The future of waste incineration in a modern circular economy

NABU study shows how waste prevention, recycling, and the implementation of existing waste legislation could significantly reduce waste incineration capacities needed in Germany.

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Summary

In a study conducted on behalf of NABU, the Oeko-Institut and Alwast Consulting set out to assess the status quo of waste incineration in Germany, looking at current waste incineration capacities, the composition of waste, as well as the future role of waste incineration in an ambitious circular economy. Per year, 26.3 million tonnes of waste is currently incinerated in 66 waste incineration plants and 32 refuse-derived fuel plants (RDF plants). The study's conservative estimate suggests that around 50 out of these 66 waste incineration plants will need to undergo modernisation by 2030. In three scenarios, the study then shows how the waste incineration capacities could be reduced from 26.3 million tonnes to 17 million tonnes. The scenarios comprise measures including the implementation of existing legislation, waste reduction, and improved separate waste collection. The study primarily focuses on biowaste, plastic waste, commercial waste, and bulky waste, all of which are fractions with significant potential for recycling and reduction. The study concludes by highlighting several measures that will help to fuel the transition towards circularity in Germany: binding waste reduction targets, minimum recycled content targets for producers, pay-as-you-throw schemes, and regional concepts to scale down those incineration capacities that are in need of modernisation.

Introduction

In the circular economy model, energy recovery from waste is the fourth level of the waste management hierarchy, behind waste prevention, preparation for reuse, and recycling. However, this legally binding waste hierarchy has so far failed to make an impression on the reality of how waste is managed and recovered. Prevention and reuse remain far from mainstream, and recycling is still in its infancy in some areas due to poor separate waste collection efforts, insufficient "design for recycling", underdeveloped sorting and recycling infrastructure as well as a lack of demand for secondary resources. As a result, large volumes of waste that could ideally be consigned to preferable reuse or recycling streams end up being combusted.

Energy recovery from waste definitely has a relevant role to play in waste management today. It destroys hazardous substances – or concentrates them in flue ash – and thus safely removes them from the material flows of our economy, playing a vital role in the current waste system. But in order to implement the waste hierarchy, the recovery of energy from waste needs to be limited to its actual function, i.e. the combustion of those types of waste for which no better recovery or prevention options are available.

NABU study

In recent years, both the German government and the EU have stepped up their efforts to promote the shift towards circularity. The EU's Circular Economy Package and German regulations such as the Packaging Act, the Commercial Waste Ordinance, the Circular Economy Act and the Waste Prevention Programme have created a first political and regulatory framework to reduce waste and increase recycling. In light of these developments, what role can energy recovery from waste play in a modern circular economy in Germany? Seeking responses to this question, NABU turned to the Oeko-Institut and Alwast Consulting and commissioned them to conduct a study, the results of which are presented in the following.

Download study (in German):
www.NABU.de/muellverbrennung-studie

Further information:
www.NABU.de/muellverbrennung

Status quo: Waste incineration in Germany

Incineration capacities

In Germany there are currently 66 incineration plants with a combined annual capacity of 20.6 million tonnes, and 32 refuse-derived fuel plants (RDF plants) with a combined annual capacity of 5.8 million tonnes. Refuse-derived fuel (RDF) is produced from recovered waste with higher calorific values than the mixed waste fractions typically combusted in waste incineration plants, and usually consists of waste fractions extracted during mechanical biological treatment (MBT) or recycling, or fractions of commercial and packaging waste. RDF is also used as an inexpensive source of energy in cement kilns as well as in coal and industrial power plants. Annually, some 3.6 million tonnes of waste are incinerated in German cement kilns. The volume of RDF combusted in the country's 17 lignite and hard coal power plants totals 800,000 tonnes, well below the approved total capacity, which is 3.3 million tonnes.

Waste inputs

In 2017, a total of 26.3 million tonnes of waste were combusted in waste incineration plants and RDF plants in Germany (Figure 1). At 9.9 million tonnes, the largest input is residual household waste, followed by an additional 9.1 million tonnes of RDF. Other input streams include commercial waste, imports, bulky waste and other waste fractions, such as hazardous waste and mixed construction and demolition waste.

