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Nordic Ash Treatment Technologies Summary

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1 INTRODUCTION

This report focusing on ash treatment technologies has been prepared as part of the *NOWA - Nordic Waste Management Vision* project funded by the Interreg Aurora Programme supported by the European Union. The report has been prepared by [Macon Ltd](#)¹ and is part of a series of reports produced on the project.

Fly ash, a hazardous byproduct of waste-to-energy (WtE) incineration, is increasingly being managed in the Nordic countries through sustainable and circular approaches. Sweden leads in advanced valorization with the innovation company EasyMining Services Sweden Ltd's Ash2™Salt plant with the capability to commercially recover salts and ammonia. Additional Swedish technologies, including waste management company Renova Ltd and ScanArc Plasma Technologies Ltd, target metal recovery and aggregate production.

In Finland, an energy company Fortum Ltd operates a commercial-scale acidic washing facility in Pori that stabilizes heavy metals and enables safe landfilling, while experimental work is ongoing to valorize salt-rich effluents for de-icing and dust control. Other technologies in Finland, such as an industrial wastewater treatment company EPSE Ltd and MetalCirc Ltd, focus on metal recovery but remain in pilot stages. In Northern regions like Lapland, Kainuu, and Northern Ostrobothnia, fly ash is typically stabilized and transported to southern facilities, with limited local recovery except for bioash use in fertilizers and regional research efforts.

Norway maintains long-standing centralized treatment at environmental and resource company NOAH's Langøya facility, with emerging solutions like ReSalt and production of pure gypsum for plasterboards. Technology company Norsep Ltd (bankrupted in 2023) and Scanwatt Ltd have explored salt recovery and carbon sequestration.

Overall, the Nordic region is shifting from disposal-oriented practices to scalable, value-driven fly ash recovery systems. This summary presents a selection of fly ash treatment technologies which may become of interest in the Arctic region in the future. The suitability and the attractiveness of each technology for a specific region or purpose depends on a variety of factors, such as the market for the products and logistic options.

1.1 Case example of innovation development

[The AshCycle Project](#)² consortium investigates tools for reducing waste generation from waste incineration. The project members [Kiertokaari Ltd](#)³, [Syklo Ltd](#)⁴ and the [University of Oulu](#)⁵ have piloted a technology to process MSW fly ashes to earth construction products.

This technology is based on the granulation of fly ash, bottom ash, and cement. The produced material has been studied with respect to applications in earth construction. The preliminary results are promising in terms of applicability. However, the techno-economic calculations show a lack of cost competitiveness. The project is still in progress.

¹ Macon Ltd website. Accessed November 5, 2025

² The AshCycle Project website. Accessed November 5, 2025

³ Kiertokaari Ltd website. Accessed November 5, 2025

⁴ Syklo Ltd website. Accessed November 5, 2025

⁵ The University of Oulu website. Accessed November 5, 2025

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2 TECHNOLOGY DESCRIPTIONS

2.1 Fortum Recycling and Waste / NG Nordic

[NG Nordic](#)⁶, a union between Fortum Recycling & Waste and NG Group, specializes in waste treatment technologies, recycling hazardous waste and the development of material reuse and recycling concepts.

Fortum's fly ash treatment technology is based on washing with acidic solutions to remove easily soluble salts, followed by the purification of washing solution and discharge of salt solution to the sea. The pH is adjusted to keep heavy metals in an insoluble form. The solid residues from the salty washing process can be landfilled without cement stabilization.

Fortum processes up to 40 000 t/a fly ash in Pori, Finland. Experiments are ongoing to enable recovery and utilization of salts in de-icing and dust control. The TRL of current technology is evaluated to be 8-9 (commercial). The technology with salt utilization is evaluated to be 4-5 (large-scale pilot).

This technology is based on simple processes. Revenue is expected from the salt solutions which can be used in de-icing and dust control of roads. The product needs approval from the respective authorities. Patents on Fortum technology were not found.

The technology encapsulates contaminants in a stable matrix and enables discharge of salt solutions to the sea. It is notable that handling of chemicals and heavy metal rich materials requires proper equipment.

Table 1 Summary of Fortum technology

Principle	Products	Byproducts	Capacity
Acid washing of ash, sludge treatment separately	Salt solution for de-icing and dust control of roads (experiments on-going)	Water effluent Ash for landfilling	Mäntyluoto plant has capacity to treat ca. 40 000 t/a fly ash ⁷ Fortum has permission to investigate salt recovery in Mäntyluoto

2.2 Ash2™Salt

[Ash2™Salt Technology](#)⁸ was originally developed at [EasyMining Sweden Ltd](#)⁹, which was acquired by [Ragn-Sells Group](#)¹⁰ in 2014. Ragn-Sells is a privately held corporate group operating companies in Sweden, Norway, Denmark and Estonia. The company focuses on collection, treatment and recycling

⁶ NG Nordic website. Accessed November 4, 2025

⁷ Aluehallintovirasto 2020. Decision. Dnro ESAVI/23698/2020

⁸ Ash2Salt Technology on EasyMining's website. Accessed October 20, 2025

⁹ EasyMining Sweden Ltd website. Accessed October 20, 2025

¹⁰ Ragn-Sells Group website. Accessed October 20, 2025

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of waste and residues. Currently they have 100 sites in which 5.6 million tons of waste is treated annually.

Ash2™Salt technology is intended for washing of hazardous fly ash and production of salts (CaCl¹¹, KCl, NaCl, NH¹²). The technology includes four steps from which first two are for pretreatment. In the first phase the fly ash is washed with water, forming cleaned ash and a leachate which is treated further. The next phases include precipitation to remove heavy metals and strip to recover ammonia. The treated solution can be concentrated by evaporation. Salts can be recovered as crystals, separated by centrifugation, and dried. Condensate water is recirculated to the washing process. After washing, the ash residue can be landfilled without an exemption for high chloride contents or re-used as an industrial raw material.

The first Ash2™Salt plant was opened on April 21st, 2023, in Upplands-Bro, Sweden¹³. The facility is the world's first to recycle commercial salts from fly ash on a large scale. TRL is evaluated to 8-9 (commercial). This technology is based on standard processes and equipment. EasyMining has filed patent applications related to Ash2™Salt technology.^{14 15}

Ash2™Salt brings revenue from selling pure salts and ammonia which have commercial potential. The salts sodium chloride, potassium chloride, and calcium chloride can be used to produce plastics, glass, paper, soap, paints, fertilizers, and medicines. Salts can also be added to improve food, animal feed, fabrics, and construction materials or used for de-icing and dust-binding. According to Ragn-Sells, up to 400 kg salt can be extracted from 1 ton of incineration fly ash. Also, reduction of fly ash landfilling by 30% is an economic benefit.

Ragn-Sells partners with Nordic distributor of salts, [GC Rieber Minerals](#)¹⁶, for the sale of salts recovered from Ash2™Salt process¹⁷. Swedish construction company [Peab Ltd](#)¹⁸ uses these salts for de-icing and dust control¹⁹. Evaporation and crystallization are energy-intensive processes. Water cycle is closed, and the evaporated water is circulated back to the process through water treatment system. Total energy demand is ca. 1.2 MW/t. Salt products can be traded as brine or crystals. Crystals are preferred due to lower transportation costs. For instance, the market of salts in de-icing in Finland is ca. 110000 t/a with price of 100 EUR/t. The Finnish market of CaCl used in dust control is ca. 27000 t/a with price 300 EUR/t.^{20 21 22}

11 Ragn-Sells (2023). World's first facility for recycling commercial salts from fly ash inaugurated. Available at <https://newsroom.ragnsells.com/posts/pressreleases/worlds-first-facility-for-recycling-commercial>. Accessed October 20, 2025

12 Cohen. "Method and arrangement for recovery of salt." WO2017111685A1.

13 Ragn-Sells (2023). World's first facility for recycling commercial salts from fly ash inaugurated. Available at <https://newsroom.ragnsells.com/posts/pressreleases/worlds-first-facility-for-recycling-commercial>. Accessed October 20, 2025

9 Cohen. "Method and arrangement for recovery of salt." WO2017111685A1.

10 Royen & Cohen. "Processing of phosphate solutions." WO2024158333A1.

16 GC Rieber Minerals website. Accessed October 21, 2025

17 Ragn-Sells (2022). With 90 percent lower carbon footprint. Available at <https://www.ragnsells.com/about-us/press-media/articles/gc-rieber--ragn-sells/>. Accessed October 20, 2025

18 Peab (2022). Peab minskar klimatavtryck med cirkulärt vägsalt. <https://news.cision.com/se/peab/r/peab-minskar-klimatavtryck-med-cirkulart-vagsalt,c3496499>. Accessed October 20, 2025

19 Peab (2022). Peab minskar klimatavtryck med cirkulärt vägsalt. <https://news.cision.com/se/peab/r/peab-minskar-klimatavtryck-med-cirkulart-vagsalt,c3496499>. Accessed October 20, 2025

20 Stenberg, Gustav. Salt Recovery from Waste to Energy Incineration Fly Ash. Master's Thesis within the Sustainable Energy Systems programme. Chalmers University. 2016.

