# Sustainable management of C&D waste - reducing the source to ozone depletion and global warming

**Kjeldsen, Peter**

*Published in:*
Proceedings CRETE 2016, Fifth International Conference on Industrial & Hazardous Waste Management

*Publication date:*
2016

*Document Version*
Publisher's PDF, also known as Version of record


# SUSTAINABLE MANAGEMENT OF C&D WASTE – REDUCING THE SOURCE TO OZONE DEPLETION AND GLOBAL WARMING

P. KJELDSEN

*Department of Environmental Engineering, Technical University of Denmark, Bygningstorvet, DK-2800, Kgs. Lyngby, Denmark*

SUMMARY: Large quantities of construction and demolition waste (C&D waste) are produced. Buildings in many countries are thermally insulated by insulation foam containing large amounts of fluorocarbons (chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HCFCs), which are strong ozone depleting substances and/or greenhouse gases. The fluorocarbons are released extremely slowly during use. Therefore, the insulation material will still contain large quantities of fluorocarbons when the buildings reach the end-of-life and are demolished. A protocol for managing insulation foam waste in Denmark developed by DAKOFA (The Waste and Resource Network Denmark) gives recommendations on sustainable management of insulation foam waste including mapping of insulation foam waste in buildings, and further management during demolishing and recycling of the C&D waste in order to reduce the release of the harmful substances.

*Proceedings CRETE 2016, Fifth International Conference on Industrial & Hazardous Waste Management*
*Chania – Crete – Greece; 27 – 30 September 2016*
*ISBN: 978-960-8475-24-3*
*ISSN: 2241-3138*

## 1. INTRODUCTION

Construction and Demolition waste (C&D waste) is becoming a major waste type in many regions in the world. The latest Danish waste statistics showed that C&D waste now contributes with 40% of the total waste mass and was also the waste type with the highest annual increase in waste amount. There is an increasing incentive to recycle C&D waste with focus on valuable metals and concrete.

Demolition waste will in many regions of the world contain insulation material waste consisting of polystyrene or polyurethane foam containing large quantities of chlorofluorocarbon (CFC), which was used as a foam blowing agent (BA). The insulation waste may also contain hydrochlorofluorocarbons (HCFCs) or hydrofluorocarbons (HCFCs), which were used when the use of CFCs was banned according to the Montreal Protocol. CFCs (CFC-11 in polyurethane and CFC-12 in polystyrene) were used until 1994, when they were completely replaced by HCFCs (Trap et al., 2006). HCFCs (mainly HCFC-22, HCFC-141a and HCFC-142b) have been used in the period 1991-1994, after which HFCs took over (particularly HFC-134a and HFC-152a). HFCs were banned for use as a foaming agent from 2002, and was in practice already phased out during 2000 to 2001, where they were replaced by substances (especially different aliphatic hydrocarbons) with no adverse effects on the atmosphere, (Trap et al., 2006).

