

After the RISEnergy Transnational Access, Users are required to submit a User Report. This should be done within 4 weeks after the Access is completed unless otherwise agreed. The User Report will be given to the User(s) by the WP2 leader. The report contains sections related to the work performed, the main results and observations that were achieved.

This document should be completed, signed, and sent by e-mail to risenergy@for.kit.edu.

Summary questionnaire for Users who have been granted Transnational Access (TA) under the RISEnergy project Horizon Europe TA scheme. More information on RISEnergy TA can be found in "General Rules" and in "Access Policy" which can be found on the RISEnergy webpage.

Please complete, sign, and send this form, together with the Cost claim by e-mail to risenergy@for.kit.edu with title: *RISEnergy APPXXX - reports*.

General information about the project	
Project title (as used in Application)	Concentrated Solar Energy for Autorepairing Systems in High temperature materials.
Project number (APPXXX) and acronym (max 15 characters)	Project number 133 – Acronym (CASH)
RISEnergy RI(s) accessed	Odeillo Solar Furnace, France
Keywords (up to five, free text)	Concentrated solar energy, refractories, autorepairing systems, refractory phases, microstructures.
Arrival date (in town where RI is located)	September 28, 2025.
Departure date (from town where RI is located)	October 4, 2025.
Starting date of Access (first day at RI)	September 29, 2025.
Finishing date of Access (last day at RI)	October 3, 2025.
Number of days not using the RI (during the above period)	We use RI every day from September 29 to October 3.
Reason for not using RI those days (describe)	
Number of days using the RI	5 days.
Number of Users granted Access (group size)	2 users.
Comments	We departed from Mexico on September 25th by bus (12 hours) to the airport. On September 26th, our flight to Barcelona departed, and we arrived in Barcelona on September 27th. Due to the train schedule, we stayed

	<p>one night in Barcelona and left for Font Romeu on September 28th.</p> <p>For the return trip, although we left Font Romeu on Saturday, October 4th, the most affordable flight from Barcelona to Mexico was on Monday, October 6th. We spent two nights in Barcelona and arrived back at our place of origin on October 7th.</p>
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User

User group leader or sole applicant (user group member 1)
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First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	

User group member 2

First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	

User group member 3

First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	

User group member 4	
First name	
Last name	
Affiliation / Employer	
Country of Employer	
E-mail	
User travelling to RI?	
Comments	

Please insert more fields if your groups had more than four members.

Access Summary Report - work performed and initial results

Brief description of the objectives of your project (up to 200 words)

The primary objective is to investigate refractory phases with self-healing characteristics based on MgO and Al₂O₃ matrices. These matrices will be doped with a strategic combination of oxides and functional compounds through sintering using Concentrated Solar Energy (CSE). The aim is to tackle challenges in the metallurgical industry by providing materials with enhanced durability and the ability to repair themselves at high temperatures autonomously.

Activities performed (up to 600 words)

[Please summarise the work carried you (steps taken, instrumentation used, techniques employed, data sources consulted etc.)]

Before arrival at the solar furnace, the samples were prepared as follows:

An experimental design based on the chemical composition (molar ratio) was carried out for each composition, determining the exact weights for each sample.

Ceramic oxides with particle size <180 μm were purchased. Two separate matrices, MgO and Al₂O₃, were considered, to which secondary phases of MnO, SiO₂, and B₂O₃ were added at 5 and 10 wt.% for each matrix. Two batches were prepared: one batch for sintered samples at 1300 °C and 800 °C (depending on the composition) and another batch for green samples. Both batches were uniaxially pressed at 100 MPa. Table 1 summarizes the samples used for Concentrated Solar Energy (CSE) experiments.

Table 1. Samples irradiated using Concentrated Solar Energy, based on MgO and Al₂O₃.

Bacth 1 (Pre-Sintered samples)			Bacth 2 (Green samples, powders)		
Compositions	wt.%	Sintered samples	Compositions	wt.%	Green samples
MgO-MnO	5 and 10 wt.%	1300 °C	MgO-MnO	5 and 10 wt.%	✓
MgO-SiO ₂	5 and 10 wt.%	1300 °C	MgO-SiO ₂	5 and 10 wt.%	✓

MgO-B ₂ O ₃	5 and 10 wt.%	800 °C	MgO-B ₂ O ₃	5 and 10 wt.%	✓
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During the stay at the solar furnace, the following procedures and instrumentation were employed:

1. A solar furnace with a 1.5 m diameter concentrator and a shutter to control solar radiation was used. The furnace door was opened and closed for sample placement.
2. Solar power density was measured, and each sample was irradiated at energy densities between 800 and 1050 W/m².
3. A movable carriage system was used to position the samples directly under the concentrated solar flux.
4. A protective glass dome was placed over each sample on the movable system to shield the concentrator. The dome included air hoses to vent gases released during irradiation, and an exhaust hose allowed gases to escape safely.
5. After each irradiation, the glass protective dome was cleaned to ensure consistent experimental conditions.

