



## **ACKNOWLEDGEMENTS**

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M. Mongillo and  
L. Rybach
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of Iceland (Orkustofnun)  
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## CONTENTS

- IEA and IEA-GIA
- Sustainable geothermal utilization
- Annex I sustainability work
- Taupo 2008 Workshop
- *Geothermics* Special Issue
- Conclusions



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## INTERNATIONAL ENERGY AGENCY (IEA)

- ❑ An intergovernmental organization founded in 1974 (after first oil crisis)
- ❑ Energy policy advisor to the 28 member countries
- ❑ Network of 41 **Implementing Agreements**
- ❑ Based in Paris



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## GEOHERMAL IMPLEMENTING AGREEMENT (GIA)

- ❑ Established in 1997, now in 3<sup>rd</sup> 5-year term
- ❑ General scope to strengthen international collaboration
- ❑ 12 country-members + 5 other members
- ❑ Main aim currently to promote **sustainable utilization** of geothermal resources



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## THE GIA – CONTINUED

- Operates four **Annexes** at present:  
I) Environmental impacts, III) EGS,  
VII) Advanced drilling and VIII) Direct use
- Each Annex involves several **Tasks**
- **Task E** under Annex I:  
**Sustainable utilization strategies**
- See WGC2010 papers by Mongillo et al. and Bromley



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## *SUSTAINABLE GEOTHERMAL UTILIZATION*

- ❑ Decades of experience and research have shown that a new equilibrium is often attained after utilization starts, indicates that sustainable utilization should be possible
- ❑ Other case-histories exhibit excessive production
- ❑ A definition was proposed in 2001 where sustainable geothermal utilization is defined as an energy-production scheme that can be maintained for 100 – 300 years



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## *THE DEFINITION*

- ❑ Firstly based on the ***nature of geothermal systems***; i.e. new pressure-equilibrium or very slow pressure and/or temperature changes
- ❑ Secondly on a ***reference-timescale***
- ❑ Initial skepticism, but increasingly being accepted
- ❑ Sustainable potential depends on utilization method (e.g. reinjection) and technological advances (deep drilling, EGS-technology, etc.)



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## ANNEX I SUSTAINABILITY WORK

**(1) Purpose of Task E:** collect information, identify research needs, promote workshops/meetings and encourage publication of papers/reports

**(2) Literature Compilation:** see <http://www.iea-gia.org/publications.asp>

**(3) Possible Modes of Sustainable Utilization:**

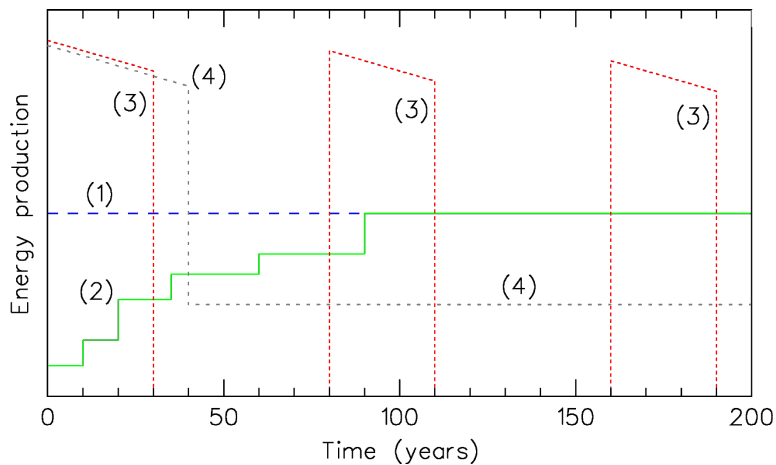
have been discussed within Task E

See next slide



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A schematic diagram showing how geothermal resources can be utilized in a sustainable manner through (1) constant production below sustainable limit, (2) step-wise increase in production, (3) cyclic production (intermittent excessive production with breaks) and (4) reduced production following an excessive period



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## ANNEX I TASK E WORK (CONT.)

