Resource recovery via distributed biogas production

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Sustainable Bioenergy
Solutions for Tomorrow

TAMPERE UNIVERSITY OF TECHNOLOGY

NATURAL RESOURCES INSTITUTE FINLAND

Our vision

A society built on sustainable bioeconomy.
Our expertise creates a knowledge-base for sustainable growth and well-being.

Global megatrends

Sufficiency of bio-based raw-materials — Global climate-change — Circular economy — Biodiversity and sustainability of natural resources — Blurring boundaries between industrial sectors — Population growth in developing countries — Population ageing in the developed countries

Our vision

Natural Resources Institute Finland is a research and expert organisation. The institute promotes bioeconomy and sustainable use of natural resources.

Research focus

- Boreal green bioeconomy
- Blue bioeconomy
- Innovative food chain
- Natural resources economy in the society
- Statutory and expert services

Strategic goals

- New biobased products and business opportunities
- Productivity by digitalization
- Healthier food profitably
- Regional vitality by circular economy
- Wellfare from immaterial values

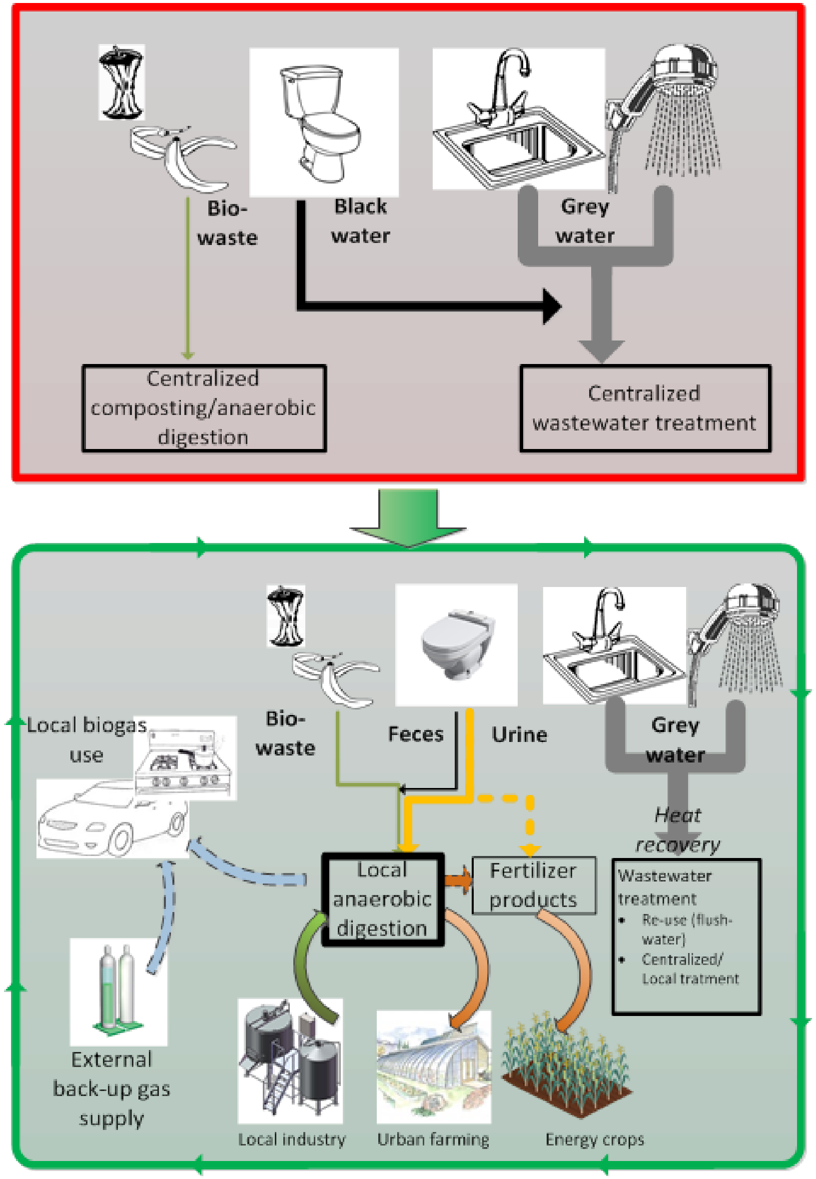
Our values

- Trust and transparency
- Strength from collaboration
- Customer orientation
- Smart actions