<https://publications.lib.chalmers.se/records/fulltext/239716/239716.pdf>. Accessed October 20, 2025

21 Personal communication with Pekka Koski, Manager Equipment and Production, VRJ Group Oy. 2019.

22 Wang et al. (2012). A critical review on additives to reduce ash related operation problems in biomass combustion applications. Energy Procedia, 20, 20-29.

<https://doi.org/10.1016/j.egypro.2012.03.004>. Accessed October 20, 2025

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Data on Ash2™Salt salt quality is not available. It is notable that salt crystals from fly ash may contain toxic substances (heavy metals and dioxins) which affect their end use. Stripping and absorption with H₂SO₄ forms ammonium sulfate. The produced ammonia can be used as fertilizer, in water-soluble insecticides, herbicides and fungicides. The quality and quantity of recovered ammonia by Ash2™Salt depends on the ash quality.

The produced hazardous heavy metal fraction requires landfilling. In case of the future Ragn-Sells plant, heavy metal fraction can probably be stored at [Högbytorp](#)²³. Overall, Ash2™Salt reduces need for fly ash landfilling by 30 %.

The technology is based on salt recovery and utilization. The metals precipitated from the process are not recovered and disposed into a suitable disposal site for hazardous waste. There is a clear added value in the closed water circuit and in the use of various salts, for example road salt. Handling chemicals requires appropriate routines for personnel. Crystallization process needs high level personnel skills to operate. Otherwise, this technology involves conventional processes and equipment.

Table 2 Summary of Ash2™Salt technology

Principle	Products	Byproducts	Location, Capacity
4-step process with washing and precipitation steps	Commercial grade Potassium chloride (KCl), Sodium chloride (NaCl), Calcium chloride (CaCl ₂), and aqueous ammonia solution (NH ₃) or ammonium sulfate ((NH ₄) ₂ SO ₄)	Washed ash (landfill), heavy metal fraction (solid or slurry, hazardous landfill)	Upplands-Bro, Sweden Capacity 150 000 t/a fly ash ²⁴

²³ Ragn-Sells. Modernt kretslopp på Högbytorp. Accessed October 20, 2025

²⁴ Ragn-Sells (2023). World's first facility for recycling commercial salts from fly ash inaugurated. <https://newsroom.ragnsells.com/posts/pressreleases/worlds-first-facility-for-recycling-commercial-salts-from-fly-ash-inaugurated>. Accessed October 20, 2025

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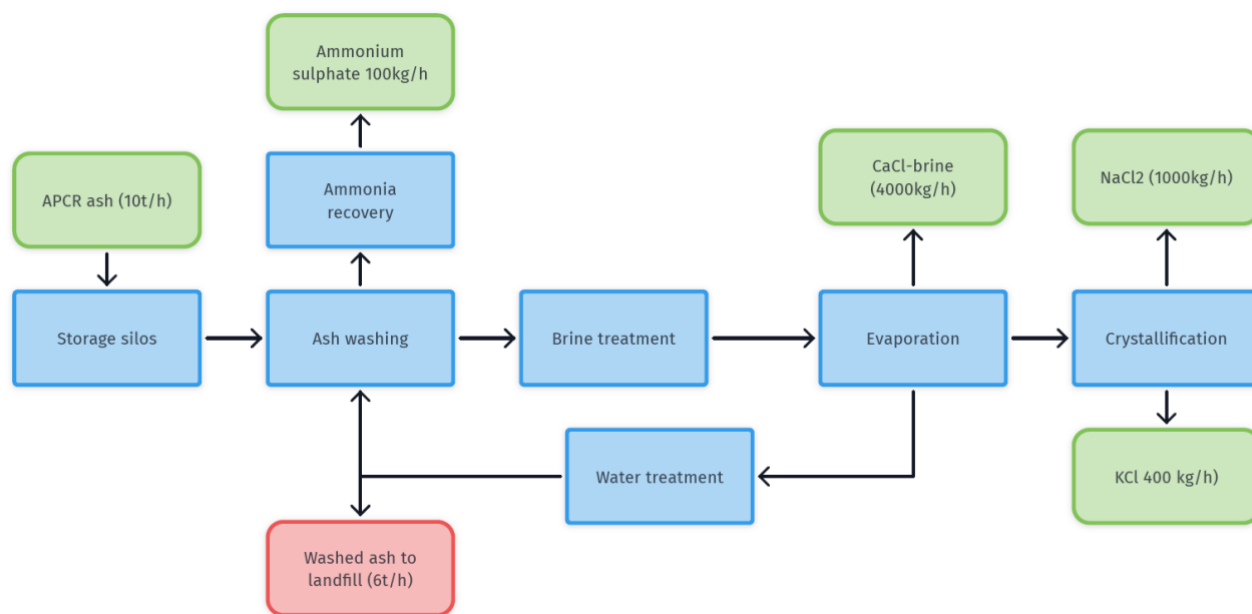


Figure 1 Ash2™ Salt technology

2.3 Accelerated Carbonation Technology

[Carbon8 Ltd](#)²⁵ (formerly part of OCO technology, UK) has developed Accelerated Carbonation Technology (ACT) which combines carbon capture from industrial side streams to treatment of MSWI fly ash. ACT enables CO₂ capture along with production of aggregate for construction industry. Fly ash is encapsulated in a solid carbonated matrix under CO₂-rich atmosphere, water, and often slight pressure (e.g. 2 bars). The process takes approximately 10-20 minutes, and it is flexible for different fly ash mixes. Modular solution, [CO₂ntainer™](#)²⁶, can process up to 12 000 t/a industrial residues. ACT is applied at three plants in UK and TRL is evaluated to 9 (commercial). This technology is based on simple processes. Carbon8 Systems has a patent application pending on Accelerated Carbonation Technology²⁷.

Revenue is obtained from the aggregate ([CircaBuild](#)²⁸) sold for construction industry and possibly also from the fertilizer ([CircaGrow](#)²⁹), and from the carbon credits. The aggregate has verified carbon content of 114 kgCO₂/t of product, and all three commercial facilities in UK are listed in [Puro Earth](#)³⁰ crediting platform for engineered carbon removal³¹. The aggregate meets EN13242 and EN13055

²⁵ Carbon8 Ltd. Accessed October 20, 2025

²⁶ Co2ntainer on Carbon8 Ltd website. Accessed October 20, 2025

²⁷ Hills & Carey. "Improved production of aggregates." US20190119158A1.

²⁸ CircaBuild on Carbon8 Ltd website. Accessed October 20, 2025

²⁹ CircaGrow on Carbon8 Ltd website. Accessed October 20, 2025

³⁰ Puro Earth website. Accessed October 20, 2025

³¹ Supplier Listings. Puro Earth website. <https://puro.earth/CORC-co2-removal-certificate/supplier-listings>. Accessed October 20, 2025

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requirements³². The technology is flexible for different fly ash mixes. The aggregates have been granted end of waste status in the UK.

[The ACT technology](#)³³ encapsulates contaminants in a stable matrix. Data on leaching contaminants from granulates is not available. [O.C.O Technology](#)³⁴ produces over 450,000 tons of aggregates a year at its three plants in Leeds, Bristol, and Brandon in Suffolk. The technology is based on the stabilization of ash and the use of stabilized ash in various infrastructure projects as building materials. The most significant advantage is also seen in the capture of carbon dioxide in the material. The process is exothermic. The aggregates have been granted end of waste status in the UK, however there is very little information available on the leaching properties of the product and the potential environmental impacts of the use of the material as a product. Dusting during handling of aggregates may cause health effects.

