Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe

Technical review report for project MUSE

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

INTRODUCTION

Technical review report is part of GeoERA's Monitoring and evaluation process for co-funded projects (*hereinafter: project*). The aim of a technical review is to assess the work carried out under the project over a certain period and provide recommendations. Such technical review evaluates the project reports and deliverables, the proper use of resources, the management of the project and the expected impact.

Technical review report consists of four sections, each representing one level of monitoring and/or evaluation of the project:

Level	Monitor / Reviewer	Input	Aim
1 – Monitoring of progress indicators	Monitoring and reporting officer (GeoZS)	MPPR* FPPR**	Monitoring of the effectiveness of implementation of selected projects with respect to finance, time and administration.
2 – Scientific review	Reviewers (GeoZS)	Submitted deliverables MPPR FPPR	Quality review of the deliverables and review of achieving scientific and professional goals.
3 – Review of the theme progress	Theme coordinators	MPPR FPPR	Review of achieving theme objectives.
4 – GeoERA Progress evaluation	Stakeholder Council member(s)	Sections 1 and 2 of this report Review meetings	Overall project progress and general recommendations.

*MPPR = Midterm Project Progress Report (see PI doc no 2)
**FPPR = Final Project Progress Report (see PI doc no 2)

Monitoring and evaluation process:

M0 = End of reporting period
M1 = Submitted (Final) Project progress Report (MPPR / FPPR)
M2 = 1 – Monitoring & 2 – Evaluation
M3 = 3 – Evaluation of the theme progress
M3 = (Final) Review Meeting & 4 – Progress evaluation

Each project will be reviewed twice: for first project period M1-M18 – Technical review report, and second project period M19-M36 – Final review report.
Technical review report is based on Horizon 2020 templates but adopted to GeoERA needs. Technical reviews of projects shall be carried out on a confidential basis.

GENERAL INFORMATION

ERA-NET Cofund Grant Agreement:	731166
ERA-NET Cofund acronym:	GeoERA
Call identifier:	H2020-LCE-2016-2017/H2020-LCE-2016-ERA
Project full title:	Managing Urban Shallow geothermal energy
Project acronym:	MUSE
Project reference number:	GeoE.171.006
Project topic:	GeoEnergy
Project specific topic:	GE2-Geothermal energy
Lead partner:	GBA Geologische Bundesanstalt (Geological Survey of Austria)
Project website:	https://geoera.eu/projects/muse3/

☐ Technical review report
☒ Final review report

Period covered	01/01/2020 – 31/10/2021
Review meeting date	26.11.2021; start at 13:30

Contributor:	Role:	Approved on:
Barbara Simić	Monitoring and reporting officer	28.11.2021
Aleksandra Trenchovska	Monitoring and reporting officer	29.11.2021
Joerg Prestor	Scientific reviewer	26.11.2021
Jasna Šinigoj	Scientific reviewer	26.11.2021
Serge van Gessel	Theme coordinator	23.12.2021
Gerdi Breembroek	GeoERA Stakeholder	29.11.2021
Peter Bayer	GeoERA Stakeholder	29.11.2021
Peter Huggenberger	GeoERA Stakeholder	6.1.2022

1 LEVEL 1 – MONITORING OF PROGRESS INDICATORS

In this section the project is monitored "remotely" on the basis of the respective reports. This part is filled in by Monitoring and reporting officer with aim to monitor the effectiveness of implementation of the selected projects with respect to finance, time and administration, based on submited MPPR and FPPR.

	Yes	Partially (comment needed)	No
PROJECT MANAGEMENT			
Has the MPPR / FPPR report been submitted on time?	☒	See comment no. 1	☐
Have there been any changes in project partnership?	☒	See comment no. 2	☐
Has the project management been performed as required?	☒		☐
Has the collaboration between partners been effective?	☒		☐
Do you identify evidence of underperforming partners, lack of commitment or change of interest of any partners?	☐ (see comment)		☒
DELIVERABLES and MILESTONES			
Have the planned deliverables for the period been submitted on time according to timeline in Project Agreement?	☐	See comment no. 3	☒
Have the planned deliverables for the period been completed (from MPPR / FPPR, sheet 4)	☒		☐
Have any changes to deliverables occur (type/ dissemination level)? (from MPPR / FPPR, sheet 4 and 5)	☒		☐
Have planned milestones been achieved for the reporting period? (from MPPR / FPPR, sheet 4)	☒		☐
Have the project partnership identify any difficulties achieving any of the deliverables / milestones?	☐		☒
DEVIATIONS (from MPPR / FPPR, sheet 5)			
Has the project partnership identify any deviations that will not affect projects outputs?	☐		☒
Have any deviations occur on the project, with impact on project outputs?	☐		☒
In case of deviations, have the project adopted corrective measures?	☒		☐

