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Company decision-making for geothermal projects

(GEOCAP course 1.07)

Topic: Optimization of "value"

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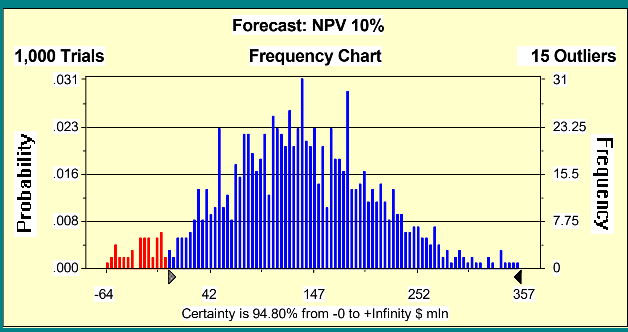
Optimization: what is "value"?

- Decision-making is about optimizing (added) "value"
  - But what is value?
- Value is related to uncertain future cashflows.
  - These are projections based on some model, and are estimates only.
- Optimization requires an objective function and constraints:
  - The task is to find the set of controllable actions that optimizes the selected objective function within some boundary conditions (constraints)
  - Optimize is either maximize or minimize
  - General formulation: OPT [Obj fct | $constr_1$; $constr_2$; $constr_3$; … ; $constr_n$]

Objective functions

- OPT [Obj fct | $constr_1$; $constr_2$; $constr_3$; … ; $constr_n$],
  - With OPT being either MAX[] or MIN[]
  - And '|' meaning 'conditional on', or 'subject to'.
  - Or: OPT [KPI_1 | KPI_2; KPI_3; KPI_4; … ; KPI_n],
- Complications:
  - Multi-criteria
  - Hierarchical objective functions in an organization
  - Uncertainty
    - Both Obj fct and constraints can be expressed as probabilistic quantities
    - For example: Obj fct = MAX[EMV], and constraint is Risk-tolerance:
      - MAX [EMV | Risk < risk tolerance] …. (see next slide)
  - Scalars vs. vectors (here: KPIs vs. time-series)
    - A scalar can be optimized, a vector cannot be optimized
    - But a vector can be translated into a scalar (e.g. Cum disc. NCF can be translated to NPV)
  - Not always clear what is a controllable vs. non-controllable, and by whom.

Introduction Crystal Ball - KPI1 (NPV)



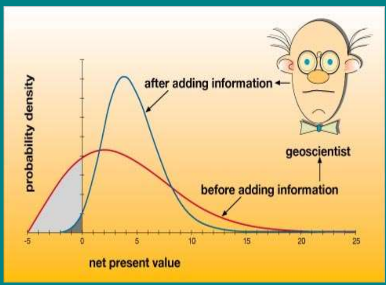
- The NPV distribution shows that there is a 5.2% probability that the 10% NPV will be negative under the assumptions used; on the other hand NPV's in excess of $300 mln cannot be excluded.

Risk and risk tolerance using Monte Carlo

- EMV = Expected Monetary Value (unit: PV currency)
  - It is the modelled NPV-histogram's 'mean value'
- Risk = undesired outcome x probability of that outcome
  - In a continuous distribution (histogram or pdf) it will be the average of the KPI samples that are 'undesired' (e.g. all samples with NPV<0) x integral of the area of the pdf below (or above) some 'hurdle rate' (defining what is 'undesired', e.g. NPV<0)

Using "Risk-tolerance" as optimization constraint

- Project Risk = $\int_{-\infty}^{WACC}$ IRR * pdf (IRR) d(IRR)
  - **i.e. cum. prob. x average IRR, if it is <WACC**
- Project Risk = $\int_{-\infty}^{0}$ NPV * pdf (NPV) d(NPV)
  - **i.e. cum. prob. x average NPV, if it is <0**



- The decision-maker should then specify his/her risk-tolerance: for the project in question, and given other (portfolio) considerations, which cumprob x average NPV, i.e. if it is <0, am I prepared to accept?
  - **Risk-tolerance criterion can then be used as optimisation constraint to cut out bad decision-alternatives**

