New Concepts – New and Innovative Applications of Geothermal Energy


Geothermal ERA-NET / IEA Geothermal Joint Activity

Report
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Orkustofnun, RVO
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Acknowledgements

The workshop was organised by partners involved in the IEA Geothermal and Geothermal ERANET together. The organisers want to thank everybody who has been involved in the preparation and organisation of the workshop, all speakers, and all those who brought all the speakers together. Special thanks go to Katharina Link, Alicja Wiktoria Stoklosa, Brian Carey and Paul Ramsak, who have invested much time and effort in getting everything right, and to Gerdi Breembroek for writing the minutes. A warm word of thanks also goes to the moderator Þóra Margrét Þorgeirsdóttir, who led us through the programme with excellent flexibility and enthusiasm. Then a word of thanks to the Swiss Federal Office of Energy that financed the involvement of Switzerland in the organisation of this workshop. The last “thank you” goes to the City of Geneva that hosted the workshop at the lovely location “Domain des Penthes” and really made us feel welcome to Switzerland.

Abstract

The report gives an overview for stimulating innovative ideas in geothermal utilization discussed during the workshop in Geneva on October 30, 2016. Workshop organised by Geothermal ERA NET leaders, Iceland and the Netherlands, together with IEA Geothermal and also supported by Swiss Federal Office of Energy. Meeting showcased and contributed to the awareness of opportunities in the geothermal sector and stimulate growth of the geothermal industry in Europe.
Executive summary

This report presents the proceedings of the workshop ‘New concepts – new and innovative applications of geothermal energy’ that was held in Geneva, Switzerland on October 30, 2016. The workshop was organised by the Geothermal ERA NET together with IEA Geothermal. These two multi-national organisation recognised a mutual interest in ‘New concepts’ with a focus on concepts for heating and cooling, but not excluding new developments in electricity generation from geothermal energy.

The aim of the workshop was to bring together new ideas and inspire each other with what is innovative throughout the world in geothermal energy utilisation. The workshop had four sessions with presentations on ‘new concepts’, highlighting Enhanced Geothermal Systems (EGS), direct use applications in the built environment, direct use applications in the industry and other sectors, and a session where direct use applications worldwide were in focus. The closing session considered the future of geothermal.

The closing session of the meeting showed that there is much potential for expansion of geothermal energy through smart and innovative applications. An important conclusion of the meeting was that there is scope for a joint call for demonstration of new concepts in geothermal. The Geothermal ERANET countries and a number of new European partners have therefore joined forces in a follow-on proposal, for the ERANET Cofund GEOTHERMICA.
1 Introduction

The proceeding provides an overview of the Joint Activity workshop of the Geothermal ERA-NET at a European level. New and innovative applications of geothermal energy utilisation was one day workshop event in Geneva organised by Geothermal ERA NET leaders, Iceland and the Netherlands, together with IEA Geothermal and supported by Swiss Federal Office of Energy. Meeting was a part of a Work Package 7 of the Geothermal ERA NET programme and be meant as a Joint Activity to develop a contractual framework. The Geothermal ERANET New Concepts may convey its aspirations to its stakeholders by communicating effectively and efficiently the benefits of such a framework and, eventually receive their long-lasting support in the development of this framework.

1.1 Geothermal ERA-NET

The Geothermal ERANET is a network of Ministries and National Agencies from 11 European countries, supported by the European Commission, seeking to promote innovation and greater utilization of Geothermal Energy in Europe. The network enhances European cooperation on geothermal energy at national and administrative levels targeting improved integration of national RD&D programs and knowledge sharing. Iceland, the Netherlands, France, Switzerland, Germany, Italy, Hungary, Turkey, Slovakia, Portugal and are working together in this ERA-NET to propel Geothermal Energy to a higher level in Europe. The website www.geothermaleranet.eu gives access to more information.

A key strategy of the Geothermal ERA-NET is the development of Joint Activities. These activities have been selected through an analysis of barriers and opportunities for geothermal energy in the participating countries. One of these joint activities was called “New Concepts”, recognising the opportunity that the development of new concepts offers to the European geothermal industry and its stakeholders. Iceland and the Netherlands led the organisation of the ‘New Concepts’ joint activity on behalf of the Geothermal ERANET.

1.2 IEA Geothermal

The International Energy Agency (IEA) – Geothermal Technical Collaboration Programme (IEA Geothermal) provides a framework for international cooperation under the auspices of the IEA on geothermal technology and research topics. Collaboration among member country experts, industries and organizations increases capability; avoids duplication; improves cost effectiveness; provides easier access to important information, research results and technological resources; and more. IEA Geothermal actively contributes to IEA’s promotion of global sustainable energy policies and the mitigation of climate change.

IEA Geothermal membership comprises 13 countries; Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, Republic of Korea, Switzerland, United Kingdom, United States; the European Commission, one industry member (Ormat Technologies) and two national organisations (CanGEA from Canada and the Geothermal Group APPA from Spain). Specific collaboration projects are called Annexes in the IEA Technical Collaboration Programmes. IEA Geothermal is pursuing activities in six Annexes. More information can be found through www.ieagia.org.
IEA Geothermal Annex VIII “Direct Use of Geothermal Energy”, initiated in 2003, includes all aspects of geothermal heat use. Annex VIII seeks to provide sound information, communication strategies and knowledge transfer to mitigate the barriers and to enhance deployment of geothermal energy. Cooperation, knowledge sharing and increasing the use of existing and new technologies are important objectives. There are five Tasks in Annex VIII. Members of Annex are the Canadian Geothermal Energy Association (CanGEA), France, Germany, Iceland, Japan, New Zealand, Republic of Korea, Switzerland, United Kingdom, and United States of America. Read more about Annex VIII at: http://iea-gia.org/work-program/annex-viii/.

Task A “New and Innovative Geothermal Direct Use Applications” focuses on innovative applications, such as opening up new possibilities for utilization, enhancing efficiency, and reducing cost.


Annex VIII “Direct Use of Geothermal Energy” initiated in 2003 includes all aspects of geothermal heat use. Annex VIII seeks to provide sound information, communication strategies and knowledge transfer to mitigate the barriers and to enhance deployment of geothermal energy. Cooperation, knowledge sharing and increasing the use of existing and new technologies are important objectives. There are five Tasks in Annex VIII. Members of Annex are the Canadian Geothermal Energy Association (CanGEA), France, Germany, Iceland, Japan, New Zealand, Republic of Korea, Switzerland, United Kingdom, and United States of America. Read more about Annex VIII at: http://iea-gia.org/work-program/annex-viii/.

Task A “New and Innovative Geothermal Direct Use Applications” focuses on innovative applications, such as opening up new possibilities for utilization, enhancing efficiency, and reducing cost. The Task is led by Brian Carey (New Zealand) along with expressed interest from Paul Ramsak (Netherlands) to take up an active leadership role.

1.4 Workshop information

As a first step towards showing and stimulating new opportunities in Europe and beyond, the Geothermal ERA-NET “New Concepts” group and IEA Geothermal Annex VIII organized a joint workshop entitled ‘New concepts - new and innovative applications of geothermal energy’ on the 30th of October 2015 in Genève (CH).

The aim of the workshop was to stimulate creative concepts for European innovators in geothermal utilization and technology. The concepts of interest included opportunities in direct utilization of low enthalpy geothermal energy such as geothermal heating & cooling for smart cities, food production, and other uses. Also, new concepts in geothermal electricity generation and process heat were part of the programme.

The workshop ‘New Concepts’ had six sessions:

- Welcome and Introduction by hosts
- Session I: EGS projects + direct use applications
• Session II: Direct use applications (new concepts – built environment)
• Session III: Direct use applications (new concepts – other sectors)
• Session IV: Innovative Applications of Geothermal Direct Use worldwide
• Visionary Panel Discussion, Conclusions and Next Steps

Each session has the significant importance on different geothermal application issues. Detailed agenda and speakers list available in chapter 3.

2 Innovative thinking

In the beginning of the workshop, participants were asked to draw their vision on future of geothermal. To solve this assignment, they were supplied with colourful vax pencils and blank white page (Please see Figure 1).

![Figure 1 Figure presents tools used to create the vision of future of geothermal, vaxlitir and blank page](image)

Their drawn visions showed amongst others heat transport by chemicals; and simple, easy to use, away-from-tailor-made systems. Also, the visions showed a bright and loving future, with geothermal families, the warm heart of mother earth, and peace to the world from using indigenous resources.

After a day of discussion and listening to visions of individuals from different countries, participants summarised their art work in few sentences and compare the image of future in geothermal energy between each other.

The results of task are presented as collage in Appendix II
3 Programme of the workshop
Friday, 30th of October 2015:

08:30 - 09:10 Welcome and Introduction to Geo Innovative Opportunities
8:30 - 8:40 Welcome – Katharina Link + Gunter Siddiqi
(Annex VIII Leader resp. ExCo member, IEA Geothermal; host country)
8:40 - 8:55 Geothermal ERA-NET + New Concepts – Paul Ramsak
(Co Leader Geothermal ERA-NET New Concepts group)
8:55 - 9:10 IEA Geothermal + Annex VIII – Brian Carey
(Secretary and Annex VIII Task Leader, IEA Geothermal)

09:10 – 10:30 Session I: EGS projects + direct use applications
9:10 - 9:30 Switzerland – Peter Meier (Geo Energie Suisse AG)
EGS-Projects of the Geo-Energie Suisse AG: the new concept
9:30 - 9:50 Hungary – László Adam (Mannvit)
What are the challenges and new concepts in South Hungarian Enhanced Geothermal System (EGS) Demonstration Project?
9:50 - 10:10 France – Martino Lacirignola (ADEME)
ECOGI - an EGS project for the industry in the Upper Rhine Graben
10:10 - 10:30 Discussion

10:30 - 10:45 Coffee break

10:45 – 12:30 Session II: Direct use applications (new concepts – built environment)
10:45 - 11:05 Iceland – Kristin Vala Matthiasdottir (Resource Park/ HS Orka)
HS Orka Resource Park – Society without waste
11:05 - 11:25 Switzerland – Matthias Kolb (Amstein + Walthert AG)
Smart thermal grids: operational experience with low temperature grids in Zurich
11:25 - 11:45 Germany – Christian Hecht (Stadtwerke München, SWM)
The Projekt GRAME - One Step towards our 2040 Vision of 100% Renewable District Heating in Munich
11:45 - 12:10 Netherlands – René Verhoeven & Herman Eijdems (Mijnwater B.V)
Minewater Heerlen - Development of carbon neutral areas with thermal smart grids and geothermal
12:10 -12:30 Discussion

12:30 - 13:45 Lunch

13:45 – 15:25 Session III: Direct use applications (new concepts – other sectors)
13:45 - 14:05 Italy – Adele Manzella, CNR
Direct use of heat for industrial and civil processes
14:05 - 14:25  Netherlands – Henk de Beijer (SolabCool®)
Cooling with Geothermal energy and local storage

14:25 - 14:45  Switzerland – Dirk Arndt & Philip Klingler (Gruner AG)
District heating coupled with a seasonal heat storage in a deep aquifer
(city of Oftringen)

14:45 - 15:05  Italy – Ruggero Bertani (Enel Green Power)
Geothermal for Agriculture and Food

15:05 - 15:25  Discussion

15:25 – 15:40  Coffee break

15:40 - 17:00  Session IV: Innovative Applications of Geothermal Direct Use worldwide

15:40 - 16:00  Northern America – Arlene Anderson (US Department of Energy, USA)

16:00 - 16:20  Asian region – Kasumi Yasukawa (National Institute of Advanced
Industrial Science and Technology (AIST), Japan)

16:20 - 16:40  New Zealand and Australia – Brian Carey (GNS, New Zealand)

16:40 - 17:00  Discussion

17:00 - 18:00  Visionary Panel Discussion, Conclusions and Next Steps

17:00 - 17:20  Alicja Wiktoria Stoklosa (Startup Energy Reykjavik, Iceland)

17:20 - 18:00  Paul Ramsak (RVO), Hjalti Pall Ingolfsson (OS) & Brian Carey (GNS)

18:00 - 19:00  Networking Réception

Moderator Póra Margrét Porgeirsdóttir
Appendix I - List of participants

Below there is a presentation of all participants attended the event in Geneva.

<table>
<thead>
<tr>
<th>Surname</th>
<th>First name</th>
<th>Organisation / company</th>
<th>Country</th>
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<tbody>
<tr>
<td>Arndt</td>
<td>Dirk</td>
<td>Gruner AG</td>
<td>Switzerland</td>
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<tr>
<td>Baria</td>
<td>Roy</td>
<td>EGS Energy</td>
<td>United Kingdom</td>
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<tr>
<td>Bendall</td>
<td>Betina</td>
<td>Department Manufacturing Innovation Trade Resource and Energy (DMITRE), State Government of South Australia</td>
<td>Australia</td>
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<tr>
<td>Bertani</td>
<td>Ruggero</td>
<td>Enel Green Power</td>
<td>Italy</td>
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<td>Breembroek</td>
<td>Gerdi</td>
<td>Rijksdienst voor Ondernemend Nederland</td>
<td>Netherlands</td>
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<tr>
<td>Bromley</td>
<td>Chris</td>
<td>GNS Science</td>
<td>New Zealand</td>
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<td>Busby</td>
<td>Jonathan</td>
<td>British Geological Survey</td>
<td>United Kingdom</td>
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<td>Carey</td>
<td>Brian</td>
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<td>Azores/Portugal</td>
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<td>de Beijer</td>
<td>Henk</td>
<td>SolabCool®</td>
<td>Netherlands</td>
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<td>Eijdems</td>
<td>Herman</td>
<td>Mijnwater B.V</td>
<td>Netherlands</td>
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<td>Faessler</td>
<td>Jérôme</td>
<td>Université de Genève - systèmes énergétiques</td>
<td>Switzerland</td>
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<tr>
<td>Glass</td>
<td>Hylke J.</td>
<td>Camborne School of Mines, University of Exeter</td>
<td>United Kingdom</td>
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<td>Hecht</td>
<td>Christian</td>
<td>Stadtwerke München SWM</td>
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<td>Ingólfsso</td>
<td>Hjalti Páll</td>
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<td>Jaudin</td>
<td>Florence</td>
<td>Bureau de Recherches Géologiques et Minières (BRGM)</td>
<td>France</td>
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<tr>
<td>Klingler</td>
<td>Philip</td>
<td>Gruner AG</td>
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<tr>
<td>Kobler</td>
<td>Rita</td>
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<td>László</td>
<td>Ádám</td>
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<td>Link</td>
<td>Katharina</td>
<td>Dr. Roland Wyss GmbH</td>
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<td>Swiss Federal Office of Energy (SFOE)</td>
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<td>Muller</td>
<td>Jiri</td>
<td>Institute for Energy Technology</td>
<td>Norway</td>
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<td>Nádor</td>
<td>Annamária</td>
<td>Geological and Geophysical Institute of Hungary</td>
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<td>Ramsak</td>
<td>Paul</td>
<td>Rijksdienst voor Ondernemend Nederland</td>
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<tr>
<td>Richter</td>
<td>Manuela</td>
<td>Project Management Jülich (PTJ)</td>
<td>Germany</td>
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<td>Sidiqqi</td>
<td>Gunter</td>
<td>Swiss Federal Office of Energy (SFOE)</td>
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<tr>
<td>Song</td>
<td>Yoonho</td>
<td>Korea Institute of Geoscience &amp; Mineral Resources (KIGAM)</td>
<td>Republic of Korea</td>
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<td>Stoklosa</td>
<td>Alicja Viktoria</td>
<td>Orkustofnun / Startup Energy Reykjavik</td>
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<td>Weber</td>
<td>Josef</td>
<td>Leibniz Institute for Applied Geophysics</td>
<td>Germany</td>
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<td>Wissing</td>
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<tr>
<td>Yasukawa</td>
<td>Kasumi</td>
<td>National Institute of Advanced Industrial Science and Technology (AIST)</td>
<td>Japan</td>
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Appendix II- Drawings initiative /Innovative thinking

The Future of Geothermal Energy- how do you see it? It is time to present results of participants work during the workshop. Their drawn visions are spread among different solutions connected to the geothermal energy. It goes from peace and love to the world using indigenous resources, warm heart of mother Earth, bright future build up on the flower “Daisy model”, which shows integrity and differential understating of geothermal energy. Visions are spread to the more technical tailor-made solutions which innovative thinkers bring out from their minds such as energy systems and their influence on the family integrity, geothermal heat and cooling solutions and other easy to use energy models, all to discover on next pages.
Drawings presenting Future of Geothermal by participants
'SEASONAL STORAGE' for Heating / Cooling

Is it just energy saving?
No, it's far beyond.
"We are creating energy!"
Future of heating & cooling.

KOREA DENAL
"THE SAME MIND"

World Peace
by geothermal

Imagine if each nation can self-supply energy 100%...
No fight for energy resources!

Dona Nobis Pacem
KORI Y.
Appendix III- Presentations

The appendix III offers all presentations given during the workshop. Each presentation is followed by short introduction of the speaker and abstract of the project. All presented slides are available as pdf file also on Geothermal ERA NET website the [http://www.geothermaleranet.is/publication/presentations/](http://www.geothermaleranet.is/publication/presentations/) under presentations page

Welcome and Introduction by hosts

Welcome note began by Katharina Link, on behalf of Swiss Federal Office of Energy which kindly supplied the facilities and catering for the meeting, the workshop started with an introduction by Paul Ramsak, representing the Geothermal ERA NET and Brian Carey representing the IEA GIA. Meeting was moderate by Þóra Margrét Jorgeirsdóttir, a business specialized lawyer working as strategy consultant at Capacent, and a tax and legal consultant at Deloitte. She participated in the creation and operation of Iceland Geothermal, which is an industry driven geothermal cluster cooperation in Iceland.