DISSEMINATION, COMMUNICATION			
Has the project adopted its dissemination plan?	☒		☐
Have the planned dissemination activities been completed for the reporting period? (from MPPR / FPPR, sheet 6)	☒		☐
Have the partners' disseminated project results and information adequately?	☒		☐
Is the project following dissemination plan?	☒		☐
Is the project interacting in a satisfactory manner with other GeoERA projects?	☒		☐
Is the project interacting in a satisfactory manner with national/international bodies?	☒		☐

FINANCE			
To the best of your estimate, have the resources used been utilised for achieving the project? (according to MPPR / FPPR, sheet 9)	☒		☐
To the best of your estimate, have the resources used been in a manner consisted with the principle of economy, efficiency and effectiveness? *	☒		☐
Are there any major deviations in the budget consumptions from the financial plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒	See comment no. 4	☐
Are there any major deviations in the Person - Months consumptions from the plan? (zero consumption in M18; deviation from plan exceeding 20% in M36)	☒		☐
Are any budget modifications for the project needed? (from MPPR / FPPR, sheet 5)	☐		☒

***The principles of economy, efficiency and effectiveness**: refers to the standard of "good housekeeping" in spending public money effectively. Economy can be understood as minimising the costs of resources used for an activity (input), having regard to the appropriate quality and can be linked to efficiency, which is the relationship between the outputs and the resources used to produce them. Effectiveness is concerned with measuring the extent to which the objectives have been achieved and the relationship between the intended impact and the actual impact of an activity. Cost effectiveness means the relationship between project costs and outcomes, expressed as costs per unit of outcome achieved.

Comments (highlighting the project progress) / deviations / recommendations:

The project MUSE addressed measures to enhance and manage the sustainable and efficient use of shallow geothermal energy in European urban areas to promote the use of green energy. The consortia investigated resources and possible conflicts related to shallow geothermal energy and focused on the connection between the management and implementation cycle. An assessment of the current regulatory framework and management strategies for the use of shallow geothermal energy in the participating countries revealed different regulatory practices and challenges in Europe. Based on the results of extensive theoretical and practical work in 14 pilot areas across Europe, the project consortia introduced a web information system as an example for future applications. Such a web information system is useful not only to promote the applicability of shallow geothermal energy and to increase its awareness, but also to provide all the necessary information for detailed planning (implementation cycle) and for setting up management strategies (management cycle) for a sustainable and efficient use of shallow geothermal energy.

The Covid 19 epidemic had an impact on the progress of the project MUSE. In December 2020, the project was extended by 4 months, from 30.6.2021 to 31.10.2021. The postponed project activities were appropriately communicated to the GeoERA Executive Board. The latter has reviewed and approved the changes in view of achieving the project outcomes. A detailed list of changes is part of the project documentation in the Project plan History of changes.

The project management structure was well defined and efficient. The pandemic situation required a high degree of flexibility of the partnership and adaptability of its involvement in the project activities. To ensure the achievement of the set objectives, the partners increased their efforts, resulting in higher person-months and budget expenditures. Overall, the project consortium spent a bit more budget than planned. The project did not identify any underperforming partners that could affect the quality of the project outputs. Only one partner, GEOINFORM, discontinued its activities in the second reporting period without any impact on the project work.

A detailed and targeted communication and dissemination plan was adopted and a description of the activities with timetable was provided. The project's communication and dissemination activities followed the plan. The project team has identified stakeholders and was regularly reaching out and interacting with them. The way the project shared its knowledge is a good case scenario.

The project benefited from the results of other EU-funded projects, namely GeoTwinn (Horizon 2020), GRETA (Interreg Alpine Space), GeoPLASMA- CE (Interreg Central Europe), SEADRION (Interreg Adrion) and GEOCOND (Horizon 2020). MUSE project regularly collaborated with other GeoERA projects: GeoConnect3d, HotLime, HIKE and GIP -P. They tried to connect and organize joint workshops also with GeoERA projects

HOVER, RESOURCE and VoGera from the Groundwater theme, but the activities were stopped due to the pandemic situation.

Comment no. 1: The Final Project Progress Report was submitted on time in draft form. Partners still have the opportunity to recalculate their financials by the end of the calendar year to include the final data, so minor deviations can be expected. The changes will not affect the content of the project.

