VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

Supporting replacement investment decisions in capital intensive industry

Expert Judgment for Asset and Project Management Practice and Challenges

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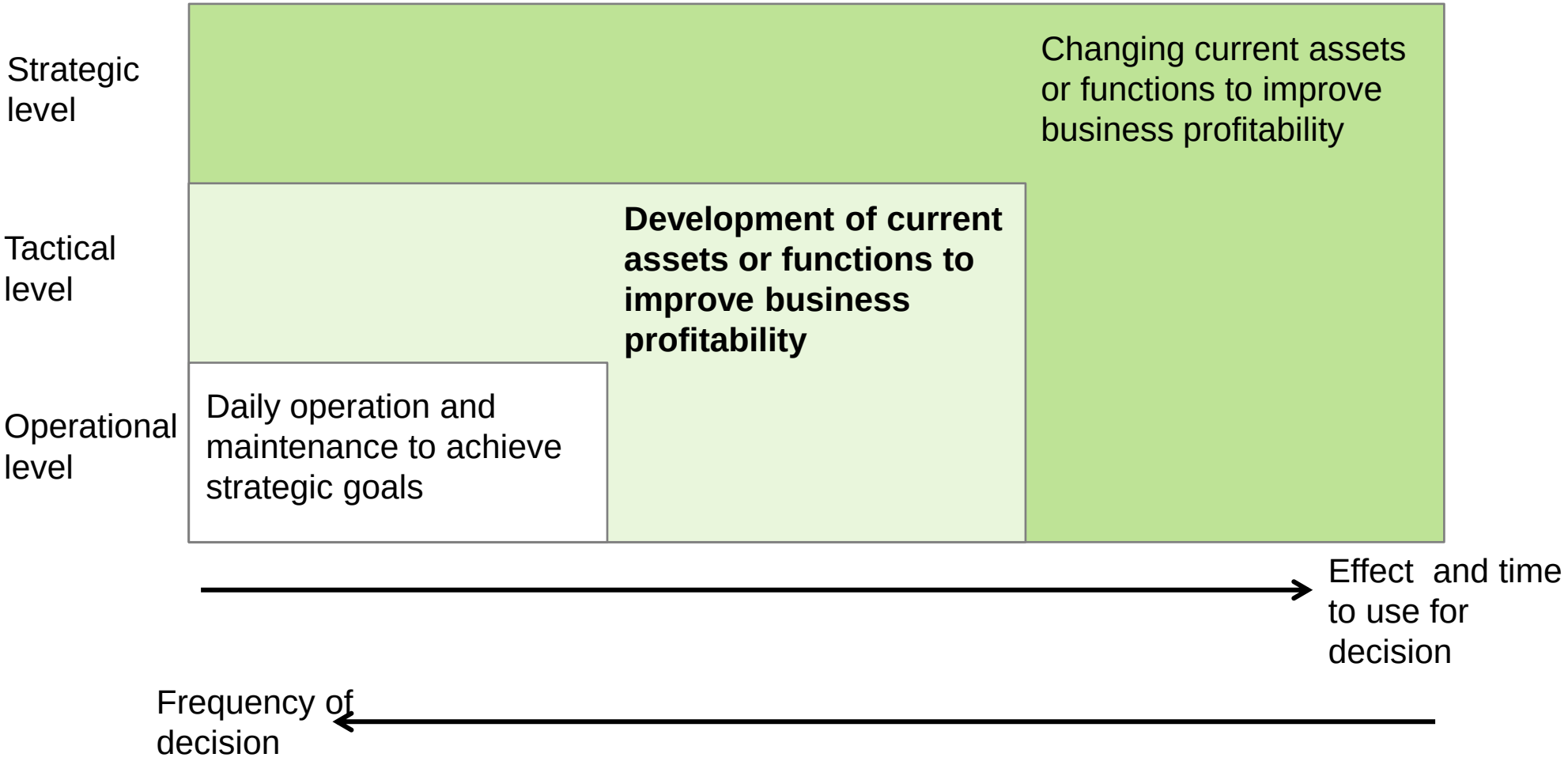
Content

- How to support transparent investment decision making by structured expert judgements?

- Categorization of decision making situations
- Problem statement

- Two practical examples about methods to support replacement investment decisions
  - Cost and benefit based method
  - Risk analysis based method
  - Aim of the methods is to structure expert knowledge to useful form

Decision Making Situations in industry



Problem statement

List of investment proposals

- Production line A – investment 1
- Production line A – investment 2
- …
- …
- Production line B – investment 1
- …
- Production line B – investment 4
- …
- …
- …
- Production line F – investment 8
- …
- …
- …

Total 3 500 000 €

Selected investment portfolio

- Production line A – investment 2
- …
- Production line B – investment 1
- …
- …
- …
- Production line F – investment 5
- …

