Ke Kelit Submission in response to the E3 Product Profile:

Residential Space Heaters in Australia & New Zealand

July 2021

KE KELIT®
NEW ZEALAND

Ke Kelit NZ welcomes this work and looks forward to contributing information on Hydronic Central Heating in New Zealand and how this form of heating can provide warm, dry, healthy homes, at affordable running costs.

Although there are many sources of information on home heating most of it is too general to be of much use, and the information on Hydronic Central Heating is often incomplete or simply wrong.

We welcome the invitation for industry experts to contribute their considerable knowledge and experience to further work.

Hydronic Central Heating has been in New Zealand homes for many decades although most New Zealanders are more familiar with it from their school days rather than their homes.

Today's central heating sector has been fuelled by the expectations of New Zealanders having spent their OE living in centrally heated homes in the UK and other countries, and by immigrants from countries where whole house heating is standard.

In general, New Zealanders have developed higher expectations regarding what constitutes adequate heating than in the past. As a result, the central heating industry has seen significant growth over the last 20 years.

In summary our submission contains:

1. Comments on the Product Profile as Published
2. An overview of Hydronic Central Heating in New Zealand.
    a. Heat sources
    b. Emitters

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Comments on Product Profile

Appliance Classification

Classification of heating appliances has been centred around describing each commonly used product as distinct types without drawing together their common functionality.

To enable comparisons to be made between different products using different fuels we propose it is better to systematically consider:

1. Fuel used.
2. Efficiency of conversion of fuel to heat energy.
3. Distribution efficiency if it is a multi-emitter system.
4. From the conversion and distribution efficiencies can be derived for each unit of delivered heat
    - **Running costs** (c/kWh)– with reference to local fuel pricing
    - **Carbon emissions** (CO_2 /kWh) - with reference to national emission factors

Heating appliances can also be classified under their main functionality as:

1. Portable heating appliances.
2. Single room fixed heaters.
3. Multi room heating systems.

Importance of Considering the Heat Loss of the House Being Heated

A major omission from this report is whether or not the heating appliances are capable of heating the house, or even part of the house, it is going to be used in. Whereas for example a fridge may work the same in any house and can be compared directly with another fridge using an energy label; the appropriateness and overall performance of a heating appliance has to be considered in relation to the home it is heating.

It is also relatively easy to work out the efficiency and from that the cost of delivered heat, but that isn’t necessarily useful to the end user if the appliance turns out to be completely inadequate in its function.

It could be argued that this reflects a traditional culture in NZ of buying certain appliances based on guesswork, and accepting that the colder it gets the more likely you will have to use expensive to run secondary heating.

It is actually very easy to calculate the heat loss of a house and know the scale of the challenge faced by the heating system. This is all the more relevant today as some new super-insulated houses hardly need any heating whilst a large part of the housing stock still cannot be properly and affordably heated even with the most efficient systems.

A basic heat loss calculation is little different from the Calculation Method used to meet part H1 of the NZ Building Code. If it was compulsory to do this calculation for all building consents home owners would have a better idea of how many KWs of heat energy they need to heat their homes.

This is touched on in the report when referring to the energy rating label for a central heating boiler where in the graphic (P82) other factors apart from boiler efficiency are considered that contribute to the overal efficiency of the system.

In some countries such as the UK the appliance efficiency data is primarily used as data used by a whole house rating system that outputs KWh of energy use per square meter, and carbon emissions per square meter. This produces a score for the overall package which allows a designer to offset parts that aren't so good against those that are. Although there are still minimum efficiency standards for appliances.

This approach would be a big improvement to the New Zealand Building Code.

We would also like to point out that the heat energy needed to heat a home to a given temperature is entirely dependent on the design of the house; its insulation levels, glazing specification, and external surface area. It is the job of the heating system designer to design a heating system that provides sufficient heat energy in the right place, at the right time, at an optimal combination or capital and running costs.

Notes:

The current New Zealand Building code specifies minimum R values for elements of a building that also act as heat emitters. For underfloor heating this is R1.9.

Figure 35. Difficult to understand what information this graph is trying to show. A given house will require exactly the same amount of heat energy to heat it no matter what form of heating is used. For example, two different forms of electric resistance heating will produce the same amount of heat from the same amount of electricity. Therefore, if they are showing different amounts of energy used, as on this graph, then they are providing different amounts of heating. So how does this graph compare. (The MJ/pa scale is of the order that we are talking about energy used per year per dwelling.)

In parts of this document "Cost Efficiency" is stated in units of kWh heat/$. As residential consumers of natural gas and electricity in NZ are charged in $/kWh, and carbon emission factors for those fuels in NZ are stated in CO_2-e/kWh, would it not make sense to state cost efficiency in $/kWh to maintain consistency with the way customers are charged for fuel.

