Nano Membrane Toilet

Alison Parker
O. Autin, H. Arslan, P. Cruddas, E. Mercer, S. Wagland, K. Patchigolla, B. Fidalgo Fernandez, T. Onabanjo, D. Hanak, M. Collins, R. Tierney, J., Larsson, K, Kentrotis, N. Jurado Pontes, F. Kamranvand, P. Hutchings, D. Barrington, A. Kolios, E. McAdam, L. Williams, E. Cartmell, S. Tyrrel

Cranfield University

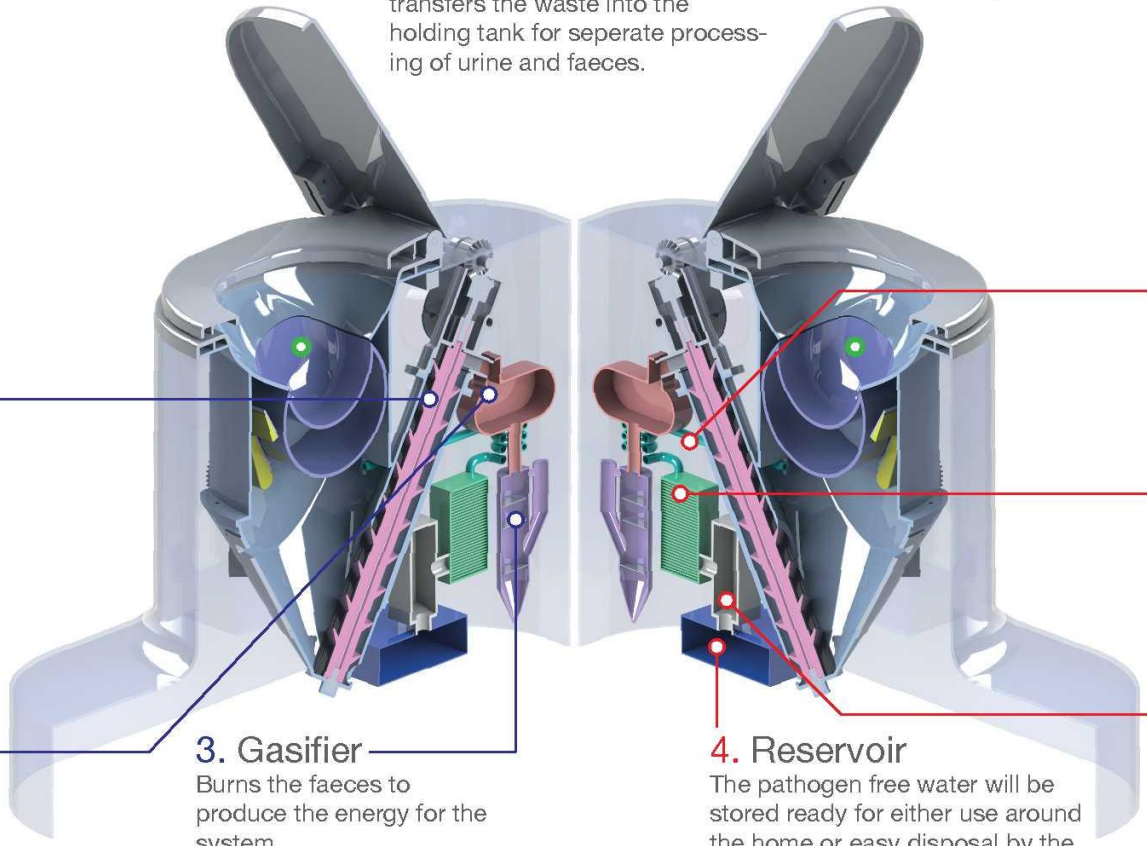
#nanomembrane

System configuration

A waterless self-contained toilet for private household of 10 people

Rotating flush

Waste enters the toilet as normal in a mixed stream. A rotating waterless flush blocks odour and transfers the waste into the holding tank for seperate processing of urine and faeces.



Faeces processing

1. Archimedes screw

Removes solid waste from holding after settling period

2. Drier pelletizer

Reduces moisture content of the solid waste before dosing the fuel into the gasifier below

3. Gasifier

Burns the faeces to produce the energy for the system

Urine processing

1. Weir channel

Urine will pass over the weir and into the channel where it will warm up around the exhaust of the gasifier

2. Membrane bundle

The urine will pass into the membrane chamber and pure water will pass out of the hollow membrane fibres