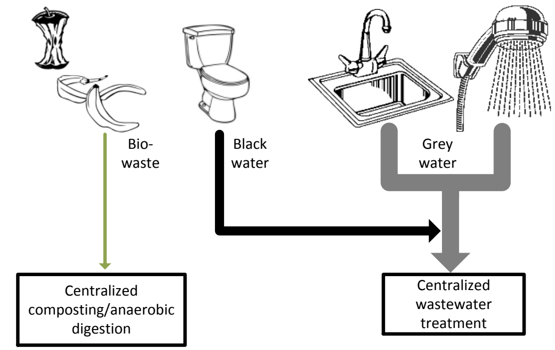
Introduction

- Conventional and resource recovery collection systems of household wastes

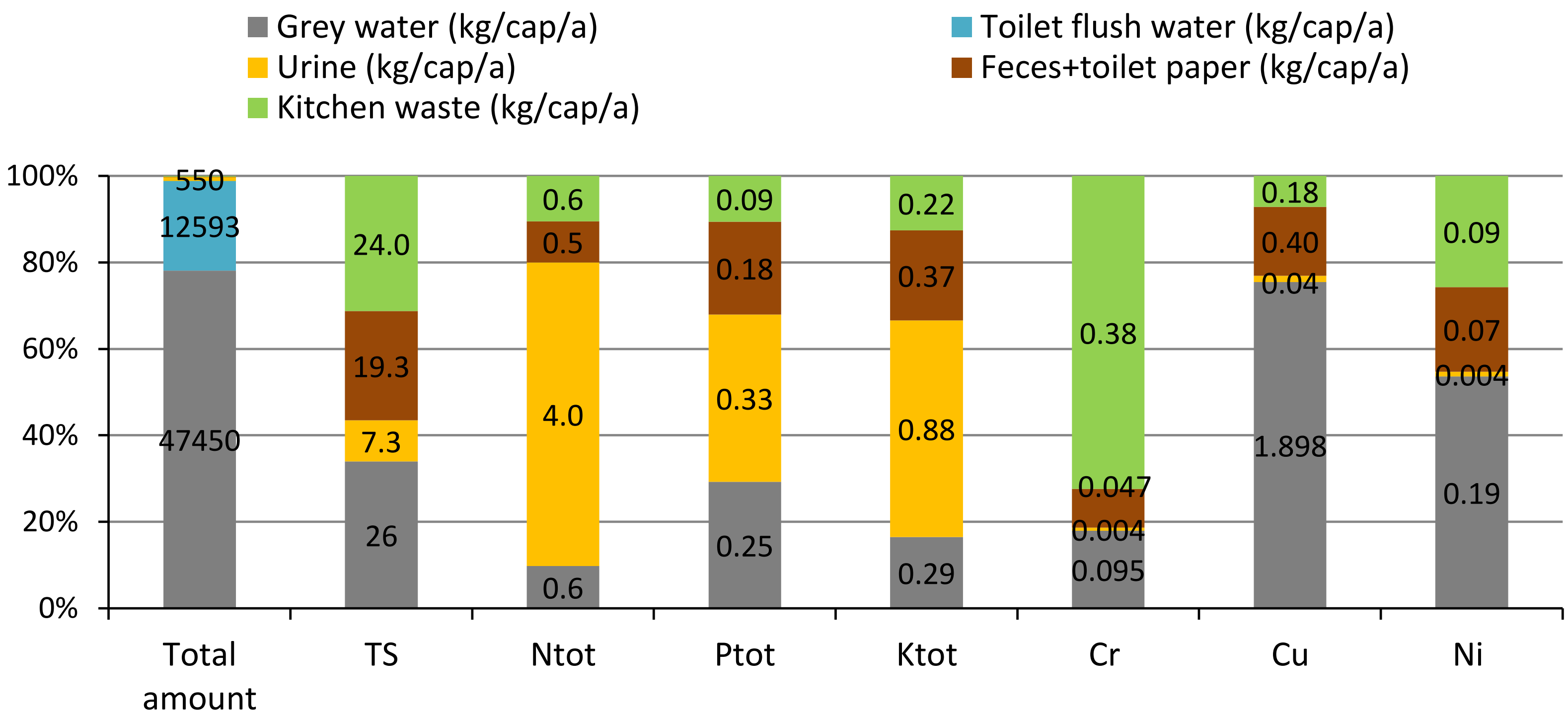
- The objective was to calculate the technical potential of a decentralized circular system for a residential area of about 10,000 people



