theramin

# thermal treatment for radioactive waste minimisation and hazard reduction


Thermal treatment research and experimentation at the University of Sheffield

## INTRODUCTION

Safe management of radioactive waste is challenging to waste producers and waste management organisations. Thermal pre-treatment or immobilisation processes result in significant volume reduction, waste passivation and destruction of organic materials, which reduces risks during waste storage and supports development of safety cases for geological disposal.

Some thermal processes, such as induction melting, plasma melting or hot isostatic pressing, immobilise the waste into a disposable product, such as a glass, ceramic or metal. Other thermal processes, such as incineration, pyrolysis, calcination and gasification, are pre-treatment steps and the product may need further processing prior to disposal.

## CONTENTS



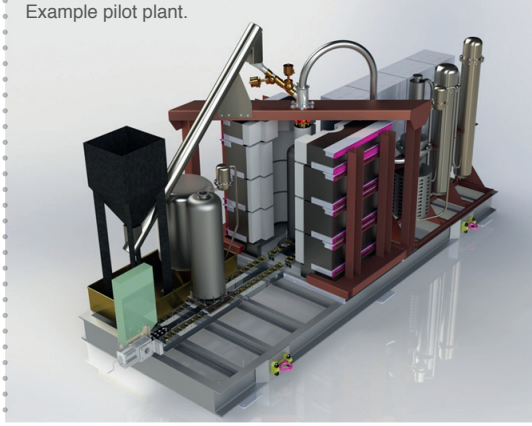
**For further information:**
please see our website at http://www.theramin-h2020.eu or contact the project coordinator Matti Nieminen, VTT at Matti.Nieminen@vtt.fi

## PROJECT SUMMARY

**theramin** aims to identify which wastes could benefit from thermal treatment, which processes are under development in participating countries, and how these can be combined to deliver a range of benefits across Europe.

**theramin** is being carried out by a consortium of 12 partners representing a European-wide community of experts on thermal treatment technologies and radioactive waste management and disposal. The project includes an advisory group of waste producers and management organisations to provide an end user view.

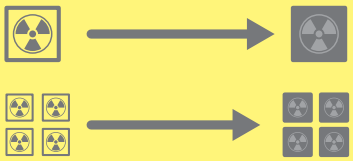
Example pilot plant.



## the theramin PROJECT IS:

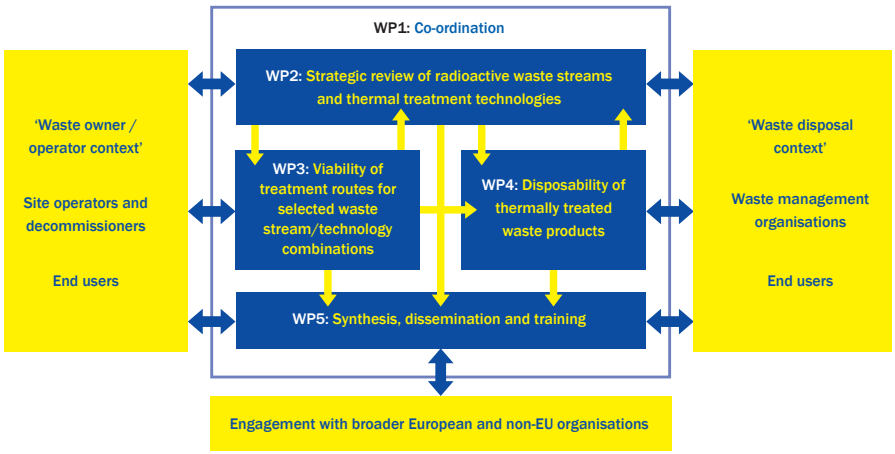
- Providing an EU-wide strategic review and assessment of the value of thermal treatment technologies applicable to a broad range of waste streams (e.g. ion exchange media, soft operational wastes, sludge, organics and liquids).

