STANDARDS NEW ZEALAND
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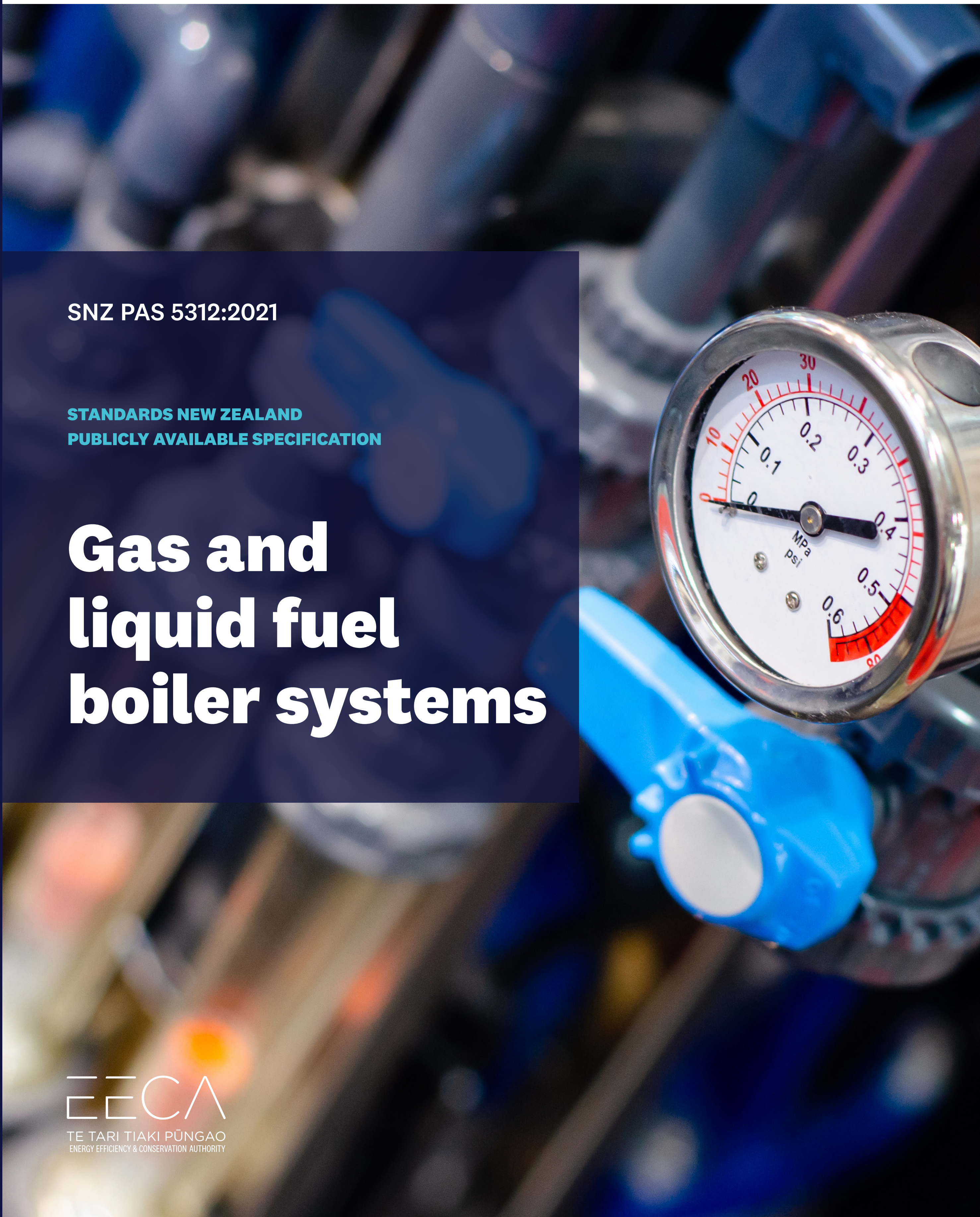
SNZ PAS 5312:2021

STANDARDS NEW ZEALAND
PUBLICLY AVAILABLE SPECIFICATION

Gas and liquid fuel boiler systems



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TECHNICAL ADVISORY GROUP REPRESENTATION

This publicly available specification was prepared by the P5312 Gas and Liquid Fuel Boiler Systems Technical Advisory Group (TAG). The membership of the TAG was approved by the New Zealand Standards Executive.

The TAG consisted of representatives of the following nominating organisations:

Auckland University of Technology

Energy Efficiency and Conservation Authority

Gas Industry Company Limited

Rinnai

Tubman Heating Limited

WorkSafe New Zealand

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Gas and liquid fuel boiler systems

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NOTES

CONTENTS

Technical advisory group representation ..... IFC
Acknowledgement ..... IFC
Copyright ..... IFC
Referenced documents v
Latest revisions vi
Review vi
Foreword vii

Section

1 General 1
  1.1 Introduction 1
  1.2 Scope 1
  1.3 Objectives 2
  1.4 Interpretation 2
  1.5 Definitions 3
  1.6 Abbreviations 5
2 Overview 6
  2.1 How does a gas or liquid fuel boiler space heating system work? 6
  2.2 Boiler fuels 10
  2.3 Configuration of gas and liquid fuel boiler systems 12
  2.4 Operation, maintenance and safety 16
  2.5 Where to start? Evaluation of options 18
  2.6 Scoping and conceptual assessment 21
  2.7 Building Code compliance 23
  2.8 Consenting compliance 25
  2.9 Regulatory safety requirements 26
  2.10 Checklist 27
3 Technical specification 29
  3.1 System operation and efficiency 29
  3.2 Fuels 32

Table

1 Boiler fuel compatibility....12
2 Advantages of gas and liquid fuel boiler systems 20
3 Limitations of gas and liquid fuel boiler systems....21

Figure

1 Example of boiler space heating system with thermal store/buffer....6
2 Heat supply system features....7
3 Components of a boiler 9
4 Non-condensing (left) and condensing (right) boiler schematic 10
5a Single-boiler system configuration 13
5b Centralised multi-boiler system configuration 13
5c Distributed multi-boiler system configuration....14
6 System selection....23
7 System efficiency....29

REFERENCED DOCUMENTS

Reference is made in this document to the following:

New Zealand standards

NZS 5435:1996	Specification for liquefied petroleum gas (LPG)
NZS 5442:2008	Specification for reticulated natural gas
SNZ PAS 5210:2021	High-temperature heat pumps
SNZ PAS 5311:2021	Biomass boilers for small and medium heat loads

Joint Australian/New Zealand standards

AS/NZS 4234:2021	Heated water systems – Calculation of energy consumption
AS/NZS 5263:----	Gas appliances
Part 1.2:2020	Gas fired water heaters for hot water supply and/or central heating

American standards

ANSI/AHRI 1500-2015	Performance rating of commercial space heating boilers

British standards

BS 7190:1989	Method for assessing thermal performance of low temperature hot water boilers using a test rig
BS EN 12828:2012+A1:2014	Heating systems in buildings. Design for water-based heating systems
BS EN 15502:----	Gas-fired heating boilers
Part 1:2012+A1:2015	General requirements and tests

Other publications

Ministry for the Environment (MfE). *Measuring emissions: A guide for organisations: 2020 detailed guide*. Wellington: MfE, 2020.

New Zealand legislation

Building Act 2004

Building Regulations 1992 (New Zealand Building Code)

Engine Fuel Specifications Regulations 2011

Gas Act 1992

Gas (Safety and Measurement) Regulations 2010

Health and Safety at Work Act 2015

Health and Safety at Work (Hazardous Substances) Regulations 2017

Plumbers, Gasfitters, and Drainlayers Act 2006

Websites

www.building.govt.nz

www.legislation.govt.nz

www.worksafe.govt.nz

LATEST REVISIONS

The users of this specification should ensure that their copies of the above-mentioned standards are the latest revisions. Amendments to referenced New Zealand and joint Australian/New Zealand standards can be found on www.standards.govt.nz.

REVIEW

Suggestions for improvement of this specification will be welcomed. They should be sent to the Manager, Standards New Zealand, PO Box 1473, Wellington 6140.

FOREWORD

This document has been prepared as a guidance document and published as a publicly available specification (PAS). A PAS is an ISO-recognised category for documents that are not national standards but are produced by a national standards body to respond to a market need, representing either consensus in an organisation or industry or consensus of the experts within a working group.

The New Zealand Government has set ambitious targets under the Climate Change Response (Zero Carbon) Amendment Act 2019 to achieve net zero carbon emissions by 2050. Government agencies are reviewing all aspects of the economy to develop 5-year budgets to deliver on this target.

Reducing coal use across New Zealand has been flagged as an obvious target. Coal continues to be used in many schools, hospitals, prisons, and much of industry as the primary fuel for heating water and providing steam. Natural gas, LPG, and diesel are commonly used alternatives to coal, but as they are also fossil fuels, they need to be assessed to provide a fair and accurate comparison between their use and realistic alternatives across a range of temperatures and applications.

The objective of this PAS is to provide advice and information on gas and liquid fuel boiler systems to enable an assessment of their performance and efficiency.

NOTES

Publicly Available Specification

Gas and liquid fuel boiler systems

1 GENERAL

1.1 Introduction

Gas and liquid fuel boiler systems are common space-heating technologies used in facilities such as schools, hospitals, and commercial buildings, and also as part of industrial processes.

This publicly available specification (PAS) provides advice and information on gas and liquid fuel boiler systems used primarily in space-heating applications that provide hot water between 30°C and 100°C. This broadly encompasses systems between 40 kW and 2 MW. Much of the guidance provided assumes that the gas or liquid fuel boiler system will be used to heat hot water but, where applicable, the general advice provided is also valid for other applications such as industrial process heat.

This PAS has been prepared by representatives of the New Zealand gas and liquid fuel energy sector as a collation of best-practice advice for potential new owners of gas and liquid fuel boiler systems and their advisors.

Gas and liquid fuel boiler systems are common in New Zealand and will continue to have appeal in future applications where lower-carbon alternatives are not practical or possible. Lower-carbon gas alternatives are planned to be available from 2025. Zero-carbon gas is planned to be available by 2050.