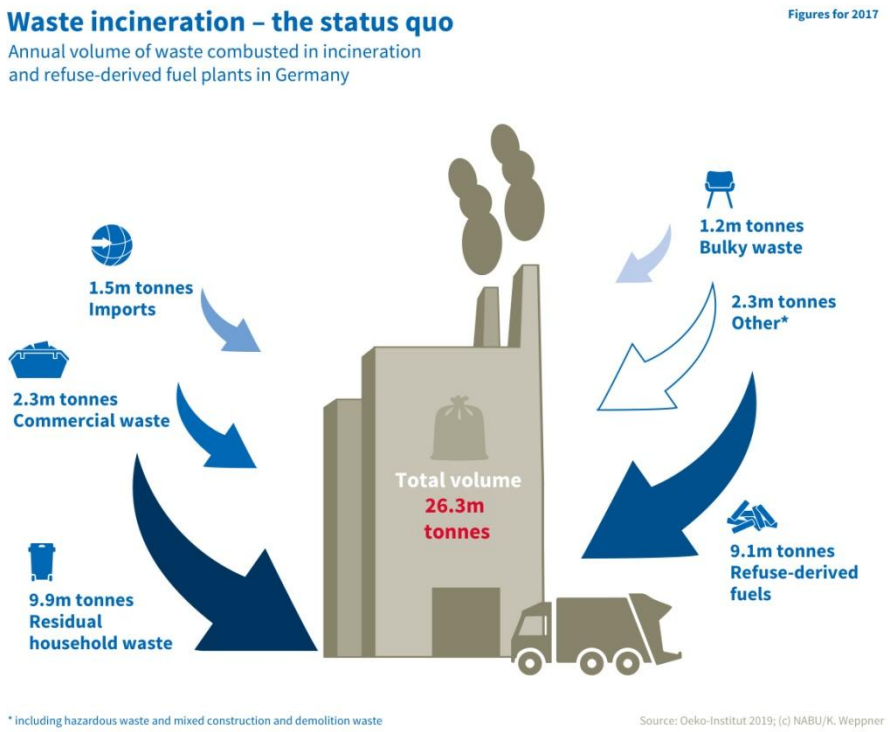

Figure 1: Waste incineration – the status quo. Diagram: NABU/K. Weppner

Technical equipment and modernisation

A majority of waste incineration plants will need to undergo modernisation by 2030. Assuming that, on average, a plant's incineration lines were last overhauled 30 years ago, the study identifies 49 out of 66 waste incineration plants – over 60% of the country's total waste incineration capacity – that will require modernisation in the coming decade. An incinerator's energy efficiency is calculated by determining its so-called R1 factor, a reference value taking into account the best available technologies for waste incineration. Currently, 59% of facilities achieve good energy efficiency (R1 > 0.8), while 41% are deemed less efficient (R1 < 0.8).

The combined rated thermal input of all waste incineration plants is 7.5 gigawatts. To put that into perspective: the total power harvested from photovoltaics in Germany amounts to around 45 gigawatts. In 2016, energy exported from waste incineration and RDF plants in the form of electricity, heat or steam totalled 136 petajoules, which corresponds to a 1.5% share of final energy consumption in Germany and 6% of final energy consumed by German households.

Waste incineration since 2009 and plans for future development

Between 2009 and 2019, the number of waste incineration plants dropped from 69 to 66, while modernisation and expansion helped to increase total capacity across Germany from 18.6 million tonnes to currently 20.6 million tonnes. The number of RDF plants rose from 20 to 32 and, in step with this, their total capacity expanded from 2.2 million tonnes to 5.8 million tonnes. As a result, total capacity has risen over the past ten years from 20.8 million tonnes to 26.5 million tonnes, i.e. by more than a quarter.

There are plans to erect new facilities or replace or expand existing ones and, if all these were to be implemented, total capacity would increase to 27.6 million tonnes by

around 2025. The largest among these projects is the new RDF facility currently being planned in Jänschwalde in Brandenburg. As Germany will shut down its coal-fired power plants by 2038, it will no longer be possible to burn RDF in the existing coal-fired facility in Jänschwalde, which is why the new plant will be designed to handle the 500,000 tonnes currently incinerated in the old facility.

Waste incineration in a modern circular economy

Given the political targets promoting the shift towards circularity, the question is whether investing in the modernisation of more than 50% of current incineration capacities over the next ten years is actually necessary. The NABU study therefore developed three scenarios to evaluate the potential to reduce waste incineration in Germany.

Scenario 1: Current legislation is fully implemented

Separate collection of biowaste became mandatory in Germany in early 2015. Yet 20% of districts have not implemented this fully – if at all.[1] In 2017, 4.4 million tonnes of biowaste, or 53.5 kg per inhabitant and year (kg/inh/yr), were collected from biowaste bins, alongside 5.7 million tonnes (67.4 kg/inh/yr) of biodegradable garden and park waste. Based on the assumption that 60 kg/inh/yr of biowaste and 144 kg/inh/yr of garden and park waste (green waste) could potentially be collected, and making sure to include only those waste quantities recovered from household waste bins, the study estimates that this waste fraction could be reduced by 3.7 million tonnes per year.

