DRAINWATER HEAT RECOVERY SYSTEM -
AN ENERGY CONSERVATION PROJECT

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Objective

This project assesses a novel means to recycle hot water, for both domestic and industrial situations and thereby conserve energy.

Rationale

This is an investigation of a new plumbing product, the gravity film exchanger (GFX), developed to recycle the enormous amount of energy carried by hot drain water from residential and industrial situations. The GFX acts as a comfort booster that increases the ability of a water heater to meet hot water requirements without increasing the size of an existing water heater.

As water falls down a vertical section of drain pipe, it clings to the inner surface in a very thin film. The heat from this film is efficiently transferred to the cold water that circulates around the device on the outside of the drain pipe. The GFX raises the temperature of incoming cold water by recycling free heat from waste water going down the drain. Approximately 80% to 90% of all hot water energy goes down the drain, allowing the GFX to recycle as much as 60-70% of wasted heat. The more hot water used, the greater the saving.

The GFX unit can be fitted into a residential drain water system to effectively conduct waste water heat from a variety of sources. Preheated water may be supplied to the entire house, or fed to only the water heater and/or the cold water input of a shower.

As a result of the simple design, the device has several important features:

- Inexpensive
- Easy to install
- Short pay-back period

This investigation assesses the capabilities of the GFX system.

The Test Facility

To assess the GFX system, a test facility was constructed (Figure 1). This allowed a measured amount of water to be heated to a known temperature and then released through the drain water side of the heat exchanger under controlled conditions. Equally, the temperature and flow rate of the water to be heated (mains water) was also known.

Using this system, sets of results have been obtained for different operating conditions including different input temperatures and flow rates. Two flow rates were chosen and the lower flow rate represents a typical domestic application. The experimental parameters are shown in Table 1.

Results

Figure 2 demonstrates the test circuit operating at 50°C inlet water temperature. This was the initial condition chosen to evaluate the test facility. The use of cold water on the input side means that the GFX will always start from about 11°C±1°C. Therefore the GFX requires a "settling time" of 1-1.5 minutes before a steady output is obtained. Once this is achieved, the steady state condition will remain until the water flow rate from the heat source reduces. Having analysed the performance of the heat exchanger under this initial condition and established the appropriate levels of control and instrumentation the following range of tests was carried out.

The test results are illustrated in Figures 3 to 6. These highlight both the hot and cold water inputs and outputs for configurations **a** and **d** of Table 1. These two conditions are the maximum and minimum conditions chosen for the experiment, with configuration **d** approximating a residential shower application

For both experimental configurations, results show an increase in temperature difference between the cold input stream and cold output stream over the full range of operating temperatures chosen. These results are translated into recovered heat values of 60%±2% at the minimum test conditions (**d**) while at the maximum test conditions, value of heat recovered was seen to be 75%±2% of the waste heat (**a**).

The greater volume of water for condition (**a**) was not affected by the air temperature within the GFX to the same extent as condition (**d**), allowing the metal walls to fully heat. Conversely, at very low flow rates, it has been noted that the falling film was not fully developed and therefore cold spots were created in the heat exchanger. Further results are presented in Table 2, illustrating the typical recorded temperature values for different flow rates.

To demonstrate the possible energy savings of a unit, values in kWh for the four conditions, **a - d**, have been calculated and results are shown in Figures 7 to 10. The results illustrate four time periods, 2, 4, 6 and 8 minutes and the possible daily savings that maybe gained through using the GFX system. These values can be translated into a yearly cost saving using an electricity unit price of £0.1 as an example and assuming that the water is electrically heated at 100% conversion efficiency. The results, in Figures 11 to 14 are for a time period of one year for the two extreme conditions, illustrating the saving for different daily amounts of use (2 minutes – 8 hours).