Table 3 Summary of Accelerated Carbonation Technology

Principle	Products	Byproducts	Capacity
1-step process based on encapsulation of fly ash	CircaBuild and CircaGrow, carbon negative alternatives to virgin aggregate and fertilizer ³⁵	Carbonates (landfill?)	UK: Bristol, Norfolk, Leeds Bristol plant 25 000 t/a fly ash CO ₂ tainer capacity 12 000 t/a

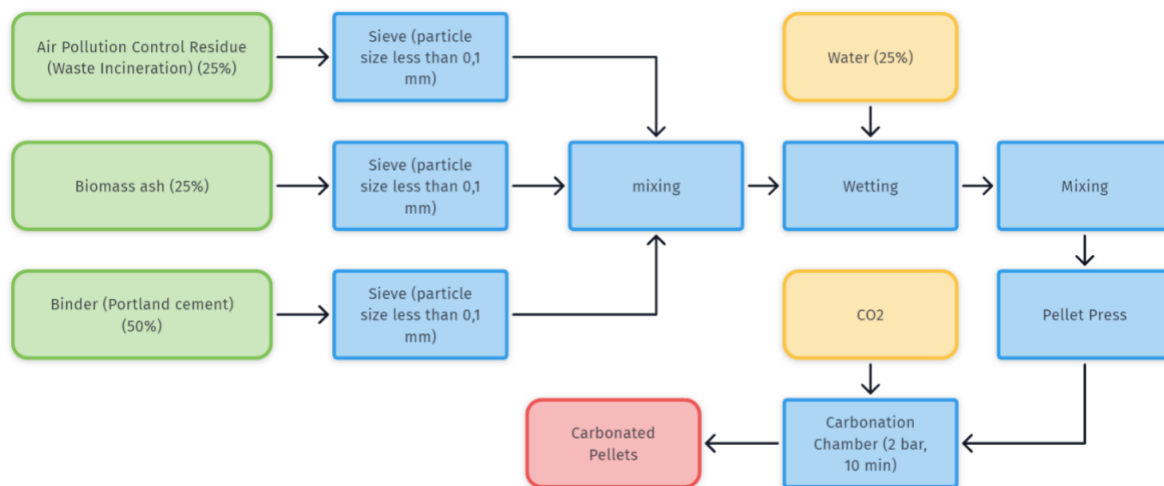


Figure 2 Accelerated Carbonation Technology

³² Leeds production facility CORC-co2 removal certificate. Puro Earth website. <https://puro.earth/CORC-co2-removal-certificate/supplier-listing/leeds-production-facility-64>. Accessed October 20, 2025

³³ Accelerating CCS Technologies website. Accessed October 20, 2025

³⁴ O.C.O Technology website. Accessed October 20, 2025

³⁵ Carbon8 Products. Available at <https://www.carbon8.co.uk/products>. Accessed October 20, 2025

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2.4 EPSE

[EPSE Ltd](#)³⁶ (previously Global EcoProcess Services Ltd) is based in Ylöjärvi, Finland. The company specializes in the treatment of harmful and hazardous wastewater generated in industrial and mining processes. EPSE precipitation technology is based on a proprietary EPSE chemical and pH adjustment which leads to controlled precipitation of metals. It produces permanently insoluble precipitate including metals and treated ash and purified water. The technology is also applicable at low temperatures. EPSE initiated discussion of pilot at customer sites in Finland before the COVID-19 pandemic. Due to the pandemic restrictions, the pilot was not implemented. Since then, EPSE has concentrated more on water effluent treatment applications, however the company is still interested in developing the technology further³⁷. TRL is evaluated to be 4 (pilot). EPSE has patented the technology. The main technology is protected in relevant industrial countries.^{38 39}

This technology is based on simple precipitation processes. Revenue is expected from the precipitate which can be used in construction. The product needs approval. Based on pilot investigation, the quality of produced precipitate would meet demands of the [Finnish Market Abuse Regulation \(MAR\)](#). EPSE technology does not address treatment of salts. The technology is flexible for different metal concentrations.

There was no data on the patent of the amounts of boric acid used. Boric acid is generally considered an expensive raw material in industrial processes. The market price of boric acid is currently about 700 EUR/t. Regarding equipment investment; the technology is inexpensive because it does not require complex evaporation or electro-precipitation methods. The developer of the method claims on his website that the method is cost effective compared to other technologies. However, lack of data impairs detailed assessment.

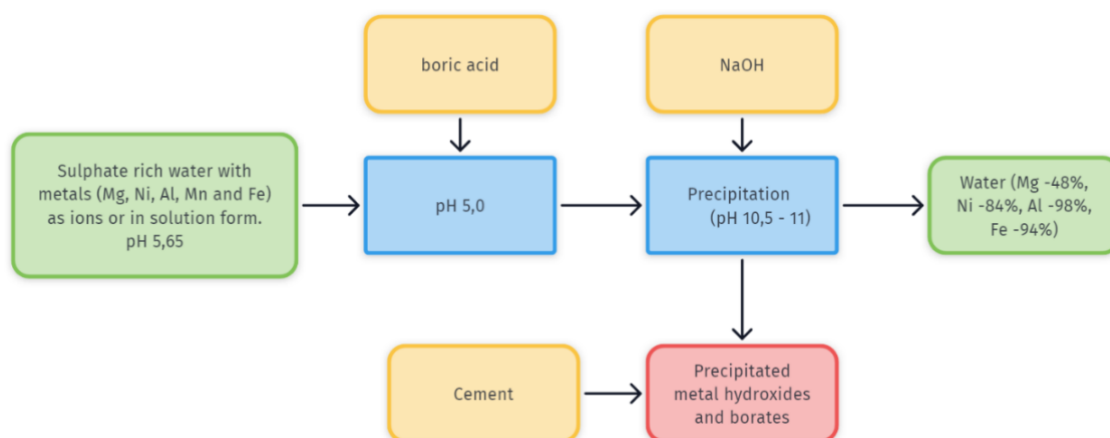


Figure 3 EPSE technology

³⁶ EPSE Ltd website. Accessed October 20, 2025

³⁷ EPSE Ltd (2024). Personal communication with Jouni Jääskeläinen and Anni Honkonen. 04.10.2024.

³⁸ Rissanen. "Menetelmä metallien talteenottamiseksi." FI124262B.

³⁹ Rissanen. "Method for the treatment of metals. US40214434B2.

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EPSE encapsulates contaminants in a stable matrix. Based on recent research, the effluent from EPSE does not cause adverse effects on biological wastewater treatment plants or water bodies.⁴⁰ Handling of chemicals and heavy metal rich materials requires proper equipment.

2.5 FLUWA and FLUREC

[AIK Technik Ltd](#)⁴¹ (previously BSH Umweltservice Ltd) based in Switzerland is specialized in waste treatment technologies. The company has developed FLUWA and FLUREC technologies for treatment of fly ash. Ca. 60% of Swiss fly ash is treated with FLUWA.⁴² In FLUWA process, a heavy metal -rich fraction is leached from the fly ash by means of acidic effluent from another process. The process produces a filter cake which is mixed with the bottom ash and landfilled (if permitted). FLUREC process can be used to enrich specific metals from the leachate. FLUWA is the leading fly ash treatment process in Switzerland, and there are several plants in Switzerland. FLUREC is in use at one commercial plant since 2013. TRL is evaluated to be 9 (commercial). Patents on FLUWA or FLUREC were not found. Presentation of FLUWA/FLUREC at Task36 IEA Bioenergy seminar in 2020 available on [YouTube](#)⁴³.

Revenue is generated from metal-rich fractions; however the process itself is not economically self-sustainable without subsidies. FLUWA consumes 0.0472 kg CaO, 0.0845 kg H₂S₂, 0.0322 kg HCl, 0.0241 kg NaOH per kg of fly ash.⁴⁴ Energy consumption of FLUWA process is 146.3 kWh/ t of fly ash⁴⁵. Data on water usage is not available. Water treatment is necessary after FLUWA. The fly ash residue requires landfilling (no hazardous fractions) unless it can be recycled back to furnace. Handling chemicals and heavy metal rich materials requires proper procedures.