- Compiling a database of thermally treatable wastes in participant countries, documenting the strategic benefits of thermal treatment, and identifying the opportunities, synergies, challenges, timescales and cost implications to improve radioactive waste management.



- Evaluating the applicability and achievable volume reduction of the technologies through active and non-active pilot-scale and full-scale demonstration tests, and assessing the disposability of residues.

**theramin** is divided into five work packages. The aim of each work package (WP) is summarised in the diagram below, which also shows how information flows between WPs.

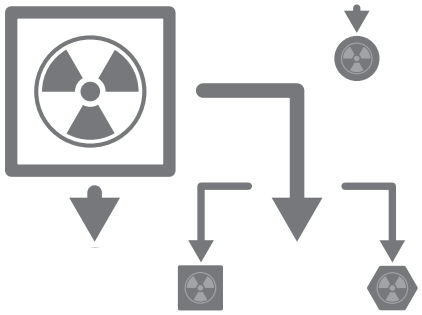



## UPCOMING EVENTS

**This newsletter highlights the following upcoming events:**

- **theramin** Technical Training School (Marcoule, France, 12-14 June 2019)
- **theramin** 2020 Project Conference Manchester, UK, 4-5 February 2020)
- EURADWASTE'19 Conference (Pitesti, Romania, 4-7 June 2019)

## WP2:
# STRATEGIC REVIEW OF RADIOACTIVE WASTE STREAMS AND THERMAL TREATMENT TECHNOLOGIES



**WP2 has identified a wide range of wastes that could benefit from thermal treatment and documented thermal treatment technologies available in Europe (summarised within the first theramin newsletter).**

The technological viability of particular waste-stream technology combinations was assessed, together with a high-level evaluation of the value of thermally treating the wastes, compared to alternative non-thermal methods. Specifically, the thermal treatment technologies were assessed in terms of their:

- Operational safety
- Environmental impacts
- Timescales for construction, operation and decommissioning
- Technological readiness
- Strategic impacts
- Impact on disposability
- Cost

Initial assessments were conducted for example technologies where the treatment of a single waste group was assessed against a baseline non-thermal technology (commonly cementation or overpacking). In 2020, the intention is to apply this methodology to the waste-technology combinations being tested in WP3, using the results from the WP3 trials and learning from WP4 on the disposability of thermally treated products, to inform the final assessments.

## VTT hosts
# GENERAL ASSEMBLY MEETING, ESPOO

VTT hosted the third **theramin** General Assembly meeting on 2nd October 2018 at the VTT Centre for Nuclear Safety in Espoo, Finland. The meeting was attended by **theramin** Partners and End Users and an update on progress was given for each WP, including detailed discussions of the ongoing WP3 trials and agreement of the characterisation tests to be conducted in WP4. The meeting also included a visit to VTT's thermal gasification pilot plants in Bioruukki Pilot Centre.


**theramin** meeting participants at VTT Center for Nuclear Safety, Espoo, in October 2018.

## WP3:
# VIABILITY OF TREATMENT ROUTES FOR SELECTED WASTE STREAM/ TECHNOLOGY COMBINATIONS

**Since February 2018, a number of partners have completed thermal treatment demonstrations for specific waste streams of interest across the EU, selected for this experimental programme based on the output from WP2.**

The output from each partner has been summarised in published deliverables, which are available from the **theramin** website http://www.theramin-h2020.eu/downloads.htm :

