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Company decision-making for geothermal projects

(GEOCAP course 1.07)

Topic: Framing the Problem

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Public document (GEOCAP-2016-REP-TNO-1.07-xx)

D&RA - 5 main steps

1. Frame the problem

- Agree dec. crit.
 - ✓ opt. criteria
 - ✓ opt. constr.
- Risk register
- Agree decisions
 - ✓ static
 - ✓ dynamic
 - ✓ real options
 - ✓ data acq.
- Agree scenarios
- Construct tree
- Prune tree
- Agree tree

2. Set-up quantitat. models

- Agree models
- Populate model
- Agree stoch. parameter pdf's & scenario prob.
- Agree / est. correlations
 - ✓ regular
 - ✓ copulas
- Agree KPIs
- Agree risk def.
- Agree assumptions

3. Generate range of outcomes

- Set MC runpar
 - ✓ Sample no.
 - ✓ MC type:
 - Regular
 - LHS
 - ✓ Tree prop.
- Pdf's of KPI's
- Quantify risks
- Assess impact on portfolio
- Est. utility fct, risk tolerance

4. Perform Sensitivity Analysis

- Tornado etc
- Fine-tune decision altern.
- Test robustness of decis:
 - ✓ model input
 - ✓ process par
 - ✓ utility fct
 - ✓ dec.sequence
- VoI, VoF, ROV

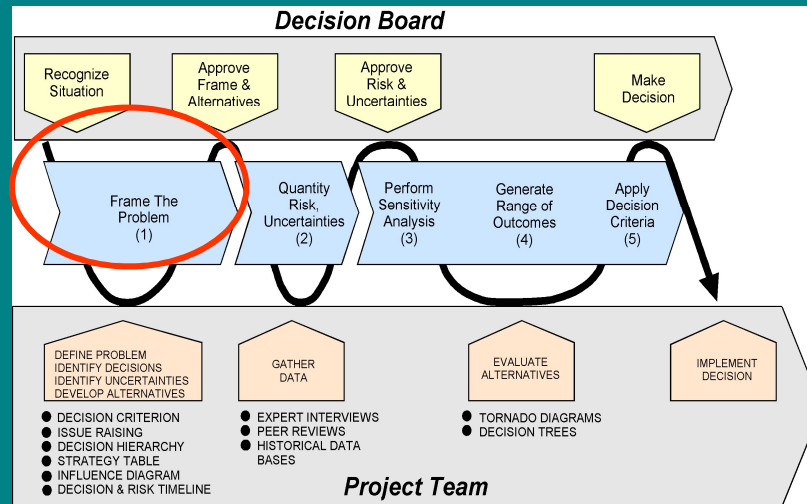
5. Apply Decision Criteria

- Describe process
- Propose optim. solution + impact on portfolio
- Report
- Decide
- Execute
- Monitor
- Update model

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2

The D&RA Process



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3

Framing the problem (1)

- Brainstorm with multi-disciplines
 - Establish inventory of risk factors ("risk register") and business drivers**
 - Qualitative only, no ranking yet
 - Highly multi-disciplinary: needs moderator to allow less vocal team members to speak up
- Construct graphs of:
 - x=Probability of Risk-factor vs. y=Adverse impact on "Value"**
 - Qualitative: estimate hi/med/lo standard deviation
 - Initially, non-specific definition of "value"
 - Position risk-factor in quadrant
 - x=Manageability of Risk-factor vs. y=Adverse impact on "Value" : "to which extent do we control the risk-factor?"**
 - Ditto
- Move risk-factors relatively within quadrants
 - Relative positioning & ranking of risk-factors**

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4

Framing the problem (2)

4. Repeat steps 1 and 2, but now per KPI-group
 1. LT economics (e.g. reserves, opex)
 2. ST economics (e.g. capex, production next 5 years, 1 yr)
 3. HSE
 4. Construct graphs of:
 1. x =Probability of Risk-factor vs. y =Impact on "Value"
 2. x =Manageability of Risk-factor vs. y =Impact on Risk-reduction
5. Move risk-factors relatively within quadrants
 - Relative positioning & ranking of risk-factors
6. Using charts, agree how to translate risk-factors into "discrete uncertainties" (scenarios) OR "decision alternatives"
 - High manageability -> decision
 - Low manageability -> discrete uncertainty (scenario)
 - Low impact, low probability -> discard initially
 - Very high impact, very low probability ("train wrecks") -> discard initially