The German Packaging Act came into force in early 2019. Its newly introduced recycling quotas, e.g. 63% for plastic packaging waste by 2023, will increase the fraction of recycled packaging waste (made of plastic, composite materials, aluminium and metal) and conversely reduce the volume of waste delivered to incineration plants as RDF and sorting residues. This translates into a potential reduction of roughly 250,000 tonnes per year.

According to the Commercial Waste Ordinance of 2017, producers and owners of commercial waste are obliged to send their waste to a pre-treatment facility unless they can prove that 90% of their waste is kept separately and consigned to recycling. Pre-treatment plants have to send at least 30% of all commercial waste for recycling. In 2017, a total of 5.7 million tonnes of mixed commercial waste was produced, but currently only 5% of it is recycled.[2] This means that consistent implementation of the 30% target would potentially reduce waste by an additional 1.4 million tonnes per year, if not more.

Scenario 1 therefore shows that incineration capacities could be cut by more than 5 million tonnes simply by implementing existing legislation. This corresponds to one fifth of current capacities.

[1] NABU: Mehr Biotonnen braucht das Land, https://www.NABU.de/biotonne.
[2] Dehne, I. et al., (uec/Oeko-Institut): Stoffstromorientierte Lösungsansätze für eine hochwertige Verwertung von gemischten gewerblichen Siedlungsabfällen; ed.: German Environment Agency, Dessau-Rosslau, 2015.

Scenario 2: Existing legislation is implemented in conjunction with additional measures

Scenario 2 considers the impact of two additional measures that would complement scenario 1.

Currently, most German municipalities collect plastic and metal packaging waste separately in yellow bags or yellow bins. Other plastic and metal wastes, by contrast, usually end up in household or residual waste bins. The introduction of a nationwide recyclables bin for packaging and non-packaging could trigger a shift and allow larger quantities to be consigned to recycling. Allied with comprehensive local waste advisory campaigns and the introduction of pay-as-you-throw schemes, this could help reduce the total volume of residual waste by a further 1.25 million tonnes.

The second measure would be to increase the reuse and recycling of bulky waste through improved collection and recovery. 40% of bulky waste – 1.15 million tonnes annually – is currently incinerated. Based on best practices employed in Flanders (Belgium), reductions in Germany could divert as much as 600,000 tonnes of waste per year away from incineration towards reuse and recycling.

Scenario 2 would thus allow incineration capacities to be scaled down by 7 million tonnes, or one quarter of current total capacity.

Scenario 3: Successful transition towards an active circular economy

In scenario 3, waste incineration would be further minimised through the comprehensive collection of recyclables and biowaste as well as extensive waste prevention measures. The latter would include information and awareness-raising campaigns, the creation of nationwide infrastructures to promote reuse, and the setting up of new services, e.g. sharing. Local waste advisory campaigns, the nationwide introduction of recyclables and biowaste bins as well as pay-as-you-throw schemes in multi-storey dwellings would help to meet higher separate collection quotas for recyclables and biowaste. The scenario further assumes a slight population decrease and an increase in urbanisation, based on a study conducted by Oeko-Institut/DIFU for the German Environment Agency.[3]

Residual waste volumes could be reduced by an estimated 37% by 2030 in urban districts, where an average of 153 kg/inh/yr would be generated. In sum, actively implementing all waste management options in Germany would amount to a 43% reduction, from an average of 193 kg/inh/yr in 2012 to 110 kg/inh/yr by 2030.

In addition, the scenario estimates that minimised volumes of residual household waste treated in MBT plants would reduce the quantities of RDF produced by such facilities by 400,000 tonnes per year. Looking beyond Germany, EU measures would also promote the creation of recycling capacities in neighbouring countries that currently still export waste to Germany for incineration, removing the need for these exports.

Scenario 3 would therefore see incineration capacity requirements reduced by more than 9 million tonnes. This corresponds to more than one third of current capacity.

[3] Buchert, M. et al. (Oeko-Institut/DIFU): Demografischer Wandel und Auswirkungen auf die Abfallwirtschaft; ed.: German Environment Agency, Dessau-Rosslau, 2018.