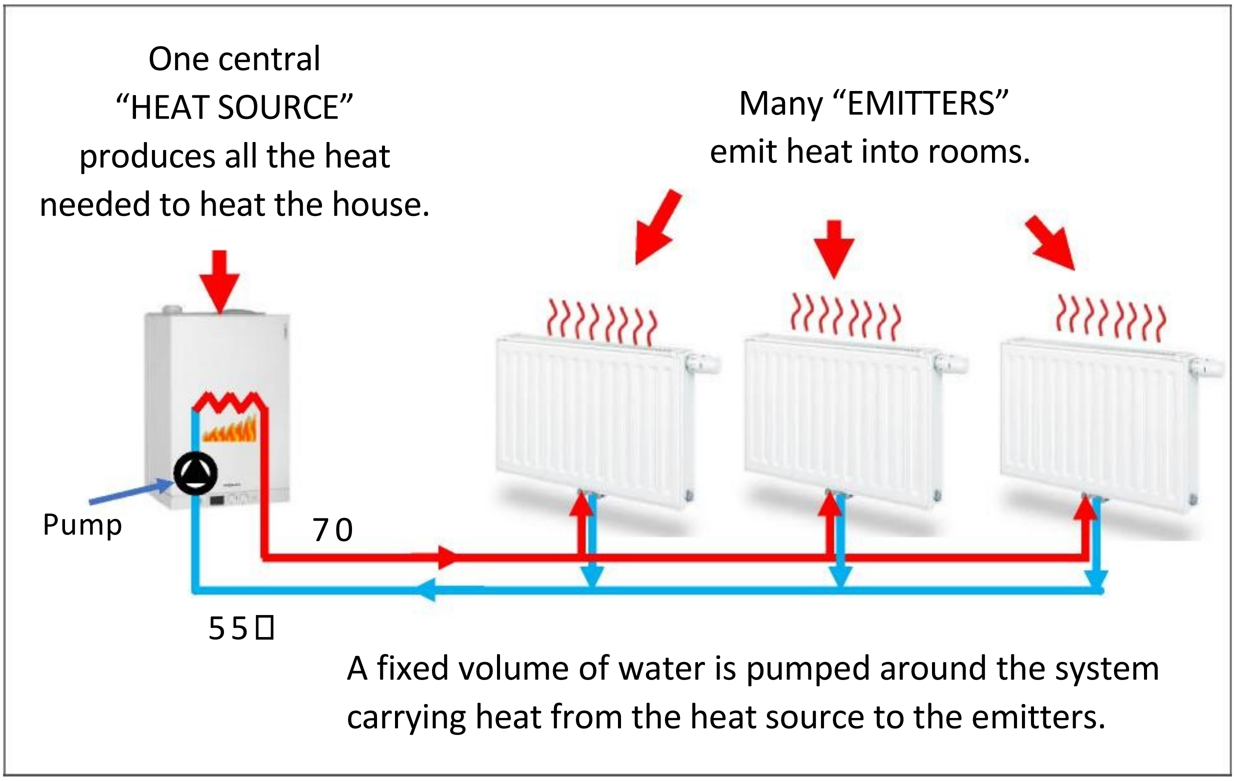
Hydronic Central Heating

So named because:

1. It uses one single ***heat source*** to provide the heat energy to multiple emitters.
2. The heat is distributed to the ***emitters*** by pumping water around a closed

loop. ***Features of hydronic central heating***

- Hydronic central heating is usually, but not always, whole-house heating.
- More than one different type of emitter may be run from one heat source.
- It is usually fully automated which means you can get up to a warm home and come home to a warm home.
- A large proportion of systems also use the same heat source to provide DHW.
- Can be integrated with solar thermal or photovoltaics.
- The heat distribution and emitters have a lifetime of decades, the heat source usually around 15 years if maintained correctly.



Central heating systems are usually custom designed to meet the heat load of individual rooms and so provide design target temperatures of, for example, 21°C in living areas and 18°C in bedrooms, at the design outside temperature which is the lowest outside temperature generally experienced.

As with all heating systems the single biggest factor in the energy use of a central heating system is the heat loss of the home it is designed to heat.

Heat Sources	**Emitters**
Top 3 1. Gas boilers* 2. Air to water heat pumps 3. Diesel (oil) fired boilers* Less widely used. 4. Log fuelled stoves and boilers. 5. Ground source heat pumps. 6. Wood pellet boilers. 7. Solar assisted.	Top 2 1. Underfloor (In-slab) 2. Radiators Often with 3. Towel warmers Less often used. 4. Fan convector heaters – such as kick space heaters and trench heaters. 5. Ceiling heating
Any one heat source can supply heat to any one, or any combination of, the emitters on the right.	

**In hydronic central heating a boiler is an appliance that heats the heating water that is pumped round the system. Some people refer to a hot water cylinder as a boiler but that will not be used in this document.*

The reference to "Furnaces" in the report is not terminology I have ever heard in NZ.

Heat Sources

Gas boilers

Viessmann Vitodens 100-W

Heat output from 11kW to 35kW

Main Variations

System Boiler: Can be used only for heating the heating system and for heating a Hot Water Cylinder (HWC) if present. The HWC will use a coil heat exchanger. No potable water passes through the boiler.

Gas boilers can reheat a HWC from cold in 30 to 40 minutes depending on the size of cylinder and output of gas boiler.