This approach allowed precise control of sample placement, irradiation conditions, and protection of the solar concentrator while ensuring reproducible exposure to concentrated solar energy. The combination of careful sample preparation, controlled irradiation, and protective measures enabled high-quality data collection for the evaluation of sintered and green refractory materials under solar-driven conditions

Scientific results (up to 800 words)

[Summarise the (initial) outcomes of your study at the RI(s).]

The incident solar power density on the samples was measured, recording values between 800 and 1050 W/m².

The analysis of the results obtained from the combination of Magnesium Oxide (MgO) pellets with additives of Manganese Oxide (MnO), Silicon Dioxide (SiO₂), and Boron Oxide (B₂O₃), treated in a solar furnace, focuses mainly on the effects of sintering (green pellets) and fusion (of pre-sintered pellets) on the material properties, driven by the high solar power density.

Microstructural and morphological changes will be evident with the support of techniques such as X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM). The expected scientific results are as follows:

Pre-sintered samples

These samples were exposed to direct irradiation (concentrated heat) above 1800 °C, which caused accelerated surface changes.

- **MgO–MnO:**
Localized grain growth is expected, leading the specimen to visually resemble an electrofused material. Solar irradiation promotes ionic diffusion within the solid solution between these two materials, resulting in larger MgO grains.

- **MgO–SiO₂:**
A possible accelerated conversion of in situ formed forsterite (when the specimen was pre-sintered) may have occurred. The evident microcrack formation in the irradiated specimen is likely due to phase change expansion/contraction, causing volume variation in the forsterite phase.
- **MgO–B₂O₃:**
These samples are expected to exhibit surface vitrification, leading to 100% densification. Since the samples contained magnesium borate, which melts easily (favoring vitrification), the result is the formation of a dense, glassy surface layer that completely seals the residual porosity.
- **Al₂O₃–MnO:**
These samples showed electrofused specimens, and XRD analysis is expected to reveal a greater formation of spinel (MnAl₂O₄). SEM observations are expected to show grain growth and a highly densified morphology.
- **Al₂O₃–SiO₂:**
These samples possibly developed a glassy surface layer, and although the results differ from those of Al₂O₃–MnO, this layer may act as a surface sealant, reducing open porosity.
- **Al₂O₃–B₂O₃:**
In these pellets, localized fusion and high thermal stress were visually observed; however, rapid heating and cooling may have induced thermal shock fractures due to the vitrified layer.

Green samples

Due to the high concentration of energy used over an area of 78.54 cm², the green samples fractured (since they consisted only of pressed powders). Although attempts were made to control the energy impact using a shutter (at less than 80%), this was not sufficient for the samples to withstand the supplied energy. As a result, the pellets disintegrated into loose powder. The following presents the results obtained from the powder mixtures of each composition.

For the samples composed of MgO, Al₂O₃, and combinations MgO–MnO, MgO–SiO₂, MgO–B₂O₃, Al₂O₃–MnO, Al₂O₃–SiO₂, and Al₂O₃–B₂O₃ (all at 5 wt.% and 10 wt.%), irradiated with concentrated solar energy, different in situ phases were obtained, which have not been previously studied using ESC. These phases will also be analyzed by Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD), performing phase quantification through Rietveld analysis.

A thermal process simulation will be carried out on the samples irradiated with concentrated solar energy. Thermodynamic simulations will be performed using HSC Chemistry 5.1 to estimate the energy required for phase formation and synthesis. In addition, ANSYS software will be employed to simulate the thermal behavior of the samples and determine the temperatures reached during solar irradiation. These simulations will provide valuable insights to correlate the phases identified by X-ray diffraction (XRD) with the microstructural features observed through scanning electron microscopy (SEM).

Interpretation of the results (up to 400 words)

[Discuss the data obtained and describe the major scientific conclusions drawn.]