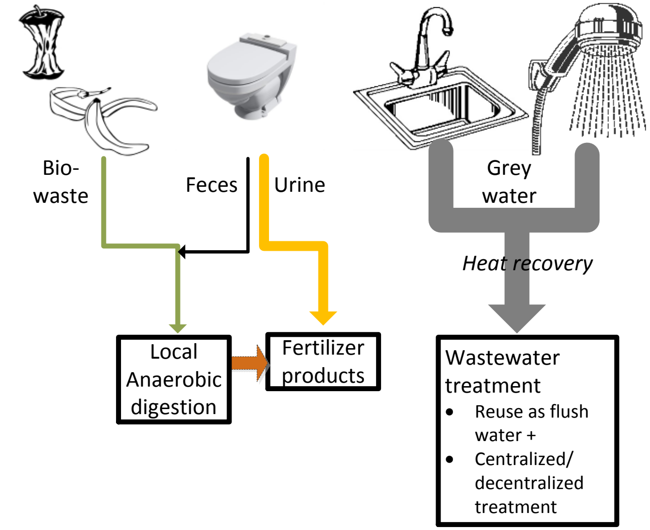
Resource recovery potentials from household wastes



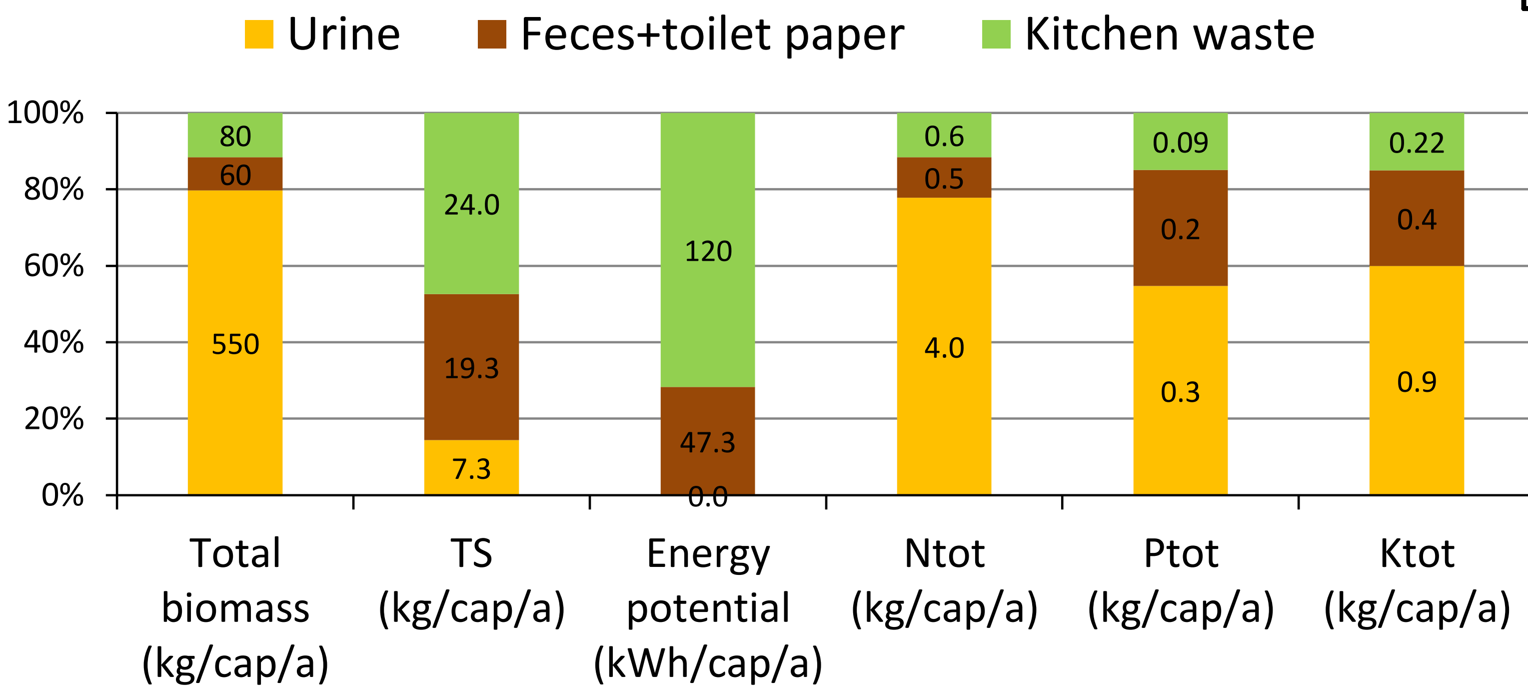
- The share of volumes, nutrients and heavy metals between household waste streams