40 Honkonen, Anni. Lentotuhkan ja APC-jätteen käsittely - Katsaus nykytilanteeseen ja EPSE Menetelmän tuomia mahdollisuuksia tulevaan. Opinnäytetyö (AMK). Energia- ja ympäristötekniikka. Turku AMK. 2019. https://www.theseus.fi/bitstream/handle/10024/227614/Honkonen_Anni.pdf?sequence=2&isAllowed=y

41 AIK Technik Ltd website. Accessed October 20, 2025

42 Weibel et al. Extraction of heavy metals from MSWI fly ash using hydrochloric acid and sodium chlorite solution. Waste Management 76:457-471. 2018. <https://doi.org/10.1016/j.wasman.2018.03.022>

43 Siegfried Reithaar, AIK Technik. EA Bioenergy Task 36. 2020. Accessed October 20, 2025

44 Doka. Life cycle inventories of municipal waste incineration with residual landfill &

FLUWA filter ash treatment. Technical report. 2015. <https://www.doka.ch/ecoinventMSWIupdateLCI2015.pdf>. Accessed October 20, 2025

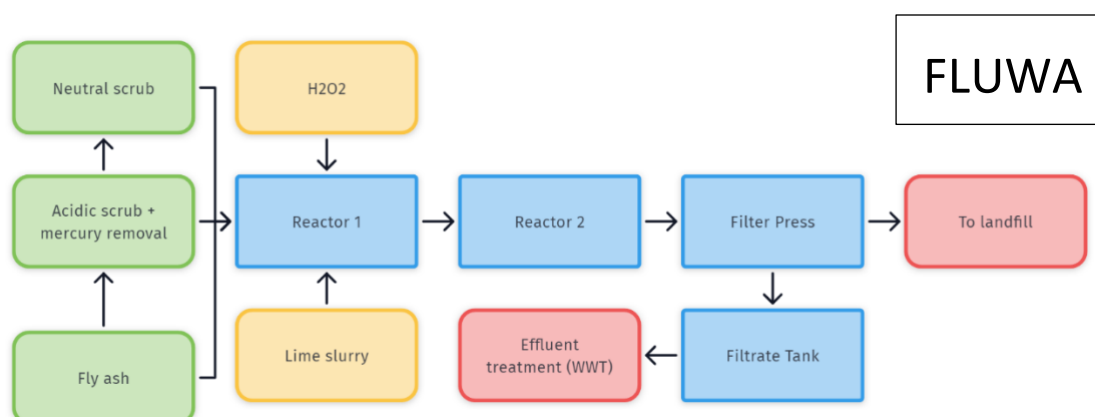
45 Doka. Life cycle inventories of municipal waste incineration with residual landfill &

FLUWA filter ash treatment. Technical report. 2015. <https://www.doka.ch/ecoinventMSWIupdateLCI2015.pdf>. Accessed October 20, 2025

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Table 4 Summary of FLUWA and FLUREC

Principle	Products	Byproducts	Capacity
FLUWA is a multistep process based on acid leaching	Metal-rich leachate	Filter cake (landfilled if permitted)	Several plants in Switzerland One planned in Sweden (Ragn-Sells / Ash2™Salt? ⁴⁶)ha Capacity of Thun plant 3570 t/a fly ash
FLUREC is based selective-reactive solvent extraction and electrolysis	Zinc for smelteries Solid mixture of Cd, Cu and Pb for smelteries	Residue, can be fed back to waste to energy plant	One commercial plant in at Zuchwil, Switzerland Capacity 7400 t/a fly ash (400 t/a zinc produced)



46 AIK Technik AG Acid wash of fly ash: Overview of basics, improvements and challenges. Presentation at IEA Bioenergy Webinar Valorisation of fly ash from Waste-to-Energy in October 2020. <https://task36.ieabioenergy.com/publications/webinar-valorisation-of-fly-ash-from-waste-to-energy/>. Accessed October 20, 2025

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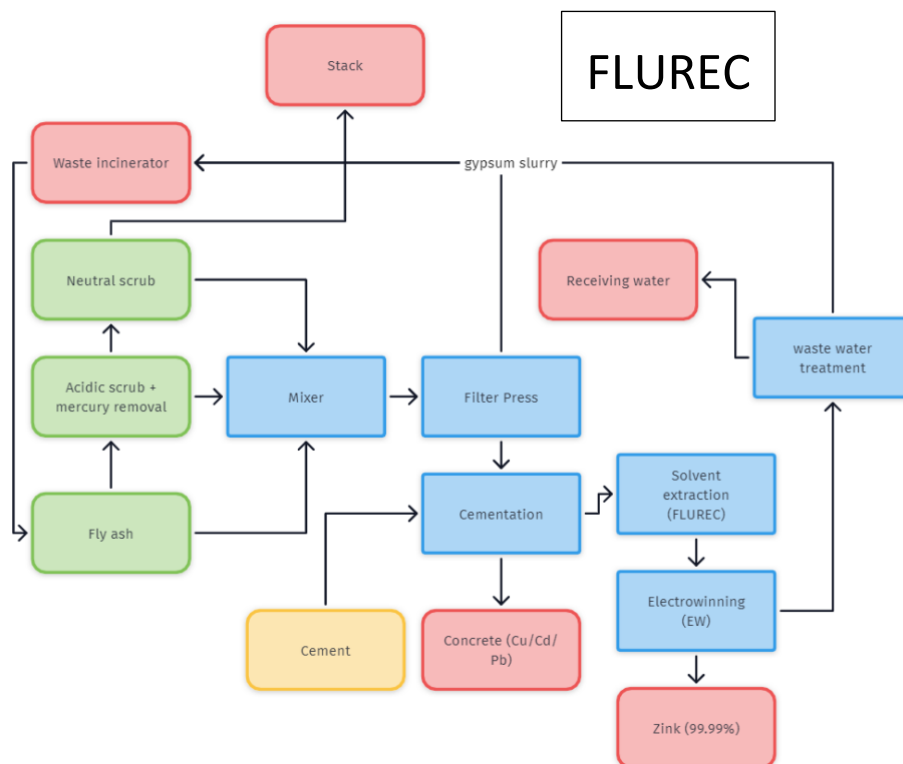


Figure 4 FLUWA and FLUREC

2.6 HALOSEP

[HaloSep](#)⁴⁷ technology was originally developed at [Stena Metall](#)'s⁴⁸ R&D department in 2010. Demonstrations were operated at Vestforbrænding incineration plant in Copenhagen, Denmark during an EU Life project (2016-2022). HaloSep Ltd was operational during 2020-2025.

HaloSep technology was developed to co-process fly ash and flue gas waste with hot scrubber effluents. Versions for wet flue gas treatment and semi-dry flue gas treatment have been developed. The process produces salt products for de-icing and metal-rich fraction for smelteries. Byproducts are treated fly ash for landfilling and oversized material which is fed back to furnace.

HaloSep technology can be included either in greenfield projects or retrofitted to existing waste to energy plants. The first full-scale HaloSep plant was operated during the previously mentioned EU LIFE project until 2022. The capacity was 13000 t/a of fly ash. TRL can be evaluated as 6-7 (demonstration) until commercial plants are in operation and more performance data is available. Stena Recycling has filed patent application on HaloSep technology⁴⁹. According to press release by,

⁴⁷ HaloSep Technology website. Stena Metall Ltd. Accessed October 20, 2025

⁴⁸ Stena Metall Ltd website. Accessed October 20, 2025

⁴⁹ Rasmussen. "Co-treatment of flue gas cleaning waste and acidic scrubber liquid." WO2018029290A1.

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the know-how and technology will be incorporated in the Research and Development function with the intention of offering a viable solution when the market is ready⁵⁰.

Revenue from HaloSep is expected from selling salts and metal-rich fraction⁵¹. Salt product was reported to comply with the European standard for de-icing product⁵². Reduction of landfilling by up to 60% is an economic benefit. The energy demand is ca. 25 kWh/t. The raw material flexibility of process is not known.

Energy consumption of HaloSep is 25 kWh/t of treated fly ash. The technology enables decentralized fly ash treatment which reduces transportation. HaloSep reduces landfilling by 40-60 %. Salts, zinc, and scrubber liquid are removed via this method. The method combines two waste streams (effluent and fly ash). Process advances circular economy if the metal deposits generated from the by-products can be used, for example, in metal processing. The process still generates saline water, which must be treated separately in order for the salts to be used in industry. Chemical handling requires appropriate routines for personnel.

The treated fly ash from HaloSep obtained non-hazardous waste code according to the European Waste Catalogue (EWC) system. The municipality of Glostrup in Copenhagen, Denmark approved the reclassification of the fly ash as the non-hazardous EWC code 19 02 06 “sludges from physicochemical treatment other than those mentioned in 19 02 05”.⁵³

Table 5 Summary of HaloSep technology

Principle	Products	Byproducts	Capacity
Multi-step process based on extraction, separation, and chemical methods	Salt product, metal-rich product	Washed ash (landfill), heavy metal fraction (solid or slurry, hazardous landfill)	First plant under construction since 2019, capacity 13000 t/a

⁵⁰ Stena Metall. HaloSep ceases operations. <https://www.stenametall.com/news-insights/newsroom/2024/halosep-ceases-operations>. Accessed 4.11.2025.