Total 2 000 000 €

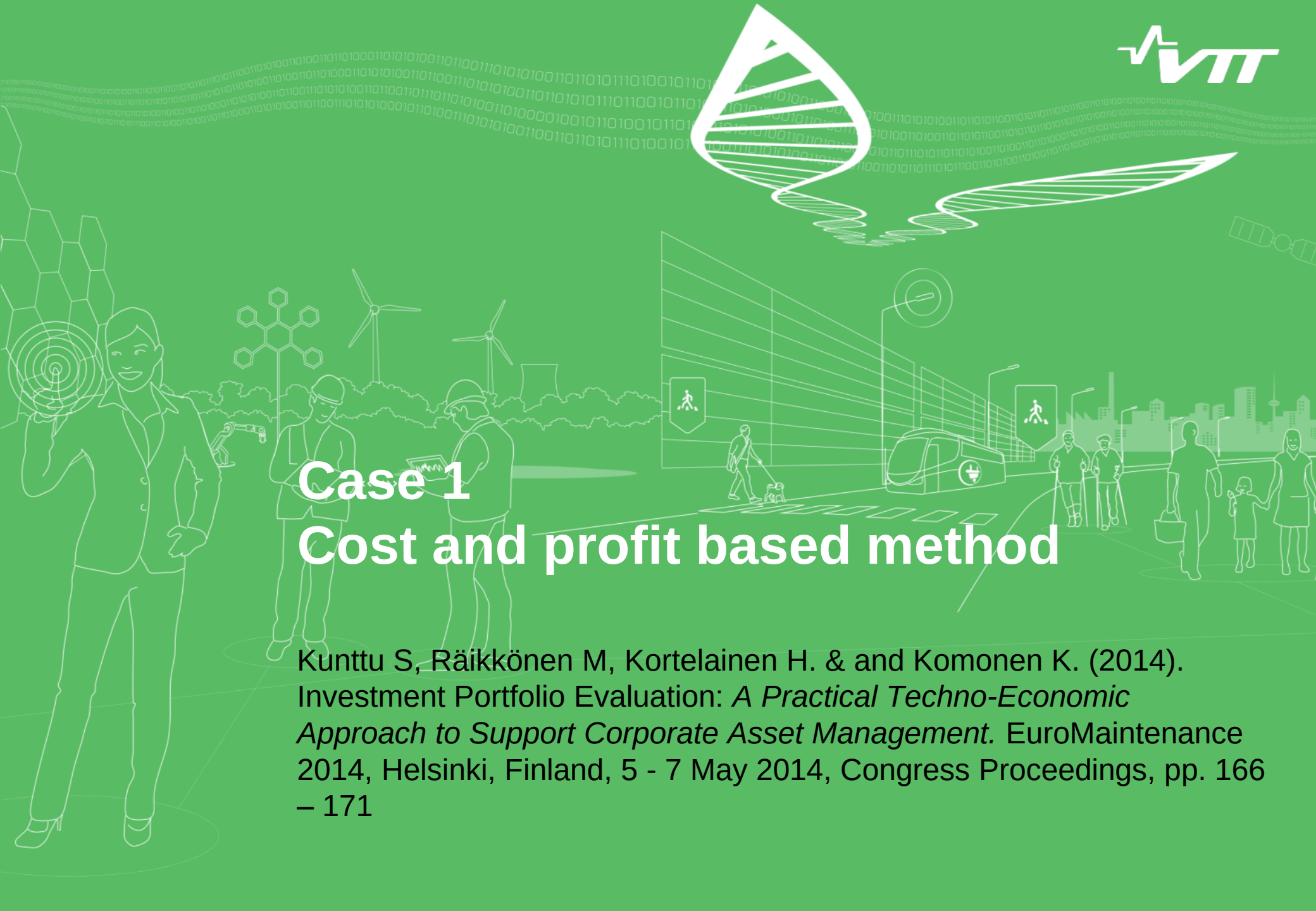
Method development vs. application

Method development
(research project)

- ✓Definition of parameters to assess investment proposals
- ✓Definition of key performance indicators
- ✓Definition of required calculations
- ✓Specifications of a calculation tool (a demo-tool by Excel)
  - ✓Data input
  - ✓Presentation of result
- ✓Testing and verification of the method

Method application (annual investment decisions by companies)

- ✓Assessing investment proposals by valuing defined parameters
- ✓Conducting calculations
- ✓Decision making