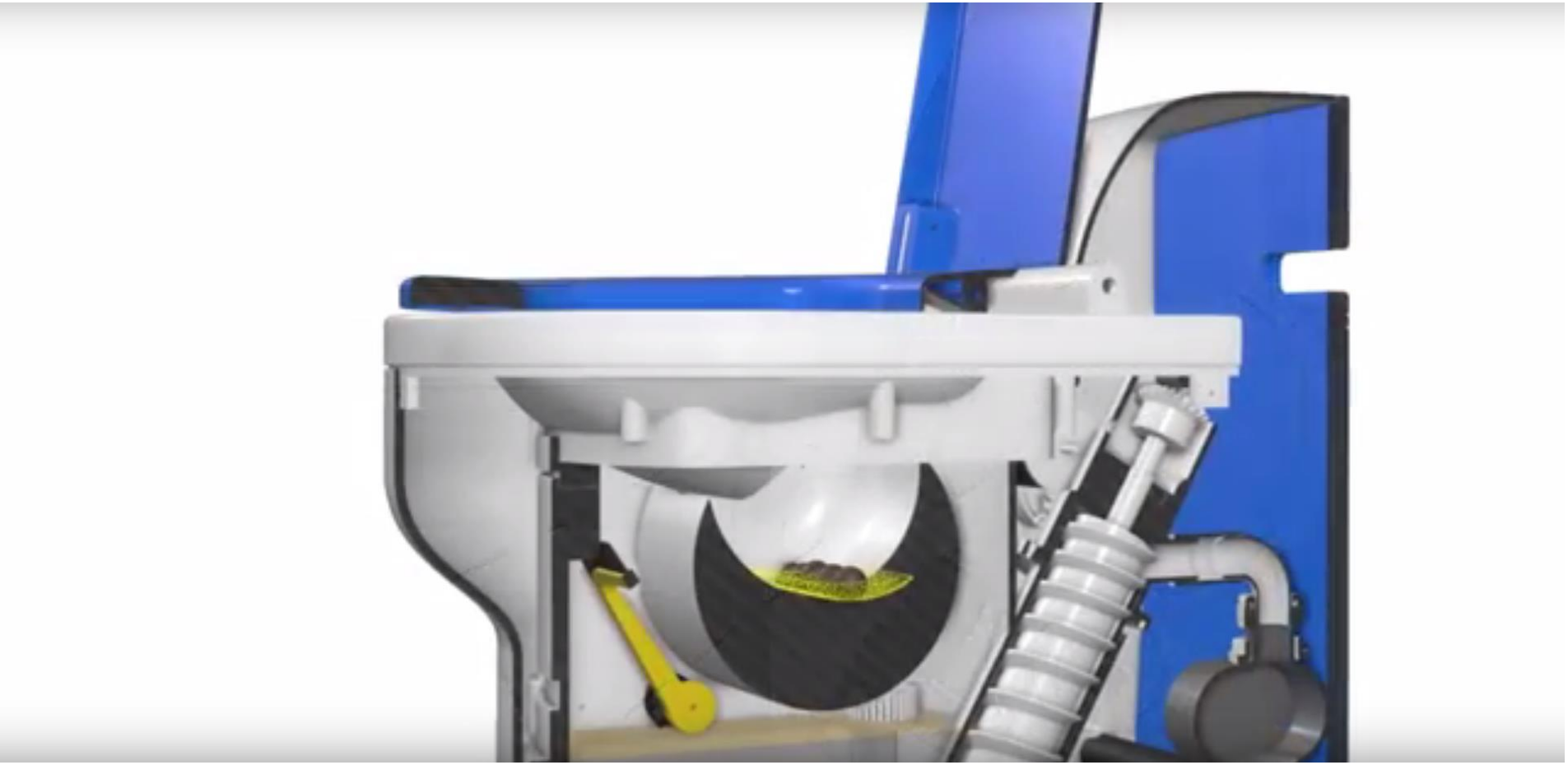
3. Heat exchanger

The water vapour will condense to liquid and fall to the bottom

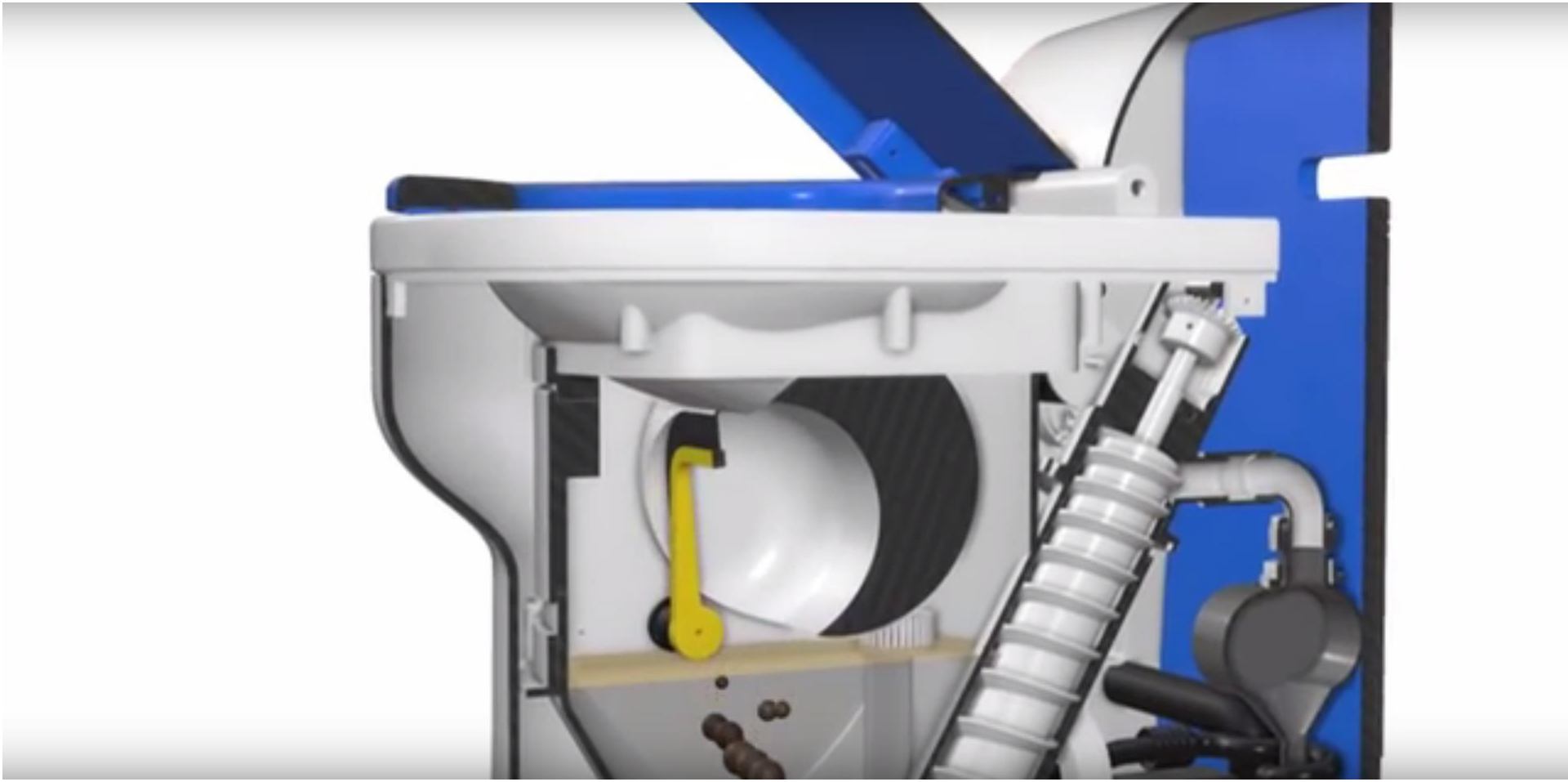
4. Reservoir

The pathogen free water will be stored ready for either use around the home or easy disposal by the home owner