The concentrated solar irradiation at temperatures above 1800 °C produced extreme thermal conditions, characterized by very high heating rates (even exceeding 2000 °C), steep surface–core thermal gradients, and intense radiative fluxes. These conditions promoted accelerated sintering when irradiating the MgO powders (with MnO, SiO₂, and B₂O₃) and the Al₂O₃ powders (with MnO, SiO₂, and B₂O₃). For the pre-sintered specimens, localized fusion/vitrification occurred in the same systems (MgO with MnO, SiO₂, and B₂O₃; and Al₂O₃ with MnO, SiO₂, and B₂O₃).

Accordingly, morphological and microstructural studies of both irradiated batches will be performed, as outlined in Table 1.

SEM–EDX Analysis

For the pre-sintered MgO–MnO, MgO–SiO₂, and MgO–B₂O₃ samples, localized grain growth is expected, showing partially melted regions due to the high solar power density (>2000 °C). The morphology will appear more compact, with coalesced MgO grains. EDS mapping will likely reveal a homogeneous distribution of Mn or Si (depending on the additive), indicating ionic diffusion between MgO–MnO or MgO–SiO₂. In the MgO–B₂O₃ samples, glassy phase formation may have occurred.

For the Al₂O₃-based samples (Al₂O₃–MnO, Al₂O₃–SiO₂, and Al₂O₃–B₂O₃), grain growth is expected—particularly for those with MnO, which exhibited visible softening during irradiation. This grain growth promotes partial densification, and the formation of the MnAl₂O₄ spinel phase may be confirmed through EDS stoichiometric ratios. In samples containing SiO₂ and B₂O₃ (in various compositions), the formation of a glassy phase is anticipated, which aids in densification. SEM imaging will help identify possible crack deformations, which are common under these thermal treatment conditions due to abrupt temperature changes.

Green Samples

For all compositions at 5 and 10 wt.%—MgO–MnO, MgO–SiO₂, MgO–B₂O₃, Al₂O₃–MnO, Al₂O₃–SiO₂, and Al₂O₃–B₂O₃—SEM analysis is expected to reveal densified spinel-type phases formed as a result of solar irradiation.

X-ray Diffraction (XRD)

In both batch 1 and batch 2, diffractograms are expected to show the primary crystalline structures of MgO and Al₂O₃. When samples contain additives (MnO, SiO₂, B₂O₃), unreacted phase peaks may appear, as well as new diffraction peaks corresponding mainly to spinel-type phase formation. The broader peak widths will indicate small crystallite sizes. In systems with SiO₂ and B₂O₃, a slight diffuse background may be observed, corresponding to the presence of amorphous (glassy or flux) phases formed during irradiation.

Main achievements during the TA related work (up to 250 words)

[Describe the main achievements during your stay at the site(s), Outputs (results, publications, models, etc.), conclusions, next steps, potential impact]

The main achievements during this stay include the successful densification of various ceramic compositions, particularly in the pre-sintered pellets (Batch 1), when irradiated with concentrated solar energy, which led to a significant increase in their density. Likewise, when irradiating the different powder compositions of Al_2O_3 and MgO , with the addition of secondary phases as indicated in Table 1, the formation of new refractory phases obtained in situ using Concentrated Solar Energy (CSE) was clearly observed.

These results confirm the high potential of solar sintering as a clean and efficient alternative to conventional thermal methods, reducing both energy consumption and carbon emissions associated with industrial material processing.

So far, the progress was presented on October 23, 2025, at the 5th International Symposium on Energy and Sustainability of the Universidad Veracruzana, where the innovative nature of this research was highlighted.

It is planned to publish one article in an international high-impact scientific journal, contributing to advances in the field of advanced refractory materials and the application of solar energy to materials science.

Furthermore, we will disseminate the results of this work to society through the official digital platforms of the Universidad Veracruzana, including the production of a podcast that will highlight the scientific relevance and social impact of the research.

Regarding the social impact, this work promotes the use of renewable energy sources for materials processing, encouraging the development of sustainable, low-impact technologies. It also creates opportunities to train students and young researchers in the use of solar energy as a scientific and industrial tool, strengthening the formation of human resources committed to energy transition and sustainable innovation.

Data Management

[Describe the further usage and storage of project data. State where the data will be kept and name a person responsible for the data. Define data]

The use and future storage of the project data will be carried out in a secure and accessible manner. The data generated—including experimental results, models, simulations, and technical reports—will be stored in the cloud through institutional email and reliable platforms such as Google Cloud.

The person responsible for safeguarding and managing the data will be **Dr. Cristian Gómez Rodríguez**, who will ensure security, controlled access, and the performance of periodic backup copies to prevent data loss.

