Measurement of the in-situ performance of solid biomass boilers

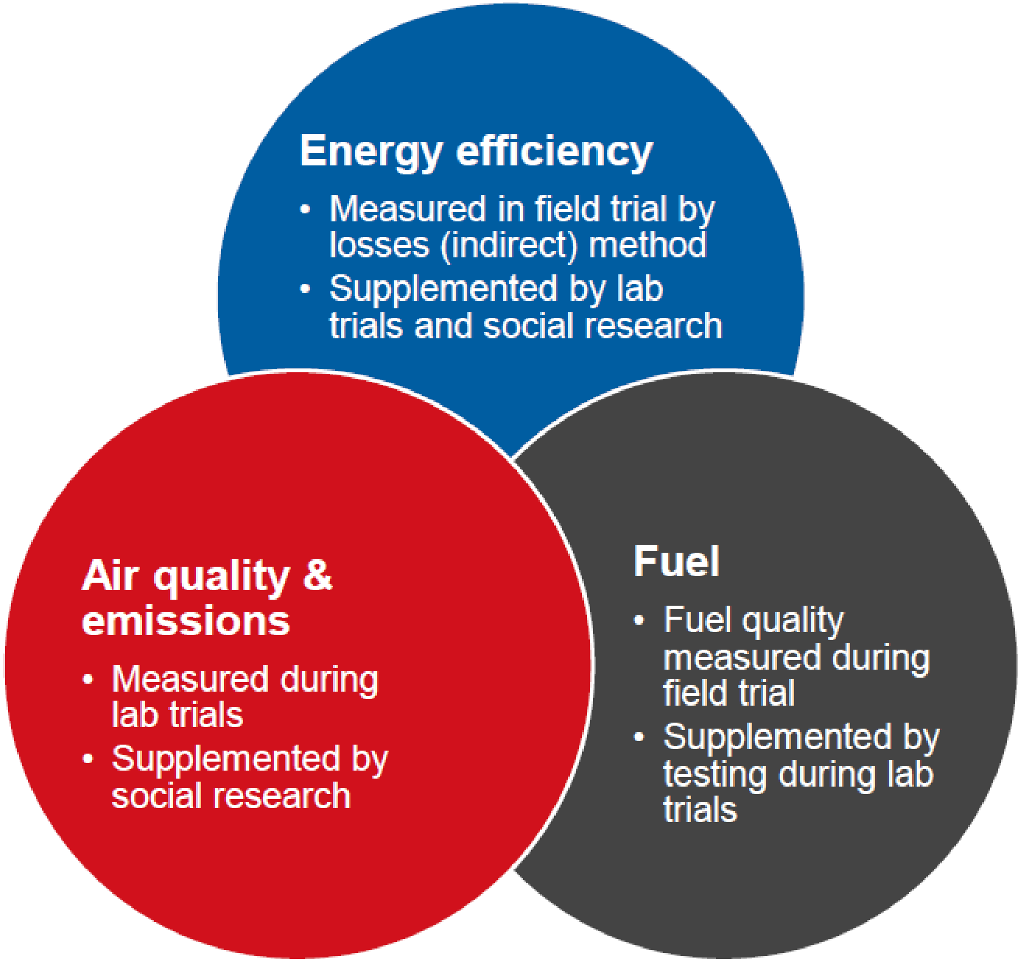
Iain Summerfield
iain.summerfield@kiwa.com

Kiwa Gastec

Trust
Quality
Progress

BEIS's reasons for research

- Government supported technologies are tested in laboratories to assess performance based on BS and EN standards
- The question is how they perform outside the laboratory i.e. in-situ
- What affects performance of these systems?
- Are BEIS assumptions for modelling correct?