Resource recovery potentials from household wastes



- The share of total weight, energy potential (as methane), and nutrients between household waste streams



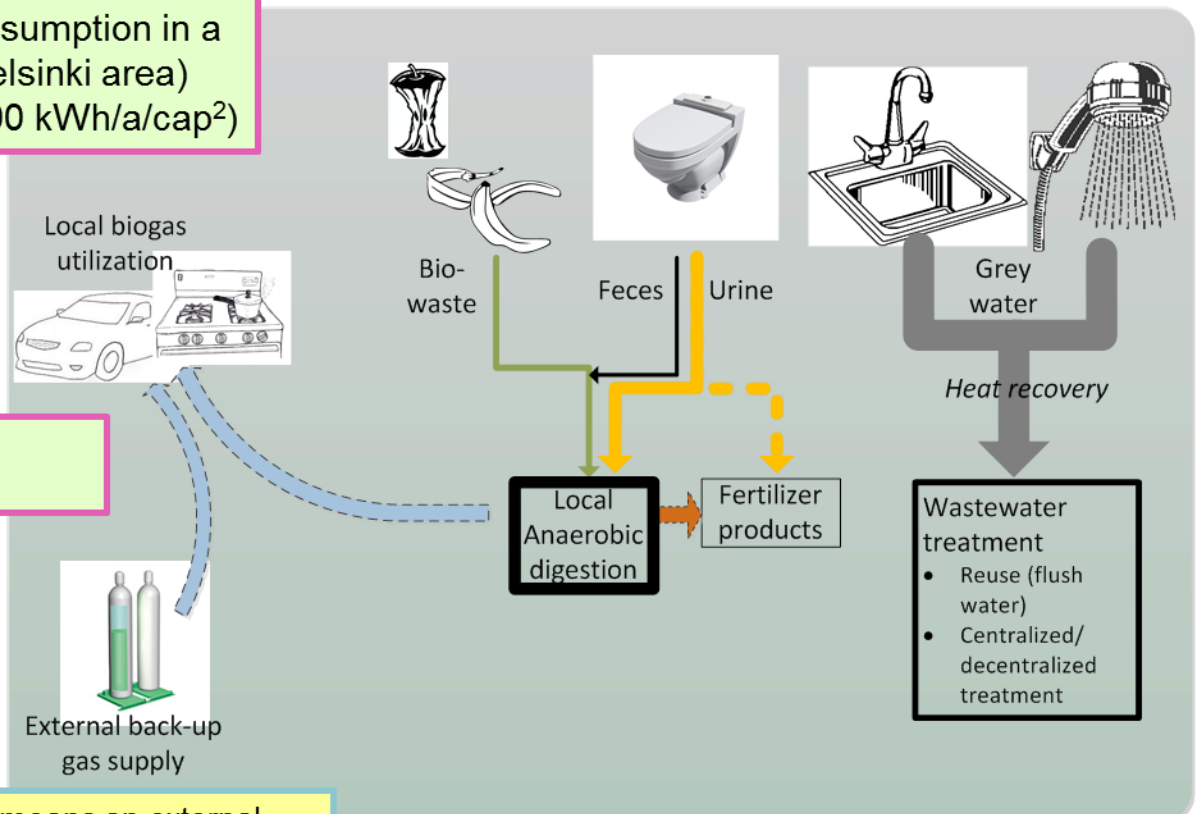
Primary energy potential of household wastes in 10 000 resident example area

1.7 GWh/a (167 kWh/a/cap)

- 2% of average heat and electricity consumption in a residential area (8,500 kWh/a/cap[1], Helsinki area)
- 0.7% of all energy consumption (23,400 kWh/a/cap[2])