Comment no. 2: During the implementation of the project, there were two changes in the partnership: the partner IGME-Sp Geological Survey of Spain was integrated into CSIC Agencia Estatal Consejo Superior de Investigaciones Científicas. At the end of reporting period 1, the project partner GEOINFORM State Research and Development Enterprise State Information Geological Fund of Ukraine ended its activities and did not participate in the second period. None of the above changes affected the ability of the project to achieve its objectives and outputs.

Comment no. 3: Due to the pandemic situation, some activities were delayed, and deliverables had to be submitted later than planned. The revised dates were communicated to the Monitoring team and the GeoERA Secretariat by amending the project plan.

The deliverable changes in the project implementation period are:

Reporting period 1:
D5.1 postponed from M7 (31.1.2019) → M12 (30.6.2019)
D5.7 postponed from M8 (28.2.2019) → M38 (31.8.2021)
D5.3 postponed from M9 (31.3.2019) → M19 (31.1.2020)
D3.1 postponed from M18 (31.12.2019) → M21 (31.3.2020)

Reporting period 2:
D5.4 postponed from M27 (30.9.2020) → M39 (30.9.2021)
D2.2 postponed from M28 (31.10.2020) → M31 (31.1.2021)
M1.5 postponed from M30 (31.12.2020) → M40 (31.10.2021)
D2.1 postponed from M30 (31.12.2020) → M39 (30.9.2021)
D4.1 postponed from M30 (31.12.2020) → M32 (28.2.2021)
D3.2 postponed from M32 (28.2.2021) → M39 (30.9.2021)
D4.3 postponed from M32 (28.2.2021) → M39 (30.9.2021)
D5.5 postponed from M32 (28.2.2021) → M39 (30.9.2021)
D5.6 postponed from M32 (28.2.2021) → M36 (30.6.2021)
D6.1 postponed from M32 (28.2.2021) → M40 (31.10.2021)
D6.2 postponed from M33 (31.3.2021) → M40 (31.10.2021)
D4.2 postponed from M34 (30.4.2021) → M37 (31.7.2021)
D1.2 postponed from M36 (30.6.2021) → M39 (30.9.2021)
D1.4 postponed from M36 (30.6.2021) → M40 (31.10.2021)

Comment no. 4: Some project partners spent 20% more than their planned budget, others spent less than 80%. The partner that has exceeded their budget is IGME-Sp. Partner that spent less than their planned budget is TNO. The consumption of man-months followed the EUR consumption.

The project has coped well with the negative external factors and has overcome its challenges in such a way that it has achieved its planned objectives and project results. For this reason, the project is rated "excellent" at level 1 and thus receives a rating of 4 - Objectives and targets fully achieved.

Overall assessment of the project:

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Summary of dissemination activities:

	SCIENTIFIC COMMUNITY	GENERAL PUBLIC	POLICY MAKERS	EUROPEAN INSTITUTION	NATIONAL INSTITUTION	REGIONAL INSTITUTION	INTERNATIONAL INSTITUTION	LOCAL INSTITUTION	PRIVATE COMPANIES	OTHER	Total Target Group reach
EVENTS	573	450	9	8	70	6	12		20	45	1193
MEDIA	250	600			50	50				550	1500
MEETINGS	597	100		9	77	19	5	15	13	55	890
ONLINE_MEDIA	50	214489									214539
PUBLICATIONS	3127	1120	3				5		30	60	4345
Total	**4597**	**216759**	**12**	**17**	**197**	**75**	**22**	**15**	**63**	**710**	**222467**

	BLOG	CONGRESS	FACEBOOK	INTERNAL PROJECT MEETING	LEAFLET	LINKEDIN	MAGAZINE	MEETING	MEETING WITH OTHER GEOERA PROJECTS	ORAL PRESENTATION	OTHER	OTHER	POSTER	SCIENTIFIC PUBLICATION	TWITER	WEBINAR	WEBSITE	WORKSHOP	YOUTUBE	INSTAGRAM	Total
EVENTS		6														3		4			13
MEDIA							3														3
MEETINGS				36				2	2		2							1			43
ONLINE_MEDIA	45		40			16						8			98		1		1	31	240
PUBLICATIONS					2					4			3	5							14
Total	**45**	**6**	**40**	**36**	**2**	**16**	**3**	**2**	**2**	**4**	**2**	**8**	**3**	**5**	**98**	**3**	**1**	**5**	**1**	**31**	**313**

Are the dissemination activities adequate?