Conclusion

GFX has the ability to recover between 60% - 75% of heat from waste water, the system can provide savings even for a 2 minute shower over a one year period. From operating the GFX, it has demonstrated an ability to recover heat under controlled conditions. In a real application, the GFX will be affected by external conditions, heating and cooling the cylinder, also, the inner GFX air temperature will alter the heat transfer and will affect the input water temperature. Therefore, it is recommended that an insulated covering of the device will improve operation. Also, contaminants or particulates in the water e.g. soap etc., will also alter the heat transfer conditions. However due to the smooth inner tube, the possibility of the build up of contaminates will be reduced, but as with any household/industrial waste water pipe, some form of build up is possible.

Configuration	**Cold Water Inlet (l/s)**	**Hot Water Inlet (l/s)**
a	0.18518	0.3125
b	0.18518	0.158
c	0.156	0.3125
d	0.156	0.158

Table 1 – Chosen Operating Conditions

	Hotin = 35°C Coldin = 10°C		**Hotin = 45°C Coldin = 10°C**		**Hotin = 55°C Coldin = 10°C**	
FlowRate	**Tempdiff Hot**	**Tempdiff Cold**	**Tempdiff Hot**	**Tempdiff Cold**	**Tempdiff Hot**	**Tempdiff Cold**
A H=0.3125 C=0.1851	8°C	16°C	11°C	22°C	13°C	32°C
B H=0.145 C=0.1851	13°C	10°C	17°C	16°C	21°C	22°C
C H=0.3125 C=0.156	8°C	17°C	11°C	25°C	13°C	32°C
D H=0.145 C=0.156	14°C	11°C	18°C	17°C	22°C	23°C