1.2 Scope

1.2.1 Inclusions

This PAS includes both technical and non-technical guidance on the following:

(a) Single-boiler and modular-boiler systems, condensing and non-condensing types, primarily designed to provide space heating from 40 kW to 2 MW, including:

  (i) Determining load

  (ii) Determining efficiency of the boiler system;

(b) Multiple-boiler systems, condensing and non-condensing types, primarily designed to provide space heating, including:

  (i) Determining load for each boiler

  (ii) Determining efficiency of each boiler

  (iii) Calculating overall efficiency of the system;

(c) Boiler systems designed to deliver water from the system at a temperature range between 30°C and 100°C;

(d) Boiler systems designed to provide heating for spaces with a floor area greater than 300 m^2;

(e) Gas and liquid fuels (specifications are contained in 3.2);

(f) Energy efficiency aspects of a boiler system;

(g) Emissions and carbon dioxide (CO_2) impact;

(h) Fuel combustion efficiency;

(i) New Zealand safety requirements; and

(j) New Zealand Building Code requirements.

1.2.2 Exclusions

Excluded from this document are the following:

(a) Heat pump units;

(b) Single-dwelling domestic applications;

(c) Large or bespoke boiler systems;

(d) Coal, biomass, non-fossil fuel types, or co-firing coal boilers;

(e) Installation advice (other than generic information);

(f) Boiler systems designed to provide potable water (as a primary function).

1.3 Objectives

The intended audience for this PAS includes potential owners, evaluators, installers, maintenance and operations staff, purchasers, consultants, designers, equipment and service suppliers, and any others wanting to make an informed choice around gas and liquid fuel boiler system options.

Section 1 and 2 are written to be broadly accessible to a non-technical audience who might be making decisions about the purchase and use of a gas or liquid fuel boiler system. Section 2 also includes a checklist of key points to consider in relation to the selection of a gas or liquid fuel boiler system.

Section 3 includes a detailed performance specification and is written primarily for a technical audience (for example, specifiers, consultants, or installers).

The guidance in this document includes New Zealand safety requirements. It refers to regulatory requirements and provides non-regulatory best-practice recommendations.

1.4 Interpretation

For the purposes of this PAS, the word ‘shall’ refers to requirements that are essential for compliance with this specification, while the word ‘should’ refers to practices that are advised or recommended.

1.5 Definitions

For the purposes of this PAS, the following definitions apply:

Biogas	A mixture of methane, carbon dioxide, and other contaminants produced by the bacterial decomposition of organic wastes. Biogas is corrosive to the materials of most gas-burning appliances and use will normally invalidate any warranty. Use of biogas might not be safe. Refer to the appliance supplier before using
Biodiesel	Fatty acid methyl esters, whether or not containing additives, intended for use as a fuel in combustion technology, at 100% concentration or as a blending component with diesel
Biomethane	A near-pure source of methane produced either by upgrading biogas (a process that removes any CO_2 and other contaminants present in the biogas) or through the gasification of solid biomass followed by methanation. For the purposes of this PAS, biomethane refers to a gas complying with NZS 5442
Boiler	An appliance using gaseous [or liquid] fuel designed to heat water to a maximum of 100°C with the purpose of providing heat to a building or process
Combustion	A chemical process in which a substance reacts rapidly with oxygen and gives off heat
Condensing boiler	A boiler in which, under normal operating conditions and at certain operating water temperatures, the water vapour in the combustion products is partially condensed in order to make use of the latent heat of this water vapour for heating purposes
Gas	Following the Gas Act 1992, any fuel that is supplied through pipes or in containers and is a gas at a temperature of 15°C and an absolute pressure of 101.325 kPa, and includes: (a) Biogas, coal gas, liquefied petroleum gas, natural gas, oil gas, producer gas, refinery gas, reformed natural gas, and tempered liquefied petroleum gas; (b) Any gaseous substance that the Governor-General declares by Order in Council to be a gas for the purposes of the Gas Act 1992; (c) Any mixture of gases

Gross calorific value	The amount of heat that would be released by the complete combustion with oxygen of a specified quantity of fuel in such a way that the pressure at which the reaction takes place remains constant and with the products of combustion returned to the temperature of the reactants with all products of combustion being in the gaseous state except for water, which is condensed to the liquid state
Gross thermal efficiency	The increase in energy of the water/process-fluid stream between the inlet and outlet of the boiler (heating device) divided by the gross calorific value of the fuel consumed, expressed as a percentage
Heat exchanger	A device that exchanges heat between two fluids
Heat distribution system	Configuration of interconnected components for the dispersal of heat between the heat supply system and the heat emission system. Examples include radiators, fan coils, and variable air volume units
Heat supply system	Configuration of interconnected components/appliances for supply of heat to the heat distribution system
Heated space	A room or enclosure that is to be heated to the specified internal design temperature
Heating value	The number of megajoules (MJ) liberated when a unit of gas or liquid fuel is completely burnt in air with all the water formed by the combustion process in the liquid state
High turndown	The heat output at high output divided by the heat output at low output
Hydrocarbon	A naturally occurring organic chemical compound primarily composed of hydrogen and carbon atoms. The term includes natural gas and oil
Modular boiler	A boiler consisting of an assembly of two or more generally identical modules, each of which consists of a heat exchanger, burner, and control and safety devices
Short cycling	A cycle is the period of time a boiler system is operating. A short cycle is when a boiler (heating device) turns on and off too often
Thermal efficiency	A ratio of the heat a boiler can deliver to the water of its heat exchanger to the gas energy used. It can be stated at full load, part load, or a combination of the two
Turndown ratio	A boiler's combustion unit will vary its fuel input and output or 'turn down' as the demand for heat decreases in an attempt to meet only the required load. The turndown ratio provides the minimum output the boiler can achieve before turning off and then cycling on and off frequently

1.6 Abbreviations

This PAS uses the following abbreviations:

CO_2-e	Carbon dioxide equivalent
LPG	Liquid petroleum gas
MJ/m^3	Megajoules per cubic metre
PAS	Publicly available specification

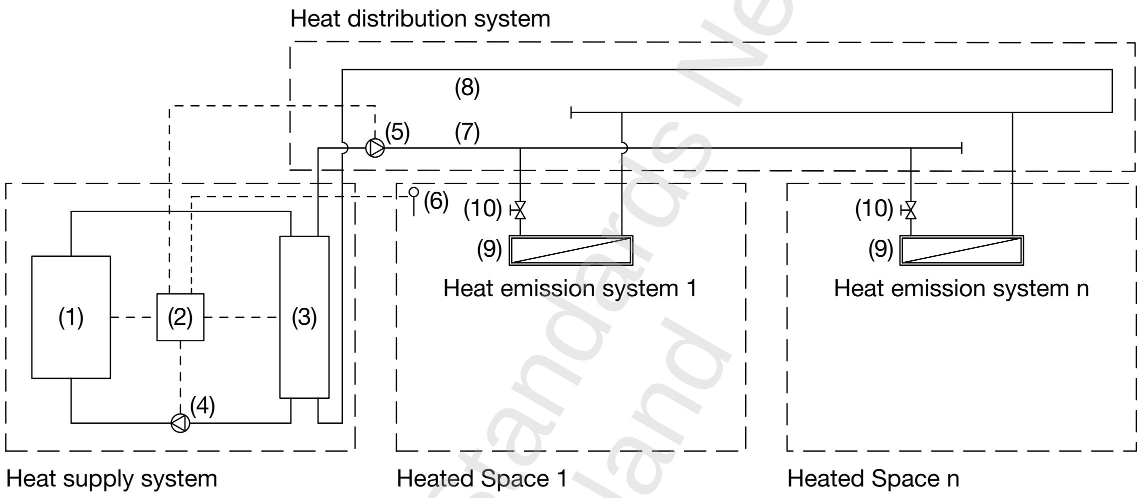
2 OVERVIEW

2.1 How does a gas or liquid fuel boiler space heating system work?

2.1.1 Operation

The heat supply system, consisting of the boiler and associated components, transfers the heat of combustion to the water. The heat distribution system transfers the heated water around the building(s). The heat emission system transfers the heat from the water to the heated spaces.

See Figure 1 for a generalised schematic of a boiler space heating system.



Key: (1) Boiler; (2) Control system; (3) Thermal store/buffer; (4) Primary circulating pump; (5) Heating fluid circulating pump; (6) Room temperature sensor; (7) Heating fluid flow; (8) Heating fluid return; (9) Space-heating device; (10) Manual or thermostatically operated valve.

Figure 1 – Example of boiler space heating system with thermal store/buffer

These are the basic principles of operation (see Figure 1 for numbered components):

(a) The room temperature sensor (6) indicates the current room temperature to the control system (2);

(b) When the current room temperature falls below the required temperature, the control system starts the heating fluid circulating pump (5);

(c) This circulates hot fluid from the thermal store/buffer (3) through the heating fluid flow pipe (7) to the heat emission system(s) (9) – usually radiators or fan coils, which extract energy from the heated fluid and pass it to the heated space;

(d) The heating fluid, which is now cooler, passes through the heating fluid return pipe (8) and back to the thermal storage/buffer;

(e) When the temperature of the thermal store/buffer falls below the required level, the control system starts the primary circulating pump (4), which starts fluid flow from the thermal store/buffer to the boiler (1);

(f) The boiler ignites and heats the fluid before it passes back to the thermal store/buffer;

(g) Once the thermal store/buffer is heated to the required temperature, the control system shuts off the primary circulating pump.

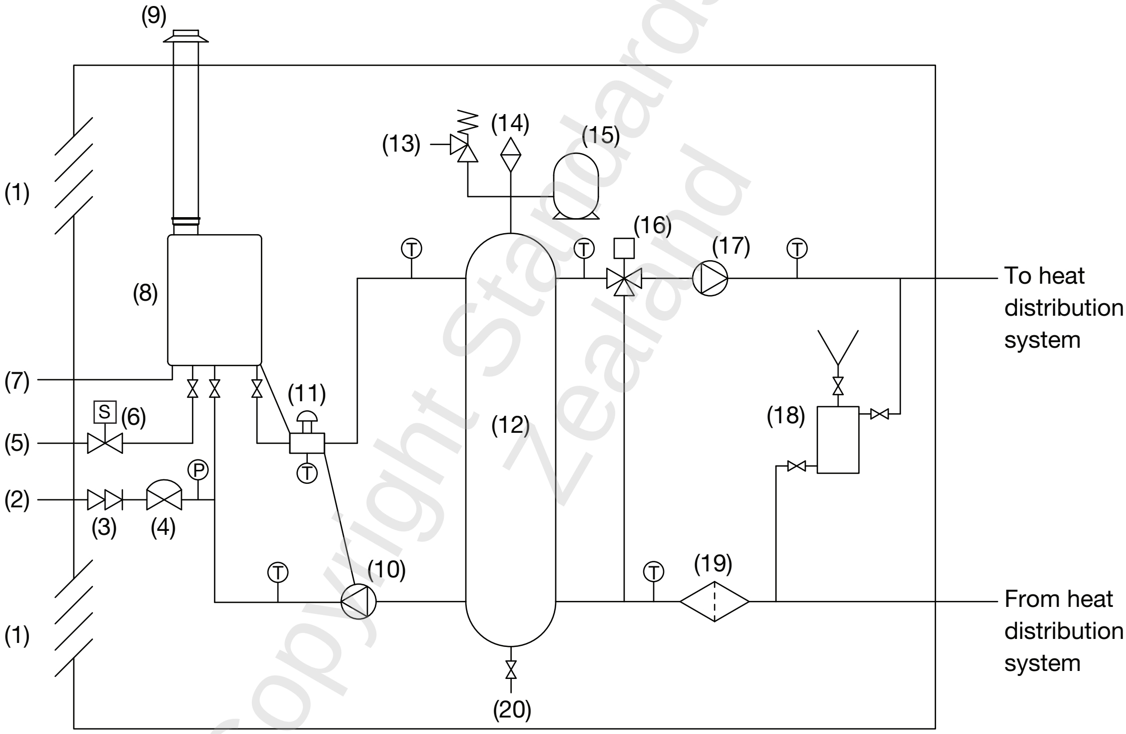
Note that not all systems incorporate a thermal store or buffer. In some systems, the heating fluid circulating pump (5) circulates directly from the boiler to the heating fluid flow pipe, making the primary circulating pump (4) redundant.