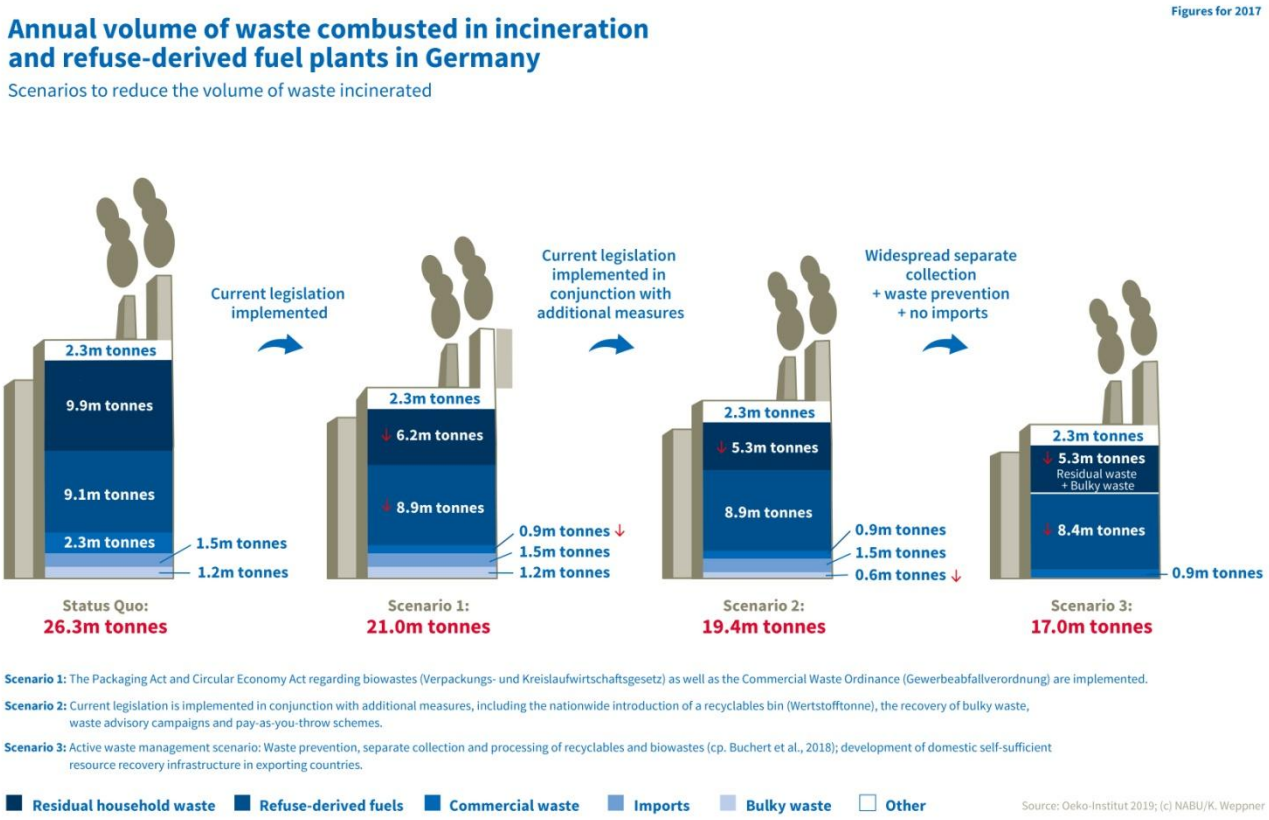

Figure 2: Reduction of residual waste consigned to incineration. Diagram: NABU/K. Weppner

A comparison of the potential reductions outlined above with the investments required to modernise waste incineration and RDF power plants puts the volume of remaining residual waste at 17 million tonnes per year, as opposed to a capacity of 13.8 million tonnes per year in existing facilities that do not require modernisation. This means that only 3.2 million tonnes of incineration capacity per year would actually require modernisation, instead of the projected 12.5 million tonnes per year. These savings could be channelled into projects to modernise circular economy infrastructure.

In addition, each scenario would make a significant contribution to curbing climate change:

- → Scenario 1 would reduce CO_2 emissions by an estimated 3.6 million megagrams per year (Mg/yr),
- → Scenario 2 would reduce CO_2 emissions by around 8 million Mg/yr, and
- → Scenario 3 would reduce CO_2 emissions by more than 8 million Mg/yr.

High-quality recycling of plastics has the greatest potential to cut CO_2 emissions, saving between 1.5 and 2.5 tonnes of CO_2 per tonne of plastics. By contrast, incineration causes additional emissions of approximately 1 tonne of CO_2 per tonne of plastics, even after deducting the energy recovered in the form of electricity and heat.

