYPICAL NO\textsubscript{x} CONVERSIONS**

<table>
<thead>
<tr>
<th>To convert</th>
<th>into</th>
<th>multiply</th>
</tr>
</thead>
<tbody>
<tr>
<td>ppm</td>
<td>mg/m\textsuperscript{3}</td>
<td>1.36</td>
</tr>
<tr>
<td>ppm</td>
<td>mg/l</td>
<td>648.7</td>
</tr>
<tr>
<td>ppm</td>
<td>mg/l</td>
<td>2.095</td>
</tr>
</tbody>
</table>

**KEY**

- CR = Corrected result
- OI = Oxygen reading on instrument
- OR = Oxygen reference level

Most NO\textsubscript{x} guarantees are referenced to 3% but can be referenced at any oxygen level regardless of the O\textsubscript{2} level in flue gas. The results can be corrected as follows:

\[
\text{CR} = \left( \frac{(21-O\text{R})}{(21-OR)} \right) \times \text{NOx-R}
\]

- OR = O. reading on instrument
ASSESS pros and cons of flue gas recirculation to control NOx

Advantages of flue gas recirculation (FGR)
FGR is a popular and proven technique for reducing NOx levels—particularly thermal NOx.

Disadvantages of flue gas recirculation
Reductions of NOx levels can be relatively modest and installing FGR does create major restrictions in boiler design. For example, if the quantity of re-circulated gas is 20%, the capacity within the boiler will need to be increased—thus increasing its size.
This means that FGR cannot be easily retrofitted without the boilers being down-rated.
FGR also requires sophisticated control, extensive and cumbersome external pipework and in some instances, blowers—all of which have to operate at exhaust gas temperatures. As a result, first costs and maintenance costs increase and boiler reliability diminishes.

Flue gas analyser
Dunphy's Ecom flue gas analyser provides accurate, semi-continuous measurements of flue gas emissions for both gas and oil-fired plant. This compact and portable tool will provide accurate values as shown in the right-hand column—essential for increasing fuel efficiency, maintenance and compliance.

<table>
<thead>
<tr>
<th>Measured values</th>
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</thead>
<tbody>
<tr>
<td>Oxygen, O₂</td>
</tr>
<tr>
<td>Carbon monoxide, CO</td>
</tr>
<tr>
<td>Flue gas temperature</td>
</tr>
<tr>
<td>Ambient temperature</td>
</tr>
<tr>
<td>Soot particles</td>
</tr>
<tr>
<td>Nitric oxide, NO</td>
</tr>
<tr>
<td>Nitrogen dioxide, NO₂</td>
</tr>
<tr>
<td>SO₂, module optional</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Calculated values</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO in undiluted flue gas</td>
</tr>
<tr>
<td>Carbon dioxide, CO₂</td>
</tr>
<tr>
<td>% Carbon monoxide, CO %</td>
</tr>
<tr>
<td>Boiler efficiency</td>
</tr>
<tr>
<td>Conversion of ppm to mg/m³</td>
</tr>
<tr>
<td>Conversion of ppm to mg/kW/hr</td>
</tr>
<tr>
<td>Excess air</td>
</tr>
</tbody>
</table>
Dunphy burners are designed for single and multi fuel use with:

- natural gas of varying CVs, biogas, coal and coke, propane, butane
- recoverable solvents and waste, light and heavy oils, kerosene
- carbon neutral fuels including rapeseed and tallow oils and biodiesel

Our 12kW to 30MW burners:

- fit all makes and types of boiler, oven or heat treatment plant and interface with all BMS, energy management and SCADA systems
- are factory tested and pre-assembled for fast on site connection

Fuel is too expensive to waste. Check the efficiency of your boiler/burner with a Dunphy energy audit.

You will receive a full technical report with fuel saving recommendations.

To book an audit or to request further information, contact
sharon.kuligowski@dunphy.co.uk

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