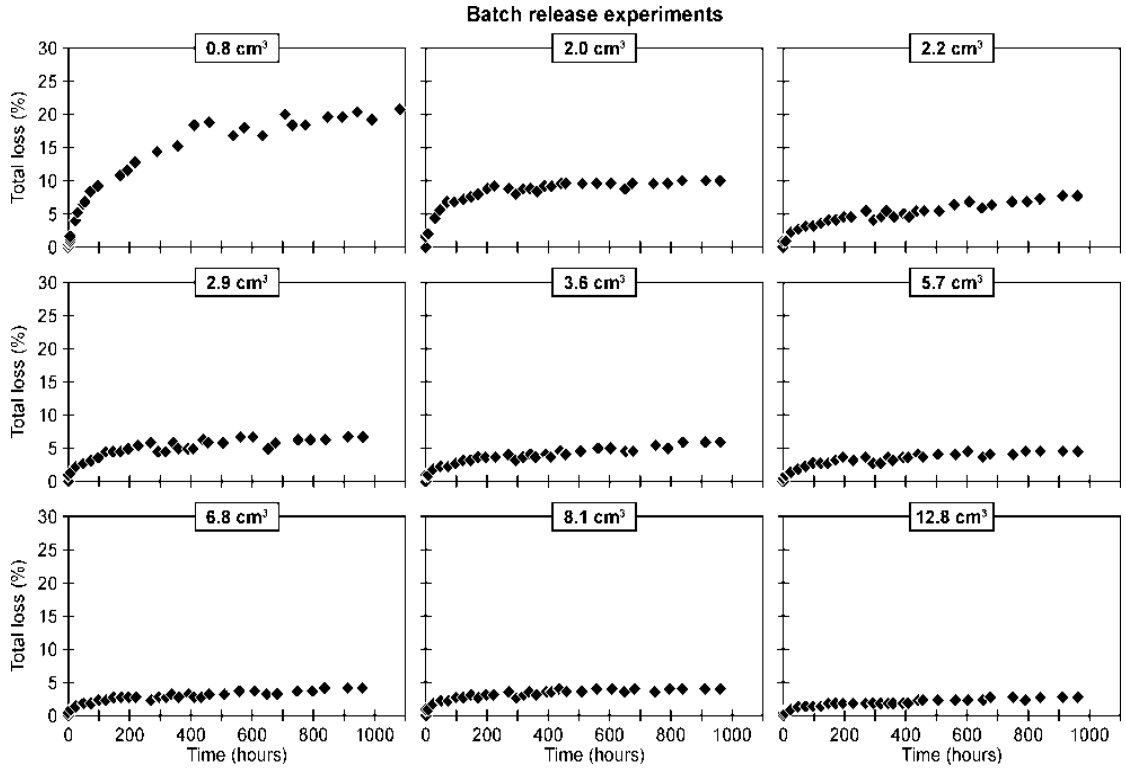


Figure 1. The time dependency of the total loss of HCFC-141b in percentage of initial content from foam particles with different sizes (Kjeldsen and Scheutz 2003).

Insulation panels and spray foam were mainly made of polyurethane (PUR) or polystyrene (PS). Spray foam was only a minor fraction of the used insulation foam (<15%, Trap et al., 2006). The blown PUR or PS forms rigid, closed cell foams containing BA in tiny gas bubbles. The bubbles are maintained in the foam after hardening of the PUR/PS. The BA is a low heat conductivity gas adding to the insulation properties of the foam. The content of BA in closed cell foam is typically in the range of 10-15% (w/w) with a significant amount solubilized in the polymer itself (Kjeldsen and Jensen, 2001).

CFCs are harmful substances, since they are very potent ozone depletion and greenhouse gases (GHG) that contribute to global warming if released to the atmosphere. Many of the gases are controlled by the Montreal Protocol and have been banned for industrial purposes. The HCFCs are less potent ozone depletion substances; HFCs are not ozone depleting but both groups are very strong greenhouse gases. The gases are very slowly released from the foam during use (Kjeldsen and Jensen, 2001). However, if the insulation foam is crushed, a significant fraction will be instantaneously released depending on the extent of crushing (see Fig. 1). By avoiding substantial shredding of the insulating foam during demolition process only an insignificant proportion of BA is to be released (Kjeldsen and Scheutz, 2003).

Studies carried out for the European Commission revealed that insulation foam in buildings in the EU is the most significant stock of ozone depleting substances (ODS) in society. The content in the building insulation in the EU-27 is estimated at roughly 700,000 ODS tons representing about a third of the global ODS banks. Besides, the global warming potential of the stock is estimated to be equivalent to one year's total emissions of $CO_2$ for the whole region (Milieu Ltd. & Ecosphere Lda, 2007). Despite of the large quantities of CFCs, the EU legislation does not require any documentation on the fate of CFC during demolition or during the further handling of recyclables and residuals.

Insulating foam waste blown by CFC is expected to go into the C&D waste stream in Denmark especially from 2010 to 2026. It is therefore urgent to make sustainable recommendations for the management of insulating foam waste from demolition, so the release of CFCs into the atmosphere is minimized. The main objective of this paper is to present sustainable recommendations for management of insulation foam waste from the C&D sector developed in Denmark by DAKOFA (The Waste and Resource Network Denmark).

## 2. SUSTAINABLE MANAGEMENT OF INSULATION FOAM WASTE

To reduce the release of the fluorocarbons while demolishing buildings in Denmark a working group under DAKOFA (The Waste and Resource Network Denmark) has made recommendations on how to handle insulation foam materials during the demolishing process and the further handling of the insulation foam waste (DAKOFA, 2015). The recommendations contain several steps, which are summarized here.