Project objectives

- To assess RHI biomass boiler population performance, both in terms of efficiency (taking into account all energy inputs and outputs) and emissions (CO_2, GHG, PM, NO_x and SO_x)
- Identify the key causes of good and poor performance and quantify their impact
- Understand how different uses of boilers and user interaction affect their overall performance

Previous work

Develop Field Trial Methodology

Phase 1

Nov 2015 – Mar 2016

Literature Review

Assess UK Biomass Population

Phase 2

Apr 2016 – Jul 2017

Field Trial

67 boilers
60 sites

Laboratory Trials

2 boilers

Social Research

23 sites

Stakeholder Engagement

2 sessions

Phase 3

Aug 2017 – Jul 2018

Interventions

15 changes
6 controls

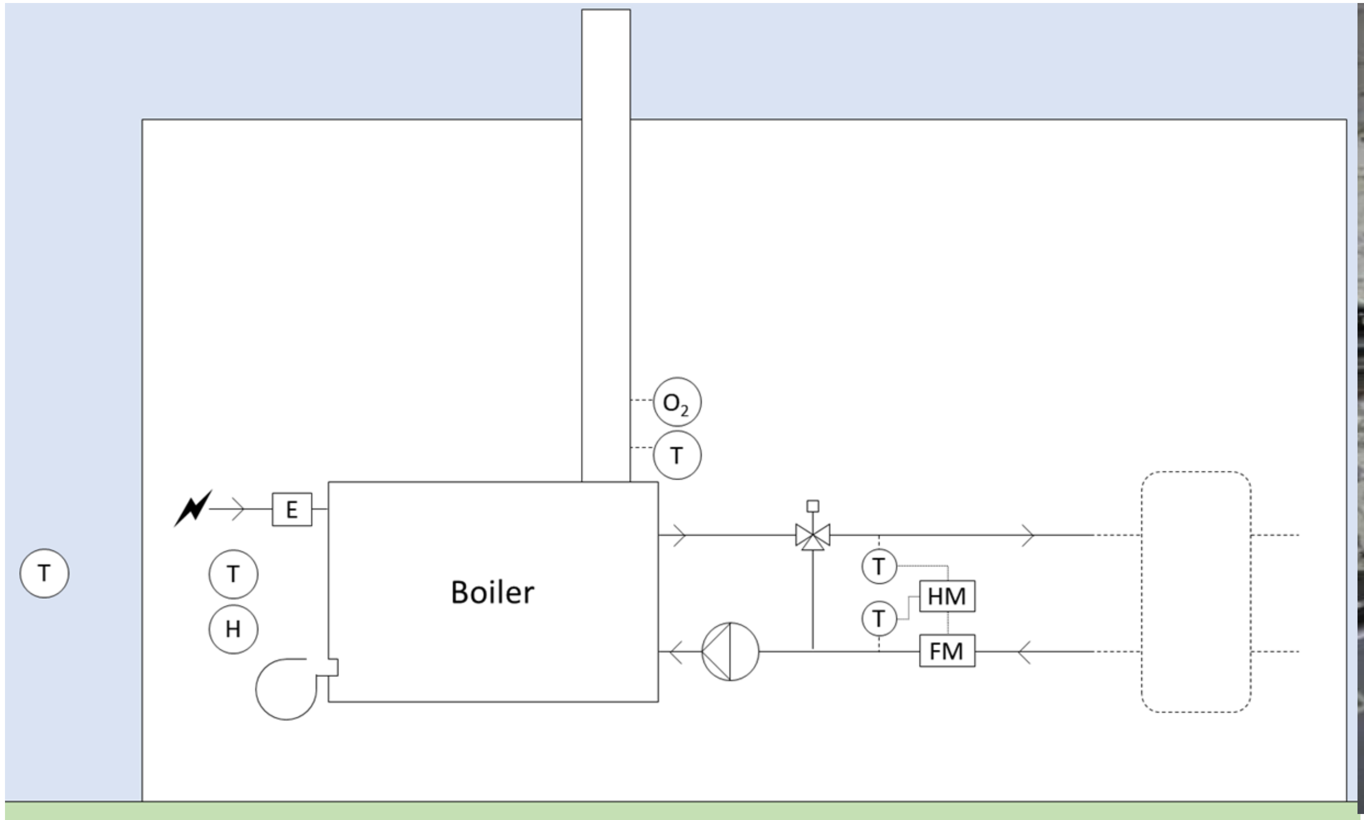
Guidance Documents

Assessment of UK biomass population

Scheme	Output (kW)	Fuel	Percent of population	Percent of capacity	Percent of sample
Domestic	<45	Pellet	34%	8%	16%
		Log	3%	1%	6%
Non-Domestic	<100	Chip	5%	3%	12%
		Pellet	13%	8%	6%
		Log	7%	4%	6%
	100-150	Chip	3%	4%	4%
		Pellet	5%	5%	4%
		Log	1%	1%	
	150-200	Chip	12%	19%	12%
		Pellet	10%	16%	13%
		Log	2%	4%	
	200-1000	Chip	3%	15%	12%
		Pellet	2%	10%	7%
		Log	<1%	1%	
Total			**100%**	**100%**	**100%**

