CANETIS TECHNOLOGIES

Discussion Paper Outlining the Technical Solution of a High Performance Domestic Hot Water System

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Overview

The heating and hot water industry has for many years focussed attention of improved heating efficiency while Domestic Hot Water (DHW) production has been driven more by comfort levels normally expressed in litres per minute and less by regulation. However, improved building insulation, tighter emission controls and emerging regulations aimed at addressing overall systems efficiency, require industry stakeholders including boiler manufacturers and suppliers to come up with innovative solutions that will meet new regulatory requirements and present new opportunities to protect and potentially increase revenues of core product sales.

An innovative solution from Canetis Technologies Limited (Canetis) called SuperFlow™ is a patented DHW technology that helps address both regulatory requirements and improves performance and comfort levels for the consumer. SuperFlow™ provides a simple add-on to improve DHW for both new and existing combination gas boilers, ranging from low cost retrofit of any standard wall hung combination boiler through optimised accessories as well as new-integrated core platforms required for emerging standards.

SuperFlow™ is unique in that it optimises the DHW cold-water input temperature to a combination boiler by providing a sustained, on-demand preheat function that works to address the negative effect of seasonality thereby increasing the delivery of DHW to the boiler's maximum potential even during the coldest winter months. Consequently, SuperFlow™ reduces the instantaneous gas required to deliver a standard temperature rise/litre per minute rate of DHW or put another way, when comparing a standard 30kW combination boiler, for the same instantaneous gas rate, SuperFlow™ will virtually double DHW output culminating in an average increase of ~36% over a 10-minute period sufficient to deliver over 100 litres of DHW, all from a pocket sized 25 litre thermal store that can recover to a primary flow temperature setting in under two minutes.

In areas with low mains gas pressure the performance enhancements available from SuperFlow™ resolve the problems associated with underperforming Combination boilers during DHW production and especially prevalent at peak times during the winter months.

SuperFlow™ provides a significant step forward in the direction of improved hot water comfort while at the same time enabling lower heat input combination boilers to deliver recognised levels of DHW with improved heating efficiency and in the UK improved SAP scores. In addition, SuperFlow™ also creates new market opportunities for low cost passive renewables, for example 12-volt photo voltaic solar that can be used as both preheat to the gas boiler and as part of the SuperFlow™ installation to help reduce electricity consumption for household appliances that would otherwise use mains electricity to heat water e.g. washing machines & dish washers.

Introduction

SuperFlow™ is a unique patented solution that addresses the problems associated with combination boilers that struggle to produce DHW during the winter months. During the winter the input temperature of the cold water feed falls below the minimum specification of the boiler manufacturers (typically 10°C) resulting in combination boilers being unable to maintain DHW flow rates and temperature levels as per those specified by the manufacturer.

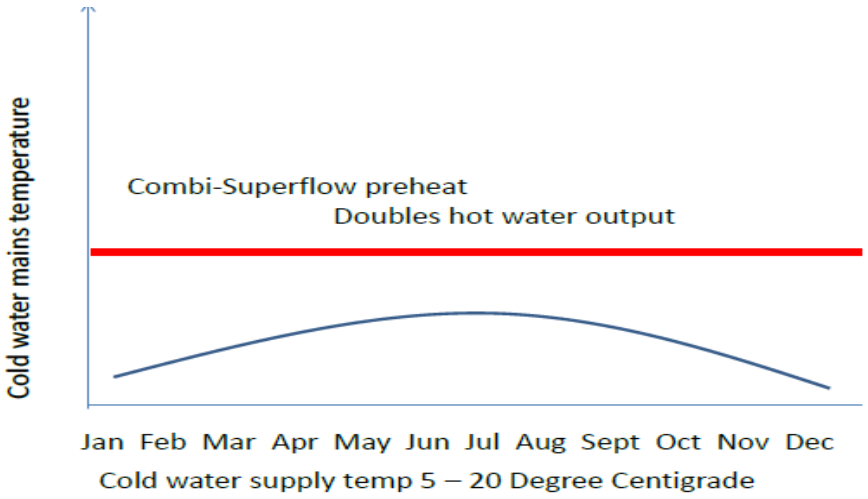


Fig 1 - Temperature seasonality curve of cold water overlaid by SuperFlow™ delivery temperature

The above graph shows the range of cold water temperature and how the active SuperFlow™ preheat substantially benefits the winter period.

British Gas, one of the largest boiler provides in the UK, quote flow rates for their combination boilers including the Worcester Greenstar 34kW which is advertised at 14.3 litres per minute. However, due to the colder winter water temperatures, reduced flow rate restrictors are installed in order increase the water output temperature, thereby reducing performance and comfort levels from those advertised.

Combination Boilers	Actual HW Flow ltrs/min	Actual flow restrictor fitted at factory	Actual Temp Rise	Advertised 35*c Flow ltrs/min
Greenstar CDi Classic 34kw	12	12	40	14.3
Greenstar i 30kw	11	11	40	12.3
Greenstar 25kw Si Compact	8.9	9	40	10.2
Worc. Greenstar 36CDi Compact	13	13	40	14.7
ecoFIT pure 25kw	8	8	42	10.4
ecoTEC plus 838	13	13	42	15.9

ecoTEC pro 30	10.4	**10.4**	42	12.3

British Gas combination boilers with advertised and non-advertised flow rates. Source British Gas.