### 2.1 Mapping the use of fluorocarbons in buildings to be demolished or remodelled

Prior to a planned demolition activity on a building the presence of insulation foam containing fluorocarbons (CFCs, HCFCs or HFCs) is to be evaluated by consulting the publically available technical building files and making additional pre investigations of the building. Special attention must be given to the building's age, which would make it probable that the insulation foam contains one of the three substance groups.

### 2.2 Management during demolition

Insulating panels should be dismantled without insulation foam is crushed and can subsequently be cut into larger pieces (> 40 cm side length) for further handling. The spray foam is detached from the nearby building parts with an effort to reduce shredding of the foam to a minimum. The spray foam can be collected along with other smaller fractions of combustible, non-recyclable materials and packed in plastic bags, closed with bag ties. Storage time of foam waste before disposal should in general be minimized.

### 2.3 Further handling

The collected spray foam and insulation materials should be brought to destruction in waste incineration facilities without significant prior storage of the waste collected. Any collected insulation foam contained in sandwich structures containing metal panels (doors, gates, and special wall elements) may be shipped for metal recycling to existing facilities for recycling of refrigerators and freezers, where the release of the fluorocarbon is collected and destructed, and where the metal is collected for recycling.

### 2.4 Disposal by incineration

Since experiences from Germany (Rittmeyer et al. 1994) has made it likely that a thermal treatment of insulating foam on a conventional waste incineration facility will lead to an effective destruction of the contained fluorocarbons, it is recommended to bring the foam waste for waste incineration. In Denmark waste incineration is still a common waste treatment technology, so managing the foam waste at waste incineration facility will be a very affordable foam waste treatment alternative.

At the waste incineration facility, the foam waste is tipped directly into the waste bunker. During the storage of the foam waste in the waste bunker and the transfer of the waste to the furnace additional releases of fluorocarbons may happened due to compaction either by the weight of the overlying waste or compression in the grab transferring the waste to the furnace. Due to the significant bunker air extraction, which is led directly to the furnace, any released fluorocarbon present in the waste bunker air will be thermally destructed in the furnace.

## 3. FATE OF HALOCARBONS AFTER DISPOSAL IN LANDFILLS

In case that incineration is not part of the municipal solid waste management scheme the insulation foam waste will in most cases be disposed of at landfills. This is the solution in many countries, including China and USA. Based on research carried out at the Technical University of Denmark on releases of CFCs from home appliances during shredding it is expected that a major part of the CFC will still be present in the insulation foam waste at disposal at landfill, (Scheutz et al. 2007a). Studies has also shown that significant emissions of CFCs, HCFCs, and HFCs to the atmosphere occur; studies ranging from top-down studies linking measures atmospheric concentrations to expected major emission areas using inverse Lagranian dispersion modelling (Keller et al., 2012), to measured ambient concentrations at Chinese landfills (Duan et al., 2014), and measured emission fluxes using static chambers at an American landfill (Hanson et al., 2016; Yesiller et al., 2016). The fate of the fluorocarbons in landfills is largely unknown. Research at DTU has shown that CFCs and HCFCs can be quickly degraded under the anaerobic conditions prevailing in landfills (Scheutz et al. 2007b), which can be an important process – if the CFC/HCFCs are not quickly released during the first time after disposal on the landfill due to compaction. HFCs are not expected to be degradable in the landfill environment. Fig. 2 shows a conceptual model of the attenuation processes in anaerobic landfills.

