Creating a strategy portfolio for climate change mitigation
A study of behavioral effects

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Portfolio perspective is needed in environmental management

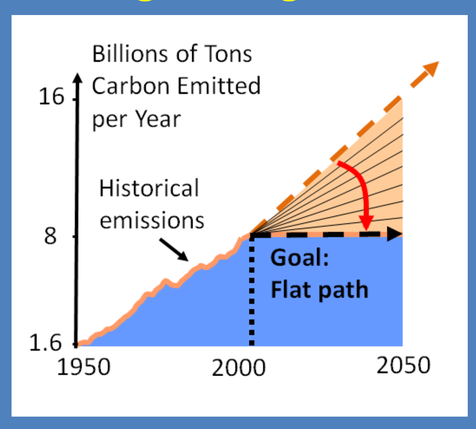
Find the best basket (portfolio) of strategies

The overall consequences matter

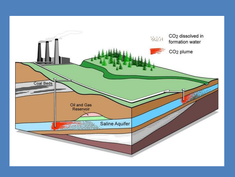
- Stakeholder perspectives, non-commensurable objectives
- Overlapping actions, synergies, constraints

Example: Climate change mitigation

Create a **basket** (portfolio) of 8 emission reduction strategies



15 strategy candidates



Strategy	Sector	Description	1 wedge could come from...	Cost	Challenges
1. Efficiency – Transport		Increase automobile fuel efficiency (2 billion cars projected in 2050)	**... doubling the efficiency of all world's cars from 30 to 60 mpg**	$	Car size & power
2. Conservation - Transport		Reduce miles traveled by passenger and/or freight vehicles	**... cutting miles traveled by all passenger vehicles in half**	$	Increased public transport, urban design
3. Efficiency - Buildings		Increase insulation, furnace and lighting efficiency	**... using best available technology in all new and existing buildings**	$	House size, consumer demand for appliances
4. Efficiency – Electricity		Increase efficiency of power generation	**... raising plant efficiency from 40% to 60%**	$	Increased plant costs
5. CCS Electricity		90% of CO_2 from fossil fuel power plants captured, then stored underground (800 large coal plants or 1600 natural gas plants)	**... injecting a volume of CO_2 every year equal to the volume of oil extracted**	$$	Possibility of CO_2 leakage
6. CCS Hydrogen		Hydrogen fuel from fossil sources with CCS displaces hydrocarbon fuels	**... producing hydrogen at 10 times the current rate**	$$$	New infrastructure needed, hydrogen safety issues
7. CCS Synfuels		Capture and store CO_2 emitted during synfuels production from coal	**... using CCS at 180 large synfuels plants**	$$	Emissions still only break even with gasoline
8. Fuel Switching – Electricity		Replacing coal-burning electric plants with natural gas plants (1400 1 GW coal plants)	**... using an amount of natural gas equal to that used for all purposes today**	$	Natural gas availability
9. Nuclear Electricity		Displace coal-burning electric plants with nuclear plants (Add double current capacity)	**... ~3 times the effort France put into expanding nuclear power in the 1980's, sustained for 50 years**	$$	Weapons proliferation, nuclear waste, local opposition
10. Wind Electricity		Wind displaces coal-based electricity (10 x current capacity)	**... using area equal to ~3% of U.S. land area for wind farms**	$$	Not In My Back Yard (NIMBY)
11. Solar Electricity		Solar PV displaces coal-based electricity (100 x current capacity)	**.. using the equivalent of a 100 x 200 km PV array**	$$$	PV cell materials
12. Wind Hydrogen		Produce hydrogen with wind electricity	**... powering half the world's cars predicted for 2050 with hydrogen**	$$$	NIMBY, Hydrogen infrastructure, safety
13. Biofuels		Biomass fuels from plantations replace petroleum fuels	**... scaling up world ethanol production by a factor of 12**	$$	Biodiversity, competing land use
14. Forest Storage		Carbon stored in new forests	**... halting deforestation in 50 years**	$	Biodiversity, competing land use
15. Soil Storage		Farming techniques increase carbon retention or storage in soils	**... practicing carbon management on all the world's agricultural soils**	$	Reversed if land is deep-plowed later

Behavioral issues in unaided step-by-step processes

Result: Sub-optimal or dominated portfolios?