For 2,772,000 km driving
~140 gas vehicles
(4.3 kg/100 km–20,000 km/a/vehicle)

Or gas for 9,900 gas stoves
(Estimated consumption 1 kg/month/gas cooker)



In vehicle use, local production of **4.2% of need** means an external supply is required
(Assumed 0.33 vehicles/cap (Helsinki, 2014) → 3,300 vehicles)[3]

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Additional local biomass sources

- Scenery fields (26 ha)
- Greenhouse cultivation of tomato and cucumber (3000 m^2)
- A Micro-brewery (500 000 L/a)

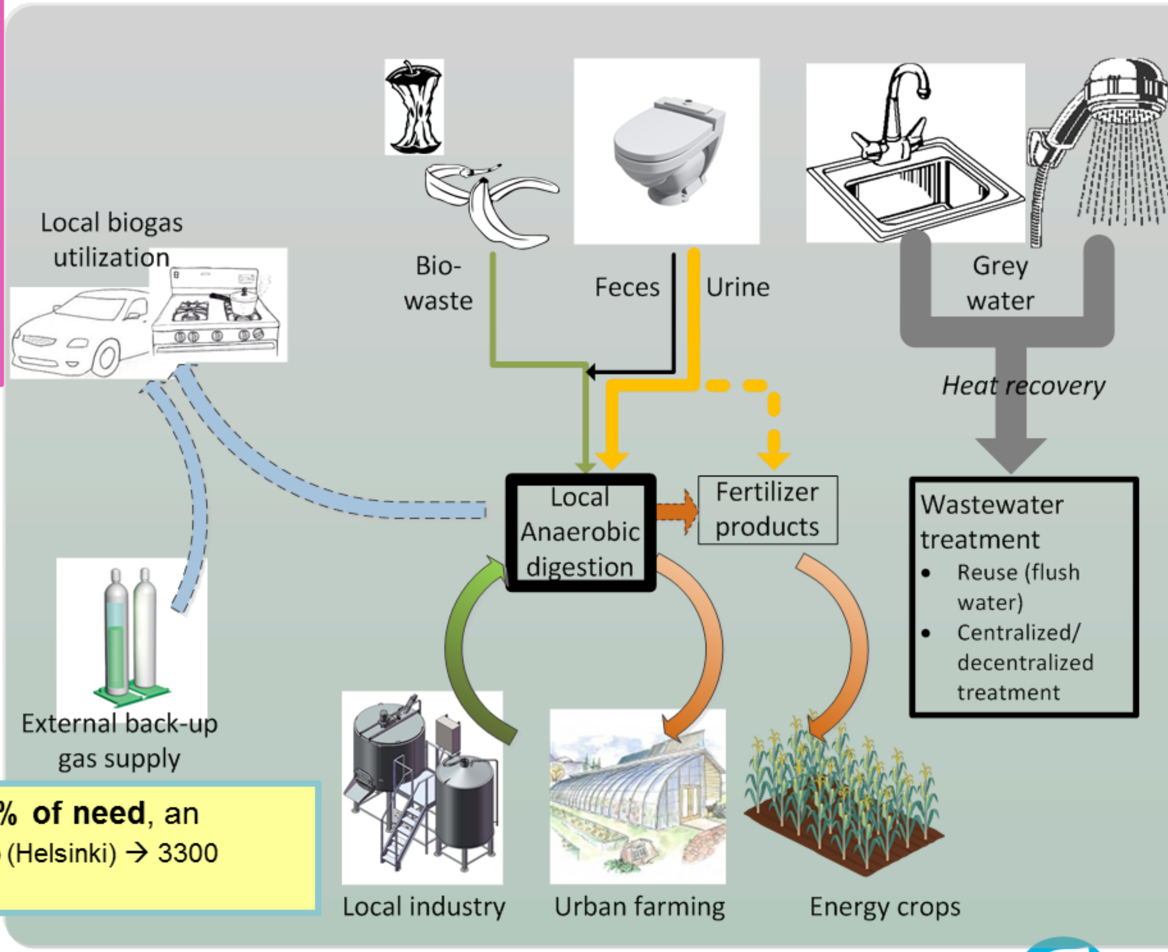
Primary energy potential of household wastes, energy crops, greenhouse residues and brewery residues