Please find presentations with presenter information and project abstract below or online as pdf version at [www.geothermaleranet.eu](http://www.geothermaleranet.eu) under publication page

Back to the program ↑
New Concepts an introduction

Paul Ramsak comes from the Energy Innovation Team within the Competitive and Sustainable Energy Sector sub-directorate. He has been involved in geothermal energy since the year 2000, and has been one of the key-persons to get geothermal energy off the ground in the Netherlands. Paul Ramsak is the central contact for geothermal energy within RVO (The Netherlands Enterprise Agency). Paul Ramsak has been involved in the work of the Geothermal ERANET from the start and was one of its founding fathers.
New Concepts
an introduction

Paul Ramsak
Netherlands Enterprise Agency
Geothermal ERANet KnowlEx leader
New Concepts steering committee

New Concepts workshop
Genève (CH)
30 oct 2015

European
Network
Cooperation

Geothermal Energy
Geothermal energy is environmentally friendly.

It produces reliable baseload power and heat – all the more important to balance intermittent supplies from other renewable energy sources.

Geothermal is a renewable energy source and independent of weather conditions.

Geothermal energy is indigenous and contributes to Europe’s security of supply.

Lead partner is Orkustofnun (National Energy Authority of Iceland)

11 partner countries up to now

NL Enterprise Agency leading Knowledge Exchange activities

Looking for knowledge exchange + cooperation possibilities

The Geothermal ERA-NET is supported by the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement No 291866.
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<thead>
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<th>Country</th>
<th>Organisation</th>
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<td>ADEME (BRGM as third party)</td>
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<td>Electricidade dos Acores</td>
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**Cooperation between European (member) states**

**Geothermal ERA-NET**

**Ministries and National Agencies programme owners & managers**
Three important EU pillars to strengthen the geothermal sector in Europe

Geothermal ERA NET
VISION
- Minimize the fragmentation of geothermal research in Europe
- Build on European know-how and knowledge to utilize geothermal energy
- Contribute to a framework to realize large opportunities in the utilization of geothermal energy through joint activities

Organisational structure / work packages

WP1 – ICELAND
Coordination, Management & Dissemination

WP2 – NETHERLANDS
Information exchange on national incentives and status of geothermal energy

WP3 – ITALY
Towards a EU Geothermal Database

WP4 – GERMANY
Development of joint activities

WP5 – SWITZERLAND
Engaging with stakeholders

WP6 – ICELAND
Transnational Mobility & Training

WP7 – ITALY
Implementation of joint activities

ERA NET +
or other
SET PLAN input

Focus on energy and climate change
Technical & non-technical barriers & opportunities (task 2.2a CNR/RVO)

10-bullet lists (per country)

clustering workshop

Report (barriers & opportunities)

Technical/non-tech. barriers & opportunities

7 B&O clusters

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<td>a investment</td>
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<td>b operational support</td>
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<tr>
<td>c risk mitigation</td>
</tr>
<tr>
<td>A3 New/innovative concepts and applications</td>
</tr>
<tr>
<td>A4 Operational issues</td>
</tr>
<tr>
<td>A5 Sub-surface knowledge/data</td>
</tr>
<tr>
<td>A6 Structuring the geothermal sector</td>
</tr>
<tr>
<td>A7 Public and education</td>
</tr>
<tr>
<td>a public acceptance</td>
</tr>
<tr>
<td>b visibility &amp; dissemination</td>
</tr>
<tr>
<td>c education and training</td>
</tr>
</tbody>
</table>
**RD&D needs**

**RD&D clusters**

<table>
<thead>
<tr>
<th>B1 Reservoirs</th>
<th>A reservoirs (general)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B reservoir modelling</td>
</tr>
<tr>
<td></td>
<td>C reservoir exploration</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>B2 Operation</th>
<th>A operational issues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B injection issues</td>
</tr>
<tr>
<td></td>
<td>C pumps &amp; components</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B3 PR &amp; data</th>
<th>A dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B acceptance</td>
</tr>
<tr>
<td></td>
<td>C reporting code/statistics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B4 New concepts</th>
<th>A innovative concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B heat</td>
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<td></td>
<td>C power cycle</td>
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</table>

<table>
<thead>
<tr>
<th>B5 Anthropogenic influence</th>
<th>A reservoir creation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B seismicity</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>B6 Drilling</th>
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</thead>
</table>

Propose (joint) actions to bridge gaps, overcome barriers and promote the use of geothermal energy in Europe (task 2.2c RVO)

> ready nov ’14

> basis for wp4: development of joint activities

> All reports available on: [www.geothermaleranet.eu](http://www.geothermaleranet.eu)
Common Challenges in Geothermal EraNet countries

**9 clusters**

1. Regulations (A1)
2. Economics & Risk-mitigation (A2)
3. New/innovative concepts & applications (A3/B4)
4. Operation (A4/B2)
5. Subsurface/reservoir knowledge (A5/B1)
6. Structuring the geothermal sector (A6)
7. Public & Education (A7/B3)
8. Anthropogenic Influence (B5)
9. Drilling (B6)

All clusters are relevant for the progression of geothermal energy in Europe

**How to collaborate?**

- **JA1** Information exchange (groups)
  - regular meetings, workshops, visits, idea factories, etc.

- **JA2** Joint work
  - Joint assignment: detailed study on specific issue

- **JA3** Joint call
  - Jointly developing new insights, new systems

- Appropriate (and feasible) JA-type should be chosen for a specific challenge
- JA’s can evolve from JA1 > JA2 > JA3
- Effectiveness/Impact more important than amount of €’s
How to start/organise joint activities?

- Bottom-up
- Bi- or multilateral
- Based on countries preferences (within the clusters)

At least two countries to take the initiative

The Geothermal Era Network as a continuing vehicle to launch JA’s!

7 Joint Activities

- NWW
- New Concepts
- PRGeo
- EGIP
- ReSus
- OpERA
- GeoStat
First Joint Activity: OpERA

- **OpERA**tional issues of geothermal installations
- **workshop** – 1+2 oct 2015
  - Scaling
  - Corrosion
  - Gas content
  - Reinjection

- **follow-up**
  - Expert group > solved/unsolved issues/best practices (JA1)
  - Joint studies (JA2/JA3)
  - ...

OpERA workshop 1+2 okt 2015
Vaals, Dutch Mountains (NL/D)
Common Challenges in Geothermal EraNet countries

9 clusters

1. Regulations (A1)  
2. Economics & Risk-mitigation (A2)  
3. New/innovative concepts & applications (A3/B4)  
4. Operation (A4/B2)  
5. Subsurface/reservoir knowledge (A5/B1)  
6. Structuring the geothermal sector (A6)  
7. Public & Education (A7/B3)  
8. Anthropogenic Influence (B5)  
9. Drilling (B6)

All clusters are relevant for the progression of geothermal energy in Europe

JA New Concepts
imagine the opportunities of Geothermal
Why New Concepts?

- Mentioned by all:

- Crucial cluster full of opportunities! (not barriers)
- New Concepts/Innovations in technology and application crucial for future of geothermal
- Strategic positioning of geothermal in the (EU) Energy System

New Concepts – the EuRopeAn team

Coordination
IS + NL

EraNet Partners
CH + I + H + F + D + SLO
+P +TR

Paul Ramsak 30/10/2015
How to collaborate?

- Information exchange (groups)
  - regular meetings, workshops, visits, idea factories, etc.

- Joint work
  - Joint assignment: detailed study on specific issue(s)

- Joint call
  - Jointly developing new insights, new systems

- Appropriate (and feasible) JA-type should be chosen for a specific challenge
- JA’s can evolve from JA1 > JA2 > JA3
- Effectiveness/Impact more important than amount of €’s

The New Concepts Concept

Two types of events:
1) **Showcase** new concepts/innovative projects in Geothermal
2) Creative **idea generating** events (Idea Factories/Labs)

**INSPIRATIONAL POSITIVE CREATIVE PEOPLE + EVENTS**
Today in Geneva first event of the first type

*Building the base for a vibrant geothermal community*
  - open to innovations and opportunities
Geothermal EraNet Cofund Action **Geothermica** continued cooperation

Creating a European research & innovation framework

- organize and pool national financial and human resources as well as national research infrastructures, **to accelerate research and innovation**.

- Building on relationships with industry and researchers and bridge the gap between research and the market with **innovative solutions**.

- Focus on what is often called “deep” geothermal energy. The scope includes the integration of geothermal reservoirs into novel energy system concepts (e.g., use of reservoirs for energy storage, CO2 storage, integration with near-surface geothermal applications).

---

**New Concepts** workshop Participants

- Innovative Project developers & entrepreneurs
- Country representatives for Geothermal Innovation
- Positive, inspirational, creative, motivated

40 participants from 11 European countries + 4 non-European countries. 20 speakers

- Building a network
- New Concepts JA as a platform to stimulate creativity and innovation in Geothermal
- You’re part of that network!

*We need Creativity and Innovation and a Positive Vibe for Geothermal Energy to flourish*
Your task

What is your vision of -
How do you imagine
the Future of Geothermal?
Your tools
Your instructions

What is your vision of -
How do you imagine
the Future of Geothermal?

Draw it!
be inspired
use your imagination
your name on front side
any tekst comments on the back
you have to be ready at 17:00h

Good luck !...
New Concepts Program

Morning  8:30-12:30

Welcome & Introduction

EGS + Direct Use

Break

Built Environment NewCon

Lunch

afternoon  13:45-19:00

III Other Sectors NewCon

Break

IV Worldwide InnovApp

Visionary Panel, Conclusions & Next Steps

Networking Réception
Your New Concepts Moderator

Póra borgeirs dóttir
Presentation IEA GIA – Brian Carey (GNS, New Zealand)

New Concepts Joint Activity

Brian Carey has over 25 years’ involvement in geothermal energy developments at a commercial and project level. Since 2007 he is working at GNS. He has a strong, established network of geothermal contacts both in New Zealand and overseas, supported by membership of a number of professional organisations, including IPENZ and the NZ Geothermal Association. Brian’s professional interests include geothermal resource utilisation specialising in reservoir utilisation, steam field engineering, steam field energy management, electric power generation and environmental planning.

Back to the program ⬆️
New Concepts

30th October 2015 8:30 am to 5 pm Penthes Geneva

Today

➢ Dream – how high can geothermal use go
➢ Growing geothermal energy
➢ Great opportunities for networking
   – Broadening your geothermal connections
➢ Thank you
   – Gunter Siddiqi, SFOE for hosting
   – Katharina Link for the inspiration for today
   – Geothermal ERA-NET for working together
   – Presenters
Introduction - Brian Carey

- **Geothermal Resource Management Specialist**
  - GNS Science
- **President**
  - New Zealand Geothermal Association
- **Chair**
  - Geothermal Heat Pump Association of NZ
- **Executive Secretary**
  - IEA Geothermal
- **Co-organiser**

Geothermal at Heart

- 30 + years in Geothermal Energy
  - 1981 to now
- 20 + years – resource operations
  - 1985 - 2007
- Trained
  - Mechanical Engineer
IEA Geothermal

- **Cooperation and collaboration**
  - National, organisational and industry geothermal programmes
- **17 members**
- **Sharing Information**
- **Developing technologies, techniques and best practice**
- **Preparing & disseminating authoritative information**
- **Operative since March 1997**
  - IEA - Geothermal Implementing Agreement
    - IEA - GIA

17 IEA Geothermal Members

- **13 Countries.**
  - Australia, France, Germany, Iceland, Italy, Japan, Mexico, New Zealand, Norway, Republic of Korea, Switzerland, United Kingdom, United States.
- **European Commission**
- **Three Industry / Organization Members**
  - Ormat
  - CanGEA
  - APPA
Technical Activity

- Working Groups
  - Called Annexes
- Geothermal has five
  - Environmental
  - Direct Geothermal
  - Deep Roots of Volcanic Systems
  - Emerging Geothermal Technologies
  - Data and Information Collection

Web presence

www.iea-gia.org

Great Information

- Trend reports
- Country reports
- Annual Summary Reports
- Technical Reports
- Workshop Presentations
Direct Use - Annex VIII
Includes Geothermal Heat Pumps

Direct Use

Lead by Katharina Link
Dr. Roland Wyss GmbH, Switzerland
Email: link@rwgeo.ch

A New and innovative direct use applications
Brian Carey, GNS Science, New Zealand

B Communication
Alison Thompson, CanGEA, Canada

C Guidelines for Geothermal Energy Statistics
Jonas Ketilsson, Orkustofnun, Iceland

D Guidelines for GSHP statistics
Yoonho Song, KIGAM, Korea

E Design Configuration and Engineering Standards
Rudolf Minder, SFOE, Switzerland
Direct Use - Objectives

- Cooperation and sharing
  International arena
- Increasing the use of direct geothermal energy technologies
- Raising awareness of the advantages of direct geothermal
- Targeting several different topic workshops each year

Get involved

- If your nation is a member of IEA Geothermal
  – You can be actively involved in leading work activity.
- If not organise your government to join, or
- Work with a sponsor organisation to join.
Future Workshops

- Geothermal cooling
- Direct use
  - Mexico, and Central and South America
- Keep a look out

Todays Programme

- **Fantastic**
  - Variety
  - Novelty
  - Conceptual
  - Implemented
- **Paul Ramsak will introduce the programme**
- **From IEA Geothermal a very big thank you**
  - Katharina Link
  - Paul Ramsak
  - Alicja Stoklosa
  - Hjalti Ingolfsson
Enjoys
Session I EGS projects + direct use applications

Switzerland – Peter Meier (Geo Energie Suisse AG)

Title: EGS-Projects of the Geo-Energie Suisse AG: the new concept

Presenter Mr. Peter Meier a civil engineer for rural areas from the Federal Institute of Technology in Zürich. Since 2011 he is CEO of Geo-Energie Suisse AG, a company founded in November 2010 by seven Swiss utilities with the objective to get a break-through of deep geothermal energy in Switzerland.

Abstract

The Haute-Sorne pilot project in Canton Jura, Switzerland, is the first project worldwide that foresees multistage stimulation to achieve water circulation between two deep boreholes drilled through the crystalline basement. The project is in the final phase of obtaining the risk guarantee from the State that covers up to 60% of the exploration costs in case of failure. As a pilot and demonstration project, subsidies from the State can be expected. There are three stages of implementing it: 1st Phase: 2016-2018, 2nd Phase: 2018-2019, 3rd Phase: 2019-2020.

Back to the program
Swiss centre of competence for deep geothermal energy for power and heat production

MULTI-STAGE EGS HAUTE-SORNE PROJECT

DR. PETER MEIER, CEO

GEOTHERMAL ERA-NET NEW CONCEPTS PROGRAM, GENEVA 30.10.2015

Basel reservoir stimulation in principle successful, but 1) induced seismicity too strong, 2) permeability too low
Key findings seismicity (Serianex, 2009): Magnitude of induced seismicity increases with stimulated reservoir area.

Detailed analysis of the Basel data set and numerical simulations corroborate this general relationship from many data sets worldwide. Also the project in St. Gallen follows this relationship.

Concept DHM Basel vs. „new“ horizontal multi-frac system
Drilling

Weight on Bit

Rotary steerable

PDC bit

Tricone drill bits

Multi-zonal isolation
Monte Carlo simulations demonstrate the improvement of circulation rates using a multi-stage stimulation system instead of a massive stimulation in an open borehole assuming rock conditions of the Gotthard base tunnel (Masset & Loew, 2013).

Flow rates from MC calculations for different numbers of successful stages versus open-hole stimulation:

- 30 stages: 111 l/s
- 20 stages: 75 l/s
- 15 stages: 52 l/s
- Open-hole stimulation of 3 fractures: 32 l/s
- Open-hole Stimulation of 1 fracture: 17 l/s

Medium Transmissivity (Gneiss, Masset & Loew 2013, Higher Bound K)
Monte-Carlo simulations of circulation flow rates assuming fractured Gneiss of the 50 km Gotthard Base Tunnel in Switzerland. Horizontal 30-(or 20 or 15 or 3) stage-stimulations vs. Open-hole stimulation.