Multi-criteria objective functions

- Single KPI to be optimized:
  - OPT [Obj fct | $constr_1$; $constr_2$; $constr_3$; … ; $constr_n$],
    - With OPT being either MAX[] or MIN[]
    - And '|' meaning 'conditional on', or 'subject to'.
- Or: OPT [KPI_1 | KPI_2; KPI_3; KPI_4; … ; KPI_n]

- Multi-KPIs to be optimized:
  - Establish a weighted function of the KPIs to be optimized:
    - *KPI'* = $KPI_1 \times w_1 + KPI_2 \times w_2 + KPI_3 \times w_3 + KPI_4 \times w_4 + \ldots + KPI_n \times w_n$
    - With $\sum_{1}^{n} w_x = 1$
    - In practice, it is hard to agree on these weights. Also, information is being lost. And in case of quantitative portfolio models (rolling up all projects and assets) it is often preferred to preserve all information explicitly, rather than implicitly.

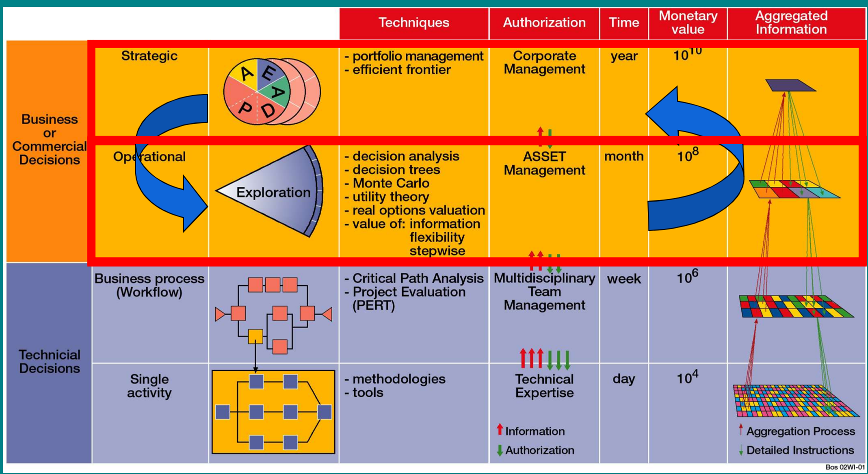
Decision-making = value optimization =

hierarchical constrained optimization under uncertainty given targets

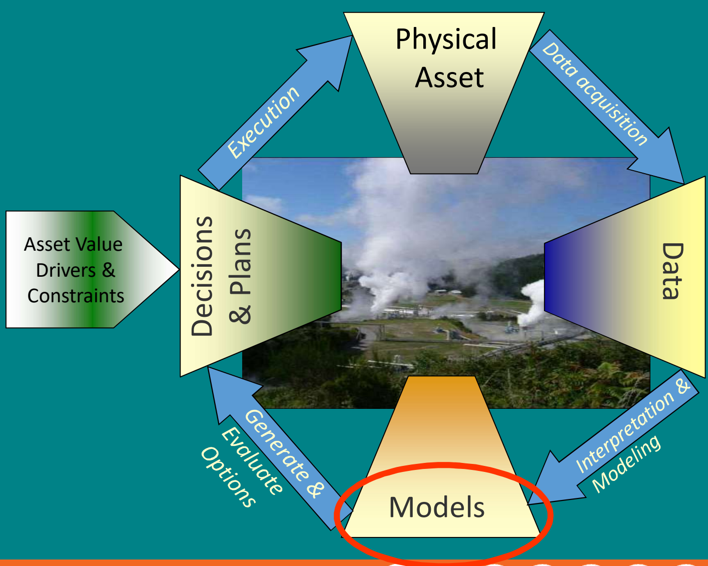
Possibe definition of Δvalue = Δprobability of meeting a set of pre-defined time-series targets at the next hierarchical decision-level

Hierarchical optimization asset/portfolio

Decisions and Levels of Aggregation



The 'Value Loop' (Shell)



Summary of main optimization process

The full process can be summarized as:

- hierarchical
- constrained
- (time-domain)
- multi-criteria optimization
- under endogenous and exogenous uncertainty,
- given targets,
- with decisions as optimization controls