



**GEOCAP**

Geothermal Capacity Building Program Indonesia - Netherlands

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## Study Guide Course I.07

### *'Company investment decision-analysis for geothermal projects'*

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## SUMMARY

This report describes the objectives, topics, methods, course structure and study load of GEOCAP course WP1.07 on 'Company investment decision-analysis for geothermal projects'.

A short introductory course to this course has been given on 28-29 March 2016, prior to the 30-31 March 2016 IIGW workshop at ITB. Feedback from the participants to this short course, with valuable comments, are included at the end of this study guide.

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## 1 CONTEXT OF COURSE

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The WP1.07 course "*Company investment decision-analysis for geothermal projects*" is one of the courses offered by the GEOCAP program (Geothermal Capacity Building Program Indonesia-Netherlands, see [www.geocap.nl](http://www.geocap.nl) and [www.geocap.nl/index.php/workpackages/training/wp-1-07](http://www.geocap.nl/index.php/workpackages/training/wp-1-07)).

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## 2 DEVELOPMENT AND USE

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Work package course: 1.07

Course name: "*Company investment decision-analysis for geothermal projects*"

Location: (venue Jakarta)

Date: 28 October – 3 November 2017, five-day course)

Authors of course: Ali Ashat, Christian Bos

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Students, who have successfully completed the course, will grasp *at a basic level* the concepts of the geothermal project maturation process, i.e.

- 1) fundamentals of the corporate value creation process
- 2) how to frame complex decision-making problems pertaining to geothermal investment opportunities in Indonesia
- 3) how to compute the pertinent KPIs / decision criteria (including the associated uncertainty) required to support decision-making by corporate decision-makers
- 4) how to propose decision alternatives aimed at mitigating risk and capturing the upside through flexibility options
- 5) how to propose optimal strategies under a variety of corporate decision-criteria to further mature a geothermal investment opportunity.

It should be noted that many concepts, to be discussed during the course, generally take considerable time to master. In a limited five-day course, such as this course, it will therefore not be possible to go in-depth.

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### 3 ABSTRACT

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Keywords: *corporate economics, project economics, bankability, project maturation, decision-gate process, decision analysis, framing the problem, decision tree analysis, technical-to-business integration, uncertainty quantification, probabilistic production forecasting, risk mitigation, value of flexibility, value of information, multivariate sensitivity analysis, multi-criteria decision-analysis, multi-stakeholder decision-analysis, portfolio theory, decision quality.*

The course is based on the Decision Gate (project maturation) and Decision Analysis (DA) processes, as developed and practiced by the oil and gas exploration & production (E&P) industry, and has been tailored to the geothermal industry as practiced in Indonesia. Both industries deal with large technical (subsurface) and systemic (market, political etc.) uncertainties and can be characterized by the requirement to make high upfront investments when large uncertainties about the productive system (i.e. technical uncertainties) have not yet been resolved. These conditions render investments in the subsurface unique and call for a unique project maturation / risk mitigation approach.

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### 4 TARGET GROUP

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The course has been designed to broaden technical practitioners (i.e. with an engineering or scientific background, e.g. geoscience, mechanical engineers, etc.) towards creating added value for their organisation. However, corporate economists / lawyers and government policy-makers (such as economists, lawyers, sociologists, environmental scientists etc.) are more than welcome as it is the *multidisciplinary* approach that is the guiding principle of this course. Course participants should be interested in the corporate process of value creation, and should be willing to understand the value of *quantifying probabilistically* the Key Performance Indicators (i.e. decision criteria) for the various decision alternatives. The course participants will be trained in identifying business opportunities and maturing these opportunities to pass the various corporate decision gates, up to Final Investment Decision (FID).

The entry level of the course participants is ideally a BSc or MSc level in geosciences and/or engineering sciences, complemented by at least three years of practical experience in a geothermal company. However, other backgrounds and entry levels may be acceptable,

depending on experience and course subscriptions. Upon entry, course participants need to master basic scientific and engineering skills such as maths, computing, statistics, geoscience, chemistry, well engineering, power plant design, etc. Course participants should be interested in *integrating multi-disciplinary processes* in order to support corporate decision-making.