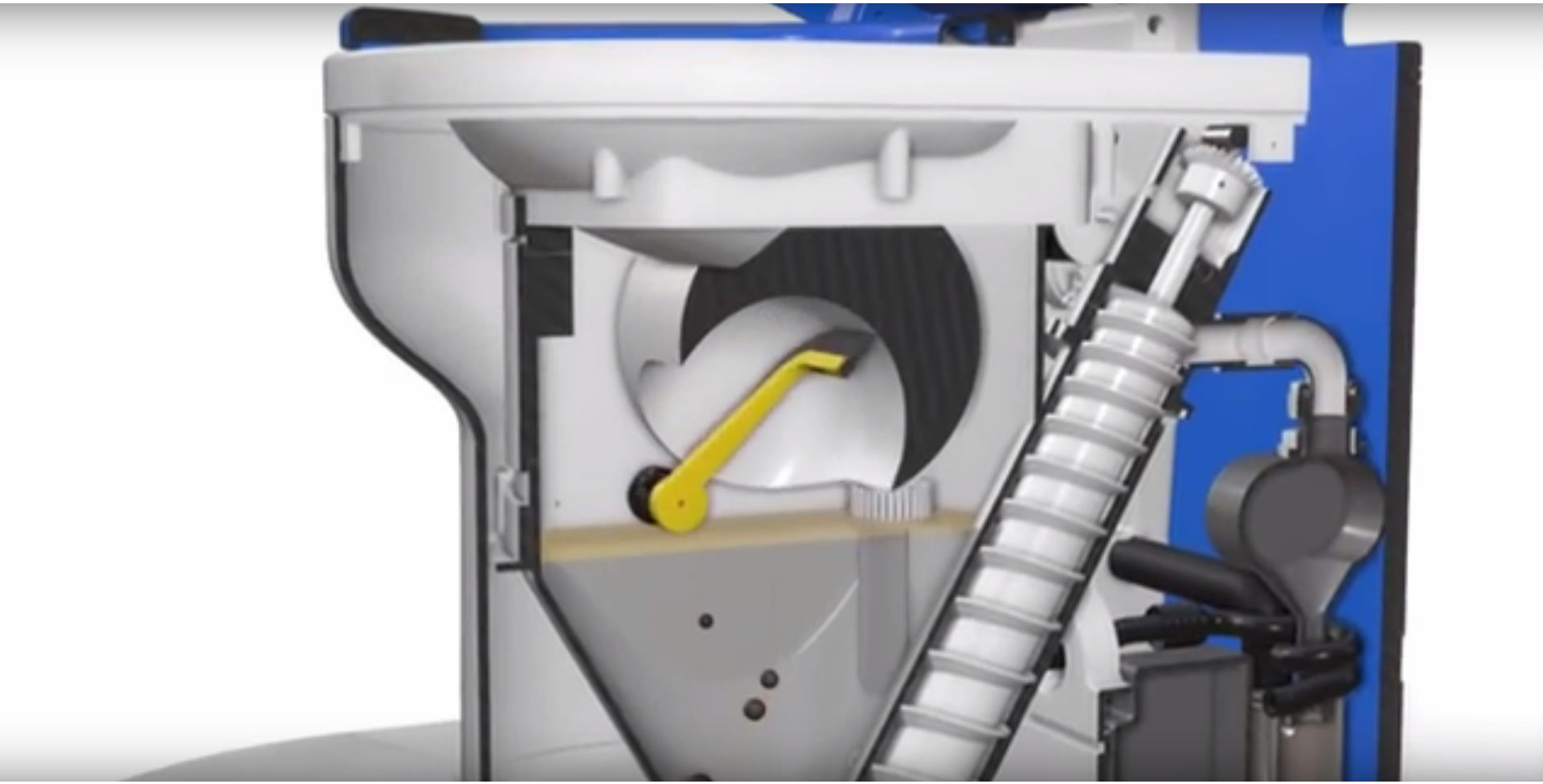
Waterless flush



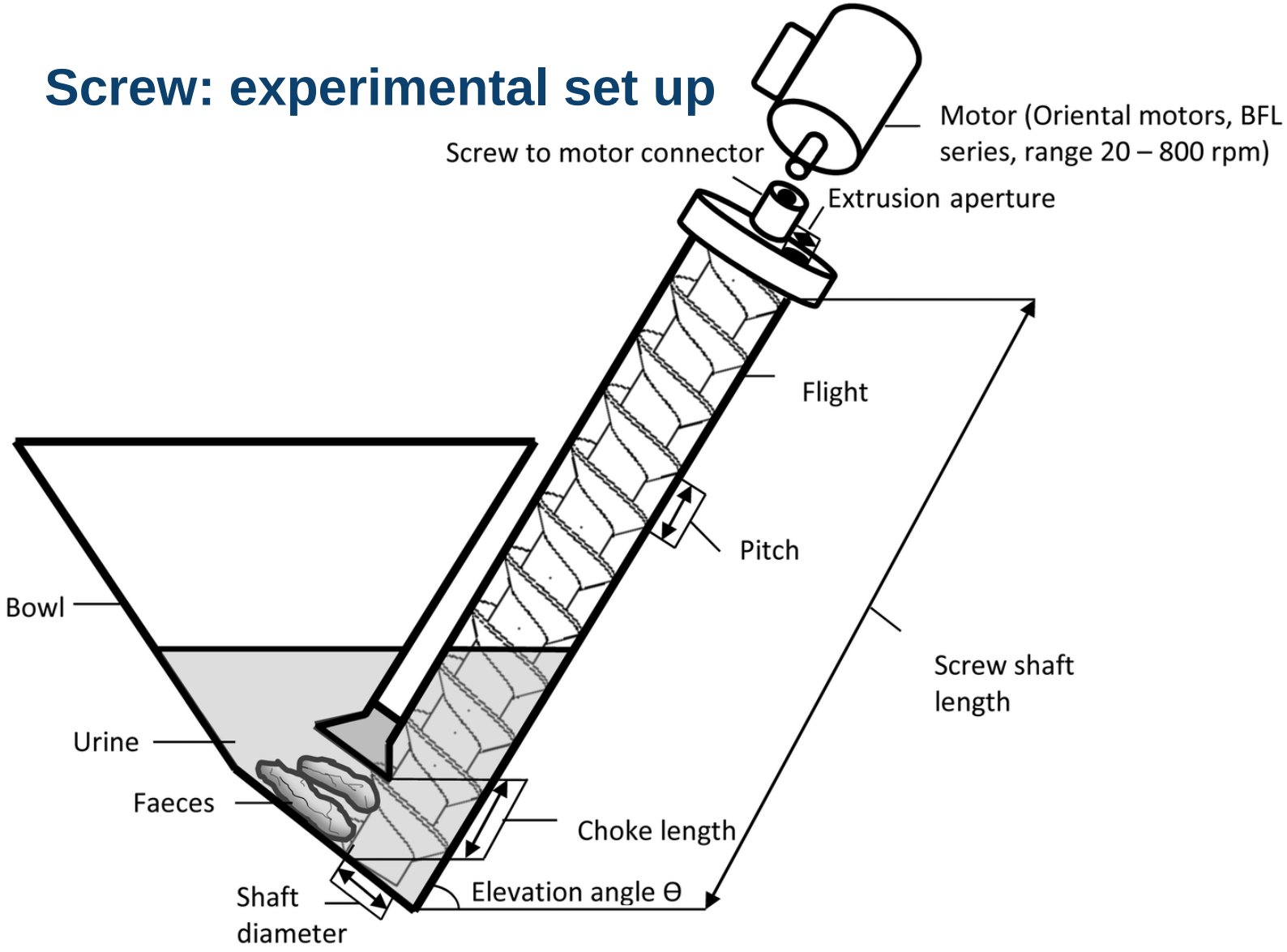
Waterless flush



Waterless flush

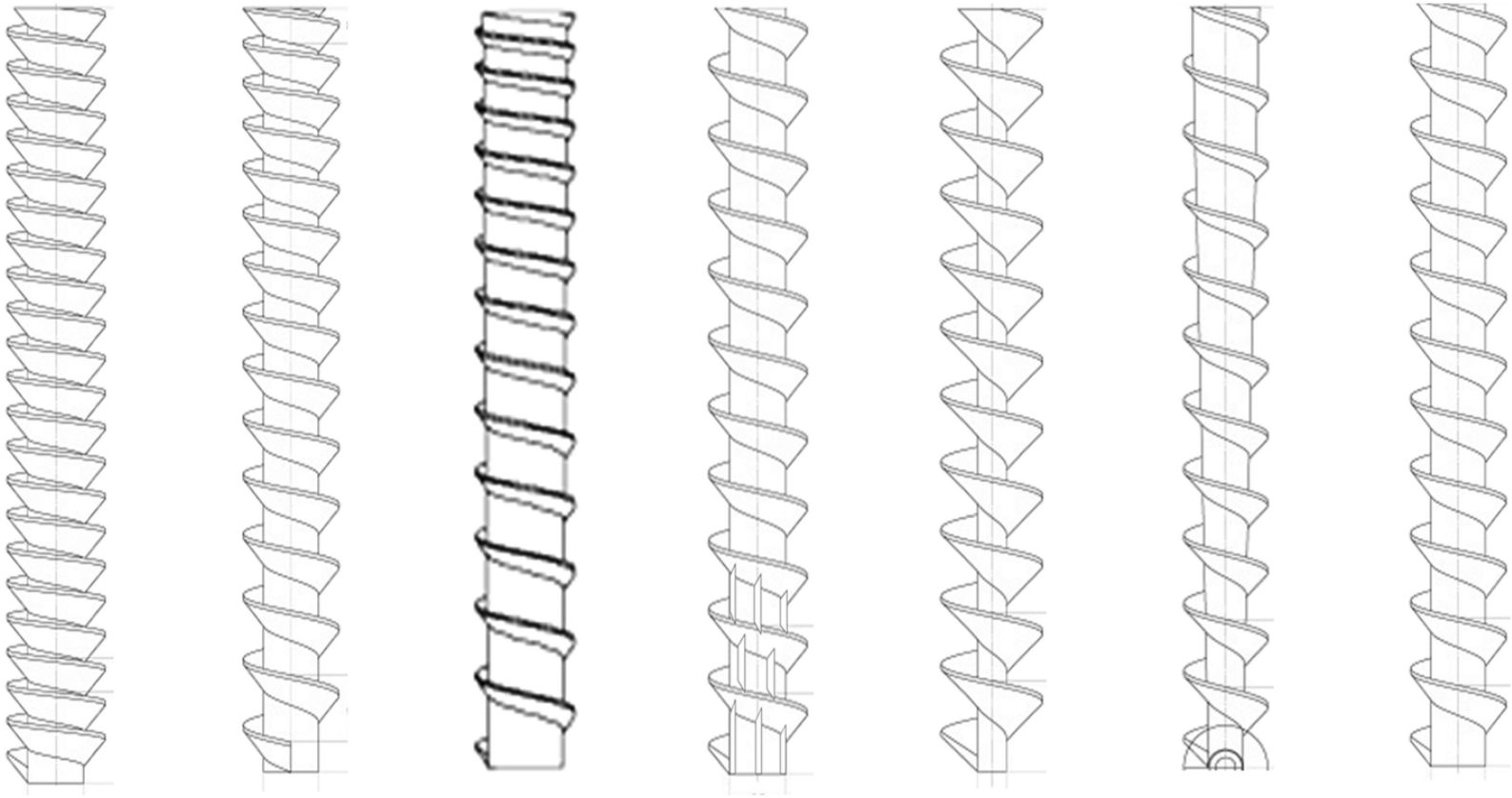


Screw: experimental set up



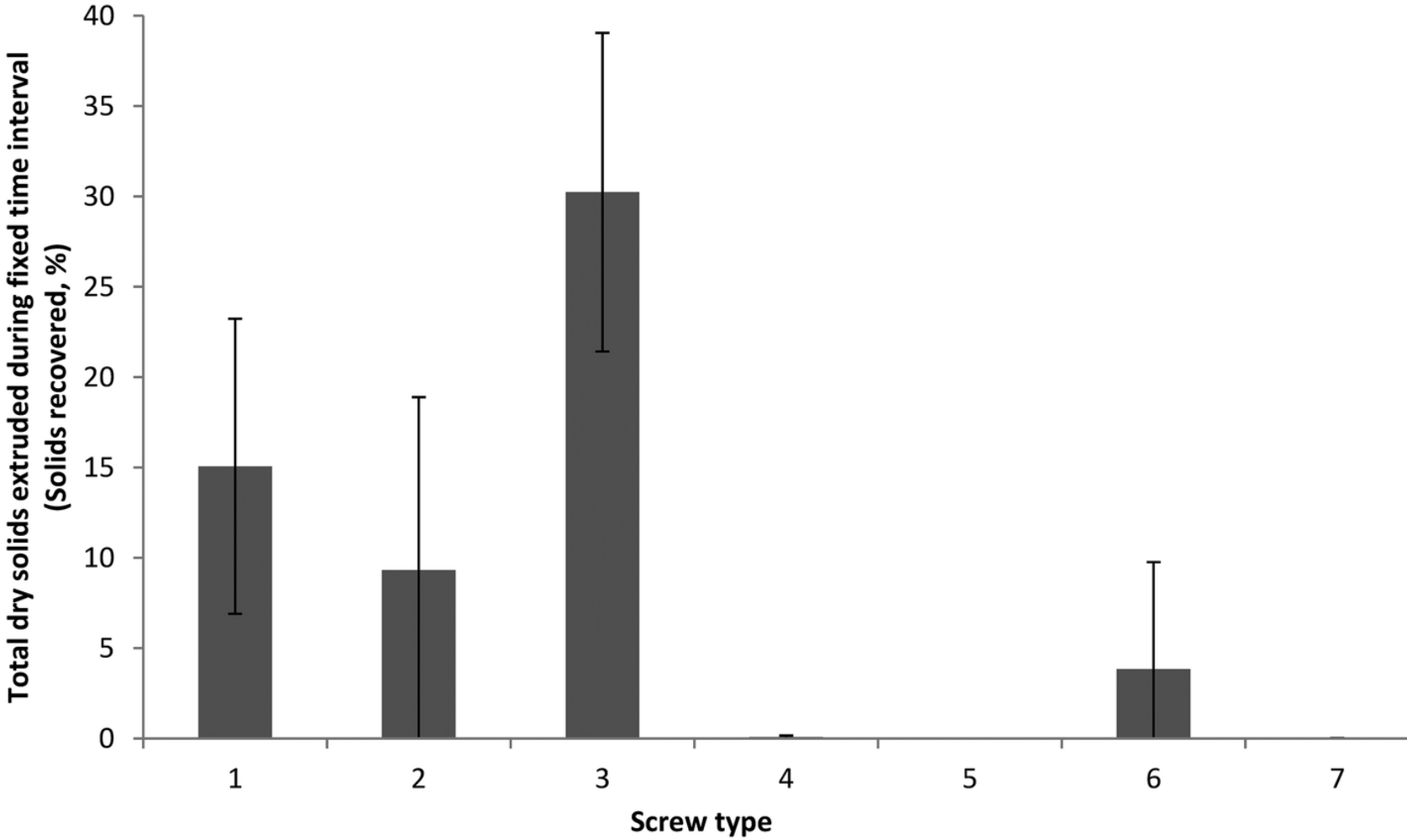
Mercer, E., Cruddas, P., Williams, L., Kolios, A., Parker, A.H., Tyrrel, S.F., Cartmell, E., Pidou, M., McAdam,E. (2016) Selection of screw characteristics and operational boundary conditions to facilitate post-flush urine and faeces separation