**Efficiency of the multi-stage vs. single open-hole systems**

<table>
<thead>
<tr>
<th>Utilisation System</th>
<th>Increase Factor of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>El. Power</td>
</tr>
<tr>
<td>Vertical Single-Open-Hole-System, 1 fracture</td>
<td>1</td>
</tr>
<tr>
<td>Single-Open-Hole-System, 3 fractures</td>
<td>1.8</td>
</tr>
<tr>
<td>Multi-Stage-System; 50% failure rate of stages.</td>
<td>2.9</td>
</tr>
<tr>
<td>Multi-Stage-System; 30% failure rate of stages.</td>
<td>4.2</td>
</tr>
<tr>
<td>Multi-Stage-System; 0% failure rate of stages.</td>
<td>6.2</td>
</tr>
</tbody>
</table>
Low risk areas for first pilot projects and safety distance to large fault zones

130 potential sites for pilot projects were evaluated within different plays within crystalline basement and sediments
Regional geology
Construction of the geological model

Geological cross-section with well and reservoir sketch
Conceptual design

Deterministic study (Q-con)
Numerical modeling of ground motions

- $M_w=2.6$
- Damage < 5000 CHF
Probabilistic risk study according to SED philosophy & ATLS

Project site in Haute-Sorne
Power plant construction permit: $P_{\text{max}} = 5 \text{ MW}_{\text{el}}$

Electrical Power will be sold to Swissgrid (KEV-waiting list)

Request for construction permit: environmental impact study & extensive risk study

January 2014
Accompanying Group

- Deliver detailed information to all stakeholders
- Communication relay with the population
- Project improvement driven by the group’s feedback

All press releases and news can be downloaded at: http://www.geo-energie.ch
Haute-Sorne: construction permit from the République and Canton du Jura (15.6.15)

Signature of the collaboration contract Canton Jura, Community of Haute-Sorne And Geo-Energie Jura SA

P. Meier, CEO Geo-Energie Suisse  Ph. Receveur, Minister Canton Jura  J.- B. Vallat, Mayor Haute-Sorne
## Time plan Haute-Sorne

<table>
<thead>
<tr>
<th>Year</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Preliminary impact and risk studies</td>
</tr>
</tbody>
</table>
| 2013 | - Accompanying groups  
| | - Application for construction permit and main environmental impact and risk studies |
| 2014 | Examination by authorities |
| 2015 | Risk guarantee BFE/Swissgrid |
| 2017/2018 | Drilling (if financing successful) |
| 2020+ | Power plant working |

Two visits of geothermal power plants in Germany organised for the accompanying group and representatives of the communal and cantonal authorities
Stimulation factor (Evans, 2013)

Traffic light system with lower thresholds

A system of predefined thresholds allows an automated stop before damage occurs.
1. Société de projet domiciliée dans la commune
2. Possibilité de participation des collectivités publiques
3. Accès de la Commune et du Canton à toutes les informations relatives à la société

Geo-Energie Suisse SA 15 juin 2015

Rémunérations

1. Redevance de 0.5 cts / kWh électrique produit
2. 60% au Canton et 40% à la Commune. La Commune l’investira dans les énergies renouvelables et l’efficacité énergétique
3. Redevance unique de 100’000 francs à la Commune et au Canton

Geo-Energie Suisse SA 15 juin 2015
Risque sismique

Expertise du Service sismologique suisse

Maîtrise du risque

Groupe d’experts neutres

Seuils d’arrêt plus bas

Surveillance en temps réel

Etablissement des preuves et assurances

Etablissement des preuves

- Protocoles de fissure
- Mesures de vibration
- Mise en œuvre avant le début du forage

Assurance RC

- Couverture risques sismiques et environnementaux
- Expertise aux frais de Geo-Energie
- Police validée par le Canton
Protection des eaux souterraines
Protection contre le bruit

Contrôle des émissions sonores

Geo-En
Hungary – László Adam (Mannvit)

Title: What are the challenges and new concepts in South Hungarian Enhanced Geothermal System (EGS) Demonstration Project?

Presenter: Mr. László Ádám, a head geologist employed by Mannvit with professional experience in geothermal research, tectonics, sedimentology, environmental geology and GIS. In the implementation of SHEGSDP he is responsible for evaluation of geological and geophysical data for locating EGS wells, description of expected circumstances, interpretation of seismic data, mapping of fracture zones.

Abstract

Project SHEGSD- the South Hungarian Enhanced Geothermal System project, which jointly promoted by NER300 funding program, Hungarian Government and the Steering Group of the EU Strategy for the Danube Region is a technological initiative to test the suitability of implementation of an EGS pilot plant in Pannonian basin, Central Europe. The project aims 8.9 MWe net power to grid expecting 280 kg/s sum production flow rate, 170 °C inlet and 90 °C outlet temperature of power plant by drilling approximately 10 wells into 3000-3500 m depth interval. The project is in Exploration Phase, the Technical Operation Plan for drilling has been approved and the expected date for drilling of first EGS well is 1st half of 2016. The project will be executed in Békés County, in the vicinity of towns of Mezőkovácsháza and Kunágota. Technology resulting power increase, cost savings and reduced operational risk, in good case both at once. Special attention will be given for EGS characterization tools. By using stress and fracture analysis from BHTV, hydro shear model, interpretation of size and shape of induced seismicity and data of distributed temperature sensing system significant dataset will be gathered to evaluate and characterize relationships between observed phenomena and processes.

Back to the program
Challenges and new concepts in South Hungarian Enhanced Geothermal System (EGS) Demonstration Project?

László Ádám
Head geologist
Mannvit Kft.

Geothermal ERA-NET / IEA Geothermal
Joint Workshop on „New Concepts – New and Innovative Applications of Geothermal Energy”
Geneva, 30th October 2015

Abstract

The South Hungarian Enhanced Geothermal System Demonstration Project jointly promoted by NER300 funding program, Hungarian Government and the Steering Group of the EU Strategy for the Danube Region is a technological initiative to test the suitability of implementation of an EGS pilot plant in Pannonian basin, Central Europe, which is a compressional tectonic setting.

The project aims 8.9 MWe net power to grid expecting 280 kg/s sum production flow rate, 170 °C inlet and 90 °C outlet temperature of power plant by drilling approximately 10 wells into 3000-3500 m depth interval. The project is in Exploration Phase, the Technical Operation Plan for drilling has been approved and the expected date for drilling of first EGS well is 1st half of 2016. The project will be executed in Békés County, in the vicinity of towns of Mezőkovácsáza and Kunágota.

The area is a plain, agricultural area characterized by low population density within Hungary. The EGS reservoir will be created in the likely fractured, pre-Tertiary basement, in which the expected rocks are granitoids (granite, granodiorite) and metamorphic crystalline schists (gneiss, mica-schist). Well-explored sediments of Neogene and Quaternary age overlie pre-Tertiary basement. The first well will be deviated one with 3500 m true vertical depth respectively. The expected bottom hole temperature is 200 °C.
The main professional requirements of the well are: protection of shallow aquifers with a separate casing string, minimum 1000 m long casing for protecting the top part of the basement, because of excess formation fracturing, and minimum 1000 m long open hole. By drilling technical point of view the crystalline basement is poorly explored, in addition to risk of overpressure is anticipated. During the reservoir stimulation several thousands cubic meter water will be injected at moderate well head pressure inducing shearing processes within the rock frame. Due to prevailing present stress the slipping fractures remain open because of self-propping characteristic of uneven surfaces.

The growth of seismic cloud will be monitored by micro seismic array, and traffic light system described in induced seismic risk mitigation plan will be used avoiding damages caused by induced seismicity. Most of the stimulation job performed in EGS could induce only one fracture system per well. The multi-zone stimulation, when succeeding fractures zones are temporary closed and stimulated at the same time by adding thermally-degradable zonal isolation materials (TZIM) could provide solution to increase the power output of a well. SHEGSDP will use AltaRock TZIM Technology resulting power increase, cost savings and reduced operational risk, in good case both at once. Special attention will be given for EGS characterization tools.

By using stress and fracture analysis from BHTV, hydroshear model, interpretation of size and shape of induced seismicity and data of distributed temperature sensing system significant dataset will be gathered to evaluate and characterize relationships between observed phenomena and processes. Increasing the reliability of stimulation job two, electric, centrifugal, 14 stage pumps connected by 10 inch pipes and four valves will be used.
France – Martino Lacirignola (ADEME)

Title: ECOGI - an EGS project for the industry in the Upper Rhine Graben

Presenter: Mr. Martino Lacirignola is a project officer and scientific advisor for the French Environment and Energy Management Agency (ADEME). He is involved in the coordination of several supporting programs for renewable energies, including the Investments for the future scheme and the Renewable heat fund. Martino represents ADEME as the French delegate for the geothermal ERA-NET program.

Abstract

The ECOGI geothermal project, located in the Upper Rhine Graben, was initiated in 2011. It is designed to deliver a power of 25 MWth at the “Roquette Frères” bio-refinery in Beinheim in order to cover around 25% of the process heat needed by this industrial site. The drilling site is located in Rittershoffen, 6 km east of Soultz-sous-Forêts, in Northern Alsace, France. The project is supported by the “ADEME”, the “Conseil Régional d'Alsace” and “SAF Environnement”. ECOGI is a joint venture; the shareholders are “Electricité de Strasbourg” Group, “Roquette Frères” and a public institution “Caisse des Dépôts et Consignation”
ECOGI: an EGS project for the industry in the Upper Rhine Graben

Martino LACIRIGNOLA, M.Eng.
ADME
French Environment and Energy Management Agency

About ADEME
French environment and energy management agency

ADME is a public agency under the joint authority of the Ministry for Ecology, Sustainable Development and Energy and the Ministry for Higher Education and Research.

Missions:
✓ supervising & coordinating the application of environmental policies and supporting public authorities for their design
✓ encouraging and animating the sector, providing expertise and advice
✓ facilitating and undertaking operations of private & public entities with the aim of protecting the environment and managing energy
ECOGI: 
Exploitation de la Chaleur d’Origine Géothermale pour l’Industrie 
(Exploitation of geothermal heat for industrial applications)

- **First geothermal project** at high temperature (>150° C) in France for a heat application (target of 24MWth)
- **Lessons learned from the Soultz-sous-Forêts EGS** successfully applied for enhancing permeability and targeting the second well
- **15 km** transport loop
- Development of **expertise** for stimulations, optimized well emplacement and hydraulic testing of deep fractured rocks

---

**The application**

**Roquette Frères** bio-refinery in *Beinheim*
- Major player in starch manufacturing (3.1 B€ turnover, >8k employees, 21 sites)
- Products: Polyols (Sugar alcohols), Proteins & Derivatives, Starches
- Markets: Nutrition, pharmacy, green chemistry

- Beinheim site energy needs: ~ 100MWth
  → Geothermal project: 25% of the energy demand
- Global strategy: reduction of the gas consumption by 70%: geothermal energy, biomass, reduction of the demand
The project

Joint venture:
- Groupe *Electricité de Strasbourg* (energy provider): 40%
- *Roquette Frères* (bio-refinery): 40%
- *Caisse des dépôts*: 20%

- 55 M€ Total investment
- 18+6 M€ French incentive from the *Renewable Heat Fund* (ADEME)
- Risk insurance mechanism:
  - *Short term guarantee* covering 10% to 60%
  - *Long term guarantee*

Technical data

<table>
<thead>
<tr>
<th>2 Wells</th>
<th>2500-3000 m</th>
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<tbody>
<tr>
<td>Operating Hours</td>
<td>8,000 h/year</td>
</tr>
<tr>
<td>Temperature</td>
<td>170° C</td>
</tr>
<tr>
<td>Transport Loop</td>
<td>15 km</td>
</tr>
<tr>
<td>Thermal Power</td>
<td>24 MW&lt;sub&gt;th&lt;/sub&gt;</td>
</tr>
<tr>
<td>Reduction of GHG emissions</td>
<td>40 kt/y</td>
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</tbody>
</table>
**The ECOGI concept**

15 km transport of overheated hot water:
- double-envelope pipe to lower energy losses (maximum 3° C)

**Production site in Rittershoffen**

**Industrial site in Beinheim**

*multiple applications in series:*
- kneading machine
- Water/water HH
- Water/air HH
- Starch dryer
- steam prod.

**Planning**

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<td>ECOGI</td>
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<tr>
<td>JV creation</td>
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<tr>
<td>Civil works</td>
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<tr>
<td>Platform construction</td>
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<td>GRT1</td>
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<td>Drilling and well development</td>
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<td>ECOGI</td>
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</tbody>
</table>
Background: a series of geothermal anomalies in the Upper Rhine Graben (URG)

Fault map and temperature field between Soultz and Rittershoffen

Temperature distribution within the URG at 1500 m depth (LIAG)

Baillieux, 2012

Modelisation

✓ Seismic acquisition
✓ Acoustic imaging
✓ Elaboration of data from existing oil wells
✓ …

→ New skills and expertise developed by ES-Group
Geothermal doublet: GRT-1 + GRT-2

- **GRT-1**: vertical well, 2600 m (600 m open section)
- **GRT-2**: deviated well, 3200 m (1000 m open section)
- Distance at the bottom: 1200 m
- Target: a faulted structure
- All wells achieved in 2014

Over-heated pipeline from Rittershoffen and Beinheim

15 km transport loop between Rittershoffen and Beinheim
High temperature pipe:
- Steel cased pipe-in-pipe with vacuum, preloaded
  - ID: 250 mm
  - OD: 450 mm
  - Thermal losses: 4°C/15 km

Return pipe:
- Insulated pipe
  - ID: 250 mm
  - OD: 450 mm
  - Thermal losses: 3°C/15 km

ECOGI: Well development and testing

GRT-1 Well development
- Cold fluid reinjection (4200 m³, < 25 l/s, < 35 bars)
- Chemical cleaning with biodegradable products
- Hydraulic improvement of the well (3150 m³, < 80 l/s, < 35 bars)
  ⇒ Injectivity x 5

GRT-2 Well testing
- Good production well
- No need for stimulation
- Tracer test between GRT-1 (injection well) and GRT-2 (production well)
Seismic monitoring

- More than 300 stations installed
- More than 500 micro-EQ automatically detected between 2012 and 2015
- Mlv max : 1.5
- No micro-EQ felt by population

An example of collaboration: an Upper Rhine Valley alliance

- ÉCOGI benefits from the know-how of the German-French pilote project of Soultz-sous-Forêts
- ÉCOGI contributes to the development of industry in Northern Alsace
- For drilling activities, different French actors are involved: drilling operations, borehole supervision and prime contractor, well testing, cementing, geological & fluid data
- Project owner delegate: ÉS Géothermie, a daughter company from Groupe ÉS, is specialized in the technical supervision of geothermal energy project
- German expertise is involved through the reservoir development program
- Local support from academic research for seismic monitoring from Strasbourg university (EOST-LABEX in Deep Geothermal energy) and Karlsruhe with KIT
Conclusions

✓ First industrial EGS in France
✓ Valorization of the lessons learned from the pilot EGS in Soultz
✓ Development of expertise for stimulations, optimized well emplacement and hydraulic testing of deep fractured rocks
✓ Enhancement of the energy mix of the Beinheim site of RF
✓ Local energy for local industry
✓ Further developments: ongoing exploration phase in Illkirch...

More information

Baujard et al., 2014, “The ECOGI EGS project in Rittershoffen, France”, GRC, Portland, Oregon
Baujard et al., 2015, “ECOGI, a new deep EGS project in Alsace, Rhine Graben, France”, WGC, Melbourne, Australia
Maurer et al., 2015, “Seismic monitoring of the Rittershoffen EGS project (Alsace, France)”, WGC, Melbourne, Australia
Gaucher et al., 2015, “Migration based detection and location of the seismicity induced at Rittershoffen EGS (France)”, WGC, Melbourne, Australia

Contacts

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Clément ROBERT – clement.robert@roquette.com
Thank you

Martino Lacirignola, M.Eng
ADEME – French Environment and Energy Management Agency
Networks and Renewable Energy Department
martino.lacirignola@ademe.fr

Questions?
Session II Direct use applications (new concepts – built environment)

Iceland – Kristin Vala Matthiasdottir (Resource Park/ HS Orka)

Title: HS Orka Resource Park – Society without waste

Presenter: Ms. Kristín Vala Matthíasdóttir, VP Resource Park. Kristin Vala works for HS Orka and is the chairman of the Iceland Geothermal Association. She has an M.Sc. degree in Chemical Engineering from University of Lund, Sweden and wide experience within the geothermal industry. Prior joining HS Orka Kristín Vala worked for Magma Energy Iceland, Geysir Green Energy and Enex.

Abstract:

HS Orka operates two power plants at Svartsengi and in Reykjanes. Their core operations have been in the production of electricity and hot water. Excess resource streams have been used by an incredibly varied range of businesses, such as the Blue Lagoon, cosmetics manufacturers, biotechnology companies and aquaculture. Moore than 500 jobs can be directly attributed to HS Orka’s Resource Park, in addition to other derived jobs. The Resource Park that has been developed in the neighbourhood of HS Orka’s geothermal plants in the Suðurnes region is unique; it heralds the future, new ways of thinking and encourages even further development of increased and more efficient utilisation of what the geothermal plants produce. More information about the project http://www.resourcepark.is/

Back to the program ‹☆›
HS Orka Resource Park
Society without waste

Kristin Vala Matthiasdottir
VP Resource Park

Founded on the 31\textsuperscript{st} of December 1974

As Hitaveita Suðurnesja

HS Orka has over 40 years experience in the geothermal power industry

HS Orka now has a capacity of 175 MW\textsubscript{e} and 190 MW\textsubscript{th}

- Svartsengi: 75 MW\textsubscript{e} and 190 MW\textsubscript{th}
- Reykjanes: 100 MW\textsubscript{e}

Third largest power company in Iceland

- The only one privately owned
The Resource Park Goals

- Society without waste
- Goals
  - Ecological balance
  - Economic prosperity
  - Social progress
- Read the Nature—holistic approach to the project – be in the nature

HS Orka Physical Resource streams
One of the wonders of the world. The Blue Lagoon is made of excess brine from Svartsengi Power plant.

In the Blue Lagoon health clinic utilizes the beneficial effects of the mineral-rich geothermal seawater for its treatments.
Researching the geothermal seawater, microbial community, Silica and Minerals

Blue Lagoon Clinical Research – Healing Power

71 year old man from the Faeroe Islands. 2 years history of psoriasis.

4 weeks treatment at Blue Lagoon Medical Clinic.
CRI

Develops renewable methanol from carbon dioxide, hydrogen, and electricity for energy storage, fuel applications, and efficiency enhancement.

ORF Genetics

Pioneer in the manufacturing of growth factors and other recombinant proteins in plants.
Holistic Fish Processing Haustak & Háteigur

Complete utilization of fish products using Steam from Reykjanes Power Plant

Stolt Sea Farm Senegal Sol

The largest fish farm in Iceland. Excess cooling sea water from Reykjanes Power Plant is used to grow the product.
Within the Resource Park 550 jobs have been created.

### HS Orka resource park—next steps

- Investigate further opportunities for the expansion of the Resource Park
- Approach companies with business ideas that align with the Resource Park concept
- Planning and installation of necessary utilities for future Resource Park projects
- Develop further the Resource Park Concept

**HS Orka’s Mission statement**

Harness renewable georesources in a sustainable way. The Resource Park concept is the tool to attain the goal.

**Resource streams**

- Silica $\text{SiO}_2$
- Tourism/Education
- Effluent heat
- Gas extraction from geothermal fluid
- Metal and mineral extraction from the Geothermal Brine
The Resource Park Concept has proofed to be successful for treading the bumpy road of supporting sustainable development in the local society.

It is unwise to look at the geothermal resource as a sole source of energy/enthalpy/power.