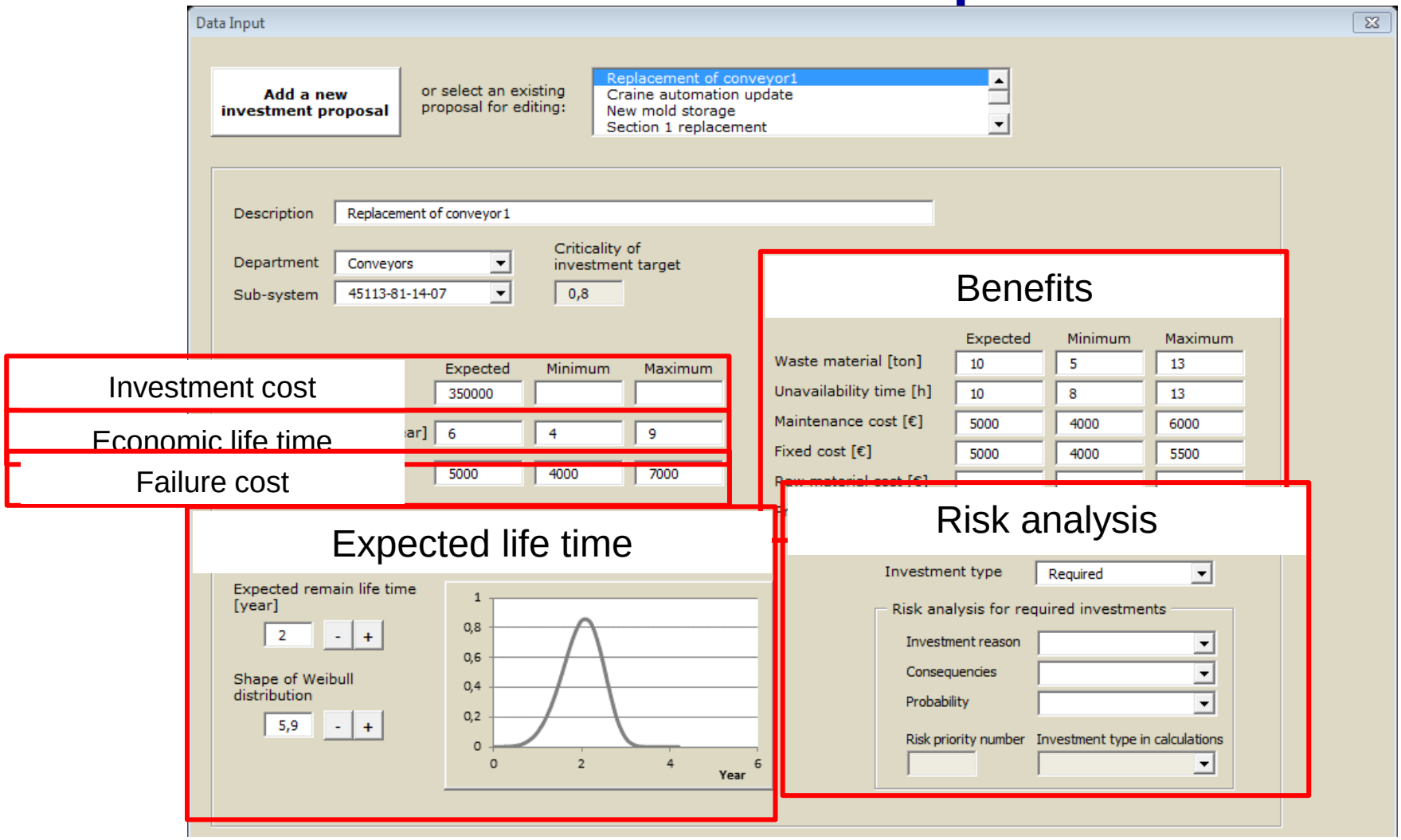
Case 1
Cost and profit based method

Kunttu S, Räikkönen M, Kortelainen H. & and Komonen K. (2014). Investment Portfolio Evaluation: *A Practical Techno-Economic Approach to Support Corporate Asset Management.* EuroMaintenance 2014, Helsinki, Finland, 5 - 7 May 2014, Congress Proceedings, pp. 166 – 171

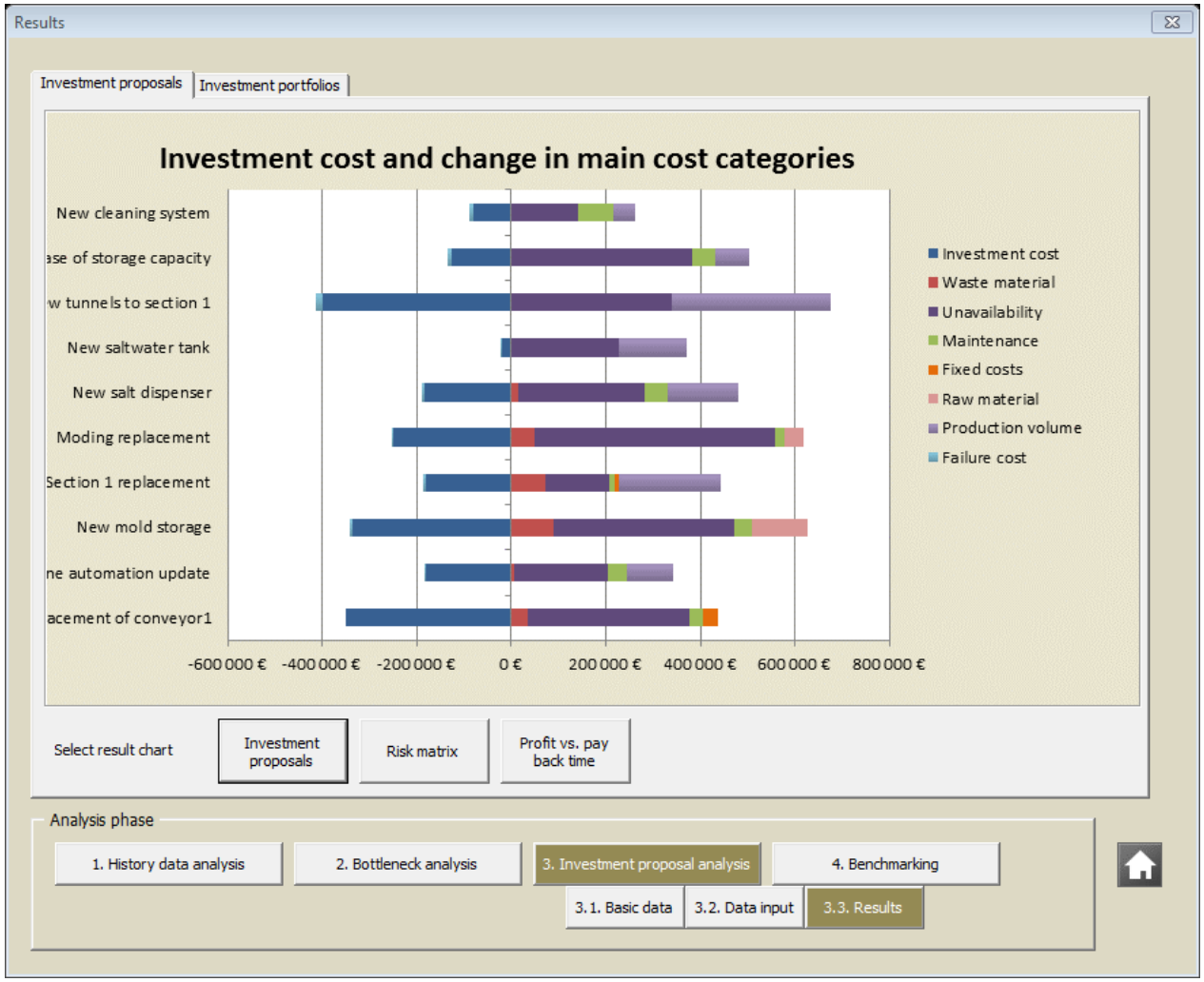
Investment decisions based on economic criterion