SuperFlow™ solves the problem of the cold water feed being too cold for a combination boiler to effectively work and as a result maintains the maximum flow rate of DHW pre-determined by the boiler manufacturer – PLUS - SuperFlow™ enables a boiler to continue operating at its specified temperature rise (normally in the range of 35°C to 40°C) however producing higher temperature DHW output (higher energy to water) all due to the pre-warmed water being input to the boiler.

How SuperFlow™ Works

In essence SuperFlow™ works by selectively preheating the incoming cold water used for DHW production via a small cylinder, called a temporal store. The store can be heated from the boiler's heating circuit, or an immersion heater and/or an optional plug-in solar preheat kit.

The effect of pre-heating the cold water is that it enables the combination boiler to maintain the DHW flow rate at the maximum level set by the boiler manufacturer whilst continuing to produce DHW at a temperature above the manufacturers specified minimum (>40°C) even when the cold-water input temperature falls below the 10°C threshold specified by the boiler manufacturer.

Benefits include –

1. Performant DHW production from combination boilers 365 days of the year, even during the winter months when the cold-water feed is at 5°C or below and combination boiler DHW performance would typically underperform.
2. Due to the increased DHW output temperature (>55°C) the effective flow rate of DHW within the dwelling is increased as the hotter DHW produced is blended down with cold water at the point of application (shower, bath, etc.).

Space Heating vs Domestic Hot Water

Powering a SuperFlow™ from the boilers heating circuit is an efficient and effective approach given typical domestic heating and DHW usage patterns as outlined below.

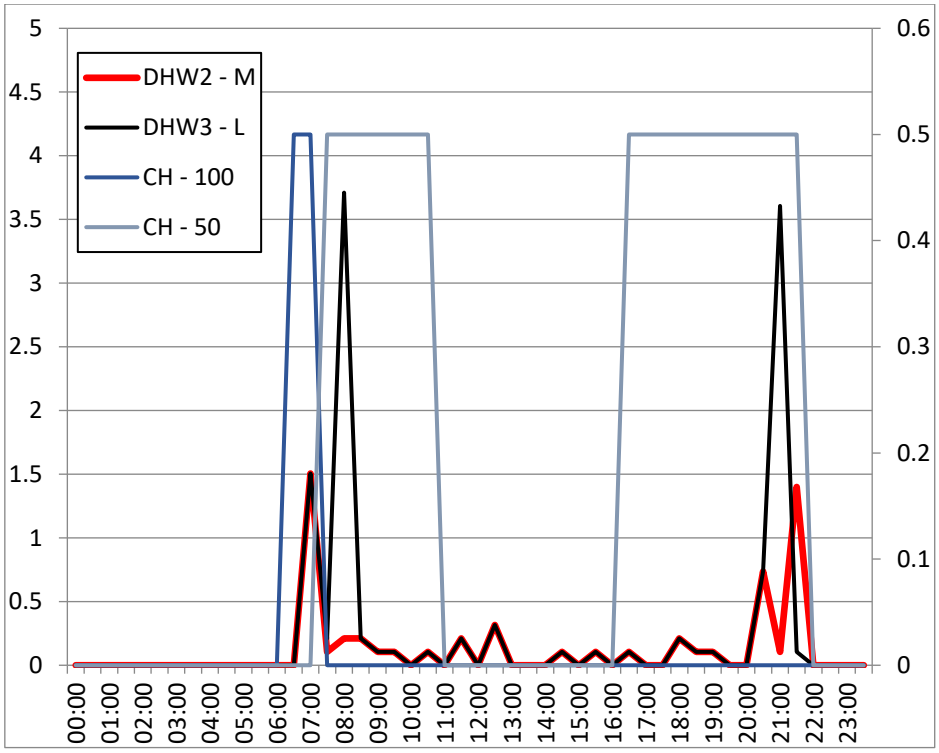


Fig 2 - Typical UK heating and hot water interaction

Fig 2 shows the typical interaction between heating and DHW for a UK home and whilst other EU countries may have different heating and hot water temperature ranges, most do operate around a Monday through Friday work day. More than 90% of total DHW demand occurs when the boiler is already in operation for domestic heating. When the boiler is not running for domestic heating it is possible, depending on the required level of optimisation, to perform a balance between space heating and DHW delivery to further improve the overall efficiency of a SuperFlow™. For example, a heating system that is due to shut down may elect to recovery some heat energy from the heating system to the SuperFlow™ store for the benefit of future DHW production or even future space heating needs.

SuperFlow™ Technical Overview

The SuperFlow™ 25 litre store has been tested and found to deliver a range of performance depending on the temperature of the primary heating circuit. It is estimated that the optimal primary heating water temperature is ~70°C. However, tests show that when heated to a temperature of 80°C SuperFlow™ is able to deliver over 100 litres of preheated water benefit. This delivery of preheated water would virtually double the useful winter heat to water capability of existing wall hung combination boilers e.g. the Worcester Junior 24kW.