Field Trial

- Monitoring Equipment Installed on 67 boilers at 60 sites
- Fuel samples taken

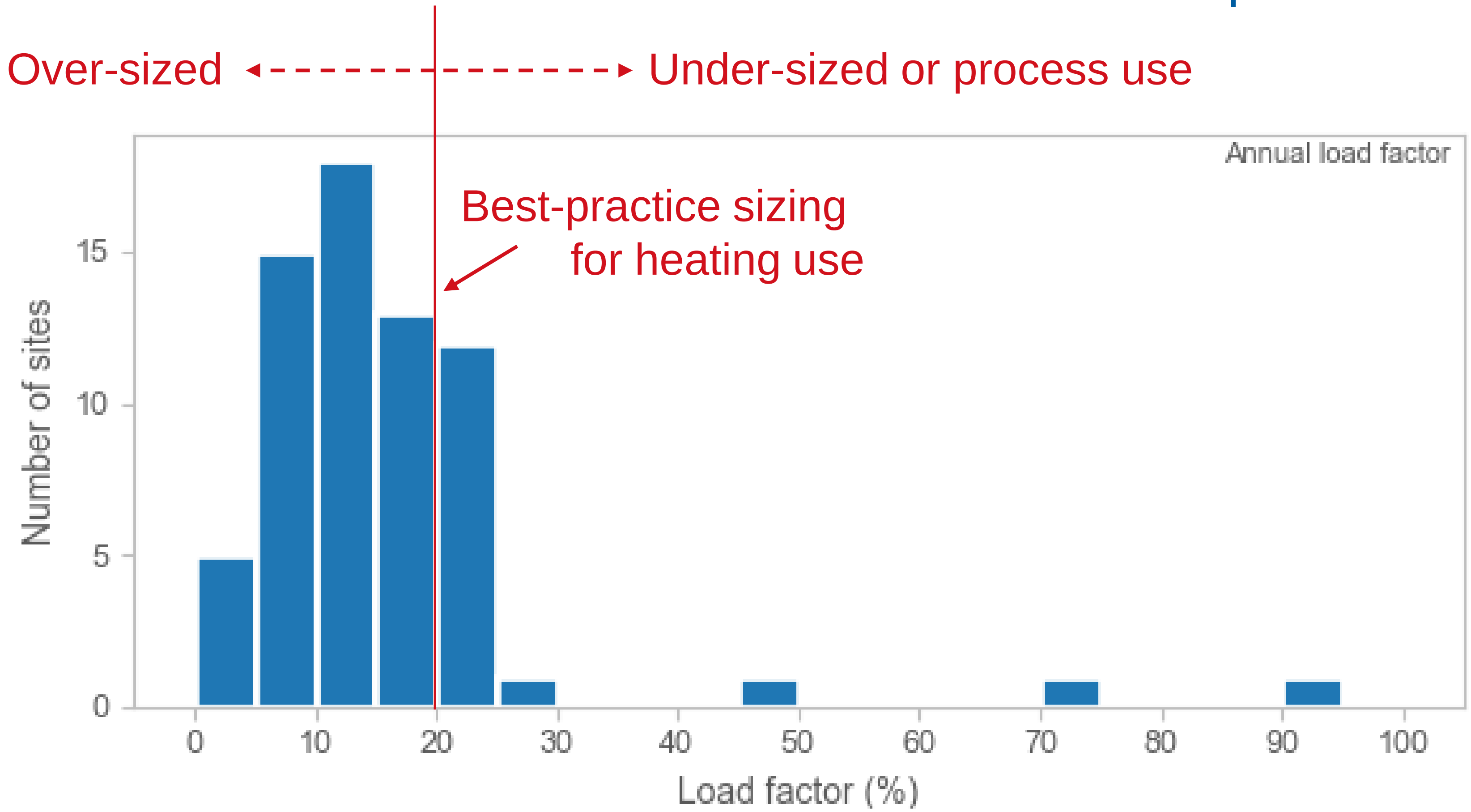


Geographical spread

Boiler oversizing

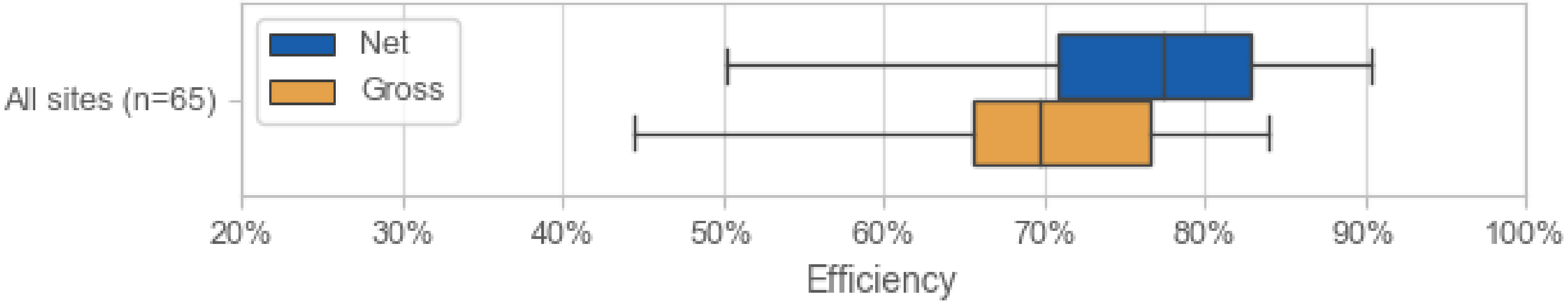
- Measure using **load factor**

$$\text{Load factor} = \frac{\text{Heat delivered in a period}}{\text{Total possible heat delivered}}$$



Annual average = 14%
⅓ sites <10%
Winter average = 24%

Performance gap: Efficiency



× 0.9

77% (net)

70% (gross)

- These differ from declared ‘EN test’ values, where higher efficiencies expected:

  85–95% (net) or **77–86%** (gross)

- Mirrored in laboratory tests

Performance gap: Emissions

- RHI limits for boilers in the field trial
  - 30 g/GJ net heat input for particulate emissions
  - 150 g/GJ net heat input for NOx emissions