Table 2 – Temperature Differences

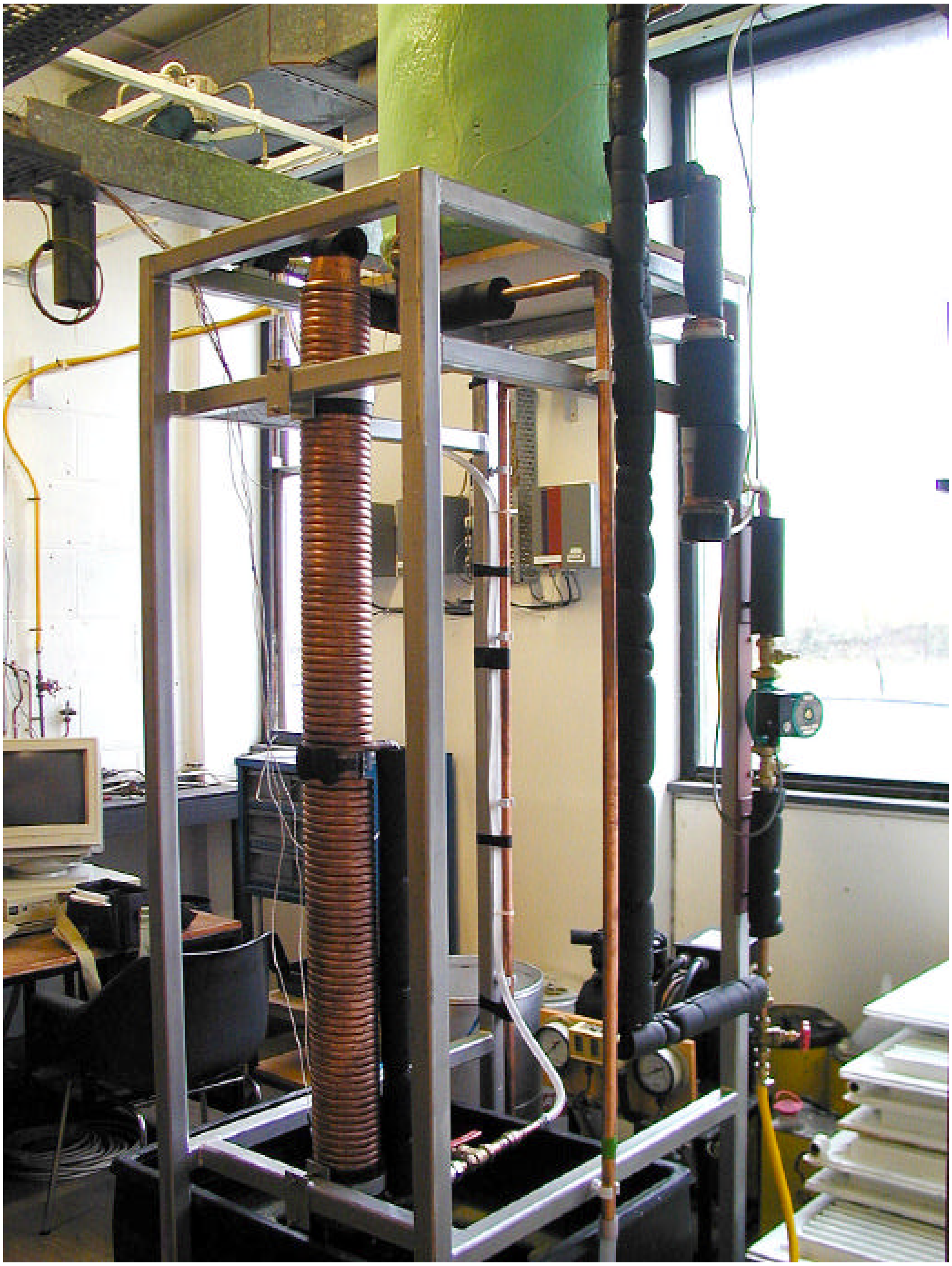

Figure 1. GFX Test Facility

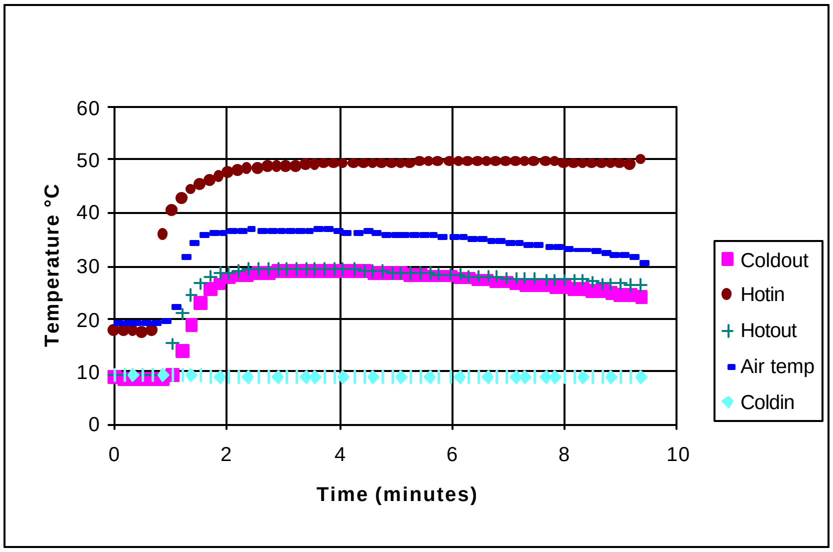

Figure 2. Typical Performance of GFX at 50°C Drain Water Inlet Temperature.

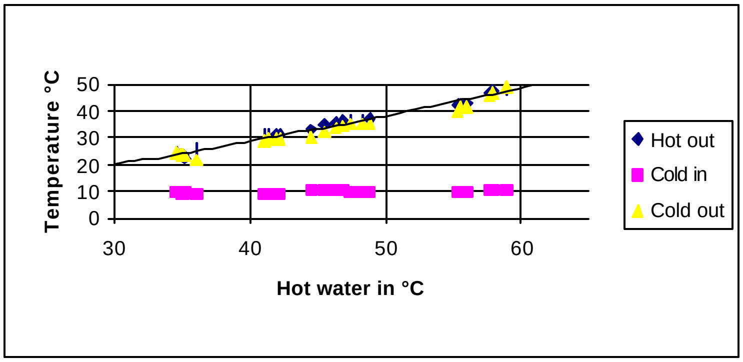

Figure 3. Higher Flow Rate Performance of GFX (Configuration a).