Recommendations and conclusions

Waste prevention and reuse

Efforts to promote the first two levels of the waste hierarchy need to be stepped up, and wealth must be effectively decoupled from raw material consumption. Legal guidelines should reflect this aim, which is why a waste prevention target for all municipal waste in Germany should be introduced, initially set at 5%, but subsequently increased to at least 10% within 10 years, based on the volume generated per capita.

Better eco-design guidelines can also help to promote waste prevention. Product responsibility must be extended, and manufacturers must be pushed to integrate resource conservation, multiple use, durability, reparability and updateability as well as harmless and high-quality recycling into their design processes. “Right to repair” schemes must enable consumers to mend products themselves or have them easily and affordably repaired by independent professionals.

Reuse infrastructures need to be improved. A major obstacle blocking preparation for reuse efforts is reuse actors’ lack of access to collection points. Cooperation between reuse actors and public waste disposal companies needs to be improved, and separate collection of recyclable devices must be made mandatory.

Separate collection and recycling

High-quality recycling cannot be implemented if different types of waste are not collected separately. To begin with, existing legislation must be fully implemented. Biowaste bins must become mandatory for all households throughout Germany, with exceptions for residents who can demonstrate that they meet appropriate home composting standards.

Authorities urgently require additional staff to ensure proper enforcement of the Commercial Waste Ordinance. While companies are obliged to keep their commercial waste fractions separately, monitoring of these obligations is generally inadequate, and sometimes even non-existent. This places an unnecessary burden both on the environment and on those companies that may find themselves at a competitive disadvantage as a result of meeting these obligations.

Local waste advisory campaigns and waste disposal charges are two important instruments for promoting separate waste collection. Ongoing waste advisory services should be provided by municipalities and waste disposal companies and become mandatory, which is why minimum requirements regarding the frequency and quality of such advisory services need to be set out. Pay-as-you-throw schemes can help to improve waste separation in households. Studies show that such schemes reduce the volume of residual waste, especially in multi-family dwellings and residential blocks. They would also help prevent waste.

No ambitious targets exist to stimulate the reuse and recycling of bulky waste and used textiles. Mandatory collection and recycling quotas must be set to maximise the recovery of reusable materials from these wastes, and the incineration of untreated waste must be banned. Fast fashion must be addressed, ideally in the form of an end-of-life textiles regulation that assigns financial responsibility for textiles placed on the market and for the take-back of used textiles.

Given the far-reaching environmental and social impacts of the extraction of rare metals and the use of hazardous substances, the collection of WEEE (waste electrical and electronic equipment) will have to be improved. In the medium term, a deposit on small electrical appliances must be introduced and customer-friendly take-back systems must be extended by establishing a network of designated collection points. Output-based recycling quotas are needed for specific materials, especially for critical metals and plastics.

There are still major (technical) challenges and reservations regarding the use of secondary raw materials, especially plastics. Minimum recycled content targets for plastics would encourage the emergence of a secondary raw materials market and simultaneously increase the quality and quantity of recycled materials. In addition, a levy should be imposed on the primary materials that continue to be used in order to incentivise producers to increase the share of recycled materials in their products and exceed the minimum quota. Public procurement should also focus on circularity and increase demand for recycled materials in products and packaging.

Energy recovery

Incineration plants are set to remain a relevant pillar of waste management in the medium term. However, total capacity in Germany must be scaled down to reflect the general decline in demand for incineration capacity in a modern circular economy. Plants requiring modernisation, in particular, must undergo assessment prior to being updated. All stakeholders must cooperate to develop regional recycling systems and a network of reduced incineration capacities distributed according to actual demand. The funds freed up by this downsizing – amounting to millions of euros – should be invested in recycling infrastructure.

Waste incineration and the energy transition

As Germany transitions towards a nuclear-free and low-carbon energy economy, the share of energy recovered from waste will gradually shrink. For electricity, this will already be the case in the near future. Regarding the provision of heat in winter, waste incineration can temporarily help to replace the contributions coming from those coal-fired plants that will be shut down. However, since coal's contribution to heating has already dropped to a mere 3.5%, it can easily be replaced by improving thermal insulation and increasing the share of renewables. What is more, the CO_2 emissions caused by waste incineration are at least as high as for heat generated from gas, which accounts for the vast majority of heat generated in Germany today.

In current political debates, incineration is often falsely described as carbon-neutral, sharing the same advantages as energy from renewables. This view completely ignores the amount of fossil carbon locked in municipal waste. What is more, the incineration of fossil-based plastics is currently not taxed, which is tantamount to subsidising a practice that harms the environment. In order to create economic incentives that promote the separate collection of waste and, indirectly, eco-friendly design, policymakers will have to introduce an energy tax on plastic waste sent for incineration.

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