Combi Boiler: Largely the same as a system boiler but contains a stainless-steel plate heat exchanger so it can also provide instantaneous DHW. An attractive option in smaller homes.

Storage-Combi: A system boiler with a small HWC inside the same case, usually around 50 litres. This provides a buffer to provide high flow rates over the short term without taking up the space and having the heat loss of a full size HWC.

Most boilers also contain a circulation pump and other basic heating system components for ease of installation.

Fuel: Natural gas or LPG. Currently certified for 20% hydrogen. Viessmann intend to have all boilers certified for 100% hydrogen by 2025 and all current models retrofittable.

Running Costs

Absolute running cost are largely dependent on the heat loss of the house that is being heated. The cost per unit of delivered heat when using natural gas is also dependent on total units used as the daily charge for natural gas in NZ can be a significant part of the overall cost.

If using natural gas for heating and DHW it can be very economical as the total number of kWh of gas used increases.

LPG is the most expensive way to generate heat energy after electric resistance heating, but can still be attractive for smaller homes due to the lowest capital cost by far of any central heating option.

Gas boiler efficiency.

Modern gas boilers are so efficient that the water in the exhaust gases can condense in the combustion heat exchanger, hence the name *condensing boilers*. This results in significant extra energy recovered from the latent heat of condensation. The flue gases are so cool you can hold your hand over the end of the flue for as long as you want without being burnt. Viessmann have been selling condensing boilers since 1992.

Importance of Control to Optimise Efficiency

These boilers also modulate allowing them to run continuously at lower output and lower temperatures to maximise efficiency. Modulating condensing boilers are more efficient at part load. Using a control system that can do this will have a significant benefit efficiency.

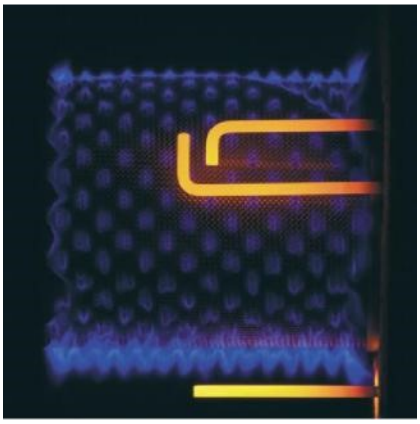
The best control systems track room temperature and if it is falling below the target temperature they increase the temperature of the boiler so the emitters emit more heat, and reduce the temperature of the boiler if the room temperature is exceeding the target temperature.

This is the best method for optimising efficiency as it runs the boiler at the lowest temperature possible to meet the heat load. This method is better than traditional outside temperature compensation as it automatically takes into account changes in heat load caused by outside temperature, solar gain, and incidental gains.

As underfloor heating runs at a much lower temperature than radiators, condensing boilers will also be running close to optimum efficiency.

Combustion control

High efficiency boilers can control combustion by measuring current passed though the burner flame which in conjunction with flue temperature enables the boilers software to constantly adjust the air fuel ratio for optimum combustion.



Efficiency Testing and Rating

All European central heating boilers are tested for efficiency using standard EN303.

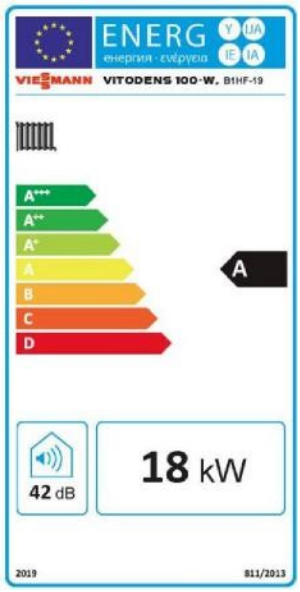
As modern control systems dynamically alter the boilers running temperature, boilers are tested at higher running temperatures where no condensing takes place and lower temperatures where full condensing takes place.

Both data points are stated in test results and both are applied to to a formula to calculate a seasonal efficiency. This reflects that the boiler will spend a lot of time running at part load where it is more efficient than running at high load.

For example the Viessmann boiler shown has a seasonal efficiency of 94% (Gross).

It should be noted that there are two ways of calculating thermal efficiency, Net and Gross that use Net and Gross Calorific values respectively. (Also known as Lower and Higher Calorific Values.)

Net calorific value will give higher results, over 100% for condensing boilers. Efficiencies also vary with fuel used which needs to be taken into account when setting minimum efficiencies.



Air to Water Heat Pumps

Outdoor unit

Heat output:

Single Phase: 6kW to 14kW
3-Phase: 16kW - 30kW +

Main variations

Monobloc: This is simply defined by the heating system water passing through the heat pump so that the heat is transferred from the heat pump to the house using the same water that circulates around the heating system within the house.

Sometimes there is a circulating pump and other system components within the heat pump outdoor unit, and sometimes a separate unit within the house.

Monobloc heat pumps can be installed by plumbers without the need for a refrigeration engineer.