Innovative thinking, research and development, interdisciplinary cooperation of different entities and entrepreneurial spirit are vital components of an active Resource Park.

Commercially the multiple revenue streams generated in the Park and distributed financial risk is of great importance.

Do what you can - with what you have - where you are.

Nothing ages faster than the future.

If you can dream it, you can do it.

Art museum

Thank you
Switzerland – Matthias Kolb (Amstein + Walthert AG)

Title: Smart thermal grids: operational experience with low temperature grids in Zurich

Presenter: Mr. Mathias Kolb studied environmental sciences at the Swiss Federal Institute of Technology in Zurich. He is currently working for Amstein + Walthert AG as an engineer in the building sector. In the last few years they started to consider whole areas and not 'only' distinct buildings to be served with energy. This leads to new energy concepts, such as the low temperature network with substantial potential to reduce primary energy demand and CO$_2$ emissions.

Abstract:

“Smart thermal grids” is a concept which integrates all sources of heating and cooling either coming from thermal plants, industrial waste or residential. They can play important role in the future of Smart Cities by ensuring reliable and affordable heating and cooling supply to the customers. The concept of thermal networks aims at reduction of CO$_2$ emissions, sustainable energy supply, and higher security of energy supply, focus on life cycle cost and low usage of primary energy. The operational experience is greatly shown in the presentation on a case of Zurich grids.

Back to the program ☁️
Aim of Thermal Networks

- Thermal connection
- Seasonal storage
- Primary energy reduction

Reduction of CO₂ emissions
Principle of a Low Temperature Network

Agenda

1) Aim of thermal networks
2) Principle of low temperature networks with seasonal heat storage
3) Implementation examples in Zurich
   • Network ‘Campus Hönggerberg’
     (Swiss Federal Institute of Technology)
   • Network ‘Friesenberg’
   • Network ‘Richti Areal’
4) Operational Experiences
Seasonal Balancing of Heating / Cooling Demand

- **Summer**
- **Winter**

![Geothermal Probe Field](image)

Bidirectional Network

- Unidirectional
- Bidirectional

![Bidirectional Network](image)

Anergy Network

- 'Conventional District Heating'
- Anergy Network
ETH Hönggerberg

10'000 students
53'000 MWh electricity demand
27'000 MWh heat demand
16'000 MWh cooling demand

Übersicht

Movie
Heat Pump Station

Familienheim-Genossenschaft Zürich (FGZ)

2'300 apartments and houses
5'700 inhabitants
35'000 MWh heat demand
80'000 MWh cooling demand
Energy Mix

heat demand in MWh/a

- Fossil fuels (gas and oil)
- Electricity for heat pumps
- Waste heat

Greenhouse Gas Emissions

CO₂-equivalent emissions in t/a
Waste Heat from Data Center Swisscom

Heat Exchange Station Swisscom
Heat Exchange Station Swisscom

‘Anergy’ Pipes
‘Anergy’ Pipes

Geothermal Storage
Energy Management System

Future Installation by Stages
**Future Installation by Stages**

```
Future Installations

Heuried ice rank

'anergy network' (underground pipes)
probe storage
heat pump station
supply area 'anergy grid'
```

**Future Installations**

```
Future Installation by Stages

Heuried ice rank

'anergy network' (underground pipes)
probe storage
heat pump station
supply area 'anergy grid'
```
Future Installations

Simulation – Network Temperature Development
Simulation – Hydraulics for Pump Dimensioning

Operating Figures – Waste heat demand and delivery
Operating Figures – Temperature Profile of Network

Operating Figures – Load of Bore Hole Field
Network ‘Richti Areal’ in Wallisellen (Zurich)

145,000 m² energy reference surface
5’700 MWh heat demand
6’000 MWh cooling demand

Overview Anergy Network ‘Richti’ Area
Operating Figures – Energy Balance, Temperatures

Outlook – Potential Areas for Anergy Networks
Thank you very much for your attention

Matthias Kolb
Amstein+Walthert AG
matthias.kolb@amstein-walthert.ch
phone: +41 44 305 94 62
Germany – Christian Hecht (Stadtwerke München, SWM)

Title: The Projekt GRAME - One Step towards our 2040 Vision of 100% Renewable District Heating in Munich

Presenter: Dr. rer. nat. habil. Christian Hecht is an Applied Geologist. Present position holds as Chief Geologist and Geothermal Expert Department for the Conception of Energy Generation Plants Stadtwerke München Service GmbH

Abstract:

The 3D seismic is a part of scientific project GRAME, which was funded by the Federal Ministry of Economics and Technology (BMWi). Partners of the SWM are the Leibniz Institute for Applied Geophysics LIAG, the planning office Erdwerk GmbH, the Institute of Energy Systems of the Technical University of Munich and the GGL geophysics, and geotechnical engineering Leipzig GmbH. The GRAME project focuses on the basics of optimization and sustainable exploration on the Bavarian Molasse Basin and beforehand identified geothermal sites in Munich area. As an outcome it is expected to receive technical, environmental and economic concept to integrate current geothermal production and distribution to the new SWM system.

Back to the program ↩️
The Projekt GRAME - One Step towards our 2040 Vision of 100% Renewable District Heating in Munich

Christian Hecht, Nadine Frank, Christian Pletl

Contents

- SWM Energy
- 2040 Munich District Heat Vision
- The Project GRAME
- 3D Seismic Munich South
SWM Business Units

- Power (Production, Distribution, Sales)
- District Heating (Production, Distribution, Sales)
- Gas (Distribution, Sales, Exploration)
- Water (Production, Distribution, Sales)
- Public Swimming Pools (Indoor, Outdoor, Saunas, Ice Skating)
- Mobility (MVG: Metro, Tram, Bus)
- Telecommunication (Networks, Sales, M-Net)

SWM District Heating Vision

The vision for SWM’s district heating system fully renewable from 2040

To achieve this vision, SWM aims at the continuous development of deep geothermal resources
Geothermal – **M**-Energy Geological Conditions

**Malms**
Thermal Water Reservoir
Fractures, Karst, Facies

100 °C

Energy Supply SWM
Project GRAME

“Ganzheitlich optimierte und nachhaltige Reservoirerschließung für tiefengeothermische Anlagen im bayerischen Molassebecken

Entwicklung eines 50 MWel Kraftwerks und Erschließung von 400 MWth für die Fernwärme in München“

Optimized and Sustainable Reservoir Development for Deep Geothermal Plants in the Bavarian Molasse Basin

Design of a 50 MWe Powerplant and Development of 400 MWth for the Munich District Heating

GRAME Topics

- Development Concept of 400 MWth
- Reservoir Drilling and Engineering
- Standard Well Design
- 3 D Seismic Survey
- Geothermal District Heating Model
Participants in GRAME

- SWM Services GmbH
  - Coordinator GRAME
  - Project Conception
  - Project Realisation
- Erdwerk GmbH
  - Geological Modeling
  - Seismic Interpretation
  - Reservoir Modeling
- Chair of Energy Systems
  - Innovative Plants
  - Net Connection Geothermal
  - Energetic Calculations
- LIAG Leibniz Institute for Applied Geophysics
  - Physical Methods
  - Probability of Success Studies
  - Large Scale Modeling

Timetable

Year 1 2015
- Geological Models
- Concepts and Simulations
- Innovative Technologies
- Public Relations

Year 2 2016
- 3D Seismic Data Acquisition
- Processing and Interpretation
- 3D Modeling
- Innovative Technologies

Year 3 2017
- True Reservoir Model Development Design
- Geothermal District Heating Model
SWM Seismic Surveys

1. SWM Seismic Surveys Munich
   - 2 D Line Length = 200 km
   - 3 D Survey Area = 20 km²

2. SWM Seismic Survey GRAME 2015
   - 3 D Survey Area = 170 km²

Seismic Campaign 2015-2016

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<tr>
<th>Surveys</th>
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<tbody>
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<td>3 D Seismic</td>
<td>170 km², 7587 Vibro Points, 35 Vibro Lines, Line Spacing 400 m in the Northwest, 500 m in the Southeast</td>
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<tr>
<td>2 D Seismic</td>
<td>4 Lines of 6 km, Distance of Vibro Points 50 m</td>
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<tr>
<td>Sheawave experiment</td>
<td>35 Vibro Points, 4 Vibro-Trucks, Distance of Vibro Points 500 m</td>
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<tr>
<td>Check-Shot-Surveys</td>
<td>In the Riem Th1 and Freiam Th1 Wells, Distance of Measurement Points 25 m, 130 Depth Levels, one external Vibro-Truck</td>
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Project Development

Thanks for your attention!
Netherlands – René Verhoeven & Herman Eijdems (Mijnwater B.V)

Title: Minewater Heerlen - Development of carbon neutral areas with thermal smart grids and geothermal

Presenter: Mr. René Verhoeven has a long experience in sustainable ESCO-projects and District heating networks. In Mijnwater in Heerlen he is a Cluster manager, designer of the new innovative Minewater 2.0 concept and responsible for the transformation and development of the Minewater project from a pilot system into a full-scale hybrid sustainable energy infrastructure. In this job his water energy experience come together which is highly satisfying.

Presenter: Mr. Herman Eijdems Researcher Bouwcentrum is technical consultant NCIV, technical consultant Damen consultancy, managing consultant Cauberg-Huygen Raadgevende Ingenieurs, head of building Physics Unit Rijksgebouwendienst, sr. consultant/knowledge manager Rijksgebouwendienst, teacher building-physics at Vitriuvian opleidingen, Board Member Dutch Flemish building physics Association and member of the advisory board of Dutch Green Building Council. Herman acted as researcher in IEA Tasks 8 and 13 and in a broad range of energy saving and indoor environment projects in the Netherlands.

Abstract:

Mijnwater BV's site in Heerlen (Netherlands) is a unique front runner within the Netherlands and the EU of a mine water heat recovery system that has become a true hydraulic thermal smart grid. Mijnwater BV is a modern utility company owned by the municipality Heerlen to realize the targets of the PArkstad Limburg Energy Transition (PALET) with the goal to become a carbon neutral region in 2040. Mijnwater BV takes care of innovation, development, realization and exploitation of the energy infrastructure and energy stations at the end-users. Integral, innovative and pragmatic thinking, own know-how (master of concept) and partnership are key in our approach. Mijnwater BV has an open mind for exchange of know-how and support of other parties with the development of mine water heat recovery systems and thermal smart grids in the EU and is looking for innovative European partners to join this development.

Back to the program 🔺
Minewater Heerlen
Workshop New Concepts Geothermal EraNet

Development of carbon neutral areas
with thermal smart grids and geothermal

Geneva, October 30th 2015
René Verhoeven (r.verhoeven@mijnwater.com)
Herman Eijdems (h.eijdems@mijnwater.com)
Mijnwater B.V.
1. System development:
   - Minewater 1.0 (past)
   - Minewater 2.0 (present)
   - Minewater 3.0 (next step)
   - Summary

2. Roadmap to carbon neutral areas

Minewater Heerlen
Location Minewater Project
Minewater 1.0
Pilot (2008–2013)

- Traditional network (tree)
- Only heat and cold supply
- Simple change-over-system
- Minewater as source
- Bivalent energy stations (HP + Boilers + Chillers)
- Mijnwater owner and operator grid

CO₂-Reduction 35 %

Minewater 1.0
Minewater as source

- Hot and cold return in same injection well
  - Thot supply 28°C
  - Tcold supply 16°C
  - Thot return 18°C
  - Tcold return 22°C

Minewater as source = limited capacity or depletion
Minewater 2.0
Clusters of buildings (since 2013)

- Hydraulic cloud network
- Instant heat/cold exchange
- Minewater as storage
- Fully demand driven
- Bidirectional wells
- Multiple sources
- All electric (100% HP)
- Mijnwater owner/operator network & energy stations

Minewater 2.0
Minewater as storage

Minewater as storage = regeneration = no depletion = increase capacity
Minewater 2.0
Smart grid: 3 levels of control

- Building
  Temperature
- Cluster
  Flow
- Minewater
  Pressure

Minewater 2.0
Smart grid: Exchange!

Artist impression Minewater 2.0 with geographically dispersed Minewater Installations (MI)
Minewater 2.0
Advanced process control

Minewater 3.0
The NEXT step!

Balancing with.....

Time

CO₂-Reduction 80-100 %
Minewater Heerlen

Summary

- Transition Minewater project Heerlen into a hybrid sustainable thermal smart grid:
  - Cloud structure (3 levels of control/decentralized)
  - Exchange (reuse; prosumers)
  - Storage (time)
  - Multiple sources (hybrid)
  - Intelligence (Demand & supply side management)
  - All-electric
  - Integratable with (smart) electricity grid
  - Low-exergy (LT-heating & HT-cooling)
- Increased CO₂-emission reduction:
  - 1.0: 35%; 2.0: 65%; 3.0: 80–100%
- Concept replicable for future DHC-systems:
  - Not restricted to old mining areas
  - Blueprint for sustainable thermal smart grids
Geothermal fed low-exergy 4thG-DHC grid in Heerlen
Urban Energy Development

Herman Eijdems
Mijnwater B.V.

Geneva
30.10.2015
- 2 -
• Everybody has the right to save, secure and continual access to energy;
• Energy should facilitate a healthy and comfortable life style and give opportunity for evolution and mobility;
• Everybody has the right to participate in, but also has a responsibility for the generation of our energy needs;
• Energy supply is based on infinite resources;
• A minimal impact on the environment is considered at the generation of energy;
• Revenues from energy benefit to the local community and are being fairly and evenly distributed (energy dependence may not lead to speculative or monopolistic profit for individuals or businesses);
• Energy is generated in the own region to prevent dependency on energy-producing countries or regimes and to save local money and employment;
• We strive -in a cycle of continuous improvement- to building knowledge and make this knowledge accessible to all stakeholders.
Depletion of fossil resources

THE GROWING GAP

Past discovery based on ExxonMobil (2002). Revisions backdated

Depletion of fossil resources

ASPO: OIL & GAS PRODUCTION PROFILES
2005 Base Case

- Regular Oil - Heavy etc - Deepwater - Polar - NGL - Gas - Non-Con Gas
Population growth, urbanisation

In 1950, 30% of the world's population was urban, and by 2050, 66% of the world's population is projected to be urban.
People need energy

Therefore..

Long term energy support should be secured

We need strategies and concepts which will last

Security of support and welfare

DID YOU KNOW?

IN SCOTLAND

40% of households are in Fuel Poverty

This number has significantly risen, and will continue to rise, due to subsiding wind energy and associated infrastructure, by adding the costs onto household energy bills.

What are the financial costs?

Feed-In-Tariffs
Construction of National Grid Interconnectors
Renewable Obligation Certificates
New Transmission Lines
Constraint Payments
Construction of backup fossil fuel stations
Cost of installing Smart Meters
Paying for Diesel Back-up Generators

Learn the FACTS

www.ScotlandAgainstSpin.org

CO2/global warming/sea level rise

Warming of 5 °C could result in US$7 trn in losses

Most Dutch cities experience a substantial impact of Urban Heat Islands
Past 140 years the sealevel raised by 0.25 m. A global warming of 5 degree will cause a raise of > 1 m.

Storage is one of a number of key technologies that can support decarbonisation. Thermal energy storage systems appear well-positioned to reduce the amount of heat that is currently wasted in the energy system (IEA).
Instability E-grid

Mean existing dwelling NL

- Electr
- Dhw
- Heat
- Sun

<table>
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<tr>
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</table>

Solar irradiation: 1000 kWh/m² per year

Demand: 20 kWh/m² per year

Buffer 6 kWh/m² shift in time

Supplementary (local)
sustainable sources
- wind, PV, IT biomass
- hydropower, local buffers

Social-Cultural-Economical context
- independency, employment
- Innovation, local pride, participation

100 million m³ water = 1 million GJ
Heating of 30,000 dwellings = 28,000 m³ gasoline = 75,000 tons of CO₂
> € 20,000,000
Mijnwater modeling the reservoir

3D model of the underground mine water network (VITO)
Mijnwater Energy concept

- Mijnwater Energy concept

- Typering:
  - Mijn als buffer W/K
  - Minder afhankelijk van backbone
  - Levering van elke opredende vraag
  - Cluster energieneutraal
  - Mix van duurzame opwekkingsbronnen

Mijnwater businesscase

- National Gas Consumption for dwellings: 310 PJ ($10^{15}$ J) per year

- Investment space is €19,- per GJ

- Investmentspace: €5,9 Billion per year

- Within 30 years: €100 Billion

- €14.500,- per dwelling + €4.000,- of costs for CV boiler (7 million dwellings)
Mijnwater performance on trends

<table>
<thead>
<tr>
<th>Notes</th>
<th>Reference - basic 1550 m³/a 3200 kWh</th>
<th>Retrofit to label A CV HR &amp; isolation</th>
<th>All Electric WP-PV + highly insulated</th>
<th>All Electric WP-PV + LTV/HTK</th>
<th>mijwater</th>
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</thead>
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<td>-</td>
<td>+</td>
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<td>EROI from 100 to 1</td>
<td>--</td>
<td>-</td>
<td>+</td>
<td>+++</td>
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<td>Population growth, urbanisation</td>
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<td>Security of support and welfare</td>
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<td>++</td>
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<td>CO₂ / global warming/sea level rise</td>
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<td>-</td>
<td>+</td>
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<td>+</td>
<td>++</td>
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<td>7</td>
<td>Prosumentism (Uber, Airbnb, PV) / participation</td>
<td>--</td>
<td>-</td>
<td>0</td>
<td>+</td>
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<tr>
<td>8</td>
<td>Value of buildings / flexibilility</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
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<tr>
<td>9</td>
<td>Local economy</td>
<td>--</td>
<td>-</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>10</td>
<td>From 'big sources' to 'clouds'</td>
<td>-</td>
<td>-</td>
<td>0</td>
<td>++</td>
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<tr>
<td>11</td>
<td>Urban Heat Islands</td>
<td>-</td>
<td>-</td>
<td>---</td>
<td>++</td>
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<tr>
<td>12</td>
<td>Instability E-grid</td>
<td>+</td>
<td>+</td>
<td>---</td>
<td>++</td>
</tr>
<tr>
<td>13</td>
<td>Social costs</td>
<td>-</td>
<td>-</td>
<td>---</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td>Limited resources raw materials</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>15</td>
<td>Destruction of capital</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

Winning is 80 bln m³, stock < 1.100 bln m³, earth quackes, soil subsidence
The efficiency of production is declining
Denser areas, spatial scarceness, air pollution
Energy = basic, spreading of resources, exchange
Reduction on fossil fuels
National resources
Involvement and awareness, social support
Sustainability sells
Dependent on development of local industry
Better data, insight, critical population
More and more caused by cooling demand
PV limited to 7 %
Varrying from € 30.000,- to € 75.000,- per dwelling
Copper and other metals for infrastructure
Value during life cycle of 50 years

Mijnwater
a sustainable hybrid solution for urban areas

Thanks for your attention
Questions?
Session III Direct use applications (new concepts – other sectors)

Italy – Adele Manzella, CNR

Title: Direct use of heat for industrial and civil processes

Presenter: Adele Manzella is a Senior Scientist working at the Italian National Research Council (CNR) as a geophysicist in geothermal exploration to conduct field and theoretical investigations of geothermal systems in Italy and abroad. She coordinates for CNR the national geothermal evaluation projects and participated in national ventures dedicated to crustal, volcanological and geothermal exploration. She has led the CNR participation in most of the EU funded projects of CNR in the geothermal sector I-GET, ENGINE, Development of the young researcher’s competences at UE standards in the geothermal field and GEOELEC. Projects she is currently involved in, i.e.: IMAGE, Geothermal ERA-NET and DESCRAMBLE. Her activity nowadays tackles research, training, information and promotion of the geothermal energy.