- Assessment of investment proposals
  - Costs and benefits
  - Life time of current equipment
  - Risk analysis
  - Market and competitive analysis
- Selection of investment portfolio based on selected indicator
- Uncertainty analysis
  - Monte Carlo simulation

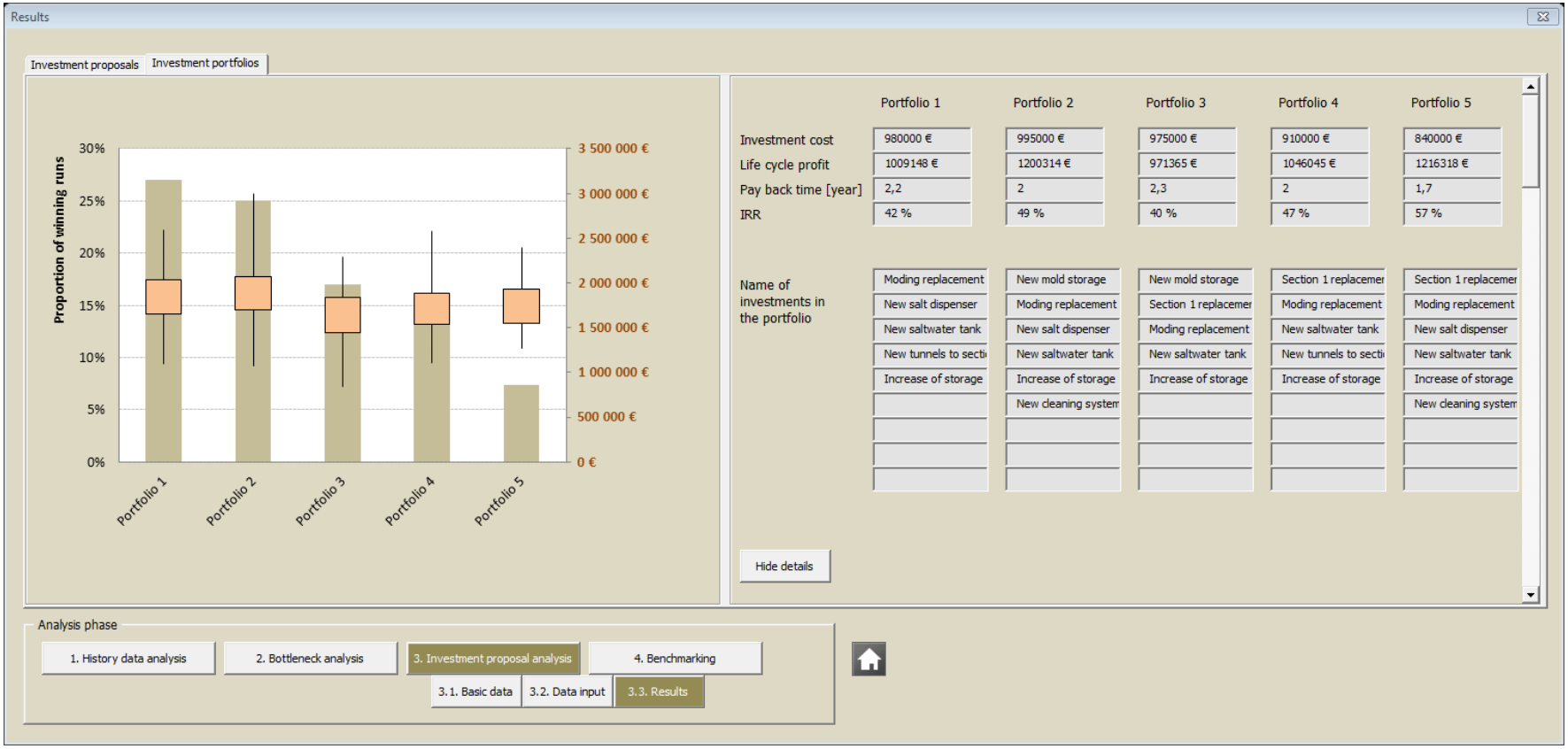
Assessment of Investment Proposals