within single household sanitation systems, *Environmental Science: Water Research & Technology* 2, 953-964

Different screws trialled



Mercer, E., Cruddas, P., Williams, L., Kolios, A., Parker, A.H., Tyrrel, S.F., Cartmell, E., Pidou, M., McAdam,E. (2016) Selection of screw characteristics and operational boundary conditions to facilitate post-flush urine and faeces separation within single household sanitation systems, *Environmental Science: Water Research & Technology* 2, 953-964

Total dry solids extruded within fixed time interval



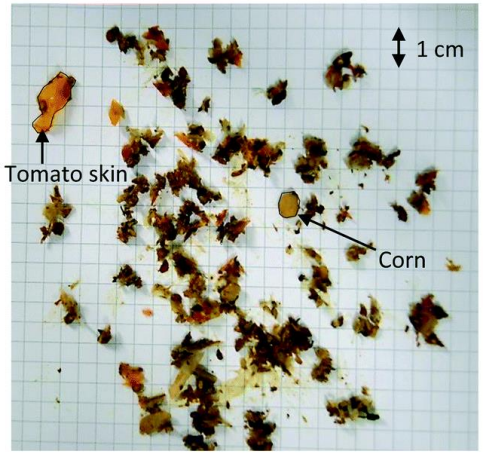
Mercer, E., Cruddas, P., Williams, L., Kolios, A., Parker, A.H., Tyrrel, S.F., Cartmell, E., Pidou, M., McAdam,E. (2016) Selection of screw characteristics and operational boundary conditions to facilitate post-flush urine and faeces separation within single household sanitation systems, *Environmental Science: Water Research & Technology* 2, 953-964

Experiments with real faeces

(a)

(b)