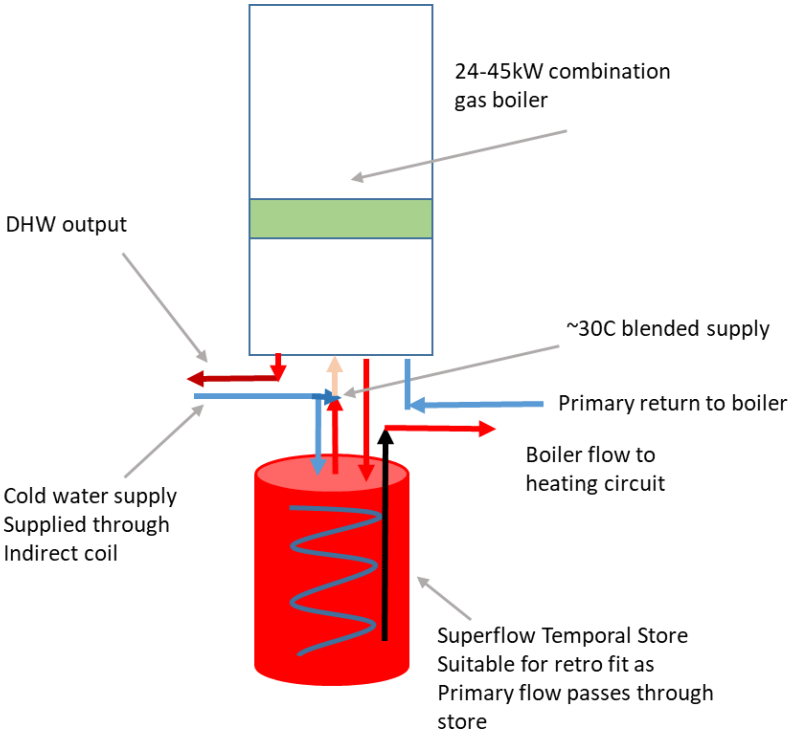


Fig 3 - SuperFlow™ hydraulic principle of operation

UK homes traditionally have baths that require ~75 litres of hot water. Therefore, during the winter months it will be necessary to reduce the flow rate of a traditional combination gas boiler in order to produce sufficient hot water temperature. Whereas a SuperFlow™ equipped boiler would maintain maximum flow rate for the same hot water requirement. For example, filling a bath requires hot water at ~50 degrees Centigrade. During the winter months the cold-water supply might be only 5 degrees centigrade, a Worcester junior boiler capable of 10 litres per minute at a 30 degree centigrade temperature rise will only produce water at 35 degrees Centigrade. In order for the boiler to achieve 50 degrees Centigrade then the flow rate will have to be reduced to approximately 5 litres per minute as a 15 degrees' centigrade short fall on temperature is half of the boiler's output capability. Therefore, it will take more than 15 minutes to fill a bath.

SuperFlow™ changes the user's experience as the store preheats the incoming supply to an optimum temperature ~30 degrees centigrade. As a consequence of the preheat the boiler can operate at its full 10 litres per minute flow rate and still achieve the target temperature of 50 degrees centigrade to fill the bath in 7 minutes, or half the time.