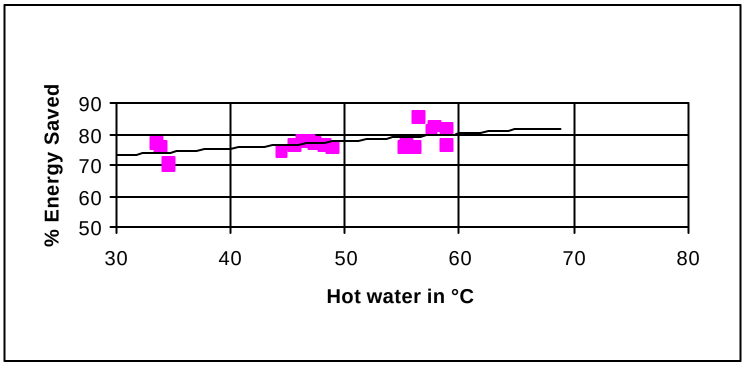

Figure 4. Percentage Recovered Heat at the Higher Flow Rate (Configuration a).

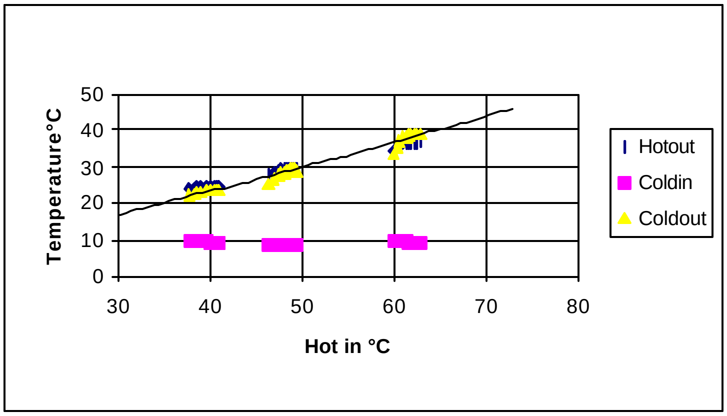

Figure 5. Lower Flow Rate GFX Performance (Configuration d).

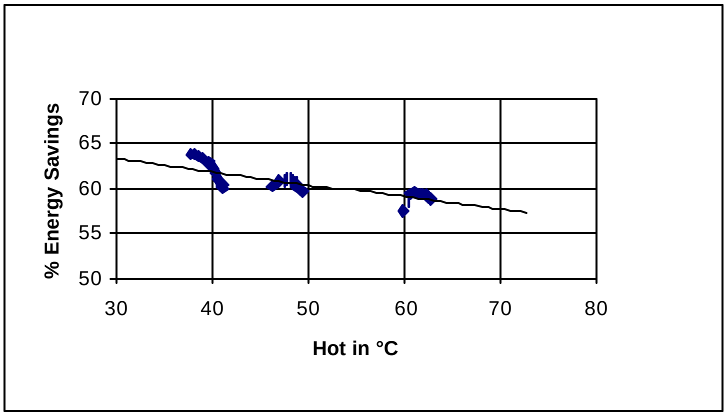

Figure 6. Percentage Recovered Heat at the Lower Flow Rate (Configuration d)

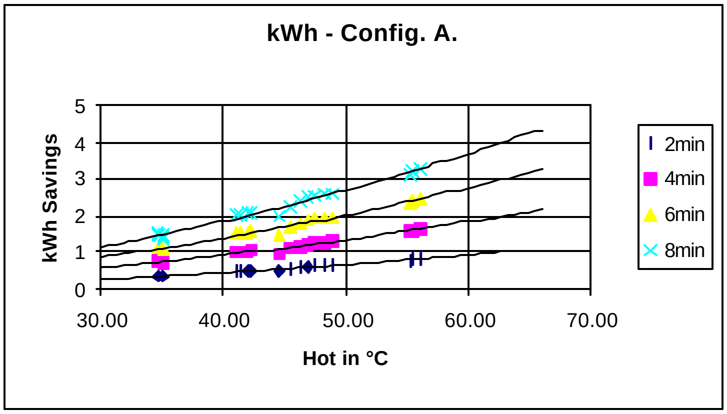

Figure 7. Energy Savings over time for Configuration a.