Standard laboratory testing

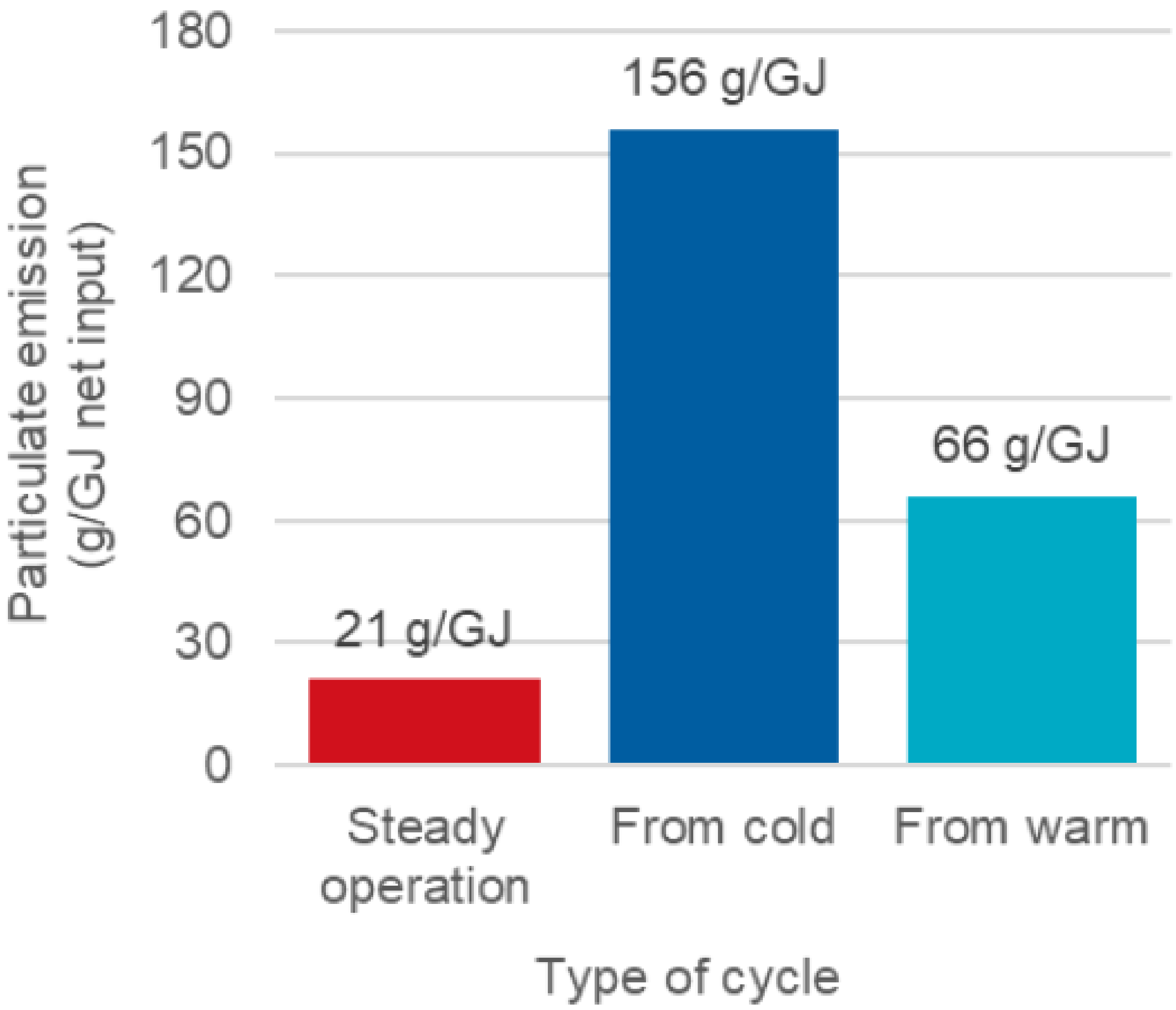
- Steady state testing
  - Both boilers tested passed RHI limits under steady state testing

“Real world testing”

- Boilers tested in a range of cycling regimes
  - Low daily load factors of 5-30%
  - The flow and return temperatures were not fixed.
  - Start-ups and shutdowns were included