The course is related to GEOCAP course 1.06 (*Government policy-making and decision-making for geothermal projects*), which is targeted mainly at governmental policy-support staff / policy-makers / decision-makers, and focuses on how to design generic governmental measures to promote the investment climate for geothermal energy, and on the governance of the licensing / permitting process for geothermal projects. The vantage points of the respective courses are therefore 1.06: *Governance* (governmental policy and decision support) and 1.07: *Corporate investment decision-support*. The relationship between the two courses is that government officials need to understand the corporate processes pertaining to investment decision-making (notably the perception of risk by private companies and how this impacts on their hurdle rates for capital efficiency), while the corporate decision-support staff need to understand the Governmental drivers impacting on corporate constraints such as licensing, power purchase agreements, tax, HSE / public acceptance / employment etc.

## 5 CONTENT OF COURSE

### 5.1 KNOWLEDGE






The following topics will be covered by course 1.07 ("*Company investment decision-analysis for geothermal projects*"):

<i>DG</i>	<i>Decision Gate process</i> – project maturation from brainwave to bankability to FID
<i>DA</i>	<i>DA process</i> – Decision Analysis, to be updated at various 'Decision Gates'
<i>FtP</i>	<i>Framing (the Problem)</i> – Part of DRA process: defining uncertainties, decision alternatives, models, decision criteria
<i>DTA</i>	<i>DTA</i> – Decision Tree Analysis: setting up a logical structure for Decisions and Scenarios and resolving the tree
<i>T2B</i>	<i>T2B</i> – Technical-to-Business: modelling technique to couple physics/technical/economics (and HSE)

<i>Stat</i>	<i>Basic Statistics</i> – understanding how to model uncertainties, 'Frequentists' vs. 'Bayesians', preventing bias / psychology
<i>MC</i>	<i>MC</i> – Monte Carlo, probabilistic sampling technique for modelling KPI-uncertainties, incl. correlations
<i>SA</i>	<i>SA</i> – Sensitivity Analysis: understanding main high-impact uncertainties + what to do about it
<i>Robustness</i>	<i>Robustness</i> – definition of robustness: how to use this when recommending a decision?
<i>CAPM</i> <i>WACC</i>	<i>CAPM &amp; WACC</i> – Capital Asset Pricing Model & Weighted Average Cost of Capital: how to use in DCF?
<i>DCF</i>	<i>DCF</i> – Discounted Cash Flow analysis: understanding the underlying assumptions of DCF analysis and computing project KPIs
<i>MLO</i>	<i>Multi-level optimization</i> – Portfolio and corporate KPIs
<i>MCA</i>	<i>MCA</i> – <i>Multi-Criteria Analysis</i> : understanding how to optimize the future in case of multi-criteria
<i>HGT</i>	<i>HGT</i> – Host Government Take, tax, royalty, levies, depreciation, ring-fencing
<i>Vol</i>	<i>Vol</i> – Value of Information: understanding when to propose new data acquisition
<i>VoF</i>	<i>VoF</i> – Value of Flexibility: understanding when to propose flexibility-options in an engineering design
<i>MPT</i>	<i>MPT</i> – Modern Portfolio Theory: better understanding the nature of risk and how the portfolio of projects determines how to assess individual project risk.
<i>MSA</i>	<i>MSA</i> – Multi-Stakeholder Analysis: understanding how to make a Multi-Stakeholder project fly
<i>DQ</i>	<i>DQ</i> – Decision Quality: a way to measure and monitor the quality of the decision-making process
<i>RC</i>	<i>RC</i> – Geothermal Resource Classification as a portfolio management tool
<i>RM</i>	<i>RM</i> – Geothermal Reservoir Management
<i>Markets</i>	<i>Markets</i> – electricity markets in liberalized economies: spot market, imbalance market, merit order

For a detailed description of the course contents, reference is made to the following GEOCAP documents:



-  GEOCAP-2016-REP-TNO-1.07-1 ppt of short course.pdf - Shortcut
-  GEOCAP-2016-REP-TNO-1.07-2 Impressions WP107 post-IIGW5.docx - Shortcut
-  GEOCAP-2016-REP-TNO-1.07-3 Study Guide for WP107\_v4.docx - Shortcut
-  GEOCAP-2016-REP-TNO-1.07-4 Questionnaire prior-post WP107course.docx - Shortcut
-  GEOCAP-2016-REP-TNO-1.07-5\_Course-notes-WP107\_v11May2016.pdf - Shortcut

## 5.2 PRACTICAL CAPABILITY

Course graduates will have some basic understanding to apply the knowledge in order to:

- Contribute more effectively to the corporate geothermal project identification and maturation process
- Identify opportunities for improved geothermal asset management of existing fields, including a producing field's economics for incremental developments
- Understand the relationship between reservoir properties and economics through integrated asset modelling
- Contribute more effectively to governmental geothermal policy-making

## 5.3 SKILLS AND ATTITUDE

Course graduates will have enhanced their awareness of the following key skills and attitudes:

- Thinking in terms of *uncertainties*, rather than in terms of *certainties*: asking questions rather than giving answers (in the face of uncertainty, the 'truth' does not exist)
- Understanding complexity and adopting an attitude of humility and respect for the unknown
- Critically distinguishing value creating activities from activities having no added value.
- The advantages of working in multidisciplinary teams
- Engaging with specialists from other disciplines, not only the technical functions of drilling, production engineering, reservoir engineering, petrophysics, geochemistry, geophysics, and facility engineering, but also economists, environmentalists, lawyers, sociologists etc.
- Engaging between government and company staff: understanding each other's needs and constraints, reaching out
- Understanding critical decision-making aspects such as incompleteness, over-completeness, bias, overconfidence, fitness-for-purpose, relevant detail, decision quality

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- Fostering *integrated* geothermal sciences in Indonesia (participate in professional societies, help developing best practices in Indonesia, etc.)

## 6 LEARNING OUTCOMES

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At a more abstract level, the course is also intended to stimulate students to:

- Acquire, interpret and conceptualize knowledge
- Analyse, structure and synthesize information
- Structure new needs and activities
- Apply methods and techniques
- Synthesize and assess (own) output / research results
- Reason and argue in an articulated way
- Collaborate in teams
- Develop a broad view and apply knowledge within in a wider context
- Develop an attitude re professional growth

However, as indicated above, what one can achieve in a five-day course is limited.

## 7 STUDY LOAD

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The study load will be as follows:

- Pre-reading: course participants will be expected to pre-read the course syllabus and formulate questions. The course syllabus will be circulated ca. one month prior to the course. The pre-reading is *required*. Reading the course syllabus takes a study load of ca. 8 hrs.
- On-campus: the course will last a full week, from Monday to Friday, starting each day at 08:30 and ending each day at 17:00 hrs. Being on-campus full-time is *required*: participants who cannot be present full-time are not recommended to register for the course. Study load: 35 hrs, excluding breaks.
- Post-course: course participants will have the opportunity, on a *voluntary* basis, to engage post-course and form a discussion group. A web-based platform may be set-up to discuss future (training, research, consultancy etc.) needs. If the enthusiasm exists, a professional group of geothermal decision analysts may be facilitated.

## 8 COURSE STRUCTURE

The daily structure of the five-day on-campus course shall have the following format:

- Interactive, participative lectures
- Engagement sessions: plenary and small group discussions
- Exercises

The daily schedule would be tentatively as follows:

<i>Pre-reading</i>	Study load some 8 hrs for pre-reading and preparing questions				
<i>On-campus</i>	<i>Monday</i>	<i>Tuesday</i>	<i>Wednesday</i>	<i>Thursday</i>	<i>Friday</i>
08:30 - 10:15	Intro /Q/L	L	L	L	L
10:15 - 10:30	B	B	B	B	B
10:30 - 12:30	E&E	E&E	E&E	E&E	E&E
12:30 - 13:15	B	B	B	B	B
13:15 - 15:00	L	L	L	L	L
15:00 - 15:15	B	B	B	B	B
15:15 - 17:00	E&E	E&E	E&E	E&E	Q/Wrap-up
<i>Post-course</i>	Establish with course participants any further activities				