☒ 5 - **Overachieved** (the projects dissemination activities have exceeded expectations)

☐ 4 - **Excellent** (the projects dissemination activities have fully achieved its expectations)

☐ 3 - **Good** (the projects dissemination activities are adequate)

☐ 2 - **Acceptable** (the projects dissemination activities are acceptable)

☐ 1 - **Unsatisfactory** (the project has failed to disseminate)

Cummulative financial statement:

	Person months	Total eligible costs	Reimbursement rate	GeoERA contribution	In-kind contribution
Plan	**197,17**	**1.366.757,50**	**29,7 %**	**405.919,89**	**960.837,61**
1st period consumption	85,47	560.064,87	29,7 %	166.339,27	393.725,60
2nd period consumption	147,03	851.722,04	29,7 %	252.961,44	598.760,60
TOTAL	**232,50**	**1.411.786,91**	**27,9 %**	**419.300,71**	**992.486,20**

2 LEVEL 2 – SCIENTIFIC REVIEW

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by reviewer with aim to review the quality of the deliverables and review of achieving scientific and professional goals. Scientific review is based on submitted deliverables and reported Impact statement in MPPR/FPPR.

Impact statement (from MPPR / FPPR, sheet 8):

MUSE addresses measures to enhance and manage sustainable and efficient use of shallow geothermal energy in European urban areas for prompoting green energy uptakes. According to the MUSE project application, the following activities have been planned to maximize the impact of the project: C-D-E plan: The preliminary C-D-E plan submitted at the project application, was further developed during the initial phase of MUSE and is updated on a regular basis. The C-D-E plan plans and monitors all activities related to external communication. Web platform on the use of shallow geothermal energy: A dedicated web interface addressing shallow geothermal energy inside EGDI was developed. One general map shows all output data sets produced for the pilot areas sorted by the parameters (for international stakeholders) and 14 separate maps were set-up specific for the pilot areas (for local stakeholders). The web platforms serve as example for future applications. To enhance the impact of our results, our final data sets were transferred partly to already established web portals of the pilot areas. In some pilot areas the results of the pilot areas provided useful input for the elaboration of management strategies for shallow geothermal energy and for follow-up projects e.g. dealing with more detailed resource assessment (project "Heat below the city" in Vienna). Developing of joint quality standards and approaches for managing shallow geothermal energy use: In the first reporting period, the different approaches and methodologies for mapping resources and limitations of use have been assessed inside the MUSE team and are currently harmonized to a joint catalogue of methods. Furthermore, different management approaches and management requirements associated to the use of shallow geothermal energy have been assessed and compiled to a catalogue of management approaches, which will be finalized in the second reporting period. The MUSE team also assessed and is currently evaluating the legal framework for the use of shallow geothermal energy. A joint evaluation will be published in the second reporting period. Identifying and promoting promising concepts and approaches how to use shallow geothermal: In the first reporting period, fact sheets on the gesocientific and market related conditions for the use of shallow geothermal had been created for all 14 MUSE pilot areas. The fact sheets were published at the MUSE website. in 2019, the MUSE team started to collect good practice examples on the use of shallow geothermal energy in all pilot areas. The good practice examples were included in fact sheets about proven and prospective technical solutions for shallow geothermal energy

based heating and cooling supply that were elaborated and published on the MUSE website in the second reporting period.
Targeted stakeholder communication: In MUSE a joint guidelines on targeted stakeholder communication was developed and published in the Deliverable D5.7. Targeted communication intended to raise awareness towards the use of shallow geothermal, management aspects to ensure sustainability and efficiency and role Geological Survey Organizations should play in managing urban shallow geothermal energy use. In total, more than 40 individual targeted stakeholder interaction activities were reported for the MUSE pilot areas. Most activities focused on consultation meetings with local authorities and communities for raising awareness and initiating strategic cooperation. Several national spin-off projects were started linked to the activities performed in MUSE. Moreover, the produced resource and limitation of use maps were adopted by local stakeholders in several MUSE pilot areas like Vienna, Cardiff, Cork, Ljubljana, Brussels, Linköping and Warsaw. On an international level, MUSE successfully interacted with the European Geothermal Energy Council, the EU COST Action CA18219 Geothermal-DHC and several US Geological Surveys in the framework of the GPS 2021 event. MUSE also endorsed and co-organized the international Shallow Geothermal Energy Days events in 2020 and 2021. The SGE Days event 2022 will be co-organized by the MUSE partners GBA and ICGC and will take place in Barcelona.
Knowledge exchange and capitalization: In the second reporting period, MUSE contributed to 5 knowledge exchange activities. The events were: GeoERA webinar, 2020; Shallow Geothermal Energy Days, 2020; Webinar with GEOCOND, 2020; GPS2021 – Geothermal session; GPS2021 Side Event - Urban Geothermal energy. To enhance the impact of the events, recordings of the presentations were also published on the MUSE YouTube channel. Furthermore, strategic cooperation was initialized with other European networks like JPI, EGEC, RHC and IAH.