⁵¹ Halosep Fly Ash Treatment at Waste to Energy Plants. 2018. Erik Rasmussen, Stena Recycling Ltd. <https://www.energiforetagen.se/globalassets/energiforetagen/det-erbjuder-vi/sakomraden/askdagen/erik-rasmussen-stena.pdf>. Accessed October 20, 2025

⁵² European Committee for Standardization. “CEN/TC 337. Road operation equipment and products.”

⁵³ LIFE HaloSep project. Treated fly ash from the HaloSep process now officially classified as non-hazardous. 2023. <https://www.lifehalosep.eu/treated-fly-ash-from-the-HaloSep-process-now-officially-classified-as-non-hazardous/>. Accessed October 20, 2025

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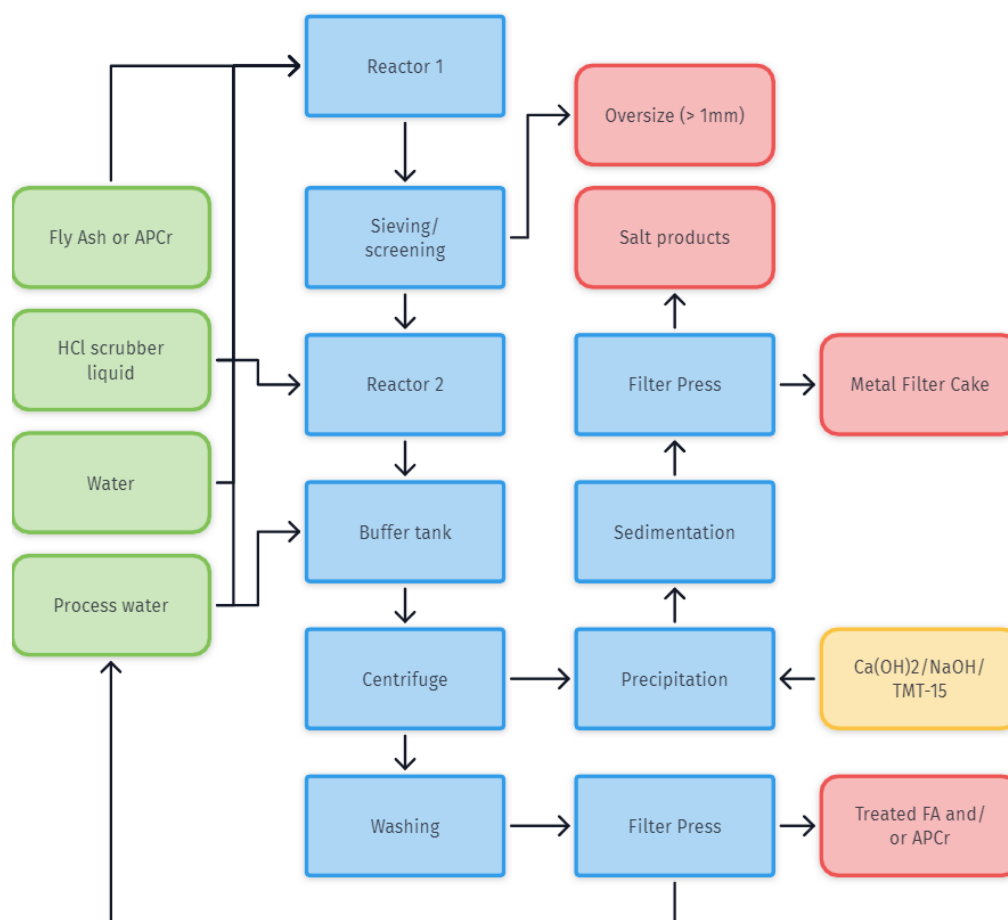


Figure 5 HaloSep technology

2.7 NOAH

[Norsk Avfallshantering \(NOAH\)](#)⁵⁴ AS is a Norwegian company owned 100% by Gjølsten Holding AS. NOAH specializes in environmental technologies and handling of inorganic hazardous waste. The company operates e.g. at Langøya outside Holmestrand, Oslofjord, Norway. The company has developed technologies, here named NOAH Langøya, NOAH CarbonTech and [NOAH ReSalt](#)⁵⁵.

NOAH Langøya is a multi-step acid and base neutralization process of MSWI fly ash and spent sulphuric acid from TiO₂ production at Kronos Titan. The final product is the non-reactive material which can be landfilled as non-hazardous waste on a permitted landfill^{56,57}. Langøya technology is

⁵⁴ Norsk Avfallshantering website. Accessed October 20, 2025

⁵⁵ Building pilot plant for salt recovery from fly ash. Norsk Avfallshantering. Accessed October 20, 2025

⁵⁶ <https://www.noah.no/wp-content/uploads/2025/02/Kemakta-Klassning-av-filterkaka-och-aska-fran-NOAH-Solitions-AS.pdf>

⁵⁷ <https://www.miljodirektoratet.no/link/4a9650d2dd3e41129fb1649d6db80e6a.aspx>

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fully commercial since early 1990s and it handles fly ash from 80 plants. It is at TRL 9. The technology is robust and flexible for raw materials.



Langøya facility, NOAH. Picture: NOAH Ltd.

NOAH CarbonTech is a patented process based on accelerated carbonation⁵⁸. The fly ash is mixed with CO₂-rich gas which leads to encapsulation of ash in a carbonated matrix with 1-2 hours depending on operational parameters. The technology is still under development. It is assumed to be at TRL 4-5; however, technology has not been developed further since 2020⁵⁹

NOAH has developed ReSalt process in which brine is separated from gypsum slurry using press filter, brine is subjected to heavy metal and sulphate removal, and salts are recovered via crystallization. NOAH operated a ReSalt pilot plant in Herøya. The decision on full-scale plant investment is still waiting for a solid business case⁶⁰.

NOAH technologies are simple and employ standard equipment. Operating costs are therefore low. They combine treatment of several waste streams. At the moment, the most potential commercial products from NOAH technologies are salts. According to NOAH, all salts could be used industrially:

⁵⁸ Noah Solutions As. Method and apparatus for neutralizing and stabilizing of fly ash. NO20210383A1.

⁵⁹ NOAH Fly Ash Treatment – New Technologies. Morten Breinholt Jense, Valorization of fly ash from Waste-to-Energy. IEA Bioenergy Task 36 seminar. October 7, 2020. Available at <https://task36.ieabioenergy.com/wp-content/uploads/sites/4/2020/11/Morten-Breinholt-Jensen-Head-of-technology-NOAH-%E2%80%93-NOAHs-RD-project-about-fly-ash.pdf>. Accessed October 20, 2025

⁶⁰ Personal communication between Haakon Rui, Langøya KompetanseHub Leader, and KAMK. November 3, 2025.

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KCl in fertilizers by [Yara](#)⁶¹, NaCl by [INOVYN](#)⁶² for chlorovinyl production and CaCl₂ for some not assigned application.

The foreseen applications of other products, including treated fly ash, gypsum and waste acids, are currently limited by challenges related to process feasibility, environmental standards or industrial / product related requirements.

Additional product options for fly ash are, limited by potential challenging substances, recovery of Zn and use of ash as cement replacement or raw material for clinkers. Gypsum could be used in concrete industry as a filler material, in cement industry as a retarder, or in plasterboards.

NOAH technologies stabilize and immobilize most of the contaminants in fly ash. According to report from 2018, the energy demand of NOAH Langøya is 23 kwh/t and freshwater consumption 0.1 m³/t per treated fly ash⁶³. Surplus water is treated and discharged to sea. This is a centralized solution which requires transportation. When complemented with ReSalt, the salts of fly ash can be utilized.

In NOAH CarbonTech aqueous effluents are not produced. The technology captures CO₂ (ca. 75 kg/ton of fly ash). Total energy demand is ca. 5-6 kWh/t and water consumption 18-19 wt.% of the final carbonated material. This technology is likely to be applicable either as a centralized or decentralized system, depending on the demand. CarbonTech enables meeting criteria for non-hazardous landfilling for all species except chlorides⁶⁴.

NOAH CarbonTech has shown to be demanding to operate in manual mode and automation is under development. Langøya technology involves with large quantities of chemicals and hazardous wastes which requires appropriate equipment and procedures. If KCl was used in fertilizing, heavy metals should be removed. The absence of harmful substances such as dioxins should be verified.

⁶¹ Yara Ltd website. Accessed October 20, 2025

⁶² INOVYN on INEOS Ltd website. Accessed October 20, 2025

⁶³ Becidan, M. (2018). Report. Fly ash treatment technologies. An overview of commercial and upcoming technologies for Norway and Scandinavia.