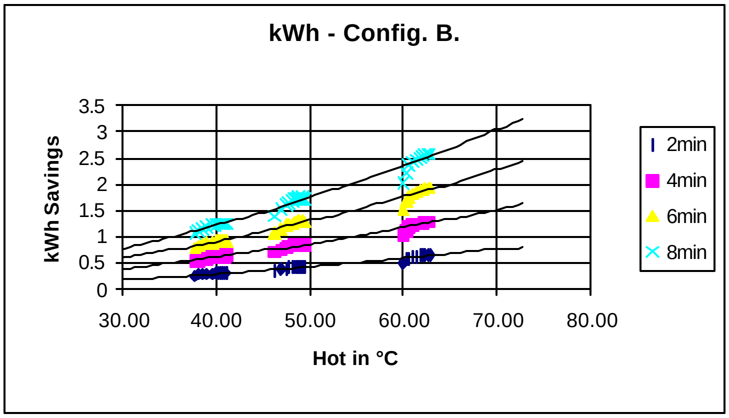

Figure 8. Energy Savings over time for Configuration b.

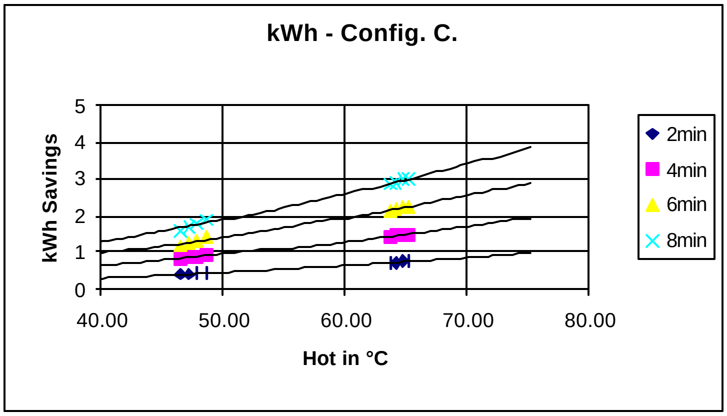

Figure 9. Energy Savings over time for Configuration c.

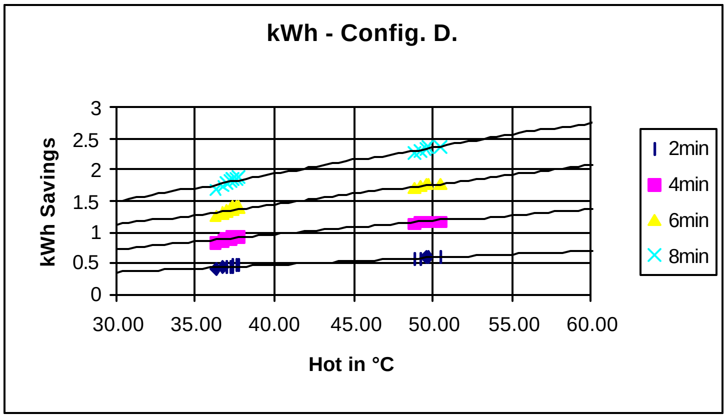

Figure 10. Energy Savings over time for Configuration d.