Expected impact (from Project Agreement):

The European Union already faces a rather high degree of urbanisation (74.8% according to the World Bank), which is expected to further increase in the upcoming decades. Therefore, strategies and actions on the uptake of green energy supplies in Europe need to focus on urban areas. Here, shallow geothermal energy (SGE) use for heating, cooling and seasonal storage has the potential to become a key instrument for reducing the dependency on energy imports and lowering emissions by enhancing the decarbonization of the heating and cooling market. Although around two thirds of the total installed capacities and more than 85% of all investments in the European geothermal sector is related to SGE use (European Geothermal Energy Council, Market Report 2015, fifth edition April 2016), these simple and very adaptable heating and cooling techniques still suffer from a lack of visibility and awareness by the general public.
The Market Report 2015 also reveals that the top five nations of SGE use in Europe (Sweden, Germany, France, Switzerland and Norway) account for 69% of the overall

installed capacities, thus indicating that SGE use has a large potential in many other countries across Europe. The GeoDH project (http://geodh.eu/) concluded that “more than 25% of the EU population lives in areas directly suitable for deep geothermal district heating”. In contrast, the general suitability of applying SGE methods for low temperature heating and cooling supply is expected to be significantly higher compared
to deep geothermal systems. In general, the application of closed-loop systems is only limited to land-use restrictions (e.g. groundwater protection zones or problematic geological conditions) and already existing subsurface installations. Based on a recent survey in Vienna (Austria), closed-loop systems may either provide or store energy of up to 7,000 MWh/ha/year. Moreover, the entire heating and cooling demand of Vienna referring to the year 2015 could be supplied by closed-loop systems occupying less than only 17% of the available city area (WC-33 project executed by the Geological Survey of Austria).

Taking the above-mentioned aspects into account, MUSE addresses measures to enhance and manage sustainable and efficient use of SGE methods for fostering green energy uptakes in Europe. The project contributes to the following aims of the Specific Research Topic GE2 and the GeoERA programme in general:

- Delivery of a well-documented knowledge base (catalogue of joint methods and workflows) for local-scale assessment of resources and possible conflicts related to shallow geothermal energy in cities.
- Developing interoperable quality standards and criteria for supervising the whole management circle including exploration and assessment, planning & licensing as well as monitoring of use and related impact on the subsurface, especially on shallow groundwater bodies. In this context, the project especially addresses the problems of mutually interfering SGE installations.
- Developing strategies and related actions (roadmaps), as well as policy tools, for managing and supporting SGE use in cities. This also includes the evaluation of the current legal framework on regulating and support for shallow geothermal energy.
- Identifying and describing proven and promising technical concepts of SGE use for heating, cooling and seasonal heat storage.
- Describing technical and environmental risks related to inappropriate SGE use and providing risk intervention and mitigation measures.
- Demonstrating the developed methods, workflows and concepts in 14 urban pilot areas across Europe.
- Developing modern web-based information- and decision-support systems for investors and regulators.
- Involving local stakeholders in the pilot areas by targeted communication and transfer of knowledge activities to ensure a long-term impact of MUSE with regard to enhancing the use of SGE to reduce greenhouse gas emissions and improve air quality and urban well-being.

After the end of MUSE, all results can be transferred to other Geological Survey Organisations or similar entities to be used in other European urban areas. The comprehensive toolboxes provided by MUSE aim to cover all relevant aspects dealing

with possible future SGE use in European urban areas. This is seen as the most important added value of MUSE beside the tailored thematic outputs, strategies and web services for the pilot areas. To achieve these aims, MUSE integrates Geological Survey Organisations from 15 European countries and 14 selected urban areas, which face different geological, climatological and socio-economic settings with regard to the present heating and cooling market, legislation and regulation.