Note: L = Lecture; B = Break; E&E = Exercise and/or Engagement session; Q = Questionnaire

## 9 TEACHING AND LEARNING METHODS

Teaching and learning methods shall comprise the following:

- Pre-reading prior to the course
- Contact hours during the course week:
  - o Lectures
  - o Discussions, engagement sessions
  - o Exercises
- Post-course voluntary engagement

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## 10 ASSESSMENT

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It is intended to distribute a short pre-course and post-course questionnaire, and test the difference in knowledge before and after the course. Students will not receive a mark for this: the quiz will merely be used to understand better how much the course has contributed, in general terms, to the participants' knowledge, and how to improve the course for the next time.

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## 11 STUDY MATERIALS

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Study materials shall comprise the following:

- Pdf computer files for (pre-)reading (to be supplied by teacher)
- Pdf computer files for classroom exercises (to be supplied by teacher)
- Students shall have a laptop/pc with XL and Crystal Ball (statistical XL plug-in by Oracle; academic license to be obtained by ITB). If necessary, two students can share one pc.
- XL and Crystal Ball computer files for classroom exercises (to be supplied by teacher)
- Pdf computer files of some pertinent geothermal literature

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## 12 TEACHING MATERIALS

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Study materials shall comprise the following:

- One air-conditioned classroom with sufficient seats and tables, preferably with low noise, seating capacity of, say, 20-25 students
- Pdf computer files for reading (to be supplied by teacher)
- Ppt computer files for presenting (to be supplied by teacher)
- Beamer and projection screen
- White board
- Flip-over paper charts
- Sound amplification
- Students shall have a laptop/pc with XL and Crystal Ball (statistical XL plug-in by Oracle; academic license to be obtained by ITB). If preferred, two students can share one pc.
- XL and Crystal Ball computer files for classroom exercises (to be supplied by teacher)
- Pdf computer files for classroom exercises (to be supplied by teacher)

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- Access to a copy machine

## 13 FEEDBACK FROM INTRODUCTORY COURSE 28-29MAR16

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On 28-29 March, 2016, an abridged, introductory version of the GEOCAP 1.07 course was held, in conjunction with introductions by courses 1.06 (*Government policy-making and decision-making for geothermal projects*) and 1.08 (*Environmental aspects of geothermal projects*). The participants' feedback on the contents and format of WP1.07 is a clear testimony that the course's content fulfils a much needed knowledge gap, as evidenced by the following comments received from participants:

1. *"Even after having worked for over 8 years with an Indonesian geothermal Operator, I've never heard anything of what you've been teaching us on company decision-making. Yet, this knowledge seems crucial for expediting the development of Indonesia's geothermal resources."*
2. *"The sooner you can give the full course, the better. Then we can apply your teachings earlier."*
3. *"I liked this course so much.... This course opened up my mind."*
4. *"I hope someday this course will show the solution for Indonesian conditions. Then it can help us grow and build more geothermal energy in Indonesia."*
5. *"So much new information for me in a short time, very exciting! The instructor really understands and masters the topic, excellent."*
6. *"We learned a new sophisticated way of how to formulate geothermal risk. It is a big opportunity for Indonesia to gain more knowledge and to tackle the problems in the geothermal industry."*
7. *"The Government should be involved in this kind of workshops / courses."*
8. *"We received such a lot of new information, especially on how to make decisions."*
9. *"We liked the multidisciplinary approach in decision-making and how the various types of information from people with different backgrounds come together into one 'language'."*
10. *"I really liked the decision-making course. However, the time was too short to grasp all concepts and hopefully during the planned full course you will be able to cover all aspects adequately."*

11. *"Very experienced and approachable presenter. Especially the exploration decision exercise was challenging and insightful".*
12. *"I liked learning about the 'learning process' during the life-cycle of a geothermal development, and how anticipating on possible future new information conditions current decision-making."*