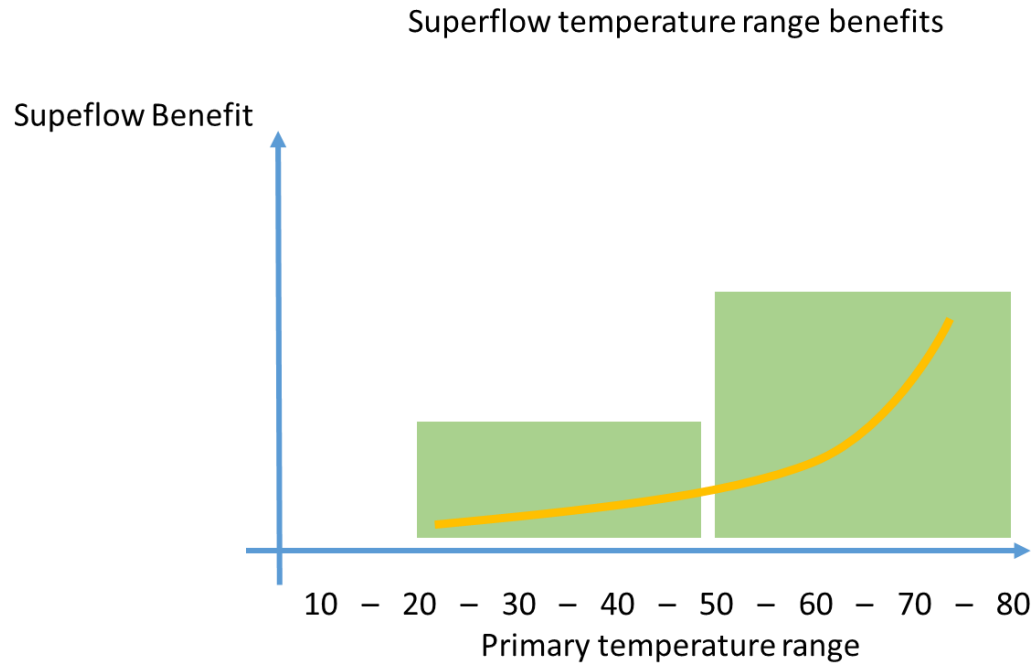


Fig 4 - SuperFlow™ benefits for a range of primary temperatures

The chart above shows an extrapolation of the preheat to water benefit of the store compared with primary flow temperature from the boiler. It is normal for boilers in the UK to operate in the temperature region of between 60 and 80 degrees centigrade and often with a primary flow of 80 degrees centigrade.

SuperFlow™ Test Data

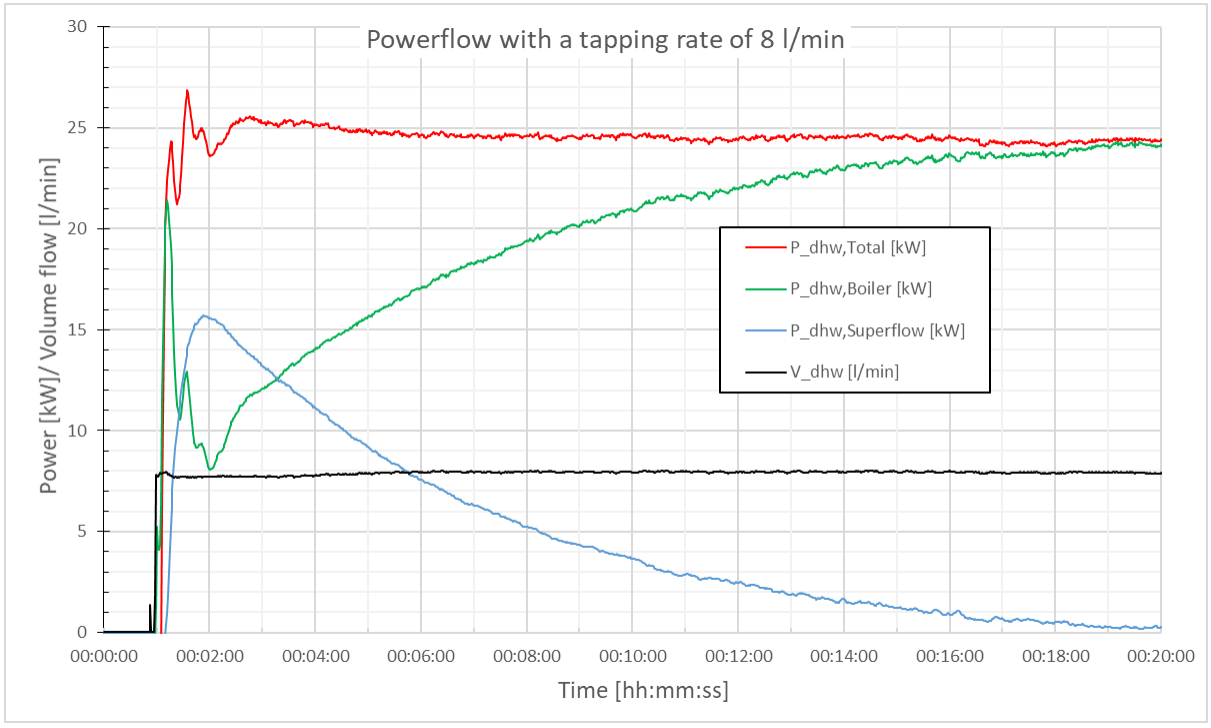


Fig 5 - 25 litre SuperFlow™ test at 8 litres per minutes

Following SuperFlow™ tests Fig 5 above shows the output graph for an 8 litre per minute graph for DHW at 60 degrees centigrade. The key to the graph shows:

- V_dhw is the flow rate of DHW from 10 to 60 degrees centigrade
- P_dhw, superflow (KW) is the heat input benefit of the SuperFlow™ store
- P_dhw, Boiler (KW) is the heat input of the boiler during the test
- P_dhw, Total (KW) is the combine Superflow and boiler heat input in (KW

