Multi-Attribute Risk Analysis in Nuclear Emergency Management

by

Raimo P. Hämäläinen, Mats Lindstedt,
and Kari Sinkko

Systems
Analysis Laboratory
Helsinki University of Technology

Governmental DA in Finland:

- Nuclear Power Debate in the Parliament

  facts, values, communication

- Finnish Environment Institute

  a standard approach in environmental decision making

- Nuclear emergency management

  How to benefit from multi attribute risk analysis ?

  EU-RODOS software project

Nuclear Emergency Management

- Decisions on countermeasures are multi-attribute problems

  projected dose, avertable dose, environmental issues, monetary costs and socio-psychological factors
- Consequences over long time periods
- Severe time pressures and high uncertainty
- Moral and ethical values as important as technical issues about the consequences

How to support this complex decision making process ?

= Research topic

RODOS Project

- a Real-time On-line DecisiOn Support project to develop a group support system for nuclear emergency management
- funded by the European Union starting in 1990
- in Finland STUK (Radiation and Nuclear Safety Authority) participates in the project
- Finnish decision conference studies part of the RODOS project and organized by STUK

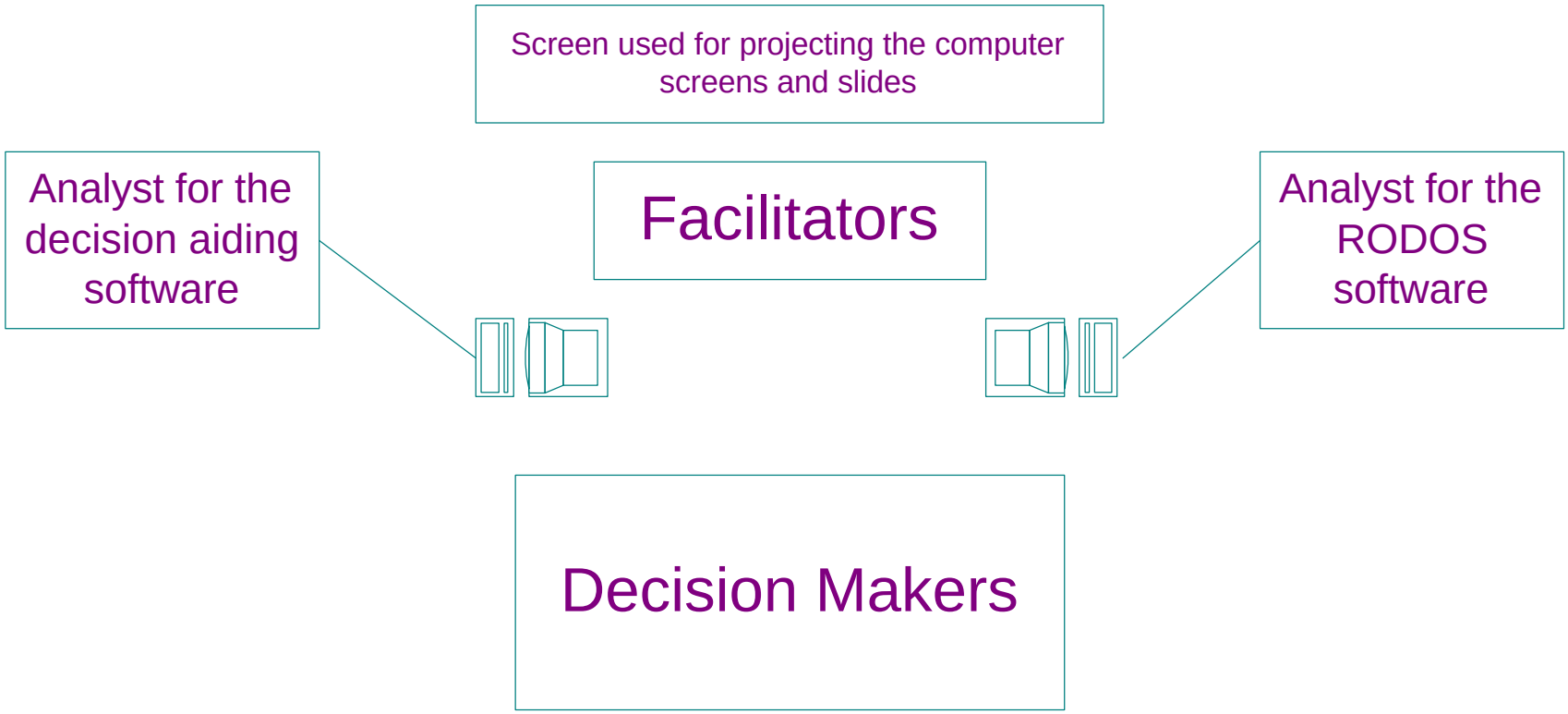
Decision Conference

- intensive computer supported meeting assisted by a facilitator
- a group of people develops a shared understanding of a common problem
- develops a decision analysis model
- originally a two-day meeting
- often for one time policy decisions

Emergency Exercises

- early phase decisions a few hours after the accident
- countermeasures: iodine tablets, sheltering, and evacuation
- RODOS software calculates accident data and impacts of countermeasures
- first series focused on: values and attributes
- second series focused on: uncertainties
- later series: later phase decisions/interviews
- participants: Finnish authorities, STUK and nuclear power companies