Modern boilers usually have a modulating burner. Where a system has no buffer, a high turndown ratio will improve efficiency.

2.1.2 Heat supply system

The components of the heat supply system are often grouped together in a plant room. Much of the equipment will not be suitable for exterior mounting and needs to be protected from water ingress and UV light. The boiler(s) could be remote from the other equipment, and externally mounted boilers are available.

The main components of the heat supply system for a gas or liquid fuel boiler system are shown in Figure 2. In small systems, much of this equipment could be contained within the enclosure of the boiler.



Key: (1) Ventilation air supply for combustion; (2) Water supply; (3) Double non-return valve to protect the potable water system from contamination; (4) Auto-fill valve to ensure system remains full of water; (5) Fuel supply; (6) Fire alarm/ earthquake automatic shut-off valve; (7) Condensate drain to sanitary sewer; (8) Gas or liquid fuel burner including heat exchanger; (9) Combustion products exhaust terminal; (10) Primary boiler circulating pump; (11) Over-temperature automatic shut-off with manual reset to prevent steam forming in the system; (12) Thermal store/buffer; (13) Over-pressure relief valve – drained to waste; (14) Automatic air release valve(s), typically at the system's high point; (15) Expansion tank – to provide for the change in volume as the water heats and cools; (16) Temperature control valve to ensure correct temperature is supplied to the heat distribution system; (17) Heat distribution system circulating pump; (18) Dosing pot – to provide anti-corrosive additive to the system; (19) Filter to protect heat supply system from debris – can be magnetic; (20) System drain.

Figure 2 – Heat supply system features

Considerations for a plant room include:

(a) Having a dedicated space that is appropriate for the size of the boiler system and the building(s) it is supplying;

(b) Use of suitable finishes such as impervious slip-resistant flooring;

(c) Adequate ventilation;

(d) Potential noise from the boiler system when it is operating;

(e) Safe access for operation, maintenance, and equipment replacement;

(f) A practical route and termination for the flue system;

(g) Drains to sanitary sewer for condensate and water expansion;

(h) Ensuring it is suitably bunded and drained to prevent damage to building elements from leaking water;

(i) Security and restrictions on access for unauthorised people; and

(j) Any possible future expansion of the system, for example, pipework configuration and sizing.

Some boiler systems can be suitable for installation in a secure location outdoors.

2.1.3 Boiler components

A gas boiler uses a gas as its fuel source. This gas is typically supplied to the boiler via a reticulated (piped) supply or from a bulk storage cylinder or replaceable cylinders situated on site.

A liquid fuel boiler uses diesel (or occasionally kerosene or light fuel oil) as its fuel source. The liquid fuel is stored in a tank near the boiler.

A gas or liquid fuel boiler is generally made up of the following components (see Figure 3):

(a) Water outlet;

(b) Water inlet;

(c) Fuel inlet;

(d) Air intake;

(e) Combustion fan – controls the flow of air required for correct combustion;

(f) Fuel supply control valve – controls the flow of fuel into the appliance;

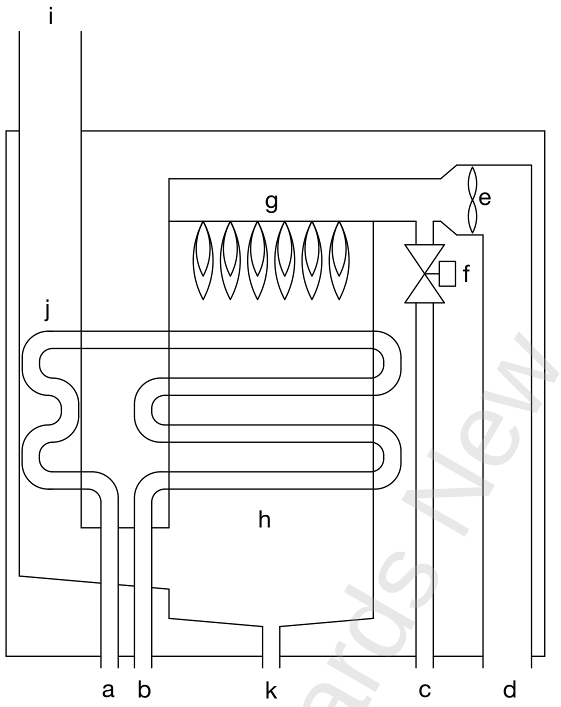
(g) Burner – allows the air and fuel to mix correctly and combust cleanly;

(h) Heat exchanger – allows transfer of heat energy from fuel combustion to the heating fluid;

(i) Flue – conveys products of combustion away from the appliance;

(j) Exhaust heat-recovery heat exchanger – extracts additional heat from exhaust (condensing boilers only); and

(k) Condensate drain (condensing boilers only).



Key: (a) Water outlet; (b) Water inlet; (c) Fuel inlet; (d) Air intake; (e) Combustion fan; (f) Fuel supply control valve; (g) Burner; (h) Heat exchanger; (i) Flue (exhaust) outlet; (j) Exhaust heat-recovery heat exchanger; (k) Condensate drain.

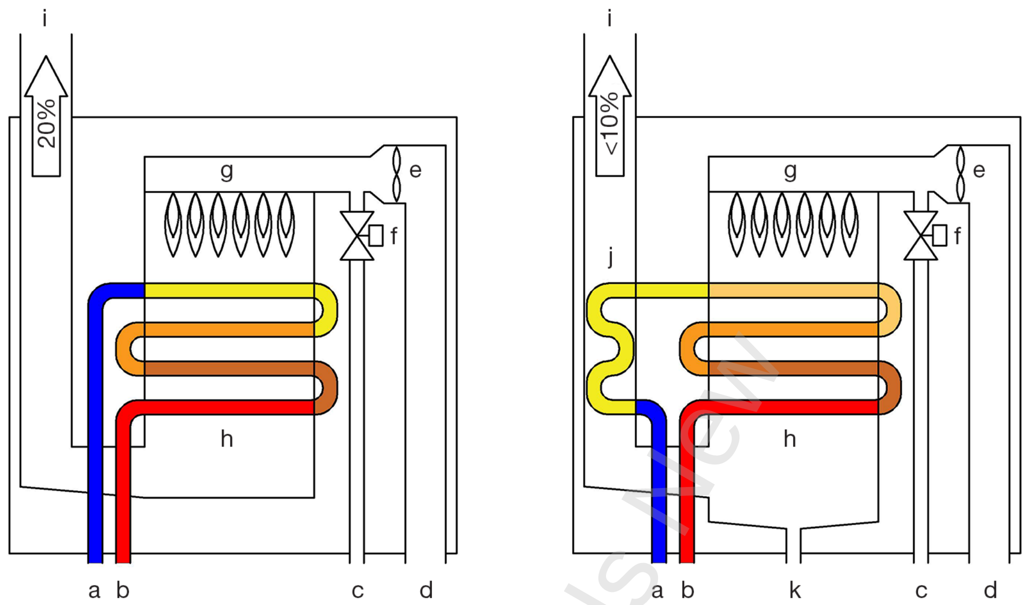
Figure 3 – Components of a boiler

A gas or liquid fuel boiler will also have a control system to control appliance operation and provide safety functions in the event of a fault.

2.1.4 Condensing and non-condensing boilers

Gas and liquid fuel boilers produce heat by combustion – burning fuel combined with oxygen, which produces carbon dioxide and steam that are exhausted via the flue.

A condensing boiler condenses the water vapour in the exhaust gas and can extract some of that heat energy and use it to pre-heat the return fluid flowing into the boiler. Moisture produced by the condensing process is drained away (see Figure 4).



Key: (a) Water outlet; (b) Water inlet; (c) Fuel inlet; (d) Air intake; (e) Combustion fan; (f) Fuel supply control valve; (g) Burner; (h) Heat exchanger; (i) Flue (exhaust) outlet; (j) Exhaust heat-recovery heat exchanger; (k) Condensate drain.

Figure 4 – Non-condensing (left) and condensing (right) boiler schematic

There are two advantages of condensing boilers:

(a) They employ a more thermally efficient system that transfers more of the energy from the fuel into the heating fluid than a non-condensing boiler; and

(b) They cost less to run and produce fewer emissions than non-condensing boilers.

Some elements of condensing boilers to be aware of:

(c) They produce moisture though condensing the exhaust gases. A drain to the sanitary sewer system will be connected to a condensing boiler;

(d) Condensing boilers are more expensive than non-condensing boilers due to the materials of construction, additional sensors, and the components required to drain the condensate; and

(e) If the heating fluid entering a condensing boiler is too hot, the appliance will not be able to operate in condensing mode, and its thermal efficiency will reduce to that of a non-condensing appliance.

2.2 Boiler fuels

2.2.1 Key considerations

The type of fuel a boiler uses affects the system's environmental impact and operation costs. The transport cost of the fuel (getting the fuel from its source to the site) can also impact overall operating costs.

It is important to use the correct fuel as specified by the boiler manufacturer to ensure the boiler system works correctly and any warranty is not voided.