⁶⁴ NOAH Fly Ash Treatment – New Technologies. Morten Breinholt Jense, Valorization of fly ash from Waste-to-Energy. IEA Bioenergy Task 36 seminar. October 7, 2020. Available at <https://task36.ieabioenergy.com/wp-content/uploads/sites/4/2020/11/Morten-Breinholt-Jensen-Head-of-technology-NOAH-%E2%80%93-NOAHs-RD-project-about-fly-ash.pdf>. Accessed October 20, 2025

Ash Treatment Technologies Summary



NOAH is also looking into nature reclamation with their end filter-cake product. Picture: NOAH Ltd.

Table 6 Summary of NOAH technologies

Principle	Products	Byproducts	Capacity
CarbonTech: 1-step process based on encapsulation of fly ash	Construction material?	Carbonated fly ash for hazardous landfilling	Only pilot level investigations reported
Langøya: Multi-step neutralization process	Gypsum	Carbonated fly ash for hazardous landfilling	Langøya plant handles 300 000 t/a fly ash and other waste
ReSalt: Additional to Langøya	NaCl, KCl and CaCl ₂	Filter cake from press filtering of gypsum slurry	-

Ash Treatment Technologies Summary

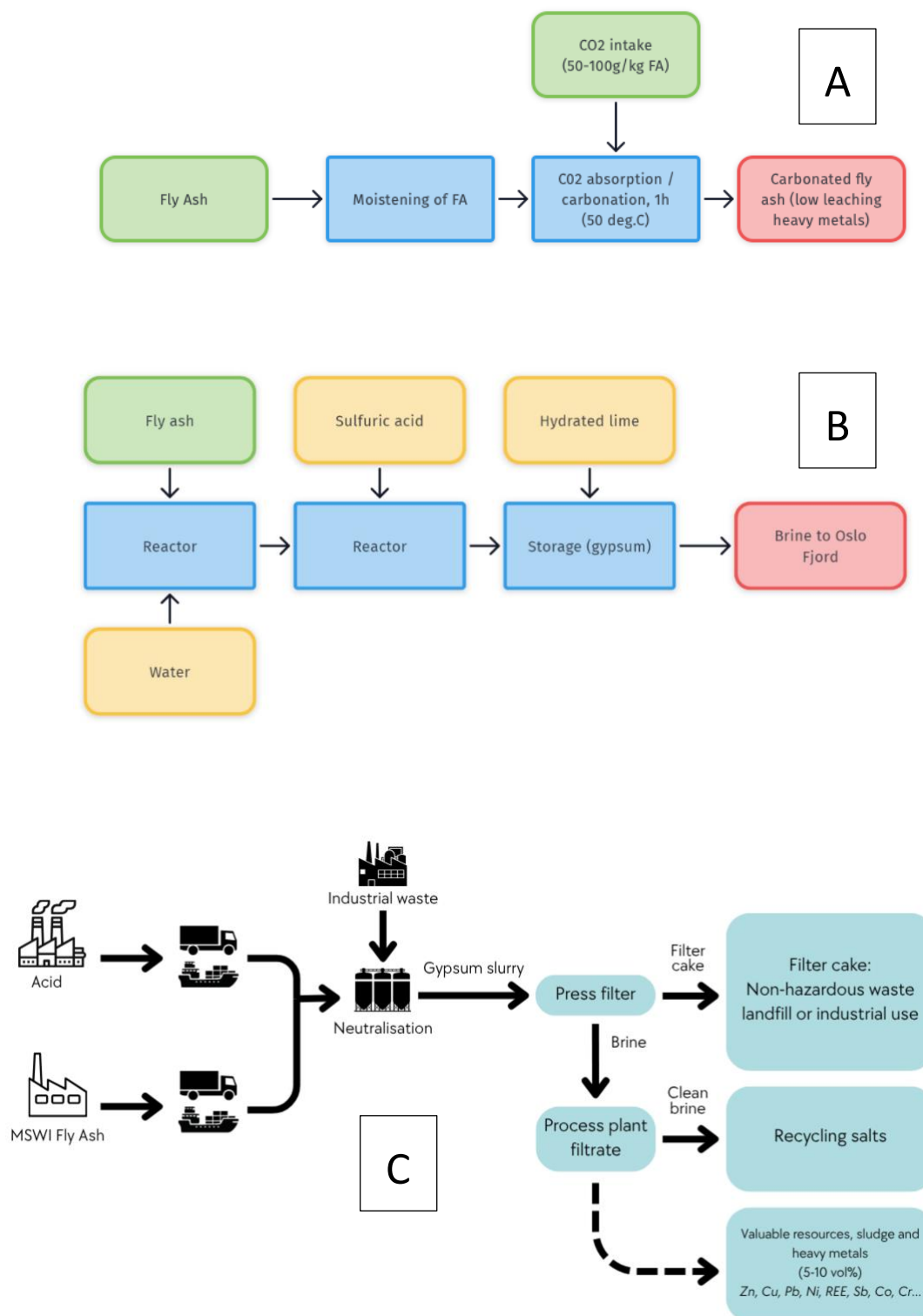


Figure 6 NOAH technologies CarbonTech (A), Langøya (B) and ReSalt (C)

Ash Treatment Technologies Summary

2.8 NORSEP

[OiW Process Ltd](#)⁶⁵ was a Norwegian company specializing in process engineering and solutions within wastewater, produced water and chemical systems. The company went bankrupt in 2023. OiW subsidiary [Norsep Ltd](#)⁶⁶ developed a process to convert hazardous waste fly ash from waste to energy plants into non-toxic residue and commercially attractive products. The NORSEP technology is based on dissolving fly ash in hydrochloric acid, filtering the fly ash, and removal of the organic toxins using heat treatment. Potential products are treated with fly ash, metal-rich fraction, and salt-rich water. Treated fly ash requires landfilling unless it is approved as a product (non-hazardous). OiW has started the operation of its pilot plant in Herøya, Norway, in 2020. The TRL is evaluated to be 6-7. The company planned construction of a 2000 t/a demonstration facility. OiW has filed a patent application on NORSEP technology⁶⁷.

Revenue was expected from selling treated fly ash, salt-rich water, and metal-rich fraction. These products have not been approved and quality data of them is not available. NORSEP is a multi-step process with three major product fractions which indicate various post-treatments and at least medium cost. The flexibility of process for different fly ashes has not been assigned. Energy and water consumption of NORSEP has not been assigned. The technology enables decentralized fly ash treatment which reduces transportation. An advantage is that the method employs other waste streams (e.g. scrubber effluents for acid). The need for landfilling has not been assigned. NORSEP promotes circular economy if the metal deposits generated from the by-products can be utilized economically, for example in metal processing. The process still generates saline water, which must be treated separately for the salts to be used in industry. Handling chemicals requires appropriate routines for personnel.

Table 7 Summary of NORSEP technology

Principle	Products	Byproducts	Capacity
Multi-step process based on extraction, separation, and heat treatment	(Insoluble fly ash fraction) Metal-rich fraction (zinc concentrate) Salt-rich water (brine)	Insoluble fly ash fraction for landfill? (not hazardous)	First plant was under construction since 2019, capacity 13000 t/a; The current status is not known

⁶⁵ OiW Process Ltd website. Accessed October 20, 2025

⁶⁶ Norsep Ltd on Business Norway's website. Accessed October 20, 2025

⁶⁷ Bakke. "Method and apparatus for forming a suspension of partly dissolved fly ash in a mineral acid." EP3556468A1.

Ash Treatment Technologies Summary

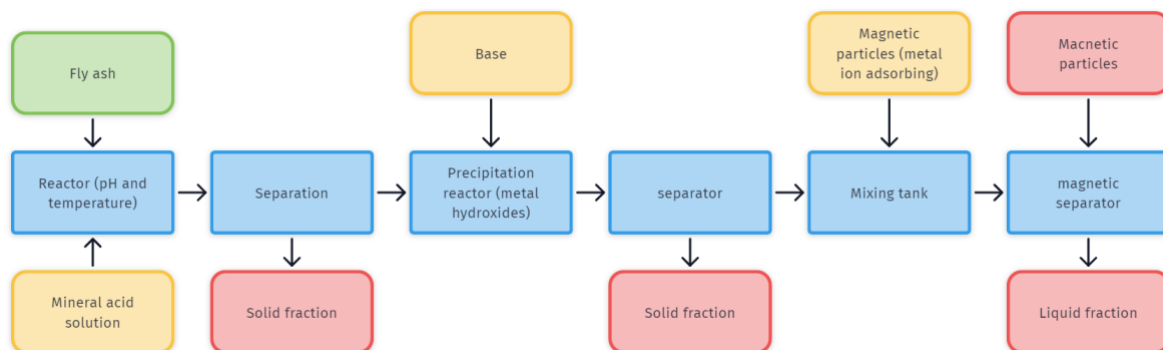


Figure 7 NORSEP technology

2.9 RENOVA

[The Renova Group](#)⁶⁸, headquartered in Gothenburg, is owned by ten municipalities in western Sweden. The company specializes in waste and recycling. The Group consists of the parent company Renova AB and subsidiary Renova Miljö AB of which the latter offers complete solutions in waste and recycling. Renova and Chalmers University have developed technology for fly ash treatment.