Conference setting

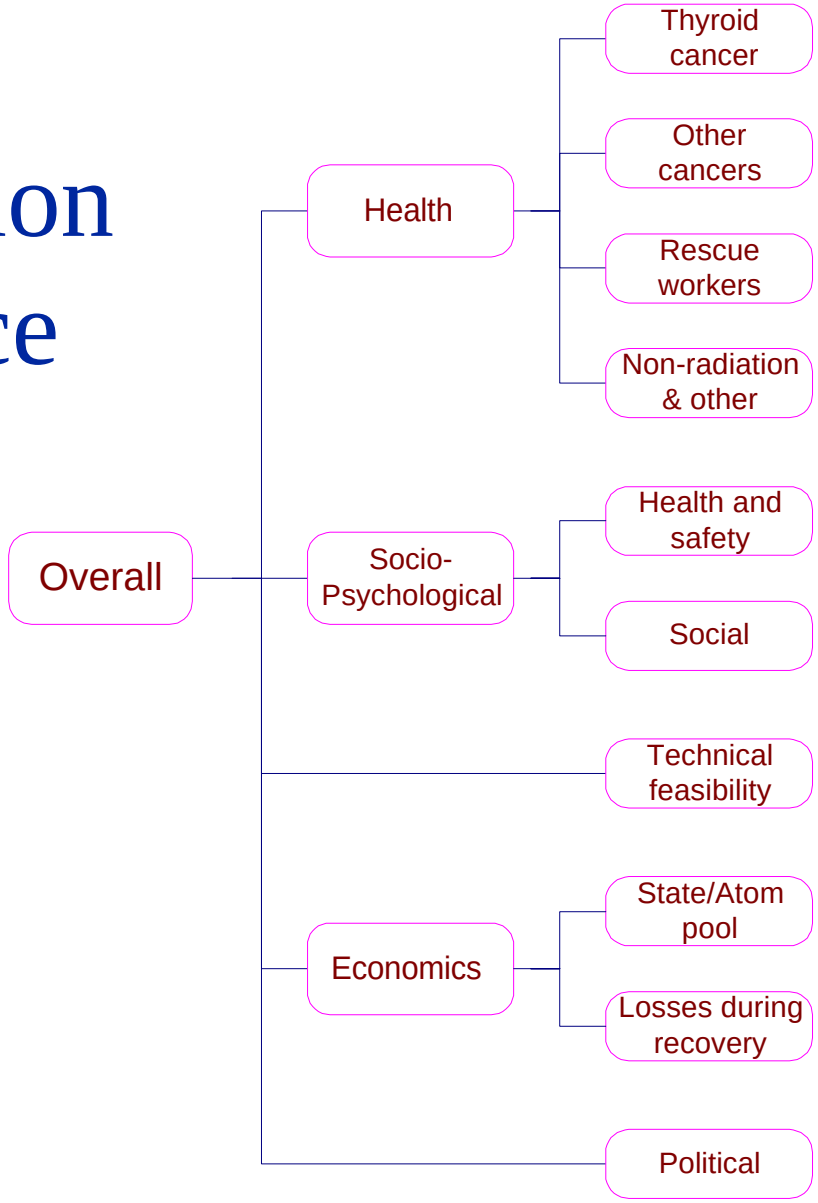


Problem structuring session

Preliminary value tree

First decision conference

Final value tree



First decision conference

-the strategies and their impacts

Attribute	Unit	No action	Reluctant	Medium	Rigorous
Health					
Thyroid cancer	number of incidents	1000	900	700	0
Other cancers	number of cancer deaths	400	300	220	0
Rescue workers	number of deaths	0	1	1	2
Non-radiation and other	number of deaths	0	3	7	10
Socio-Psychological					
Health and safety	very neg-very pos (100 - 0)	80	80	70	40
Social	very neg-very pos (100 - 0)	0	5	40	80
Technical feasibility	very low-very high (100 - 0)	0	1	10	100
Economics					
State/ Atom pool	MFIM	250	240	500	20000
Losses during recovery	MFIM	1000	1000	1000	10000
Political	very neg-no change (100 - 0)	100	30	30	80

First decision conference

- weights given by participants

Attribute	Least Preferred Level	Most Preferred Level	DM 1 SMARTER	DM 2 SMART	DM 3 SMART
Thyroid cancer	1000	0	0.337	0.250	0.235
Other cancers	400	0	0.212	0.250	0.188
Rescue workers	2	0	0.013	0	0.047
Non-radiation & other	10	0	0.013	0	0.012
Health and safety	100	0	0.076	0	0.235
Social	100	0	0.030	0	0.118
Technical feasibility	100	0	0.107	0	0.047
State/ Atom pool	20000	0	0.149	0.250	0
Losses during recovery	10000	0	0.013	0.250	0
Political	100	0	0.051	0	0.118