Upon completion of the project, the research team will be responsible for long-term preservation and archiving. Critical data will be deposited in public or private repositories,

in accordance with the provisions established in the RISEnergy call, ensuring compliance with privacy, data protection, and intellectual property regulations.

Difficulties during the TA related work (up to 250 words)

[List problems and issues, you had, completing out your research project: Did you get access to all the necessary equipment, facilities, databases, etc.? If not, please specify the problems that occurred and list equipment the was not working or accessible.]

We had full access to the requested equipment without any issues regarding availability or operation.

The only difficulty encountered was related to the pressed pellets (green powders), since one of the objectives was to irradiate them. However, due to the high energy density to which they were exposed under concentrated solar energy (CSE), the pellets disintegrated during irradiation. Therefore, it was decided to grind the pellets again and irradiate only the resulting powder mixture, which was successfully irradiated without any problems.

In conclusion, no difficulties were encountered during the TA.

Intended publications

[Explain where and how you expect to publish the outcomes of your project work. Include also anything already published (What and where?)]

The results are expected to be effectively communicated through the publication of one article in a high-impact journal listed in the Journal Citation Reports (JCR), such as *Solar Energy* or *Ceramics International*.

Additionally, on October 23, participation in an international conference took place, where the project's progress and findings were presented.

To further disseminate the results and reach a broader audience, a podcast will also be produced on the official digital platform of the Universidad Veracruzana (UV), making the results accessible to both the academic community and the general public.

Expected impact

[The impact the expected results will have on current and future research or practice, public safety, European standardization, competitiveness, integration and cohesion and on sustainable growth. any follow on proposals, projects, collaborations, commercialisation]

The main achievements during this stay include the successful densification of various ceramic compositions, particularly in the pre-sintered pellets (Batch 1), when irradiated with concentrated solar energy, which led to a significant increase in their density. Likewise, when irradiating the different powder compositions of Al_2O_3 and MgO , with the addition of secondary phases as indicated in Table 1, the formation of new refractory phases obtained *in situ* through the use of Concentrated Solar Energy (CSE) was clearly observed.

These results have a relevant impact on current and future research, as they demonstrate the feasibility of solar sintering as a sustainable and highly efficient alternative for ceramic material processing. This approach directly contributes to reducing energy consumption and carbon emissions, aligning with European strategies for a cleaner, circular, and more sustainable industry.

In terms of competitiveness and standardization, the findings strengthen the development of technologies based on concentrated solar energy applied to refractory materials, promoting the creation of new protocols and methodologies that could be considered in future European standards.

Furthermore, the results encourage international integration and collaboration by opening opportunities for joint projects focused on the use of renewable energy sources in advanced manufacturing processes. In the future, this research line is expected to continue through new proposals aimed at optimizing solar sintering (in collaboration between the University of Oviedo (Spain), Universidad Veracruzana (Mexico), and CINN (Spain)), as well as the potential technological transfer to the industrial sector, thus fostering competitiveness and sustainable growth.

Conclusions / additional comments

[Provide any other comments you might have on your work]

The results evidenced the densification of pre-sintered ceramic samples when irradiated with concentrated solar energy. The compositions that showed complete densification, up to the point of partial melting, were mainly the Al_2O_3 – MnO samples. This represents a first approach demonstrating that concentrated solar energy can be used for the self-repair of ceramic materials through *in situ* electrofusion, leading to the formation of alumina– MnO electrofused composites.

Furthermore, when loose powders with a refractory phase of Al_2O_3 or MgO and secondary phases such as MnO , B_2O_3 , or SiO_2 were irradiated, new ceramic phases were formed *in situ* using concentrated solar energy.

These findings confirm the potential of solar sintering as a sustainable and efficient method for the advanced processing of ceramic materials, reducing energy consumption and environmental impact. The results also strengthen technological development in solar-based processing and promote future collaborations between the University of Oviedo, Universidad Veracruzana, and CINN (Spain), with perspectives for industrial application and knowledge dissemination through scientific and communication platforms.

The outcomes will be disseminated through the publication of a high-impact journal article (e.g., *Solar Energy* or *Ceramics International*), an conference presentation, and a podcast on the Universidad Veracruzana digital platform.