The test demonstrates that –

1. For the first 2 minutes, and 16 litres of water, 60% of the heat to water was derived from the SuperFlow™ store.

2. Over the first 5 minutes, and 40 litres of water, 50% of the heat to water was derived from the SuperFlow™ store.

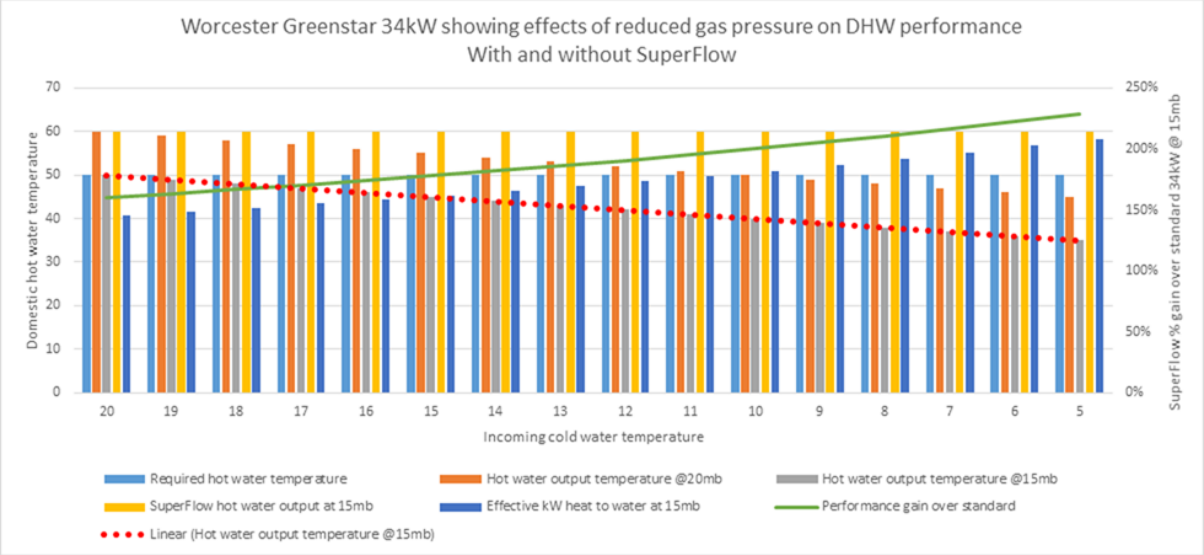
3. For the first 7 minutes SuperFlow™ provided an average of heat to water benefit of 11.2kW equivalent to 45% of the total heat input. The boiler heat input averaged 13.3kW.

Overall the test shows that SuperFlow™ can raise the maximum flow rate for the boiler from 10 litres per minute to 14.5 litres per minute.

SuperFlow™ For Lower Gas Pressures & Reduced Heat Input Combi-Boilers

In areas where mains gas pressure falls below 20mb, boilers will underperform and although this would be considered AT RISK by the Gas Industries Unsafe Situations Procedure, for an existing installation it is not uncommon, especially with the increased heat input requirement of modern gas appliances. As a result of this situation the DHW performance is also compromised. Upgrading to a higher rated boiler to resolve the DHW performance issue is obviously not possible due to the limitation imposed by the reduced gas pressure.

The DHW performance benefits offered by SuperFlow™ resolve this issue by improving DHW performance whilst removing the need for increased boiler capacity or the installation of a larger gas main.



The above graph illustrates that at 15mb the boiler would have a heat to water kW output of ~25.5kW and at 10C cold water temperature produce 40C hot water with a temperature rise of 30C at max flow rate. Reducing the cold-water temperature to 5C reduces the output temperature to 35C, 42% lower than normally stated. Whereas with SuperFlow™ the boiler with 15mb gas pressure and a 5C cold water feed would still produce domestic hot water at 60C at 12lpm. Alternatively, a 25kW boiler could be installed that would then operate at the required 20mb working gas pressures.

The green trend line shows the % gain over standard while the red trend line shows the decline in hot water output of the standard boiler with reduced gas rate and lower incoming cold-water temperatures.

SuperFlow™ 25L vs 50L – Hot Water Return

Currently, there are two sizes of SuperFlow™ cylinder available including a small 25 litre under-sink store and mid-sized 50 litre store suitable for larger properties. The 50 litre SuperFlow™ includes a further feature of a second heat exchanger coil used to maintain a pumped hot water circuit (hot water return), reducing the time it takes to deliver hot water to remote points of use.

SuperFlow™ Features & Benefits

The key features & benefits of SuperFlow™ are:

- Improved Efficiency
  - Effective DHW flow almost **doubled**
  - Pre-heat input water to 30°C **optimises DHW** generation
  - Lower heat input requirement for like for like DHW performance – a solution for **lower gas pressures**
  - SuperFlow™ operational running costs ~£1 per annum
    - As heat loses 250Wh/day * 85% useful =0.0375Wh/day * 250 operational days = 9.3kwhs heat loss per annum ~£1e operational costs. (Note: Operational costs would be negative given that the pre heat originates from space heating with higher seasonal efficiency

transferred to DHW generation)

- Comfort
  - 25 litre SuperFlow™ & a 30kW combination boiler are **equivalent** to 200 litre G3 unvented cylinder (**Megaflow**)
  - Two-minute recovery time compared to 20+ minutes for a G3 cylinder.