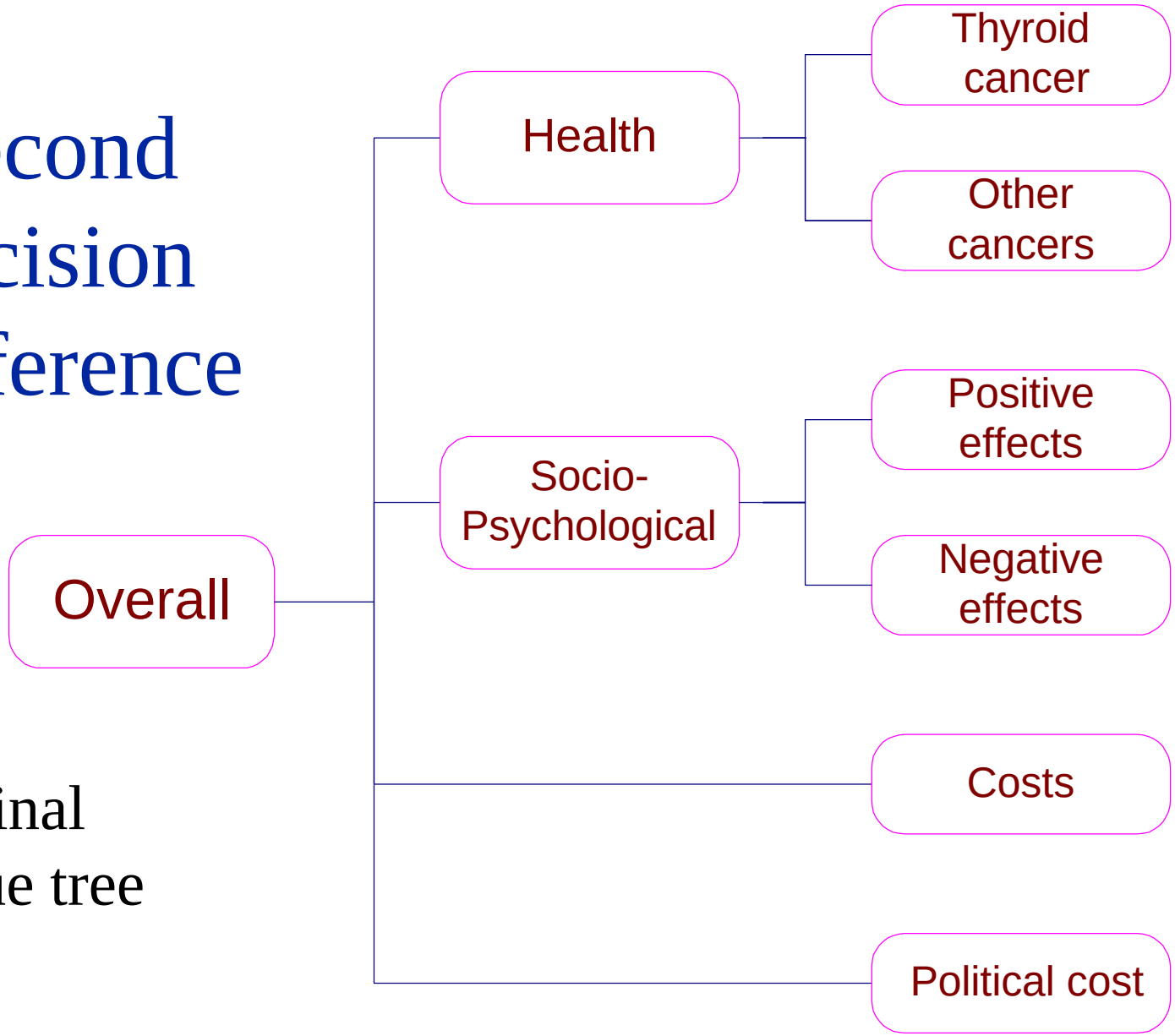
Second decision conference

- uncertainties included
- it was known that an accident had happened, but it was not known how severe it had been
- 5%, 50%, and 95% fractiles used

⇨ three accident scenarios

Second decision conference

Final value tree



Second decision conference-impacts

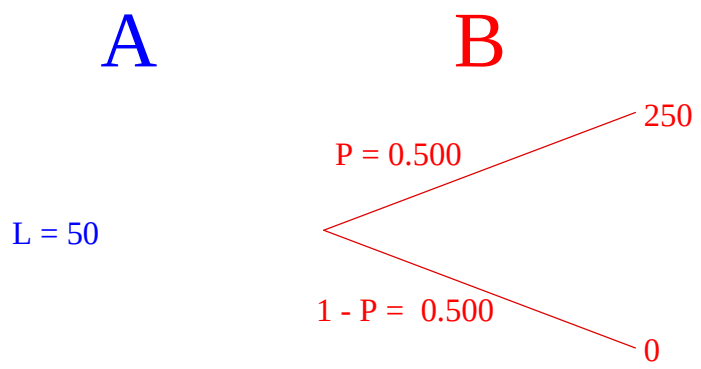
Attribute	Unit		Strategy 0	Strategy 1	Strategy 2	Strategy 3	Strategy 4
Health							
Thyroid cancer	nr of cancer	5%	0	0	0	0	0
	incidents	50%	20	5	2	2	4
		95%	240	50	20	20	40
Other cancers	nr of cancer	5%	0	0	0	0	0
	incidents	50%	22	20	20	20	12
		95%	320	286	288	286	204
Socio-Psychological							
Positive effects	no change-	5%	0	100	10	10	0
	very pos	50%	0	75	50	45	40
	(0 - 100)	95%	0	50	90	80	80
Negative effects	no change-	5%	40	0	90	80	50
	very neg	50%	70	40	50	45	35
	(0 - 100)	95%	100	80	10	10	20
Costs	MFIM	5%	0	9.7	13.5	13.5	960.2
	MFIM	50%	11.8	18.7	22.5	22.5	962.9
	MFIM	95%	166.2	143.1	145.3	144.5	1056.2
Political cost	no change-	5%	30	0	0	20	80
	very neg	50%	65	40	40	30	50
	(100 -0)	95%	100	80	80	40	20