Renova technology is based on washing fly ash with acidic scrubber effluent forming a solid residue and zinc-rich leachate. It has similarities with FLUWA and FLUREC processes apart from the thermal treatment. The leachate is further treated using chemical precipitation, flocculation, filtration, and water washing to obtain a zinc fraction. The formed fly ash residue is either circulated back to the furnace or landfilled, depending on regulations. The TRL of the technology is evaluated to be 8 (commercial). The second Renova technology is based on the acid leaching and precipitation process. As a result, 70% of phosphorus content of the ash can be recovered⁶⁹. Phosphorus recovery technology is under development. It is assumed to be at TRL 3-4. The flexibility of process for different fly ashes has been assigned as satisfactory. Patents on Renova technology were not found.

Renova is a multi-step technology including chemical and thermal processes and overall cost is estimated to be medium to high, because of relatively high chemical costs. Revenue is expected from the zinc concentrate which can be sold to smelters. The flexibility of process for different fly ashes has not been assigned.

The final product from acid leaching and precipitation contains ca. 3% phosphorus, which is slightly higher than the content in sewage sludge or in the low-grade phosphate ore. However, the trace metal content limits direct application of this product on agricultural land.

⁶⁸ Renova Group. Accessed October 20, 2025.

⁶⁹ Yuliya Kalmykova, K. Karlfeldt Fedje. 2013. Phosphorus recovery from municipal solid waste incineration fly ash. <https://doi.org/10.1016/j.wasman.2013.01.040>. Accessed October 20, 2025

Ash Treatment Technologies Summary

The process water consumption is 6 m³/t of ash. The main cost driver is the use of hydrochloric acid ⁷⁰, but since the input of hydrochloric acid depends on the process water and ash, the amount might be lower or higher. The cost of materials, investments, and operational costs, which are not considered here, must be compensated by revenues and savings. The prices presume that purity criteria are fulfilled. Acid leaching technology has high chemical demand. The cost of HCl is ca. 40 EUR/t of fly ash. The revenue from zinc (50 kg/t ash) can be estimated to be ca. 55 EUR/t ash (80% recovery).

Data on energy or water consumption is not available. Water treatment is necessary after Renova. The fly ash residue requires landfilling (no hazardous fractions) unless it can be recycled back to furnace. Solid from acid leaching process (phosphorus-rich product) can be used as a secondary resource for phosphates production, thereby mitigating the use of this non-renewable mineral resource. Handling chemicals and heavy metal rich materials requires proper procedures.

Table 8 Summary of Renova Technology

Principle	Products	Byproducts	Capacity
Multi-step process including chemical and thermal treatments	Zinc-rich leachate, treated further to zinc concentrate	Fly ash residue (circulated back to furnace or landfilled)	Recovery at Sävenäs Waste-to-Energy plant, Gothenburg, Sweden
Acid leaching, precipitation	Fe rich solid, P rich solid	Fly ash residue, residual filtrate	Laboratory tests

2.10 ArcFume

[ScanArc Plasma Technologies](#) ⁷¹ is based in Hofors, Sweden. The company specializes in plasma technologies for extraction of valuable materials from industrial residues. ArcFume is a thermal process based on melting and vitrification, i.e. transformation of a material into glass, under temperature of ca. 1250 °C. It produces a metal-rich filter cake which may be further treated to extract zinc and other metals, and metallurgical slag which may have commercial potential e.g. in road construction. SCANARC has conducted a pilot and feasibility study at Hofors, Sweden, in 2016. Similar technology has been used in Europe in the metallurgical sector but not for MSW fly ash treatment. The TRL is evaluated to be at TRL 5-6, however recent update was not found. SCANARC has filed a patent application on plasma technology ⁷².

ArcFume is based on high temperature, and its economy is strongly dependent on electricity price. Typically, such processes relate to high investment costs. Based on feasibility study, energy consumption is ca. 633 kWh/t of feedstock (fly ash/sand). Treatment cost may be up to 600 EUR/t

⁷⁰ Assuming 72 EUR/t of concentrated HCl and a density of 1.169 g/cm³ for HCl

⁷¹ ScanArc Plasma Technologies Ltd website. Accessed October 20, 2025

⁷² Korostenski et al. "A method for plasma treatment of waste." WO2011136727A1.

Ash Treatment Technologies Summary

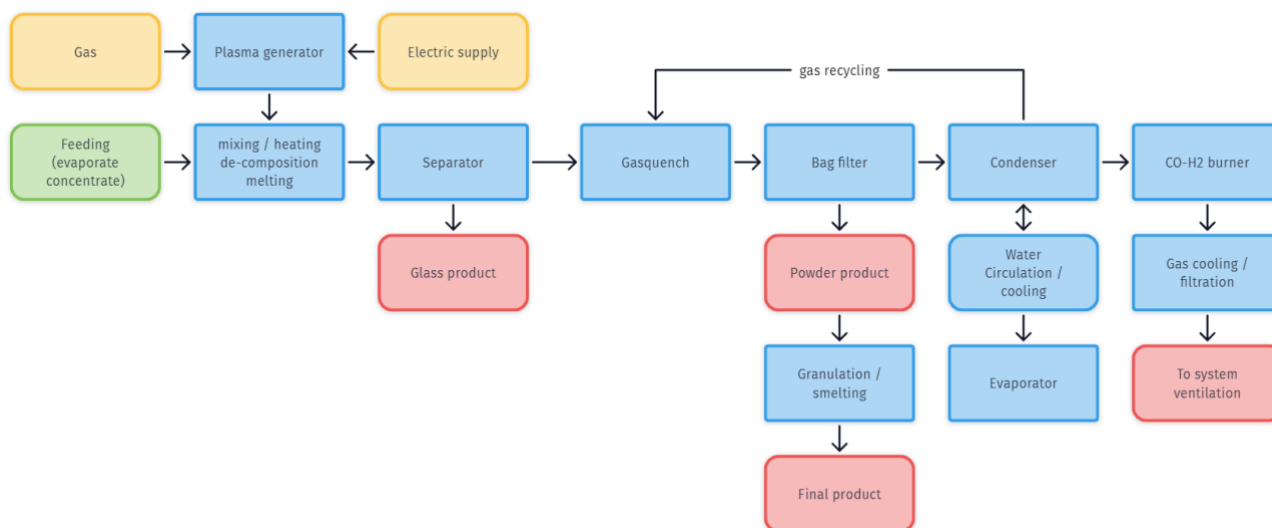
of fly ash (due to high manufacturing and energy costs (60 EUR/t). Revenue is expected from the extracted metals and slag. Vitrification may require additional chemicals for which data is not available. Overall cost is estimated to be high. The flexibility of process for different fly ashes has not been assigned. Generally, this kind of process is relatively flexible for feedstock.

ArcFume technology is energy extensive, consuming ca. 633 kWh/t of feedstock. Water consumption is 0.18 m³/t of feedstock. Additionally, 21 Nm³/t of LNG are consumed. This is a centralized solution which requires transportation. From a circular economy point of view, the method does not utilize metals or salts. It may, however, bring new product options if safety of the metal products is ensured. Working conditions in the process are similar to metallurgical industry, including dust, heat, noise and melting masses.

Table 9 Summary of ArcFume technology

Principle	Products	Byproducts	Capacity
Thermal process based on vitrification	Metal extracts (and slag)	Slag if it is not commercialized	Pilot was conducted with 3905 kg fly ash; Feasibility study calculated for 100000 t/a of fly ash

Figure 8 ArcFume technology



Ash Treatment Technologies Summary**2.11 SCANWATT**

[Scanwatt Ltd](#)⁷³ was established in 2011 in Norway with focus on renewable technologies. In 2013, the company started to investigate conversion of air pollution control waste to road construction materials.

SCANWATT technology is based on vitrification and has similarities with ArcFume. Technology starts with washing of fly ash with water for salt removal and drying of the residue at waste to energy plant. Dried residue is transported to a central facility for further treatment. Residue is mixed with liquid metallurgical slag and vitrified at high temperature. The produced vitrified slag mixture may be used in road construction if allowed by regulations. The flexibility of process for different fly ashes has not been assigned. Generally, this kind of processes are relatively flexible for feedstock.