Abstract:

The VIGOR project aims to propose applications for exploiting geothermal heat resources of southern Italy, meet heat demands of local industrial/civil processes; and support economic and social growth of the south Italian regions. It is a number of 8 projects in the Convergence Regions (Campania, Calabria, Puglia and Sicily), which study natural potential and the possibilities of exploitation. Simulations of plants operation aims to assess the produced thermal/electrical energy and define if it meets the energy demand, environmental impact, energy saving and economic profitability. The project will bring the necessary elements of technical and socio-economic study and will promote geothermal awareness in these regions.

Back to the program
Direct use of geothermal heat as proposed in VIGOR project

Adele Manzella, Giuseppe Lombardo

30 October 2015
Geothermal ERA-NET
New Concept Workshop

VIGOR aims

➢ To propose applications for:
  – exploiting geothermal heat resources of southern of Italy;
  – meet heat demands of local industrial/civil processes;
  – support economic and social growth of the south Italian regions

n. 8 projects as examples of potential use of geothermal resources in the Convergence Regions
Interdisciplinary approach with a common and systemic vision

Geothermal Heat Resources (GHRs) match heat demands

- **GHRs** $T > 120^\circ$ C
  - Heat exchanger
  - Binary Plants

- **GHRs** $60 < T < 120^\circ$ C
  - Heat exchanger
  - Geothermal Heat Pump (water-source)

- **GHRs** $T < 60^\circ$ C
  - Heat exchanger
  - Geothermal Heat Pump (ground/water-source)
Plant proposals in VIGOR

- Sludge drying
  - Location: Terme di Caronte (Calabria)

- Seawater desalination
  - Location: Case di Termini Imerese

- Pasta drying: craft process
  - Location: Case di Termini Imerese

- Pasta drying: industrial process
  - Location: Case di Termini Imerese

- Space heating and cooling
  - Location: Case di Termini Imerese

- District heating
  - Location: Case di Termini Imerese

- District heating and cooling
  - Location: Case di Termini Imerese

- Power production
  - Location: Case di Termini Imerese

---

Geothermal plant for drying sewage sludge

- **Plant proposal**
  - Geothermal plant for drying sludge from wastewater treatment;
  - Location: Terme di Caronte (Calabria)

- **Wastewater treatment plant:**
  - Controlled automatically by a PLC (Programmable Logic Controller)
  - Water treatment: 1000 m$^3$/h (8,760,000 m$^3$/year)
  - Treatment for water and sludges.
Actual sludge disposal cost

- Disposal cost: **HIGH**
  - 780 K€/year, since sludge is disposed in landfill with a cost of 130€/t (since it is considered high risk waste)

Is it possible to make the process of disposal sludge cheaper?

Use of geothermal heat for increasing the content of dried sludge

18% → 80-90% -30% €/t Low environmental impact

Geothermal resources

- **Geothermal shallow resource:**
  - \( T = 17^\circ \) C
  - \( Q = 16 \) l/s
  - \( h = 40 \) m

- **Deep geothermal resource:**
  - \( T = 40^\circ \) C
  - \( Q = 10 \) l/s
  - \( h = 1000 \) m
Sludge dryer powered by geothermal heat

Two different plant proposals with GHP:
1. drying with integral air recirculation;
2. drying without air recirculation

Sludge with 18% in dried weight

Condensing moist air with recirculation (CASE 1)
Thermal and Electrical dryers needs

- Case 1 (Dryer with air recirculation)
  - Thermal Power = 850 KW
  - Cooling Power = 420 KW
  - Electrical power = 70 KW

- Case 2 (Dryer without air recirculation)
  - Thermal Power = 1200 KW
  - Electrical Power = 35 KW

Estimated operation hours: 7500 h/year
Estimated dried sludge produced: 1500 t/year

Schematic diagram – CASE 1

**Energy balance**

- sludge in: 18 % dried
- sludge out: 80-90% dried

**Thermal balance**

- \( T_{\text{ess}} = 78^\circ \text{C} \)

**Cooling Tower**

- 420 KW\(_t\)

**GHP**

- 630 KW\(_t\)

**Co-generator**

- Motor

**Operation**

- \( T_{\text{out}} = 75^\circ \text{C} \)
- \( T_{\text{in}} = 17^\circ \text{C} \)
- 240 KW\(_e\)
- 850 KW\(_t\)
- 70 KW\(_e\)
- 220 KW\(_t\)
- 250 KW\(_e\)

www.vigor-geotermia.it
Main plant characteristics

- The condenser of the heat pumps in series with one or two (only CASE 2) co-generative motors for heat recovery from the flue gases and from the cooling system at high temperature (only CASE 1);
- Green system and stand-alone with energy consumption produced by vegetable oil co-generators

Energy saving with respect a conventional system

Case 1: 81 %
Case 2: 100 %

www.vigor-geotermia.it
Technical/Economical simulation

- Simulation of plants operation to assess
  - the produced thermal/electrical energy and define if it meets the energy demand
  - environmental impact
  - energy saving
  - economic profitability

Estimated cost – CASE 1

- Cost estimated for the investment 2.187 K€
  - Dryer: 930 K€
  - GHP: 80 K€
  - Co-generator motor: 450 K€
  - Mechanical, Electrical and Electronic components: 420 K€
  - Civil works: 150 K€
  - Plant design and project management: 157 K€
Estimated cost – CASE 2

- Cost estimated for the investment **1,998 K€**
  - Dryer: **350 K€**
  - GHP: **80 K€**
  - N.2 co-generator motor: **900 K€**
  - Mechanical, Electrical and Electronic components: **370 K€**
  - Civil works: **150 K€**
  - Plant design and project management: **148 K€**

CASH FLOW

- Revenues:
  - cost saved from sludge weight reduced;
  - landfilling lower cost ;
  - green certificates;
- Costs:
  - purchases of fuel for co-generative motor ;
  - Maintenance and consumables;

**EBITDA = 299 K€/year (Case 1)**
**= 392 K€/year (Case 2)**
Conclusions

- Plants proposals as complete feasibility studies are ready to be implemented in the Convergence Regions (and not only) as *Best Practices*:
  - Some geothermal plants have already been implemented (Bari and Mondragone space heating and cooling systems, by Interventi innovativi di utilizzo della fonte geotermica decreto 14 July 2014 MISE)

- All proposed plant are GREEN and ENERGETICALLY stand alone
  - Development of *SMART THERMAL GRID*

Geothermal heat use can be a driving force for socio-economic growth of the territory
Netherlands – Henk de Beijer (SolabCool®)

**Title:** Cooling with Geothermal energy and local storage

**Presenter:** Henk de Beijer has been trained in the field of Mechanical/Construction Engineering, subsequent to which his focus was on thermodynamics, innovation and industrial marketing. He has worked extensively in the field of renewable energy. For the last thirty years he is the owner and director of several companies, e.g.: De Beijer RTB BV, Strategy, MKB Winstpunt, or SolabCool BV. He is involved in the Netherlands & International Energy Agency (IEA) and European Union (EU) Energy research programs. Production, product development and testing is one of the main areas of focus of De Beijer RTB, which works closely with all European Universities and institutes like TNO, ECN, Vito, WI and industrial companies. Through his collaborations with the Universities, he has published works in the field of heat pumps, solar and solar cooling and energy storage.

**Abstract:**

SolabCool is an environmental friendly cooling system with minimal CO₂ emission that uses residual heat that is normally lost to the environment. Key to the sustainability of SolabCool is the “sorption cooling” technology. This technology uses heat as a source of energy through which energy is saved. The SolabCool cooling system is an unique and ground-breaking sorption system by its compactness and range of power the ability is obtained to be used in both buildings as well as homes. Each room gets a pleasant temperature. Because of the use of water as a coolant, the system can easily be connected to the floor heating for example.

[Back to the program](#)
Introduction De Beijer RTB:

Profile:
• Engineering company with 30 years of experience in renewable energy solutions and products.
• Many international cooperation's with institutes and universities.
• Various renewable energy products successfully launched to the market in the past.

Main activity:
De Beijer RTB is mainly active in the field of Solar, thermo-chemical-energy storage and thermo-chemical conversion technology.

Main projects:
Development and the pre-production SunRidge and thermo-chemical energy storage
Problems with building cooling?
Comfort spectrum

Growing Demand for air conditioning

Trend of World Demand for Air Conditioners

- World Total
- China
- Asia (excl. Japan & China)
- Europe
- North America

Trend line

JRAIA
Key players and market drivers

Growing demand for cooling driven by improved insulation
Demand for improved living comfort
Legislation reduction F-gases

Cooling is a must
- Shifts in comfort culture, behavioural patterns, affordability and consumer expectation
- Perception that comfort cooling contributes to higher productivity
- Direct impact on rental value of commercial buildings
- Increase in internal loads (computers etc.)

Cooling is also business
- 10% of electricity used for cooling (global) and 16% in US
- >80% of commercial and institutional buildings in USA and Japan has air conditioning
- <40% in EU, but expanding rapidly, 60% is expected by 2020
District heating: excess heat in summer

Geothermal & Cooling
Soultz, Alsace, Fr.

Production 5 km depth at 200°C & Organic Rankine Cycle (ORC) -> 2 MWe -> re-injected temp 70°C

Geothermal in the world
Geothermal in Nevis

Geothermal in the Netherlands

<table>
<thead>
<tr>
<th>Nr</th>
<th>Locatie</th>
<th>Toevoeging</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aalsmeer e.o.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Bleiswijk e.o.</td>
<td>“B-driehoek”, Zuidplaspolder</td>
</tr>
<tr>
<td>3</td>
<td>Vleuten, Harmelen</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Deurne</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Terneuzen</td>
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<tr>
<td>6</td>
<td>Zuidhollandse eilanden</td>
<td>Hoeksche Waard/Voorne Putten</td>
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<td>7a</td>
<td>Moerdijk</td>
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</tr>
<tr>
<td>7b</td>
<td>Dinteloord</td>
<td>nieuw te ontwikkelen</td>
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<tr>
<td>7c</td>
<td>Made</td>
<td>nabij Amer centrale</td>
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<tr>
<td>8</td>
<td>Bergen op Zoom</td>
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<tr>
<td>9</td>
<td>Wieringermeer</td>
<td>“Agriport A7”</td>
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<td>10</td>
<td>Luttelgeest</td>
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<td>Westland</td>
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<td>Berlikum</td>
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<tr>
<td>13</td>
<td>Huissen/Bemmelen</td>
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<td>Klazienaveen</td>
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<td>Horst a/d Maas</td>
<td>“Californie”</td>
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<td>16</td>
<td>Maasbree</td>
<td>“Siberie”</td>
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<td>Omgeving</td>
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<td>‘t Grootslag</td>
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<td>Hoogeland-Sappemeer</td>
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<td>Roelofarendsweven</td>
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<td>Nieuwkoop</td>
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<td>Heerhugowaard</td>
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<tr>
<td>28</td>
<td>Ens</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Koekoekspolder</td>
<td></td>
</tr>
</tbody>
</table>
IEA Task 28 Arnhem Netherlands
energy storage & geothermal

Concentrating solar energy for electricity or heat

A power of tower near Seville
Bright Source Energy California
Electric Power Research based in Palo Alto
Solar island District heating ‘Almere’

Flat Plate Collectors 7000 m² Production 10,000 GJ/y at 75°C

Energy storage and conversion

Energy storage and conversion
Heat-driven cooling

SolabCool product range

SolabChiller

SolabCascade
Cooling office incineration plant AVR Duiven

Company presentation SolabCool BV

Residential
Absorption Chiller fed with heat from a district heating network

Two 3.5 MW absorption chillers for district cooling network making use of the heat delivered by the district heating system of the city of Helsinki. These units are installed in a rock cavern under the ground.

Chilling Capacity: 2 x 3 500 kW
Driving Heat: 80°C / 69°C

District Cooling in Europe cities

Amsterdam 76 MW Freecooling/Absorption chillers
Barcelona 66 MW
Helsinki 60 MW
Lisbon 40 MW
Stockholm 188 MW
Paris
Berlin
Cooling on District level
### Energy density of the materials

<table>
<thead>
<tr>
<th>Storage options</th>
<th>Hot water</th>
<th>Phase change materials</th>
<th>Thermochemical</th>
<th>Electrical Batteries</th>
<th>Chemical Looping</th>
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</thead>
<tbody>
<tr>
<td>Storage density</td>
<td>&lt; 0.2 GJ/m$^3$ (dT= 50°C)</td>
<td>&lt; 0.3 GJ/m$^3$</td>
<td>~ 1 GJ/m$^3$</td>
<td>~ 1 GJ/m$^3$</td>
<td>~ 3 GJ/m$^3$</td>
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<tr>
<td>Storage duration</td>
<td>Day</td>
<td>day-year</td>
<td>day-year</td>
<td>minites-months</td>
<td>day-year</td>
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<tr>
<td>Storage</td>
<td>Thermal</td>
<td>Thermal</td>
<td>Thermal</td>
<td>Electrical</td>
<td>Electrical &gt; thermal</td>
</tr>
<tr>
<td>Cycling efficiency</td>
<td>~ 70%</td>
<td>~ 90%</td>
<td>~ 90%</td>
<td>75%</td>
<td>70%</td>
</tr>
</tbody>
</table>

### Chemical Looping Combustion for Energy Storage Applications

![Chemical Looping Combustion for Energy Storage Applications](image_url)

**Diagram Description**
- **Hot N$_2$ (+ O$_2$)**: To heating need
- **Reduction**: Me + Fuel → MeO
- **Buffer Capacity**: Reaction front Me → MeO
- **Oxidation**: MeO + H$_2$O → Me + H$_2$ + CO$_2$
- **Energy storage**: Solar H$_2$ Production → H$_2$ to CLC reactor
- **Heat supply**: Simple heat control
- **Bed reduction**: Solar energy from summer is stored as chemical energy, without losses, until the heat is needed
- **Bed oxidation**: Humid air through the reactor oxidizes the bed and provides heat all winter long
Solar/Heat/Cold storage distribution system

Stenograaf 1
6921 EX Duiven
Tel: +31 26 3210289
www.Ares-RTB.nl
Company ‘Principles’

- Spirit
- Reliability
- Flexibility
- Innovation
- Fun

*It’s our Competence that makes the difference*

District Heating Units
Electrical Heatpumpboiler

Inclusie mechanische ventilatie

Automotive airco

District heating

Storage and conversion 1e generatie

Automotive airco
Product characteristics

Sunridge > 3 tubes system:
Performance: 2,5 GJ/yr

Components
Integration

Ridge integrated solution
No use of space indoors
Optimal irradiation
Independent of orientation
Electrical Heatpumps

Geotherm

Energion®
Heatpipe for renovating electrical boilers to Solarboiler
Switzerland – Dirk Arndt & Philip Klingler (Gruner AG)

Title: District heating coupled with a seasonal heat storage in a deep aquifer (city of Oftringen)

Presenter: Philip Klingler is a geothermal consultant and project manager at the Gruner Group since 2012. As project manager Philip develops geothermal heat plants, geothermal heat storage systems and district heating schemes. Philip closely consults the only operating Swiss geothermal heat plant and district heating scheme in Riehen. His interest and commitment to the geothermal heating scheme of Riehen dates back to his master thesis in Hydrogeology and Geothermal Energy at the CHYN in 2010, where he analysed the reservoir properties with a 3D geological model, gravity analysis and tracer test.

Abstract:

Geothermal heat storage in Oftringen city is a project of Gruner AG Company in Switzerland. It aims at creating synergies of incineration (erzo), geothermal energy (ewo) and district heating. Use of excess heat (erzo) in summer due to innovative heat storage system. Reduction of project risks. Site is geologically representative for other sites in Switzerland (and Europe) and has a high copy potential. Optimizing investment costs for geothermal energy and district heating. Building on existing structures. High Standard for supply guarantee with low costs through integration of "erzo.