2.6 GWh/a (grass)–3.5 GWh/a (maize)

- 3.1– 4.1% of average heat and electricity consumption in a residential area (8,500 kWh/a/cap[1], Helsinki area)
- 1.1–1.5% of all energy consumption (23,300kWh/a/cap[2])

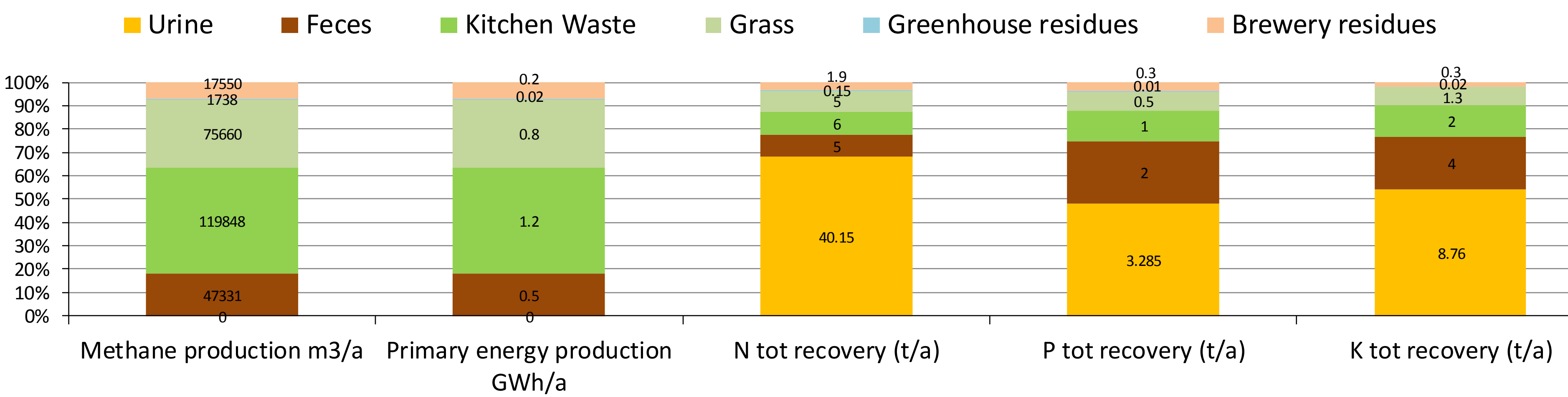
For 4,343,000–5,789,000 km driving
Gas for 217/289 gas vehicles
(4.3 kg/100km–20,000 km/a/vehicle)

Gas for 15,000/21,000 gas stoves
(Estimated consumption 1kg/month/gas cooker)



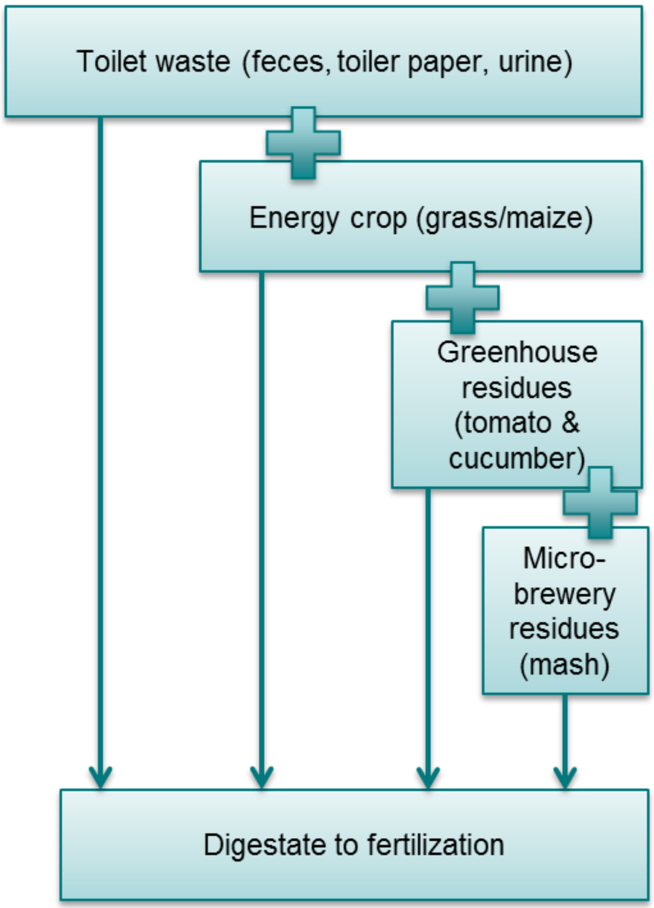
In vehicle use, local biomethane production of **7–9% of need**, an external supply is required (Assumed 0.33 vehicles/cap (Helsinki) → 3300 vehicles).

