Energy
National Research Programmes 70 and 71

Project

Waste management to support the energy turnaround

What our waste can contribute to the energy turnaround

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There is a great deal of energy in waste that can be recovered. However, the energy yield could be bigger. What would be necessary to achieve this was investigated in a joint project. And an analysis was also conducted to identify which political conditions need to be considered for the implementation of the proposed measures.

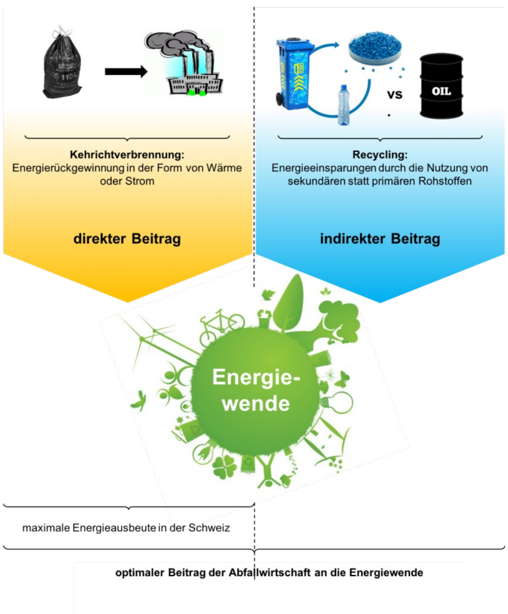
The positive side of waste: at the Hagenholz waste incineration plant in Zurich (right), the incineration heat is captured and utilised. Together with the Aubrugg wood-fired power plant (left in the image), the plant supplies the majority of the district heating grid of the city of Zurich. *Source:* Melanie Haupt, ETH Zürich

At a glance

- Significantly more energy can be recovered from the waste from Swiss private households and the industrial sector than is currently the case. This is shown by a comprehensive investigation conducted by researchers at ETH Zurich.
- The research team has also determined which measures and framework conditions are needed in order to optimise the energy yielded from waste recovery.
- Moreover, in two sub-projects, the team analysed the financial flows and political processes in the waste management sector and outlined how support could be provided to put the proposed measures into practice. The results should provide the stakeholders in the waste management system with a basis for discussion.

Waste is not useless rubbish. Energy that can be recovered is contained in the variety of waste from Swiss private households and the industrial sector. This already takes place through the use of heat and electricity from incineration plants and the recycling of materials – including paper, cardboard, glass, metal, PET, organic waste and, to some extent, plastic. However, a great deal of energy is still lost in the recovery chains. “This could be changed by optimising waste management to ensure that it yields the greatest possible amount of energy and has the smallest possible negative impact on the environment”, says Stefanie Hellweg, an environmental engineer at ETH Zurich. “This would allow waste management to make a much bigger contribution to the energy turnaround”. Together with her research team, two other teams from ETH Zurich and a team from the University of Applied Sciences and Arts Northwestern Switzerland, Hellweg investigated what would be required to this end as part of a joint project.

The researchers initially determined what waste is actually being generated in Switzerland and what is happening with it in the existing recovery processes. They conducted material flow analyses and energy flow analyses for all waste recovery processes in Switzerland and in doing so recorded all transport and storage processes as well as all energy flows within the recovery chains. They also modelled all recycling and incineration processes using computers. Moreover, the environmental engineers calculated all environmental impacts of the various types of waste and their recovery in a total of 190 life cycle analyses. This allowed them to simulate the influence of possible optimisation measures in a targeted manner.



Waste recovery measures see energy recovered in two ways: firstly, directly in incineration and biogas plants where the energy is siphoned off as heat, gas or electricity and, secondly, through recycling, which sees recovered materials replace new raw materials.
Melanie Haupt, ETH Zürich

Best energy suppliers: private waste and the chemical industry

The results showed that more than half of the usable energy from waste is stored in so-called municipal waste, i.e. in waste from private households or waste with a similar composition from industrial enterprises. In a first sub-project, the researchers therefore took a closer look at the recovery of this municipal waste and determined where the greatest potential for improvement exists.

In a second sub-project, the researchers looked at industrial waste. Here, they identified waste from the chemical industry as the biggest energy store and drew up measures for siphoning off more energy from this source.

The sub-projects three and four finally examined the practical implementation of the improvement measures identified by the research teams: on the one hand, they analysed the financial flows of existing recovery chains and the conditions that would be necessary in order to optimise them with a view to gaining the best possible energy yield. On the other, they scrutinised the political framework conditions for such a transition.

Firstly: municipal waste

In Switzerland, each person creates an average of 700 kilograms of waste per year. Half of this is recycled, while the rest is incinerated. Both processes recover energy: the thermal energy from the incineration plants can be used in industrial production processes, for the heating of buildings or entire settlements and the production of electricity. And in the case of recycling, the reused materials replace new raw materials and thus indirectly ensure a positive energy balance.