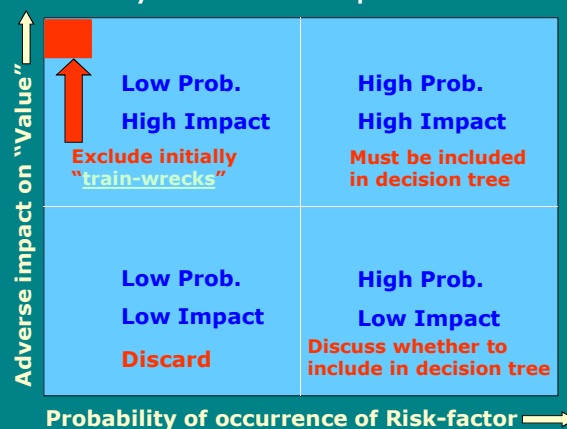
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5

Ranking risk-factors in terms of Impact

- Probability versus Impact



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6

Further refinement of risk factors + group scores

- Split risk-factors (model input parameters) in smaller groups and score relative importance of risk-factors for each KPI

Ranking criteria	occurrence
Complexity (commercial)	4
Reserves	4
NPV (increment)	3
Flexibility	2
HSE costs	2
IRR (increment)	2
Confidence	1
Maximum exposure	1
Modification reduction	1
PI ratio	1
Robustness	1
Capex	1

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7

Per main decision alternative, make inventory of importance of risk factor relative to pertinent KPIs

KPI →	NPV	IRR	Early prod.	Max. exposure	ΔUR
Risk factor ↓	Life cycle		Short term		Long term
Prod. start-up					
Commercial Complexity					
HSE-costs					
Capex-facilities					
Drillex					

- Uncertainty in may have a (pos/neg) impact on KPI
- Use e.g. ---, --, -, 0, +, ++, +++

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8

Important: consistently and clearly distinguish (terminology)

- Value drivers or risk factors
 - Uncertain model input data that have material impact on KPIs (initially qualitative estimate of sensitivity)
 - Optimization criteria
 - KPIs (“*Key Performance Indicator*”, i.e. uncertain model output data, e.g. NPV, next year’s average daily production, etc.
 - Boundary conditions or constraints
 - Internal/external conditions that define frame within which to optimise KPIs
 - Decision alternatives – you control this
 - Scenarios - you do not control this; scenarios describe uncertainties, e.g. in fiscal regime, steel price, etc.
- Threat to understanding each other!
- Be explicit and precise
 - Use clear **terminology** for risk, scenario, decision, driver, risk factor, hurdle rate, constraint, assumption, etc. Link terms to workflow!!

Example Tampen (NCS)

alternatives	New PF	Local DBL 3x	Local DBL 3y	Brent	Area DBL 6a	Area DBL 6d	Area DBL 6e	Snorre SA	Snorre TP
Value drivers									
reserves	+,+,+	++	+,+	+	+,+,+	-,+,+	+,+		+,+,+
capex	-,+,+,+,+	+,+,+,+	+	-,+	+,+,+	+		+	+
opex	+,+,+,+,+,+,+	-,+,+,+	---	-,+	-,+	+,+,+,+,+,+	-	+	+
Threats									
HSE	+,+,+,+,+,+,+	---	---	-,+,+	-,+	+,+,+	-	+	-
Commercial complexity	-,+,+	+++	+++	-,+		-	-	-	-
Opportunities									
Flexibility	-,+,+	+		-,+,+,+,+,+,+	+,+	-,+,+	+,+	+,+,+	+,+
Miscible flood	++			-,+,+,+,+,+,+	++	-	++		
New technology	+	-		-				-	-

Inventory of risk factors (or value drivers)

- Initially, no need to distinguish continuous and discrete uncertainties (later)
- $\Delta(\text{Value})$ vs. $P(\text{risk factor})$ plot may be done for each different KPI rather than for a lumped "value" definition
 - Meaningful to split at least into LT and ST KPIs.

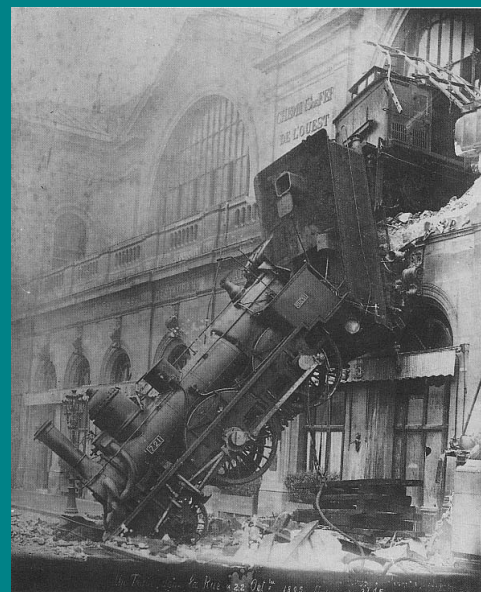
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11

Train Wrecks

- As a rule of thumb an event could be considered a train wreck
 - if it had a probability of occurrence in the time period considered of less than 10%
 - and a magnitude sufficient to move the P50 of the forecast distribution outside of the P10/90 range.
- Events with a probability lower than 1% are usually ignored.
- Cataloguing train wrecks is a creative brain storming exercise and these guidelines are designed to avoid the "Suppose a meteorite crashed into the platform, just as a nuclear submarine was passing?" type of suggestion.