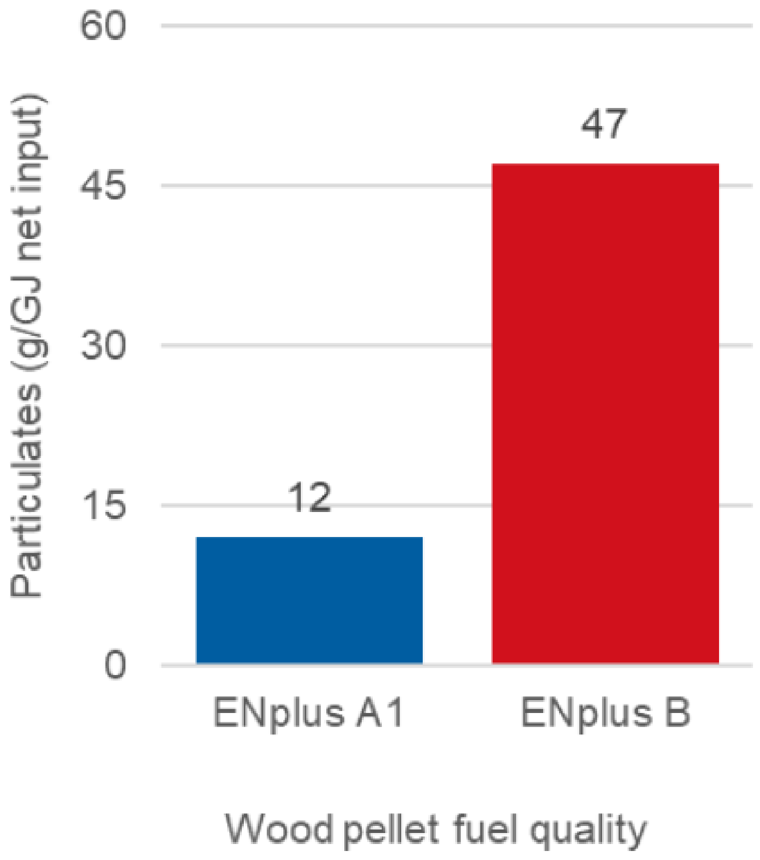
Performance gap: Emissions

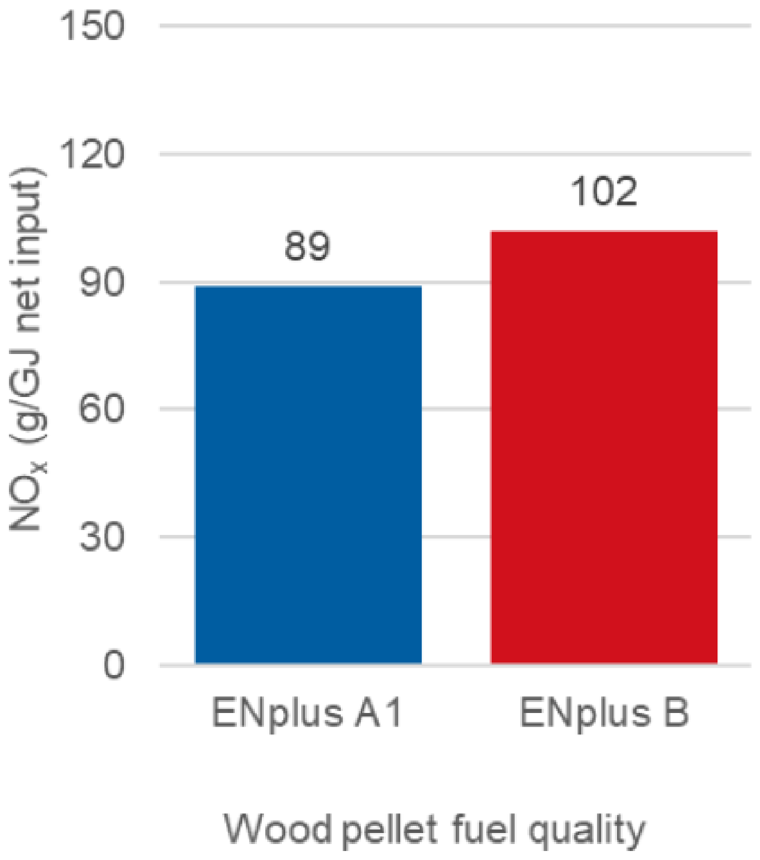
- Particulate emissions larger boiler tests
- Emissions affected by start-ups and shut downs
- Difference found between cold and warm starts