SCANWATT has conducted a pilot in Kristiansand, Norway during 2013-2016. Capacity data is not available. In 2020 the TRL was evaluated to be at 5-7 after which updates have not been published. SCANWATT has filed patent application on plasma technology⁷⁴.

This technology is based on high temperature, and its economy is strongly dependent on electricity price. Typically, such processes relate to high investment cost. Revenue is expected from the vitrified slag if it is approved as an earth construction product. Vitrification may require additional chemicals for which data is not available. Overall cost is estimated to be at medium level.

Data on energy or water consumption is not available. This kind of thermal processing is energy intensive. According to SCANWATT, this can be decentralized or centralized solution (further data not available). The process is not very attractive for the circular economy as it does not recover salts or metals. Product can be used as road construction material. The process needs a hot slag melt from the metal industry to support the process. Working conditions in the process are similar to metallurgical industry, including dust, heat, noise and melting masses.

Table 10 Summary of ArcWatt Technology

Principle	Products	Byproducts	Capacity
Thermal process based on vitrification	Vitrified slag (if allowed by regulations)	Vitrified slag if not commercialized Salt-rich water effluent	Pilot was conducted with scale of “tons” in Kristiansand during 2013-2016 (exact scale not assigned)

⁷³ Scanwatt Ltd. Accessed October 20, 2025

⁷⁴ Henriksen. “A process for treatment of fly ash.” WO2018127478A1.

Ash Treatment Technologies Summary

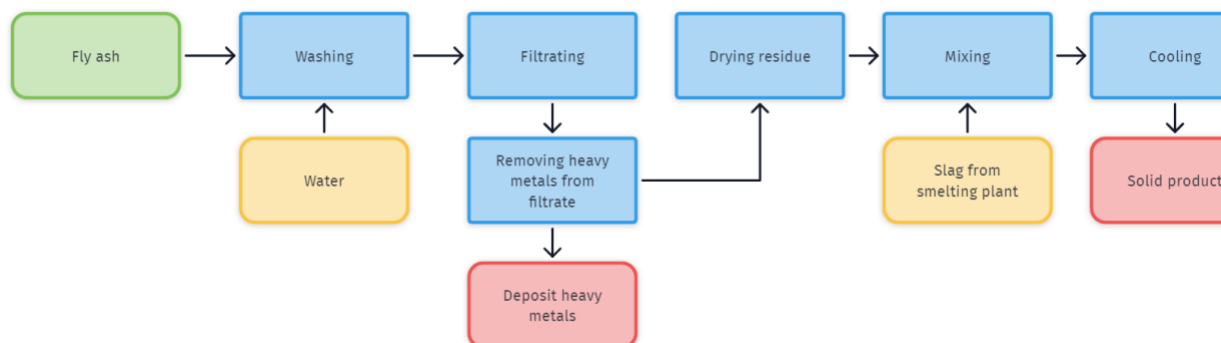


Figure 9 SCANWATT technology

2.12 TERRATEAM

[Miljøteknikk Terrateam Ltd](#)⁷⁵ was established in 1987 in Mo i Rana, Norway with focus on remediation of contaminated land. The company has developed and operated technology for fly ash treatment since 1993. Terrateam technology is based on cement solidification and stabilization of fly ash. The process is similar to other technologies used in Europe (cement stabilization). The produced solidified fly ash is landfilled (hazardous waste).

Terrateam technology has been used in Mofjelled, Norway, since 1990s. Currently it handles 100000 t/a of hazardous waste from which 15000 t/a is fly ash from waste to energy plants. The TRL is 9. Patents on Terrateam technology were not found.

This technology is based on simple cement stabilization process for which the cost is country specific (in EU ca. 25 EUR/t). Overall cost is estimated to be low. Products with commercial value are not produced. The process is flexible for different fly ashes although there are predefined criteria for feedstock (exact data not available).

The energy consumption of Terrateam technology was ca. 1917 MWh diesel and 799 MWh electricity in 2014 for the whole plant (140000 of fly ash). Terrateam technology increases the quantity of landfilled material by a factor of 2-3. This is a centralized solution and transportation is required. The process does not recover salts or metals. Conditions during solidification are similar to concrete/cement industry, including dusting. Dusting is low after solidification.

⁷⁵ Miljøteknikk Terrateam Ltd website. Accessed October 20, 2025

Ash Treatment Technologies Summary

Table 11 Summary of Terrateam technology

Principle	Products	Byproducts	Capacity
Solidification of fly ash by cement stabilization	-	Solidified fly ash (landfill)	In commercial use, handles 15000 t/a of fly ash

2.13 MetalCirc

[MetalCirc Ltd](#)⁷⁶ was established in 2019 in Vantaa, Finland as a spin-off from University of Eastern Finland. The company specializes in fly ash treatment and recovery of metals. The company team has extensive experience of nanoparticle production. Finnish material technology company Betolar acquired MetalCirc's patent on fly ash treatment in 2024. MetalCirc technology is based on neutralization of ash, followed by recovery of valuable metals and their use in production of catalyst materials. The products include metal oxides, salts and residue which can be used in catalyst production or as construction material.

In the laboratory, two different types of plants, the grate incineration plant (GF) and the circulating bed plant (CFB), were studied. When ash was heated at 1000 °C in air, all chlorine and carbon were removed. Moreover, approximately 20-30% of sulfur, 60-80% of potassium, 40-50% of sodium, 80-90% of lead, 70-90% of cadmium, 30-50% of copper, and 80-90% zinc was removed. MetalCirc has conducted pilot investigation in cooperation with HSY under kg scale. The TRL is evaluated to be at 6. Patent of MetalCirc was acquired by [Betolar Ltd](#)⁷⁷ in 2024⁷⁸.

Based on the laboratory results, thermochemical treatment enables stabilization of several metals for which concentrations may otherwise exceed permit levels. For instance, chromium is converted to non-toxic and insoluble trivalent chromium, and almost all cadmium can be removed. These advantages enable meeting stringent solubility limit values for landfilling. Residual material contains mainly aluminum, silicon and calcium oxides which can be used in earth construction and cement products. These products need approval.

It has been concluded that the thermochemical treatment enables conversion of fly ash in form which meets landfill regulation limits. Additionally, precious metals such as zinc can be recovered from the ash and the final ash can be utilized, for example, as a soil builder, cement additive or catalyst. Toxic fumes may be formed during the process.

⁷⁶ MetalCirc Ltd on Tracxn. Accessed October 20, 2025

⁷⁷ Betolar Ltd website. Accessed October 20, 2025

⁷⁸ Jokiniemi et al. Method and system for ash treatment." WO2020174123A1.

Ash Treatment Technologies Summary

Table 12 Summary of MetalCirc technology

Principle	Products	Byproducts	Capacity
Thermal heating	Evaporated metals	Residue (slag)	Not known

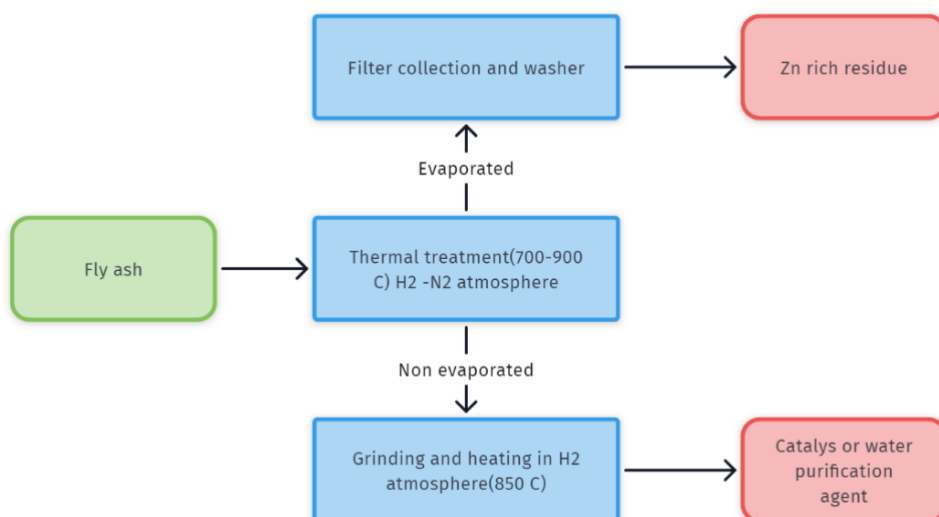


Figure 10 MetalCirc technology