Split: The heat is transferred into the house using the refrigerant which is then transferred to the heating water in an indoor unit. This arrangement is preferred where there is a risk of

Indoor unit

freezing and because the refrigerant pipes are smaller than pipes carrying water.

Indoor units may contain a heat exchanger, circulation pump, pressure gauge, expansion vessel etc and allow these items to be easily frost protected and services out of the weather.

Air to water heat pumps

Heat pumps for hydronic central heating have only come into the NZ market since around 2008 when oil prices became very high and as more people are motivated to use renewable energy.

Operating Temperature Limitations

Current air to water heat pump technology limits the heating water temperature to around 55°C , compared to a boiler which can easily heat water to 80°C.

As underfloor heating works at a maximum safe temperature of around 55°C heat pumps and underfloor heating have become the dominant form of central heating in new homes in areas of New Zealand that don't have natural gas. Largely replacing diesel boilers in this market.

Heat pumps can also heat radiator systems but due to their lower operating temperature the radiators need to be bigger, adding cost to the system, and more wall space taken up. But this is a very efficient option which is being used more over the last 5 years.

Heat Output Limitations

Although generally the heat pumps used for central heating are much bigger than the typical air-to-air heat pump, a single-phase heat pump is limited to around 14kW heat output. The actual heat output also depends on the air temperature so varies according to location.

By lucky coincidence, most new homes in New Zealand have a heat loss of around 10 to 15 kW so are able to be heated by a large single-phase heat pump. If the heat loss is greater sometimes more than one single-phase heat pump is used, or a 3-phase heat pump if a 3-phase electrical supply is available and affordable.

However, in the retrofit market with less well insulated homes use of heat pumps is limited by the low heat output compared to boilers. Also, it is generally necessary to use radiators, which when sized for heat pump temperatures add up to an expensive install.

DHW

Air to water heat pumps used for central heating are often also used for heating DHW, sometimes using bespoke units such as used by Mitsubishi or simply heating a HWC through a large surface area coil, or plate heat exchanger.

As the heating water temperature of most heat pumps is limited to around 55°C this means the DHW temperature needs to be boosted for legionella prevention, or a UV filter used.

Current heat pumps are working at their maximum limit to heat DHW and so doing it efficiently whilst also meeting legionella prevention requirements can be challenging.

Residential Ground Source Heat Pumps

Viessmann Vitocal 300

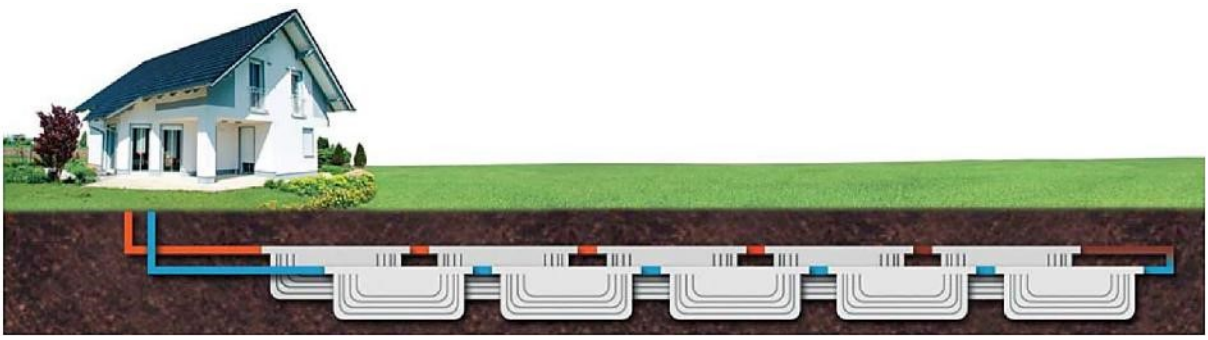
Ground source or Geothermal Heat pumps are significantly more expensive to install than air source heat pumps. They are the best choice where snow lays on the ground throughout the winter but usually harder to justify in temperate climates.

The most cost-effective method in New Zealand is to lay pipes buried at around 1.8 meters depth which requires significant land area. Other methods are putting in horizontal ground loops to 100m depth, or using ground water both of which can involve expensive drilling.

Overall, there are very small numbers of ground source heat pumps compared to air source heat pumps used in the residential sector due to cost and land constraints.

Ground source heat pumps largely have the same constraints as air source in terms of being limited to around 12 – 14kW maximum heat output and 55°C maximum temperature.

However, they are not affected by cold weather and their output stays constant providing the ground loop has been designed correctly. Running costs are potentially lower than air-source heat pumps for this reason.



Most commonly ground collectors are installed 1.5 to 2m below the surface to avoid expensive drilling, but this take up more space.

Diesel (Oil) Boilers

A Viessmann Vitorondens 200-T oil boiler

Heat Output: 24kW to 50kW +

Diesel (or oil) boilers tend to be larger and heavier than gas boilers and are therefore floor standing.

As they take longer to start than a gas boiler they are more likely to be heating a heating system and often a hot water cylinder in the same way as a gas boiler.

Storage combi boilers do exist but are less often used.