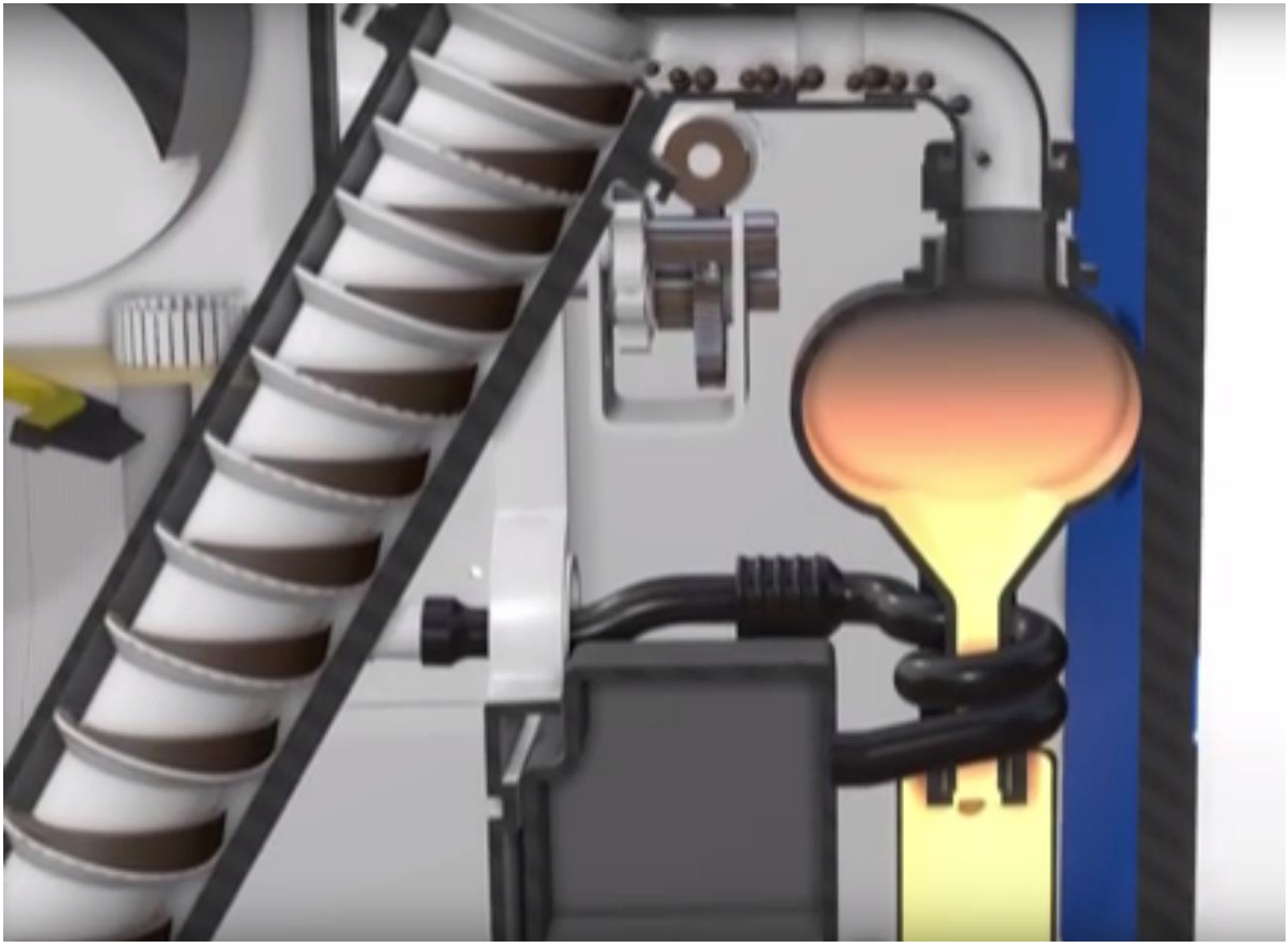
(c)



(d)

Mercer, E., Cruddas, P., Williams, L., Kolios, A., Parker, A.H., Tyrrel, S.F., Cartmell, E., Pidou, M., McAdam,E. (2016) Selection of screw characteristics and operational boundary conditions to facilitate post-flush urine and faeces separation within single household sanitation systems, *Environmental Science: Water Research & Technology* 2, 953-964