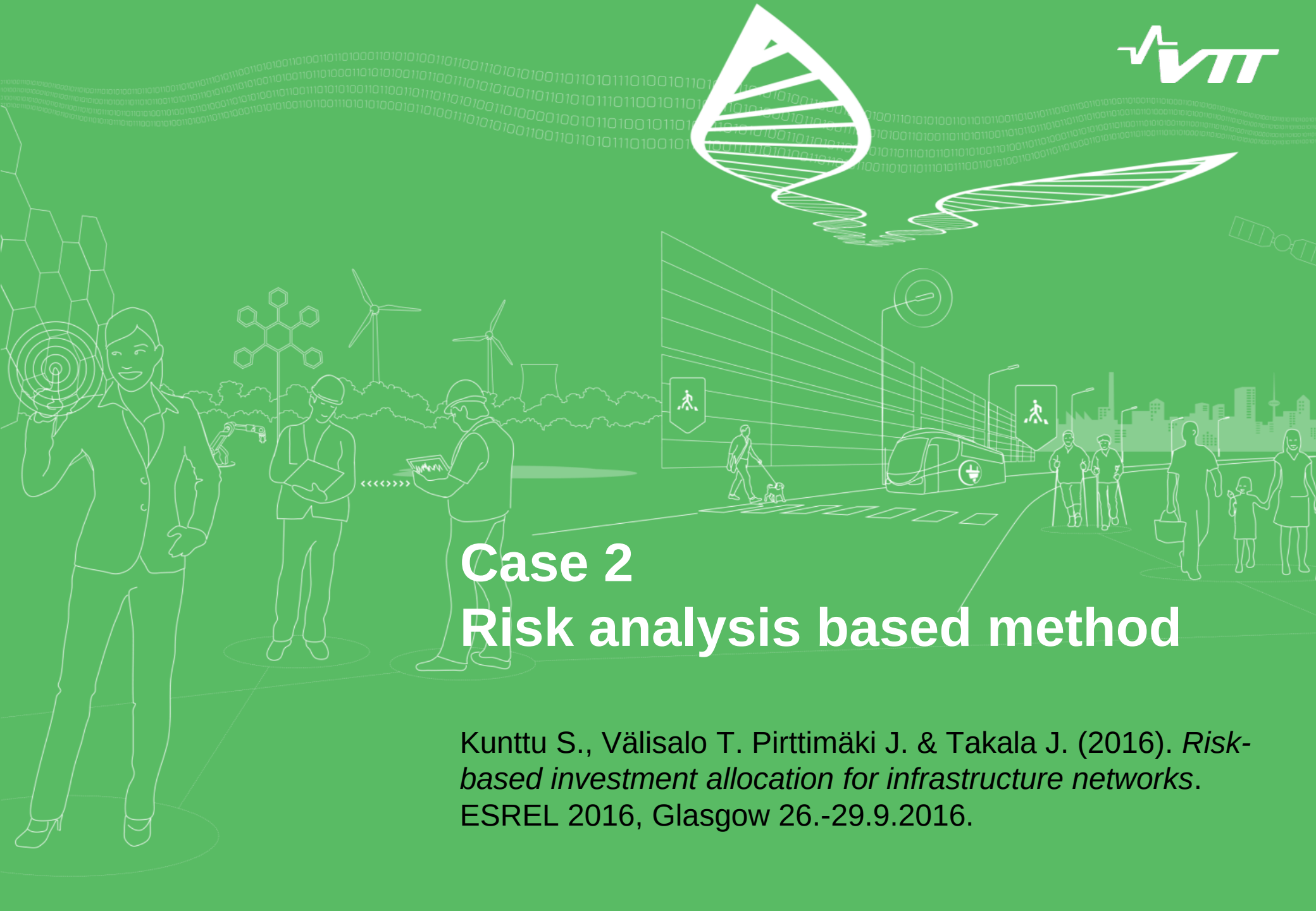


Costs and benefits of investment proposals



Investment portfolios





Case 2
Risk analysis based method

Kunttu S., Välisalo T. Pirttimäki J. & Takala J. (2016). *Risk-based investment allocation for infrastructure networks*. ESREL 2016, Glasgow 26.-29.9.2016.