Back to the program ↑
GEOTHERMAL HEAT STORAGE
OFTRINGEN

Designing our habitat

COMPETENCES

> ENERGY
> BUILDING TECHNOLOGIES
> GENERAL PLANNING
> CIVIL ENGINEERING
> CONSTRUCTION
> SAFETY
> ENVIRONMENT

22 Companies
1057 Employees
1862 since
LOCATIONS IN SWITZERLAND

24 LOCATIONS

LOCATIONS WORLDWIDE

10 LOCATIONS

Gruner GmbH, Köln
Gruner GmbH, Stuttgart
Gruner GmbH, Leipzig
Gruner GmbH, Wien

Stucky Balkans d.o.o., Belgrad
Stucky Caucasus Ltd, Tbilisi
Stucky Teknik Ltd, Ankara

Stucky Asia, Bangkok

Gruner Peru S.A.C, Lima
ENERGY FOCUS

- Geothermal energy
- District heating
- Hydro power
- Energy plants
- Power transmission

ENERGY REFERENCES

Hydro dam Muttsee, Glarner Alps
for: Axpo Power AG

Geothermal district heating Riehen
for: Erdwärmeriehen AG

ETDE, Mosambik
for: ETDE France
Now back to Oftringen…

Increased geothermal gradient
Geothermal Timeline of Oftringen

- 2007 Deep BHE reveals a high geothermal gradient
- 2012 Study on the potential of deep geothermal energy
- 2013 Conclusion preliminary design study
- Nov. 2013 Incorporation of Erdwärme Oftringen AG
- 2014 Deep exploration well (swissnuclear) reveals high geothermal gradient too
- 2014/2015 roundup of of private and public investors
- May 2015 Exploration licence approved
- 2015 … just a minute…

Preliminary design study: Geological Model
On the basis of a thorough geological analysis four potential areas of interest were defined

→ Section 1 was chosen

Preliminary design study: site evaluation
District heating sales potential study

> Goals
  > Verification of expected district heating sales potential
  > Pathways for district heating network
  > Cost evaluation
  > Basis for economic evaluation

> Results
  > Connection Power: 21-40 MW (theoretical 71 MW)
  > Heat sales potential: 49-93 GWh (theoretical 166 GWh)

Potential for district heating in Oftringen

<table>
<thead>
<tr>
<th>Potential</th>
<th>(Study &quot;nova&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>72 MW</td>
<td>166 GWh/a</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Current district heating</th>
<th>(ebm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5 MW</td>
<td>20 GWh/a</td>
</tr>
</tbody>
</table>
District heating development Oftringen

Phase 1
Development DH & Replacement of fossil heatings
21 MW 49 GWh/a
250 – 300 households

Phase 2
Full development of DH (66 % connection concentration)
40 MW 93 GWh/a
Over 600 households

Project idea

How can we optimize costs of peak load plant?

How can we reduce risks of not insufficient geothermal reservoir properties?
Project idea

Geothermal energy - seasonal heat storage - incineration erzo

Function in winter

Distilling heat Oftringen

Cold well

Heat pump possible

Discharging heat storage

Warm well
Function in summer

District heating Oftringen

Cold well

Discharging heat storage

Warm well

Kopplung erzo / Geothermie Oftringen

Two-stage steam turbine

Peak load HE

Charging HE

Cold well

Warm well

Geo-HE
Steam extraction of low pressure steam

Two-stage steam turbine

Boiler
24 MW
400 °C
40 bara

Generator
3.8 MW – 5.3 MW

Cooling Tower
5 MW – 18 MW

130° C - 90° C
η: 3%-1%

η: 16%
η: 6%

50° C

Modelling

> Validation of the idea

> Determination of energetic parameters for an economic evaluation
Reducing Risks

**Temperature:**
- Increasing temperature for direct use through heat storage

**Hydraulic short cut:**
- Reversing flow directions eliminate the risk of a hydraulic short cut.
- No permanent reservoir cooling

**Multi-reservoir strategy**
- More independence of reservoir temperature
Multi-Reservoir-Strategy

Primary Reservoir: Muschelkalk (triassic)

Alternative Reservoirs:
- Top crystalline basement
- Mesozoic limestones

Projekt status

- Preliminary design study concluded
- Heat consumption potential study concluded
- Licence for seismic exploration approved
- Letters of intent of private investors
- Government subsidies pending
Next steps

2015

> Concluding process for public subsidies
> Incorporation of a supply and maintenance/running company

2016

> Stakeholder orientated marketing and communication
> Seismic exploration study
> First investments for district heating extension

2017

> Geological & technical planning for geothermal wells & reservoir management

Conclusion

> Synergies of incineration (erzo) – geothermal energy (ewo) and district heating
> Use of excess heat (erzo) in summer due to innovative heat storage system
> Reduction of project risks
> Site is geologically representative for other sites in Switzerland (and Europe) and has a high copy potential
> Optimizing investment costs for geothermal energy and district heating
> Building on existing structures
> High Standard for supply guarantee with low costs through integration of "erzo"
Thank you for your attention!
Italy – Ruggero Bertani (Enel Green Power)

Title: Geothermal for Agriculture and Food

Presenter: Mr. Ruggero Bertani is a Manager of innovation Geothermal Business Opportunities in Innovation and Sustainability Division of ENEL GREEN POWER S.p.A in Italy and also Vice President of the European Geothermal Council (EGEC). Ruggero Bertani holds a degree in physics from Pisa University. From 1979 to 1982 he worked for different Nuclear Physics Laboratories in Italy (INFN, Roma and Pisa) and abroad (CERN, Geneva and Fermilab, Chicago). In 1982 he started working for ENEL (since 1992 with geothermal energy). At ENEL he has been responsible for reservoir modelling activities, development projects in El Salvador and Turkey, for reservoir assessment in Italy and geothermal fields’ acquisitions in USA. He participates actively in a range of different international activities and is author or co-author of about 70 papers, published in international journals as well as in official publications of International Bodies.

Abstract

In Italy geothermal electricity generation is only in Tuscany, whereas direct uses are scattered throughout the country, mainly for bathing and district heating purposes. The Enel Green Power focuses also on geothermal for agriculture and food development. The potential development of new activities in the food and agriculture fields, using geothermal, is still high in Italy, especially in Tuscany. Perspective on the opportunities created by geothermal energy are based on good resource availability, incentive solutions, and availability of financing for start-ups located on geothermal territory. Main defined barriers are on locations, which are far from main roads, and lack of knowledge about the real opportunities. Enel Green Power efforts, together with local communities that host geothermal power plants, strongly committee to support start-ups supplying heat for their production process and find opportunities to lower the costs of electricity in the area.

Back to the program
Enel Green Power
Geothermal for Agriculture and Food

- Enel Green Power – Geothermal leader in Italy
- The business of Heat supply
- Some examples for the use of geothermal heat for food and agriculture
- Opportunities and how to support them
**Enel Green Power**

**Geothermal Leader in Italy**

- 761 MW of net installed capacity (1)
- 5.5 TWh Production per year (1)
- 360 GWht of sold heat (1)
- 87.3% load factor (1)
- In operation since 1904
- 37 Power units
- 496 wells
- 570 Km pipelines (1)
- 700 employees

- The biggest fully integrated geothermal operator
- Pioneer in the exploitation of the resource – international player
- Culture of field “cultivation” – reinjection as main strategy to compensate the field decline
- Performance leadership: efficiency and availability of power plants.
- Proprietary Technologies
- Innovation.

700 EGP employees, more than 1000 contractor workers.

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**Enel Green Power Heat Business**

**FY 2014**

- Supplied heat (GWht) 360 split (4% of Italian district heating business and 17% from renewable resource in the same business)
  - 52.1% building heating
  - 40.4% greenhouses
  - 7.2% industrial uses
  - 0.3% food industry

- Contracts 282
  - 7 supplies to district heating systems including Ferrara (HERA)
  - 6 supplies for greenhouses – 282,000sm
  - 4 supplies for food industry
  - 3 other industrial consumers
  - 275 minor contracts

- Source: Company information.
  - (1) As of 2014
Heat Business

Production wells

steam 200 - 220 °C

Water 40 °C

Reinjection well

water 30 °C

80%

20%

Heat Business

€ cent/Mcal

<table>
<thead>
<tr>
<th>Fuel</th>
<th>State Support</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPL</td>
<td>25</td>
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<tr>
<td>Methane</td>
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<tr>
<td>Diesel</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Agricultural Diesel</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Steam for Electricity</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Steam byproduct</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Heat Business: Greenhouses

Up today there are more than 280,000 sqm of greenhouses with 250 workers involved. Production characterized by the necessity to have constant high temperature during the entire year.
- Many types of flowers
- Basil
- etc.

40% of the heat is delivered to Greenhouses
Heat business: food

Most of our customers are part of associations like “SlowFood” and “Comunità del Cibo”

Geothermal as the driver for adding value to traditional and high quality food productions

1% of the total heat is used in cheese and salami production activities
1% of the total heat is used in cheese and salami production activities.

Heat business: food
The potential development of new activities in the food and agriculture fields, using geothermal, is still high in Italy, especially in Tuscany.

**Opportunities**

- Good resource availability
- Incentives
- EGP – Regione Toscana agreement on supply of heat to support new start-ups and local economy
- Availability of financing for start-ups located on geothermal territory

**Barriers**

- Locations quite far from main roads
- Lack of knowledge about the real opportunities

---

**Future Development**

**General Market for Food**

- Costs for Greenhouse near main communication roads
  - Thermal Energy = 22%
  - Transportation = 12%

**Costs for Greenhouse at Radicondoli**

- Thermal Energy = 7%
- Transportation = 20%

**Geothermal savings 34%-27%=7%**
How to Incentivate Development

Enel Green Power efforts

- Enel green Power, together with local communities that host geothermal power plants, is strongly committed to support start-ups supplying heat for their production process
- Geothermal district heating is an important element to mitigate logistical difficulties
- The opportunity to operate directly next to geothermal power plants makes access to the heat easier and cheaper than in other locations
- Lower cost of electricity inside “geothermal area”

What’s missing?

- More information about opportunities offered by the geothermal
- A systematic research focus on discovering activities/productions could maximize the benefits that geothermal can bring

Thanks for your kind attention
Session IV Innovative Applications of Geothermal Direct Use worldwide

USA- Arlene Anderson (US Department of Energy, USA)

Title: Systems Analysis and Low Temperature Program Overview.


Presentation was held by Mr. Brian Carey

Abstract

The mission of the Geothermal Technologies Program is to accelerate the deployment of domestic energy generation from geothermal resources by investing in transformative research, development, analysis and demonstration-scale projects that will catalyse commercial adoption. Successful efforts will promote a stronger, more productive economy; provide valuable, stable, and secure renewable energy to power the U.S.; and support a cleaner environment.

Back to the program ↑
Introduce you to

- Geothermal Technologies Office – GTO
  - Goals and Objectives
- Technology Road Map
- Systems Analysis and Low Temperature Program - SALT
  - Barriers to low temperature uptake
  - Research into additional value streams
- Direct use Workshop – Pittsburgh – August 2015
  - Key Messages
- National Geothermal Data System - NGDS
The mission of the Geothermal Technologies Program is to accelerate the deployment of domestic energy generation from geothermal resources by investing in transformative research, development, analysis and demonstration-scale projects that will catalyze commercial adoption. Successful efforts will promote a stronger, more productive economy; provide valuable, stable, and secure renewable energy to power the U.S.; and support a cleaner environment.

**Supported Administration Goals**
- By 2035, generate 80% of electricity from a diverse set of clean energy resources
- Reduce GHG emissions by 17% by 2020 and 83% by 2050 from 2005 baseline

**GTO Program Goals and Objectives**

<table>
<thead>
<tr>
<th>GTO Goals</th>
<th>GTO Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Develop advanced remote resource characterization tools to identify geothermal opportunities without surface expression</td>
<td>• Demonstrate the capability to create and sustain a greenfield 5 MW Enhanced Geothermal Systems reservoir by 2020.</td>
</tr>
<tr>
<td>• Purposeful control of subsurface fracturing and flow</td>
<td>• Reduce the LCOE of undiscovered hydrothermal to $.10/kWh by 2020</td>
</tr>
<tr>
<td>• Improve and lower $/MW subsurface access technologies</td>
<td>• Lower the levelized cost of electricity from newly developed geothermal systems to $0.06/kWh by 2030.</td>
</tr>
<tr>
<td>• Develop mineral recovery and hybrid systems to provide second stream of value</td>
<td>• Achieve $1.70-$2.60/m³ for desalinated water from geothermal by 2018.</td>
</tr>
</tbody>
</table>

**2016 Vision Study Activities:**
- DOE will develop credible analysis jointly with the geothermal community that:
  - Articulates clear strategies across different sectors and has a cohesive plan to attain the goals
  - Discusses geothermal growth scenarios for 2020, 2030 and 2050 backed by robust data, modeling and analysis
  - Addresses all market segments: existing and potential hydrothermal, electrical and non-electrical usages, new EGS sector, and other value streams
  - Supported by objective and peer-reviewed industry data and available to decision-makers
  - Is aspirational and inspirational

**2017 Vision Study Activities:**
- Complete strategic planning based upon growth scenario modeling.
- Use completed analysis to feed into technology roadmaps that will cover all identified market segments.
- Utilize peer-reviewed data and analysis as the basis for developing various technology R&D pathways.
**LT Technology Roadmap**
*Pathways: Create, Innovate and Operate*

**CREATE**
- System for Geopressured power production
- Multiple-boiling cycle to improve plant performance
- Super-critical bottoming cycle
- Materials extraction with power production

**Metric:** Enable utilization of lower temperature resources

**INNOVATE**
- Supercritical cycles with mixed working fluids
- Variable phase turbine development
- Cascaded systems and coproduced
- Hybrid power generation systems

**Metric:** Enthalpy used for work per volume of fluid produced

**OPERATE**
- Scaling and corrosion inhibition technologies
- Enhanced air-cooled condenser performance
- Real-time remote monitoring and operation
- Large scale direct-use operations

**Metric:** Minimize O&M Costs

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**Systems Analysis and Low-Temperature Program**
*Adding Value - Materials Extraction, Direct Use, Hybrid Systems & Thermal Desalination*

- **Low-Temperature Mineral Extraction** - Resource assessment and feasibility (ongoing)
- **Large-scale Direct Use**: where does it make technical and commercial sense?
- Use geothermal hot fluids for heating and cooling
- Potential displacement of traditional baseload generation on site-by-site basis
- Targeted RD&D on innovative energy conversion, additional *revenue-stream creation* (e.g., hybrid systems & thermal desalination), and further development of power generation cycles
GTO Mineral Recovery Program’s Rationale

Benefits of Coupling mineral/material extraction methods with geothermal power:

- Rare Earth (REE) and Near Rare Earth Elements may be relatively prevalent in the brines
- Chemical elements are critical for domestic industries
- Geothermal fluid can contain minerals that are a major source of corrosion and scaling

Technology metals produced as byproducts of base metals.

This matrix was used in the “Critical Materials for Sustainable Energy Applications” report by the Resnick Institute in 2011. (Original source: Hageluken, C., and Meskers, C.E.M.: Complex Life Cycles of Precious and Special Metals)

Technology metals produced as byproducts of base metals.

Key Barriers to LT Expansion

<table>
<thead>
<tr>
<th>Technology Barriers</th>
<th>GTO-Funded Solution Set</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal</strong></td>
<td><strong>Leveraging O&amp;G infrastructure</strong></td>
</tr>
<tr>
<td><strong>Cooling Technologies</strong></td>
<td><strong>Innovative conversion cycles</strong></td>
</tr>
<tr>
<td>Air-cooled systems are constrained in hotter areas of the arid, but geothermally-concentrated Western U.S.</td>
<td><strong>Hybrid cooling cycles</strong></td>
</tr>
<tr>
<td><strong>Fluid Value</strong></td>
<td><strong>Materials Extraction</strong></td>
</tr>
<tr>
<td>Lower temperature fluids are inherently less valuable for power generation than hotter; additional uses/revenue sources are needed</td>
<td><strong>Advanced working fluids</strong></td>
</tr>
<tr>
<td><strong>Energy Conversion</strong></td>
<td><strong>Improved binary system components</strong></td>
</tr>
<tr>
<td>Improve efficiencies for lower temperatures, operation &amp; maintenance, cost</td>
<td><strong>Hydrogen Coproduction</strong></td>
</tr>
<tr>
<td><strong>Game-changers</strong></td>
<td></td>
</tr>
</tbody>
</table>
government/contractors

- Leverages DOE (NETL) 21st Century Infrastructure MOU with City of Pittsburgh by exposing energy and green buildings stakeholders to the potential for Geothermal Direct Use in key MOU localities within the Appalachian Basin

- City of Pittsburgh, Chief Resilience Officer presented emerging opportunities to develop district energy in cities like Pittsburgh that are experiencing growth and re-development.

- Icelandic consultant discussed geothermal district heating with an established geothermal resource, and provided insights into different heating and cooling needs and approaches that would be relevant to Pittsburgh.
Industry Engagement

- **NRG Energy District Energy** CEO and Plant Manager toured workshop participants through their Northside District Energy Plant discussing potential methods to integrate geothermal energy. Interested in EGS and cascaded Direct Use applications.

- **GRC** Executive Director and Incoming President attended interested in incorporating Direct Use and GSHP into membership base and working with International Ground Source Heat Pump members.

- **GEA** 2015 Update to include Direct Use – a first!

- **Frick Park Environmental Center**, through use of geothermal heating and cooling, slated to meet “Living Building Challenge” requiring stringent use of water and net zero energy

Potential Partnerships

- **WV National Guard** (Camp Dawson)
- City of Pittsburgh – 21st Century Infrastructure MOU
- UAE Sustainable Fish Production
- Bayer MaterialScience
- CMU Center for Building Performance
- Kasese Solar Power Ltd
- Thar Energy
- NETL, NREL, and ORNL resource assessment
- Pittsburgh Southpointe Chamber of Commerce (Exhibitor)

Map Courtesy of Marcellus Shale Chamber

Key Messages:

- Hot spots in NY, PA and WV can result in Deep Direct Use Applications. Cornell Case Study including EGS and Deep Direct Use of interest to others interested in pursuing sustainable development.