Drier



Combustor

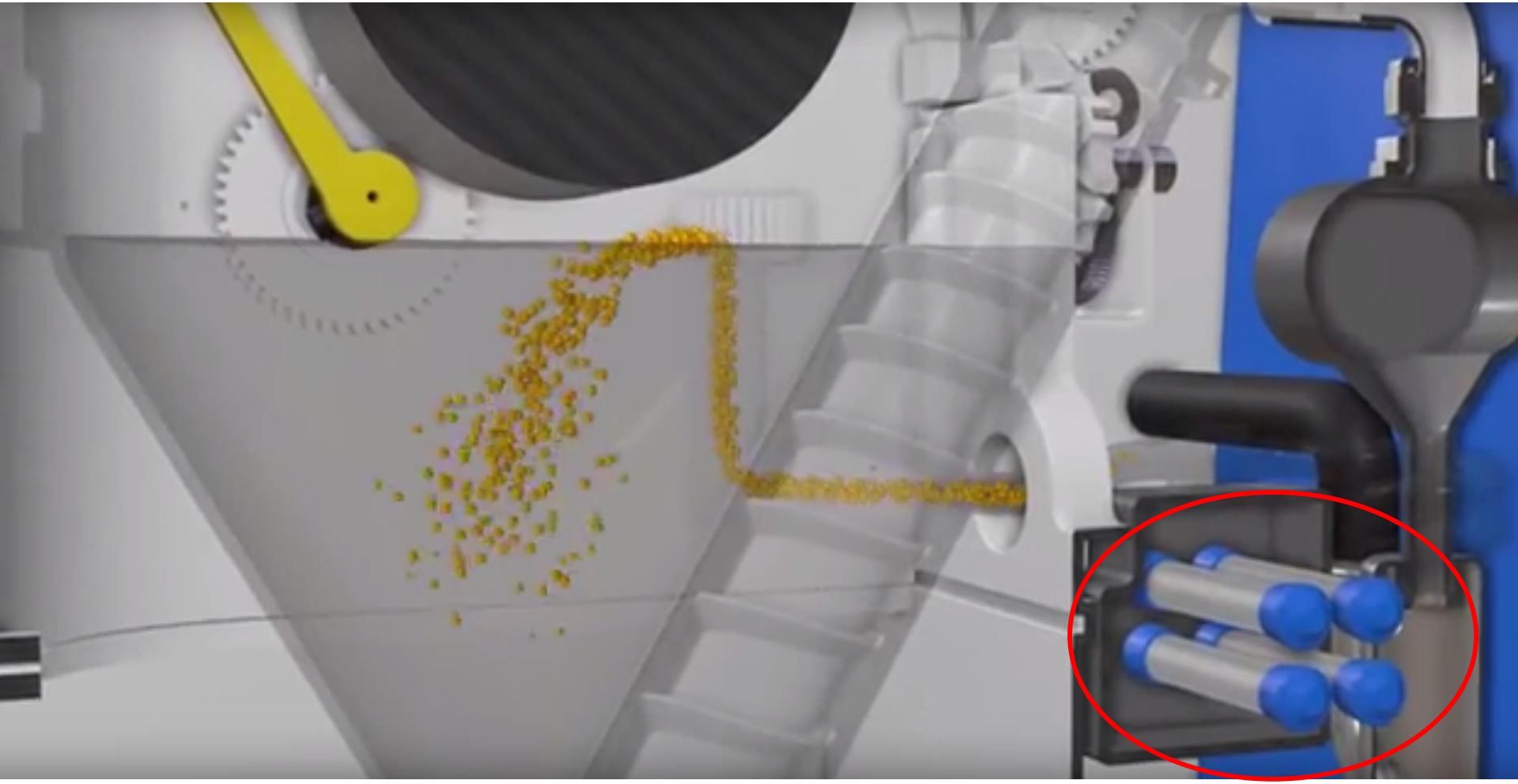
Energy recovery from human faeces

- Modelling showed that the maximum recoverable exergy potential from average adult moist human faeces can be up to 15 MJ/kg.
- Experimental work has also showed that dry human faeces had a higher energy content than wood biomass.
- Simulant faeces can be successfully combusted even if the moisture levels are as high as 60% by weight.

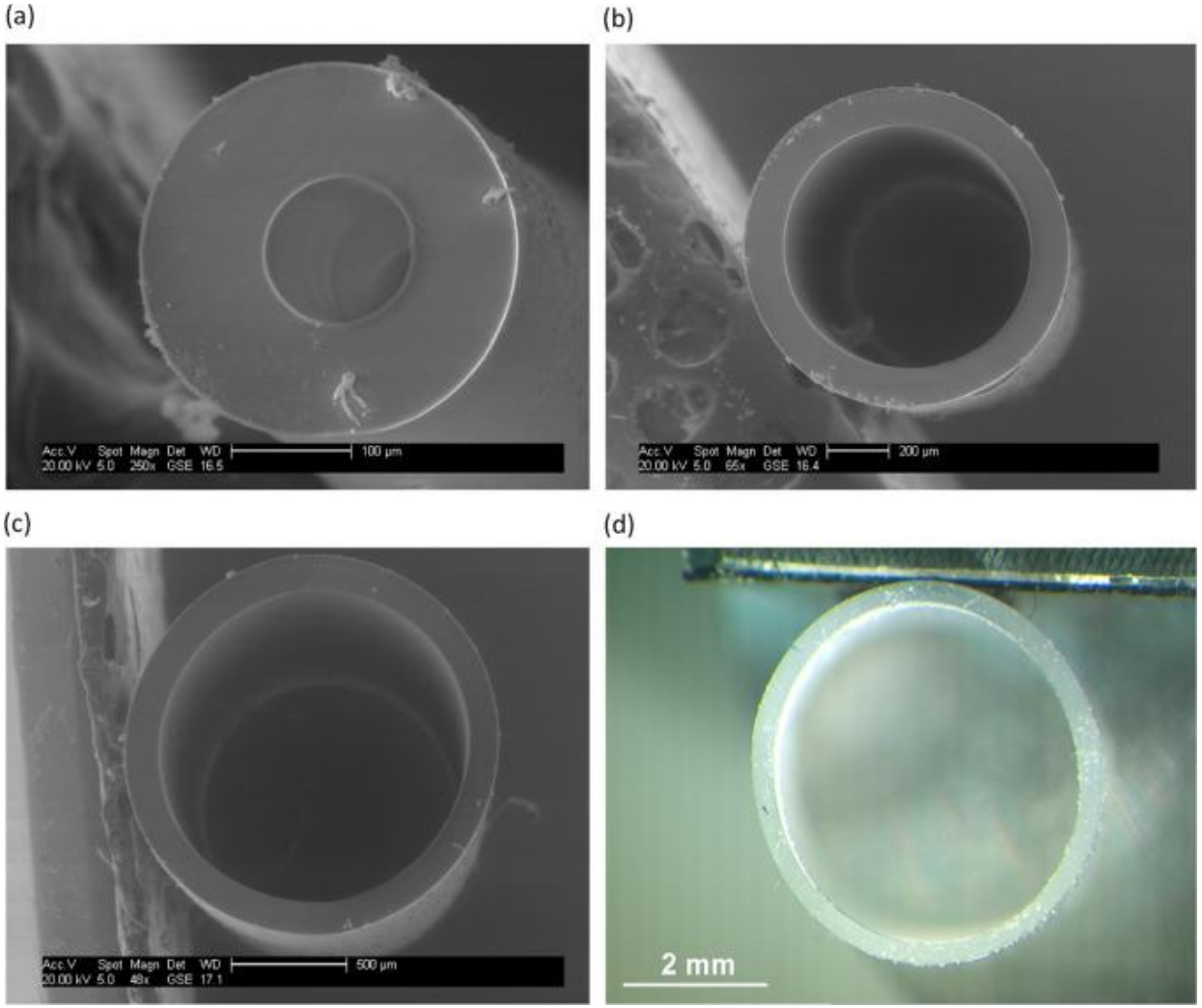
Onabanjo, T., Patchigolla, K., Wagland, S., Fidalgo, B., Kolios, A., McAdam, E., Parker, A., Williams, L., Tyrrel, S., Cartmell, E (2016) Energy Recovery From Human Faeces via Gasification: A Thermodynamic Equilibrium Modelling Approach, *Energy Conversion and Management* 118, 364-376