The share of methane production potential and nutrients in household waste streams, plant biomass (grass as an example), greenhouse residues, and brewery residues



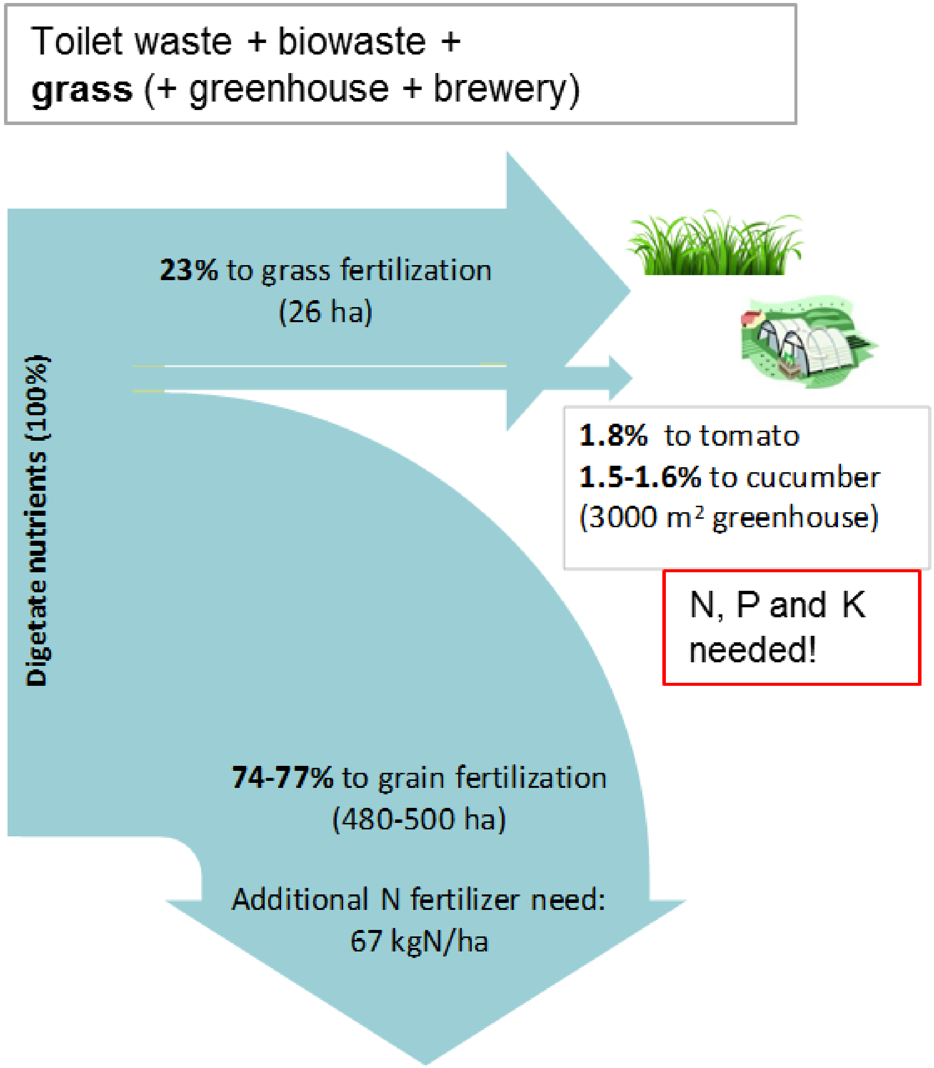
Digestate nutrient utilisation

- What is the effect of different digester co-feedstocks on the digestate nutrient value and potential in crop fertilization?
- Does the digestate from the theoretical digester provide sufficient nutrients for the fertilization of the energy crops (to increase the energy potential of the digester) and for the fertilization of greenhouse-grown vegetables produced for the inhabitants of the area?