Evaluation of deliverables

No.	Title	Status (Approve/ Reject)
D1.2	Summary reports on the outcomes of the External Evaluation and Advisory Board meetings (3 reports)	Approved
D1.4	Project presentations at scientific and targeted events (>5 oral or poster presentations)	Approved
D1.5	Cumulative research article published in a special journal issue on “shallow geothermal application in European urban areas” (1 cumulative research paper issue)	Approved
D2.1	Catalogue of evaluated methods and guidelines on exploration, assessment and technical monitoring of shallow geothermal energy use in urban regions (1 report)	Approved
D2.2	Catalogue of factsheets of evaluated and characterised SGE concepts of use in urban areas (1 report)	Approved
D3.1	Report on the current legal framework, procedures and policies on SGE use in selected European cities (1 report)	Approved
D3.2	Guideline for integrating and managing the use of SGE in urban areas (1 report)	Approved
D4.1	Fact sheets on the pilot areas including the main findings of MUSE (13 fact sheets)	Approved
D4.2	Summary report about the outcomes in the pilot areas (1 report)	Approved
D4.3	Documented thematic output datasets for web presentation of selected pilot area	Approved
D5.2	Data Management Plan for MUSE (2 report)	Approved
D5.3	Guideline on the delivery of geodata and knowledge related to SGE to the GeoERA Information Platform (1 report)	Approved
D5.4	Guideline on the use of the SGE web platform tools at the Information Platform (1 report)	Approved
D5.5	Publically-accessible web platform inside the GIP on SGE use (1 web platform)	Approved
D5.6	Contributions to the joint GeoERA knowledge infrastructure (1 tool)	Approved

D5.7	Guideline on targeted communication to stakeholders on shallow geothermal use in urban areas (1 report)	Approved
D6.1	Knowledge exchange workshops on cross cutting topics relevant for MUSE (at least 3 workshops)	Approved
D6.2	Activity report on capitalising activities with other project teams inside GeoERA (1 report)	Approved

Has the quality as a whole been achieved according the objectives? Has the project as a whole been making satisfactory progress?

☐ 5 - **Overachiever** (the project has achieved all objectives and goals for the period and has even exceeded expectations)

☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals for the period)

☐ 3 - **Good progress** (the project has achieved most of its objectives and goals for the period with relatively minor deviations)

☐ 2 - **Acceptable progress** (the project has achieved some of its objectives)

☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives)

Comments (highlighting the project progress) / deviations / recommendations:

Deliverables are good promotion of specific objectives of the project.

The work plan was demonstrably adhered to in order to achieve these objectives.

The scientific potential of the work lies in the use of multiple parameters in complex assessments - under very different aspects.

The results are effectively aimed at management in urban areas and consideration of local conditions.

Deliverables will be very useful for the development of local energy concepts of municipalities.

The results obtained are a good basis for further development of knowledge on "how to make the best use of local geological conditions", and thus also at regional level.

The factsheets presented are likely to be developed in the future for the reporting

and presentation of the "water, heat and mass shift" at local level and across local administrative boundaries.

The further development of minimum distances in urban planning is really the most needed, actually, as the very important planning regulation elements.

Perhaps the widely used statement "geology is uncertain" will be replaced by "how to make the best use of the geological features on the property and in the surrounding area" in terms of sustainability and long-term impact.
I congratulate colleagues on their truly stimulating work and interest.

3 LEVEL 3 – REVIEW OF THE THEME PROGRESS

In this section the project is reviewed ”remotely” on the basis of the respective reports. This part is filled in by Theme coordinator with aim to review the achieved scientific goals in accordance with theme objectives, on the basis of Sheet 3 in MPPR / FPPR – Project contribution to GeoERA project.

Project contribution to GeoERA project (from MPPR / FPPR, sheet 3):

GeoERA-MUSE contributes to the topic GE2 - GEOTHERMAL ENERGY according to the doc no 9 of the joint call by the sub topic "Geothermal energy and groundwater in urban areas". It supports the expected impact of doc no 9 in the following way:
1) Improved and better harmonized European overview of prospective and identified geothermal energy resources: MUSE created local scale resource maps for up to 14 individual urban pilot areas, which were published at EGDI. Please note that MUSE did not produce large scale pan-European maps as questions related to the use of shallow geothermal are always related to small-scale local hydrogeological settings;
2) Provision of a consistent and data-driven knowledge base to aid in the formulation of policy tools and strategies aiming for large-scale geothermal energy developments across Europe: MUSE developed a methodological catalogue on mapping resources and limitations of use, which was published on the project's website. Harmonization included technical language (joint glossary of terms as project vocabularies), which is linked to joint workflows and connected to the data sets shown on the EGDI web interface.
3) A further stimulus for green thermal energy uptake in European urban regions: MUSE developed a stakeholder interaction strategy to raise awareness towards an efficient and sustainable use of shallow geothermal in urban areas. The collection of good practices, executed in all pilot areas and participating countries moreover aimed at promoting state of the art technological concepts and an exchange of technological experiences between well developed and emerging markets in Europe.
4) Increased confidence in the prospectivity and potential contribution of geothermal resources across Europe: This topic was supposed to be addressed mainly via stakeholder interviews including SWOT analyses on the use of shallow geothermal in the second half of MUSE, however it could not be achieved due to the pandemic. However, the spatial information based on our output data sets about possible resources of shallow geothermal energy on multiple web platforms will boost the confidence in the prospectivity of geothermal resources across Europe. Our results are not only included in the EGDI web interface, but they will also be implemented in local web platforms of the project partners or connected stakeholders.
5) More effective and extended information support of the public-private-policy dialogue on geothermal energy resources in relation to the license to operate and the European Union’s energy and climate targets: MUSE developed a catalogue of different management strategies for the use shallow geothermal energy, which can feed into tailored local strategies in the MUSE pilot areas.