A further consideration is greenhouse gas emissions from the chosen fuel. For example, based on Ministry for the Environment figures tabulated in its 2020 guide to measuring emissions, emissions from a range of fuels are:

(a) Coal – 90 kg to 93 kg of carbon dioxide equivalent (CO_2-e) per gigajoule;

(b) Fuel oil – 72 kg to 74 kg of CO_2-e per gigajoule;

(c) Diesel – 69 kg of CO_2-e per gigajoule;

(d) LPG – 60 kg of CO_2-e per gigajoule; and

(e) Gas – 54 kg of CO_2-e per gigajoule.

2.2.2 Gas fuels

Natural gas is generally the least-cost fuel option and produces the lowest emissions for gas and liquid fuel boilers. It is usually supplied to a site by pipeline. However, pipeline supply is not available in the South Island and some areas of the North Island.

Liquefied petroleum gas (LPG) is a gas that will readily liquefy under pressure at ordinary temperatures and can be transported in pressurised containers. LPG is a convenient alternative to natural gas in rural areas and cities not served by the natural gas distribution network. LPG is also reticulated by pipeline to some areas of the South Island.

2.2.3 Liquid fuels

Diesel is the predominant liquid boiler fuel used in New Zealand. Diesel delivery is available throughout the country. An external storage tank is required.

Biodiesel, while not yet widely available, is an option in New Zealand. Availability is expected to expand in the future.

2.2.4 Emerging fuel options

Use of biofuels, which are produced from renewable plant or animal material, can reduce or eliminate CO_2 emissions. Potential biofuel substitutes for gas include bioLPG and biomethane. Ensure you contact your equipment supplier for appropriate advice on use of biofuels.

Synthetic methane (although not a biofuel) can be produced by combining hydrogen and carbon dioxide and can be distributed as a partial substitute for natural gas.

Another option that will soon be available is a hydrogen and natural gas blend. One hundred-percent hydrogen boilers are also being developed for future use.

Existing boilers might be able to use some of these emerging fuel options (Table 1). Boilers being developed in Europe can take various burner types, which potentially offers flexibility in the choice of fuel.

Table 1 – Boiler fuel compatibility

Currently suitable for burning	Can burn (without modification to the boiler)
Natural gas	Synthetic methane compliant with NZS 5442
	Biomethane compliant with NZS 5442
	Hydrogen and natural gas blend compliant with NZS 5442
LPG	BioLPG compliant with NZS 5435
Diesel	Biodiesel

NOTE – The suitability of boilers to run on alternative fuels is subject to the following:

(1) The alternative fuels are compliant with the standards referenced; and

(2) The equipment supplier has confirmed that the equipment is suitable for use with the alternative fuel type selected.

2.3 Configuration of gas and liquid fuel boiler systems

2.3.1 Boiler system configuration

Configuration options for boiler systems (Figure 5) include:

(a) Single-boiler systems;

(b) Centralised multi-boiler systems; and

(c) Distributed multi-boiler systems.

Each system is made up of the following:

(d) Fuel source: This must be sized correctly for the consumption rate of the boiler(s) and the expected usage of the heating system, with consideration given to the logistics of fuel replenishment;

(e) Boiler(s) or heating device(s): The heat source for the heating system turning the fuel into heat energy via combustion and transferring this heat energy into the heating system water;

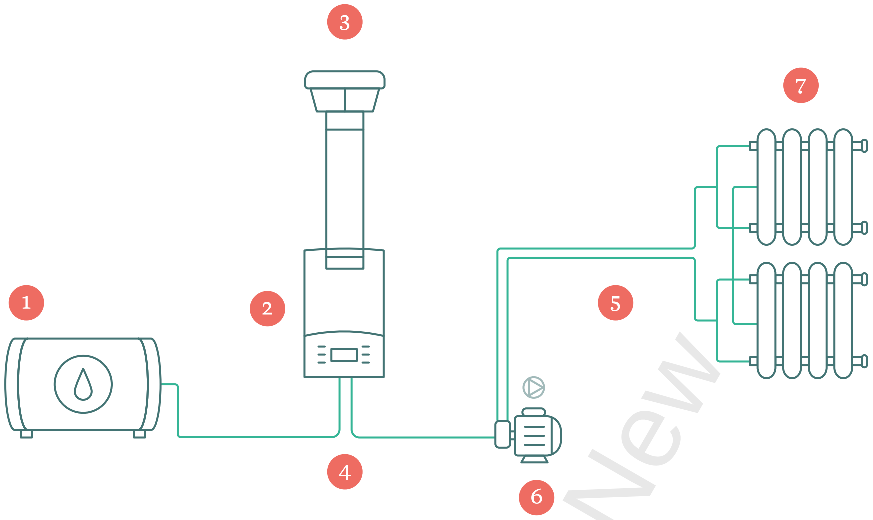
(f) Flue system: This allows safe disposal of the products of fuel combustion. Depending on boiler type, the flue could also supply fresh air for combustion;

(g) Boiler pipework: This supplies fuel to the boiler(s) and conveys water through the boiler(s) to allow for heat transfer;

(h) Heating system pipework: This allows the heated water to circulate from the boiler to the point of heat delivery into the space to be heated;

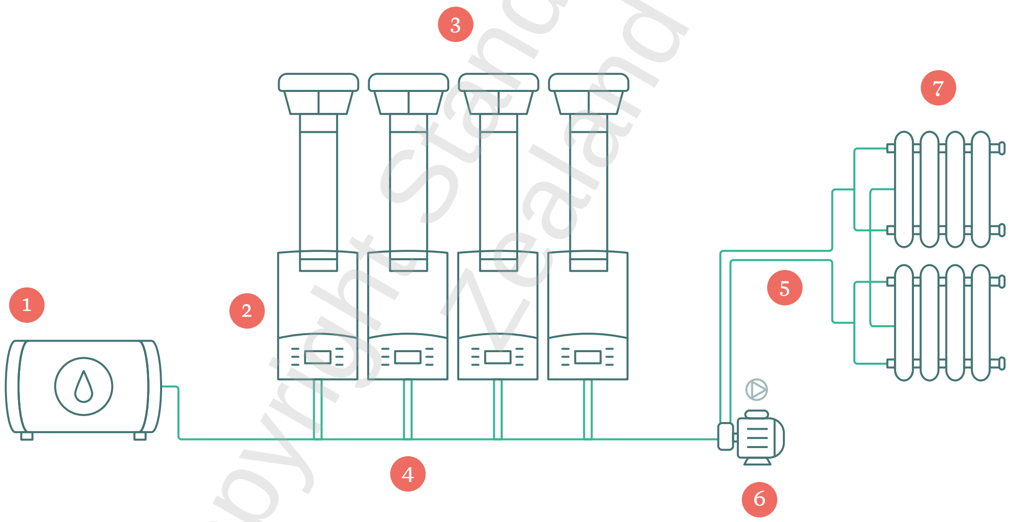
(i) Circulating pump: This circulates the hot water around the pipework and returns it to the boiler(s) for reheating;

(j) Space heating system: This transfers the heat in the water to the room to effectively heat the space. Common types are radiators or underfloor pipework.



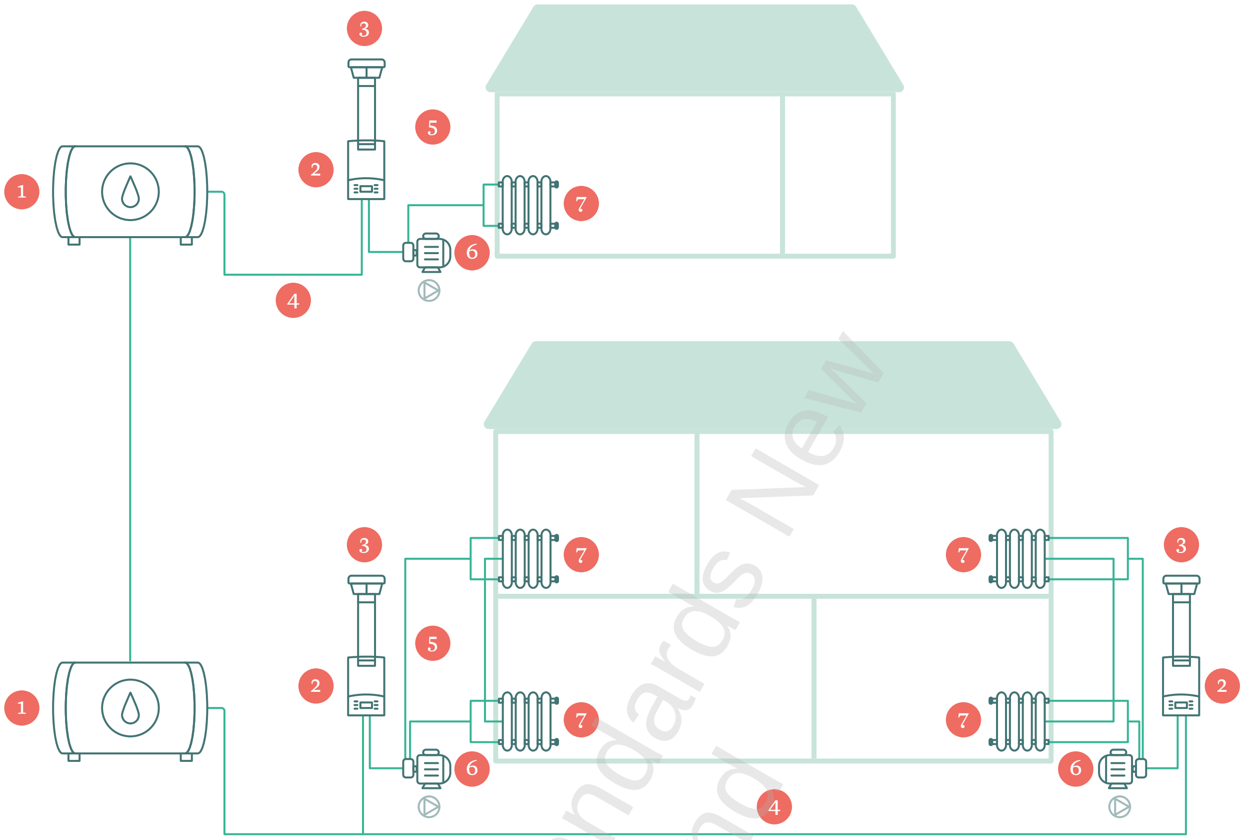
Key: (1) Fuel source; (2) Boiler; (3) Flue system; (4) Boiler pipework; (5) Heating system pipework; (6) Circulating pump; (7) Space heating system.