**(4) Research issues:** various issues identified and analyzed, see Rybach and Mongillo (2006) and Axelsson *et al.* (2010; this work) – main issues focus on long production history data and long-term modelling

**(5) Taupo (NZ) 2008 Sustainability Workshop:** 40 participants, 17 presentations from 7 countries examining development strategies, geothermal modelling and related issues – see next slides

**(6) Fruitful discussions**



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## TAUPO 2008 WORKSHOP

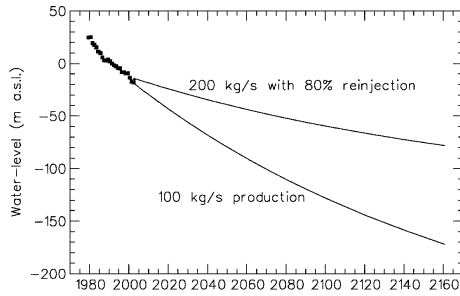
Speaker	Subject
M. Mongillo	Introduction to IEA-GIA
C. Bromley	Outline of sustainability issues
G. Axelsson	Case histories, research issues and modelling
M. O'Sullivan	Sustainability modelling for Wairakei (New Zealand)
W. Kissing	Deeper, larger-scale modelling
S. Zarrouk	Ohaaki (New Zealand) modelling
A. Clotworthy	Geothermal development end point (example from Nicaragua)
M. Monterrosa	Assessing sustainability, the Ahuachapan (El Salvador) case
T. Dwikorianto	Kamojang (Indonesia) case history
P. White	Groundwater management and sustainability
B. Cumming	Geothermal decision making and risk
E. Kaya	Reinjection modelling
P. Leary	Surveying fracture heterogeneity
S. Onacha	Integration of geophysical data in reservoir modelling (Olkaria/Kenya)
G. Siddiqi	Direct geothermal use in Switzerland
S. Ehara	Sustainable development at Hatchobaru (Japan) based on gravity monitoring
G. Björnsson	Sustainable power production in Hengill (Iceland)



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# TAUPO WORKSHOP MODELLING STUDIES



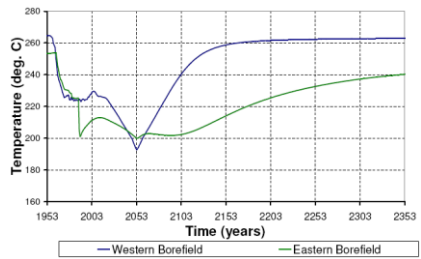
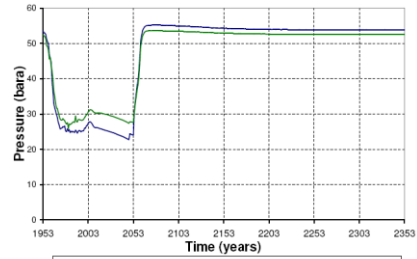
Beijing, China

Wairakei,  
New Zealand

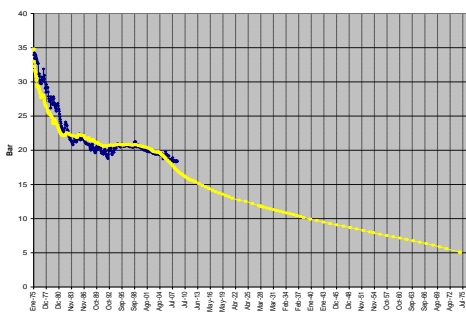


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# TAUPO WORKSHOP MODELLING STUDIES



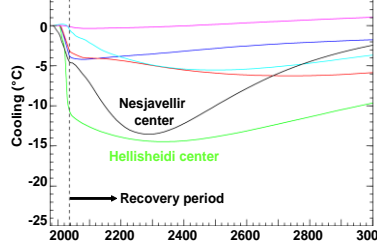
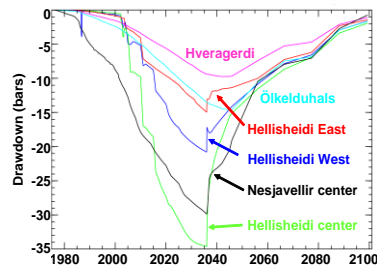
Ahuachapan, El Salvador

Hengill, Iceland



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## CONTINUING WORK

- ❑ Research aimed at research-issues identified
- ❑ Sustainability modelling w. predictions for 100 – 300 years
- ❑ Modelling aimed at “correctly” incorporating boundary conditions, i.e. through the integration of far-field pressure data, surface deformation data, gravity data, chemical data and more
- ❑ Sustainability protocol definition?



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## CONCLUSIONS

- ☉ Main aim of IEA-GIA to promote sustainable geothermal utilization -> Task E under Annex I
- ☉ Main highlights: Taupo Workshop, Geothermics Special Issue and fruitful discussions
- ☉ Research aimed at relevant research issues is needed, mainly through modelling



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***Thank you!***

