Wastewater heat recovery systems:

a simple, cost-effective way to help meet the Renovation Wave energy saving and decarbonisation targets

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Introduction

According to the European Commission, buildings are responsible for approximately 40 percent of energy consumption and 36 percent of CO_2 emissions in the EU. Renovation and improved energy efficiency have the potential to lead to significant energy and CO_2 emission savings and the Commission's Renovation Wave strategy has set ambitious targets, requiring effective technical solutions.

Over recent years, the energy needed to produce hot water has become an ever-larger share of total household energy use due to the dramatic fall in energy required for domestic space heating. Every day, more than 22,000,000 m^3 of hot water are consumed by European homes alone. It is the main source of energy consumption for new housing, and yet 80 percent of this heat ends up in sewers and is wasted. Considering 80 percent of hot water is used in showers, harvesting heat from shower drains could be a simple way to save around 40 percent of energy and CO_2 emissions.

How Wastewater Heat Recovery (WWHR) Works

Principle

Most heat recovery systems have no moving parts and require no electricity to operate. A specifically engineered heat exchanger transfers heat energy from the waste hot shower water to the incoming fresh water supply, warming it from around 10 up to 30°C. When the cold water arrives at the mixing valve, it is much warmer, and therefore substantially less hot water is required from the water heater or solar array.

The shower is not only the application with the highest consumption of hot water, but also the place where heat exchange is easily possible. This is because a constant stream of warm wastewater flows downwards while a cold stream of fresh water flows upwards to the shower mixer. These two streams only need to be brought close together and massive energy savings can be achieved. In this case no storage and control system are necessary. A wastewater heat recovery system could effectively recapture and reuse instantly up to 70 percent of waste energy, reducing energy consumption in a cost-effective manner.

In addition, the shower water is relatively unpolluted, compared to other domestic wastewater from kitchen sinks, and is therefore also ideal for heat exchange. The recaptured heat from the shower might also be used to preheat the tank water.

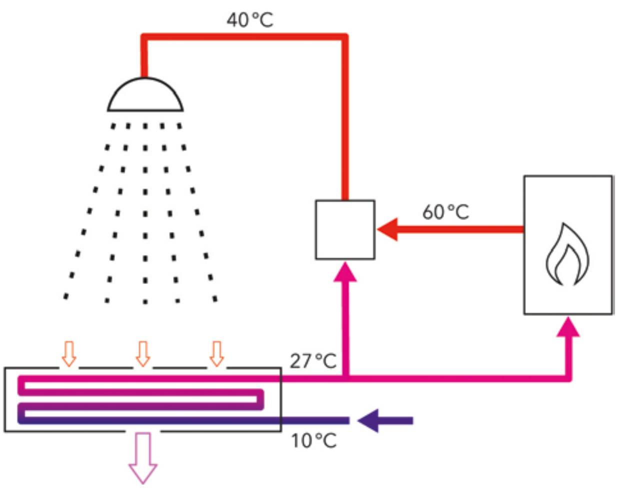


Figure 1. The preheated fresh water goes to a mixing valve or to a boiler/storage tank.

Efficiency

System efficiency varies by manufacturer and product. The lower the flow rate, the higher the efficiency, the higher the flow rate, the higher the performance. Efficiency, as a percentage of energy gained from drain water varies by system used, up to 70 percent.

Additional benefits of a WWHR system

1. The hot water preparation system can be designed smaller, reducing running costs.
2. Installed renewable systems (photovoltaic, solar thermal or heat pumps) can be downsized or energy generated redirected for uses other than for hot water.
3. Circular construction is supported as systems have a long lifespan and contain easy to recycle and highly recycled materials (copper, stainless steel).
4. The recovery and generation of energy adapt continuously and in real time with the usage, without over- or under-production (no storage and control system necessary)
5. Systems are hidden, either by integration into showers, or installation in ducts or technical rooms.

Market ready solution

Europe has the greatest technological lead in the world on this subject, with 326 patent applications since 2010, which is 70 percent of all patent applications in the world. Together, WWHR systems have already recovered 300 GWh corresponding to the annual domestic hot water consumption of **17,000** households. The most used system is the vertical pipe with more than 150,000 systems already installed in Europe.

WWHR systems can be used in single- and multi-family homes, and non-residential premises with higher hot water consumption: sports facilities, hairdressers, hotels, and swimming pools. Systems can be individual or collective, serving multiple showers or dwellings simultaneously. Due to ease of installation, they can be applied in renovations as well.

