Popular scientific abstract

Modern municipal solid waste (MSW) management makes crucial contributions, besides protection of the environment and human heath, to resources conservation through recycling of materials and plant nutrients, and to climate change mitigation through waste-derived energy utilization, which avoids utilization of fossil fuels. The framework conditions around the waste sector are however changing and will continue to change considerably in the future, from: (1) a substantial increase in focus on material efficiency and the "circular economy", which puts priority on waste prevention and recycling, to (2) increased integration of renewable and fluctuating energy source in the energy system, which calls for reassessment of the role of waste-to-energy (WtE) technologies, to (3) measures that will establish a well-functioning European waste market, aimed at the optimal utilization of treatment capacities. Comprehensive and strategic waste management planning is more important than ever and should address future background conditions in order to avoid miss-optimization and/or technological lock-in effects.

This PhD work revisited the concept of waste central sorting and investigated its role and implications as a key waste management technology for strategies that aim at achieving both resource and energy recovery optimization and to minimize climate impacts of waste management in the context of future framework conditions. Central sorting are approaches based on mechanical processing (e.g. materials recovery facilities), which have the aim to separate materials for subsequent dedicated treatment, such as: (1) sorting of materials that can be recycled, (2) biodegradable organic fractions that can be treated through biological processes, and (3) material fractions with energy contents suitable for utilization as solid waste-derived fuels.

During this work, alternative waste management systems based on central sorting were designed, simulated and evaluated through systems analysis methods (mass and energy flow analysis, techno-economic analysis and carbon footprint). Environmental and resource implications were measured in the context of changing background conditions (simulated through a large number of scenario variations). A number of conditional synergies and indirect effects occurring in background systems due to waste management decisions were identified and modelled for the first time.

Central sorting concepts were found to be technically feasible solutions to both materials recovery and converting remaining mixed waste to (partially) storable waste-derived fuels, which can be used for flexible production of power and heat. The utilization of waste-derived fuels ensures, by providing peak demand production, a better integration of waste-derived energy in background energy systems based on large shares of renewable but also fluctuating sources such as wind and solar. Results indicated that these systems, compared to current approaches, consistently displayed significantly higher environmental and economic benefits in framework conditions reflecting possible long term development. This was connected both to better systems integration of energy production and to synergetic effects with other adjoining systems.