Figure 5a – Single-boiler system configuration



Key: (1) Fuel source; (2) Boiler; (3) Flue system; (4) Boiler pipework; (5) Heating system pipework; (6) Circulating pump; (7) Space heating system.

Figure 5b – Centralised multi-boiler system configuration



Key: (1) Fuel source; (2) Boiler; (3) Flue system; (4) Boiler pipework; (5) Heating system pipework; (6) Circulating pump; (7) Space heating system.

Figure 5c – Distributed multi-boiler system configuration

2.3.2 Single-boiler system

A single-boiler system (Figure 5a) uses a single gas or liquid fuel boiler (heating device), which needs to be matched to the expected maximum load placed on it. Where the heating load is well understood and will not need to be expanded in future (for example, with additional classrooms, offices, or workshops), a single boiler could be sufficient.

If the boiler does not have enough heat-generating capacity, it will not be able to meet the heating load if this is expanded. The heating load could outstrip the capacity of the boiler to produce heat.

If the boiler has an excessive heating capacity for the heat load placed on it, the system could run inefficiently as the heat load underutilises the boiler's heat-making capacity. Generally, boilers are priced based on output, so a boiler with a large heat-making capacity usually costs more than a boiler with a smaller heat-making capacity.

A single-boiler system is good for:

(a) Spaces where the heating load is unlikely to change;

(b) Heating systems with a small number of heat output devices (radiators or underfloor heat systems); and

(c) Areas where space restrictions make other systems impractical.

A single-boiler system is not good for:

(d) Spaces where heating load might need to be increased (for example, with expansion on site);

(e) Where reliance on heating being available is critical. If the boiler breaks down, there is no back-up.

2.3.3 Centralised multi-boiler system

A centralised multi-boiler system (Figure 5b) uses multiple gas or liquid fuel boilers (heating devices), which need to be matched to the expected maximum load placed on them. The boilers are placed in a centralised location such as a plant or boiler room, and the hot water they produce is distributed to the heating system from this location.

With multiple boilers, a degree of flexibility exists if the heating load grows over time as additional boilers can be added to the system to meet the additional load. Consideration needs to be given to any future expansion of the system at the time of installation. A plant or boiler room will need to be able to accommodate any future expansion of the boiler system, and the boiler pipework needs to be configured to allow additional boilers to be added to the system.

Most modern multi-boiler systems use electronic control systems where the boilers interact with each other and switch on and off as the heating load increases and decreases. This increases the overall efficiency of the system.

Systems can also be configured so that different boilers switch on and off to spread the load over each boiler. As the boilers are individual units, it is possible to isolate an individual boiler for replacement or maintenance and keep the system running while this is happening.

A centralised multi-boiler system is good for:

(a) Expanding a system as the heat load demand grows;

(b) Providing redundancy and ease of repair or replacement if a boiler fails at a critical time; and

(c) Heating only part of a site or building as fewer boilers in the system run this way can be more efficient.

A centralised multi-boiler system is not good for buildings without a plant or boiler room or with restricted space for a boiler system.

Centralised systems are typically more expensive than single-boiler systems.

2.3.4 Distributed multi-boiler system

A distributed multi-boiler system (Figure 5c) uses multiple boilers throughout a site or large building. As the boilers are distributed throughout the building or site, the fuel source and boiler pipework could be centralised or local to the boiler locations.

This allows the overall system to meet the heating load, with the individual boilers only responsible for part of the overall system. This configuration provides a great deal of flexibility, so that individual parts can be turned on or off when parts of the site or building have different heating requirements or are not in use.

However, there is additional complexity in the pipework and set-up of the system, and the control system can be more complex. The heating load for each boiler also needs to be calculated individually, and a breakdown of a boiler will mean the areas served by that boiler will not receive any heating.

A distributed multi-boiler system is good for:

(a) Providing heating to large complex sites or buildings;

(b) Heating specific areas;

(c) Providing flexibility and different heating needs to a building or site.

A distributed multi-boiler system is not good for:

(d) Small sites with simple heating needs;

(e) Sites that cannot accommodate the boilers and associated pipework.

2.3.5 Boiler control systems

All boiler systems will have some form of control system. In simple systems, this control can be incorporated into the individual boiler. In more complex systems, this is likely to be external to the boilers.

The control system ensures that the heating system is able to meet the designed indoor temperatures, taking into consideration variation of the heating load on the system and variations in external climate. It also protects buildings and equipment against damage from frost and moisture when normal comfort temperature level is not required.

BS EN 12828 gives details and guidance on design for heating systems in buildings, including requirements for control systems.

2.4 Operation, maintenance and safety

2.4.1 Boiler system operation

Owners of new boiler systems should expect the equipment supplier to provide manuals and other documentation that offer guidance for the safe operation and maintenance of the equipment as part of the handover or induction process. This should also include operational training or familiarisation.

Many modern boiler systems are now largely automated, and can be operated and monitored remotely or configured to work with central building control systems. However, some aspects of safe and efficient boiler operation still require manual checks. Most important is the real-time monitoring of alarms and safety devices. The type of control system needs to be discussed and specified prior to installation.

Owners of small and medium-sized boiler systems will generally outsource the maintenance to professional maintenance service providers. Where operation or maintenance services are provided by a third party, the contract for such services should make clear the activities and responsibilities of the respective parties.

Boiler operation sequences are generally individual to each appliance, but a base sequence of operation is as follows:

(a) The system assesses how much heat is required to heat the water in the boiler system so space heating can commence;

(b) The circulation pump turns on, circulating water in the heating systems through the boiler;

(c) The boiler cycles an internal combustion fan to purge the burner of old, stale air and ensure the burner is full of fresh air for combustion;

(d) The ignition system starts in preparation for the fuel – this can be a spark ignition system in a gas boiler or a pre-heater system in a liquid fuel boiler;

(e) The fuel supply to the burner is switched on, and the burner ignites;

(f) The burner stabilises after ignition and begins to heat the water flowing around the heat exchanger;

(g) The heated water is circulated around the heating system.

2.4.2 Boiler system maintenance

It is important that a gas or liquid fuel boiler is serviced regularly to ensure:

(a) It is operating efficiently to minimise excessive fuel use and emissions production;

(b) All components in the boiler system are in good condition to minimise breakdowns.

System reliability and safe operation are dependent on facility owners ensuring that proper maintenance and operation procedures are established and appropriately known to all personnel with responsibility relating to the facility. These procedures should be easily available within the plant room for personnel to reference when necessary. A plan view of the installation should also be accessible in the plant room, preferably printed out and attached to a wall. Audits to ensure that the actual maintenance and operation activities are being correctly implemented should be undertaken at least annually.

To ensure safe and efficient operation and the longevity of the system, a routine maintenance schedule should be established and followed. This should be provided by the equipment supplier. It should include tasks that need to be completed at regular intervals.

Generally, the following servicing frequency is suggested according to the fuel used:

(c) Gas-fired boilers: twice a year;

(d) Liquid fuel-fired boilers: twice a year, or more often if there is reason to doubt their adjustment.

All servicing should be undertaken by a qualified person familiar with the type of boiler system in use and its operating characteristics. Servicing may be undertaken by the installer, a representative of the manufacturer, or other approved person who is legally entitled to undertake the work.

2.4.3 Safety considerations

Owners and operators of facilities have obligations under the Health and Safety at Work Act 2015 to ensure the safety of workers and the public. Obligations include, but are not limited to, the safe operation of the boiler system. This requires that all personnel with responsibilities relating to the facility operation should be appropriately trained, with regular refreshers as appropriate.

All modern boiler systems have several inbuilt safety features to prevent the boiler:

(a) Failing to ignite and the fuel being left on;

(b) Overheating;

(c) Operating with a blocked flue;

(d) Operating with a fuel leak.

These safety systems are built into the boiler and are mandated in the standards the boilers are manufactured to. In New Zealand, all gas and liquid fuel boilers are required to meet an appropriate manufacturing standard and be certified as having met that standard. Additionally, installers and maintenance personnel are required to hold the appropriate qualifications to work on boilers. For example, to install a gas boiler, the installer is required to be a licensed gasfitter.

The location for the boiler installation is also mandated by installation requirements (defined in the Gas (Safety and Measurement) Regulations 2010). A boiler must be installed in an appropriate place. Generally, a boiler room or plant room provides an adequate location. Flue locations are also important, and where the flue discharges is also mandated by the installation regulations and, often, manufacturer’s instructions. Where a site has special requirements around access and safety requirements, these are best discussed with the installer before the installation commences.

Hydraulic safety requirements are discussed in 2.9.3.

2.5 Where to start? Evaluation of options

2.5.1 Objective

When considering an upgrade or change to a heating plant, energy efficiency and emission reduction should be some of the first things reviewed. In its simplest form, energy efficiency is obtaining the highest level of energy service (for example, delivered hot water) for the lowest resource input (for example, fuel quantity and financial cost).

2.5.2 Heating demand

To suitably size a boiler system, it is recommended to calculate existing heating demand on an hourly basis and adjust for seasonal, weekly, and peak demand. Peak demand determines the overall required capacity of the system. To meet peak demand, the boiler system can either be sized to meet the existing demand profile, or a smaller gas or liquid fuel boiler can be used along with an energy storage tank.

An energy storage tank is a back-up storage tank designed to help meet peak demand, maintain a more even boiler output and thus increase efficiency, reduce short cycling, and increase heat plant longevity. Considerations for calculating existing heating demand are discussed in 2.6.1.

2.5.3 Seasonal impacts

One of the genuine advantages of gas and liquid fuel boiler systems is that the conversion of fuel energy to heat energy is not impacted by seasonal ambient temperature or other climatic conditions.

The heat losses of the heat distribution system are impacted by ambient temperature in a similar manner to other technologies.

2.5.4 System efficiency

The objective of a boiler system is to release energy from the fuel and transfer this energy to the space being heated in the most efficient way.

Conversion of gas or liquid fuel energy to heat energy is typically between 75% and 95%, depending on whether the boiler (heating device) is condensing or non-condensing, and can vary depending on water inlet temperature.

The efficiency of delivering the heat energy to the space to be heated is dependent on the design of the distribution system. If you are reusing your existing distribution system and simply replacing the boiler (heating device), similar results can be expected. If this is the case, it is recommended that a full assessment of your existing system be undertaken to identify current limitations or system 'pinch points' to ensure that the entire boiler system is optimised, and the best value is obtained from your investment.