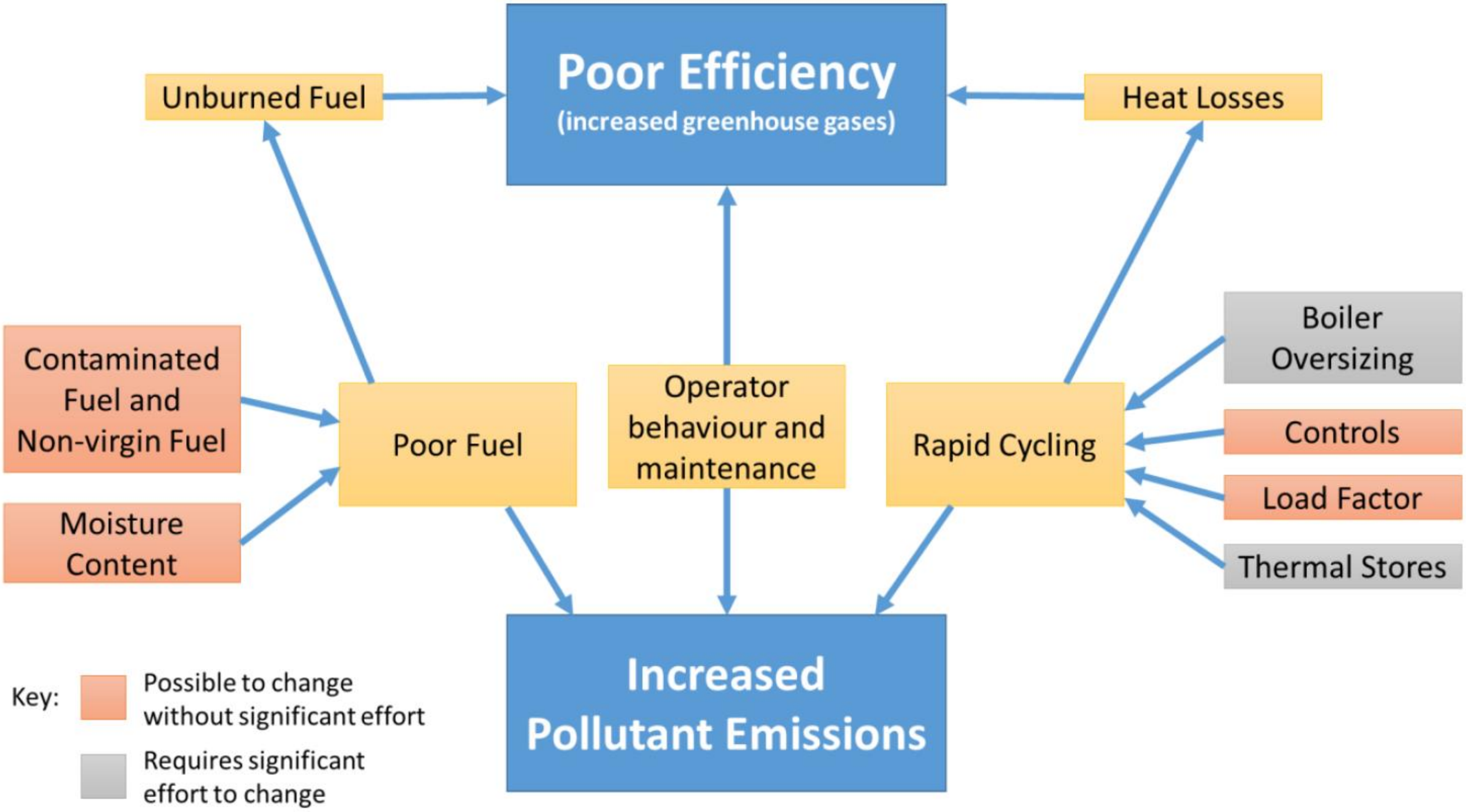
Poor Fuel

- Particulates and NOx emissions
  - Difference between pellet fuels





Key themes & root causes

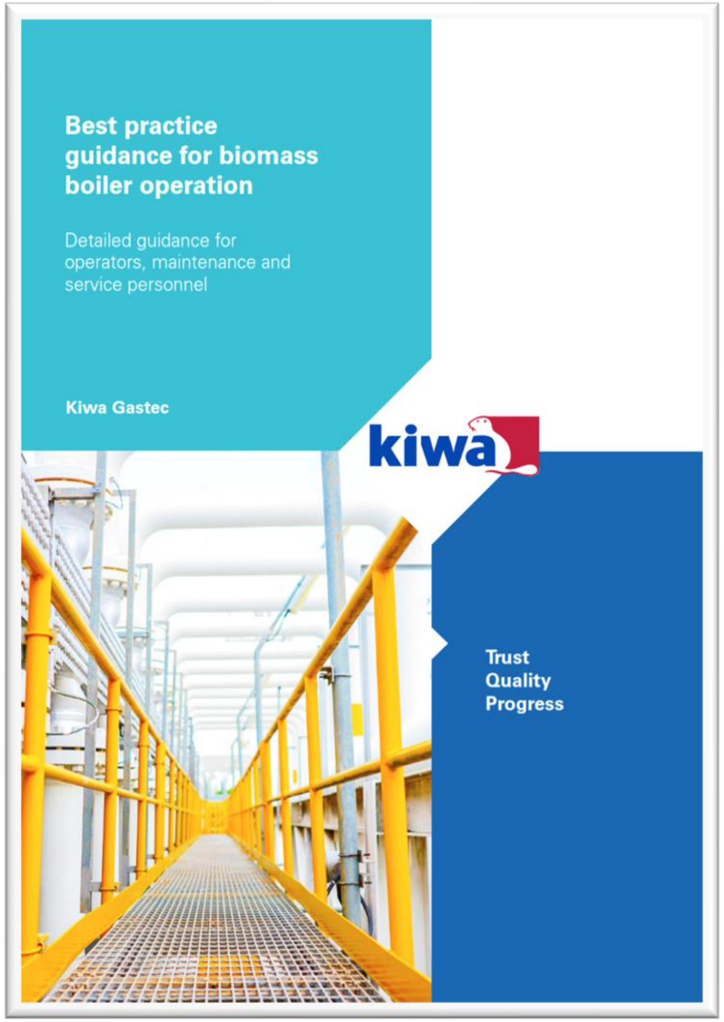


Interventions

- **Most widespread issue was boiler cycling** (two thirds of interventions)
  - Improved maintenance was the most effective method of improving efficiency
- **Operation of the boiler when not required**
  or when another source of heat should be used instead (one third of interventions)
  - Difficult to change (human-factors)

Guidance Documentation

- Two guidance documents produced:
  - **Simple guidance for boiler owners**
    Small scale commercial and domestic
  - **Detailed guidance for boiler operators**
    Non-domestic biomass boilers



Key recommendations

- **Educate boiler owners and operators on indicators of poor performance**

- **Comprehensive annual boiler service to check the operation of the boiler**

- **Service engineer is vital to get the best out of a biomass boiler**