- Savings
  - Lower gas consumption and **CO2 emissions**
  - SuperFlow™ has a **smaller equipment footprint**, when compared to the likes of a G3 unvented cylinder, with equivalent hot water output capability
  - Lower initial **purchase price** and installation costs when compared to a G3 unvented cylinder – a few hundred pounds vs >£2.5k
  - Lower **water bills** through reduction in lukewarm water rejection

SuperFlow™ Deployment Options

Existing Combi-Boiler Retrofit

SuperFlow™ can easily be retrofitted to any existing make, model or brand of combi boiler

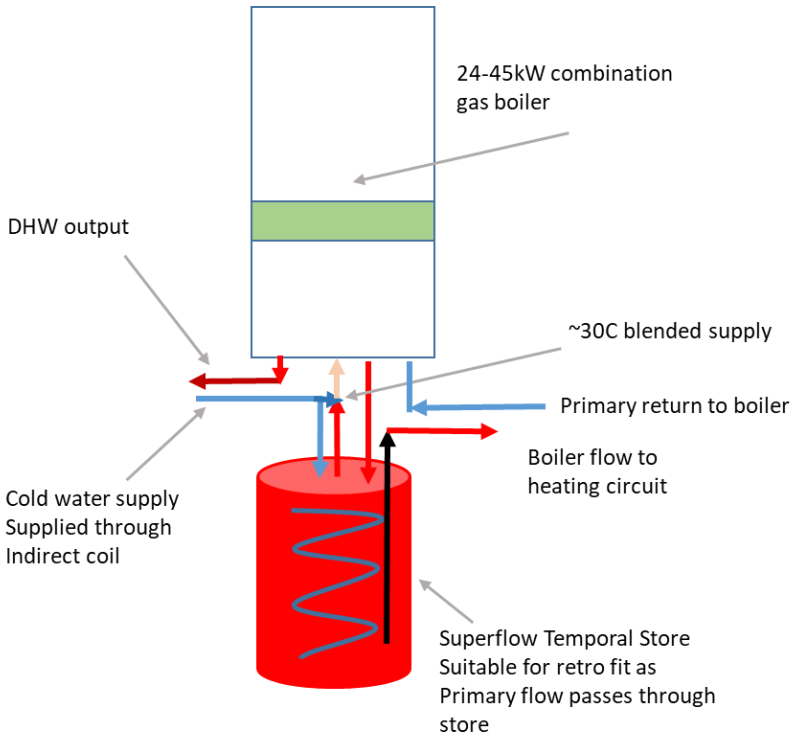


Fig 2 - Retrofit SuperFlow™, where boiler primary flow passes through the store, requires no controls or electricity supply.

New Builds

SuperFlow™ is ideal for new builds saving the developer space and cost of a G3 cylinder whilst improving SAP scores

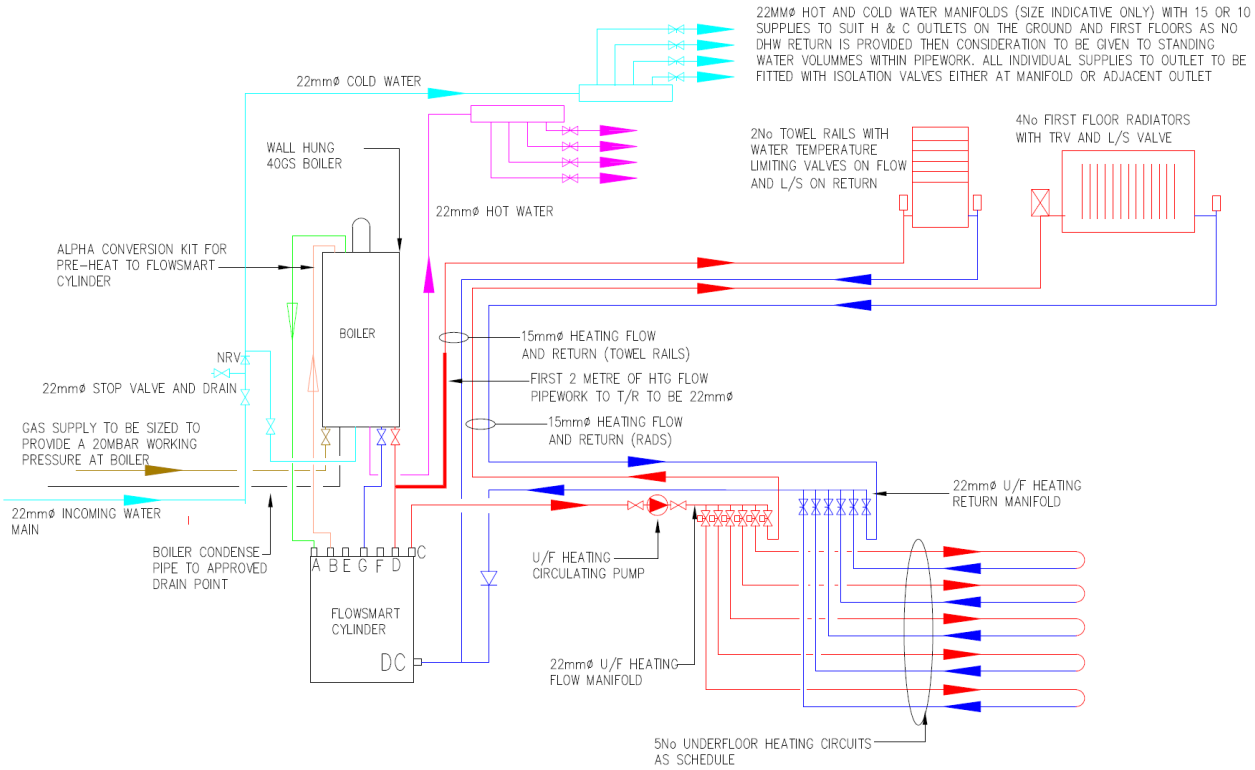


Fig 3 – 50 litre SuperFlow™ configuration for new build project designed as low loss header

Larger Houses

SuperFlow™ can also be configured for larger, multi-bathroom, houses to provide a hot water return.