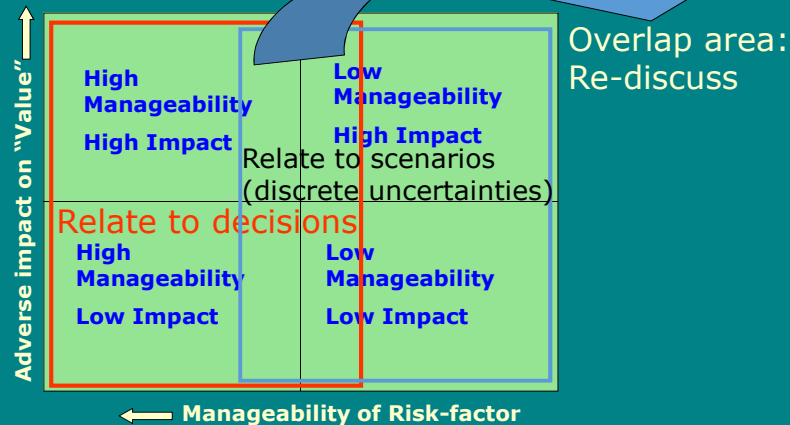
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12

Ranking risk-factors in terms of manageability

• Manageability versus impact



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13

Constructing tree

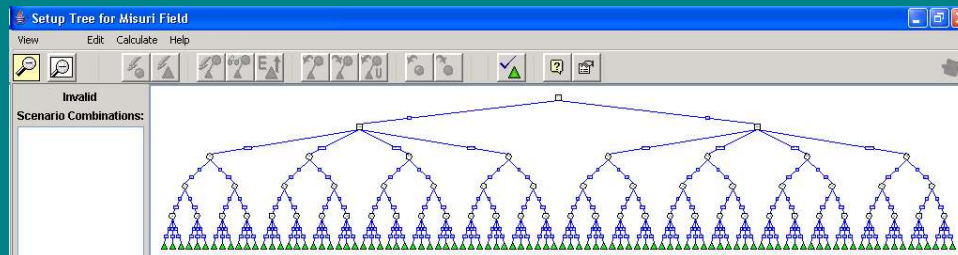
- Select from "Probability versus Impact" plot which risk factors to include in "Manageability versus Impact" plot.
- Select from "Manageability versus Impact" plot which decision and scenarios to be modelled.
- Discuss which other decisions to be included.
- Discuss which risk factors to be modelled as discrete / continuous uncertainties.
- Prune tree by removing invalid / less meaningful scenario/scenario or scenario/decision combinations

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14

Pruning the tree (1)



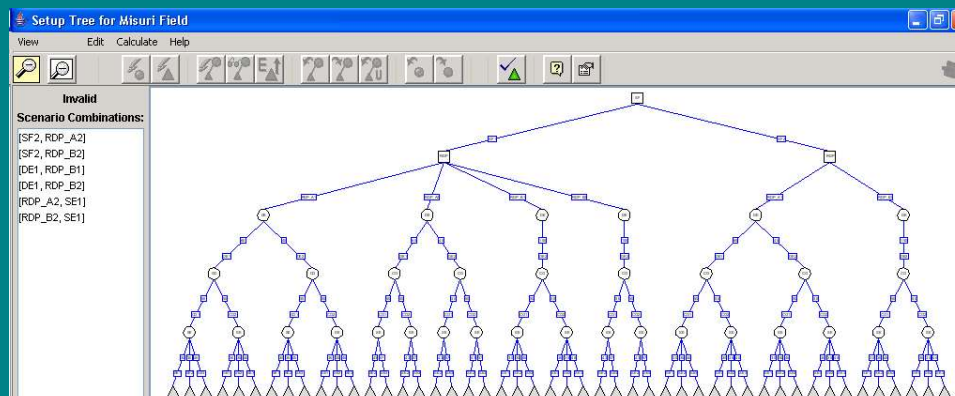
- 96 end-nodes

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15

Pruning the tree (2)