Diesel boilers with radiators are still a good choice for heating existing high heat load houses. These will usually be radiator systems as retrofitting underfloor is very expansive compared to a radiator system.

Most diesel burners will burn bio-diesel but the burner has to be approved for that fuel. A 20% mix is available in NZ.

Fuel is stored in a fuel tank generally of less than 1000L and is delivered by a mini-tanker by companies suppling fuel to farms etc.

Running Costs

The price paid for diesel fuel is the same as pump price for vehicles but of course no road duty is paid. It is the only fuel that goes down as well as up in price.

Diesel Boiler efficiency

Diesel boilers are much like gas boilers in that modern high efficiency versions are known as condensing boilers for the same reasons as gas boilers.

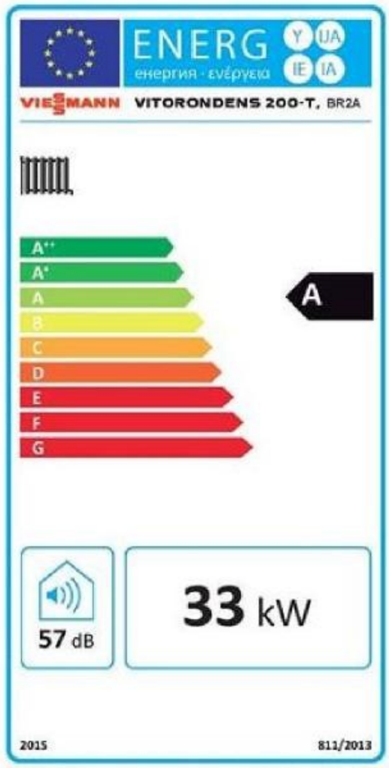
Unlike gas boilers they are generally not able to modulate, but some, like this Viessmann boiler can still be run at lower temperatures for increased efficiency.

Efficiency Testing and Rating

European diesel boilers are also tested according to EN303.

Due to the different hydrogen carbon ratio of the fuel compared to say natural gas the Gross efficiencies are much higher than you would see with gas boilers, but the difference between Gross and Net efficiencies much less.

The Gross seasonal efficiency for the Viessmann Vitorondens diesel boiler is 97%.



Wood Pellet Boilers

Heat Output: 8kW – 38kW +

Wood pellet boilers have been used in small numbers in NZ since at least 2005 when wood pellets were far cheaper than now.

Wood pellet fuel allows a biomass heating system to be entirely automated with the exception of manually filling the hopper with bags of fuel every few days. This can also be avoided if a large fuel hopper is installed.

They can be used with any heat emitter, but like other boilers can supply a greater heat output at a higher temperature than heat pumps and so be used for renewable energy heating of older large heat load properties using radiators. Like other heat sources they can be used for heating DHW using a HWC with a coil heat exchanger.

Most modern boilers have auto de-ashing and self-cleaning so that ash containers only need occasional emptying.

Wood pellets are largely supplied in 15kg bags but can be delivered by the tonne provided the user has a bunker large enough to take them and suitably equipped for delivery.

The small number of wood pellet boilers in use reflects the high capital cost of most systems and the cost of wood pellets when bought in bags. If you had a large property you wanted to heat renewably and don't live too far from the wood pellet factory, and can afford a multi-tonne fuel store then the running costs are very competitive.

Other items needed such as buffer tanks and insulated flues make this a higher capital cost option.

An entry level wood pellet boiler from KWB in Austria.

Many of the biomass boilers on the market are made in Austria as this country has focussed on developing biomass heating technology for the last 25 years.

Wood chip boilers are also available for larger outputs.

Testing Emissions and Efficiency

European biomass boilers are also tested using EN303. For biomass boilers this also includes particulate emissions.

Boilers can be approved for clean air approval in NZ using the EN303 test reports although approvals although getting approval at a local level varies depending on the regional council. This takes into account efficiency and particulate emissions.

The residential wood pellet boilers have a Gross Efficiency of 85% to 87%

Example below for the range of KWB Easyfire boilers which are EU energy rated A+.. (Also an example of the difference between net and Gross efficiency.)