D3.3: SHIVA and In-CAN melting

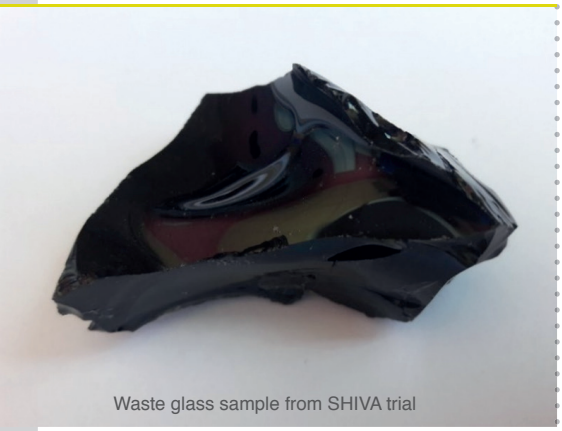
D3.4: Gasification

D3.5: Geomelt

D3.6: Hot Isostatic Pressing (HIP)

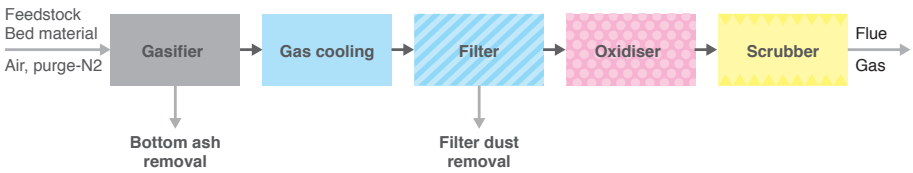
### SHIVA Trial

The SHIVA process allows, in a single reactor, waste incineration by plasma burner and vitrification of the resulting ashes in a cold-wall direct glass induction melting system. It is well suited to treat organic and mineral waste with high alpha contamination. The SHIVA trial was carried out by CEA, and demonstrated successful processing of a waste stream containing a mixture of mineral and organic ion exchange media. The load rate reached a promising 38 wt% and the product appears homogeneous on the millimeter scale.



Waste glass sample from SHIVA trial

### Thermal Gasification Trial




Principle of the gasification thermal treatment facility (patented by VTT).

VTT has developed, constructed and tested a thermal gasification treatment method to reduce the volume of radioactive waste containing a high proportion of organic matter. The method was designed for organic ion exchange resins, but can also be used for low-level operational waste containing organic matter, if crushed before treatment. The product is fine dust (collected on a filter) and bottom ash, which consists mainly of bed material (e.g. aluminium oxide). These products have to be immobilised (e.g. by cementation, vitrification) before final disposal.


VTT's pilot scale thermal gasification test facility

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GeoMelt rig

NNL operator adding activity to the filled Cast Refractory Box (CRB).

### GeoMelt Trials

NNL has used the GeoMelt In-Container Vitrification (ICV) system in the NNL Central Laboratory at Sellafield to demonstrate treatment of two active wastestreams:

- TH01- A cementitious stream representative of sea dump drums or failing cement wastes packages.

Link to video left.

- TH02- A sludge stream made up of a naturally occurring zeolite (clinoptilolite), sand, Magnox storage pond sludge and miscellaneous.

Link to video left.

Both experiments have provided successful demonstrations of co-processing; utilising one potential waste material to form the primary glass former for other waste components.

### Hot Isostatic Pressing (HIP) Trials

Both NNL (in the NNL Workington laboratory) and the University of Sheffield (USFD) have used HIP to demonstrate treatment of surrogates for Magnox sludge and clinoptilolite. NNL carried out two HIP trials, the results of which suggest that the products would be suitable for disposal.

Examples of HIP containers produced during the NNL trials

USFD prepared and HIPed seven conceptual wasteforms. The primary aim was to demonstrate use of an active furnace isolation chamber that allows processing of radioactive waste simulants without risk of contamination to the processing equipment. Five wasteforms were produced, using $U_3O_8$ to simulate Magnox sludges located at the Sellafield Ltd site.

NNL HIP operator

## WP4: WASTE ACCEPTANCE CRITERIA

Waste Acceptance Criteria (WAC) identify the characteristics required in a waste product in order to ensure that the waste cannot have a significant detrimental impact on the long-term safety provided by a disposal facility. They also provide a measure of the 'quality' of a waste product and, if applied sufficiently broadly, give a basis for consistent comparison between the products generated from the treatment / conditioning of different wastes and/or via different routes.

