Energy
National Research Programmes 70 and 71

Project

Waste-to-energy and resource recovery

Optimised waste incineration power plants

Optimised waste incineration power plants

Waste from the chemical industry has to be transported from almost all facilities to incineration plants – this entails costs and negative environmental impacts. Researchers therefore developed a mathematical model to optimise disposal. It was shown that networked planning and investments in furnaces are important for making combustion more efficient.

Mountains of rubbish: suitable methods allow for the generation of electricity and heat. *Source:* Shutterstock

At a glance

- The so-called oxyfuel process is the best method for increasing the capacity of waste incineration power plants. Instead of air, the combustible material is burnt with almost pure oxygen.
- The environmentally harmful and hazardous transportation of waste by the chemical industry can be avoided if different waste incineration power plants plan together. In return, they could be exempted from CO_2 taxes.
- The electricity requirements for steel recycling are dependent on the scrap quality. High-quality scrap reduces electricity consumption by 40 % compared to low-quality scrap. Pre-treatment therefore makes sense.

Waste is valuable – in waste incineration power plants it is used to generate electricity and heat. It is not only waste from households that has a high calorific value, but rather also waste from the industrial sector – for example from the pharmaceutical and chemical industries. Only a few of these plants in Switzerland have their own incineration plants, however. This is why numerous companies have to transport their sometimes toxic waste to furnaces that have been set up for this purpose – sometimes even abroad. This transportation can be dangerous, generate costs and pollute the environment.

With clever planning, all of these factors could be improved. This is shown by a research project conducted by scientists at ETH Zurich. It has investigated various strategies for optimising energy consumption in the waste management sector. The scientists also analysed the influence of the material quality of steel scrap on the recycling process. Their aim was to improve the energy efficiency of waste disposal and thus to contribute to the fulfilment of Energy Strategy 2050.

Mathematical models developed

Firstly, the researchers calculated the energy potential of all hazardous liquid waste from the chemical industry in Switzerland: this amounts to 6.5 petajoules, of which 2.5 petajoules was neither used in the five investigated waste incineration plants (WIPs) nor in cement works. This equates to the energy content of approximately 62 million cubic metres of natural gas. It would make sense to utilise this potential domestically – this would eliminate environmentally damaging transportation. In particular, however, fewer auxiliary fuels would be required in WIPs and cement works. Overall, an optimisation could therefore lead to a significant reduction in energy consumption owing to transportation as well as the consumption of auxiliary fuels.

What is required is a networked view comprising all stakeholders. To provide a decision-making basis for this, the researchers have developed mathematical models. These take account of possible management decisions and technical limits as well as an expansion of storage possibilities and incineration capacities. In order to compare the different strategies, the researchers calculated various key figures for energy consumption, environmental impacts and economic viability in each model run. As the calculations required a great deal of computing power, the researchers carried out the optimisations at the "Swiss National Supercomputing Centre" in Lugano.

More oxygen and greater collaboration

The results showed that if all waste incineration plants worked optimally together, they could burn 8 % more waste and convert it into energy. A further 5 % more would be gained if the plants were upgraded with the oxyfuel process. In this process, pure oxygen is used instead of air to burn the waste, resulting in high flame temperatures. This allows for more waste to be incinerated – meaning that less transportation is required. The oxyfuel process also emits fewer nitrogen oxides than conventional incineration.

The various model runs showed that this expansion represents the best possible investment in all strategies. The researchers suggest that investments could be stimulated through an exemption from the CO_2 tax. Furthermore, subsidies for upgrades using the oxyfuel process could prove useful. The developed mathematical models provide a basis for such decisions.

Recycling of steel

In addition to optimising the waste networks, the researchers also focused on the recycling of steel, which can be recovered from the residual materials even after waste incineration. The amount of energy needed to reprocess the metal depends on the quality of the scrap used. The scientists analysed a large data set from the industrial sector in order to quantify the differences. It was revealed that the electricity requirements for a tonne of liquid steel vary between 386 kilowatt hours for the recycling of sheet steel and 559 kilowatt hours for steel residues in the so-called slag, i.e. the residues from the waste incineration – a difference of 45 %. In order to reduce electricity requirements, it would therefore make sense to pre-treat steel scrap of a low quality, in particular the scrap from the slag generated during waste incineration. The researchers write that significant savings could thus be made in terms of energy consumption.

Produkte aus diesem Projekt

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