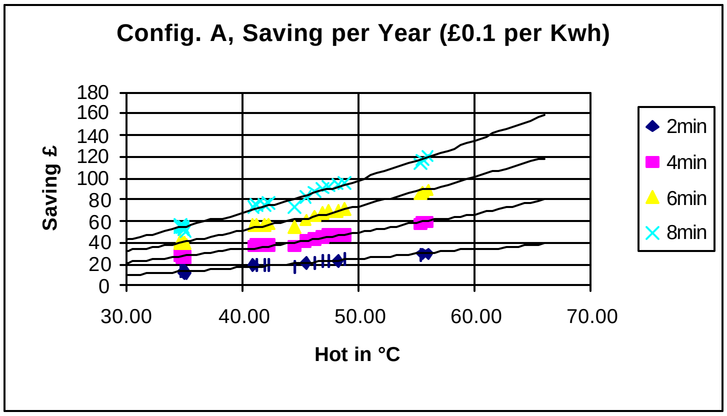

Figure 11. Estimated Savings for High Flow Rate, Low Use Application.

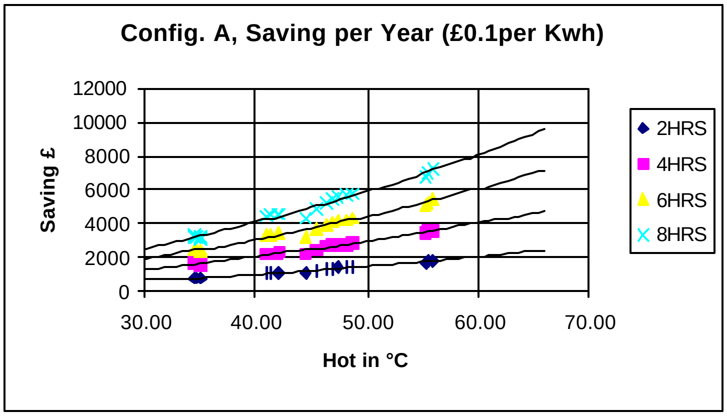

Figure 12. Estimated Savings for High Flow Rate, High Use Application.

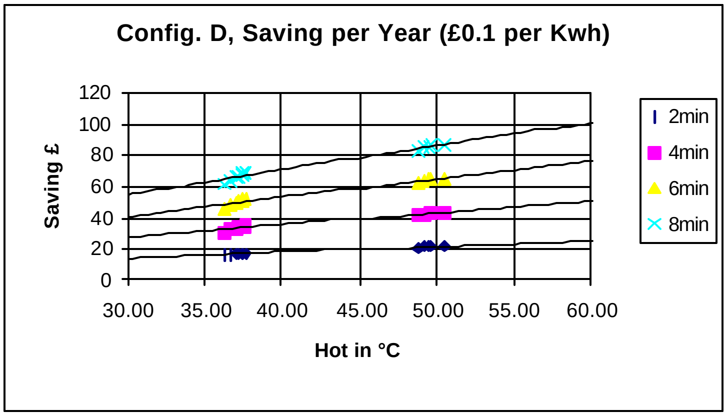

Figure 13. Estimated Savings for Low Flow Rate, Low Use Application.

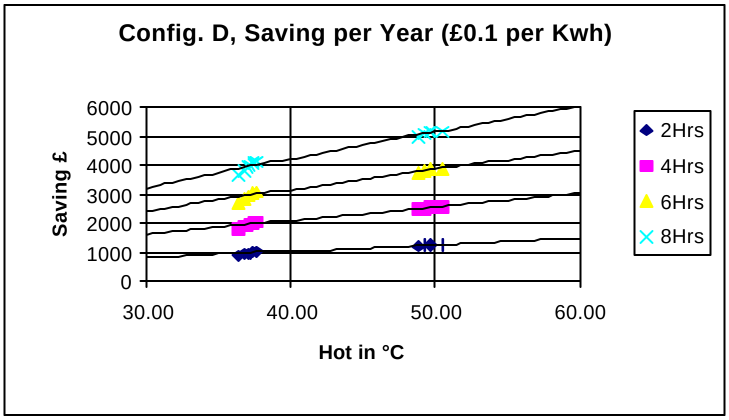

Figure 14. Estimated Savings for Low Flow Rate, High Use Application.