After a first step of identification of WAC by each participating country, some generic criteria were developed that can be used to evaluate products from thermal treatment for disposal regardless of the political, regulatory or socio-economic context. This set of criteria can be considered as a starting point for waste management organisations to develop their own disposability criteria in a more specific context, with a high level of confidence that they have taken the key factors into account.

These generic criteria can be found in the public report D4.1, available here:

http://www.theramin-h2020.eu/downloads/THERAMIN_D4_1_Waste_Acceptance_Criteria_and_requirements.pdf

## WP4:
# CHARACTERISATION OF THERMALLY TREATED WASTE PRODUCTS

In order to be disposed of, radioactive waste must comply with the WAC for a disposal facility. This compliance can be checked by characterisation of the thermally treated products. A set of characterisation tests to be carried out within WP4 was developed by the partners using the following methodology: selection of WAC requiring characterisation tests, identification of physico-chemical parameters that relate to these WAC, identification of available characterisation tools, and, finally, selection of characterisation tests.

All of the samples from WP3 will be characterised, as will some additional samples from thermal treatment processes not demonstrated within the **theramin** project. At this point, the characterisation tests are ongoing.

The selected techniques will provide data on:

- the degree of homogeneity of the sample and the absence of free liquid or gas,
- the overall chemical composition of a homogeneous sample or the local compositions of a heterogeneous sample,
- the amorphous or crystalline nature of a sample and the structure of the crystals present in a crystallised sample, and
- the chemical durability of the samples against the hydrolysis process (leaching tests).

More details on the ongoing characterisation tests are available here:
http://www.theramin-h2020.eu/downloads/THERAMIN_MS12_Report_vf.pdf

## WP5:
# SYNTHESIS, DISSEMINATION AND TRAINING

**theramin** WP5 aims to disseminate knowledge and the outcomes of the project within the technical community and more widely. This includes:

- training placements linked to experimental trials or sampling and analysis being conducted in WP3 and WP4.
- technical training school hosted by the CEA, Marcoule in June 2019.
- project conference in Manchester, UK, in February 2020.

### Training placements hosted by USFD, VTT and the CEA

The first **theramin** training placement took place in November 2018, with a four-day visit to the University of Sheffield, by Mr. Viktor Krasnov and Dr. Sergey Sayenko (respectively, from the Institute for Safety Problems of Nuclear Power Plants of the National Academy of Ukraine and the Kharkov Institute of Physics and Technology). The placement provided the opportunity for participants to understand and experience the HIP process at pilot scale. The participants took part in a week-long experiment, as part of WP3, to demonstrate the key principles of the HIP process, from can preparation, through operation of the hot isostatic press, to recovery of the processed material for analysis. The participants identified potential applications of HIP technology in the Ukraine.

Participants and hosts of the first **theramin** training placement at the University of Sheffield.

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The second **theramin** training placement took place in January 2019, with a four-day visit to VTT, by Mr. Viktor Krasnov and Dr. Sergey Sayenko.

Viktor and Sergey followed the thermal gasification test trial with simulated ion exchange resin at the VTT's Bioruukki Pilot Centre. The placement also included a tour of VTT's Centre for Nuclear Safety and VTT's other facilities related to testing and characterisation of radioactive waste.


Participants and hosts of the second **theramin** training placement at VTT.

The third **theramin** training placement took place in February 2019, with a three-day visit to the French Alternative Energies and Atomic Energy Commission (CEA), by Laura Leay (The University of Manchester), Seif Ben Hadj Hassine (ONDRAF), Adam Fuller (Galson Sciences Ltd), Viktor Krasnov (National Academy of Sciences of Ukraine) and Sergey Sayenko (Ukraine National Science Center).