Second decision conference
- eliciting utility functions

Please set Level L and probability P so that certain Alternative A and lottery Alternative B are equally preferred

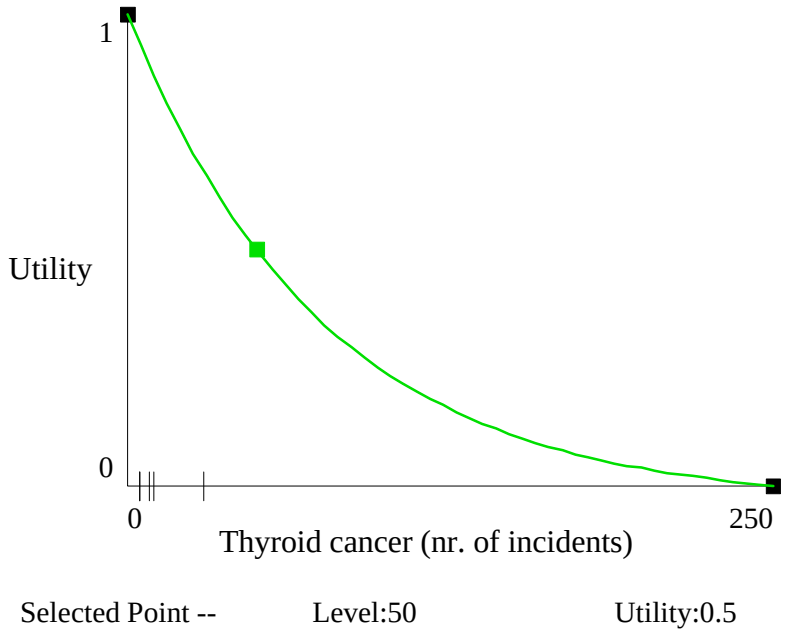
Lottery question:

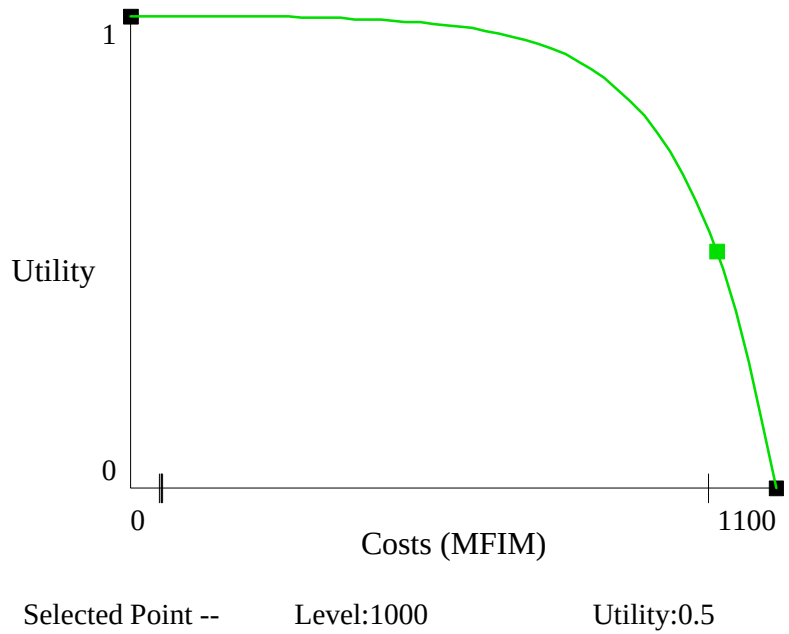
Please select the number of cancer incidents (L) that would make you indifferent between getting that amount for sure and a fifty-fifty chance of getting 250 cancer incidents or 0 incidents.