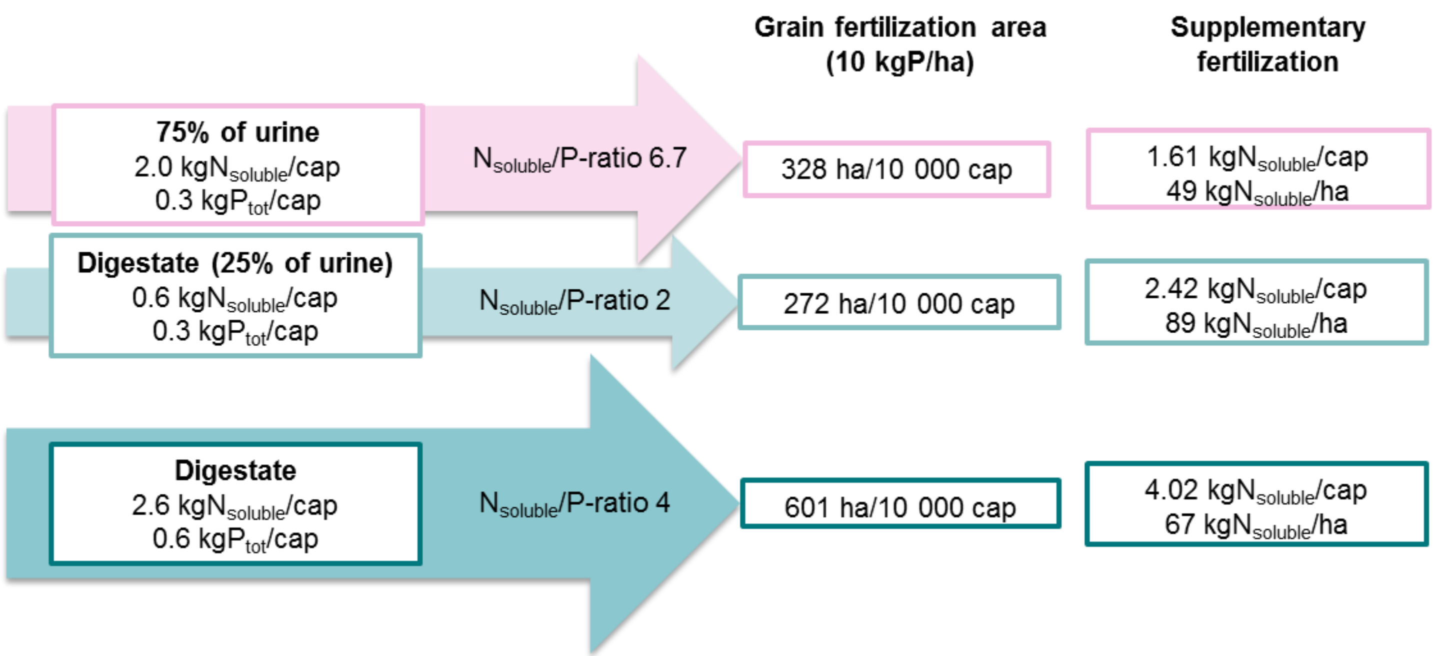
Utilisation of digestate nutrients

- 100% of the digestate nutrients from the digestion of only biowaste and toilet waste were assumed to be utilized in grain crops fertilization
- The residual digestate was assumed to be used in the fertilization of grain crops outside the planned city area



Overall, the digestate nutrients from different studied AD feedstock and co-feedstock cases can be utilized in the fertilization of energy crops and greenhouse vegetables in the studied region, while the residual digestate could be utilized in the fertilization of, e.g., grains in the nearby agricultural fields.

The effect of urine separation on the fertilizer potential



- Urine contains high amount of N and P which could be utilized in agriculture without anaerobic digestion
- Assumed urine separation capacity 75%
- The sole urine could be used to fertilize 330 ha of grain fields

Conclusions

- There is potential to decrease water use and to obtain a semi-closed nutrient cycle by utilizing residential biowaste and black water from a new sanitation system
- Total primary biogas production potential from human waste, biowaste is relatively small but the indirect benefits like decreasing the water use brings savings in waste water treatment and clean water manufacturing
- The cultivation of energy crops in the local scenery fields and vegetables in greenhouse increases the methane production and nutrient use
  - Excess nutrients still remain to be used in crop production

Thank you!

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