Theme objectives:

General Theme objectives: (Excellent)
MUSE has sucessfully established a uniform quantified assessment and presentation of Shallow Geothermal Energy (SGE) assessments including technical aspects, standards, best practices and concepts (WP2), regulatory aspects, and strategies for cost-efficient exploration and urban development and subsurface management (WP3) in 13 pilot areas across Europe (WP4). The results are presented in a format and information system that are tailored for local stakeholders (supporting decision making) (WP5). In order to reach this goal, MUSE has actively invovled external stakeholders which has generally contributed to a better link between geosciences and potential end users. This approach substantially contributes to a more effective and succesfull delevelopment and promotion (better understanding) of SGE and thereby contributes to the decarbonization of heat demand in the built environment. The project provides technical concepts and datasets for implementing geoscientific knowledge related to SGE use in the EGDI information platform, including catalogues of evaluated methods and guidelines for exploration, assessment and technical monitoring of shallow geothermal energy use in urban regions (WP5). These efforts have significantly increased the knowledge base at geological surveys in Europe (WP6).

Theme scope and approach/methods: Excellent
MUSE is dedicated to shallow geothermal energy (SGE) inluding concepts for storage of heat and cold. The project assesses conflicts of use associated with open- and closed-loop systems in urban areas and emphasizes these topics through presented policy/stakeholder guidelines and development strategies.

The project addresses monitoring and evaluation of the efficiency and impacts (environmental, land-use, land planning) of shallow geothermal installations. These aspects are investigated in urban areas across different countries. Although individual pilot areas are not defined across borders, the project delivers blue prints that are applicable to urban areas across Europe. The project assesses conflicts of use associated with open- and closed-loop systems in urban areas. MUSE has strongly contributed to knowledge exchange and interaction between projects covering overlapping and cross-cutting aspects of SGE use in urban areas, such as groundwater protection and 3D spatial planning. Information is well structured and presented in easily accessible factsheets.

Beyond state of art (Excellent)
MUSE has particularly focused on methodologies to objectively weigh interacting or mutually exclusive potential uses of space between the geo-energy theme and groundwater theme. These insights are developed and evaluated in WP3
It is noteworthy to mention that MUSE considers a wide variety of aspects (also non-geological) which influence prospectivity and successful development of SGE.

Environmental planning instruments, decision support information is co-created with and tailored for end-users/stakeholders (e.g. traffic-light maps). Guidelines for integrating and managing SGE in urban environments, addressing technical, ecological and social sustainability aspects
Muse considers the entire SGE value chain (exploration, development, regulation, monitoring) which stimulates a much better integration and valorization of geoscience knowledge within stakeholder challenges.
MUSE's proven stakeholder interaction and targeted scientific communication concepts are a great example for future geoscience projects.

Project-2-Project:
MUSE shares various cross-cutting topics with other projects (GeoERA and external). Specific collaborations were established with HotLime (subsurface temperature modelling) and GeoConnect3d (subsurface planning and conflicts of use). Various projects participated in knowledge exchange workshops.

Has the project as a whole achieved the objectives and expected impact of the theme?

☐ 5 - **Overachiever** (the project has achieved greater impact on project theme and/or other themes than expected)
☒ 4 - **Excellent progress** (the project has fully achieved its objectives and goals towards the theme as expected)
☐ 3 - **Good progress** (the project has achieved most of its impact towards the theme for the period with relatively minor deviations)
☐ 2 - **Acceptable progress** (the project has minor impact)
☐ 1 - **Unsatisfactory progress** (the project has failed to achieve critical objectives and/or has no impact on the theme)

Comments / deviations / recommendations:

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4 LEVEL 4 – GEOERA PROGRESS EVALUATION

In this section the project is reviewed on the Review meetings, where projects present their overall progress and achievements. This section relates to particular project, broader impact of GeoERA as a whole on policies will be covered at the Final Review meeting with questionnaire and interview with Evaluator.