Recognition of WWHR in national building codes is growing. In France, the national energy efficiency standards, RT2012 and the forthcoming RE2020, acknowledge the contribution WWHR can make to targets for heat from renewables.

In the Netherlands, WWHR systems are included in the calculation software for new construction projects as they have a positive bearing on the energy performance of a building. This is the case for the existing EPC (energy performance coefficient) regulation. It will also be the case with the BENG (nearly energy neutral buildings) regulation that will come into effect on 01 January 2021.

In October 2019, the Ministry of Housing, Communities and Local Government (MHCLG) in the UK published a consultation on the Future Homes Standard, regarding changes to Part L of the Building Regulations for new dwellings. WWHRS

Figure 2. Horizontal type heat exchanger with efficiency around 50%.

Figure 3. Vertical type heat exchanger with efficiency 60–64%.

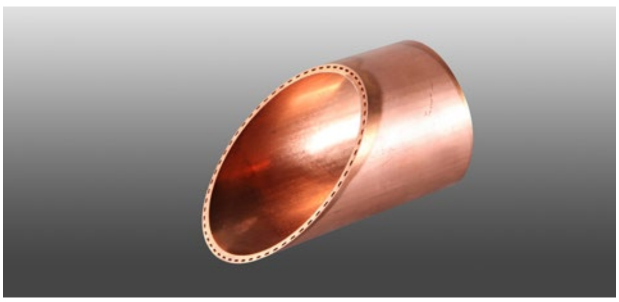


Figure 4. Double-walled tubes ensure safe and reliable separation of potable and grey water.

is widely recognised as one of the most cost-effective SAP-listed energy efficiency technologies available, and proposed changes to Part L in 2020 suggest WWHRS will have an even bigger impact under the new regulations.

Evaluation of WWHR potential for decarbonisation – household level

In calculations at household level energy consumption and emissions of shower systems depend on many variables, e.g. temperature of incoming cold, hot water and shower water used, shower time, fuel used to heat water (electricity, gas…) size/design of shower enclosure and flow rate.

Assumptions used in sample calculation:

Shower time:	9 min./shower
Cold water temperature:	10°C
Hot water temp. from the boiler:	60°C
Mixed shower water temp.:	38°C
Flow rate:	9.2 ℓ/min
Number of days:	365 (one shower/person/day)
Number of residents per home:	2.30
WWHR unit efficiency:	**56% (market average)**

CO_2 emission coefficient (based on Dutch standard NTA8800, "Energy performance of buildings – Determination method"):

Electricity:	0.34 kg/kWh
Gas:	0.183 kg/kWh

In this sample household, with deployment of an average efficiency WWHR system, 833 kWh electrical energy and associated 283 kg of CO_2 emissions can be saved, or consumption of 85 m³ natural gas, equivalent to 153 kg CO_2 can be avoided.

37 percent of energy consumption and CO_2 emissions are avoided by deploying a WWHR system with an average efficiency (56 percent).

Return on Investment

Electricity and natural gas prices vary across Member States and there is a wide range of WWHR systems available on the market, so the exact return on investment needs to be calculated specifically for each project.

An average family can save around €50–150 annually on their hot water bill after deployment of a WWHR unit and this justifies the investment into this safe, energy efficient, environmentally friendly, simple, and easy to install, operate and maintain system with a long lifespan.

A 2030 WWHR Scenario – energy saving potential in 2030

In October 2020, the European Commission published its Renovation Wave Strategy to improve the energy performance of buildings. The Commission aims to at least double renovation rates in the next ten years and make sure renovations lead to higher energy and resource efficiency. By 2030, **35 million buildings could be renovated.** In our calculation we assume 82 percent of these are residential dwellings. In addition to this, by 2030 around **16 million new dwellings** will be completed in the EU.

In the **Table 2**, an annual energy saving for a "2030 WWHR scenario" is calculated for the year of 2030, assuming 50 percent of new built and energy renovated dwellings deploy WWHR systems by 2030.

Contribution to the Renovation Wave Strategy targets

The Commission has proposed in the Climate Target Plan 2030 to cut net greenhouse gas emissions in the EU by at least 55% by 2030 compared to 1990.