Investment decisions based on risk analysis

- A method to support investment portfolio selection when investment proposals are from electricity, water and district heating networks
- Due to the intangible values achieved by investments, traditional economic indicators are not relevant
  - For example, payback time cannot usually be calculated because replacement investments have only a minor effect on the company's profit.
- Two criteria for selected investments
  - Residual risk must be minimized
  - Total investment cost must be lower than the budget

Risk assessment

- Risk identification
  - All the risks an investment proposal will reduce are identified
- Risk analysis
  - Probability and consequencies were categorized to five categories
  - Consequences were defined by four different aspects
    - Consequences to human and environmental safety
    - Consequences to customers, which describes inconvenience caused to customers
    - Economic consequences, which includes all costs the company need to pay because the risk has been realized
    - Asset functionality, which covers issues related to a network's ability to perform its function also in the future, for example, the availability of spare parts and capacity

Risk matrix x 4

	Concequencies for each of the four aspects
	Level 1 / Level 2 / Level 3 / Level 4 / Level 5
P ~ 0.05 - “Hard to imagine a scenario where this risk will be realized. Several things have to go wrong.”	
P ~ 0.25 - “In some circumstances this risk could be realized.”	
P ~ 0.5 - “It seems rather possible that this risk could be realized.”	
P ~ 0.75 - “It is much more probable that this risk will be realized.”	
P ~ 0.95 - “It is hard to imagine a future where this risk will not be realized.”	

Comparability of consequencies

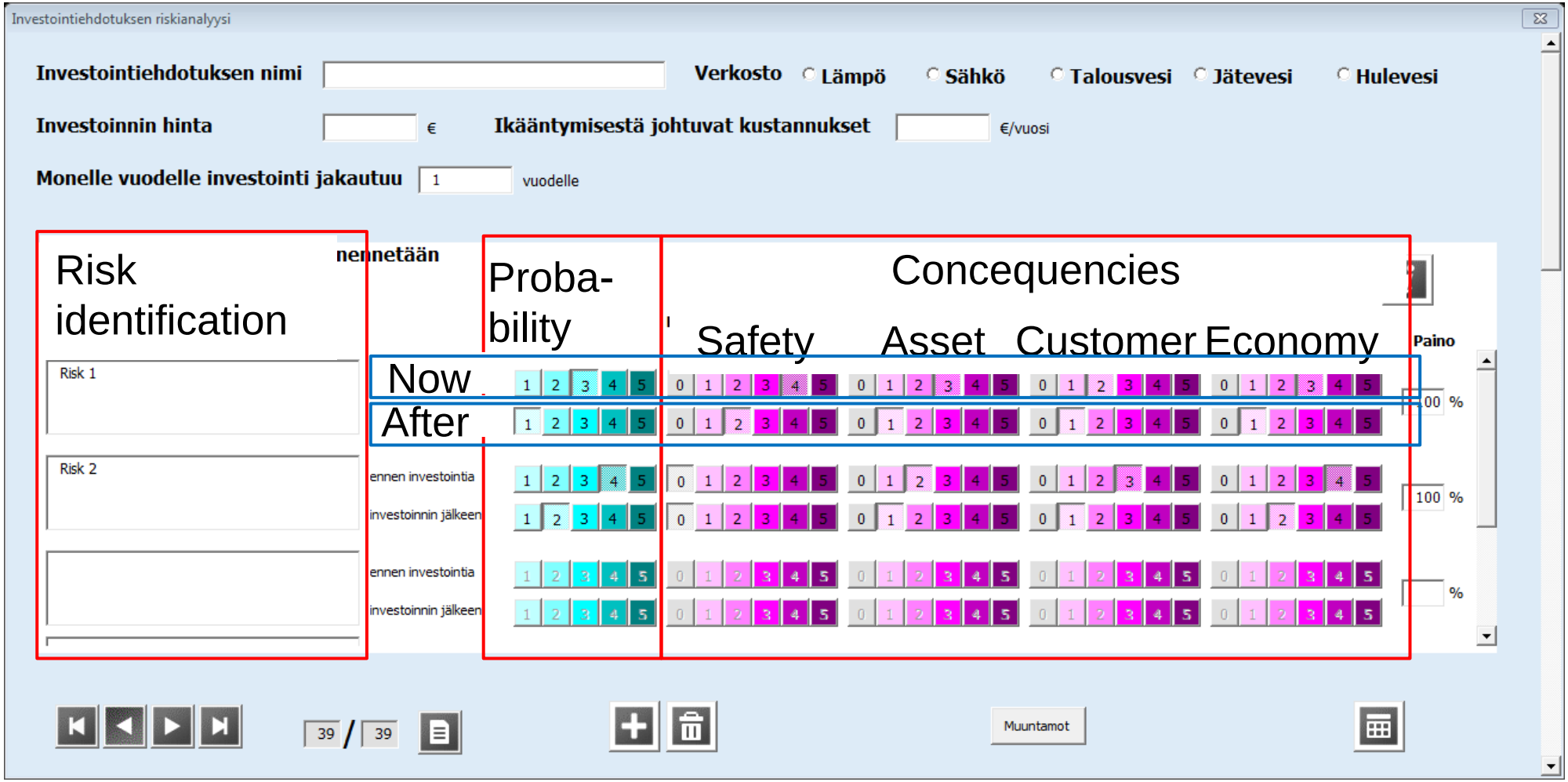
- How to align consequence levels?
- Numerical reference value was given to all levels