EF2 S / EF2 GS / EF2 V	UNIT	EF2 8 KW	EF2 12 KW	EF2 15 KW	EF2 22 KW	EF2 25 KW	EF2 30 KW	EF2 35 KW	EF2 38 KW
Stoking mode (manual/automatic)		automatic							
Share of partial load in relation to nominal load (30%/50%)	%	30							
Temperature control integrated in the boiler (yes/no)		yes							
Temperature control class		VI							
Contribution of the temperature control to the energy efficiency index of the package	%	4							
Factor II (Weighting primary solid fuel boiler and additional heating device)		0							
Value for III (294/(11*Pr))		3.34	2.23	1.78	1.21	1.07	0.89	0.77	0.70
Value for IV (115/(11*Pr))		1.31	0.87	0.70	0.48	0.42	0.35	0.30	0.28
Condensing boiler (yes/no)		no							
Combination boiler for hot water and heating (yes/no)		no							
Solid Fuel cogeneration boiler		no							
Preferred fuel		Wood pellets							
Rated power	kW	8	12	15	22	25	30	34.9	38
Partial load	kW	2.4	3.5	4.4	6.4	7.3	8.7	10.1	11.4
Boiler efficiency at rated power (NCV*/GCV**)	%	92,4 / 85,1	94,0 / 86,8	94,3 / 87,1	95,0 / 87,7	95,2 / 87,9	95,4 / 88,1	95,7 / 88,4	95,3 / 87,7
Boiler efficiency at partial load (NCV*/GCV**)	%	91,4 / 84,2	89,4 / 82,5	90,0 / 83,2	91,5 / 84,5	92,4 / 85,3	93,8 / 86,7	95,3 / 88,0	94,9 / 87,4
Electrical power consumption at maximum output	kW	0.0600	0.0660	0.0716	0.0830	0.0900	0.1016	0.1085	0.1150
Electrical power consumption at partial output	kW	0.0460	0.0480	0.0483	0.0490	0.0524	0.0580	0.0613	0.0620
Electrical power consumption at standby	kW	0.0095	0.0095	0.0095	0.0096	0.0096	0.0096	0.0096	0.1010
EU energy label		A+	A+	A+	A+	A+	A+	A+	A+
Energy efficiency index – boiler		113.0	113.0	116.0	117.0	118.0	118.0	119.0	121.0
EU energy label – integration with heating circuit control		A+	A+	A+	A+	A+	A+	A+	A+
Energy efficiency index – integration with heating circuit control		117.0	117.0	120.0	121.0	122.0	122.0	123.0	125.0
Seasonal space heating energy efficiency in active mode	%	75.0	76.0	78.0	79.0	80.0	80.0	80.0	82.0
Seasonal space heating emissions – PM	mg/m^3 (10% O_2)	<40	<40	<40	<40	<40	<40	<40	<40
Seasonal space heating emissions – OGC	mg/m^3 (10% O_2)	<20	<20	<20	<20	<20	<20	<20	<20
Seasonal space heating emissions – CO	mg/m^3 (10% O_2)	<500	<500	<500	<500	<500	<500	<500	<500
Seasonal space heating emissions – NOx	mg/m^3 (10% O_2)	<200	<200	<200	<200	<200	<200	<200	<200

Log Boilers

Log boilers specifically for central heating systems have a small market which is mainly for customers with their own wood fuel supplies.

Although they are manually loaded the KWB log boilers have automatic ignition so can be loaded the night before to come on at a set time in the morning.

This type of boiler also has electronic control of the combustion fan to improve combustion quality and has a cooling coil to prevent the boiler from over-heating so does not have to be installed as an uncontrolled heat source.

Log boiler systems usually require at least one buffer tank of the order of 1000L all of which adds up to make this a high capital cost item.

Customers need to understand that you use a lot more energy, and therefore logs, to heat a whole house morning and evening; than just the main living area, just in the evening, that many New Zealanders have been used to.

This option does suit some people who are dedicated to burning logs especially if they have high energy needs and want to be green, or being green is part of their business marketing.

Boiler Efficiency & Testing

Like all other European boilers they are tested using EN303, and like wood pellet boilers there is an emphasis on emissions as well as efficiency.

Example below showing this boiler is EU Energy Label A+ and how the various emissions tested for are converted to seasonal averages.

CF1.5 / CF2	UNIT	CF1.5 18 KW	CF1.5 28 KW	CF1.5 32 KW	CF1.5 38 KW	CF2 18 KW	CF2 28 KW	CF2 32 KW	CF2 38 KW
Stoking mode (manual/automatic)		manual							
Share of partial load in relation to nominal load (30%/50%)	%	50							
Temperature control integrated in the boiler (yes/no)		yes							
Temperature control class		VI							
Contribution of the temperature control to the energy efficiency index of the package	%	4							
Factor II (Weighting primary solid fuel boiler and additional heating device)		0							
Value for III (294/(11*Pr))		1.46	0.93	0.84	0.70	1.46	0.93	0.84	0.70
Value for IV (115/(11*Pr))		0.57	0.37	0.33	0.28	0.57	0.37	0.33	0.28
Condensing boiler (yes/no)		no							
Combination boiler for hot water and heating (yes/no)		no							
Solid Fuel cogeneration boiler		no							
Preferred fuel		Log wood							
Rated power	kW	18.3	28.6	31.9	38	18.3	28.6	31.9	38
Partial load	kW	14.3	14.3	14.2	14.2	14.3	14.3	14.2	14.2
Boiler efficiency at rated power (NCV* / GCV**)	%	93,4 / 83,1	92,4 / 81,7	92,4 / 83,6	91,8 / 83,7	93,4 / 83,1	92,4 / 81,7	92,4 / 83,6	91,8 / 83,7
Boiler efficiency at partial load (NCV* / GCV**)	%	93,0 / 82,3	93,0 / 82,3	93,0 / 83,7	93,0 / 83,7	93,0 / 82,3	93,0 / 82,3	93,0 / 83,7	93,0 / 83,7
Electrical power consumption at maximum output	kW	0.0660	0.0910	0.0710	0.0800	0.0660	0.0910	0.0710	0.0800
Electrical power consumption at partial output	kW	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550	0.0550
Electrical power consumption at standby	kW	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090
EU energy label		A+	A+	A+	A+	A+	A+	A+	A+
Energy efficiency index – boiler		116.0	116.0	116.0	116.0	116.0	116.0	116.0	116.0
EU energy label – integration with heating circuit control		A+	A+	A+	A+	A+	A+	A+	A+
Energy efficiency index – integration with heating circuit control		120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
Seasonal space heating energy efficiency in active mode	%	78.0	78.0	79.0	78.0	78.0	78.0	79.0	78.0
Seasonal space heating emissions – PM	mg/m^3 (10% O_2)	<60	<60	<60	<60	<60	<60	<60	<60
Seasonal space heating emissions – OGC	mg/m^3 (10% O_2)	<30	<30	<30	<30	<30	<30	<30	<30
Seasonal space heating emissions – CO	mg/m^3 (10% O_2)	<700	<700	<700	<700	<700	<700	<700	<700
Seasonal space heating emissions – NOx	mg/m^3 (10% O_2)	<200	<200	<200	<200	<200	<200	<200	<200

