Recovery and utilisation of nutrients for low impact fertiliser

Deliverable 2.1 Development of a novel ultra-low flush vacuum toilet

What is the deliverable about?

A novel type of vacuum toilet was developed with the goal to halve the flushing water consumption compared to existing vacuum toilet models. This was achieved by providing a dual flush interface, allowing users the choice between a regular flush and a water saving flush. For this purpose, the at present usual hydraulic valve control needed to be replaced with an electronical system, allowing a finer control of the flushing valve.

This factsheet

This factsheet is a summary of the main outputs of Deliverable 2.1, which will be made public via a peer reviewed paper.

Why minimising toilet flushing volume

Minimising the flushing volume saves valuable drinking water. Additionally, the resulting toilet wastewater will be highly concentrated, allowing for a more efficient recovery of resources and the application of novel resource recovery processes.

What is the goal of Run4Life?

The goal of Run4Life is to demonstrate the feasibility of recovering nutrients from domestic waste streams for its subsequent application in agriculture. Run4Life proposes a new technological concept of circularity models for wastewater treatment and nutrient recovery. Success in these new circularity models requires a change in thinking from involved stakeholders and interested groups, regarding the technical, organisational, social and governance dimensions. In order to achieve this, we need to generate an understanding of how stakeholder groups currently view the context of wastewater reuse, how they interact and engage with one another and how this can be improved.

Development goal and R&D approach

The goal of this work was to halve the freshwater consumption compared to the currently commercially available vacuum toilet models for residential and office buildings, by developing a new vacuum toilet that can be flushed with 0.5-0.7 litre of water. Vacuum toilets and connected vacuum sewer systems are using mainly air to flush away toilet wastes, but some water is needed to clean the toilet bowl. The R&D work followed an iterative development approach divided into three phases:

1. Development and initial testing within a laboratory environment,
2. Pilot testing and refinement of design and parameters with eight toilets in an office building,
3. Large scale demonstration with 54 toilets at 28 residential houses at Run4Life demo-site Sneek.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 730285.

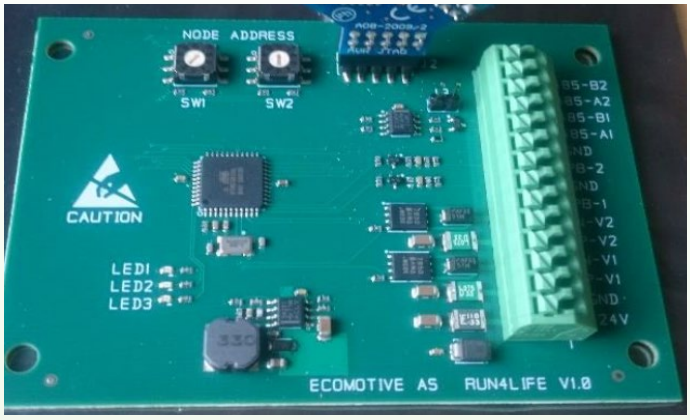
https://run4life-project.eu

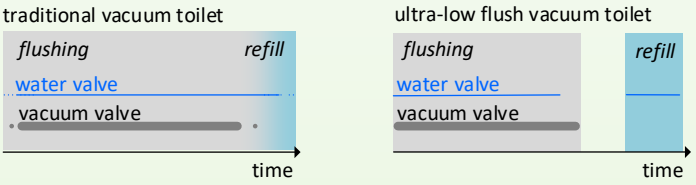
Development and preliminary testing

Development and initial testing

Ultra water-saving vacuum toilets are so far only found in trains and busses. These mobile vacuum sewer systems achieve a low water consumption using a fine-tuned flushing sequence with distinct separation between the flushing and refill of the toilet bowl, controlled via PLC. This is an expensive solution, requiring extensive wiring for systems with more than one toilet. In buildings, only low-cost simple hydraulic flush controllers are used so far, with the trade-off of a less fine control and accordingly larger flushing water consumption (1-1.5 litre).

The main outcome of the R&D work that was performed at the lab facilities of Jets™ is a microcontroller which integrates the advantages of electronical flush control into a cheap and flexible solution that can be installed behind the flushing button of each toilet. Wiring was reduced to a power supply and an optional 2-wire communication line for remote calibration and monitoring. The parameters of the water and air flushing sequences were tested and refined for typical pressure ranges expected in the freshwater supply lines in different types of buildings.