Risk Premium = 75, Local Risk Aversion (r) = 0.0131251

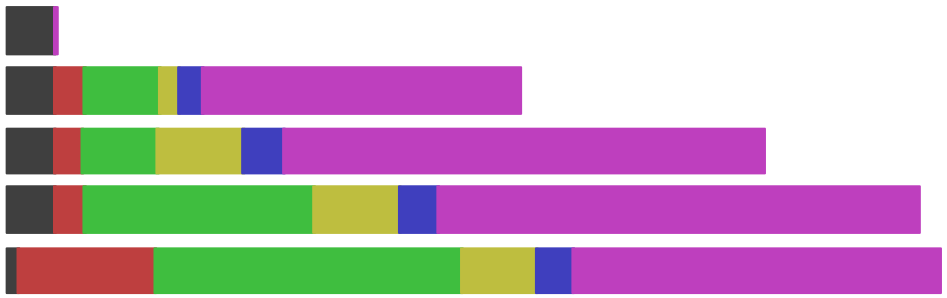
Second decision conference
- utility functions





Second decision conference
- weighting with SMART (95% fractile)

Alternative	Utility
Strategy 0	0.043
Strategy 1	0.431
Strategy 2	0.636
Strategy 3	0.762
Strategy 4	0.781



Costs
Other cancers
Political cost
Soc.-Psych Negative
Soc.-Psych Positive
Thyroid cancer

Decision conferencing can be useful

- a lot of progress can be made in just a few hours
- provides a common framework for assessing the situation and justifying the decisions
- prestructured value trees or benchmarks help
- with more training this setting could be used in a real situation

  for later phase decisions

  for creating a way and language of communication

  for the emergency management group beforehand

Understanding uncertainties

- was found to be very difficult
- the participants rather focused on the worst case scenario (95% fractile) and ignored the probabilities
- there was no uncertainty about the accident, if there had been the situation would have been even more difficult

RODOS software

- provides useful data
- still too slow and complex to be used on-line during the conferences
- participants did not think that RODOS could help in a early phase decision making situation
- differences in national emergency management laws need to be taken into account
- RODOS remains a training tool ?

Lessons learned

- **Analyst**
  - neutral facilitator in problem structuring
  - understands methods and behavioral issues
  - independent of responsible DM organizations
- **Software**
  - interaction creates transparency/credibility
  - public participation on the web
- **Culture**

  reporting experiences and continuing exercises create readiness to use DA and to see the multidimensionality of the problem

References

Hämäläinen R.P., Sinkko K., Lindstedt M. 1999. **Multi-Attribute Risk Analysis in Nuclear Emergency Management.** Risk Analysis, 2000. Downloadable at http://www.hut.fi/Units/SAL/Publications/pdf-files/rham00b.pdf

Hämäläinen R.P., Sinkko K., Lindstedt M., Ammann M. and Salo A. 1998. **RODOS and decision conferencing on early phase protective actions in Finland**, Radiation and Nuclear Safety Authority, STUK-A159, December, pp. 1-76. Downloadable at http://www.hut.fi/Units/SAL/Publications/pdf-files/rham98.pdf

Hämäläinen R.P., Sinkko K., Lindstedt M., Ammann M. and Salo A. 1999. **Decision analysis interviews on protective actions in Finland supported by RODOS system**. Radiation and Nuclear Safety Authority, STUK-A173, February 2000, pp. 57. Also RODOS Report, RODOS(WG7)-TN(99)-04. Downloadable at

http://www.hut.fi/Units/SAL/Publications/pdf-files/rham00.pdf

Hämäläinen R P. 1988. **Computer Assisted Energy Policy Analysis in the Parliament of Finland**. Interfaces; 4 (Vol. 18): 12-23.

Hämäläinen, R. P., **Facts or values - how do parliamentarians and experts see nuclear power?.** Energy Policy 19 (5), June 1991, pp. 464-472.

Hämäläinen, R. P., Leikola, O. 1996. **Spontaneous Decision Conferencing with Top-level Politicians.** OR Insights Vol 9, pp. 24-28.

Hämäläinen, R.P., **The use of modern decision analytical and multicriteria optimization methods in the development of a new regulation policy for the Päijänne-Kymijoki lake-river system,** http://www.paijanne.hut.fi/