Onabanjo, T., Kolios, A.J., Patchigolla, K., Wagland, S., Fidalgo, B. Jurado, N., Hanak, D.P., Manovic, V., Parker, A., McAdam, E., Williams, L., Tyrrel, S. (2016) Cartmell, E., An experimental investigation of the combustion performance of human faeces, *Fuel* 184, 780–791

Liquid processing



Optimising membrane processes



Wang, C.Y., Cartmell, E., Kolios, A., McAdam, E., Parker, A.H., Tyrrel, S.F., Williams, L. (2016) Tube-side mass transfer for hollow fibre membrane contactors operated in the low Graetz range, *Journal of Membrane Science* 523, 235–246

Overall energy balance

- Energy modelling suggests that the Nano Membrane Toilet will be a net exporter of energy and power, and can be optimised for either water or energy recovery.
- If optimised for energy recovery its output could be equivalent to a USB port

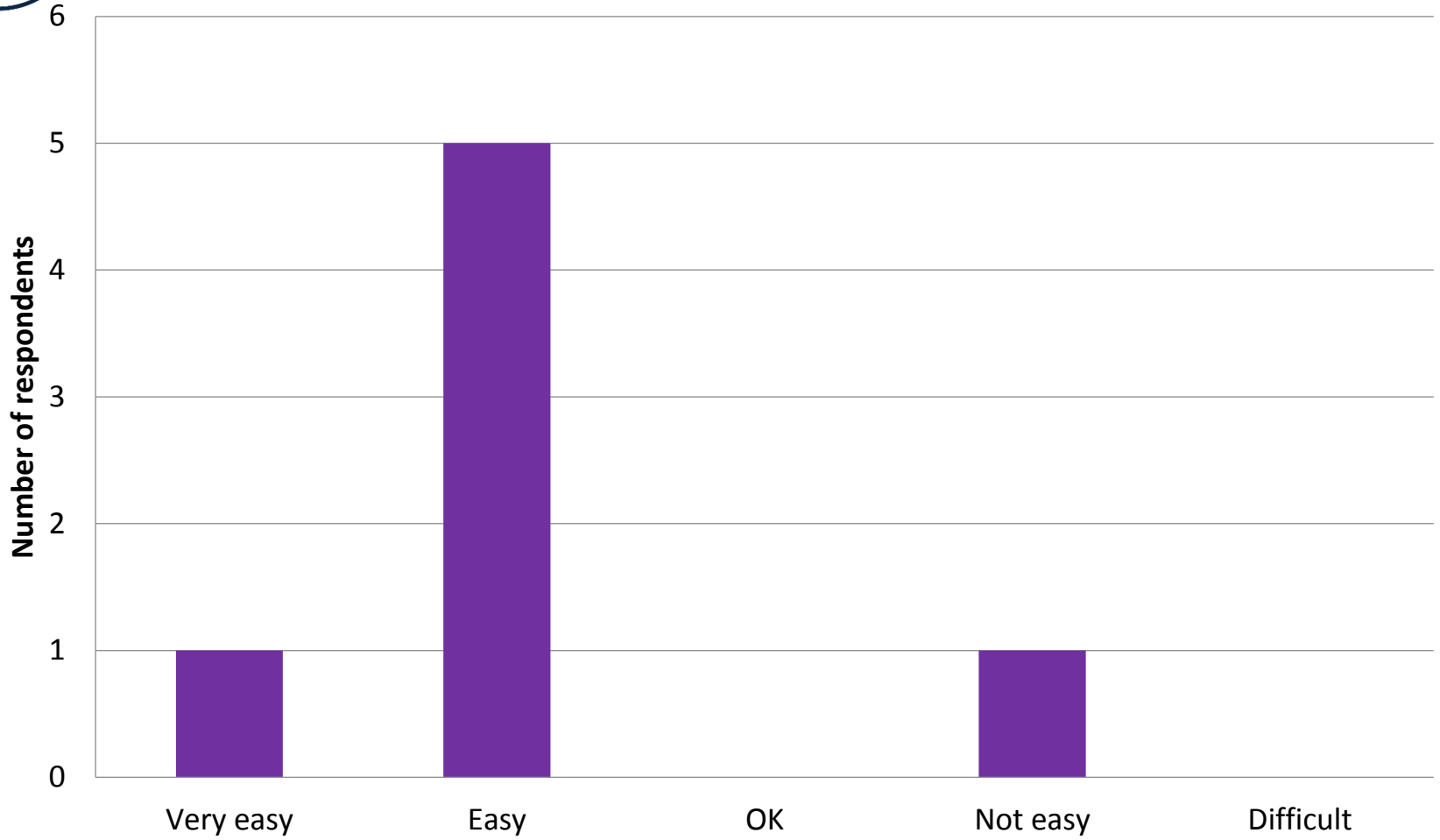
Hanak, D., Kolios, A., Fidalgo, B., McAdam, E., Parker, A., Williams, L., Tyrrel, S., Cartmell, E., (2016) Conceptual energy and water recovery system for self-sustained nano-membrane toilet , *Energy Conversion and Management* 126, 352-361

User perspectives

- Surveys with prospective users in Ghana have informed development

Larsson, J., Tierney, R., Goffin, K., Kolios, A., McAdam, E., Parker, A., Williams, L., Tyrrel, S., Cartmell, E., Translating Insights from Ethnography on Low-Income users of Bucket Collection Toilets in Ghana, Journal of Water, Sanitation and Hygiene for Development, accepted subject to revisions

User testing in the UK



Users responses to the question “how easy was the toilet to use?”

a.parker@cranfield.ac.uk

www.nanomembranetoilet.org

#nanomembrane

www.cranfield.ac.uk