	Safety	Customers	Economic	Functionality
Level 0 – no consequencies	0	0	0	0
Level 1 – Minor		5	10	
Level 2		50	100	
Level 3		500	1000	
Level 4		20 000	100 000	
Level 5 - severe		300 000	1 000 000	

Risk evaluation

- Risk values are calculated to each aspects probability x consequences
- Risk index for an investment proposal is the weighted average of risk values
- Weights for considered four aspects were defined by case company's steering committee
  - Analytical hierarchy process (AHP) was applied

Interface for risk identification and analysis



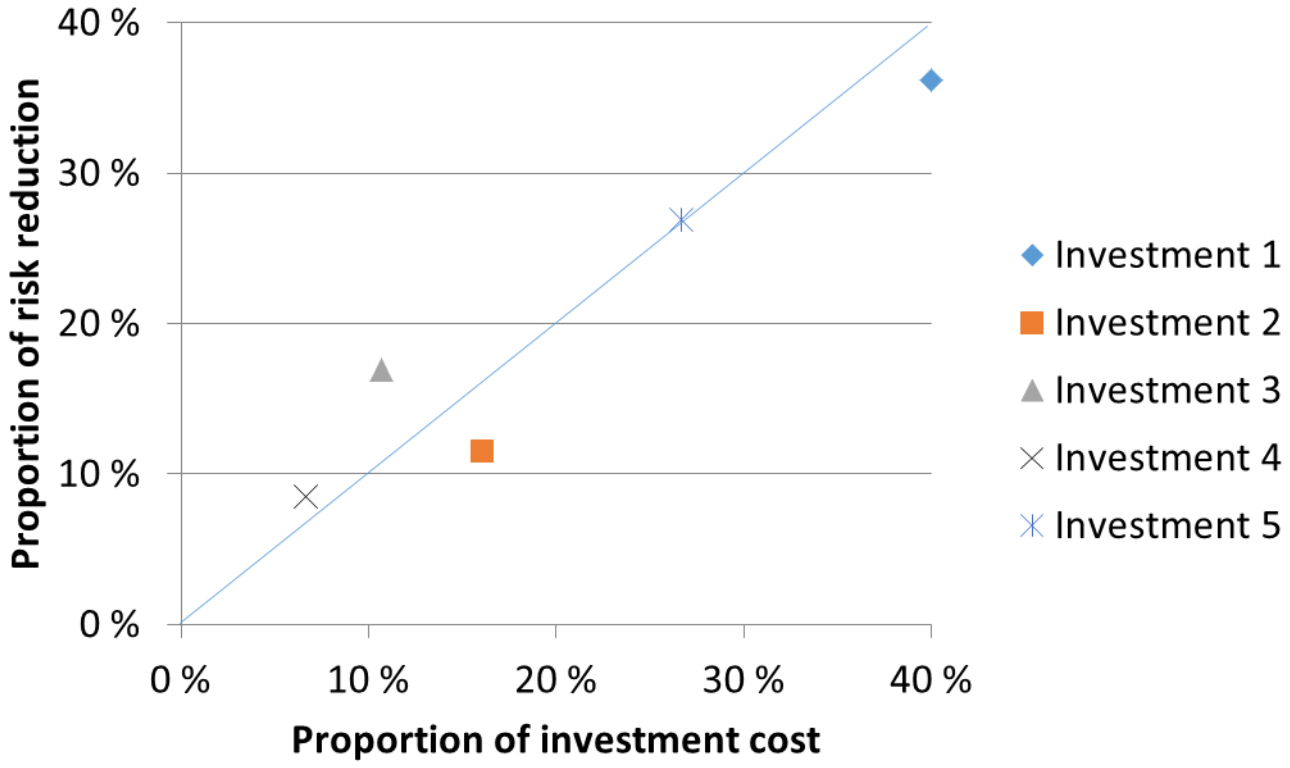
Key performance indicators

	Cost [k€]	Risk index now	Risk index after	Risk reduc-tion	Cost/ reduc-tion	Proportion of costs	Proportion of risk reduction
Investment 1	300	550	80	470	638 €	40 %	36 %
Investment 2	120	200	50	150	800 €	16 %	12 %
Investment 3	80	300	80	220	364 €	11 %	17 %
Investment 4	50	150	40	110	455 €	7 %	8 %
Investment 5	200	600	250	350	571 €	27 %	27 %

Total cost 750 k€

Total risk reduction 1300

Example of key performance indicators



Selection of the investment portfolio

- The selection of investments to be realized from a long list of investment proposals is known as the traditional knapsack problem, where the objective is to select a set of choices that optimize the selected parameter and meet the defined constraints
  - Constrain: budget
  - Optimized parameter: residual risk after realization of the investment portfolio
  - In the tool was applied Excel's Solver add in

Knapsack example

Budget 400 k€ (total cost of proposals is 750 k€)