First, the visitors took the opportunity to become familiar with the management of radioactive waste in France by visiting the scientific museum Le Visiatome® Marcoule. The main focus of the placement was related to the trials carried out in the **theramin** project, and participants visited the thermal treatment facilities using plasma and vitrification technologies and the laboratories where a range of techniques for materials characterisation were demonstrated. The participants also visited the hot cells of the "DHA" installation in the CEA's Atalante facility, where research is conducted on high-level waste treatment and vitrification, the development of the DELOS process for improved organic effluent management (based on a total and rapid oxidation reaction between contaminated organic liquid waste and an oxidant in supercritical water medium), and the research laboratories for cement matrices.

Participants in the third **theramin** training placement at CEA, visiting the Atalante facility.

## UPCOMING EVENTS

**theramin Technical Training School**

**Hosted by CEA, Marcoule 12-14th June 2019**

This is the first call for applications to the **theramin** technical training school, which is being held in Marcoule in June 2019. The course is aimed at early-career scientists and engineers working in the field of radioactive waste management, and at participants from countries that do not currently use thermal treatment for radioactive waste. Topics covered will include:

- The benefits and strategic impact of thermal treatment
- Treatment technologies demonstrated within the **theramin** project
- Material characterisation and disposability

The course will include lectures, a poster session and visits to thermal treatment facilities owned by CEA and EDF, as well as cultural and networking activities.

**Registration deadline: Friday 12th April 2019**

Places are limited, so please apply as soon as possible to secure your place. EC funding may be available to support attendance. An application form and further details are available here: www.theramin-h2020.eu/downloads.htm

**theramin 2020 conference**

**4-5th February 2020, Manchester**

**theramin** will host a conference to share the results of the project and other recent developments in the field of thermal treatment of radioactive waste. Abstracts are invited for presentations (oral or poster) relating to the following themes:

- Strategic impact of thermal treatment
- Demonstration of thermal treatment technologies
- Disposability of thermal products and characterisation techniques

There will be a networking reception and conference dinner, as well as an optional visit to the Immobilisation Science Laboratory at the University of Sheffield on 6th February (limited spaces). Further details are available here: www.theramin-h2020.eu/conference.htm

**EURADWASTE'19**

Another upcoming event is the 9th European Commission Conference on EURATOM Research and Training in Radioactive Waste Management will be held in Pitesti, Romania from **4-7th June 2019**. A paper will be presented on the results of the Theramin project. Further details are available here: http://fisa-euradwaste2019.nuclear.ro/

**Project participants:**

The theramin project benefits from participation from waste management organisations, waste producers, and research organisations, with input from technology specialists. It therefore offers a "joined-up" perspective of the advantages and disadvantages of using thermal treatment within the waste management lifecycle.

**theramin partners:**

- VTT Technical Research Centre of Finland (VTT), Finland
- Agence Nationale pour la Gestion des Déchets Radioactifs (Andra), France
- Orano, France
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), France
- Galson Sciences Limited (GSL), United Kingdom
- Forschungszentrum Jülich GmbH (FZJ), Germany
- Lithuanian Energy Institute (LEI), Lithuania
- National Nuclear Laboratory Limited (NNL), United Kingdom
- Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS), Belgium
- Studiecentrum voor Kernenergie/Centre d'Etude de l'Energie Nucléaire (SCK•CEN), Belgium
- University of Sheffield (USFD), United Kingdom
- VUJE a.s. (VUJ), Slovakia

**End users:**

- National Cooperative for the Disposal of Radioactive Waste (Nagra), Switzerland
- Radioactive Waste Management (RWM), UK
- Sellafield Limited, UK
- Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP)
- Électricité de France (EDF), France
- Fortum, Finland
- Teollisuuden Voima Oy (TVO), Finland
- Agence Nationale pour la Gestion des Déchets Radioactifs (Andra), France - Project Partner as well
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), France - Project Partner as well
- Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS), Belgium - Project Partner as well
- AWE, UK
- Idaho National Laboratory (INL), USA

European Commission

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