The energy efficiency of the whole system is affected by several factors. To maximise the system efficiency:

(a) Use high-efficiency condensing boilers;

(b) Configure the system so that water returning to the boiler is as cool as possible;

(c) Insulate the plant room equipment as well as possible – this includes piping, thermal store/buffer, and pumps;

(d) Ensure the boiler system and thermal store/buffer are appropriately sized to avoid short cycling of the boiler (heating device);

(e) Insulate the distribution piping as well as possible and minimise the fluid volume within it;

(f) Circulate fluid at as low a temperature as practical (that is, don't overheat fluid unnecessarily);

(g) Eliminate leaks from the distribution piping;

(h) Avoid overheating spaces, and heat them only for as long as required;

(i) Use a buffer to match heat demand with heat output from the boiler or, in the absence of a buffer, use a modulating boiler with a high turndown ratio.

Note that, if using existing heat distribution equipment, it might not be practical to do all of the above.

2.5.5 Advantages and limitations

The advantages and limitations of gas and liquid fuel boiler systems are presented and compared in Tables 2 and 3.

Table 2 – Advantages of gas and liquid fuel boiler systems

	Gas	Liquid fuel
Gas and liquid fuel boiler systems are a long-established technology, with well-established installation and service networks, spare parts, and technical support	Y	Y
The industry is competitive, with a range of suppliers and installers to select from	Y	Y
Fuel supply is readily available, consistent, and well-regulated, using recognised standards	Y	Y
Future fuels, including bioLPG, synthetic methane, and hydrogen blends, are suitable for use in modern gas boiler technologies (some boilers will require burner modification)	Y	N/A
Liquid fuel boiler systems might be able to run on biofuels that meet New Zealand liquid fuel standards	N/A	Y
The boiler (heating device) component of a boiler system is often less expensive than an equivalently sized alternative technology system	Y	Y
Boiler (heating device) output is independent of climatic conditions	Y	Y
Gas boiler systems have no particulate emissions and provide very clean combustion	Y	N
Resource consent might not be required for installation – a phone call to your local authority can establish this	Y	Y
Modern gas and liquid fuel boiler systems are electronically controlled and therefore have potential for more precise and advanced control methods, which can include remote access and monitoring capabilities that are easily integrated within an existing building management system or similar	Y	Y
Gas and liquid fuel boiler systems are not subject to variable time-of-use tariffs such as those applied to electricity-using technologies, nor do demand management requirements apply at times of high electricity use	Y	Y
Well-designed gas and liquid fuel boiler systems can have high part-load and variable-load efficiency	Y	Y
Gas and liquid fuel boiler systems have no impact on the electricity distribution system of the building	Y	Y
Life-cycle costs for gas and liquid fuel boilers could be lower than alternative technologies due to their lower initial capital cost	Y	Y
The space occupied by the boiler (heating device) can be significantly smaller than alternative technologies	Y	N
The boiler (heating device) contains no environmentally harmful materials and is readily recycled	Y	Y

Table 3 – Limitations of gas and liquid fuel boiler systems

	Gas	Liquid fuel
Gas and liquid fuel boiler systems are required to be flued to the atmosphere and to discharge where the products of combustion will not cause hazard or inconvenience	Y	Y
Condensate from condensing boiler operation is required to be drained to sanitary waste	Y	N
Regional availability of fuel in remote areas and the availability and delivery time of bottled gas supply or bulk liquid fuel should be carefully considered	Y	Y
LPG bottled gas can require an additional system to convert the liquid into a gas, and storage of larger quantities of LPG can require additional compliance measures that require annual renewal	Y	N
Most gas and liquid fuel boiler systems require a small and reliable supply of electricity to operate	Y	Y
The site requires adequate access for fuel delivery	Y	Y
LPG boiler systems require space to be allocated for a bulk LPG tank or multiple LPG cylinders	Y	N
Liquid fuel boilers will mostly require a bulk fuel storage tank, and adequate protection should be given to minimise the effects of fuel spillage on the environment	N	Y
A gas or liquid fuel boiler system will generate noise in operation	Y	Y

2.6 Scoping and conceptual assessment

2.6.1 Estimation of required heating capacity – Installing the right system for the space

A good estimate of required heating demand is important to ensure that the designed and installed system is fit for purpose. Heating demand requirements should be calculated by an independent professional (not necessarily the installing contractor). Online calculators are available for space heating. If a calculator is used, ensure it is optimised for New Zealand conditions.

The following parameters shall be considered to obtain an estimate of heating demand:

(a) For new space heating applications:

(i) The size and number of spaces to be heated, noting detailed floor areas and room volumes

(ii) The construction of the space's floors, walls, and ceilings, particularly noting overall insulation values

(iii) The area of windows for each space and whether the windows are double or triple glazed

(iv) An estimate of the air infiltration or leakage for each room or ventilation quantity ($m^3 s^{-1}$) for each space if the space has a separate ventilation system

(v) Building Code and local authority compliance shall be checked before committing investment – the New Zealand Building Code is undergoing changes that are likely to come into force towards the end of 2022 or early in 2023 and could affect the efficiency, control system, and energy monitoring requirements of a new space heating installation;

(b) For new process heating applications:

(i) The temperature and heat load of each application

(ii) The expected schedule of application heat loads, including variations throughout an operating shift;

(c) For a retrofit application, existing monitored data of heating demand can be used if the data is reliable. Monitoring equipment can be installed in advance of considering a prospective gas or liquid fuel boiler system proposal. So that distribution heat losses can be estimated, monitoring of an existing installation should be designed to separate the energy supplied by the heating unit from the energy supplied to the occupied spaces or applications. Where changes to the distribution system are proposed as part of the installation, the effect of these changes should also be measured by the data collected;

(d) For heating demands that are influenced by ambient temperature (such as space heating), climate files (used for setting the design conditions) should be agreed, along with agreement on an allowance for weather extremes.

2.6.2 System selection

The selection of a gas or liquid fuel boiler system solution shall consider the following:

(a) The life-cycle cost of the system. This shall be defined as the amortised sum of the capital cost, the operating cost, the maintenance cost, and the installation cost for an operating period of 15 years;

(b) The availability of local support capability;

(c) On sites with buildings spread out in blocks, a distributed gas or liquid fuel boiler system is a possibility to explore. Such systems place smaller gas or liquid fuel boilers around the site so the supply of heated water can be delivered more directly to the areas of heating demand;

(d) The use of thermal storage (typically in the form of an insulated hot water tank) to smooth out heating demand and minimise delay in providing heating.

In addition to the above, when considering a retrofit or replacement of an existing system, the energy expected to be saved from the operation of the total installed system compared with the existing system shall be determined by the methodology described in AS/NZS 4234.

Figure 6 shows a flowchart of key decision points for system selection.

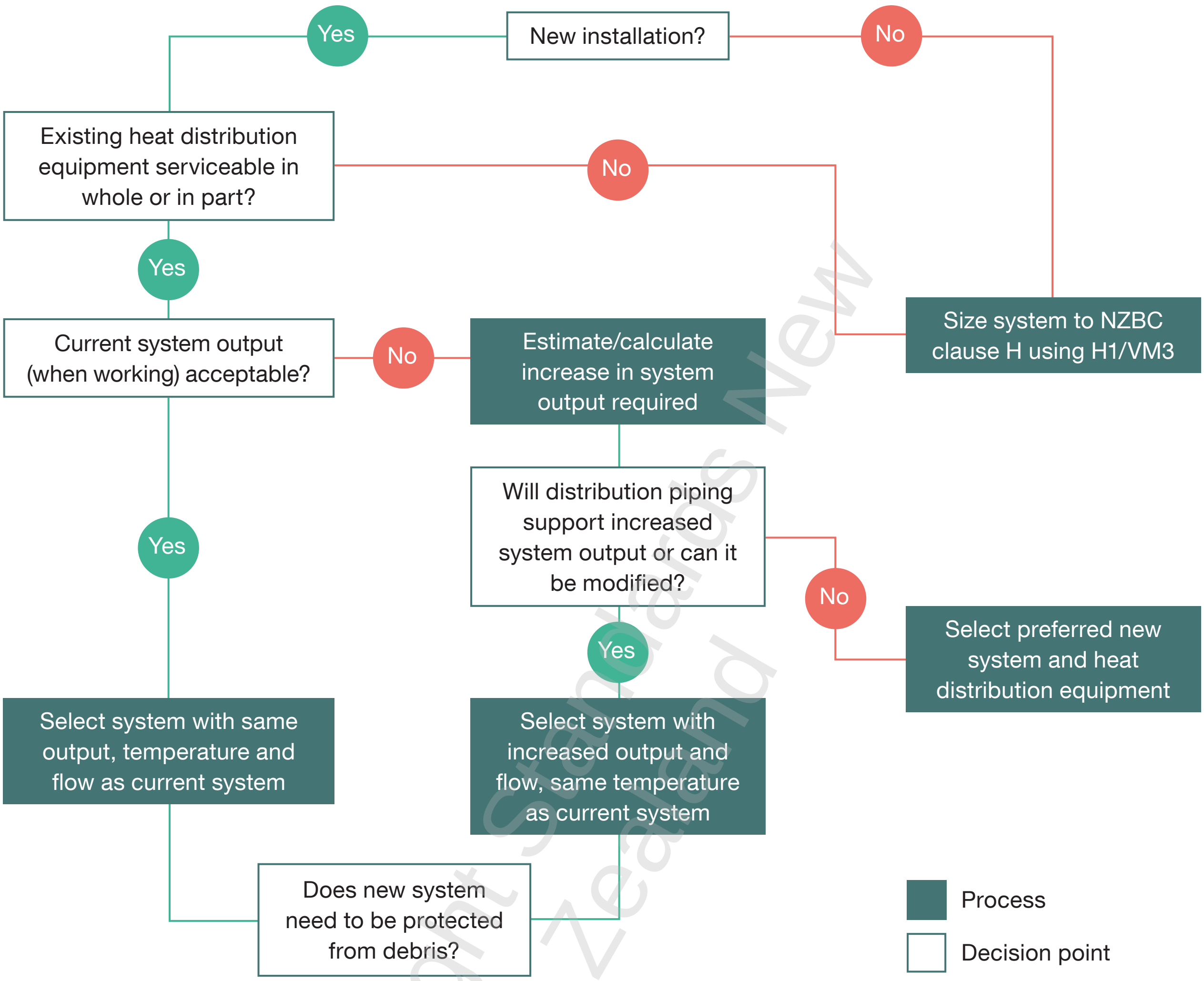


Figure 6 – System selection

2.7 Building Code compliance

2.7.1 H1 Energy efficiency

Gas and liquid fuel boiler system performance is covered under clause H1 (Energy Efficiency) of the Building Code, which in turn is issued under section 22(1) of the Building Act 2004. The information provided within this section of the PAS is based on the 2021 Building Code specification, including standards cited. Refer to www.building.govt.nz for current requirements.