Did you complete the European Commission User questionnaire
<https://ec.europa.eu/eusurvey/runner/RIsurveyUSERS?>

Yes No

Feedback - HSE, Ethics and Satisfaction

Please rate on a scale from 1 (excellent) to 5 (poor). Feel free to provide additional comments

Practical information on how to apply for Transnational Access and the overall application process

1 (excellent)	2	3 (neutral)	4	5 (poor)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment

Information provided, once your project was accepted, on how to proceed

1 (excellent)	2	3 (neutral)	4	5 (poor)
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comment

Support received at the site(s) regarding technical/scientific matters and logistics

Have you got sufficient support from the RI staff during the project? If not, please, specify the problems. Yes No

Please specify any problems

The RI staff always provided support before and during the stay, and there was always prompt and smooth communication that allowed us to stay informed about the details of how to get there, what materials we needed to work with, if we required any special dietary arrangements, etc.

RI extension / upgrades required

In your opinion, is the RI needed to be upgraded? If yes, please give an explanation.
 Yes No

Please specify

For the scope of my project, the equipment available at the RI was sufficient; however, I observed that the RI continue to improve with the acquisition of new equipment.

Problems with local regulations	<p>Have you had any problems with regulations of the visited RI owner (HSE, lab working hours, etc.)? If yes, please, specify</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>
<p><i>Please specify</i></p> <p>We did not have any issues with the owner's regulations.</p>	
Health and safety issues	<p>Did you encounter any health or safety issue during your research? Please provide details.</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>
<p><i>Please provide details</i></p> <p>We did not have any health or safety issues during our stay.</p>	
Environment & Ethics	<p>Did your research involve the use of elements that may cause harm to the environment, to animals or plants? Please provide details.</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>
<p><i>Please provide details</i></p> <p>The materials we used were sintered ceramics, which did not cause any environmental harm when exposed to solar irradiation.</p>	
Environment & Ethics	<p>Did your research deal with endangered fauna and/or flora and/or protected areas? Please provide details.</p> <p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>
<p><i>Please provide details</i></p> <p>The materials we used were sintered ceramics.</p>	
Environment & Ethics	<p>Did your research involve the use of elements that may cause harm to humans, including research staff? Please provide details.</p> <p><input type="checkbox"/> Yes <input checked="" type="checkbox"/> No</p>
<p><i>Please provide details</i></p>	

The materials we used were sintered ceramics.											
Environment & Ethics - Dual use	Does your research have the potential for military applications? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No										
<i>Please provide details</i>											
Environment & Ethics - Misuse	Does your research have the potential for malevolent /criminal/terrorist abuse? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No										
<i>Please provide details</i>											
Environmental issues	Were any potentially dangerous substances (materials / gases etc.) released into the environment (atmosphere, water, or land)? Please provide details. <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No										
<i>Please provide details</i>											
The materials we used were sintered ceramics, which did not cause any environmental harm when exposed to solar irradiation.											
Ethics issues	Are there any other ethics issues that should be taken into consideration? Please specify <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No										
<i>Please provide details</i>											
Overall impression of communication and interaction after finishing your TA and related work	<table border="1"> <thead> <tr> <th>1 (excellent)</th> <th>2</th> <th>3 (neutral)</th> <th>4</th> <th>5 (poor)</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;"><input checked="" type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> </tr> </tbody> </table>	1 (excellent)	2	3 (neutral)	4	5 (poor)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1 (excellent)	2	3 (neutral)	4	5 (poor)							
<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>							
Comment											
Suggestions for facilities not included in RISEnergy which you would use for your research											
[Please provide suggestions for specific type of facilities missing (RI gaps) or measurement / experiments you would like to perform which can not be done on current RISEnergy facilities.]											

So far, all the samples I have brought have been sintered (in terms of facilities, I have not encountered any problems). In particular, the only issue I find challenging is the shipment of samples (outside the European Union), as customs service's sometimes may retain them. It would be helpful if, in the future, the center could handle the shipment of samples to the country of origin (outside the EU), or at least issue a letter certifying that the samples were sintered in a RISEnergy Research Infrastructure (RI) and that these samples are intended for research purposes, being sent to an academic or research institution as their final destination.

Suggestions how RISEnergy can improve future TA programme, how to make the TA more impactful and how to enable the achievement of high TRL levels

[Your suggestions]

Feedback - Pro-active Innovation Support

Awareness

Did you know about the pro-active innovation support of RISEnergy?

Yes No

[Please specify how you learned about the pro-active innovation support]

Personal experience

Have you taken advantage of or benefited from the pro-active innovation support?

Yes No

[Please provide details]

Information/service provided by the pro-active innovation support?

1 (excellent)	2	3 (neutral)	4	5 (poor)
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

[Please provide details]

I declare that the above provided information and especially that information on the number of days visited the RI is correct.

I have read the [RISEnergy privacy policy](#) for participation in the RISEnergy TA and consent to participation and the associated data processing.



Your full name: (

Your signature: