INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Special Report on Renewable Energy Sources and Climate Change Mitigation

Government and Expert Review of the Second Order Draft
Jun 21, 2010 – Aug 16, 2010

Chapter 4

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[1] *see <<http://ipcc.ch/pdf/ipcc-principles/ipcc-principles-appendix-a.pdf>>, Section 4.1 and clarification in decision 8 on procedures taken at the 33rd Session of the Panel <<http://www.ipcc.ch/meetings/session33/ipcc_p33_decisions_taken_procedures.pdf>>*

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Australia (0)	4	0	-	-	-	-	-	-	Additional clarifying statements and context for Chapter 4 are required: One of the major debates in geothermal industry is about the level of achievable acceleration of growth. How fast the industry can accelerate is a big question for EGS. Reductions in the cost curve will require a lot of learning wells to be drilled. A significant amount of time will be necessary to achieve efficiencies.	Partially accepted. Rates of growth of geothermal deployment are indeed debatable, but projections included in Chapter 4 seem to be well founded. Additionally, Table 4.2 was re-designed to separate EGS and conventional resources. We'll include some reference about the exclusion of volcanic (USGS Circular 729.
United States (U.S. Department of State)	4	0	-	-	-	-	-	-	General comment: Although Chapter 4 ¿ Geothermal does not comment on small-scale, distributed geothermal development, such development could be an important base-load power source for isolated population centers in close proximity to shallow geothermal resources. Particular areas include Indonesia, Philippines, and Central and South America.	It was included a new paragraph in Section 4.8.1, Version 2.
United States (U.S. Department of State)	4	0	-	-	-	-	-	-	The chapter could better identify, upfront, the primary conclusions drawn from the chapter's discussion as it pertains to the role that the technology has on climate change. For example, the reader doesn't find such a primary conclusion until the very last sentence of the Introduction section (page. 7, lines 42-46), which states "As presented in this chapter, climate change has no major impacts on geothermal energy, but the widespread development of geothermal energy could considerably reduce the future emissions of carbon dioxide into the atmosphere, and play a significant role in reducing anthropogenic effects on climate change by replacing fossil fuel burning plants." I believe the chapter/document would be better served to highlight the primary conclusions upfront, first thing, in each chapter instead of leaving it to the reader to dig through the body of the document.	Paragraph was moved to the beginning of Introduction in Ver. 2.
United States (U.S. Department of State)	4	0	-	-	-	-	-	-	This chapter needs a more thoughtful and rigorous analysis of the benefits of large scale deployment of ground-source geothermal for heating and cooling of large buildings (e.g. high density residence, offices, stores). This is a low cost option that reduces demand for other resources for heating and cooling with minimal land-use impacts. There is a huge opportunity for ground-source geothermal to reduce the GHG emissions associated with heating and cooling of buildings; but few reports that examine it.	We agree with the general opinion about GHP, but this is only a part of the geothermal resources and can not have more room, considering the total lenght of Chapter 4. We'll re-phrase the proper sections of the chapter, highlithling the benefits of GHP.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	1	1	-	-	-	-	-	Line 1 should read ¿¿thermal energy generated and stored in¿¿	Partially accepted. "Stored" was added but It is not appropriate leave “generated“ here, as the energy really is a result of two phenomena – the initial energy contained in the planet formation and the additional generation from radionuclide decay. So, it seems preferable to use only the term "stored".

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Ladislaus Rybach (Geowatt AG Zurich (company))	4	4	23	-	-	-	-	-	Line 23 should read ¿in 78 countries at 0.4 EJ/y with 50.6 GWt capacity mainly for heating and cooling, with GHP applications having¿¿	What would be the point to do this? If we indicate the equivalence in EJ/y for direct uses, we must do the same for electricity generation.
Brazil (Ministry of Science and Technology)	4	4	16	4	17	-	-	-	Change the way the phrase is written: ¿EGS method and direct heating technologies using Geothermal Heat Pumps (GHP) and district heating are available, with different degrees of maturities¿	Sentence re-phrased in Version 2.
United States (U.S. Department of State)	4	4	3	-	-	-	-	-	Change to "or in other applications requiring heat"	Done in Version 2.
ALFONSO GARCIA (Instituto de Investigaciones Eléctricas)	4	4	34	4	37	-	-	-	For completeness, what is the full life-cycle CO2-equivalent emmisions of steam/flash geothermal power plants?	Sentence was deleted in Version 2, but anyway some data on LCA emissions from condensing plants will be included in section 4.5.
United States (U.S. Department of State)	4	4	32	-	-	-	-	-	Geothermal flash and steam plants do emit CO2 that would not be emitted without exploitation. Delete this sentence since lines 34-37 explain the emissions.	Sentence will be re-phrased by Chris.
United States (U.S. Department of State)	4	4	44	5	1	-	-	-	Pages 4-5 (lines 44-1): does the estimate of a projected 50% cost decline for EGS include improvements in drilling technology and if so what improvements (ROP? How big of an improvement?)? As written it seems that successful stimulation technologies are driving the cost down.	Partially accepted: paragraph was re-phrased in Version 2, but in general the statement is supported in the section 4.7.2 of the chapter. It is impossible to include all explanations in the Executive Summary.
United States (U.S. Department of State)	4	4	38	-	-	-	-	-	Spell out "RE" as "renewable energy (RE)" on line 38, since it doesn't appear to be spelled out anywhere prior to that point in the chapter.	Done in Version 2.
SHINSUKE NAKAO (National Institute of Advanced Industrial Science and Technology (AIST))	4	4	19	4	24	-	-	-	Thank you for excellent drafting works. A comment in the executive summary: I think the numbers of 11 GW in Line 20 and 50 GW in Line 23 should be referred accurately as 10.7 GW and 50.6 GW, respectively, as described in the main body.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	4	44	-	-	ES	-	-	"Costs are expected to decrease ¿" Not transparent, how widely this belief is shared and what it is based on. Currently, the chapter does not provide any learning rate estimate that are based on historically observed cost reductions for a consistent measure of performance (e.g. unit cost of electricity or capital cost/kW). This gap in the scientific literature should be pointed out. The expectations of cost reductions for EGS seem to be based on Tester et al. (2006) and Huenges (2010). Hence, an adequate formulation would be along the following lines: "The limited number of studies on future costs of EGS expects cost to decrease to a range of ..."	In section 4.7.4 (Future costs trends) is explained how and why future costs for electricity from hydrothermal resources are expected to decrease in that % (see Figure 4.7). Regarding EGS, the last paragraph os section 4.7.2 supports that EGS costs could decrease "potentially by 50% for EGS by 2050".
Zhonghe Pang (Institute of Geology and Geophysics)	4	4	12	4	18	ES	-	-	District heating is widely applied in the world and is also a mature technology.	Sentence re-phrased in Version 2.

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Steffen Schlömer (IPCC WGIII)	4	4	39	4	42	ES	-	-	Rephrase to avoid misunderstanding by lay readers, e.g.:"Conventional hydrothermal technologies are competitive, if average annual electricity prices are at or above their current levelized cost of electricity (LCOE) of 43 to 84 US$ (2005) per megawatt-hour (MWh). This is the case in many of today's electricity markets." This is a sufficient, but no necessary condition. Actually, the weighted average of those prices during the year at which power is sold to the market has to be at or above the LCOE to make geothermal power plants profitable (assuming that the capacity utilisation has been correctly anticipated). However, the latter condition is hard to phrase in an easy but yet correct way.	The sentence actually reads: "The levelised costs of electricity (LCOE) from conventional hydrothermal resources are competitive in today's electricity markets, ranging from 43 to 84 US$ (2005) per megawatt-hour (MWh)." This competitiveness is independent of electricity market prices, since competitiveness is not the same that profitability. But this is the case of all electric energy sources (fossil & renewables). Thus, what we want to point out is not that geothermal-electricity is profitable (that depends on several factors) but it is competitive in the current electricity markets.
Steffen Schlömer (IPCC WGIII)	4	4	25	4	37	ES	-	-	You do not mention explicitly any of the potentially adverse effects of using geothermal energy except for a positive, but small carbon footprint. Instead, you finish that paragraph with a scientifically unsound value judgment suggesting that "the net energy supplied more than offsets the environmental impacts of human, energy and material inputs." There is no commonly agreed way to compare energy with "human inputs".	Partially accepted. There are no adverse effects of using geothermal energy, but the word "human" has been deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	4	2	4	11	ES	-	-	You state point estimates for near-term and long-term deployment instead of ranges. This can hardly be representative of the full set of studies available in the scientific literature. Please replace by ranges found in the scientific literature.	We'll use ranges in the new version of SOD.
Trevor Demayo (Chevron Energy Technology Cvo.)	4	4	22	-	-	Exe. Sum.	-	-	their"" should probably be changed to ""the""	Done in Version 2.
Trevor Demayo (Chevron Energy Technology Cvo.)	4	4	8	-	-	Exe. Sum.	-	-	Which countries may get their 1ary energy from geothermal in 2050? Might list some examples.	The sentence actually reads: "with some countries obtaining most of their primary energy needs (heating, cooling and electricity) from geothermal energy". Among this: El Salvador, Iceland, Indonesia, but the ES is not a proper place to list these countries.
ALFONSO GARCIA (Instituto de Investigaciones Eléctricas)	4	5	16	5	16	-	-	-	Is it correct to say ""¿. Especially suitable for supplying disptaching base-load power."" ?	It was re-phrased in Version 2.

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Gerrit Hansen (TSU)	4	5	16	-	18	-	-	-	please rephrase sentence "intermittent RE sources like wind, solar, hydro" - hydro is not an intermittent source, and not all solar technologies are variable. It was agreed to use the term variable instead of "intermittent"	"Intermittent" was changed to "variable" in Version 2. (But of course all solar, wind and hydro power plants are intermittent since are not base-load.)
John Twidell (AMSET Centre)	4	5	17	-	-	-	-	-	replace 'intermittent' by 'variable'. This is important, since 'intermittent' implies 'all off ' to 'all on' and does not allow for prediction. I aditiobn, hydro should not be included in this list of examples, since reservoir-hydro is very controllable.	"Intermittent" was changed to "variable" in Version 2. (Hydro is variable depending of the rain station.)
Steffen Schlömer (IPCC WGIII)	4	5	14	-	-	ES	-	-	"many other positive environmental attributes" - This reads like an adovacy statement, not like a balanced assessment of the technology. Clearly geothermal does not only have positive environmental impacts. There is probably no power generation option that does not have any adverse effects on the environment. Goethermal may be comparatively advantageous. However, it should remain clear that, just like any other technology, geothermal energy does leave a footprint.	The sentence was deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	5	5	5	6	ES	-	-	Belongs to paragraph above.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	5	19	5	22	ES	-	-	Please include in earlier paragraphs and summarize here the "clear challenges" that you are mentioning here. The terms "massive potential", "modest investment" are not very scientific and need to be replaced by more adequate and precise language. The last sentence does not contain any precise information, but reads like an advertisement. This has to be avoided.	Last paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	5	7	5	12	ES	-	-	The list of potential policy instruments to support increased deployment of geothermal energy is not comprehensive. FITs are included, Feed-in premiums and Renewable Portfolio Standards with technology banding are not. In order to avoid perceived bias at least the most important alternatives should be presented. Generally, it does not become clear to which extent technology-neutral support for low-carbon development suffices to lead to enhanced deployment of geothermal technologies and to which extent technology-specific support is needed. This should be made more clear.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	5	16	5	18	ES	-	-	This sentence attributes a one-sided negative image (intermittency) to hydro, wind and solar. However, each of these technologies comes with very different load curves that coincide more or less with real time demand. Rephrase in a more neutral way. Use the term "variability" instead of "intermittency", since this was decided to be the more appropriate term during the MGMT in Oxford.	"Intermittent" was changed to "variable" in Version 2.
United States (U.S. Department of State)	4	6	33	-	-	-	-	-	Add brief explanation here of how GHP utilizes 5-10C temperatures for heating/cooling and energy storage.	Paragraph was re-phrased, deleting the reference to GHP.

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United States (U.S. Department of State)	4	6	10	-	-	-	-	-	Delete last sentence of paragraph; not needed in the introduction (even though it may be true)	LA consider important to keep this sentence ("However, there are several notable exceptions, and under appropriate conditions, high, intermediate and low temperature geothermal fields can be utilised for both power generation and the direct use of heat.")
Ladislaus Rybach (Geowatt AG Zurich (company))	4	6	2	-	-	-	-	-	Line 2 should read ¿¿thermal energy generated and stored in¿¿	Done in Version 2.
United States (U.S. Department of State)	4	6	34	-	-	-	-	-	Page 6 (lines 34): the 5-10 C temperature range is somewhat confusing.	Paragraph was re-phrased, deleting the reference to GHP.
Brazil (Ministry of Science and Technology)	4	6	27	6	34	-	-	-	The paragraph is very confused and its suppression would not affect the overall comprehension of the theme.	Paragraph was re-phrased and shortened in Version 2.
Brazil (Ministry of Science and Technology)	4	6	25	6	26	-	-	-	The same observation as above	It seems to refer to the temperature limits. Same explanation as in comment No. 436/105.
Brazil (Ministry of Science and Technology)	4	6	4	6	7	-	-	-	There is no reference from where the temperature limits came from [¿high temperature (> 180o C)¿ ¿Intermediate temperature (100o C - 180o C)¿and ¿low temperature (< 100o C)¿]. Williams, Reed and Mariner (2008) use other temperature limits to classifying geothermal resources. According to those authors high temperature is over 150o C and moderate temperature from 90o C to 150o C. There are at least 7 geothermal commercial plants in operation in 2005 (Bertani 2005) that operates with temperature bellow 180o C. The complete reference to Williams, Reed and Mariner (2008) is Williams, C.F., Reed, M.J., and Mariner, R.H., 2008, A review of methods applied by the U.S. Geological Survey in the assessment of identified geothermal resources: U.S. Geological Survey Open-File Report 2008-1296, 27 p. [http://pubs.usgs.gov/of/2008/1296/]	180°C was chosen based on two-phase self-discharging wells and we'll include the reference.
Brazil (Ministry of Science and Technology)	4	6	21	6	21	-	-	-	There isn't any EGS for direct heating; its first goal is to electric power. It can be associated to direct use, but it is hard to believe that anyone would drill and stimulate hot dry rocks just for heating proposes.	The sentence was re-phrased in Version 2.

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ALFONSO GARCIA (Instituto de Investigaciones Eléctricas)	4	6	2	6	3	4.1	-	-	The definition given here of geothermal energy is valid for hydrothermal systems since steam and water are included in the definition. Furthermore, Table 4.1 excludes natural fluids in conductive geothermal resources.	The general definition is valid for all type of geothermal systems (please check again: "Geothermal resources consist of thermal energy generated and stored at depth within the earth in both rock and trapped steam or liquid water."). Conductive systems don't have natural fluids, because otherwise they would be hydrothermal (Table 4.1).
United States (U.S. Department of State)	4	7	2	-	-	-	-	-	"Heat flow" should be replace by "temperature gradient"	Terms were changed in Ver. 2.
United States (U.S. Department of State)	4	7	4	-	-	-	-	-	EGS experiments have not investigated the potential of EGS in "large areas." What do we mean by "large areas"? These experiments are few and isolated. Do we really mean "several areas". Possibly change to "continental settings in North America and Asia".	"Large" changed to "several" in Ver. 2.
Grant Ferguson (St. Francis Xavier University)	4	7	27	7	27	-	-	-	Geothermal heat pumps can't be used quite everywhere. Substantial difficulties exist in using these in permafrost areas or areas with very low subsurface temperatures. This doesn't significantly limit their use but should be noted.	It was changed to "almost anywhere" in Version 2.
United States (U.S. Department of State)	4	7	13	-	-	-	-	-	Might mention that Larderello is still producing	Short sentence added to this paragraph in Ver 2.
United States (U.S. Department of State)	4	7	6	-	-	-	-	-	Suggest changing to "may be exploitable in broad area at depths as shallow as 7 km	Sentence was re-phrased in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	8	32	8	32	-	-	-	Replace porous with permeable. Porosity is a storage term and doesn't necessarily correlate with permeability.	Done in Version 2.
Fritz Vahrenholt (Prof. Dr.) (RWE Innogy GmbH)	4	8	13	8	16	-	-	-	Shorten this passage - replace it by table 4.2.	Done in Version 2.
United States (U.S. Department of State)	4	8	5	-	-	-	-	-	Suggest adding the word "on" to the end of line 5 just after the word "crust". Also, colloquial phrase is "on the order of" and not "of the order of".	Done in Version 2.
Brazil (Ministry of Science and Technology)	4	8	9	8	10	-	-	-	There is no reference from where those values come from.	The reference is placed at the end of the paragraph (Stefansson, 2005).
Steffen Schlömer (IPCC WGIII)	4	8	21	8	25	4.2	-	-	Continue this paragraph with an explanation that the technical potential increases once new technologies, like EGS, are taken into account as they relax the technical constraints of accessing theoretically available resources like conductive resources. The technical potential should generally be presented as dynamically changing over time with technological progress. Compare Table SPM 4.	Paragraph was amended in Version 2.
Steffen Schlömer (IPCC WGIII)	4	8	19	-	-	4.2	-	-	include "¿, theoretically available resource is clearly not a limiting factor ¿"	Done in Version 2.

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Juan Llanes (Centre for Environmental Studies)	4	8	18	-	20	4.2.1	-	-	What is the meaning of ¿not a limiting factor for geothermal deployment globally? ¿ Please clarify	Yes, the availability of the resource is not a limiting factor for geothermal deployment. Sentence slightly modified in Version 2. See the next comment.
China (China Meteorological Administration)	4	8	-	-	-	4.2.1	-	4,2	Table 4.2 seems to be unnecessary since Table 4.3 already provides detailes.	Table 4.2 also presents theoretical potentials, which are not included in Table 4.3.
Norway (Climate and Pollution Agency)	4	9	19	9	20	-	-	-	In the previous paragraph it is referred to Tester et al. 2006 where it was estimated that 13.6*10^6 EJ of stored geothermal energy to 10 km depth would result in a technical potential of 35.4 EJ/y. The information in the parentheses must be changed to "(1*10^6 EJ theoretical ~2.61 EJ/y of technical potential at 90% capacity factor for 30 years)	That's correct. Changed in Version 2. Very good observation.
United States (U.S. Department of State)	4	9	26	9	29	-	-	-	Projects will remove heat from specific areas and not equally over the earth's surface as this comparison requires. Systems are only sustainable locally when the extraction rate equals the original local heat flow. Possibly remove this sentence - Geothermal sustainability depends on the dimensions - delete most of lines 26-29.	Sentence was re-phrased in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	9	17	9	17	-	-	-	Replace ""this country"" with ""that country"". The USA is not the subject of this report.	Omitted in the new version of the paragraph (Version 2).
United States (U.S. Department of State)	4	9	19	-	-	-	-	-	Section 4.2.1, page 9/45, line 19: it is not clear how one goes from 1 EJ theoretical to 2.61 x 10^6 EJ/yr for 30 yr at a 90% capacity factor.	Conversion is wrong. Correct conversion is 1 x 10^6 EJ ~ 2.61 EJ/y. Done in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	9	26	9	29	-	-	-	The extraction rate is less than recharge but I seriously doubt this is sustainable with current or any foreseeable future technology. It is simply not possible to capture 87% of crustal heat flow without having unacceptable decreases in temperature locally. This sort of heat budget calculation is very misleading.	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	9	19	9	19	4.2	-	-	1 EJ theoretical ~ 2.61 x 10 to the power of MINUS 6 of technical potential	Conversion is wrong. Correct conversion is 1 x 10^6 EJ ~ 2.61 EJ/y. Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	9	18	9	21	4.2	-	-	Again, rephrase to make clear what you do here: "Based on the assumptions of Tesler et al. (2006) estimates for the technical potential of EGS-based energy supply can be derived from estimates of the theoretical potential, i.e. from estimates of the total heat stored in the earth's crust (cf. Table 4.2). This is added to Stefansson's (2005) calculation of the technical potential of already identified hydrothermal resources in order to include the potential that non-hydrothermal resources offer via EGS technology."	Paragraph re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	9	26	9	29	4.2	-	-	Avoid biased presentation! Mention explicitely that the maximum technical potential of estimated 1043 EJ/y is well above the natural heat recharge ensured by continental heat flow of 315 EJ/y and that this effectively imposes a limit on the technical potential that can be used sustainably in the long term.	Why biased? The statement is a fact, not an interpretation. Anyway, the last sentence of this paragraph was also re-phrased in Version 2.

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Steffen Schlömer (IPCC WGIII)	4	9	8	9	17	4.2	-	-	Same as above. Rephrase to better reflect main message: "Tester et al. (2006) estimate the additional technical potential in the United States from utilizing EGS technology to access conduction-dominated resources at depths of up to 10km to be 1249 GWe (35.4 EJ/y [Include assumptions on capacity factor in footnote]). This estimate equals ß-times the theoretical potential, where ß = 2.61 x 10^(-6) reflects several assumptions on the fraction of the stored heat that is recoverable (2%) as well as on the efficiencies of converting heat into electricity. [Include further assumptions in footnotes if necessary]"	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	9	1	9	7	4.2	-	-	The essential message is lost in assumptions. Make it more clear that Stefansson assumes hidden resources are 5-10 times higher than identified ones and, as a consequence, arrives at relatively low estimates of global technical potential.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	9	1	9	29	4.2	-	-	The paragraphs are overloaded with assumptions that distract the reader's attention from the essentials. Assumptions taken for conversion from capacities (GWe) into power (EJ/y) should go into a footnote.	It is important to make clear the assumptions and conversiones, since the result is an original input from Chapter 4. Footnotes would be too large to do that.
Steffen Schlömer (IPCC WGIII)	4	9	25	9	26	4.2	-	-	There's nothing about global distribution that can be derived from the statements made so far. Sounds like wishful thinking, but not like science.	All the paragraph was re-phrased, including that sentence.
United States (U.S. Department of State)	4	10	9	-	-	-	-	-	Add: "and reduced exploration risk relative to naturally occurring hydrothermal systems."	Sentence added in Version 2.
Brazil (Ministry of Science and Technology)	4	10	10	10	16	-	-	-	Delete. The geothermal submarine resources linked to oceanic ridge is more an author¿s guess than a technological possibility, even in the long term. It is like using the energy of lightings of a storm or the winds of a hurricane: there is a huge amount of energy but there isn¿t technology to covert it to useful electricity. Most of the oceanic ridges are located on very deep waters and very far from the coast; even we do have any kind of successful conversion, transmitting it to cities will be almost impossible and very expensive.	There is sufficient evidence about submarine geothermal resources and its possible use, as published references can prove. Here we are presenting potentials, not deployment prospectives and it seems to be valid to include this type of resources. Text has been added emphazising the uncertainity of these resources.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	10	-	-	38	-	-	-	Life-cycle assessment: Numbers need to be added for steam-based power plants. The LCA values for geothermal heat pumps (line 30) depend much on the source of electricity that drives the heat pumps (currently there are great differences from country to country, depending on the electricity mix; orders of magnitude between Norway (hydropower) and Poland (coal-fired plants)).	Sentence added in page 25, Section 4.5.2. in Version 2, regarding GHP. Regarding LCA values for condensing plants, we need some data about.
United States (U.S. Department of State)	4	10	1	-	-	-	-	-	Page 10 Line 1: Remove first sentence - not accurate.	Sentence was deleted in Version 2.

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United States (U.S. Department of State)	4	10	10	10	16	-	-	-	Sect 4.2.1 p.10, line 10-16 This paragraph could be deleted to shorten the chapter. This resource is likely to be uneconomic for the foreseeable future. See also comment for page Section 4.3.6, p.14, line 26-31.	There is sufficient evidence about submarine geothermal resources and its possible use, as published references can prove. Here we are presenting potentials, not deployment prospectives and it seems to be valid to include this type of resources. Text has been added emphazising the uncertainity of these resources.
Steffen Schlömer (IPCC WGIII)	4	10	7	10	9	4.2	-	-	"¿ EGS will become a leading technology ¿" - This is a pure value judgement and has to be removed.	Partially accepted. Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	10	27	11	7	4.2	-	-	include above table: "The regional breakdown in Table 4.3 is based on the methodology applied by EPRI (1978) to theoretical potentials: The disaggregation of the global theoretical and technical potential, respectively, is based on factors accounting for regional variations in the average geothermal gradient and the presence of .... Applying these factors to the global technical potentials listed in Table 4.2 gives the values stated in Table 4.3." Keep sentence on arbitrary separation into electric and thermal potentials!	Paragraph was re-phrased accordingly in Version 2.
China (China Meteorological Administration)	4	10	28	-	29	4.2.2	-	4,3	China and India fall into the same "developing Asia". It is suggested to merge China and India into the "developing Asia".	That is correct, but the IEA separates China and India from the rest.
United States (U.S. Department of State)	4	11	38	11	40	-	-	-	Change to " ¿ rainfall patterns, and this may require air cooled power plant condensers." Take out sentence starting on Line 39 (last sentence of paragraph). Add new sentence: "Lack of water may have a serious impact on the development of water deficient EGS."	Partially accepted (last sentence was not deleted but re-phrased) in Version 2.
United States (U.S. Department of State)	4	11	23	11	30	-	-	-	Delete lines 23-30; more detail than is needed.	It is an important issue of sustainable geothermal resource utilisation and it must be retained.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	11	10	-	-	-	-	-	Line 10 should read ¿¿..it creates locally cooler regions temporarily.¿	It was done in Version 2 (paragraph moved to Section 4.1).
United States (U.S. Department of State)	4	11	17	-	-	-	-	-	Line 17 delete "that this type of¿"	Words deleted in Version 2.
United States (U.S. Department of State)	4	11	9	11	30	-	-	-	Page 11 (lines 9-30) Given the heading for section 4.2.3 it is not clear why the 1st two paragraphs are included in the discussion of climate change and resource potential.	One paragraph was moved to Section 4.1, one was deleted and Section 4.2.3 was re-structured.
United States (U.S. Department of State)	4	11	37	11	40	-	-	-	Page 11 (lines 37-40): The authors mention the impact of changing climate on the availability of surface water for cooling and then state that this effect occurs it can be remedied by simple adjustments to the technology ¿ what adjustments in technology will impact the need and availability of cooling water?	Answer is the next comment by the same reviewer.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	11	31	11	40	-	-	-	Section 4.2.3 Page 11, Lines 31-40. Note also that while climate change may not affect the resources, it may affect the ability to reject heat and perhaps adversely impact power generation (e.g., air cooled binary not as efficient in warming temperatures).	A sentence was added to this paragraph in Version 2.
United States (U.S. Department of State)	4	11	9	11	30	-	-	-	Section 4.2.3, page 11: The 1st and 3rd paragraphs do not pertain to climate change. They refer more to a decline in resource productivity. They could be eliminated to reduce the # of pages.	First paragraph was moved to Section 4.1. Third paragraph was moved to the end of the section.
United States (U.S. Department of State)	4	11	37	11	40	-	-	-	The impacts on resource potential with respect to availability of water for cooling of power plants condensers seem to be minimized. For some areas this could become a serious barrier for project development.	It is improbable that resource potential will be affected in any way for climate change due to a probable lower availability of water for cooling towers. So, the risk is not minimized: it is minimum.
United States (U.S. Department of State)	4	11	14	11	30	-	-	-	The sentence starting on line 14 that discusses time scales for thermal and pressure recovery seems better suited to be included in the paragraph that starts on line 23. In fact, the information expressed on line 14 is repetitive of the information expressed throughout the paragraph starting on line 23 - Consider removing this sentence (on line 14), and change the next one starting "detailed modeling studies have shown resource exploitation can be..."	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	11	18	-	-	4.2	-	-	"on a timescale useful to society" - unclear	It was re-phrased in Version 2 (paragraph moved to Section 4.1).
Steffen Schlömer (IPCC WGIII)	4	11	23	11	30	4.2	-	-	Does this mean that it takes some 25 years, until it is possible or economical to built a new geothermal power plant in an old plant's location? If so, this needs to be pointed out, as this would imply that brownfield investments are basically infeasible and that each investment in EGS requires new drilling expenditures.	No, this means exactly what is stated: "Time scales for naturally recharging depleted geothermal reservoirs following the cessation of production... (are) of the same order as the lifetime of the geothermal production cycle where the extraction rate is designed to be sustainable over a 20-30 year period". This is about a geothermal system, not for additional power plants (brownfield) in the same system. Power plants do not need to be re-built because resource development can be adaptively managed.
Zhonghe Pang (Institute of Geology and Geophysics)	4	11	8	11	30	4.2.3	-	-	This section is supposed to discuss the impact of climate change on geothermal availability but the text here is about renewablity that indepandent of climate. The three paragraphs can be shifted to a more appropriate context or deleted to reduce length of document.	One paragraph was moved to Section 4.1, one was deleted and Section 4.2.3 was re-structured.
United States (U.S. Department of State)	4	12	24	-	-	-	-	-	"directional drilling capability"	"drilling" added in Version 2.
United States (U.S. Department of State)	4	12	20	-	-	-	-	-	"estimating its location, lateral extent, and depth"	"location" added in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	12	9	-	-	-	-	-	Change to read -- binary cycle or in direct use. The fluids are injected back into the reservoir.	Done in Version 2.
United States (U.S. Department of State)	4	12	8	12	9	-	-	-	Page 12, Lines 8-9: The sentence is not entirely clear. The intent appears to be that extracted heat can be used to produce power in a binary cycle or for heating in some direct use application. The cooled fluid is then injected. The reviewers had to read this a couple of times because they read it to say the heat was used to produce power or heat the injected fluid, which made no sense. Some punctuation or multiple sentences would help.	This sentence was re-phrased in Version 2.
United States (U.S. Department of State)	4	12	2	-	-	-	-	-	Section 4.3.1, Page 12, Line 2: My knowledge of non-USA plants is limited, however I¿m not aware of any plants that utilize 2 or 3 flashes after the 1st flash/separation ¿ the wording implies a plant that utilizes steam from 3 or 4 flashing processes.	Sentence was re-phrased in Version 2.
United States (U.S. Department of State)	4	12	30	-	-	-	-	-	Section 4.3.2, page 12, line 30: remove ¿in built up areas¿.	Words deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	12	11	-	-	4.3	-	-	This is certainly not the case for EGS!	Sentence modified in Version 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	12	15	12	21	4.3.2	-	-	Assessment of fluid qulality/property is another aspect very often necessary in geothermal exploration. Geochemistry plays a major role in this so worth to mention.	Short sentence added to this paragraph in Ver 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	12	38	12	42		-	-	In injection management, tracer technology is an essential part in the portfolio.	New sentence added in this paragraph.
United States (U.S. Department of State)	4	13	28	-	-	-	-	-	Change to -- passes through a heat exchanger heating a 'working' fluid with a low boiling point such as...	Paragraph re-phrased in Version 2.
United States (U.S. Department of State)	4	13	36	-	-	-	-	-	delete -- district heating or	Done in Version 2.
United States (U.S. Department of State)	4	13	33	-	-	-	-	-	delete -- would	Done in Version 2.
United States (U.S. Department of State)	4	13	16	-	-	-	-	-	Page 13, line 16: Suggest saying the flash plants may utilize multiple flash pressures in order to maximize utilization of the energy in the geothermal fluid with the constraint that the lowest flash pressure always be above 1 atmosphere. When multiple flashes are used, the turbines have inlets corresponding to each flash pressure.	New paragraph added in Version 2.
United States (U.S. Department of State)	4	13	30	13	31	-	-	-	Page 13, line 30-31: The text suggests that binary plants are small modular units that are linked together to provide a desired output. This has been the approach used by Ormat (and others), however others have designed plants to provide the desired output without using this modular approach taking advantage of economies of scale, and to engineer the cycle to optimize the power production. The small modular approach is well suited for small projects having few wells and when the wells are cheap to drill and are very productive. The engineered plant approach will provide lower generation costs for larger projects, especially when the cost to develop the well field is high.	The sentence reads: "Binary plants are often constructed as linked modular units of a few MWe in capacity or as bottoming cycle with flash steam plants." This is currently a fact. The other approach is a possibility.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	13	36	14	1	-	-	-	Page13&14, lines 36 and 1: I don¿t believe that using a geothermal fluid to both produce electricity and supply heat for a direct use application provides a significantly higher utilization efficiency that using the heat directly. If you are going to say this, you need to define utilization efficiency.	Sentence was deleted in Version 2. Actually, Chapter 4 authors do believe that, but it is not a significant point in this section.
United States (U.S. Department of State)	4	13	26	-	-	-	-	-	Page13/45 line 26: The binary plant upper temperature is too low - Soda Lake NV use 385F (196C) brine	It mentions the general rank, not the exceptions (like Soda Lake).
United States (U.S. Department of State)	4	13	9	-	-	-	-	-	Section 4.3.4, page 13, line 9: The reviewers want to point out that though they are not that familiar with non-US plants, they are not sure that in the US the barometric type of condenser is usually used ¿ I think there is a mix of both barometric and surface condensers.	There is no mention to barometric or surface condensers.
China (China Meteorological Administration)	4	13	10	-	13	4.3.4	4,2	-	No. 6 should be replaced with No. 7 in right figure. It is a heat-exchanger, not a condenser.	Corrected in Version 2. We need to change in figures sent to TSU.
United States (U.S. Department of State)	4	14	14	-	-	-	-	-	Change district heating to direct uses	Done in Version 2.
Brazil (Ministry of Science and Technology)	4	14	25	15	10	-	-	-	Delete. All the assessments made in this chapter do not compute those so called ¿submarine resources¿, just the continental ones. A specific item highlights this so called ¿resource¿ putting it in the same technical level as EGS and even the Deep Continental Drilling in Iceland.	Partially rejected. In version 2 this subsection was moved to Section 4.6 and was shortened.
United States (U.S. Department of State)	4	14	15	14	19	-	-	-	Page 14 (lines 15-19): the concept of ¿managing seismic risks¿ seem to be added on as an after thought, yet in the reality of the policy world it may be a show stopper.	Agree, but it has to be mentioned. Anyway, in Section 4.5 it is explained more deeply.
United States (U.S. Department of State)	4	14	6	-	-	-	-	-	You may need a comma after the word "staff" and should probably add the word "plant" after CHP.	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	14	1	14	8	4.3.4	-	-	This paragraph contains some information on specific markets in Iceland, Germany and Austria that rather belong in section 4.4. Advantages and prerequisites of co-generation should be explained as such more explicitely.	Rejected because examples are used to illustrate the use of these plants. However some references will be added to this paragraph to explain the advantages of this type of combined plants.
Zhonghe Pang (Institute of Geology and Geophysics)	4	14	9	14	24	4.3.5	-	-	The text here is supposed to focus on current status of the respective technology.	In Version 2 the original Table 4.4 was moved to Section 4.6, where a new sub-section was created (4.6.1. Technological and process challenges in EGS). Heading 4.3.5 was changed.
Steffen Schlömer (IPCC WGIII)	4	14	30	-	-	4.3.6	-	-	change "should be" into "needs to be" to avoid being policy.prescriptive	Done in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	14	26	14	29	4.3.6	-	-	Shouldn't this rather be included in the section on resource potential?	Partially rejected. In version 2 this subsection was moved to Section 4.6 and was shortened. Additionally, there is a paragraph regarding this resource in Section 4.2 (Resource potential).
China (China Meteorological Administration)	4	14	25	15	10	4.3.6	-	-	Submarine geothermal fluids are unlikely to be used in a large scale in the foreseeable future so it may be deleted due to the space limit.	Partially accepted. In version 2 this subseection was moved to Section 4.6 and was shortened.
Zhonghe Pang (Institute of Geology and Geophysics)	4	14	25	15	10	4.3.6	-	-	Submarine geothermal fluids are unlikely to be used in a large scale in the foreseeable future so may be deleted due to the page limits. It may be shifted to 4.7 as a future prospect with shortened text. If included, the difficulty in handling supper saline and corrosive fluid should also be discussed.	Partially accepted. In version 2 this subseection was moved to Section 4.6 and was shortened.
Germany (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)	4	15	35	16	2	-	-	-	According to the technical guideline of VDI 4640 (Thermal use of the underground: Fundamentals, approvals, environmental aspects) it is not allowed to operate a vertical probe in a way that leads to constant cooling of the soil. This has to be considered when dimensioning the number and depth of the probes. Change the wording to: "Extracting energy cools the ground. This effect has to be minimized by dimensioning the number and depth of probes in order to avoid harmful impacts on the ground (freezing, change of microbiology, change of soil structure etc.). This effect could be reduced by storing heat from passive cooling."	Done in Version 2.
Brazil (Ministry of Science and Technology)	4	15	30	16	16	-	-	-	An explanation about GHP is missing, as GHP is not ¿geothermal¿ strictly speaking. In fact the 7o C to 17o C temperature reported to most part of northern hemisphere is not derived by the geothermal heat flow but represent the interaction between lithospheric and atmospheric heat systems, and because the very low soil and rocks thermal conductivities an unbalanced temperature is record.	We agree with the general opinion about GHP, but this is only a part of the geothermal resources and can not have more room, considering the total lenght of Chapter 4. We'll re-phrase the proper sections of the chapter, highlithling the benefits of GHP.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	15	13	-	-	-	-	-	Line 13 should read ¿greenhouses, wellness and swimming¿¿	Done in Version 2.
United States (U.S. Department of State)	4	15	5	15	6	-	-	-	Page 15 (lines 5-6): Perhaps should also mention the technical difficulties of transporting power from submarine vents ¿ note that cable technology limits ocean depths to <5000 feet (maybe even shallower, I remember 5000¿ from a discussion with DoD personnel).	New sentence added to this paragraph in its new location in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	15	15	15	19	-	-	-	The description of open and closed loops is backwards. Open loops are the ones where fluids are injected into geologic formations and in closed loops the working fluid is never in direct contact with in situ fluids or the geologic media.	Paragraph was re-phrased in Version 2.
China (China Meteorological Administration)	4	15	13	15	13	4.3.7	-	-	Add "bathing" after "greenhouses". As mentioned in section 4.4.3, bathing is one of the major direct utilizations of geothermal resources.	Done in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	15	15	15	26	4.3.7	-	-	It is unclear how this kind of space heating is different from GHPs. Is the heat for space heating provided by cogeneration plants or is only heat produced? Are these small scale systems or large scale? Is there always a central heat distribution network? What are the challenges wrt to heat distribution networks? Are heat losses really insignificant? If so, up to which distance? How are losses related to distance?	Partially accepted. Section 4.3.6 was re-phrased in Version 2.
John Twidell (AMSET Centre)	4	16	2	-	-	-	-	-	¿ mitigated. A depths less than about 5 m, the main reheating of cooled subsurface will come from the above, so being a form of solar energy gain. Thus, for academic pedantry, ground sourced heat pump systems should be classified as solar devices rather than geothermal. [this clarification needs to be included, especially as ground source heat pumps are very different technology than for true geothermal energy]	A short sentence was added in this paragraph in Version 2 in the meantime.
Germany (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)	4	16	13	16	16	-	-	-	Heat pumps are able to reach even COPs above 4.5. But the COP of a heat pump does only describe the efficiency at specific steady-state conditions (it is a ratio of power [kW]: (heating) output power to (mostly electric) input power) and is not representative for the overall annual efficiency. Only the Seasonal Performance Factor (SPF) can give a sound picture of the overall annual efficiency: it the ratio of useful heat to the consumed driving energy (both in [kWh]). Using the COP would overestimate the efficiency of heat pumps. Please change the wording to:"Their efficiency is described by the Seasonal Performance Factor (SPF) which is the ratio of the useful heat to the consumed driving energy (both in [kWh]). For GHP, this value lies typically between 3 and 4. In contract to the SPF, the Coefficient Of Performance (COP) does only describe the efficiency at specific steady-state conditions and is farely higher than the SPF. Using only the COP would overestimate the efficiency of a heat pump."	It will be incorporated in the re-phrasing version of this subsection to be made by Jeff Tester.
United States (U.S. Department of State)	4	16	6	-	-	-	-	-	In line 6 read "geothermal heat pump systems"	Done in Version 2.
Germany (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)	4	16	-	-	-	-	-	-	On the left example, the probes are shown in a series connection (the brine flowing through the first and then through the second probe). In practise, probes are used in parallel connection (the brine flow is equally split into the number of probes). Please change the picture accordingly.	Done in Version 2.
United States (U.S. Department of State)	4	16	16	-	-	-	-	-	Section 4.3 p. 16, line 16 perhaps add a brief section 4.3.9 mentioning the need for education of an expanding workforce to replace retiring staff and staff an expanding industry (Geothermal engineering program? Should this go in the policy section? Might be used to advance the state of the art). This is a particular problem in the USA for both electrical generation projects and geothermal heat pump systems sizing and installation.	A sentence was added, not in this paragraph but in Thrid paragraph of subsection 4.4.4 (Impact of policies), in Version 2.
United States (U.S. Department of State)	4	16	30	-	-	-	-	-	Section 4.4.1, page 16, line 30: suggest using words ¿utilized through steam power-cycles (either flash or dry steam using condensing or back-pressure turbines)	Done in Version 2.
United States (U.S. Department of State)	4	16	12	16	16	-	-	-	This sentence/paragraph will confuse many readers. Delete lines 12-16.	Paragraph seems to be clear enough.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	16	21	16	22	-	-	-	websites and full names of organizations missing	The sentence was deleted in Version 2.
United States (U.S. Department of State)	4	17	3	-	-	-	-	-	"and only a fraction of the geothermal energy potential" (replace "but" with "and")	Done in Version 2.
United States (U.S. Department of State)	4	17	19	-	-	-	-	-	Delete -- entire	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	17	27	-	-	-	-	-	In the text, the average annual growth rate is stated for the last 40 years, in the table only for the last 35 years.	Period for electricity is 40 years (1970-2010), for direct uses is 35 years (1975-2010). This is clear in both, table and text.
United States (U.S. Department of State)	4	17	14	-	-	-	-	-	Instead of saying "like" say "such as Chile"	Done in Version 2.
United States (U.S. Department of State)	4	17	22	-	-	-	-	-	Page 17, line 22: I believe it should read Figure 4.5 (instead of 4.6)	That's correct. Changed in Version 2.
Australia (0)	4	17	45	-	-	-	4,5	-	Australia currently does not have 1.1MW of installed capacity. Installed capacity is confined to Birdsville with approx 120kW	The current installed capacity of 1.1 MW is correct, but not completely operational.
China (China Meteorological Administration)	4	17	-	-	-	4.4.1	4,5	-	Geothermal installed capacity is 28.18MWe in China. Reference: Zhao Ping. Geothermal Tibet AR - an overview of resources and power generation. Geothermal Resource Council Bulletin, 2000, 29(4):137-141.	Ruggero's paper (more recent reference) reports only 24 MW (Tibet), so we're using this number.
SHINSUKE NAKAO (National Institute of Advanced Industrial Science and Technology (AIST))	4	17	22	-	-	-	4.6	-	In Line 22 of Page 17, Fig.4.6 is referred, but this must be Fig.4.5.	That's correct. Changed in Version 2.
United States (U.S. Department of State)	4	18	11	-	-	-	-	-	"licenses to develop EGS."	Added in Version 2.
United States (U.S. Department of State)	4	18	28	18	30	-	-	-	Section 4.4.3, page 18, line 28-30: Remove first two sentences.	Why? This sentence ("Direct heat supply temperatures are typically close to actual process temperatures in district heating systems which range from approximately 60 to 120°C.") seems to be correct (anyway, please check with John Lund).
Canada (Environment Canada)	4	18	21	18	22	-	-	-	Suggest also citing the availability of other lower cost renewable resources (such as hydro) as a factor.	Added in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	19	7	19	9	-	-	-	Bathing applications are probably not all that important to the world's energy problems and this could probably be deleted.	Perhaps the comment is right, but balneology and swimming are in fact extended current uses of geothermal resources, and that is waht this subsection is dealing about: status of geothermal direct uses.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Zhonghe Pang (Institute of Geology and Geophysics)	4	19	3	19	6	4.4.3	-	-	As the world's largest user of geothermal heat for space heating, China maybe mentioned here as an example of success. In the city of Tianjin alone, more than 10 million square meters of houses are heated using geothermal energy.	New sentence added to this paragraph in Version 2.
Kristin Seyboth (IPCC WG III TSU)	4	20	17	-	-	-	-	-	A reference to Chapter 11 (11.5.4) discussion of FITs would be useful here.	Done in Version 2.
United States (U.S. Department of State)	4	20	0	22	0	-	-	-	Consider shortening this section	Sub-section was re-structured and re-phrased in Version 2.
Juan Llanes (Centre for Environmental Studies)	4	20	28	-	-	-	-	-	Regional resource potential. No mention of possible resource potential in small islands. Mentioned on page 35, row 3/11. Please provide information	These islands include Japan, Indonesia, Philippines, New Zealand, Azores, etc., which are mentioned in Section 4.4
Canada (Environment Canada)	4	20	28	20	30	-	-	-	Text implies that these tax provisions are in use - suggest including reference to which countries are using them.	Text was re-phrased in Version 2 to avoid that impression.
Zhonghe Pang (Institute of Geology and Geophysics)	4	20	11	20	20	4.4.4	-	-	In China, governments in Beijing, Liaoning have implemented policies to subsidize the use of GSHPs to space, which has promoted the rapid growth of the utilization. CDM-clean development mechanism has also been introduced to geothermal development.	This is a good example of what is written in this sub-section.
John Twidell (AMSET Centre)	4	20	33	-	-	4.5	-	-	1) Do you mention the impact of neighboring ground sourced heat pumps at large city complexes? One installation can 'steal' the heat from the neighbours' beneath-ground resource. 2) Do you mention the recharging of ground heat from rejected heat when the heat pumping is used for summer cooling? This becomes a form of interseasonal heat storage.	Chris will try to include this issue not specifically to GHP but all geothermal resources in the proper part of the chapter.
Steffen Schlömer (IPCC WGIII)	4	20	35	20	38	4.5	-	-	Rephrase: "Potential adverse effects from disposal of geothermal fluids and gases, induced seismicity and ground subsidence can be minimized by sound practices. Good practice can also optimize water and land use, improve long-term sustainability of production and protect natural thermal features that are valued by the community.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	20	34	20	35	4.5	-	-	The first sentence sounds like a pure value judgment. Rephrase, e.g.: "Geothermal energy generation in general produces relatively few GHG emissions and has a limited negative environmental impact."	Done in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	21	22	21	27	-	-	-	A reference to the idea of using carbon dioxide as a working fluid would be useful. I suggest looking at some of Karsten Pruess's work on the subject, perhaps his 2006 article in Geothermics.	A more recent reference from Pruess and Spycher, 2010, has been included in Version 2.
United States (U.S. Department of State)	4	21	9	-	-	-	-	-	Change to: "but rarely of sufficient concentration to be harmful"	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	21	22	-	-	-	-	-	include cross-reference to table 4.4. How much CO2 could be stored? Is one cubic kilometer significant? How high are the risks of leakage. Seems to be a possiblity in the very distant future. If this is the case, it should be stated like that.	In fact, the paragraph was moved to section 4.6 (Prospects for technology improvement, innovation, and integration), subsection 4.6.4, where it seems to be best placed, adding a short sentence about long-term, a reference to table and a bibliographic reference in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	21	6	21	8	-	-	-	Lines 6-8: delete sentence beginning "The gases are often¿"	Why? This sentence ("The gases are often extracted from a steam turbine condenser or two-phase heat exchanger and released through a cooling tower. CO2, on average, constitutes 90% of these non-condensable gases (Bertani and Thain, 2002).") seems to be correct.
United States (U.S. Department of State)	4	21	8	-	-	-	-	-	Might want to add that closed loop binary plants do not emit CO2. Possibly add this on Line 6.	This is explictly mentioned in th paragraph: "In low-temperature applications (<100°C), direct CO2 emission from geothermal fluid is about 0-1 g/kWh (electric)…"
United States (U.S. Department of State)	4	21	22	21	27	-	-	-	Page 21 (lines 22-27): the amount of CO2 involved in the ¿closed loop¿ extraction of heat is insignificant with respect to the amount of CO2 that may be lost from the system (sequestered?) ¿ a 5-10% loss rate (equivalent to that observed at Fenton Hill) leads to ¿sequestration¿ of 3MW of coal burning per 1MW of EGS electricity. It is the loss from the CO2 reservoir that is important, not the amount of CO2 re-cycled through the heat exchanger.	Data included in paragraph, in its new location (4.6.4) in Version 2. It is still necessary a reference for this information.
United States (U.S. Department of State)	4	21	3	21	8	-	-	-	Page 21 (lines 3-8): Need to point out that CO2 (and other emissions) is dependent on plant type ¿ with geothermal moving towards lower T resources (e.g. likely EGS targets), closed system binary plants will become more prevalent, thus reducing overall average emissions.	A couple of sentences were added in Version 2.
United States (U.S. Department of State)	4	21	38	-	-	-	-	-	Page 21, line 38: Suggest eliminating the word ¿concentrated¿	Done in Version 2.
United States (U.S. Department of State)	4	21	14	-	-	-	-	-	Page 21: The paragraphs starting on line 14 and line 28 should be combined or eliminate one of them ¿ they both refer to direct use.	Done in Version 2, but all section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	21	19	-	-	-	-	-	Replace "Enhanced Geothermal Systems" with "EGS", use throughout the report, why not here?	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	21	22	-	-	-	-	-	Replace "geothermal reservoirs" with "EGS"	This possibility is not just for EGS.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	21	3	22	38	-	-	-	Section 4.5.1 and 4.5.2: Put information in tables similar to table 7.3 in wind energy chapter or as suggested below: Table 1: CO2-eq emissions during operation, 3-4 columns: 1) type of resource/application (high-temperature field, low-temp field, EGS) 2) CO2-eq. emissions 3) notes (if necessary) 4) reference Table 2: CO2-eq. life-cycle emissions, 3-4 columns: 1) type of plant (closed loop binary cycle, ...) 2) CO2-eq. life-cycle emissions 3) notes (if necessary) 4) reference	The suggestion has merit, but proved to be too difficult to simplify in a single table.
United States (U.S. Department of State)	4	21	0	-	-	-	-	-	Section 4.5.1, page 21: Somewhere it should be stated that the direct emission of CO2 and emission of other gases and liquid is 0 for binary power-cycles that inject all produced flow. Consider adding this to Line 6.	This is explictly mentioned in th paragraph ("In low-temperature applications (<100°C), direct CO2 emission from geothermal fluid is about 0-1 g/kWh (electric)…"),
United States (U.S. Department of State)	4	21	14	21	37	-	-	-	The text could be simplified here by putting all low-temperature, presumably direct use in to one paragraph.	Done in Version 2, but all section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	21	42	22	2	4.5.1	-	-	"If the discharge is significantly in excess of natural hot spring discharges, and is not strongly diluted, then the net effects on ecology of rivers, lakes or marine environments can be adverse." - This seems to be contradictory to the earlier statement that usually no brine is discharged. Please clarify.	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	21	28	21	37	4.5.1	-	-	Do Friedleifsson et al. (2008) provide all the information given here? If so, move reference to end of paragraph. Or does this reference only substantiate the first sentence? If so, additional references for the rest of the paragraph should be included.	Done in Version 2, but all section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	21	14	21	18	4.5.1	-	-	References missing.	This statement does not require a bibliographic reference.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	21	38	21	42	4.5.1	-	-	This paragraph reads as if it was in the operator's own best interest to avoid damage to ecosystems. Is this really the case? I rather assume that strictly enforced regulation is required to prevent surface disposal of geothermal fluids and ensure protection of ecosystems and ground water quality. Rearrange e.g. as follows to avoid that impression: "Most hazardous chemicals in geothermal fluids are concentrated in the water phase. If present, boron and arsenic are likely to be harmful to ecosystems if released at the surface. In the past, surface disposal of separated water has occurred at a few fields. Today it happens only in exceptional circumstances such as equipment failure, since geothermal brine is usually injected into the reservoir. [ADD EXPLANATION, e.g.: Reinjection of the brine has become common practice POSSIBLE OPTIONS a) because of strictly enforced environmental regulation; b) since it enhances the economics of plant operation; c)... .] ..."	Done in Version 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	21	22	21	27	4.5.1	-	-	Using CO2 to enhance geothermal reinjection with sequestration of CO2 has been proposed and is being tested in saline thermal aquifers in sedimentary basins in China.	Data included in paragraph, in its new location (4.6.4) in Version 2.
United States (U.S. Department of State)	4	22	6	22	9	-	-	-	Page 22 (lines 6-9): Although surplus steam condensate may be suitable for irrigation/stock uses, the reality is that it will need to be re-injected for reservoir management, particularly in areas with little or no surface water available for fluid make-up.	That's correct, but in some cases, as the one mentioned in the same paragraph, this condensate may be used for other purposes.
United States (U.S. Department of State)	4	22	6	-	-	-	-	-	Page 22, line 6: I¿m not sure what is meant by surplus steam condensate ¿ condensate not needed for make-up to the heat rejection system or injection?	That's correct: excess of condesate not needed in the condensator.
Steffen Schlömer (IPCC WGIII)	4	22	2	22	4	4.5.1	-	-	State more clearly what negative effects from hazardous chemicals in geothermal fluids can occur. Then state for each of these whether or not government action is required to prevent that or whether there are self-enforcing incentives for private operators to avoid any such risk to the environment. In the latter case, detailed explanations are required.	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	22	4	22	5	4.5.1	-	-	Unclear. Who undertakes monitoring, who mitigates? And why?	Sentence was re-phrased in Version 2.
Germany (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)	4	22	11	22	38	4.5.2	-	-	Federal environment agency of Germany uses different figures for GHG emissions (Umweltbundesamt 2009: Emissionsbilanz erneuerbarer Energieträger. Durch den Einsatz erneuerbarer Energien vermiedene Emissionen im ahr 2007. Climate-Change 12/2009, Dessau-Roßlau); based on Frick, S.et al. (2008): Umwelteffekte einer geothermischen Stromerzeugung. Analyse und Bewertung der klein- und großräumigen Umwelteffekte einer geothermischen Stromerzeugung. Unveröffentlichter Endbericht an das Umweltbundesamt. Leipzig.	In this section are used the more recent results reported by Frick et al., 2010.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	22	36	22	38	4.5.2	-	-	In Chapter 7 on wind energy, p.41, l. 7 it says that from 10 studies analysed the range for wind energy life-cycle emissions is 4.6 to 27 gCO2/kWh. The lowest estimate for life-cycle emissions from geothermal is 23 gCO2/kWh and it goes up to 202 gCO2/kWh(t) for GHPs, which contribute some 70% to direct uses. Hence, life-cycle emissions may be low but nonetheless they are not similar to wind. Therefore, delete: "is similar to other RE (hydro and wind) in total life-cycle emissions, and it".	Done in Version 2.
United States (U.S. Department of State)	4	23	25	23	30	-	-	-	Page 23 (lines 25-30): Although re-injection can minimize subsidence related to fluid withdrawal, there will still be subsidence related to thermal contraction ¿ something that is much harder to manage/mitigate.	New sentence added in this paragraph in Version 2.
United States (U.S. Department of State)	4	23	32	-	-	-	-	-	Section 4.5.4, page 23, line 32: There is a lot of detail in this paragraph that could be removed	This paragraph was shortened and moved to subsection 4.7.4 (Future cost trends), as an additional mechanism to get lower future geothermal costs, in Version 2.
Brazil (Ministry of Science and Technology)	4	23	20	23	20	-	-	-	To be include ¿Monitoring microseismicity is a fundamental tool to the engineering process of building the underground heat exchanger.¿	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	23	13	23	20	4.5.3	-	-	Again, you talk about 100 years of low-impact experience with geothermal energy in general in one sentence. In the next you talk about the methods and effects of EGS. Please insert a sentence in line 14 (or where appropriate) that makes it clear that experience with EGS has only been gained more recently (starting in 1987 at Soultz-sous-Forêts? or earlier?)	Re-structured, re-phrased and complemented paragraphs of this subsection in Version 2 make the issue clear.
Steffen Schlömer (IPCC WGIII)	4	23	6	23	9	4.5.3	-	-	Change: "Such events have not lead to human injury or major property damage FULLSTOP" The following part of that paragraph deals with monitoring and the like. This certainly increases the understanding of the risk of local hazards, and may ultimately allow to minimize these risks. However, more experience may also show that those risks cannot be controlled properly at acceptible costs. You either have to provide evidence that the risks of EGS engineering is well understood or you have to acknowledge explicitely that based on current experience the risks cannot be fully assessed. Furthermore, the risks are probably different at different sites. Are three test sites (these are the only you mention) really enough to identify site specific risk factors?	Text was re-structured and re-phrased in Version 2, and it seems to solve this comment.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	23	32	23	45	4.5.4	-	-	Partial financing of low-carbon projects via CDM credits is nothing specific to geothermal energy. Hence, it is not supposed to be discussed in this chapter. Please delete that paragraph here. One possibility to mention the impact of the CDM would be in the section on "global and regional market and industry status", since the CDM may have had a positive impact on geothermal deployment in developing countries. However, evidence for this would be needed as well, since the CDM is generally designed such that is supports increased deployment of the "lowest-hanging fruits", i.e. the least cost mitigation options first, gradually moving towards more expensive mitigation options. One possibility to mention that the CDM can be used to generate additional funding for geothermal energy projects would be to include something like the ocean energy chapter did in their section on global and regional market status, where they state that ocean energy deployment is generally policy-driven rather than market driven ("Funding mechanisms such as the Clean Development Mechanism (CDM) or Joint Implementation (JI) projects enable developing country governments to secure additional external funding for ocean energy projects.", p.18, ll. 28-32).	This paragraph was shortened and moved to subsection 4.7.4 (Future cost trends), as an additional mechanism to get lower future geothermal costs, in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	42	24	43	-	-	-	"Another measure" - then what is the first?	Changed to "A measure…" in Version 2.
Japan (the Japanese Ministry of Foreign Affairs)	4	24	32	-	37	-	-	-	It should also be explained that it is very difficult to gain social consensus for new geothermal installations, e.g. in Japan: Not only are appropriate sites often located in National Parks, which are subject to strict regulations, they are often located in or near tourist areas where hotel owners are very sensitive to possibilities of depleted spa resources.	Paragraph re-phrased and a new sentence added in Version 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	24	32	-	-	-	-	-	Line 32 should read ¿¿.(e.g. Indonesia, Japan, the USA and New Zealand)¿.	Done in Version 2.
United States (U.S. Department of State)	4	24	1	-	-	-	-	-	Page 24, line 1: see previous comment for page 23 line 32 ¿ could combine and shorten paragraphs	Done in Version 2, but all section was re-structured.
United States (U.S. Department of State)	4	24	6	-	-	-	-	-	Page 24, line 6: Public education and awareness of the probability and severity of detrimental impacts are also important ¿ no surprises.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	45	24	46	-	-	-	The focus should probably be on the surface area, not on the subsurface area. Hence, I would suggest to rephrase, e.g.: "A surface area of about one km2 typically suffices to access a subsurface resource of 10 MWe by directional or vertical geothermal boreholes."	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	32	24	37	-	-	-	This part reads as if you criticise the establishment of protected national parks. I think it would be worthwile to rephrase this, e.g. starting from the third sentence: "Good examples of unobtrusive, scenically-landscaped developments (e.g. Matsukawa, Japan), and integrated tourism/energy developments (e.g. Wairakei, New Zealand and Blue Lagoon, Iceland) exist and can help to overcome such barriers. Nonetheless, land use issues still seriously constrain new development options in some countries."	Paragraph re-phrased and a new sentence added in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	24	40	24	41	4.5.4	-	-	Add "should" if this is a recommendation. I can't image otherwise, since I don't believe that all governmental planning agencies are acting with such foresight.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	27	24	31	4.5.4	-	-	Move this paragraph either to the introduction (in that case reconcile with current introductory paragraph (amended version)) or use as introductory paragraph of suggested new section "4.5.2 Local environmental impacts", since land use specific issues are only addressed in the subsequent paragraphs.	Done in Version 2, but all section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	24	1	24	5	4.5.4	-	-	Move this paragraph to the suggested new section about operational and life-cycle GHG emissions. It is a good example of the possible climate change mitigation effects of geothermal energy use, hence, fits in well in the such a section.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	6	24	25	4.5.4	-	-	Summarize under new heading: "Social issues" or "Local social impacts".	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	24	14	24	21	4.5.4	-	-	This paragraphs lacks references and does not provide evidence. Generally, whatever power plant is being built provides job opportunities. From a macroeconomic perspective, the crucial question is whether other investments are "crowded out" and if so, whether or not the specific investment, here a geothermal power plant, is more labour intensive in operation and construction than the alternative. Only then, there will be a net benefit in terms of additional jobs. Please provide more solid evidence if available.	This paragraph was re-phrased in Version 2, but anyway we need some references..
Steffen Schlömer (IPCC WGIII)	4	24	6	24	13	4.5.4	-	-	This paragraphs lacks references and is very general. Try to provide exemplary evidence, e.g. from company reports.	We'll include some more references in the TOD.
Steffen Schlömer (IPCC WGIII)	4	24	22	24	25	4.5.4	-	-	This paragraphs lacks references. Please provide (exemplary) evidence on such small-scale rural geothermal projects or point out, if not available.	Sentence and reference added in Version 2
Steffen Schlömer (IPCC WGIII)	4	25	1	25	3	-	-	-	Does this mean that a resource of 10 MWe typically spreads over 20km2 underground? Seems to be speculative. Maybe rephrase: "Due to directional drilling techniques the land area above geothermal resources that is not covered by surface installations can stil be used for other purposes (e.g. ...)."	Done in Version 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	26	42	-	-	-	-	-	Add: ¿Technology development to create functional EGS reservoirs independent of local subsurface conditions will be essential¿	Done in Version 2.
United States (U.S. Department of State)	4	26	8	-	-	-	-	-	Delete sentence beginning Satellite based... This thought also appears in the following paragraph.	Paragraphs were merged and re-phrased in Version 2.
Brazil (Ministry of Science and Technology)	4	26	19	26	20	-	-	-	Delete the phrase: ¿Abnormally high fluid pressure in such formations causes abnormal stresses that differ considerably from those found in hydrostatic pressure gradients. ¿ This is a wrong statement, and it is not supported by geomechanics. Salt, that is impermeable, behave as fluid, so it transfers the overburden to all directions, but it does not contain any fluid like water or petroleum.	Sentence deleted in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	26	18	26	19	-	-	-	Page 26 (lines 18-19): Why? Will reservoirs in salt and shale formations play an important role in the geothermal resource potential if the US (or world)? The reviewers doubt it. What about improving rate of penetration in hard rock, developing advanced slim-hole technologies. Also the need for high temperature (450-600C, e.g. Iceland) drilling technology should not be a high priority given limited application, particularly in the US.	In version 2 the sentence was re-phrased, adding the other subjects mentioned in the comment.
United States (U.S. Department of State)	4	26	28	26	32	-	-	-	Section 4.6.3 Third paragraph - consider removing in order to shorten this section	Partially accepted: paragraph was shortened and re-phrased in Version 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	27	27	29	5	-	-	-	Costs of geothermal-electric projects and factors that affect it: at least an estimated Capex number (US$/kWe) for EGS power plants should be added.	Partially accepted: TSU indicated that only actual capex could be included in this subsection, but a note was added in Version 2.
United States (U.S. Department of State)	4	27	35	27	38	-	-	-	Page 27 (lines 35-38): Minor point -- I have yet to hear an industry consensus on what defines ¿success¿ for exploration and test wells, so the reviewers are not sure they agree with the quoted 50-60% success rate.	In the same paragraph is reported other source that reduces the percentage to 20-25%.
United States (U.S. Department of State)	4	27	7	-	-	-	-	-	Page 27, line 7: Unclear to me what is meant by the sentence starting on this line ¿ ¿For power ¿¿ I believe the intent is to state a modular unit could be used to test the performance of different working fluids ¿ my impression is that the authors are referring to a commercially available modular plant. This might be of interest if current methods of predicting fluid properties were inadequate. I don¿t believe this is the case, though there are differences between the different methods. If the properties are adequate, I don¿t see this as providing any significant benefit as most, if not all, of these modular plants are not designed for performance, but rather lower cost. If this were to be done, the test plant should be designed to take advantage of the fluids and their properties.	Paragraph was deleted in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	27	3	-	-	-	-	-	Section 4.6.4, page 27, line 3: While improving component efficiencies can be improved, it is of more importance to develop conversion systems that more efficiently utilize the energy in the produced geothermal fluid at competitive costs. Technologies exist that provide these more efficient plants, however the costs needed to build these plants do not warrant the added cost. It is inevitable that more efficient plants (and components) will be more expensive; improvements are needed to assure that the increased performance justifies these costs. The metric for performance improvement should be the power produced from a given fluid flow and not the thermal (1st law) efficiency. The thermal efficiency is a nebulous term that indicates how efficiently the energy removed from the geothermal fluid; plants having high thermal efficiencies invariably extract only a small amount of energy from the geothermal fluid. Heat exchangers do not have ¿an efficiency¿, nor do heat rejection systems. Their measure of performance is how closely they allow the fluid temperatures to approach during heat transfer processes. Closer approach temperatures are achieved by increasing surface areas (and cost) and/or by improving the heat transfer characteristics of the fluids. One component where efficiency improvements can have a significant impact power generation is the turbine; increase a turbine efficiency from 70% to 80% will increase gross output by ~14% and net power by even more.	Paragraph was re-phrased in Version 2.
United States (U.S. Department of State)	4	27	0	31	0	-	-	-	Section 4.7, page 27-31: I think this section has too much detail and could be shortened.	All the section was re-structured and re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	27	24	-	-	4.7	-	-	delete "that"	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	27	35	28	18	4.7.1	-	-	The minimum values of cost components a, b and c plus the maximum value of cost component d add up to more than 100%. Please clarify.	Explanation added in Version 2.
Australia (0)	4	28	-	-	-	-	-	-	It should be acknowledged that the long term sustainability of deep EGS is unkown and this type of geothermal system is the most capitally intensive	A sentence was added in introductory paragraphs of this section, in Version 2.
United States (U.S. Department of State)	4	28	10	-	-	-	-	-	Section 4.7.1, page 28, line 10: The cost for surface facilities and infrastructure being 10 to 20% of the total capital cost seems high. The EPRI study in 1995 gives costs of surface facility costs (which include production pumps if needed) varying from 1% to 8%. It is difficult for me to see what other large infrastructure costs would be incurred to approach 20% of the total capital costs; I don¿t have access to the referenced paper. I suggest using a lower value for the lower end of the range, and indicating that this value is also going to be dependent upon plant size and location.	Done in Version 2.
Juan Llanes (Centre for Environmental Studies)	4	28	17	-	-	-	-	4.8	to much n.s.: Not specified, please review	Column deleted in Version 2.
Juan Llanes (Centre for Environmental Studies)	4	29	2	-	-	-	-	-	Labour costs can increase by 10% when a resource is remotely located, please clarify the case of ¿remotely located¿.	Paragraph on labour costs as deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	29	36	-	37	4.7.2	-	-	delete reference to the calculator, not needed, no official publication, just operationalisation of methodology described in annex II	Done in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Rainer Walz (Fraunhofer Systems and Innovation Research)	4	30	30	-	-	-	-	-	forecast in table 4.9. only reaches until 2050, not 2100 as mentioned in the text	Done.
United States (U.S. Department of State)	4	30	28	30	32	-	-	-	Page 30, line 28-32: The role of the degradation in resource productivity (temperature, flow, enthalpy, or combination of these) on capacity factor should be described. Since 40% of the installed capacity has been operating for 25 years or more (Executive Summary) this decline has had a significant impact on the capacity factor if the initial installed capacity is used in the determination of the capacity factor. Drilling of additional wells can mitigate this effect, but do not completely alleviate it unless the entire well field is replaced (and the new field provides fluid at the initial design conditions).	New sentence was added in the proper part in Version 2.
United States (U.S. Department of State)	4	30	3	-	-	-	-	-	Section 4.7.2, page 30, line 3: I briefly looked at the MIT report and could not find the generation costs in this section. The pages in the MIT report from which these costs were taken should be identified.	It is indicated the table where these figures come from. However, it has been taken into account that were converted to 2005 US$.
United States (U.S. Department of State)	4	30	23	30	24	-	-	-	Section 4.7.3, page 30, line 23-24: In the US commodity prices began to increase between 2003 and 2004; I presume that this was also reflected in the world markets as well.	Paragraph was slightly re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	30	26	-	27	-	-	-	The decrease in cost of installation claimed here, is not evident from table 4.8. The statement is generally convincing, but better evidence is necessary. Particularly, as the global economy has since started to grow again and the decline in input prices is very likely to be only a temporary phenomenon.	A new sentence was added in the proper paragraph in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	30	28	31	11	-	-	-	This part basically discusses the impact, historical trend and future prospects of a change in the capacity factor of geothermal power plants. This discussion is important, but it should not replace a thorough discussion of historical cost trends. So this comment is twofold: a) The discussion of the capacity factor should be included, but since it does not (or only to a minor extent) affect the cost of installed capital, it should be discussed separately as suggested in my more general comment on section 4.7 and in the context of LCOEs (bottom line: LCOE (high CF) < LCOE (low CF)). b) Historical trends in the cost of installed capital should be discussed more thoroughly. From the information currently in the SOD, I am under the impression that the cost of installed capital did not change much in the past and that future changes in installed capital cost are basically expected due to changes in the cost of well drilling. Therefore, a discussion of e.g. historical trends in prices for drilling rigs or (if feasible) the costs for drilling "standard wells" could provide valuable insights. I am aware of the fact that there might be a problem in defining a common measure of performance (such as a "standard well") on the basis of which projects or project components could be compared, particularly since there seem to be little intermediate products, the price developments of which could be assessed. However, I would suggest then to point this out explicitely. Btw, the development of the success rate of exploration and test well drilling (mentioned in section 4.7.2) might be one indicator of technological progress in that part of the geothermal value chain.	Partially accepted. The sub-section and the entire section was re-structured and re-phrased in several parts in Version 2, but no more discussion on historic trends was included dur to the current space limitations for chapter 4.
Steffen Schlömer (IPCC WGIII)	4	30	3	-	15	4.7.2	-	-	Maybe some of the text can be shortened and the key factors affecting the cost of EGS projects be made more transparent, if you include another figure showing LCOE as a function of well-productivity (in kg/s) on the x-axis and different resource grades as distinct cases (cf. figure 7.19 and feel free to ask TSU staff for more detailed recommendations).	Partially accepted. The complete section was re-structured in Version 2, becoming more transparent, but no new figure was included.
Steffen Schlömer (IPCC WGIII)	4	32	21	-	-	-	-	-	Explain the term fossil fuel peaking.	Term modified in Version 2.
Steffen Schlömer (IPCC WGIII)	4	32	7	-	-	-	-	-	Income from the product does not affect the cost, but total output affects the LCOEs. Hence, delete: ",and the income from the product produced". Instead, insert: "The LCOE of direct use projects decrease with increasing total output."	Sentence re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	32	21	-	-	-	-	-	insert "excess demand in" after "meet"	Done in Version 2.
United States (U.S. Department of State)	4	32	21	-	-	-	-	-	Section 4.7.5, page 32, line 21: The intent of the sentence starting ¿ Often fossil fuel¿¿ is not clear to me	The word "peaking" was deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	32	21	33	1	-	-	-	Split sentence after "fluids" to simplify.	It belongs to the same idea and the same paragraph.
Steffen Schlömer (IPCC WGIII)	4	32	19	-	-	-	-	-	switch "was used" and "the same load factor"	Paragraph re-phrased in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	32	9	-	-	-	-	-	temperate	Done in Version 2.
Juan Llanes (Centre for Environmental Studies)	4	32	5	-	-	-	-	4.7.5	Suggest to replace ¿economics of¿ and use ¿costs of¿	Done in Version 2.
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	33	24	-	-	-	-	-	2010. PROCEEDINGS, Thirty-Fifth Workshop on Geothermal Reservoir Engineering, Stanford University,	This reference does not refer to the subject.
Steffen Schlömer (IPCC WGIII)	4	33	4	-	5	-	-	-	Add references to last sentence.	Ask to John Lund. The final draft of the SRREN will be processed by a professional copy-editor. All editorial comments such as this will be resolved at that time.
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	33	24	-	-	-	-	-	California, USA, February 1-3, 2010. (http://pangea.stanford.edu/ERE/pdf/IGAstandard/SGW/2010/lund.pdf)	This reference does not refer to the subject.
Steffen Schlömer (IPCC WGIII)	4	33	33	-	45	-	-	-	Excellent introduction, sounds promising	Accepted
United States (U.S. Department of State)	4	33	4	33	5	-	-	-	Page 33 (lines 4-5): either explain how the load density was determined or provide a reference.	Same as previous. The final draft of the SRREN will be processed by a professional copy-editor. All editorial comments such as this will be resolved at that time.
Steffen Schlömer (IPCC WGIII)	4	33	10	-	-	-	-	-	replace "as the larger the building ¿" by new sentence: "Heating and/or cooling large buildings lowers the levelized cost of capital investment and LCOE."	Done in Version 2.
United States (U.S. Department of State)	4	33	43	-	-	-	-	-	Section 4.8.1, page 33, line 43: don¿t repeat what has been said.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	33	43	34	4	-	-	-	Slight changes proposed: "Historica growth rates for geothermal-electric uses (5-year averages) have been positive but continuously declining for 20 years until 2005. From 2005 until 2010, however, this trend did not continue. According to the latest country-update reports, the capacity of geothermal-electric projects stated as under construction or planned is expected to reach 18,500 MWe by 2015 (Bertani, 2010). This represents an annual average growth of 11.5% based on the present (BAU) conditions and expectations of geothermal markets." Add something on the reliability of country reports on this. Are these projects already under construction? How certain is it that the planned projects are really going to be built?	Sub-section was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	33	9	-	10	-	-	-	Split sentence after "installation".	It belongs to the same idea and the same paragraph.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Ladislaus Rybach (Geowatt AG Zurich (company))	4	33	9	-	14	-	-	-	This paragraph refers to LCOE of geothermal heat pumps; the numerical values are gven in Table 4.10. For which GHP types are these numbers valid? Horizontal or vertical closed loop? Open loop? Identify!	The range covers all types of GHP not a specific type. The only difference is between residential and commercial.
Steffen Schlömer (IPCC WGIII)	4	34	20	-	-	-	-	-	"huge", replace by concrete numbers on developed and technical potential.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	34	24	-	-	-	-	-	"may" or may not? Degree of (un)certainty unclear. If this is basically a possibility, use the term could (based on availability of technical potential).	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	34	17	-	18	-	-	-	"prospective conventional hydrothermal resources" - term needs explanation, refer to section 4.2, consider comments on that section, particularly on defintion of "hidden potential"	It was changed to "hidden" in Version 2.
Steffen Schlömer (IPCC WGIII)	4	34	29	35	2	-	-	-	Add references	Paragraph was re-phrased in Version 2.
United States (U.S. Department of State)	4	34	17	-	-	-	-	-	Page 34, line 17: This discussion is largely about potential, which was discussed in previous section. Need something to indicate probable growth in usage or delete.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	34	5	-	-	-	-	-	quote references sharing this expectation. What has been driving this growth? Include a discussion of the drivers of the constantly high growth rates of direct uses in the past in section 4.4. Then refer to this discussion here and explain if and how the driving forces have changed.	Partially accepted, since sub-section was re-phrased in Version 2, including some of these comments.
Steffen Schlömer (IPCC WGIII)	4	34	13	-	16	-	-	-	References for expectations concerning EGS needed.	Instead, a sentence was added in Version 2.
China (China Meteorological Administration)	4	34	8	34	9	4.8.1	-	4,11	(1) Geothermal installed capacity is 28.18MWe in China. Reference: Zhao Ping. Geothermal Tibet AR - an overview of resources and power generation. Geothermal Resource Council Bulletin, 2000, 29(4):137-141. (2) China and India fall into the same "developing Asia". It is suggested to merge China and India into the "developing Asia".	The more recent paper (Bertani, 2010), based on more recent Chinese reports, is 24 MW, so perhaps some plants were dismantled since 2005.
Steffen Schlömer (IPCC WGIII)	4	35	3	-	5	-	-	-	Add comparison of current deployment vs. Technical potential.	It is not deemed necessary under the context of this paragraph.
Steffen Schlömer (IPCC WGIII)	4	35	27	-	28	-	-	-	Add further references, e.g. IEA ¿	Sentence was deleted in Version 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	35	31	-	-	-	-	-	Complete last sentence: ¿¿.energy-use in buildings and thus high potential for CO2 emission reduction¿.	Done in Version2.
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	36	11	-	-	-	-	-	followed by corresponding data for 440-600 ppm scenarios, and finally data for 300-440 ppm scenarios.	Continuation of the previous.
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	36	11	36	16	-	-	-	It is recommended to rephrase the section starting with 'Projections of geothermal energy¿'	Done in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	36	11	-	-	-	-	-	It is recommended to start with 25th-75th percentile data for 600-1000 ppm scenarios in 2020, 2030 and 2050,	Done in Version 2.
United States (U.S. Department of State)	4	36	5	36	10	-	-	-	Page 36 (lines 5-10): minor point ¿ for clarity it should be stated that the ppm values refer to stabilized CO2 volume concentrations in the atmosphere (?).	Done in Version 2.
Netherlands (KNMI (Royal Dutch Meteorological Institute))	4	36	11	-	-	-	-	-	Upper bounds, e.g. 50 EJ in 2050, are not as representative as modelled scenarios, and don't need mentioning	75th-75th interquantile is mentioned instead, in Version 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	37	15	38	11	4.8.2	-	-	As we are not preparing a report for OECD or IEA, the denotion of regions should be in the most general form for brevity. For example, China and India are parts of "developing Asia". Not everybody is immediately aware of which countries are included in OECD Europe.	Table 4.13 was deleted and the subsection was re-structured and re-phrased in Version 2.
China (China Meteorological Administration)	4	37	8	37	9	4.8.2	-	4,13	China and India fall into the same "developing Asia". It is suggested to merge China and India into the "developing Asia".	Table 4.13 was deleted and the subsection was re-structured and re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	38	14	-	-	-	-	-	not probably, but certainly. The 300-440ppm targets are not generally considered to be achievable without climate policy incentives. The range of carbon prices in the 300-440ppm scenarios will certainly be high, and one of the main drivers for geothermal to become more competitive.	"probably" deleted in Version 2.
United States (U.S. Department of State)	4	38	38	-	-	-	-	-	Page 38 (line 38): Are EGS methods being used for developing direct heating technologies?	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	38	43	-	46	-	-	-	Rephrase: "In order to achieve more efficient and sustainable geothermal energy supply, sub-surface exploration risks need to be reduced and reservoir management needs to be improved i.a. by optimizing reinjection strategies, avoiding excessive depletation and planning of future make-up wells."	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	38	40	-	-	-	-	-	replace "will" by "needs to be"	Done in Version 2.
Canada (Environment Canada)	4	38	27	38	29	-	-	-	Sentence is directly copied from section above.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	29	-	-	-	-	-	add "though costs tend to be higher than for condensing flash plants in good resource locations"	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	4	-	5	-	-	-	delete	Partially rejected. The sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	34	-	37	-	-	-	In section 4.7 you explain that increases in the cost of material and drilling rigs lead to a significant increase in the cost of installed captial for geothernal. This should be mentioned here as well, even though it does not undermine the general statement that no middle- or long-term constraints are foreseeable.	Why this must be mentioned here? The paragraph are refering to different matters.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Norway (Climate and Pollution Agency)	4	39	13	-	-	-	-	-	In the current sentence, induced seismicity is only associated with hydro-fracturing, but it could also result from operation of the reservoir as mentioned in 4.5.3.	Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	32	-	36	-	-	-	Other references than table 4.13 needed to support that statement, since table 4.13 is not a credible forecast due to methodology and the fact that it's only based on Bertani (2010).	Partially rejected. Sentence was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	39	-	41	-	-	-	Projections suggest? There's still only one source that projects this increase, i.e. Bertani (2010). It is, however, unquestionable that the resource is sufficient to support that growth.	Paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	26	-	-	-	-	-	replace "prove" by "evaluate"	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	16	-	-	-	-	-	Sound practices need to be implemented to ensure the protection of ¿	Sound practices are already in use, and does not need to be implemented.
Steffen Schlömer (IPCC WGIII)	4	39	45	-	46	-	-	-	The dispatchability is indeed one of the aspects that deserves attention. However, it is not unique to geothermal energy. Biomass is also a form of stored energy, hydropower can be stored as pumped hydro etc. Every technology is unique. This does not necessarily mean that it will play a key role. Geothermal is one of many solutions in a mix of technologies.	Partially rejected, since there are no biomass power plants feeding the grid as geothermal power plants and hydro power units depend on rain rates and then are not base-load. However, the word uniquely was changed to favourable.
Steffen Schlömer (IPCC WGIII)	4	39	23	-	25	-	-	-	This is only the expectation of Bertani (2010), but not at all shared by the 150+ scenarios asssessed! Delete!	It is not only a expectation from Bertani, it is a fact supported on the figures and tables presented in this paper.
Steffen Schlömer (IPCC WGIII)	4	39	36	-	38	-	-	-	totally confuse sentence, delete! Instead, clearly state what is required for increased deployment of direct use and GHPs.	Sentence was deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	39	1	-	4	-	-	-	Unclear	Sentece was re-phrased in Version 2.
United States (U.S. Department of State)	4	40	0	-	-	-	-	-	References to papers from the World Geothermal Congress 2010 (and also WGC 2005) should include the web address for ease of access by readers of this report to the referenced papers.	This will be done in the last version.
United States (U.S. Department of State)	4	45	7	-	-	-	-	-	The paper referenced here is available at http://geothermal.inl.gov, please indicate this.	It is the Tester et al. 2006 paper. Done in Version 2.
Patrick Matschoss (TSU)	4	-	-	-	-	-	-	-	check definitions in glossary: p. 4, l.12-7; liaise with chapter 1 if not consistent	We'll check the Glossary and propose the proper ammendments.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	-	-	-	-	-	-	-	In line 31 delete ¿shallow¿.	It refers to page 6 ("shallow systems"). Deleted in Version 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	-	-	-	-	-	-	-	Line 20 should read ¿¿.electric generation producing 67 TWhe in 24 countries¿¿	The amount reported is 67.2 TWh/y.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Henk Pagnier (0)	4	-	-	-	-	-	-	-	Management summary: I would stress the fact that geothermal energy has a LCOE which is significantly lower than wind and solar, and that geothermal development relative to these has been hampered by a lack of a level playing field for geothermal RE. Further the growth scenario in towards 150GWh is largely based on conventional (magmatic/hydrothermal sources). It is very hard to predict what will happen with EGS. In my view these growth paths should be separated (or at least mentioned as such). This is important as the EGS may well grow more rapidly than conventional when exploration and HSE risks are no issue towards levels of 1000-2000GWe (28-57EJ/yr) which is still a small fraction of the technical potential of 270-1000EJ/y.	Partially accepted. Not the role of this chapter to compare geothermal with other RE. Section 4.8 deployment projections have taken into account differences between hydrothermal and EGS deployments.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	-	-	-	Metrics: Write US$ xxx million, instead of MUS$ xxx.	It was changed in Section 4.7.5, Ver. 2.
Ladislaus Rybach (Geowatt AG Zurich (company))	4	-	-	-	-	-	-	-	My comments to Chapter 4 of the FOD have been considered.	No action required.
Peter de Haan (Ernst Basler + Partner AG)	4	-	-	-	-	-	-	-	no comments from Reviewer P de Haan	No action required.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	-	-	-	Replace the term capex by cost of installed capital or whatever standardization is agreed at LA4.	We prefer the use of capex.
Zhonghe Pang (Institute of Geology and Geophysics)	4	-	-	-	-	-	-	-	The chapter is very informative and in general well prepared. It generally reflects the current status of geothermal energy technology and industrial development globaly though the advantages of geothermal energy is expressed in a rather modest tone. The future projections are based on reasonable estimates thought with high level of technological and policy/market uncertainties. Probably owing to the large number of authors, materials are not placed in the most appropriate locations sometimes. Thorough revision and editing is strongly recommended. Length of the document can be reduced to the page limit by deleting duplicated text and refining the text of section 4.8, as detailed in the specific comments.	Accepted in general, but structure of section 4.8 was defined in the OOA and can not be modify.
United States (U.S. Department of State)	4	-	-	-	-	4,2	-	-	Section 4.2: The reviewers dislike the concurrent use of EJ/yr and GWe; suggest using one or the other when describing potential (perhaps EJ/yr). It is suggested to also refrain from using the capacity factor ¿ not sure that this parameter is that important when discussing potential. Authors may want to rethink capacity factor.	Unfortunately, the bibliographic references are sometimes in GW (capacity) and then we need to convert into EJ/y (energy generation). And the only way to convert capacity into energy generation is by using a capacity factor.
United States (U.S. Department of State)	4	-	-	-	-	4,7	-	-	Section 4.7: There seems to be some discrepancy in the numbers that are reported between different data sources. This should be clearly defined and reported.	Numbers are different because the sources are also different.
Fritz Vahrenholt (Prof. Dr.) (RWE Innogy GmbH)	4	-	-	-	-	4.1	-	-	Explain difference between hydrothermal and EGS technologies with figures.	Unfortunately Chapter 4 has not enough space. However, this difference is explained in Section 4.3.5.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.1	-	-	The introduction contains only three references despite ist lenght of 2 pages. Please repeat references quoted in the subsequent sections of the report to substantiate the information presented. Even if this is textbook knowledge, proper references are recommended.	New paragraph was included (with more references) and the section was re-phrased in some parts.
Henk Pagnier (TNO)	4	-	-	-	-	4.2	-	-	figure 4.1 projects direct use as very low contribution. It probably does not take into account using power potential for direct use. Industrial applications could strongly benefit from this use as mentioned in 4.7 line 15 and further (payout time of 2 years, LCOE ?. I recommend to but this aspect at this stage, as further developments of Relocation of energy intensive industries to energy sources (e.g. melter in iceland) is a realistic option.	Recommendation is not clear. The reviewer's assumption is correct (potential for direct uses does not take into account using power potential fir direct uses), but his recommendation is not clear.
Henk Pagnier (TNO)	4	-	-	-	-	4.2	-	-	relation between theoretical and technical appears wrong should be 1e6EJ theoretical ~ 2.61 EJ/y	Same as previous.
Henk Pagnier (0)	4	-	-	-	-	4.2	-	-	relation between theoretical and technical appears wrong should be 1e6EJ theoretical ~ 2.61 EJ/y	That's correct. Changed in Version 2. Very good observation.
United States (U.S. Department of State)	4	-	-	-	-	4.2.1	-	-	Per the organizing body's request to indicate sections of each chapter that can be shortened in terms of text and/or figures and tables. This section could be shortened and include less discussion about the methodology used to determine the various technical resource estimates and just cite the estimates and sources. In most cases, if a reader has an interest in the methodology used to estimate technical potential, they will have to review the source document regardless of how much information is conveyed in the SRREN chapter. Therefore, you can probably save space by just limiting the discussion to specific figures and limit the amount of discussion relating to how those figures were determined.	Chapter 4 is as short as it is possible, giving the diversity of geothermal resources and the need to explain them in a credible manner.
United States (U.S. Department of State)	4	-	-	-	-	4.2.1	-	-	Sect 4.2.1 p. 8, The text in Section 4.2.1 and corresponding Table 4.3 (later in Section 4.2.2) should include estimates of the energy contained in fluids produced through oil and gas operations; at a minimum the energy contained in the water. Tester et al. 2006 provides such an estimate for the United States. Co-produced water from the Teapot Dome oilfield in Wyoming, USA currently has a 250 KWe generation capacity using about 98°C water. Additional projects are being developed in the US Gulf Coast.	Technology is described in subsection 4.6.3. The potential is embeded in the estimated geothermal potentials.
Gerrit Hansen (TSU)	4	-	-	-	-	4.2.1	-	-	theoretical potential is given as a flux for all energies in the SRREN. Chapter 4 reports stocks, which is irritating to the reader. Please reconcile chapter in a way, that the difference between energy contained/stored in the earth crust, the renewable flux (heat flux reported in ln 8-12 of page 8), and the Energy flux (EJ/y) that could be theoretically and technically retrieved from this resource becomes clear, and label the results accordingly. Please also reconcile with table 4.2, and with Table 1.1 in chapter 1! (where the total stock is reported as annual flux).	It seems to be some confusion: the mentioned lines (8-12) refer to heat flow, NOT to the geothermal theoretical potential. The global heat flow is not necessarily the same as the theoretical potentials included in Table 2 (as Hansen seems to believe). Anyway, it is necessary to review table 1.1 of Chapter 1.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.3	-	-	In this section, information about what is commonly done, e.g. in reservoir engineering, is mixed with recommendations about what should be done, i.e. with what is considered to be some sort of currently known best practice. It would be valuable information if the authors could present separately (1) what is considered to be best practice, (2a) where common practice falls behind that benchmark and (2b) why (e.g. higher costs, lack of engineering knowledge, ...).	Partially accepted. The only section where is some mixing of what is currently done and what is recommendable to do is 4.3.6 (submarine). This section was re-phrased in Version 2, moving one paragraph to section 4.6.3.
United States (U.S. Department of State)	4	-	-	-	-	4.3.2	-	-	Nothing is mentioned in this section about the opportunities for using cutting edge technology to advance geothermal energy production from oil and gas fields. The primary benefit from such an opportunity is that the drilling is already in place and can greatly reduce the first costs associated with geothermal project development. Countries with oil and gas fields can re-purpose their operations to generate significant amounts of geothermal energy. Blackwell and Richards, 2005	A new paragraph was added, not here but in Section 4.6 (sub-section 4.6.3) in Version 2.
Henk Pagnier (TNO)	4	-	-	-	-	4.3.2	-	-	This paragraph would benefit going more in depth on high variability of underground conditions and associated LCOE, depending on a mix of underground temperatures (make a reference to heat flow figure 4.5) and achievable flow rates (combined effects of natural and engineering conditions). For the European setting a reference to the recent review paper on EGS exploration by Cloetingh et al, 2010 in earth science reviews (downloadable through Sciencedirect) would be appropriate	Same as previous.
Henk Pagnier (0)	4	-	-	-	-	4.3.2	-	-	This paragraph would benefit going more in depth on high variability of underground conditions and associated LCOE, depending on a mix of underground temperatures (make a reference to heat flow figure 4.5) and achievable flow rates (combined effects of natural and engineering conditions). For the European setting a reference to the recent review paper on EGS exploration by Cloetingh et al, 2010 in earth science reviews (downloadable through Sciencedirect) should be included	New paragraph and reference included in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.3.3	-	-	This section is also hard to read for lay persons. Start this paragraph with the objectives of reservoir engineering which seem to be (a) to determine the optimal plant size based on a number of conditions such as sustainable use of the available resource and (b) to ensure sound and efficient operation during the lifetime of the project.	New sentence added at the beginning of this paragraph.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.3.4	-	-	This section is hard to read for lay persons. It would be helpful to know whether there is any convergence in design and choice of power plant technologies. This does currently not become very clear. I would suggest to simplify this section and rearrange along specific technological requirements of reservoir characteristics such as type and temperature of geothermal fluid. For example, paragraph 3 could read: "Lower temperature geothermal fluids in the range of about 70°C to 170°C are not sufficient for efficient use in dry steam or flash plants. To utilize this resource more complex binary cycle plants have to be built. In these plants the geothermal fluid passes a heat exchanger, where it vaporizes another working fluid with a low boiling point (e.g. isopentane or isobutane) to drive a turbine that generates electricity." Each paragraph should contain a statement on the loss of efficiency and other trade-offs, such as higher cost.	The section was re-structured in the way suggested in Version 2.
United States (U.S. Department of State)	4	-	-	-	-	4.3.5	-	-	Section 4.3.5, Page 14: Word to similar to the following should be included in the discussion: In order to accurately simulate EGS reservoirs computer codes must fully couple flow, chemistry, poro-elasticity and temperature. Development of suitable fully-coupled reservoir simulators is a necessity. There is also a real need for the geothermal community to have access to modern laboratory facilities capable to test rock specimens under simulated downhole conditions of pressure and temperature. Need to consider non-linear deformability of fractures.	A new paragraph was added in Section 4.6 (new sub-section 4.6.1) in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.3.5	-	-	The heading of this subsection makes it very clear that the content in this section actually belongs into section 4.6. It should be renamed "Enhanced Geothermal Systems" and rather than list research needs here, it should refer to section 4.6 where a discussion of research needs and prospects belongs.	In Version 2 the original Table 4.4 was moved to Section 4.6, where a new sub-section was created (4.6.1. Technological and process challenges in EGS). Heading 4.3.5 was changed.
United States (U.S. Department of State)	4	-	-	-	-	4.3.6	-	-	Section 4.3.6 page 14: While the reviewers agree this is a potential resource, there should be some indication that use of this resource is largely conjecture at this point. While we may not know until we try to use them, is there anything to suggest that these vents would continue to produce waters at the same temperatures if one drilled into the ¿reservoir¿. If one is only able to convert 4% of the thermal energy and a vent produces up to 60 MWt, it is hard to see this having a large potential unless drilling can be done to produce larger flows without degrading the resource temperature/enthalpy.	In Version 2, this sub-section was moved to Section 4.6 as 4.6.5, and a new sentence was added.
United States (U.S. Department of State)	4	-	-	-	-	4.3.6	-	-	This section may be worthy of removing if the length of chapter is in question. This is not my area of expertise, but my inclination is that the near-term contribution and cost effectiveness of submarine geothermal generation is somewhat limited.	In Version 2, this sub-section was moved to Section 4.6 as 4.6.5.
United States (U.S. Department of State)	4	-	-	-	-	4.3.8	-	-	Add some info: Drilling costs continue to be the largest barrier to GHP deployment in the U.S. market. There are significant gaps in trained and experienced well field drillers in certain areas of the U.S. for GHP systems.	Partially accepted: a sentence was added in Version 2, not here but in Section 4.8 (Potential deployment), at the end of subsection 4.8.1.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
John Twidell (AMSET Centre)	4	-	-	-	-	4.3.8	-	-	Ground source heat pumps. I suggest you treat ground sourced heat pumps as an entirley separate subject, with its own cost analysis, social and environmental impacts, and conclusions etc. Make a new section at the end of the chapter for this. At the moment, the subject appears from nowhere and disappears as quickly.	Chapter 4 team considered previously this idea but decided not to do that, giving the space limitation of the chapter 4. In order to not ignore the contribution of widespread deployment of GHPs we declared as a special subset of direct uses in Section 4.1 (Introduction).
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.2	-	-	Cumulative investment of 248 million US$ in what? In R&D on EGS? In demonstration projects? Or is this total investment in geothermal energy deployment in general including all kinds of technologies and applications?	It seems to be clear enough that those amounts represent money invested in the exploration and development of EGS projects.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.2	-	-	In order to avoid the impression of a biased representation, it should be clearly stated that there are currently no commercially operating EGS plants in the beginning of that section.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.2	-	-	Include a statement like that found in section 4.8 :"For power, practically all the new power plants expected by 2015 will be conventional (flash and binary) in hydrothermal resources, with only a marginal contribution of EGS projects. In general terms, the worldwide trends in development of EGS are estimated to be slow in the next 5-10 years, and then present an accelerated growth." (p. 34, l. 14 ff.).	This section deals with current status not with potential deployment, thus is not proper to include comments on projections.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.2	-	-	The information about Australian stock market-registered companies is not very clear. Are they holding licenses for EGS technology or some license for conventional geothermal technologies?	The paragraph clearly states that are "geothermal exploration licences", but anyway it was re-phrased as "geothermal exploration licenses to develop EGS", as suggested in a further comment.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.2	-	-	What kind of experience has been made at demonstrations sites in Soultz-sous-Forêts, Landau and at the geothermal test site in Schönebeck?	A new sentences was added in this paragraph in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	Consider moving or repeating the introductory sentence of section 4.3.8 here: "Geothermal Heat Pumps (GHP) have experienced [replace "have experienced" with "have been"] one of the fastest growing applications of renewable energy in the world (Rybach, 2005; Lund et al., 2010)." (p.15, l. 31 f.).	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	Did the share of GHP in geothermal direct uses increase, remain constant, or decrease? This information is missing.	A sentence was added in the first paragraph of this subsection in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	Information about the "GHP industry" would be interesting.	Agree, but it would take more room. Finally, GHP are just one subset on direct uses, as stated in this chapter.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	Much of this section contains information on the application of direct use of geothermal heat and, hence, should rather be moved to section 4.3.7, also taking into accoun the open questions posed in the comment on section 4.3.7 ("It is unclear how this kind of space heating is ...").	Direct use applications are mentioned in the context of the current status, but do not include technological descriptions that allow to be moved to Section 4.3.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	The last paragraph should be moved to the very beginning of this section. Otherwise the dominant role of GHP in direct use does not become clear.	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	The relative contribution of geothermal heat to total heat consumption is missing.	We'll include the number, and Arni will provide the data and reference.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	There's no information on historical growth trends, nor a discussion thereof. This really needs to be included. Particularly, as you are, rightly so, refering to historical growth rates in the section on near-term potential deployment. However, without a discussing of the fundamental drivers of growth, an extrapolation into the future is not a sound undertaking!	A last paragraph was added to this section in TOD.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	Total heat consumption in the sectors relevant to direct use of geothermal energy should be stated as well as the percentage share of geothermal in each of these sectors (space heating; bathing, swimming and balneology; aquaculture; greenhouses; industrial process heat). Historic market development, i.e. the shares of geothermal technologies in each of this sectors over time, should be described. Did geothermal heat supply grow stronger than total heat demand?	We believe that the relative percentages already presented are enough.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.3	-	-	What is the relative importance of large-scale central heat production? Have heat distribution networks been expanded? What are the respective advantages and disadvantages of large-scale heat generation compared to small-scale decentral solutions like GHPs? What are the economics of heat networks?	It would be interesting to discuss all this points, but the fact is chapter 4 has not enough room to do that. District heating could be (and may be deserves to be) a section by itself, but it is not possible in this chapter.
Christoph von Stechow (IPCC WGIII TSU)	4	-	-	-	-	4.4.4	-	-	Instead of following the outdated taxonomy of barriers, the section on barriers should rather focus on technology-specific barriers, as agreed during the LA3 meeting in Oxford.	Sub-section was re-structured and re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.4	-	-	The taxonomy of barriers is not repeated or explained anywhere in the SRREN.	Sentece was deleted in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.4	-	-	This section does not contain any reference. Clearly, this section presents nothing but the personal opinion of the authors on what barriers are preventing uptake of geothermal.	Two references were added, and Jeff Tester will provide additional references..
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.4.4	-	-	This section does not quote any references. Particularly impacts of different policies are highly debated. These different views need to be reflected here and substantiated by adequate references.	Two references were added, and Jeff Tester will provide additional references..

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.5	-	-	I would suggest ot rearrange this somehow. CO2 and life cyle assessment could be combined into climate change impacts, other gas and liquid emissions rather belong to the class of local impacts. The latter of course also comprises hazards of induced seimicity and land use issues. 4.5.1. GHG emissions during operation and life-cycle 4.5.2. Local environmental impacts 4.5.2.1. Gas and liquid emissions during operation 4.5.2.2. Potential hazards of induced seismicity, ground subsidence and others 4.5.2.3. Land use 4.5.3. Local social impacts	All the section was re-structured as suggested in Version 2.
Grant Ferguson (St. Francis Xavier University)	4	-	-	-	-	4.5.2	-	-	There are important aspects of LCA for other geothermal applications. Of particulary interest is the source of electricity used to run the heat pump.	A new sentence was added in the proper paragraph in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.5.3	-	-	Explain the respective relevance of local hazards for different geothermal energy technologies. I assume no/low risk for GHPs, medium risk for conventional hydrothermal technology, higher risk for EGS. State historical experience separately for each of these technologies.	Partially rejected. This is a way to present this kind of risks (e.g. by type of resource/application), but the other way is like is currently presented: by specific risk and then mention where it may ocurr and what can be done ro prevent/mitigate. Anyway, sub-section and section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.5.3	-	-	In general, it would be very enlightening to get more quantitative data on the historical rate of occurence of such local hazards, say global average number of incidences per site (if possible weighted with economic damages caused or separately for each type of incidence). Is it one out of 10 or 1 out of 1000 sites, where "more serious" hazards occur?	It seems not to be the site to discuss in deep all the risks of geothermal plants and field operations and the current measures to avoid/mitigate them.
Grant Ferguson (St. Francis Xavier University)	4	-	-	-	-	4.5.3	-	-	It should probably be noted that these seismic events are not unique to geothermal developments. Nicholson and Wesson (1992, Pageoph.) provide an overview of numerous deep well projects that have caused earthquakes.	Sentence added in Version 2. We'll use the reference from Mager et al., 2007 to be provided by Chris.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	-	-	-	-	4.5.3	-	-	Section 4.5.3 p. 22: One needs to accept that injection or withdrawal of fluids from an underground formation will result in changes of the ¿effective¿ in-situ stress field which can lead to re-adjustment or re-activation of pre-existing discontinuities (from microcracks to large faults). The goal then would be to minimize the magnitude of those induced ¿earthquakes¿. This is essentially a matter of energy balance: knowing the energy level that has been input during the injection, one need to consider how this energy is spent. For example, shear fracturing and tensile fracturing will have their own seismic ¿signature¿; the shearing mode resulting in larger seismic energy release. Hence, if this failure mode can be spread over a large area, the induced seismicity will be lower. There are some discrete element models that attempt to predict the spatial location of energy release; these should be calibrated in the field and could probably be used in a predictive manner. Using such an approach, one has already been able to show that the injection fluid viscosity plays a rather important role in influencing the failure mode of hydraulically fracture treatments.	Very informative comment. A sentence was added where text refers to seismicity, in Version 2.
United States (U.S. Department of State)	4	-	-	-	-	4.5.3	-	-	Section 4.5.3: In the U.S. there is an increasing concern over seismic impacts and ground water contamination due to geothermal development. In particular hydraulic fracturing (page 6 line 36) is coming under intense scrutiny. The recommendation is to acknowledge somewhere in the chapter that this is a concern and additional study is warranted.	Short sentence added in Ver 2, but also all the section was re-structured and re-phrased covering also this recommendation.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.5.3	-	-	This section mixes impacts of conventional geothermal power plant technology with those of EGS. This can convey the impression that the risks of induced seismicity and similar effects are similar. However, this doesn't seem to be the case.	Included in the re-structured Section in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.5.4	-	-	This section should be dissolved. It is unspecific and not treating any one subject comprehensively. Specific parts should be moved elsewhere or summarized under a different heading. See for detailed suggestions below.	Done in Version 2. All the section was re-structured.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.6	-	-	INCLUDE REFERENCES! This section relies on ONE SOURCE ONLY. It is mainly about an EGS research agenda proposed by Tester at al. (2006). It is not what the reader would expect as an introduction to "Prospects for technology improvement, innovation, and integration". The section should contain the following information: 1) Clearly state the ultimate OBJECTIVE, i.e. here first and foremost cost reductions of the supplied geothermal energy services 2) Shortly summarize the main research pathways, i.e. the MEANS to achieve that objective, that have been followed in the past and today to outline new trends in research. This analysis should be based to the extent possible on QUANTITATIVE ANALYSIS of government R&D budgets and, if available, private R&D expenses on particular topics. It should NOT read like a wish list. If there are certain research areas that are believed to be particular promising to achieve the ultimative objective of lowering the cost of geothermal energy supply, you should state WHO believes this. There are a large number of GEOTHERMAL ROADMAPS from various governmental institutions and industry associations. These should be assessed to identify commonalities and differences in foci and beliefs about the most promising research areas, geothermal technologies and drivers of innvation and integration. Some relevant studies and websites for further information are: http://setis.ec.europa.eu/mapping-overview/technology-map/technologies/geothermal-power; http://ec.europa.eu/research/energy/eu/projects/index_en.cfm?researcharea=geothermal#results	Partially accepted: An introduction was added (regarding the final objective), and the section was re-structured y re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.6	-	-	This section lacks references. Some relevant references are already quoted in section 4.3.5, e.g. DRET (2008), ENGINE (2008), and IPGT (2008).	Done.
Zhonghe Pang (Institute of Geology and Geophysics)	4	-	-	-	-	4.6.1	-	-	The existing techncial barriers are not only with EGS, but also with power plants and direct use projects based on hydrothermal resourcs. Cost-effective handling of difficult fluids either extremely corrosive (high acidity or salinity) or with high scale-forming potentials, low injectivity into sandstone formation are among these problems that deserve discussion in this report.	Paragraph was re-phrased in Version 2.
United States (U.S. Department of State)	4	-	-	-	-	4.6.3	-	-	Page 26 (section 4.6.2): Remote sensing is being over emphasized. As of yet, it is still an unproven technology for exploration, although there have been some success stories. The real problem is our inability to measure, temperature, permeability, stress state and/or geologic structure at target depths without drilling.	Partially rejected. Actually there is only a sentence on satellite tools, but the paragraph was re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7	-	-	I recommend to slightly restructure the current section on cost trends by shifting certain parts of the text to enhance the logical structure of this section. Some parts, particularly that on future cost trends needs to be based on a comprehensive assessment of what is available in the literature and describe and make us of standard forecasting methods, i.e. LRs or engineering based estimates. My proposal for restructuring is included in SRREN_Draft2_TSU-Review_Schloemer_Steffen_Addendum_Geothermal_Cost.	The whole section was re-structured according to the mentioned proposal, in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Henk Pagnier (0)	4	-	-	-	-	4.7	-	-	the range of future projections for LCOE is marked by much broader bandwidth than presented in figure 4.7, focusing on CF. I strongly recommend to put this graphically in a broader perspective with a broader range of issues including a broader range of challenges (not just CF) but also HSE/induced seismicity, public acceptance and logistic etc. A paper to be presented at the fall meeting in GRC by Batini and Van Wees,2011 demonstrates the (temporary) high impact of these challenges on investment decisions.	Partially rejected: the band of future LCOE was produced by the calculator used and the interest rates. However, not only improvements in CF were considered, as explained in the text of new subsection 4.7.4.
Henk Pagnier (TNO)	4	-	-	-	-	4.7	-	-	the range of future projections for LCOE is marked by a much broader bandwidth than presented in figure 4.7, focusing solely on an improvement in CF. I strongly recommend to put this graphically in a broader perspective with a broader range of issues (not just CF) but also HSE/induced seismicity, public acceptance and logistic etc. A paper to be presented at the fall meeting in GRC by Batini and Van Wees,2011 demonstrates the high impact of these challenges on the robustness of investment decisions.	Same as above (it is the same comment).
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7.1	-	-	You list a large variety of factors influencing the cost of each of your four cost components. However, it does not become clear which of the underlying factors have the largest impact on the cost of each component and total costs. Also, it does not become clear whether the explanatory factors are correlated with one another (multicollinearity) or independently distributed. If there is no information available on the variance of the factors and their impact on the variance of total costs (or on the variance of the cost components you singled out), this should be stated as a knowledge gap. A ceteris paribus analysis varying one factor, e.g. depth of the resource, within reasonable limits (according to assumptions about the distribution of different resource grades) while holding everything else equal would be very helpful to identify (if still necessary) and particularly to exemplify the impact of the most important factors that determine the investment costs.	Paragraph was re-phrased In Version 2, including a specifi statement on the independent characteristic of each component and each factor affecting it. All section was re-structured.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7.2	-	-	If possible, I think it would make sense to include an additional figure showing the LCCI (terms yet to be standardized at LA4) as a function of drilling depths and/or resource grade (lower to higher temperature) and/or other factors deemed among the most important factors that affect the LCCI. Use similar layout as in figure 7.19, if feasible.	It would be useful to do that, but it would enlarge the section. Anyway, all this section was re-structured.
United States (U.S. Department of State)	4	-	-	-	-	4.7.2	-	-	Section 4.7.2: It isn't clear reading this section whether the cited LCOE figures factor in available incentives. Based on the ranges in Figure 4.6, it appears that incentives are included. I've seen ranges of $42 to $69 for geothermal electricity that include U.S Federal tax incentives and ranges from $82 to $116 in the absence of U.S. Federal tax incentives (LAZARD, 2008).	Partially accepted. LCOE costs were calculated using the calculator provided by the TSU and they do not include any incentives. This is explained in the text.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7.3	-	-	Only a small share of the information presented in this section is actually on historical cost trends. RESTRUCTURE	Sub-section and section was re-structured in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	-	-	-	-	4.7.4	-	-	Section 4.7.4, page 31: These costs projections/trends must be for conventional hydrothermal. Why not include EGS?	In the new re-structured section it was included a new paragraph with LCOE EGS projections.
Grant Ferguson (St. Francis Xavier University)	4	-	-	-	-	4.7.5	-	-	Is there a figure that can be used to quantify the general impact of heat pumps? Could open and closed loops be differentiated?	Partially rejected. The general impact of GHP on geothermal direct uses is mentioned, but with no differenciation between closed and open loops.
United States (U.S. Department of State)	4	-	-	-	-	4.7.5	-	-	It may be worth reminding readers that the economic viability of GHP projects is as much influenced by the LCOE of incumbent technologies as anything. Recent trends in lower natural gas prices have resulted in poor GHP project economics in parts of the U.S.	This is true for all energy alternatives and does not need to be stated.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.8	-	-	I am concerned that your approach of simply picking growth rates for the next decades that seem to be extrapolated from the historical trend by rule of thumb may not be well received. The fluctuations in the growth of geothermal in the past decades have shown that its growth is not at all determined to be continuous. The scenario analysis clearly shows the strong impact of the assumed policy scenario on the growth of geothermal energy use, obviously because of the impact on the competitiveness of geothermal energy compared to freely emitting sources. If you think that only the most optimistic scenarios out of 150+ assessed in chapter ten deliver reasonable results for future deployment, then this should be clearly stated and the reasons for this need to be explained. An insightful critique of scenario results should be based on a discussion of the cost assumptions and the technical representation of geothermal energy as well as the energy sector. However, contrasting model results with rather arbitrary extrapolations of past growth trends (table 4.13) without reasonable and consistent constraints in terms of costs is not an option with any added value. Possible reasons for scenario projections that you consider too low could include, e.g.: - too pessimistic assumptions on LRs and future costs, - too pessimistic assumptions on the availability of high-grade resources, - too low projections of overall demand for electricity and/or heat - too optimistic assumptions on the LRs and future costs of competing energy technologies, - insufficient representation of the cost of integrating intermittent sources of power due to which the dispatchability of geothermal would be inherently undervalued, - and the like ... However, I would rather recommend to delete table 4.13, since it is not embedded into a macroeconomic model in which geothermal has to compete with other sources of renewable energy, and limit your discussion to fig 4.8. You might want to discuss whether the assumptions on geothermal of the scenarios in the 75-100% interquartile range are reasonable or still too pessimistic. However, the strong dependency of geothermal deployment on the assumed policy should be pointed out as one of the most robust trends across all scenarios.	Partially accepted. Subsection was re-structured and re-phrased attending the mentioned concerns in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	ES	-	-	Please compare ES of wind energy chapter, which is a good example of cautious, neutral wording.	The revised ES follow those guidelines.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	ES	-	-	Please stick more closely to the guidelines for the Executive Summary agreed upon in Oxford.	The revised ES follow those guidelines.
Henk Pagnier (TNO)	4	-	-	-	-	management summary	-	-	Management summary: I would stress the fact that geothermal energy has a LCOE which is significantly lower than wind and solar, and that geothermal development relative to these has been hampered by a lack of a level playing field for geothermal RE.	It is part of the previous comment No. 459/1 (in red).

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Henk Pagnier (TNO)	4	-	-	-	-	management summary	-	-	the growth scenario towards 150GWh is largely based on conventional (magmatic/hydrothermal sources). It is very hard to predict what will happen with EGS. In my view these growth paths should be separated (or at least mentioned as such). This is important as the EGS may well grow more rapidly than conventional when exploration and HSE risks are no issue towards levels of 1000-2000GWe (28-57EJ/yr) which is still a small fraction of the technical potential of 270-1000EJ/y.	It is part of the previous comment No. 459/1 (in red).
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	SPM	-	-	Check comment on Table SPM 3: "Geothermal: no direct atmospheric emissions (with the exception of geothermal heat pumps)"	It corresponds to the Summary for Policy Makers (SPM), not Chapter 4. To be considered by BG & JT
Henk Pagnier (0)	4	-	-	-	-	4.2	4.1	-	projects direct use as very low contribution. It probably does not take into account using power potential for direct use. Industrial applications could strongly benefit from this use as mentioned in 4.7 line 15 and further (payout time of 2 years, LCOE ?. I recommend to but this aspect at this stage, as further developments of Relocation of energy intensive industries to energy sources (e.g. melter in iceland) is a realistic option.	It is the same previous comment.
Fritz Vahrenholt (Prof. Dr.) (RWE Innogy GmbH)	4	-	-	-	-	-	4.4	-	Figure does not look professional.	Agree, but this is a schematic to ilustrate the GHP arrangement.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7.2	4.6	-	Move up in the text and include directly below discussion of LCOE of conventional type projects. Currently EGS projects, which are not reflected in the figure are mentioned in between the discussion of conventional type projects and their figurative presentation. This is a bit confusing.	Fig. 4.6 was changed and placed in the proper site in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.7.2	4.6	-	The main messages do not become very clear from this figure. Revision recommended. Main messages seem to be: LCOE (high discount rate) > LCOE (low discount rate), LCOE (high temp, flash plants) < LCOE (low temp, binary cycle), LCOE (greenfield) > LCOE (expansion). Specifically, I recommend to give up the link to table 4.8 and explicitly include stylized characteristics of possible projects, i.e. inter alia to change the labeling. Furthermore, I would recommend to use a two-dimensional graph with LCOE on the y-axis and the most important factor displayed on the x-axis (cf. figure 7.19).	All the subsection was re-structured and a new Fig. 4.6 was prepared, similar to Fig. 7.19 (wind chapter), in Version 2.
United States (U.S. Department of State)	4	-	-	-	-	-	-	4,4	Consider relocating Table 4.4. consider locating between Sections 4.3.1 and 4.3.2 (Page 11-12) since this table is not just EGS.	Table was moved to section 4.6 in Version 2.
United States (U.S. Department of State)	4	-	-	-	-	-	-	4,7	Section 4.5.5, page 25, Table 4.7: It appears that capacity factors of 90 and 95% are used in converting from m^2 per MWe to m^2 per GW-hr/yr. Why use two different capacity factors?	Those capacity factors were used by the authors referenced. Check with Jeff Tester.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
United States (U.S. Department of State)	4	-	-	-	-	-	-	4,8	Table 4.8, page 28: I did not have access to many of the references cited. I did look at Kutscher (2000). The estimates for 2000 were ~$1,400 to $1,500 per kW for a steam project , and $2,100 per kW for a binary project. In the 1995 EPRI study, costs were $1,000 to $2,500 per kW for flash-steam projects and $2,300 to $4,200 for binary projects. Based on level of detail in both estimates, I would tend to believe the EPRI study estimates are more realistic. Regardless, Kutscher¿s estimates are for 2000 and the values in Table 4.8 are for 2005. Over this period, the costs (Producer Price Indices) for Oil and Gas well drilling in the US increased by a factor of 2, steel costs increased by 50%, and construction labor costs increased by 15%. An increase from $2,100 to $2,362 is less (12%) than the increase in construction labor costs. Some explanation should be provided as to how these costs are adjusted to 2005$ US.	Partially rejected. The TSU decided to use all costs in USD$ 2005, so older data were converted using the Excel spreadsheets provided by the TSU. This is informed in one of the annexes and then it is not necessary to repeat in this chapter.
United States (U.S. Department of State)	4	-	-	-	-	-	-	4,9	How much of the improvement in capacity factor indicated in Table 4.9 is due to adjustment of the installed capacity/retirement of old plants?	Table 4.9 was modified in Version 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	-	-	-	-	-	-	4.1	A better scheme of classification should be sought to avoid obvious inconsistancy that may be easier for the layman to follow.	Scheme will not be changed because is considered satisfactory by the writing team, but some minor wording changes have been made in the TOD.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	-	-	4.10	State intermediate capex value used for LCOE calculation. State that further assumptions are included in Annex III and which value you used for O&M costs as well. Refer also to Annex II instead of referencing the Verbruggen and Nyboer calculator.	Partially accepted. It is not possible to mention all the assumptions made to calculate LCOE, but some other data were included in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.8	-	4.11	Regional growth rates of installed capacity differ from the global average. In principle not surprising, but needs explanation.	Regional growth rates can be higher or lower than the global average. A new short sentence was added in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.8	-	4.12	The scenarios in this table are also part of the scenarios analysis presented in fig. 4.8. It is unclear on which basis these scenarios have been selected to be presented in a separate table. Also, it does not become clear what policies have been assumed in the respective scenarios. The ETP BLUE scenario, for instance, is a 450 ppm stabilization case.	Table 4.12 was prepared just to present other projections additionally to the IPPC AR4, but it was deleted in Version 2, just re-phrasing the previous paragraph.
Gerrit Hansen (TSU)	4	-	-	-	-	-	-	4.13	it is not entirely clear on what basis this table has been developed. Is it authors jugdement? The whole section (p.35 ln 33 to 38 ln 19) is not easy to read, as the variety of figures is confusing, and therefore makes information difficult to access.	Table 4.13 was deleted and the subsection was re-structured and re-phrased in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.8	-	4.13	delete. Extrapolating growth trends without a more general macroeconomic model in the background is not a valid approach for long.term projections. Growth rates will depend on a variety of factors that are not consistently taken into account here. Such projections might be used, however, to test whether the resource is large enough to support such a strong growth. However, you don't need to present the table then, but only the result, which is most likely that the technical potential is sufficient to enable even very strong growth scenarios if there are no binding cost constraints.	Table 4.13 was deleted and the subsection was re-structured and re-phrased in Version 2.

Name (Institute)	Chapter	From page	From line	To page	To line	Section	Figure	Table Info	Comments	Consideration by writing team
Brazil (Ministry of Science and Technology)	4	-	-	-	-	-	-	4.2	Include 'continental' to the title	Done in Version 2.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.2	-	4.2	Own estimation of "hidden" technical potential is not explicit from looking at the table only.	Table 4.2 was modified in Version 2. Actually, the chapter 4 own estimates are for EGS resources.
Steffen Schlömer (IPCC WGIII)	4	-	-	-	-	4.2	-	4.2	Rename "hidden" technical potential into "estimated additional technical potential". Include a note explaining that the additional technical potential estimates the amount of geothermal resources only utilizable with EGS, i.e. with a technology that has not yet been deployed commercially.	Table 4.2 was modified in Version 2. "Hidden" was changed to "Conductive (EGS)".
Ladislaus Rybach (Geowatt AG Zurich (company))	4	-	-	-	-	-	-	4.3	Delete the symbol for reinjection well in the left diagram (there is no reinjection, see line 19).	It was changed legend of number 2: "To injection well" (instead of just "injection well".
Fritz Vahrenholt (Prof. Dr.) (RWE Innogy GmbH)	4	-	-	-	-	-	-	4.4	Change the headline: technologies needed for EGS development and conventional geothermal projects.	Heading was changed in Version 2.
Zhonghe Pang (Institute of Geology and Geophysics)	4	-	-	-	-	-	-	4.4	This table can be saved by limiting the discussion to "current status" while leaving future developments to section 4.6	Table was moved to section 4.6 in Version 2.
Gerrit Hansen (TSU)	4	-	-	-	-	-	TS4.1		reconsider the use of the log scale in this graph, as it visually conceals the content of the data.	Log scale is necessary to compare the figures.