At present, 30 petajoules of energy is recovered each year from the incineration of waste. This equates to the calorific value of more than 700,000 tonnes of crude oil. By comparison: according to the overall Swiss energy statistics of the Swiss Federal Office of Energy for 2018, Switzerland's total energy consumption stands at 830 petajoules. The energy recovered from the incinerated waste thus covers around 4 % of the country's energy requirements.

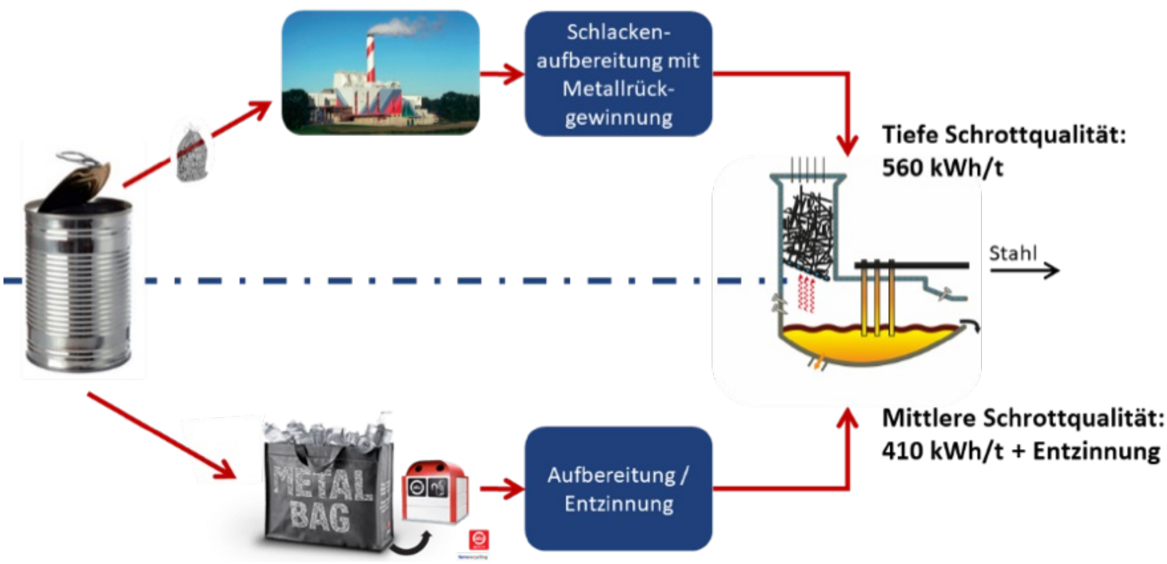
However, as the analyses now reveal, this figure could be made much higher. For example, the technical upgrading of incineration plants could make them more efficient. Furthermore, the waste heat could be used much more consistently by improving the situation with respect to the proximity of the plants to the consumers of thermal energy. They should be built in locations where, for example, industrial plants can use the heat throughout the entire year. Such consumers could also be situated around the incineration plants on a targeted basis.

Recycling, however, offers even greater energy recovery potential. This is because the reused materials replace new raw materials that would otherwise be obtained as part of energy-intensive processes. Nevertheless, the ETH researchers also identified potential for improvement in the area of recycling. For example, the materials could be recovered in a more energy-efficient manner than has been the case until now. In particular, the quality of the collected materials is decisive here. According to the analysis, the recycling of materials that have not been well separated or which are contaminated or damaged consumes more energy than is the case with high-quality recycling materials. The environmental engineers therefore recommend the more diligent collection, storage and processing of waste. For the recycling of paper, cardboard and glass, in particular, such improvements would pay off as they account for the lion's share of recycling materials. According to the calculations, these measures would allow for twice as much energy to be obtained from municipal waste than is the case at present.

Secondly: industrial waste

The analysis of industrial waste and its recovery chains revealed how important chemical and pharmaceutical companies are in this context. This is because liquid chemical waste is especially rich in energy. It accounts for a total of 18 % of the energy contained in industrial waste. And around 40 % of this energy, around 2.5 petajoules, is not yet utilised. While this is only a small amount relative to Switzerland's total energy requirements, the energy could be reused directly in the industrial plants in the form of steam that, for example, is used to drive turbines or as an alternative liquid fuel. In this way, the chemical waste would give rise to a double energy gain as it would replace primary energy sources – i.e. new energy sources that would otherwise have to be obtained with additional energy expenditure.

As a second hotspot in the area of industrial waste, the researchers investigated the recycling of steel and, in particular, the impact of the recycled material's quality. Result: the poorer the quality of the used scrap steel, the more energy that the recycling process consumes. The researchers therefore recommend that the material is prepared more carefully prior to being melted. This would allow for the electricity consumption of the recycling process to be reduced by around 100 kilowatt hours per tonne. After all, this equates to an energy saving of 18 terajoules – or 430 tonnes of crude oil.