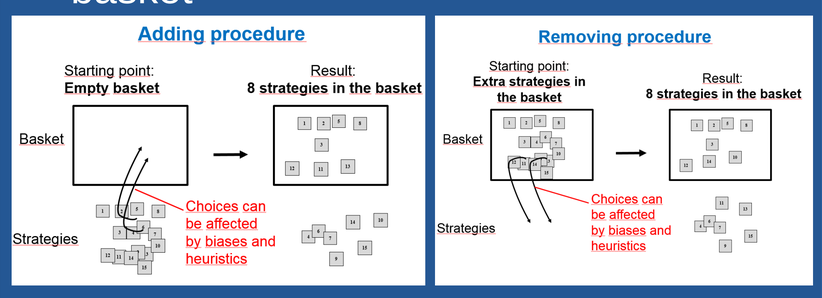
Narrow thinking: Individual strategies considered in isolation of the big picture
Elimination by aspects: thresholds in criteria
Equal allocation of resources to categories
Loss aversion: adding or removing does not feel the same
Premature commitment to strategies that first come to mind

Behavioral experiment on the web

carbcut.aalto.fi

Within-subject design
Two procedures:

- Adding strategies into the basket
- Removing extra strategies from the basket



Does the result depend on the procedure followed?

- Similarity measure: the number of same strategies in the two portfolios

How do the subjects choose their path?

Results

How many participants chose the strategies

Add	Remove

N	
Avg. Similarity (full=8)	
# Full similarity	

	Add	Remove
Avg. # dollars		
Avg. time spent		
Difficulty rating		
Preferred result		

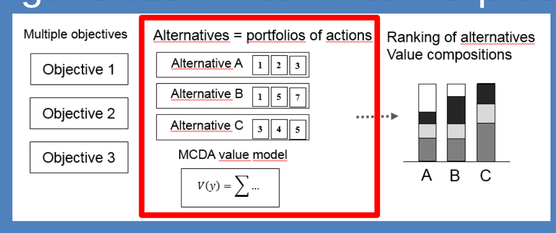
Which behavioral effects are reflected in our results?
How about the approach/avoidance conflict?

- Difficult to choose between undesirable alternatives

Portfolio approaches

MCDA – The standard approach

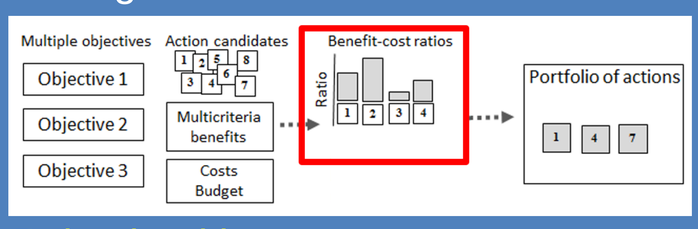
Evaluation of portfolio alternatives generated in an unaided process



Behavioral issues:
Generation of alternatives
Behavioral effects in MCDA

Benefit-cost

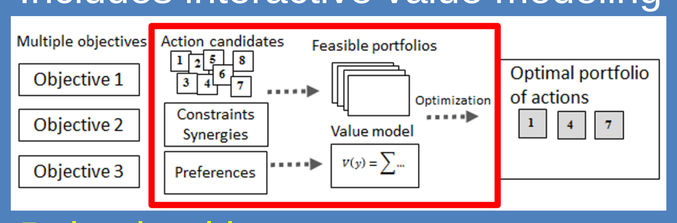
MCDA evaluation of individual strategies
Portfolio generation: Include strategies in the highest benefit-cost order



Behavioral issues:
Narrow thinking: Omission of synergies and interactions
Behavioral effects in MCDA

Portfolio decision analysis

MCDA value model + constraints + optimization
Includes interactive value modeling



Behavioral issues:
Ranges become problematic! Are weights based on consequences of individual strategies or overall consequences of portfolios of strategies?
Behavioral effects in MCDA

Conclusions

for environmental policy analysts

Behavioral research on environmental portfolio problems is very limited but important

The most important environmental issues are portfolio problems

There can be unanticipated phenomena related to the systemic nature of the problems

for decision analysts

Generation of alternatives consisting of multiple elements is not studied from the behavioral perspective

We need methods for coping with behavioral issues in portfolio problems

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