Table 1. *A sample calculation of annual energy consumptions and emissions of a shower with and without an average efficiency (56 percent) WWHR system.*

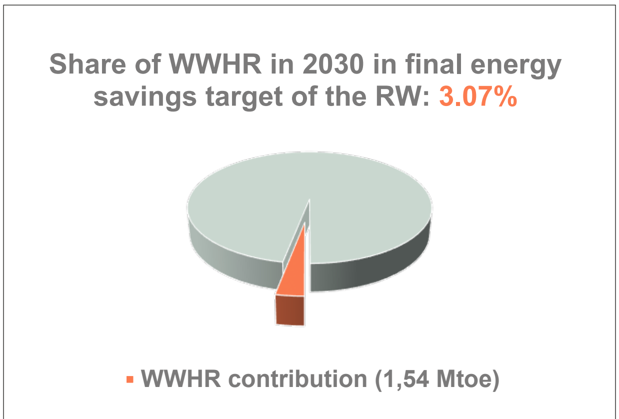
	Household Without WWHR		Household With WWHR		Household Saving with WWHR	
Hot water preparation	Energy demand per year	CO_2 emissions per year	Energy demand per year	CO_2 emissions per year	Energy saving per year	CO_2 emissions saving per year
Electricity	2,264 kWh	770 kg	1,430 kWh	486 kg	833 kWh	283 kg
Gas	231 m³/year	414 kg	144 m³/year	262 kg	85 m³/year	153 kg

Table 2. 2030 WWHR scenario - energy saving potential in 2030.

2030 WWHR scenario	Renovated	Newly built
Number of dwellings by 2030	28 700 000	16 000 000
2030 WWHR Scenario – number of dwellings by 2030 (50 percent of dwellings deploying WWHR)	14 350 000	8 000 000
Household annual energy saving (kWh/year) – See Table 1	800	800
Total annual energy savings in 2030 (TWh/year)	11.48	6.40
Grand total energy savings in 2030 (TWh/year)	17.88	
Grand total energy savings in 2030 (Mtoe/year)	1.54	

Table 3. Final energy consumption and GHG emission savings needed.

2030 WWHR scenario	Final Energy Consumption (Mtoe) –14% (2030 vs. 2015)	GHG (Mton CO_2-eq) –60% (2030 vs. 2015)
2015	370	456
2030 (BSL scenario)	334	239
2030 Green Deal (REG scenario)	320	180
Savings needed	50	276



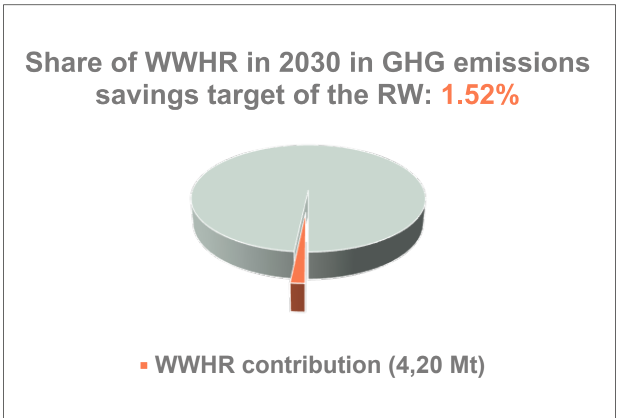


Figure 5. Contribution of WWHR 2030 scenario to the Renovation Wave Strategy targets.

According to the Renovation Wave Strategy, to achieve the 55% emission reduction target, by 2030 the EU should reduce buildings' greenhouse gas emissions by 60%, their final energy consumption by 14% and energy consumption for heating and cooling by 18% (compared to 2015).

Policy recognition needed for WWHR

The benefits of WWHR in buildings, while recognised in some national building codes, are not adequately acknowledged in EU legislation. This is despite re-use of produced energy having a high energy saving and decarbonisation potential for sanitary hot water preparation. Policy support is crucial to maximise the impact of WWHR systems we seek recognition in the EPBD of WWHR systems as energy from renewable sources and for their contribution in determination of primary energy use at building level to be taken into account. Inclusion of the WWHR technology in Renovation Wave induced policy tools, such as building renovation passport, minimum energy performance standards for existing buildings, the deep renovation standard, and minimum levels of renewables in buildings is also necessary. Member states should also include WWHR in their long-term renovation strategies. As far as energy labelling is concerned, WWHR should be considered in the package label for heating systems as a subsystem in the label, increasing overall system efficiency. ■

WWHR systems could make a significant contribution to the 2030 Renovation Wave targets by contributing 3.07 percent (1.54 Mtoe) towards the final energy savings target and 1.52 percent (4.20 Mt) towards the GHG emissions saving targets. This is based on the assumption that by 2030 half of the residential buildings targeted by the Renovation Wave strategy (14.35 million) and half of newly built dwellings (8 million) will deploy WWHR systems.