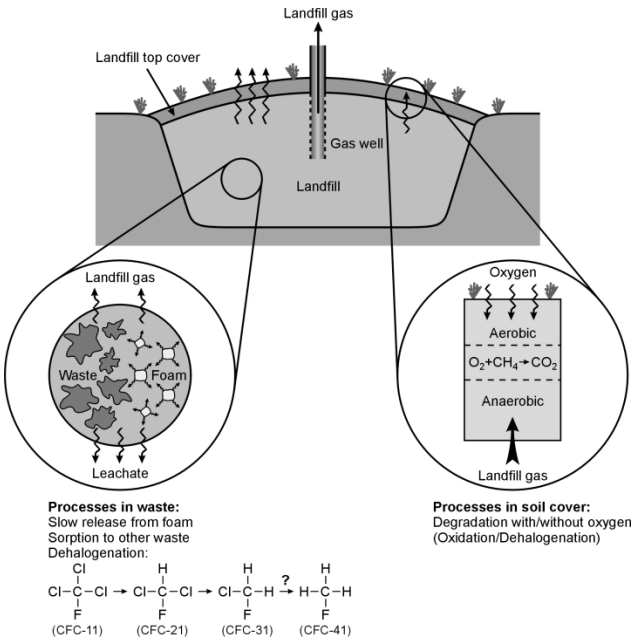


Figure 2. Conceptual model of the attenuation processes in anaerobic landfills including processes within the waste body and processes in the soil cover. The landfill gas extracted from gas wells may be vented directly to the atmosphere, flared or utilized in a gas engine.

## 4. CONCLUSIONS

It is obvious that research and development is needed to obtain sustainable and cost-effective solutions to handle ODS/GHG containing building insulation foam – especially when incineration is not part of a municipal solid waste management scheme. Due to the long lifetime of buildings and the very little loss of fluorocarbons from insulation foam during use, most of the fluorocarbons used in building insulation foam is still present in the building mass. Therefore there is still time to develop solutions for a future sustainable management of the CFC/HCFC/HFC stock in buildings and to minimize spreading of harmful substances in the environment. The recommendations for the handling of foam waste containing fluorocarbons following demolition or remodelling is based on the existing knowledge on the processes and factors governing the release and destruction of the fluorocarbons from the insulation foam waste under different environmental conditions. Following the recommendations it is believed that a substantial avoidance of releases of strong ozone depleting substances and severe greenhouse gases are avoided.

## REFERENCES

Dakofa (2015) Viden Om: Håndtering af isoleringsskum (Fact sheet: Managing insolation foam material, in Danish). Network on C&D waste management. Copenhagen, Denmark.

Duan, Z., Lu, W., Li, D. and Wang, H. (2014) Temporal variation of trace compound emission on the working surface of a landfill in Beijing, China. *Atmospheric Environment*, 88, 230-238.

Hanson, J., Yesiller, N., Bogner, J., Sohn, A. (2016) Experimental determination of emissions of F-gases from MSW landfill. In Proceedings, Global Waste Management Symposium 2016.

Keller, C.A., Hill, M., Vollmer, M.K. et al. (2012) European emissions of halogenated greenhouse gases inferred from atmospheric measurements. *Environmental Science & Technology*, 46, 217-

225.
Kjeldsen, P. and M.H. Jensen (2001) Release of CFC-11 from disposal of polyurethane from waste. *Environmental Science and Technology*, 35, 3055-3063.
Kjeldsen,P. and C. Scheutz (2003) Short and long term releases of fluorocarbons from disposal of polyurethane foam waste. *Environmental Science and Technology*, 37, 5071-5079.
Milieu Ltd. & Ecosphere Lda (2007) Review of the implementation of regulation (EC) No 2037/2000 on sub-stances that deplete the ozone layer. Regulatory options. Report for European Commission, Brussels, Belgium.
Scheutz, C., Fredenslund, A.M., Tant, M. and P. Kjeldsen (2007a) Release of fluorocarbons from insulation foam in home appliances during shredding. *Journal of the Air & Waste Management Association*, 57, 1452-1460.
Scheutz, C., Dote, Y., Fredenslund, A.M., Mosbæk, H. and P. Kjeldsen (2007b) Attenuation of insulation foam released fluorocarbons in landfills. *Environmental Science & Technology*, 41, 7714-7722.
Trap, N., Lauritzen, E.K., Rydahl, T., Egebart, C., Krogh, H., Malmgren-Hansen, B., Høeg, P., Jakobsen, J.B., Lassen, C. (2006) Problematiske stoffer i bygge- og anlægsaffald - kortlægning, prognose og bortskaffelsesmuligheder (Problematic substances in C&D waste – mapping, prognosis and disposal alternatives, in Danish). Miljøprojekt nr. 1084, Miljøstyrelsen, København.
Yesiller, N., Hanson, J.L & Bogner, J.E. (2016) Emissions of potent greenhouse gases from appliances and building waste in landfills. Draft Final Report for The California Air Resources Board and The California Environmental Protection Agency.