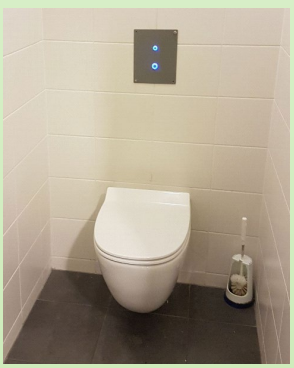




Preliminary testing with eight toilets in an office building

For preliminary testing, eight prototype toilets were installed in an office building. For monitoring as well as simple parameter calibration, microcontrollers were connected to a central PLC unit. Each flush of the eight prototype toilets is logged, as well as the actual pressure conditions in both the vacuum sewer and the freshwater supply line.

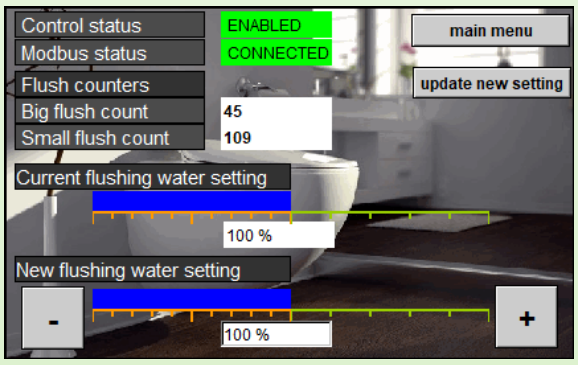
User feedback indicated that a clearly visible water table at the end of the refill phase is an important perception factor on cleanliness of the toilet bowl, and that refill volumes below 0.4 litre were perceived as insufficient and associated with unhygienic conditions. The flushing sequence was therefore adjusted to 0.5 and 0.7 litre for water saving and regular flush, respectively.

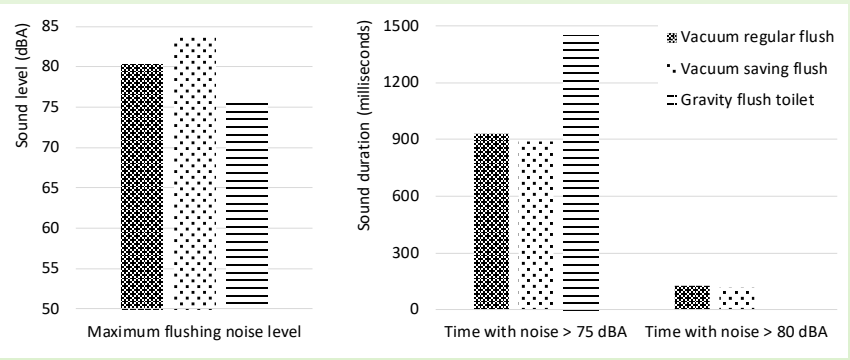


Demonstration at 28 residential houses

For the large-scale demonstration, 54 toilets were installed at 28 residential houses at the Run4Life Sneek demo-site. Freshwater supply pressure conditions vary between the first and second floor, but also between the different houses. The opening time of the flushing water valve needs therefore to be adjusted individually for each toilet. For this purpose, a handheld calibration device was developed. Its user interface (see image below) features a plus and minus button to adjust the opening time of the water valve relative to default settings, allowing a simple calibration using the water level at the end of the refill sequence as an optical indicator.

Many older vacuum toilets are noisy, with the result that people tend to be reserved about vacuum sewers in residential houses. Recently developed so called 'soft-sound' vacuum toilet models, like the one used for Run4Life, produce only slightly more sound than traditional gravity flush toilets. However, reduced flushing water volumes could result in more air sucking and thus a critical increase of noise level. To evaluate this potential trade-off, the noise level was measured at 12 randomly selected toilets as part of the final installation check. For the Run4Life vacuum toilets, 50 cm above the toilet seat a sound level of in average 84 dBA was reached with the saving flush and 80 dBA with the regular flush. This higher than the average maximum level of 76 dBA for gravity flush toilets. However, gravity flushing - and thus the noise above 75 dBA- lasts notably longer for a gravity toilet than for a vacuum toilet. Vacuum toilets produce a sound peak above 80 dBA, with its length and intensity depending on the flushing volume. These peaks are a result of air sucking at the end of the flushing sequence and can be minimised by optimising the vacuum valve opening times for each flushing mode, combined with an individual calibration of flushing water volume at each toilet.





Why does this deliverable matter?

Modern societies spend up to one third of their freshwater consumption on flushing the toilet. Reducing the flushing volume can thus substantially save drinking water and reduce vulnerability for water scarcity. Nutrients and organic matter contained in toilet wastewaters will be more concentrated, making resource recovery more efficient and accordingly enabling circular water, food and energy systems. It also allows for the application of novel resource recovery processes that require higher concentrations.

Contact:
Daniel Todt
dt@ecomotive.no