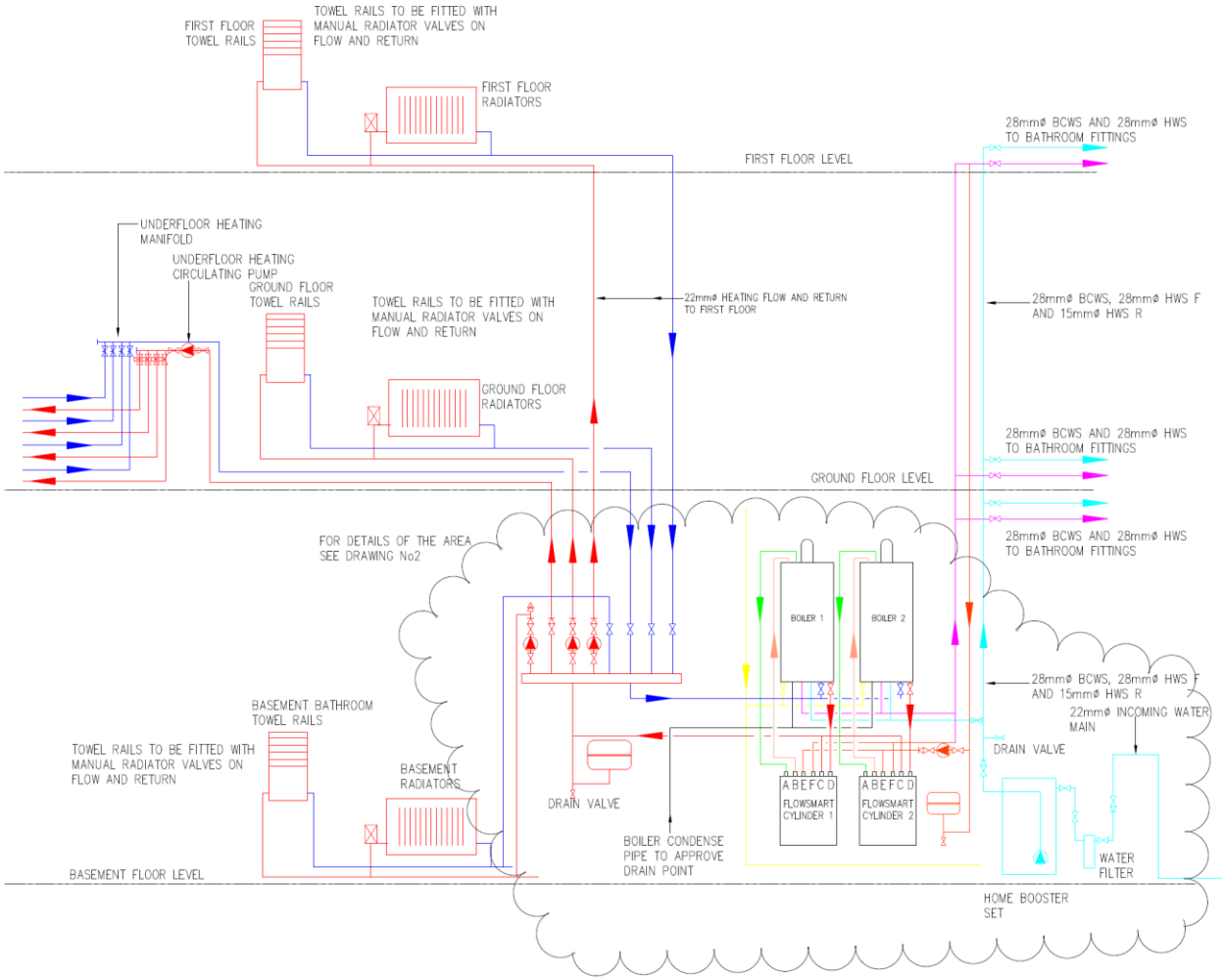


Fig 4 - Multi SuperFlow™ configuration for large house project including secondary return

Figs. 2, 3 & 4 represent varying installation design options based on either the 25 or 50 litre SuperFlow™. Alternative store designs and capacities are available including polystyrene atmospheric open vent and grey water heat recovery.

Regulation Changes

The UK Government is now embarking on a new era of heating and hot water efficiency with the announcement of Boiler Plus. Commencing in early Q2 2018, Boiler Plus sets new mandated efficiency standards for boiler installations across both new build and the replacement market. Additionally, Minimum Energy Efficiency Standards (MEES) relating to landlord responsibilities for the minimum efficiency of residential let property captures both private and social housing within the scope of this policy.