- Deep Direct Use applications lend themselves to large scale, commercially viable systems that optimize the value stream of lower temperature resources through a cascade of uses, from electricity generation to direct heating and cooling, industrial and commercial applications, and agricultural uses.

- District Heating Infrastructure in need of upgrading, opportunity to transition from natural gas to geothermal

- Documented audience opinions on potential impact for direct-use, technical challenges that require further research, and potential barriers for development, key information to present to Geothermal Vision Study Thermal Task Force.
DOE’s node on the National Geothermal Data System (NGDS) is the DOE Geothermal Data Repository (GDR)

Over 500 geothermal projects data submissions from over 60 DOE GTO funds

Over 1,000 direct downloads with more than 11,000 downloads from users discovering GDR data

“reduce the inherent risk in early stages of development and encourage an independent investment market” - Deloitte LLP, Geothermal Risk Mitigation Strategies (2008)
• To connect with Arlene Anderson

Arlene.Anderson@ee.doe.gov

Thank you
Asian region – Kasumi Yasukawa
(National Institute of Advanced Industrial Science and Technology (AIST), Japan)

Title: Innovative application Asia

Presenter: Ms. Kasumi Yasukawa is Principal Research Manager of Renewable Energy Research Center, AIST (National Institute of Advanced Industrial Science and Technology). Ever since joining to Geological Survey of Japan (GSJ: current AIST) in 1987, she has been working on geothermal studies. As a research associate in Lawrence Berkeley National Laboratory (USA), she combined a heat and mass flow simulation code with a geophysics (self-potential) code and got Master of Science in Mineral Engineering from University of California at Berkeley in 1993. Coming back to GSJ, she continued geothermal reservoir study and got Ph. D from Kyushu University in 2000. Then she has started hydrological study of non-geothermal areas for ground-source heat pump applications. She has been actively working with overseas institutes - USA, Italy, Indonesia, Korea, China, Thailand and Vietnam including field surveys - and served as a Board of Directors, International Geothermal Association from 2007-2013. She also served for environmental section (IPCC matters) of Ministry of Economy, Trade and Industry from 2009 to 2011.

Abstract

ERIA geothermal project focused on technical and social challenges for geothermal utilization (power generation, direct use, GSHP and EGS) in each member countries. Report shows common technical problems on sustainable use of geothermal energy and publish a guideline for these problems with analysed collection of case studies from member countries. As a result of ERIA Geothermal Project, following matters emphasized for sustainable use of GSHP systems. Investigation, evaluation, and monitoring in China. Importance of monitoring and its data analysis in Korea. Suitability mapping for both closed and open systems in Japan. Lastly, comparison of groundwater and atmospheric temperatures in Thailand and Vietnam. The report of the whole project will be posted on www.eria.org

Back to the program
Innovative Application of GSHP in the Asian Region
- Lessons learnt from ERIA geothermal project -

Kasumi Yasukawa, AIST
Yoonho Song, KIGAM

Contents

• Short introduction of ERIA Geothermal Project
• China: Investigation, evaluation, and monitoring
• Korea: Importance of monitoring and its data analysis
• Japan: Suitability mapping for both closed & open systems
• Thailand and Vietnam: Comparison of groundwater and atmospheric temperatures
Short introduction of ERIA

History of Economic Research Institute for ASEAN and East Asia (ERIA)

- 2006/04 Global Economic Strategy was announced.
- 2006/08 Japan proposed the establishment of ERIA at the 13th ASEAN-Japan Economic Ministers Meeting on August 23.
- 2008/06 The inaugural ERIA Governor Board Meeting was held at the ASEAN Secretariat in Jakarta. The full-scale research activity was started.
- 2008/09 Opening ceremony of ERIA was held in Jakarta.

ERIA organization

ERIA Geothermal Project (September 2013- June 2015)

“Sustainability Assessment of Utilizing Conventional and New-Type Geothermal Resources in East Asia”

Project Results

In FY2013, technical and social challenges for geothermal utilization (power generation, direct use, GSHP and EGS) in each member countries are summarized. In FY2014, common technical problems on sustainable use of geothermal energy are picked up and a guideline for these problems was made by analyzing collection of case studies from member countries.
China: Investigation, evaluation, and monitoring

The national project of investigation and evaluation of shallow geothermal energy has shown great potential. It provides heat capacity for GSHP use. The total potential is equivalent to 9.486 billion tons of standard coal (Wang, et al., 2013).

Data source: Geothermal Council of China Energy Society (GCES), Ministry of Housing and Urban-Rural Development (MHURD)

Map Showing Shallow Geothermal Energy Conditions in Beijing
Concerning the balance of heating and cooling, long-term monitoring has been conducted in typical projects for more than 10 years. Long-term monitoring of ground temperature and HP system has shown positive results for 20 or more projects in Beijing. (see next slide)

**Lessons learned**

- Mapping shallow geothermal energy conditions, such as water type and soil type, is important to perform proper design of GSHP systems.
- Monitoring of ground temperature is important to monitor thermal recovery of the ground and to assure the balance of heating and cooling.
The government building complex of Sejong Metropolitan City

- The total building area: 607,555 m².
- Total GSHP installed capacity >20 MWt, covering 38% or more heating and cooling load.
- 70% of heat is from borehole heat exchangers (BHEs) through 1,190 boreholes of 200 m deep (total length of holes: 238 km).
- 30% of heat is from ground water wells of around 400 m deep.
- Zone 1 of the building complex started operation in 2012, Zone 2 in 2013, and Zone 3 was completed in 2014.
- GSHP for other public buildings including City Hall and the Educational District Buildings are continuously being installed.

Bird's-eye View of Zones 1 and 2 of the Government Building Complex, Sejong Metropolitan City

Monitoring

The GSHP system in Sejong City is readily equipped with automated monitoring systems and the monitored data are automatically collected at each site.

But there is no systematic regulation or organisation for checking and analysing the monitoring data. It is very important not only to monitor the geothermal system, but to analyse the data.

Regulations or organisations are needed for making advice on the sustainable use of GSHP systems based on the analysis of results.
Long-term temperature monitoring in Earthquake Research Center, KIGAM

- A long-term monitoring case of ground temperature variation according to GSHP operation can be found at the Earthquake Research Center (ERC) building in KIGAM.
- The building is three storeys high with an area of 700–900 m² each, 2,435.4 m² in total, constructed in 2005.
- The heating and cooling load is 400 kW.
- 28 boreholes with a diameter of 165 mm, a depth of 200 m, and 7 m apart were drilled to be installed with double U-tube type borehole heat exchangers (BHE).

The monitoring of the inlet/outlet flow rate and temperature of the BHEs had been performed for about 3.5 years after the installation. Among 28 BHEs, in addition, fibre optic cables were attached to the outside of U-tubes of two BHEs to monitor the temperature variation with depth.
Korea: Importance of monitoring and its data analysis

Long-term temperature monitoring in Earthquake Research Center, KIGAM

The subsurface temperature beneath the borehole field was getting higher with the GSHP operations and we can see 0.5–1°C of temperature increase per year at 100 m depth. The increase of subsurface temperature was caused by unbalanced seasonal variation of load (cooling load is bigger than heating in the building), which may lead to performance degradation as GSHP operation continues year after year. This result is a good example showing that accurate monitoring of the subsurface is important for sustainable use of geothermal energy in heating and cooling applications.

- Comparison of Temperature Variations at 100 metre Depth between the Winter Seasons of 2006–2007 and 2008–2009

Problem

In South Korea, by law, all GSHP systems are subject to be monitored in terms of inlet and outlet temperature and flow rates during operation. All these data are collected by the authorised ministry. However, no analysis has been made for these data so that the actual coefficient of performance (COP) has not been calculated, although the COP is the key to understand the effectiveness of GSHP in terms of saving energy, heat extraction, and sustainability.

Lessons learned

- For long-term sustainability, monitoring of the system is important. The monitoring is mandated by law in case of South Korea, but the problem is that the monitoring data has not been properly analysed in many cases.
- Ideally, the subsurface temperature down to the depth of subsurface heat exchanger will be monitored.
- The flow rate and temperature of the primary and secondary fluids and electricity consumption of the heat pump and circulation pump should be monitored to calculate actual COP and long-term performance including extracted heat, amongst others.
In sedimentary basins and plains in monsoon Asia, sustainable heat exchange rate and preferred drilling depth of a closed loop system varies with local hydrogeological settings due to the variation of effective heat conductivity caused by groundwater flow. Therefore, suitability mapping for closed loop system is important in such regions.

Suitability index parameters for closed loop system:
- Effective heat conductivity (or equivalent overlaid parameters: see the following page)

Suitability index parameters for open loop system:
- Economical availability (accessibility) of aquifer
- Injectivity of the aquifer
- Productivity of the aquifer

The objective of this study is to assess the installation suitability of a closed-loop GSHP system by developing ‘suitability’ maps. The term suitability is mainly related to heat exchange with the subsurface, which depends on geology, groundwater flow system, and subsurface temperature distribution. Hence, suitability assessment should be done based on hydrogeological and thermal information.

<table>
<thead>
<tr>
<th>Quaternary System</th>
<th>Tertiary System</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Neogene</td>
</tr>
<tr>
<td>Hydraulic Conductivity (m/s)</td>
<td>$5 \times 10^{-5}$</td>
</tr>
<tr>
<td>Porosity (-)</td>
<td>0.4</td>
</tr>
<tr>
<td>Heat Capacity (J/m³K)</td>
<td>$2.6 \times 10^6$</td>
</tr>
<tr>
<td>Thermal Conductivity (W/mK)</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Regional scale analysis model and its input parameters (Shrestha, et al., 2015).
Suitability map for closed-loop GSHP system; development of suitability map for installation of GSHP system in the Tsugaru Plain

Normally simulation results of the regional model is compared with observed temperature profiles in observation wells. But since there is no observation wells in this plain, results of TRT at several sites are compared with calculation results of single GHE model using boundary conditions obtained by regional model. Thus the model parameters are adjusted.

Then “Thematic Maps,” to be overlaid into a suitability map, are made using simulation results of regional model.
Suitability map for closed-loop GSHP system; development of suitability map for installation of GSHP system in the Tsugaru Plain

Then “Thematic Maps” are reclassified to be overlaid into a suitability map.

<table>
<thead>
<tr>
<th>Groundwater velocity Index class (x10^{-3})m/day</th>
<th>Sand-gravel ratio Index class (%)</th>
<th>Water table depth from surface Index class (m)</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>&lt;10</td>
<td>50 &lt;</td>
<td>1</td>
</tr>
<tr>
<td>1 – 2</td>
<td>10 – 15</td>
<td>40 - 50</td>
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<tr>
<td>2 – 4</td>
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<tr>
<td>100 &lt;</td>
<td>80 &lt;</td>
<td>&lt; 1</td>
<td>10</td>
</tr>
</tbody>
</table>

Reclassification of Thematic Maps (Shrestha, et al., 2015).

For the case of heating purpose only, Subsurface temperature is also overlaid.

Weighted Overlay Model for Space Heating and Cooling (Shrestha, et al., 2015).
Lessons learned

- For sustainable use of GSHP systems, system design suitable for the subsurface condition of the location as well as GSHP application purpose is needed.
- Heat exchange rate and preferred drilling depth of a GSHP system varies with local subsurface conditions.
- In this context, a hydrogeological survey is very important for places in sedimentary basins and plains, while only rock properties are important for places with near surface hard rocks.
- To compile suitability maps of GSHP systems for sedimentary regions, groundwater and geological surveys are needed to perform numerical simulations on groundwater flow and local heat exchange rate.
- The design of a GSHP system can be improved by utilising the suitability map, such that high system performance and cost reduction may be achieved.

Lessons learned (continued)

- A suitability map can be made in the following order of procedures:
  1. Groundwater and geological survey
  2. Regional groundwater flow simulation
  3. Heat exchange simulation of the site
  4. Making suitability map
     - Weighted overlay method may be used for making suitability map.
     - For closed-loop system, groundwater velocity, sand-gravel ratio, and water table are used. For open-loop system, horizontal and vertical groundwater flow rate and permeability of geological layers are used.
     - Space heating suitability map needs subsurface temperature data additionally.

  Choice of overlaid parameters and their weight
Is GSHP applicable everywhere? Not really in tropics…

Can we use GSHP System in tropics?

- In East-Asia, where significant economical growth in this century is expected, energy saving and environmental protection are major matters of importance.
- Promotion of GSHP may contribute to energy (electricity) savings and protection of the environment.
- However, in tropics where space-cooling is needed, subsurface temperature is generally higher throughout a year and the underground is not suitable for heat exchange.
- Nevertheless in tropical regions, underground may be used as a cold source, if there exist seasonal and areal variation in atmospheric temperature, and subsurface temperature is rather low.
**Shallow subsurface temperature affected by groundwater flow**

- At recharge zones (high elevation), shallow temperature is lower, while it is higher at discharge zones
- At recharge zones, underground may be used as cold source in tropics

**Subsurface temperature profile with groundwater flow**

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**Thailand: Comparison of groundwater and atmosphere**

**Temperature measurements in Thailand**

**DGR: Department of Groundwater Resources of Thailand**
Thailand: Comparison of groundwater and atmosphere

Subsurface Temperature Profiles

Geological Survey of Japan

Comparison between subsurface and atmospheric temperature

Geological Survey of Japan

(Yasukawa et al., 2009)
Temperature measurements in the Red River Plain (Hanoi region)

Comparison between subsurface and atmospheric temperature in Hanoi

(Yasukawa et al., 2009)
Comparison of Atmospheric and Groundwater Temperatures

Ho Chi Minh area

In this case, groundwater temperatures are observed at 1m below the water level. Temperature profiles of the wells are not obtained in this region.

Ca Mau Area

Edited by ERIA project authors
Lessons learned and recommendation

- For GSHP application in tropical regions where only space cooling is needed, the underground temperature should be measured first to ensure the applicability of the GSHP system.

- If the underground temperature is lower than the atmosphere at least in daytime, GSHP may be effective. Thus temperature survey results shows the applicability of a GSHP system in many cities in Thailand and Vietnam.

- The observation wells can be used to evaluate the subsurface temperatures so that the possibility of GSHP may be evaluated.

- To extract the suitable areas for GSHP systems, more detailed investigations including suitability mapping based on hydrogeological data should be conducted.

- As for areas where the GSHP can be applied, a pilot system installation and operation including subsurface temperature monitoring is recommended before distribution of the systems.

Conclusions

- As a result of ERIA Geothermal Project, following matters are emphasized for sustainable use of GSHP systems:
  - Investigation, evaluation, and monitoring (China)
  - Importance of monitoring and its data analysis (Korea)
  - Suitability mapping for both closed & open systems (Japan)
  - Comparison of groundwater and atmospheric temperatures: Thailand and Vietnam

- The report of the whole project will be posted on: http://www.eria.org
New Zealand and Australia – Brian Carey (GNS, New Zealand)

Title: Innovative applications in New Zealand and Australia

Presenter: Brian Carey (BE, ME) has over 25 years’ involvement in geothermal energy developments at a commercial and project level. Prior to joining GNS Science as the Geothermal Manager in 2007, he was the geothermal resource manager at Contact Energy’s Wairakei Power Station. This work has included an environmental planning focus over the last 20 years, most recently working on the resource consenting for Wairakei Power Station, and coordinating the technical input, science and engineering for field development programmes. He has a strong, established network of geothermal contacts both in New Zealand and overseas, supported by membership of a number of professional organisations, including IPENZ and the NZ Geothermal Association. Brian’s professional interests include geothermal resource utilisation specialising in reservoir utilisation, steam field engineering, steam field energy management, electric power generation and environmental planning.
New Zealand and Australia

Brian Carey
New Concepts Workshop
Penthes Geneva
30th October 2015

Where are Australia and New Zealand?

• Giant Jump
Quite Different

- **New Zealand**
  - High temperature geothermal resources
  - Amongst the world leaders
  - Much more opportunity
    - Direct Use
    - Lower temperature use

- **Australia**
  - Create higher temperature reservoirs
  - Sedimentary aquifers
  - Using lower temperature
  - More can be done
Australia

- Australian Renewable Energy Agency (ARENA)
- Expert group commissioned 2014
  - Options to realise the potential of geothermal
- Time frame
  - Over coming decades

Expert Report

- Structured approach

# Readiness Matrix

5.2.1 Commercial Readiness Index – Shallow Direct Use (Type A)

<table>
<thead>
<tr>
<th>INDICATORS</th>
<th>Bankable Grade asset Data</th>
<th>Market competition driving widespread deployment</th>
<th>Multiple commercial applications</th>
<th>Commercial scale-up</th>
<th>Commercial trial</th>
<th>Hypothetical commercial proposition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

# Report

- **Findings**
  - Shallow – ready
  - Deep natural – commercial trial / hypothetical
  - EGS – hypothetical / commercial trial
- **Roadmap**
  - for developing the potential of geothermal energy in Australia
  - 2030 and beyond
Roadmap

- Data collection
- International collaboration
- Collaboration with the oil and gas sector

Australian Innovation

- Geothermal for heating and cooling in Victoria
- Melbourne University
- Professor Ian Johnston and Guillermo Narsilio
New Zealand

- Direct geothermal use is well established
- Raising Awareness
- Being purposeful to develop further

Kawerau

- Largest direct geothermal use site in world
- Timber, pulp, paper, tissue processing
- > 4 PJ per annum
Innovative

- Clean Steam from Geothermal Steam

Clean Steam Plant Kawerau
Integrating Geothermal Activities

- Tuaropaki at Mokai
- Farms
- Power Plant
  - 110 MWe
- Green houses
- Milk Processing facility
- Worm farm

www.tuaropaki.com

Geothermal Heat Pumps

- New Zealand is a technology adopter
- Unaware
- Raising Awareness
  - Heat Pump Association
Geothermal Heat Pumps in Christchurch

- Post 2011 earthquake
- City energy nodes being established

Christchurch Central City GHP Locations

At least 10 systems
Direct Geothermal Case studies

Tenon’s Earth Energy Solution

- Reduced energy costs
- Increased productivity
- Improved safety
- Easy to operate

Key Benefits:

Geothermal Energy Helps to Grow Prawns

- Easy to manage
- Good for prawn quality
- Much better than traditional methods
- Good for prawn quality

Key Benefits:

Geothermal Hot House for Gerberas

- For reliable growth - predicts, Hostel and Clinical Foundation of Wellington, making use of the earth’s energy. The energy is key to offering the best in winter conditions.