Acceptable Solutions or Verification Methods are generally used to define compliance with the relevant section of the Building Code.

Verification Method H1/VM3 can be used for space heating, ventilation, and air-conditioning systems in commercial buildings (including schools). It covers requirements for the following building elements, some of which are related to, or are directly part of, gas or liquid fuel boiler system performance:

(a) System controls;

(b) Pumps;

(c) Pipework insulation;

(d) Space heating;

(e) Facilities for energy monitoring;

(f) Maintenance access.

It is important to understand where gas and liquid fuel boiler systems fit within the wider context of the H1/VM3 air-conditioning system compliance framework. This will ensure your new or replacement boiler system can be specified to meet the compliance requirements of the Building Code.

Verification Method H1/VM3 is one commonly used option that provides a means of establishing compliance with the Building Code performance criteria defined in H1 clause 3.6. Other pathways exist (that is, using Acceptable and Alternative Solutions) and should be discussed with your local government consent provider, if a consent is required for your new or replacement boiler system.

Your system specifier will be able to advise on Building Code compliance, and evidence shall be provided in installation documentation.

2.7.2 System controls

In general terms, if a gas or liquid fuel boiler system is being installed and commissioned in a new building or retrofitted into an existing building, it must function within the prescribed control parameters of H1/VM3 to demonstrate compliance with the Building Code.

Gas and liquid fuel boiler systems are often integral components of the air-conditioning system within commercial buildings. System control will often provide inputs to the building's air-conditioning system or be integrated into the air-conditioning control system itself.

The control system requirements to demonstrate compliance with H1/VM3 include:

(a) System deactivation to ensure the system only runs when necessary and can be shut down in an emergency. Deactivation also includes advice around preventing infiltration of outdoor unconditioned air when the system is not in use;

(b) Adequate zoning controls to ensure that only spaces which require heat receive it;

(c) Operating times – for example, pre-heating of occupied spaces, shut-down outside of normal operating hours using (for example) a programmable time switch.

2.7.3 Pumps, pipework and insulation

The energy consumption of pumps that form part of a gas or liquid fuel boiler system (within an air-conditioning system) is to be limited by the use of energy efficient motors and by keeping within a prescribed pipework average pressure drop. Pipework insulation is prescribed by R value. Please refer to https://www.building.govt.nz/building-code-compliance/h-energy-efficiency/h1-energy-efficiency/ for detailed information.

2.7.4 Space heating efficiency requirements

To show compliance with H1/VM3, a boiler that is used as part of an air-conditioning system is required to have a gross thermal efficiency of 90% or more when tested under conditions that mirror the expected typical operating conditions, including the expected water inlet/outlet temperatures. This is especially important for condensing boilers, where the inlet/outlet water temperature can greatly impact overall efficiency. For further information, see https://www.building.govt.nz/building-code-compliance/h-energy-efficiency/h1-energy-efficiency/.

A number of testing standards can be used to demonstrate compliance with the gross thermal efficiency requirement:

(a) BS 7190:1989;

(b) ANSI/AHRI 1500-2015;

(c) AS/NZS 5263.1.2:2020.

Whichever testing standard is used, the test conditions shall mirror the expected typical operating conditions of the building, including water inlet and outlet temperatures.

2.7.5 Facilities for energy monitoring

To enable the required level of energy efficiency in air-conditioning systems, certain equipment is required to be used to detect excess energy use.

For buildings with a floor area of occupied space greater than 500 m^2 and less than 2500 m^2, verification of the energy monitoring design is achieved by:

(a) Providing energy meters (gas or liquid fuel) to enable individual time-of-use energy-monitoring consumption data. (Note: Buildings with a floor area of occupied space greater than 2500 m^2 have individual energy meter requirements for heating, cooling and air handling fans);

(b) Interlinking required energy meters under a common data-recording system;

(c) Ensuring the data-recording system stores air-conditioning system performance data over a minimum period of 12 months.

Guidance documents to assist gas or liquid fuel boiler system purchasers or their advisors to understand what is required under the Building Code can be found at https://www.building.govt.nz/building-code-compliance/h-energy-efficiency/h1-energy-efficiency/.

2.8 Consenting compliance

Consents to install boiler systems in new or existing building are issued by the relevant local, city, or regional council. A new or retrofitted gas or liquid fuel boiler system might not need a consent. Please contact your local authority in the first instance as this could be a primary consideration in your purchasing decision.

If a consent is required, each council can have different requirements in regards to their district plan and can interpret compliance differently depending on the geographical location, specification of the boiler system, installation, fuel type, or other matters.

Early engagement with the relevant consenting body is recommended to make sure its consenting requirements (if any) are clearly understood.

2.9 Regulatory safety requirements

2.9.1 Gas boiler systems

The safety of gas boiler systems is covered under the Gas (Safety and Measurement) Regulations 2010. These regulations also control the installation of the boiler systems concerned.

WorkSafe New Zealand provides the following advice:

(a) 'Every person who manufactures, imports, sells, or offers for sale, hires out, leases out, or installs a gas appliance or fittings must ensure as far as reasonably practicable that the gas appliance or fittings are safe. This applies to appliances and fittings whether new or used.' For more information, see www.worksafe.govt.nz/topic-and-industry/gas/gas-appliances-and-fittings;

(b) 'Before gas appliances and specified fittings can be offered for sale in New Zealand, they need to be certified by a recognised certification body or certification regime.' For more information, see www.worksafe.govt.nz/topic-and-industry/gas/gas-appliances-and-fittings/certification-regime;

(c) 'Any person who designs, constructs, maintains, uses, or manages a gas installation must do so in a way that ensures that the gas installation is safe when used for its intended purpose and in a lawful manner.' For more information, see www.worksafe.govt.nz/topic-and-industry/gas/installations-and-networks/design-and-construction.

2.9.2 Liquid fuel boiler systems

The Health and Safety at Work (Hazardous Substances) Regulations 2017 set requirements that apply to liquid fuel systems – storage, pipework, fittings, and burners.

WorkSafe New Zealand provides the following advice:

(a) 'Liquid fuel burners must be designed and constructed to comply with Part 17, subpart 11 of the Regulations. These requirements include that the burner is approved by WorkSafe.' For more information, see www.worksafe.govt.nz/topic-and-industry/hazardous-substances/certification-authorisation-approvals-and-licensing/certification-of-equipment-plant-buildings/burners;

(b) 'When installed, burners are part of a stationary container system, which is a fixed tank with associated pipe work and fittings. If there [are] more than 60 litres of fuel, then you (or the business) need to get a stationary container system compliance certificate. A location compliance certificate could also be needed.'

2.9.3 Hydraulic systems

BS EN 12828 clause 4.6.1 states that:

(a) Heating systems shall be equipped with safety arrangements against:

   (i) Exceeding the maximum operating temperature

   (ii) Exceeding the maximum operating pressure

   (iii) Lack of water;

(b) Safety arrangements shall be designed in accordance with:

(i) The type of heating system, i.e. sealed or open vented system, and its pressurisation

(ii) The type of energy source

(iii) The way in which the heat supply is provided to the heating system, i.e. automatically controlled or manually operated

(iv) The nominal output of the heat supply system; and

(c) Safety arrangements, whether provided by the appliance manufacturer as a built-in part of the heat generator or not, shall be an integral part of the heating system. The appliance manufacturer's installation instructions shall be complied with.

The remainder of BS EN 12828 clause 4.6 provides a thorough examination of the methods to achieve suitable hydraulic safety.

2.9.4 Certification requirements

WorkSafe New Zealand advises that certain plant, buildings, equipment, and people require certification from a compliance certifier or an authorisation or approval from WorkSafe:

(a) If a site has flammable or oxidising substances in excess of the threshold quantity, a location compliance certificate is required. In order to get a location compliance certificate, the building construction and related separation distances must be compliant. For more information, see www.worksafe.govt.nz/topic-and-industry/hazardous-substances/certification-authorisation-approvals-and-licensing/certification-of-equipment-plant-buildings/buildings-for-flammable-and-oxidising-substances;

(b) All gas fitting work must be certified by a certifying gasfitter or other person authorised under the Plumbers, Gasfitters, and Drainlayers Act 2006. For more information, see www.worksafe.govt.nz/topic-and-industry/gas/installations-and-networks/certification.

2.10 Checklist

2.10.1 Gas or liquid fuel boiler system selection (see 2.5)

The main points to consider in relation to the selection of a gas or liquid fuel boiler system are:

(a) Evaluation of existing plant efficiency;

(b) Determining current and future heating demand and options;

(c) Connection to existing system or plan for a new heat distribution system;

(d) The range of system options, including boiler, fuel, and hot water storage; and

(e) Attributes and costs over the economic life of the gas or liquid fuel boiler system.

2.10.2 Fuel checklist (see 2.2)

The main points to consider in relation to fuel are:

(a) Fuel selection – what to use;

(b) Fuel quality – does the chosen fuel meet the required specifications?

(c) Fuel purchase – local availability in the short term and long term; and

(d) Fuel management and storage – site delivery and fuel storage considerations.

2.10.3 Operation, maintenance, and safety (see 2.4 and 2.9)

The main points to consider in relation to operations, maintenance, and safety are:

(a) Meeting all regulated safety requirements, including training of operations staff;

(b) Availability of maintenance and servicing support;

(c) Inspection requirements; and

(d) System reliability, maintainability, spares, and after-sales support.

2.10.4 Consenting (see 2.7 and 2.8)

In terms of compliance and consent, the two areas to consider are:

(a) Building Code compliance; and

(b) Local consenting process (if any), which needs to be established as early as practical.

2.10.5 Advantages (see 2.5.5)

The main points to consider in relation to the advantages of a gas or liquid fuel boiler system are:

(a) Well-established technology;

(b) Highly regulated and consistent current fuel supply;

(c) Lower initial capital costs; and

(d) Clean combustion.