Schematic illustration of the processes during the recycling of tinplate. Separate collection (below) yields better-quality material that can be recycled with lower energy consumption. In contrast, the recycling of tinplate from the waste incineration plant (above) consumes more energy. Melanie Haupt, ETH Zürich

Thirdly: cost-covering recovery

In order to analyse the financial flows in the area of waste recovery, the researchers created two so-called life cycle cost accounts – one for municipal waste and one for industrial waste. These models reproduce the income and expenditure of the various recovery chains and also show how the cash flows are related.

The researchers divided the funds into market-related funds, i.e. those from the purchase and sale of materials and energy, and into non-market-related funds. These include, for example, income from fees and subsidies or CO2 taxes.

In doing so, they wanted to determine whether the total costs of waste recovery are covered by the various sources of income. Result: extremely few recovery methods can be operated alone using the proceeds from the market. Additional financing is required from fees and taxes. And for some recovery chains, the estimated costs are not covered by the proceeds. “Snapshots of long-term investments that make the necessary assumptions show that this situation is also difficult to avoid”, says Christoph Hugi, head of this sub-project. “It is clear, however, that over the long term the balancing of income and expenditure will at least have to be maintained in order to ensure sustainable management”. The researchers therefore fed this financial data back into the computer models for municipal and industrial waste in order to check the costs of proposed optimisations.

Fourthly: how the transition will succeed

For changes in a process such as waste management that is so important for society and at the same time highly complex, there are legal procedures – as well as unwritten rules. A further ETH research team therefore analysed the political context of waste management. The researchers identified influential groups of stakeholders and investigated their positions.

Result: while there are no insurmountable rifts between the stakeholder groups, there are significant differences. For example, between private and state stakeholders and between recycling firms and the incineration plants or the cement industry. With respect to the influence of the stakeholders on the political processes, how many resources they have access to, in particular, is currently decisive. These include both financial resources as well as political power and authority. According to the analysis, greater transparency within the political processes will be key for the implementation of measures in future – these processes are still susceptible to lobbying. With greater transparency, on the other hand, financial means and power would become less important. This would see substantive arguments – for example from the scientific world – gain in influence.

Produkte aus diesem Projekt

- Kick-off Poster
  Date of publication: 09.10.19
- Sustainable waste and resource management to support the energy turnaround
  Date of publication: 09.10.19
- “Sustainable waste and resource management to support the energy turnaround”, SwissMEM
  Date of publication: 09.10.19
- “wastEturn – Abfall als Teil der Energiewirtschaft”
  Date of publication: 09.10.19
- "Forschen für die Energiezukunft" – Technology Meeting in Kooperation mit Swissmem
  Date of publication: 09.10.19
- Life Cycle Assessment in einer Kreislaufwirtschaft
  Date of publication: 09.10.19
- Analyse von Siedlungsabfällen bringt neue Erkenntnisse für das Abfallmanagement
  Date of publication: 09.10.19
- Sustainable Waste and Secondary Resource Management to Support the Energy Turnaround (wastEturn)
  Date of publication: 09.10.19
- Geschichten lesen im Abfall
  Date of publication: 09.10.19
- Wertvoller Abfall
  Date of publication: 09.10.19
- Aus Schrott wird neuer Stahl
  Date of publication: 09.10.19
- Linking energy scenarios and waste storylines for prospective environmental assessment of waste management systems
  Date of publication: 09.10.19

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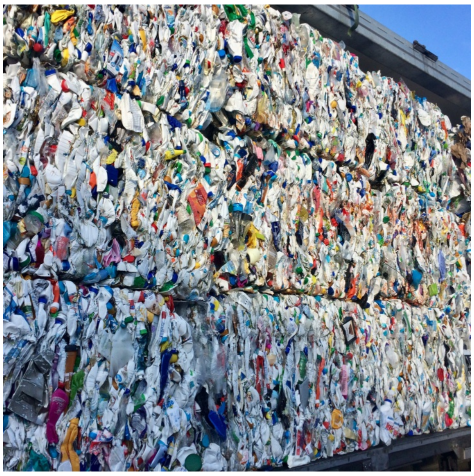
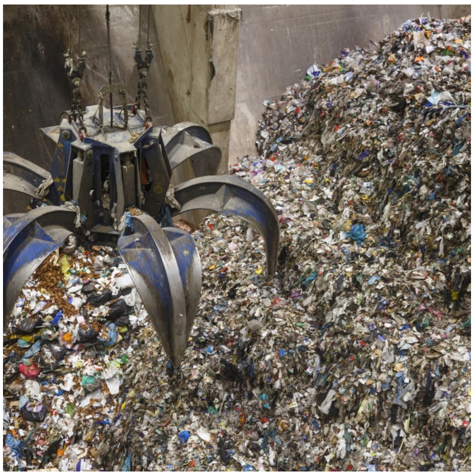
Connected projects



Energy recovery in waste management

Energy from waste: how as much as possible can be recovered



Waste-to-energy and resource recovery

Optimised waste incineration power plants

Economics of waste-to-energy systems

Making sure only combustible material reaches waste incinerators

Modernising waste management

How can environmentally friendly waste management be implemented?

All information provided on these pages corresponds to the status of knowledge as of 10.05.2019.