UK Boiler Plus & SuperFlow™

Specifically, Boiler Plus requires that every new boiler installed must include one of four efficiency options. These options are further outlined in the tables below including a high-level SAP analysis

Option 1 - Flue Gas Heat Recovery (FGHR)					
	Product	*Cost*	*SAP DER Benefit*	*Total SAP Benefit*	*Comments*
	GasSaver™	£400 - £500	17%	17%	DER benefit & consumer saving of £100 to £200 per annum
	SuperFlow™	**£300 - £400**	**4%**	**21%**	**Addn. DER benefit & increased consumer DHW comfort**
	Solar PV (SuperFlow™ top-up)	£250 - £500	1.5%	22.5%	Addn. DER benefit – developers save between £1k to £10 per new home
Option 2 - Weather Compensation					
	Product	*Cost*	*SAP DER Benefit*	*Total SAP Benefit*	*Comments*
	Weather Comp	£50 - £100	1.7%	1.7%	No real payback
Option 3 - Load Compensation					
	Product	*Cost*	*SAP DER Benefit*	*Total SAP Benefit*	*Comments*
	Load Comp	£100 - £250	0.5%	0.5%	No real payback
Option 4 - Smart Controls					
	Product	*Cost*	*SAP DER Benefit*	*Total SAP Benefit*	*Comments*
	Smart Home System	£250 - £1000	0.5%	0.5%	No real payback

N.B. Dwelling Emission Rate (DER) SAP savings are normally cumulative and % savings are house type dependent.

What the analysis clearly shows in that SuperFlow™ has the greatest impact on reducing SAP DER scores of any Boiler Plus measure. For a new build project this can translate into costs savings of many thousands of pounds. When used in combination with the Canetis

GasSaver the benefits relating to SAP DER reductions are even higher as the table clearly shows – these cost savings are estimated to be between £3k and £10k per new build house.

More on Boiler Plus

Weather Compensation, Load Compensation and Smart Home Systems are already identified by the Government as life style products that only offer energy savings when consumers are engaged in their operation. However SuperFlow™ (and GasSaver™) are recognised for their improved energy efficiency as they are passive devices requiring no user intervention.

UK SAP Analysis & Costs Savings

Fig 5 below highlights SAP benefits for SuperFlow™ (and GasSaver™) in SAP for various house types. Savings vary depending on many factors including post code, orientation and method of construction. Typically, GasSaver™ scores highest for smaller new build homes whilst a GasSaver™ & SuperFlow™ combination scores best for larger multi-bathroom properties.

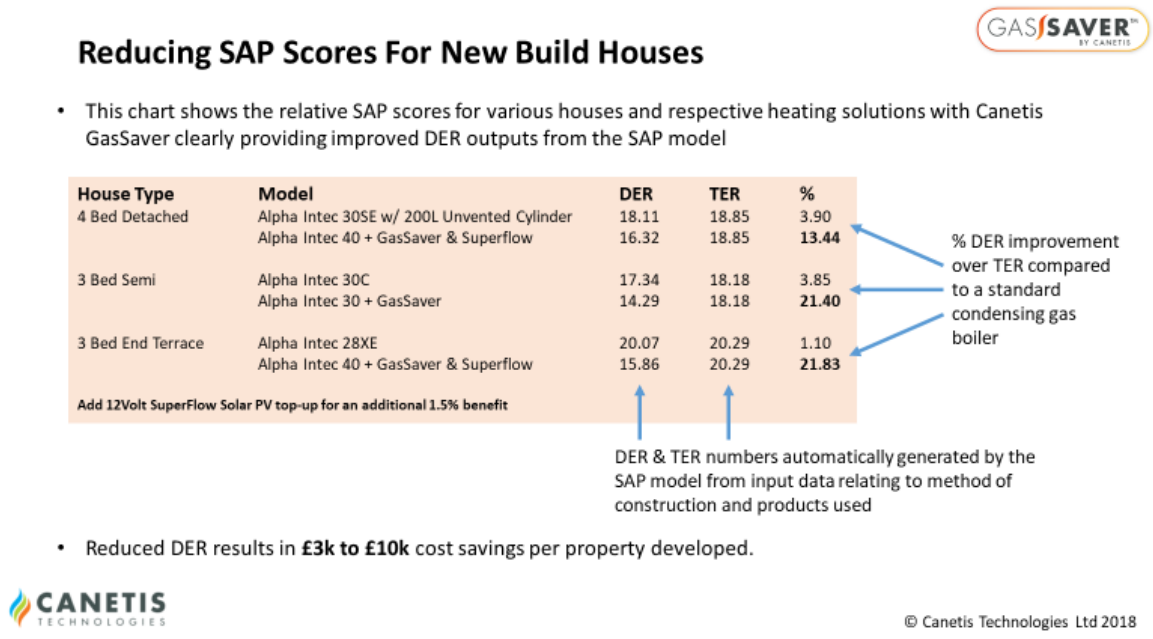


Fig 5 - Worked SAP calculation benefits for GasSaver™ & SuperFlow™ solutions.

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