Key Benefits:

www.gns.cri.nz/Home/Learning/Science-Topics/Earth-Energy/Case-Studies

Direct Use - GeoHeat Strategy

Increased Use of Geothermal Resources

- Market
- Technology
- Policy
- Geothermal Resource inc.
- Funding
- Awareness
- Expertise

champions

Coordination

kaitiaki
Direct Use Strategy

- Sponsor - New Zealand Geothermal Association
  - Overarching National Strategy
  - Developed consultatively
  - 25 year plus horizon
  - Draft expected to be released end Qtr 1 2016

- Being purposeful
  Growing Direct Geothermal

Kia Ora
Geothermal / GSHP systems for heating and cooling in Victoria

Ian Johnston & Guillermo Narsilio
Summary – Geothermal Heat Pumps

- Establishing the technology in Victoria
- Showing Casing
- Detailed Performance Monitoring of the Ground Heat Exchangers
- Analysis and modeling
  - Using the data to calibrate mathematical models
  - Reduce cost of GHE’s
- Team of ten researchers at University of Melbourne
- Well connected with the industry

Heating and cooling buildings
Full Scale Pilot Projects

- Borehole heat exchangers at University and elsewhere
- Horizontal heat exchangers – other locations in Victoria

Energy Pilot Demonstration Program – Government support

- Elizabeth Blackburn School of Sciences at University
- 20 to 40 residential-equivalent buildings

Detailed 3D Numerical Models
Instrumented Geothermal Heat Pump Systems

Around Melbourne ≈ 25 systems in place

Ground temperature below 10 m typically 18 °C

Far field temperature with depth at UoM
Main Ridge – Mornington Peninsula

Heating load = 70 kW
Temp probes (172)

Header pipes

2m

22m

0.5·D_{\text{turn}} pitch

1.0·D_{\text{turn}} pitch

44m

25m
Energy Piles - Beaurepaire Sports Centre Facility

30m Energy Piles

Numerical Model Validation

Data from: Colls, S., Johnston, I., and Narsilio, G., 2015(?), “Observations from an experimental ground-source heat pump system”, Geothermics (Under review).

![Graph showing average fluid temperature over time compared to numerical and experimental data. The graph includes a legend indicating "Numerical (UoA model)" and "Experimental (Data from GHE)". The graph also shows the total power output.]

GHE, 125 mm Ø
Pipe, 20 mm Ø
Borefield with 4 GHEs x 50m

Numerical Models

\[ T_{z=0} = T(t,0) \]

Flow rate = 6.9 L/min

\[ T_{\text{farfield}} = T(t,z) \]

Pipe, 20 mm Ø

\[ \text{L}_{\text{GHE}} = 30 \text{ m} \]

Material | \( k_m \) (W/mK) | \( c_m \) (J/kgK) | \( \rho_m \) (kg/m³) | Diameter (m) | Spacing (m) | Wall thickness (mm)
---|---|---|---|---|---|---
Soil | 2.7 | 850 | 2,350 | - | - | -
Pile (3 loops) | 2.5 | 1,190 | 2,100 | 0.6 | - | -
Pipe | 0.4 | - | 0.02 (d) | 0.105-0.23 | 1.84 | -
Carrier fluid | 0.582 | 4,180 | 1,000 | - | - | -

Inlet Outlet

GHE, 600 mm Ø

GHE, 300 mm Ø

Pipe, 25 mm Ø

Numerical Model Validation – 30m Pile Cage

\[ q = \text{f}(t) \]

12 L/min

GHE 1

50m

Ground
Quantifying Surface Thermal Recharge

\[ T_{\text{farfield}} = 18.4 \degree C \]

Under a building

NO STR

47 m

Open Space

STR

Surface Thermal Recharge = GHE cost savings

Keep a watch on the UoM work

10 Students written output will come

Theses are public

Two theses completed

Stuart Colls

Ground Heat Exchanger Design for Direct Geothermal Systems

Asal Bidarmaghz

 Numerical Modelling

Papers are being produced
Visionary Panel Discussion, Conclusions and Next Steps

Iceland, Startup Energy Reykjavik - Alicja Wiktoria Stoklosa (GEORG)

Title: Business Success Story?

Presenter: Alicja Wiktoria Stoklosa is working for Orkustofnun National Energy Authority and GEORG Geothermal Research Group in Iceland. Past five years she has been involved in innovation and entrepreneurship development projects where she gained interested and experience in startup communities within renewable energy ideas. Her work interest relates to the new concept of financial possibilities in accelerating the geothermal energy technology projects.

Abstract

Startup Energy Reykjavik is a mentorship-driven seed stage investment program with focus on energy related business projects. Startup Energy Reykjavik was founded by Landsvirkjun, Arion Bank, GEORG and Innovation Center Iceland in December 2013. The program is facilitated by Icelandic Startups and Iceland Geothermal. SER run a 10-week long program in Reykjavik, Iceland once each year and select the energy business ideas. Nominated companies or ideas get USD 40,000 in seed funding. Startup Energy Reykjavik participants also get great place to work, ten weeks of intensive top-notch mentorship, and the chance to pitch to angel investors and venture capitalists at the end of the program. There is immeasurable value in the mentorship-driven connections and advice that attendees receive with Startup Energy Reykjavik. The opportunity to pitch to angel investors and venture capitalists at the end of the program is provided during Investor and Demo Day.

Back to the program 🔼
Business Success Story?

Outline

- Startup Energy Story
  - Idea
  - Concept
  - Program

- Startup Energy Companies
  - Ideas
  - Work
  - Achievements
  - Fears
  - Benefits

- Startup Energy Innovation
How the idea began?

Startup Energy Reykjavik Concept

- Open to any energy startup ideas
- 10 weeks mentorship & coaching
- Network
- Community
- 60+ Mentors availability
- Workspace
- Powerful investors
- Pitching to angel investors and venture capitalists
- $ 40,000 seed funding

**IN RETURN**
10% equity to SER
How we make it happen?

Begin cooperation between

Icelandic Geothermal Research Group

Iceland's largest Power Company

Iceland's largest Bank

Icelandic Innovation Center

Facilitators: non-profit organizations

How we make it happen?

Creating

The holding company

Startup Energy Reykjavik

Investing

In new innovative ideas

Proceeding

With mentorship and funding
Stages

FORMING COMPANY

PROTOTYPE

RESEARCH PROJECT

IDEA

What do we look at?

- Does the product/service have the chance to compete on an international level?
- Is the business model scalable?
- Is the business idea within the energy sector or related industries?
- How well does the product/service serve the needs or solve a problem for a selected target group?
How we make it happen?

The year of Startup Energy Reykjavik

Month 1
1. Open for applications

Month 2
1. Close for applications
2. Choosing TOP finalists
3. Presentation of top teams
4. Feedback from Mentors

Month 3
1. Kick off meeting 7 winning teams
2. Program starts 10 weeks

Month 5
1. Investor Day

How we make it happen?

The program gives opportunity:

- Mentor meetings
- Management meetings
- Feedback
- Company presentation
- Networking and meet-up
- Investments
- Guest lectures
- Pitch practice
Geo Tech Companies

1. Gerosion - Casing materials for super-critical conditions in geothermal industry
   http://gerosion.com/
2. Landsværmir - Consultation in finance, sets up and operation of heat pumps for central heating of houses
3. GeoDrone - Drones (UAVs) and remote sensing technology for geothermal industry
   www.geodrone.is
4. Eta Nytnir - Small scale Sodium Chlorate production for export and more efficient use of energy.

14 startups

7 Teams per Batch

7 Geothermal base ideas

18 Geo Entrepreneurs

Startups

1. Loki Geothermal - Expanding gate valves for super-critical conditions in geothermal
   www.lkkageothermal.is
2. XRG Power - Electricity generator from non-boiling geothermal water
   www.xrg.com
3. Keynatura - Production of food, nutraceutical & pharmaceutical products from algae using Icelandic energy.
   www.keynatura.is
What do we look for

- Energy and Technology
- International possibilities
- Scalability
- Building knowledge & Business

Contact

Visit the website for information
www.startupenergyreykjavik.com

facebook.com/StartupEnergyReykjavik
Visit the website for latest news

www.startupenergyreykjavik.com
Conclusions and Next Steps - Paul Ramsak (RVO), Hjalti Pall Ingolfsson (OS) & Brian Carey (GNS)

Paul Ramsak and Hjalti Páll Ingólfsson concluded the presentation sessions with an inspiring talk about the next steps of Geothermal ERA NET cooperation and through ERA NET Co-fund action called Geothermica, before moving to the closing, we had a discussion on the innovative thinking on the Future of Geothermal, which participants worked during the workshop.

Results of thoughts on the Future of Geothermal can be visible in Appendix II

Back to the program
Geothermal ERA-NET / IEA Geothermal

Geothermal ERA NET - New Concepts
Summary and Follow up

The window of opportunity is up on us...

Geothermal competitiveness

Emphasis on Energy Security

Paris Climate Change Conference
Creating a European research & innovation framework

- organize and pool national financial and human resources as well as national research infrastructures, to accelerate research and innovation.

- Building on relationships with industry and researchers and bridge the gap between research and the market with innovative solutions.

- Focus on what is often called “deep” geothermal energy. The scope includes the integration of geothermal reservoirs into novel energy system concepts (e.g. use of reservoirs for energy storage, CO2 storage, integration with near-surface geothermal applications).
To be good at football you need a lot of practice from young age

Iceland vs the Netherlands

Iceland won both matches
Iceland vs the Netherlands

What is the reason for this?

But the main reason!!

Geothermal – of course !!!

Geothermally heated outdoor and indoor football fields are the key to success
Appendix IV Meeting Minutes


Welcome

On behalf of the organisers, Paul Ramsak (RVO), Katherina Link (Dr Roland Wyss GmbH), Gunter Siddiqi (SFOE) and Brian Carey (GNS Science) welcomed everybody to the meeting. The work of IEA Geothermal and Annex VIII on direct use, and the background of the workshop were briefly explained by Brian Carey. After that, Paul Ramsak explained the work of Geothermal ERANET and the aims for the workshop. It is about bringing together new ideas, inspiring each other with what is happening in geothermal throughout the world.

And as it is a workshop, there was a challenging task for all participants: drawing the future of geothermal, with the famous “vaxlitir” of the 100 year old Geneva-based firm “Caran d’Ache”.

Paul then introduced the moderator of the day, Þóra Þorgeirsdottir, living in Switzerland but with Icelandic and also geothermal roots.

Session I: EGS projects + direct use applications

Peter Meier presented “EGS Projects of the Geo-Energie Suisse AG – the new concept”. The company is founded by 7 power providers with the aim of realising geothermal electricity generation in Switzerland. The company is looking for low-risk areas, and aims for small stimulated areas, as this most probably limits induced seismicity. The plans are now for a horizontal borehole with multiple stages, in project site Haute Sorne (Jura). Permits are in place, current planning is drilling in 2017/18.

Lászlo Adám of Mannvit presented the “South Hungarian EGS demonstration project”. This project was awarded NER 300 in December 2012. Besides administrative issues the project has looked into a suitable location and drilling methods. Alta Rocks TZIM technology is in focus. The project location will be full South-east Hungary; the project is now in the process of securing the land.

Martino Lacirignola of ADEME presented “ECOGI – an EGS project for the industry in the Upper Rhine Graben”. This project that is in operation, supplies heat from Rittershofen to a starch processing industry. With 24 MWth, geothermal energy supplies about 25% of the total heat demand. There is 15 km transport pipeline. Induced seismicity is very intensively monitored.

During the discussion, Roy Baria of EGS Energy commented that he is sceptical about multiple stage stimulation. His experience is that in the end “one crack takes it all”. He complimented the work done in Rittershofen; especially how the experiences from (nearby) Soultz have really been used to advantage. Others commented that it is great that an industrial user has taken the initiative here. Then, a brief discussion on guarantee schemes evolved. A question to Peter, which packers he is planning to use? - There are many on the market, swelling packers might be selected, and “cement and shoot
through” is considered a last resort. How about the traffic light approach for induced seismicity? Comment from Peter: we used it in our risk studies.

**Session II: Direct use applications (new concepts – built environment)**

The “Resource Park Reykjanes” was presented by Kristin Vala Matthiasdóttir. The philosophy of HS ORKA is to create a society without waste – instead of focusing on electricity only, the company recognises 7 resource streams, and is looking for more. As examples, warm seawater from cooling is used for fish farming; steam goes to fish drying companies; and CO2 to renewable methanol and algae.

Matthias Kolb presented “Smart thermal grids”, in particular in Zürich, Switzerland. Utilising waste heat from industry – data centre cooling - to domestic heating, or waste heat from summer for heating in winter. Through thermal storage with earth probes, and heat pumps. The distribution temperatures in their networks are about 20-30°C.

Christian Hecht then showed the ambitions of München and Stadtwerke München, for “Münich 2040”. The city should operate on renewables, and for heating this means geothermal. München has district heating networks at three temperature levels. Changes to the old steam DH network will be necessary. There will be a 2D and 3D seismic campaign to better characterise the area. Drilling is already ongoing, as the next step in the right direction (Freiham, München).

René Verhoeven and Herman Eijdems presented “Minewater Heerlen – development of carbon neutral areas with thermal smart grids and geothermal”. They described the improvements to system control, from “Minewater 1.0” to “Minewater 3.0”. And the potential of seasonal (heat) storage.

The discussion first zoomed in on the resource park. The interdependency is high; how do they handle that? The system has been designed to address this issue. For example, the fish farm has a two-hour operating buffer. Kristin also mentioned that there will be a field trip to the resource park at the Conference next year. Then the discussion considered district heating in about 30-50 years. What will be the heat demand, will waste incineration still play a role then, what is the certainty that heat sources in the systems will still be there? Advanced thermal grids, multiple-source, multiple sink can be considered a risk mitigation in themselves.

**Session III: Direct use applications (new concepts – other sectors)**

Adele Manzella reported on the VIGOR project, aiming to explore viable business cases for Southern Italy, solving local problems and creating jobs. Sludge drying with geothermal heat is an option. A process configuration with venting the warm air instead of recirculation is more cost effective. The idea is, that VIGOR makes the region ready for geothermal projects – a new round of operational funds is upcoming.

Henk de Beyer introduced a different perspective. He took the meeting into a discussion of the growing need for cooling; better insulation and increasing temperatures challenge the profitability of district heating. A growing number of European cities supplies district cooling. De Beyer developed the SOLABCOOL, which is modular (5 kW) and adapted to low temperature heat sources.
Philip Klingler presented the district heating system of the city of Oftringen. This is a system with seasonal storage – the hot well is charged during summer with heat from the waste incinerator. There will be a hot (between 60-90°C) and a cold well – the flow direction is reversed depending on the operating mode.

As the last speaker in the session, Ruggero Bertani made an inspiring presentation of the various uses of geothermal energy in Tuscany, for example in greenhouses and in food production. When it concerns waste heat from power plants, very small-scale applications such as a single cheese-making farm can successfully be supplied with geothermal heat.

The discussion considered the matching of resource and demand – geothermal is everywhere, but not in equal qualities; one could turn it around and locate heat-intensive industry where there is the resource. How about bringing tourists in Tuscany to those nice locations with flowers and great Italian food, and a Laguna Azura?

**Session IV: Innovative Applications of Geothermal Direct Use Worldwide**

Brian Carey presented the contribution of Arlene Anderson, in the absence of an internet connection to Arlene herself. Her presentation showed highlights of the development going on in the USA, both on low temperature applications (SALT – system analysis low temperature), but also about EGS systems.

Kasumi Yasukawa presented the ERIA project, on geothermal heating and cooling in Asia. China has become number 2 in the world for GSHPs; Korea boasts large (> 20 MW) district heating systems; for Japan, subsurface suitability is mapped – but in the tropical regions in Asia, for example Thailand, there is only a cooling demand. One should be looking for cool ground. In many areas, indeed the daily average temperature of the ground is lower than that of the air. This offers opportunities.

Brian Carey then presented highlights from New Zealand and Australia. New Zealand has high temperature geothermal resources, and Australia does not. Brian presented ongoing work, existing and new projects, and nearly-forgotten technologies to produce clean steam from geothermal.

The discussion very much went into cooling and balancing. A balanced system is desirable and easier operable. Another aspect is that cities become hotter because of air conditioning. So bring out the air conditioning and distribute the cool water. Absorption cooling can operate on heat instead of electricity. Also hot water supply can balance heating and cooling demand.

**Visionary panel discussion**

Alicja Wiktoria Stoklosa kicked of the visionary panel discussion, by showing how “Startup Energy Reykjavik” inspires young entrepreneurs to develop their businesses. And many of their ideas are related to geothermal.

So, how did the participants see the future of geothermal? Their drawn visions showed amongst others heat transport by chemicals; and simple, easy to use, away-from-tailor-made systems. Also, the visions showed a bright and loving future, with geothermal families, the warm heart of mother earth, and peace to the world from using indigenous resources.
The organisers/Paul Ramsak and Brian Carey wrapped up the meeting and thanked everybody for their input. Integration, use of indigenous resources, job creation, an open mind and a broad approach, those are some keywords that will help us realise that bright future.