Based on technical review summaries provided by Sections 1 – 3 of this report, and project presentation on the (Final) Review meeting:

Has the project as a whole been making satisfactory progress according to your own understanding and expectations of the GeoERA project?

☒ 5 - **Overachiever** (the project has exceeded expectations)
☐ 4 - **Excellent progress** (as expected)
☐ 3 - **Good progress** (minor recommendations given below)
☐ 2 - **Acceptable progress** (below expectations)
☐ 1 - **Unsatisfactory progress** (the project did not meet expectations)

Overall comments for the project (overall recommendations, modifications, corrective actions, or re-tuning the objectives to optimize the impact or keep up with the State of the Art, re-focusing, or a simple praise)

Stakeholder one evaluation:

The MUSE project has made impressive progress. The whole approach to the topic has worked well, with work packages looking into the 'framework' in the various countries along with concrete case studies to demonstrate what the support of Geological Surveys to cities and communities can be. The quality of the website and the deliverables is excellent. The review meeting has made it clear how this will all work.

In terms of future work, I propose that thermal storage and cooling might be integrated into approaches that look into ways to use shallow geothermal to the full extent.

I congratulate the project team with this result.

Stakeholder two evaluation:

This project objectives have been highly ambitious from the beginning. Finally, the project has successfully brought together the very different perspectives of different countries. The results are impressive, with an excellent basis for the future of more

consistent and harmonized SGE management – and understanding – in the urban environments of Europe.

Stakeholder three evaluation:

The project included participants from countries and organizations with different levels of research in the field of shallow geothermal energy, be it basics about the 3D subsurface or the different geothermal processes.
This allowed all countries to benefit, even those with less experience and implementation projects.

It must be clearly seen that cutting-edge research in this area (including projects from Switzerland) has a strong influence on the overall result in the survey.

If one wants to help shallow geothermal energy to achieve a breakthrough in the future, it would be of great importance to also consider conflicts of use, which in the past have contributed to the fact that shallow geothermal energy could not develop as strongly as expected.

Especially in urban areas, where the subsurface plays an increasing role in the development of infrastructures, different technical developments of geothermal use in the construction sector should be strongly encouraged.

An important conclusion is that for the use of heat, today very different energy sources play a role, which in combination with each other allow new creative solutions of heat production. Let us not forget, however, that for the use of water resources in the subsoil are fewer alternatives available and correspond to the geothermal uses should not go at the expense of essouce water.

Especially in urban areas, concepts for the use of waste heat should be further developed and promoted.

The exchange between the different project partners (project RESOURCE) was very nice experience.

Annex 1: Review meeting list of participants

Name	Role	Organisation
Joop Hasselman	GeoERA coordinator	Netherlands Organisation for Applied Scientific Research
Gerdi Breembroek	Geoera Stakeholder	Netherlands Enterprise Agency
Peter Bayer	Geoera Stakeholder	Institute of Geosciences and Geography
Peter Huggenberger	Geoera Stakeholder	University of Basel
Barbara Simić	Monitoring and Reporting Officer	Geological Survey of Slovenia
Aleksandra Trenchovska	Monitoring and Reporting Officer	Geological Survey of Slovenia
Jasna Šinigoj	Scientific Reviewer	Geological Survey of Slovenia
Joerg Prestor	Scientific Reviewer	Geological Survey of Slovenia
Serge van Gessel	GeoEnergy Theme coordinator	Netherlands Organisation for Applied Scientific Research
Jørgen Tulstrup	Information Platform Theme coordinator	Geological Survey of Denmark and Greenland
Gregor Goetzl	MUSE Project manager	Geological Survey of Austria
Cornelia Steiner	MUSE Project member	Geological Survey of Austria
Claus Ditlefsen	MUSE Project member	Geological Survey of Denmark and Greenland
David Boon	MUSE Project member	British Geological Survey
Maciej Kłonowski	MUSE Project member	Polish Geological Institute
Mitja Janža	MUSE Project member	Geological Survey of Slovenia
Pierre-Yves Declercq	MUSE Project member	Royal Belgian Institute of Natural Sciences
Taly Hunter Williams	MUSE Project member	Geological Survey Ireland

Katie Hemon	MUSE Project member	Geological Survey Ireland