Uncontrolled Solid Fuel Heat Sources

For lower cost use of wood fuel for central heating there is a small and specialist market for using various log burner appliances to heat radiators or underfloor heating. These are classed as uncontrolled heat sources are need specific design to meet regulations and operate safely.

From a heating point of view they share the characteristics of not being automated and not providing space heating in the coldest part of the day.

Standard New Zealand Wetbacks

As the standard NZ wetback is designed primarily for heating a hot water cylinder they only produce around 1kW to 2kW of heat. This is because it takes around 12kWh of heat energy to heat a 250 litre HWC to 60C. Therefore, wetbacks are sized to heat the cylinder over the time a log burner with wetback would be providing space heating. So a 2kW wetback buring for 6 hours will reheat a 250 litre HWC from cold.

The exact amount of energy required depends on the temperature of the mains cold water, size of the HWC and if it was all cold at the start of the heat up.

Many wetback users install one or two radiators in order to dump excess heat to stop their HWC boiling and get some extra heating at the same time.

Given that even a typical new house in NZ can have a design heat load of 10 to 12kW that is not going to be met by 2kW of radiators, but the wetback will be putting out much more heat directly from the burner.

Central Heating Fires

Mainly imported from Australia these are essentially large wetbacks with a much higher output specifically for central heating. The heat output to the radiators is linked to how much heat is put into the room where the fire is located, and therefore heat output to both is controlled by how fast logs are fed to the fire.

Solid Fuel Cookers with Hydronic Heating Output

These are the same as above but provide heating to the kitchen and for cooking with outputs that connect to a hydronic heating system.

Heat Emitters

The two main emitters used are:

Underfloor heating (UFH) – which uses the floor as a large low temperature radiant heating panel

Radiators – which these days convect more heat than they radiate.

Both have the benefit that they are virtually silent as no air is blown around. UFH has the added benefit that it is invisible, takes up no wall space and comfortable under foot with hard floor finishes.

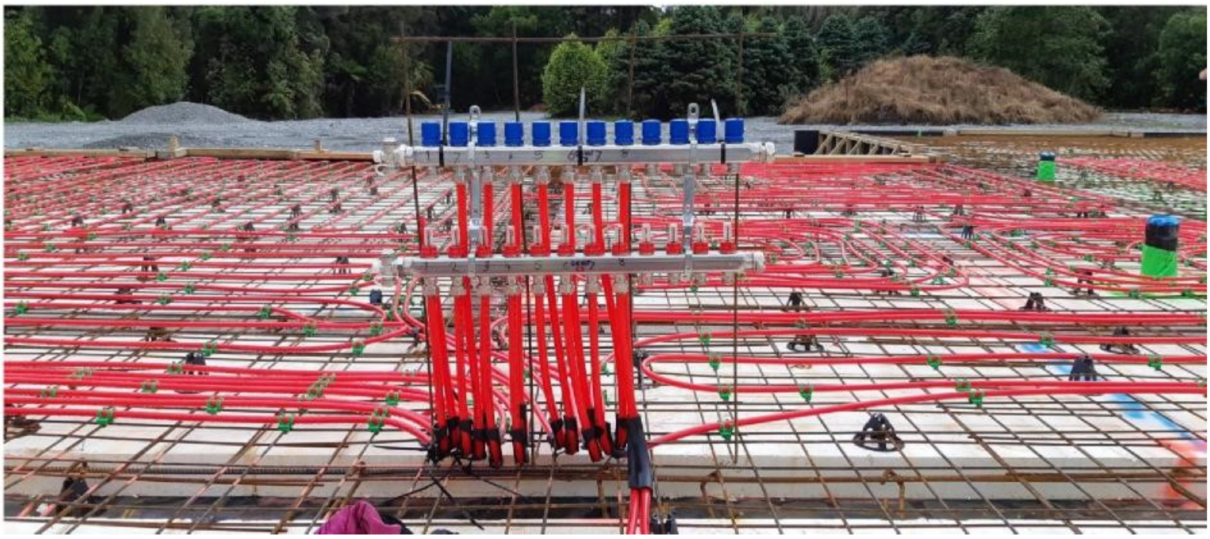
Underfloor Heating

Probably around 95% of underfloor heating installed in New Zealand is called "in-slab" as it involves fixing the pipes to the structural mesh using clips or wire ties.

This is popular as it only involves the cost of the pipe, labour and whatever the is used to fix the pipe to the mesh.

The main drawback to this method is the high thermal mass, although this can also be a benefit. There are significantly more expensive low-thermal-mass systems that can be used to improve control response and potentially efficiency.

"In-slab" is by it's nature restricted to new homes or extensions, or where a new slab is laid as part of a retrofit. There are retrofit methods but these are also significantly more expensive and radiator systems are usually preferred for retrofits.



Ke Kelit underfloor heating pipe clipped to the mesh prior to concrete being poured. Underfloor distribution manifold also shown.

Efficiency

Underfloor heating usually works at heating water temperatures between 30°C to 55°C . The actual temperature depsends on the heat load of the heated space in W/m^2 and the floor covering. This is because the heat output into the room is dependent on the difference between room temperature and the floor surface temperature.

These temperatures allow condensing boilers to run very efficiently. They are also suitable temperatures for heat pumps.

Often heat sources improve efficiency by modulating their operating temperature according to the outside temperature which is a main factor in determining heat load.

Radiators

Most retrofits use radiator emitters but also preffered by some for new-build due to their better control response than underfloor heating.

Each radiator has a heat output determined by it's size and the average temperature it is run at. Generally radiators are sized to meet the heating requirement of each room to provide a balanced heat output throughout the house.

Boiler and radiator systems can be very effective in terms of high heat output for lower capital cost. Radiators can also be used with heat pump systems but have to be larger due to their lower operating temperature.

Radiator Efficiency

Traditionaly radiators have run at higher temperatures of around 80°C in and 70°C out, but modern condensing boiler systems have led to design temperatures to to a mximum of 70°C in and 55°C out. 55°C being the temperature at which condensing boilers start to condense and become much more efficient.

Modern control systems track room temperature and alter the water temperature to keep it as low as possible to maximis boiler efficiency. This method automatically takes into account outside temperature and solar gain.

Radiators always have a thermostatic valve to adjust maximum temperature delivered to each room.

This reduces energy used by reducing the heat energy used by radiators in rooms that have more solar gain or otherheat energy gains.

A typical modern radiator

Other Emmiters that can be used in a similar way to radiators are:

- Towel warmers
- Kick space convection heaters
- Fan convectors – for high outputs and fast response

Two mini case studies

These two case studies are designed to show that central heating isn't only for wealthy people. It is also used by ordinary households who value a warm dry home.

Both case studies show that whole house heating can be affordable to run for ordinary households when the choice of heating system is appropriate.

Case Study 1: 80-year-old weatherboard Villa of 140m^2 floor area.

This house has been retrofitted with loft insulation and wall insulation to 80% of external walls. Some floor insulation is present. Windows are timber frame single glazed but only cover 25% of the external wall area which is typical of this era.

Design heat load 14kW at 0°C outside temperature.

Heating system: Nominal 16 kW air to water heat pump (12kW at 0°C.) 10 Radiators fitted throughout the house, sized for the heat load of each room, operating temperature 55/45°C for maximum output. Also, one towel warmer in the bathroom.

DHW heated by 1.2kW photovoltaic panel powering element, boosted by mains electricity. (Not grid connected.)

Electricity is used for all energy needs. The house is occupied by one adult and one child. The whole house is heated morning and evening and is very comfortable to live in.

Highest monthly electricity bill in 2020 was 350NZD.

The heat pump has its own electricity meter and heat meter for heat output which is only used for heating.

Heating Energy Use 2016 - 2018	**Annual average**
Electricity used (kWh)	5,177
Heat produced (kWh)	15,298
Heat re-absorbed for defrost (kWh)	296
Defrost heat as %	1.9%
Net heat produced (kWh)	15,002
Seasonal COP	2.9

Total annual heating cost of 1,325NZD at current electricity tariffs.

Cost of delivered energy 8.8c/kWh

The average daily heat load as measured by the heat meter is around 80kWh through most of the winter but can be as much as 150kWh on a very cold day.

Case study 2: Typical 3 bedroom New House Built near Christchurch New Zealand

House built to minimum building code except the addition of edge insulation around the slab.

Heating system: 10kW air to water heat pump heating water pumped through pipes set in the slab. Controlled by one thermostat.

Heat pump also heats most of DHW using a hot water cylinder (HWC) with coil heat exchanger.

Electricity is used for all energy needs in this house. There are no photovoltaics.

The house is occupied by a young couple with no children.

Highest monthly electricity bill in 2020 was 270NZD which covers all household energy use.

The internal temperatures were monitored over the winter and found to be consistently around the thermostat setting of 20°C, day and night.