	Cost [k€]	Risk index now	Risk index after	Risk reduc-tion	Cost/ reduc-tion	Proportion of costs	Proportion of risk reduction
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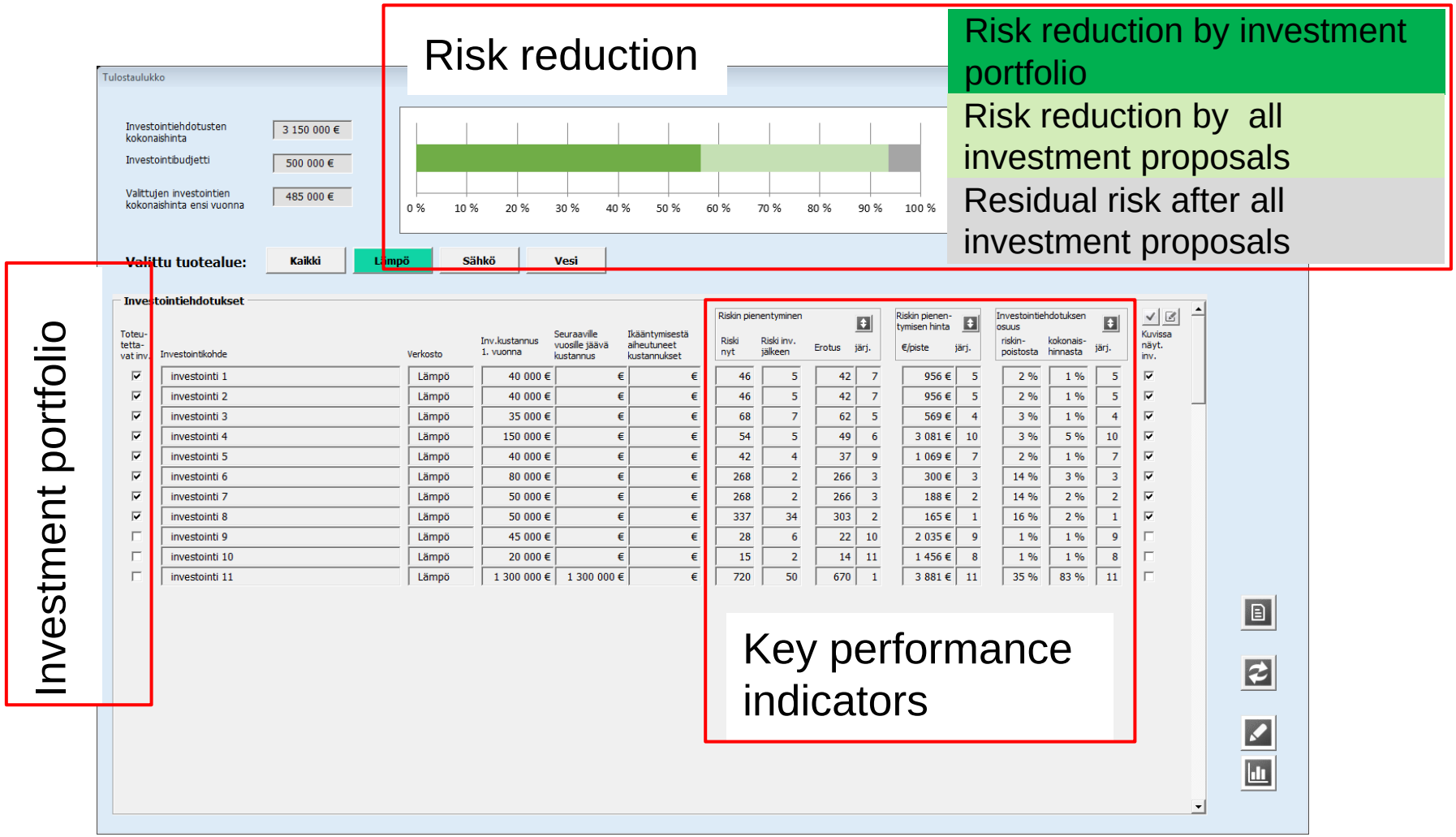
Cost of investment portfolio 400 k€
Residual risk 1080 (total risk now is 1800)

Interface for results



Conclusions

- The aim of the developed investment comparison methods is to increase transparency in decision making and to ensure development of actually problematic targets not only the latest problems
- The method can be used in the decision-making of a management group that needs structured and comparable information about investment proposals from different departments/functions/business units.
- Although the method provides an investment portfolio created according to the given objectives and constraints, it is not intended to be adopted without further consideration.

Utilization of expert judgements in investment decision making

- Data input assumes concensus expert judgements
  - Experts give their judgements related to systems of their own companies
  - Variation between expert judgements is small

- How to consider expert judgements when the best experts have own interest to overestimate benefits/criticality of proposals from their own department?
  - Intentional or unintentional


TECHNOLOGY FOR BUSINESS

Market demand and competitive analysis

Life Cycle of Investment (years)

Trend of Market Demand	Weak						Strong
Strong	6	6	10	10	10	10	10
	6	6	6	10	10	10	10
	3	6	6	6	10	10	10
	3	3	6	6	6	10	10
	3	3	3	6	6	6	10
	3	3	3	3	6	6	6
Weak	3	3	3	3	3	6	6

Competitive Position of Company

Market demand–competitive position matrix for the determination of an investment's economic life cycle