2.10.6 Limitations (see 2.5.5)

The main points to consider in relation to the limitations of a gas or liquid fuel boiler system are:

(a) The importance of good design is imperative for an efficient system;

(b) Potential fuel storage costs and delivery constraints can restrict the suitability of these technologies in some parts of New Zealand;

(c) Combustion gases are required to be flued to the atmosphere and not cause a hazard or inconvenience;

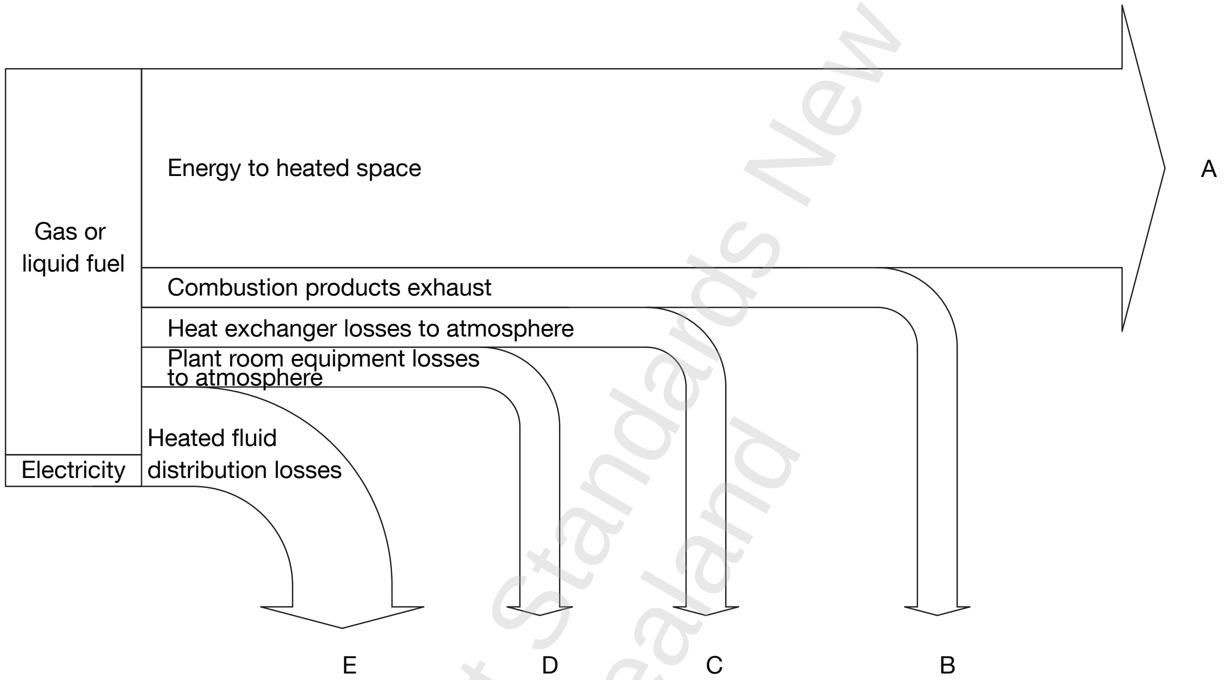
(d) Condensate from the most efficient gas boilers (condensing) must drain to sanitary waste.

3 TECHNICAL SPECIFICATION

3.1 System operation and efficiency

3.1.1 Energy efficiency aspects of a boiler system

The system efficiency of a boiler is depicted in Figure 7, showing the approximate percentage of energy delivered to the heated space and approximate percentages of the energy losses.



Energy to	Approximate range (%)	Losses increase with:		Similar losses to:	
		Reducing ambient temperature	Increasing fluid circulation temperature	Heat pump SNZ PAS 5210	Biomass SNZ PAS 5311
A. Heated space	50–75	–	–	–	–
B. Combustion product exhaust	2–30[a]	N	Y	N	Y
C. Heat exchanger losses	3–10[b]	Y	N	Y	Y
D. Plant room equipment	5–10[c]	Y	Y	Y	Y
E. Fluid distribution	10–30[d]	Y	Y	Y	Y

[a] Condensing boilers will lose less energy in the exhaust provided the incoming water temperature is below the dew point (~60°C).

[b] This is the energy lost from the heat exchanger metal to atmosphere. The longer the boiler operates, the greater the heat exchanger losses. The heat exchanger losses during operation are usually included in the stated thermal efficiency for the boiler.

[c] This includes the heat loss to atmosphere from the thermal storage/buffer tank, the electricity required to operate the system, and the plant room pipe losses to atmosphere.

[d] This is the energy lost in distributing heated fluid to spaces. This includes energy lost from the distribution piping and the circulating pump electrical requirements.

Figure 7 – System efficiency

3.1.2 Combustion – Condensing boilers explained

Combustion of hydrocarbons in a boiler is a chemical reaction with oxygen. The products of combustion are carbon dioxide and water molecules. At the temperature of the reaction, the water molecules in the combustion products are present as a vapour.

For methane (natural gas), this reaction is expressed as $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$.

In a boiler, the products of combustion pass from the burner to a heat exchanger where energy is transferred to the process water for space heating.

If up to around 80% of the energy is transferred from the products of combustion to the heating water, the temperature of the exhaust will be high enough that the water in the exhaust will remain as a vapour.

As the energy transferred increases past 80%, the combustion product water contains insufficient energy to remain as a vapour and condenses into liquid water. This change of phase from a vapour to a liquid releases significant energy (sometimes referred to as latent energy of vaporisation or condensation).

This liquid water collects in the bottom of the heat exchanger.

Appliances that operate at efficiencies up to about 83% will generally be non-condensing. This means the appliance is not equipped to drain away water that condenses. Appliances with efficiencies higher than this will be designed to drain this water to waste.

The condensed water (condensate) carries with it some impurities from the gas supply. These impurities result in the water being very slightly acidic. The material of the heat exchanger and drain system of the condensing appliance are resistant to this acidity.

The condensate is usually drained to a sanitary sewer. It is important that the material used for the drain between the appliance and the sanitary sewer is not corroded by the condensate. PVC, the most common drain material, is sufficiently resistant. Copper will be corroded over time. The condensate will also corrode most metals other than high-quality stainless steels. If it is allowed to drip onto concrete, it will slowly dissolve it over a period of years.

Some appliance designs will treat the condensate, usually by passing it through lime flakes to neutralise the acidity. The lime flakes will need to be replenished and sometimes rinsed from time to time.

It is important that the condensate can drain freely. If the drain becomes blocked, the appliance can fill with condensate. Many appliances will have sensors to stop the appliance operating if the drain is not clearing. For this reason, the condensate drain shall be protected from freezing. This is usually done with an air-break close to the appliance to ensure the condensate drain empties constantly.

The condensate is most commonly drained by gravity. Where this is not possible, a condensate pump can be used. It is important that the pump selected is suitable for use in a condensing boiler. Most condensate pump assemblies consist of a small reservoir and pump. Within the reservoir is a float with a simple mechanical microswitch. If the condensate pump fails, the reservoir will fill with condensate until the float rises to the point where the microswitch closes. Many modern condensing boilers will have connections to monitor this switch. When the boiler determines that the float switch has closed, it will cease operation. If an installation is in a position where condensate overflow from a failed condensate pump would cause damage or go undetected for a long period, a boiler with this type of interface should not be selected, or an alternative arrangement to stop the boiler should be provided.

Condensing boilers are more expensive because of the additional material, material specification, connections and sensors they contain. They will usually have a lower operating cost, provided the water entering them is below the dew point of the combustion product (see Figure 6).

The dew point of combustion gas is approximately 50°C. In heating systems, once the spaces are heated, the return water temperature could approach this temperature. As the return water temperature approaches the dew point temperature, the combustion product cannot transfer energy from the combustion product water vapour to the heated liquid water stream. When this occurs, the efficiency of the condensing boiler will reduce. To maintain the highest efficiency, it is important to keep the return water temperature to the condensing boiler below this temperature.

If the condensing boiler is operating with a high return water temperature at which it can no longer condense combustion product water vapour, it will no longer produce its full rated energy output. In most space heating applications, this is not an issue in practice (for heating as opposed to efficiency or running cost) as the boiler is rated for heating the space from a low ambient temperature. Once the return water temperature has risen close to the dew point, the spaces are nearly fully heated and the full rated energy output is not required. In some industrial and commercial applications, this might not be the case and this reduced output shall be allowed for when selection is made.

The only significant product of combustion of a boiler burning hydrogen is water. In the future, as blends and then pure hydrogen are supplied through the gas network, condensing boilers are likely to be the most future-proof model. In addition, as the cost of hydrogen blends and ultimately pure hydrogen is likely to be higher than current gas prices, condensing boilers are likely to become increasingly more attractive.

3.1.3 Boiler system maintenance

A boiler system will require regular and ongoing maintenance to ensure it is operating correctly and safely, and combusting efficiently.

Maintenance frequency will be determined by the manufacturer's recommendations and hours of operation of the boiler system, and is also potentially impacted by the local water chemistry.

An annual service interval is common for most systems. If the hours of operation are high or there are other factors such as complex water chemistry, service and maintenance requirements could be more frequent. It is important to note that both the boiler and the associated heat distribution system have separate maintenance requirements.

3.1.4 Gross thermal efficiency

Gross thermal efficiency of a condensing boiler shall be greater than 90%.

3.2 Fuels

3.2.1 Natural gas

Natural gas is a naturally occurring hydrocarbon extracted from the ground and processed to be used as a reticulated gas that meets the New Zealand gas specification NZS 5442. It is comprised mostly of methane with smaller amounts of ethane.

3.2.2 LPG

Liquefied petroleum gas (LPG) is composed predominantly of any combination of the hydrocarbons propane and butane as per NZS 5435.

3.2.3 Liquid fuels

The specifications for diesel as a (vehicle) engine fuel are in the Engine Fuel Specifications Regulations 2011. Schedule 2 applies to diesel and Schedule 3 applies to biodiesel.

Kerosene is most commonly known as 28-second oil or home-heating oil and is considerably lighter than gas oil.

Light fuel oil or gas oil is most commonly known as 35-second oil, which is related to the distillation process.

3.2.4 Biofuels

BioLPG is a renewable gas composed predominantly of any combination of the biopropane and biobutane as per NZS 5435.

Synthetic methane is a hydrocarbon created by combining hydrogen and carbon dioxide and then processed as reticulated gas that meets the New Zealand gas specification NZS 5442.

Biogas is a mixture of gases produced by anaerobic microbial decomposition of organic matter (such as food waste or wastewater) and is principally comprised of methane, carbon dioxide (30% to 40% generally), and lesser proportions of hydrogen sulphide, water vapour, or other gases. Biomethane is the processed form of biogas where the raw biogas has been refined to remove the majority of carbon dioxide, hydrogen sulphide, and other trace gases, and the remaining gas meets the natural gas specification defined in NZS 5442.

In a hydrogen and natural gas blend, the hydrogen proportion does not exceed 20%, and the resulting gas has the energy property within the heating value range of 46 MJ/m^3 to 52 MJ/m^3 defined in NZS 5442.

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