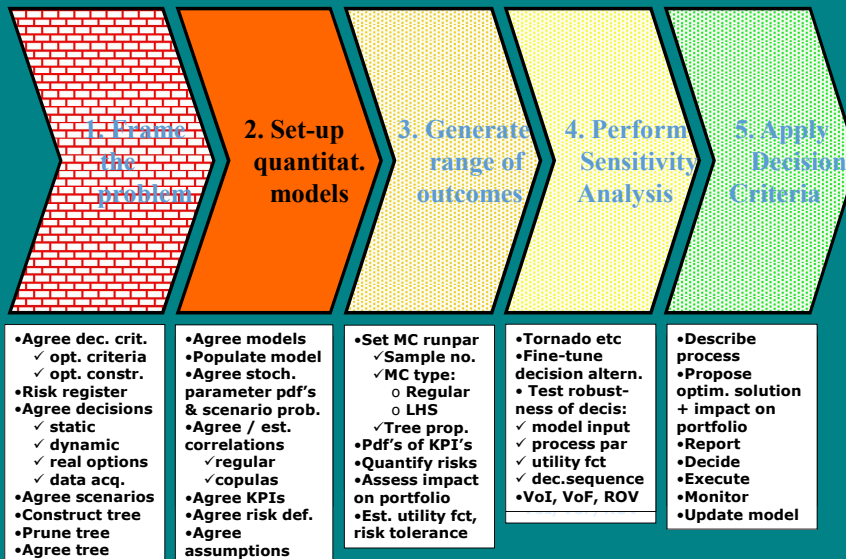
- 48 end-nodes : reduced by half

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16

D&RA – after 1st step start quantifying



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17

Case study

- Specify up to "three most important" Value Drivers:
 - **Reservoir** : Water & Gas injection, cheaper wells, miscible injection
 - **Market**: Company specific differentials and market balance, product prices
 - **Frame conditions**: Tax, licence concession, drill access in the vicinity
 - **Infrastructure**: Opex reduction, Capex reduction, residual value
 - **Technology**: Cheaper and lighter separation, Water treatment, Low NO_x turbines
 - **HSE**: emissions requirements: produced water, NO_x

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18

Value drivers

- **Financial & Operational Targets**
 - ✓ Return on capital employed
 - ✓ Production
 - ✓ Exploration and development costs USD/bbl
 - ✓ Production Costs USD/bbl
 - ✓ Other Economic Indicators
- **Invested equity / suppliers**
 - ✓ Equity in field
 - ✓ Equity in surrounding infrastructure and onshore facilities
 - ✓ Equity in surrounding fields
 - ✓ Usage of services : contractors, rigs and shipping
- **"Corporate"**
 - ✓ Company Owners
 - ✓ Corporate Business strategy – regional & international
 - ✓ Safety: People and Environment
 - ✓ E&P + Downstream : Net buyer or seller?
 - ✓ Business view on implementing new technology
 - ✓ Corporate Identity: Business culture & current "voyage to a future"
 - ✓ View on sustainable development

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19

Project Screening Methodology

- Parameters
 - **Economic**
 - NPV before tax $k = 7\%$
 - NPV after tax $k = 8\%$
 - PI-ratio = NPV per invested \$
 - **HSE Requirements for all alternatives**
 - **Sensitivities (high / low significant assumptions)**
 - **Risk Evaluation**
 - Economic
 - Commercial complexity
 - Risk Register
 - Qualitative
 - **Long term Flexibility (10 – 20 years)**
 - Market / Price
 - Technological Advancements
 - New Reserves
 - **Other?**

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20

Case: Economic Parameters & Assumptions

- Inflation: 2,0 %
- Prices:
 - **OIL 17 USD / BOE**
 - **GAS 0,09 USD / Sm³**
 - **NGL 160 USD / Ton going east, and 135 USD /Ton going west. Due to USD 16 logistics penalty at XYZ.**
- Transport / extraction tariffs Country X 0,04 USD / Sm³ GAS, and 92 USD / Ton NGL
- Transport / extraction tariffs Country Y 9.4 USD / Sm³ fluids, and 0,03 USD / Sm³ Gas, no NGL tariff.
- Environmental tariffs
 - **CO₂ 18 USD Fixed from 01.01.2005 →**
 - **NO_x 2.5 USD / KG 2005 →**
 - **VOC Increasing from 3-13 cents/BBL2003-08, and 5 cents/BBL 2009→**
- Decommissioning:
 - **Country X : Plugging year after production stop, removal starts year after that and takes 4 years for xx and yy, two years for abc and def, and one year for the sub sea templates.**
 - **Country Y : Assumed to pay none of the costs for decommissioning the infrastructure on the Y-side.**
- Tax assumption; Country X tax regime and full tax position.
- Cut off criteria: Maximised NPV after tax.
- During the construction period, 25% of the operational investments in the RNB are used in all the alternatives
- Full transportation tariffs for the "small" overshooting volumes from nearby field Q back to pipeline P.

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21