



Wir schaffen Wissen – heute für morgen

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How to Assess Different Policy Options for Energy Security

SECURE Final Conference, Brussels, 25 November 2010

- Basic approach to evaluation
- Criteria and indicator set
- Examples of quantitative indicators
- Policy evaluation sensitivity mapping
- Conclusions
- On-line tool

Security of supply and sustainability – conflict of objectives?

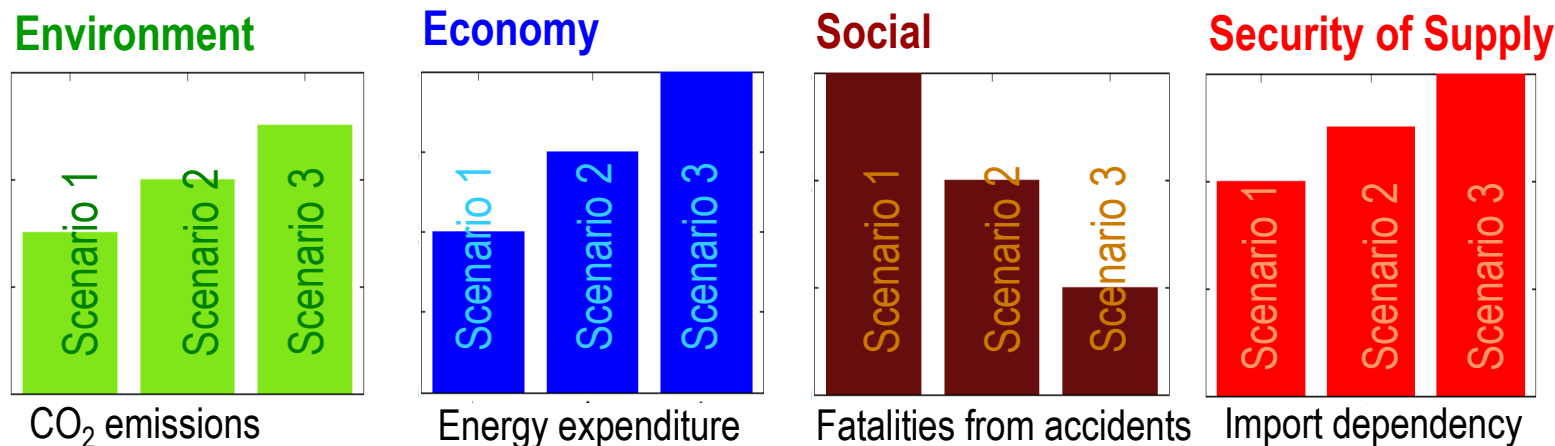
US President Gerald Ford in 1975:

- „We, the United States, are not blameless. Our growing dependence upon foreign resources has been adding to our vulnerability for years and years, and we did nothing to prepare ourselves for such an event as the embargo of 1973.“
- „Within the next 10 years my program envisions 200 major nuclear power plants, 250 major new coal mines, 150 major coal –fired power plants, 30 major new refineries, 20 major new synthetic fuel plants, the drilling of many thousands of new wells, the insulation of 18 million homes and the manufacturing and sale of millions of new automobiles, trucks and buses that use much less fuel.“

*MCDA = Multi-criteria Decision Analysis

Goal: Compare policy scenarios with different levels of CO₂ reduction

Scenarios differ in many aspects:



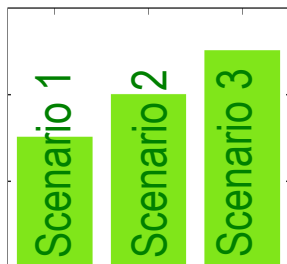
-> MCDA provides a tool to compare the scenarios on all aspects **simultaneously**

2 questions, separated in a two step process:

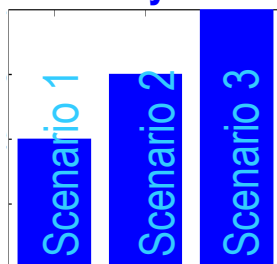
- How well does each scenario perform for each indicator: **objective calculation**
- How important is this aspect/indicator: **subjective preference**

Step 1: **Objective** performance of the scenarios | Step 2: **Subjective** weighting of the importance

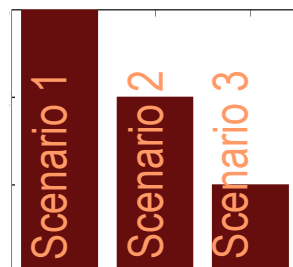
Environment



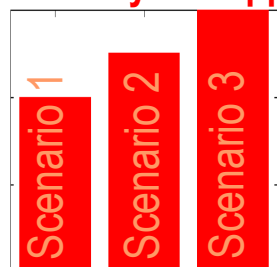
Economy



Social



Security of Supply



Importance of environmental aspects



Importance of economical aspects



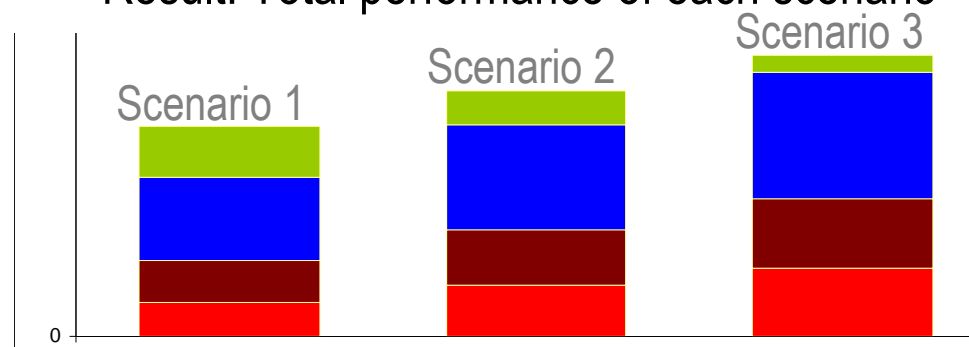
Importance of social aspects



Importance of supply security aspects



Result: Total performance of each scenario

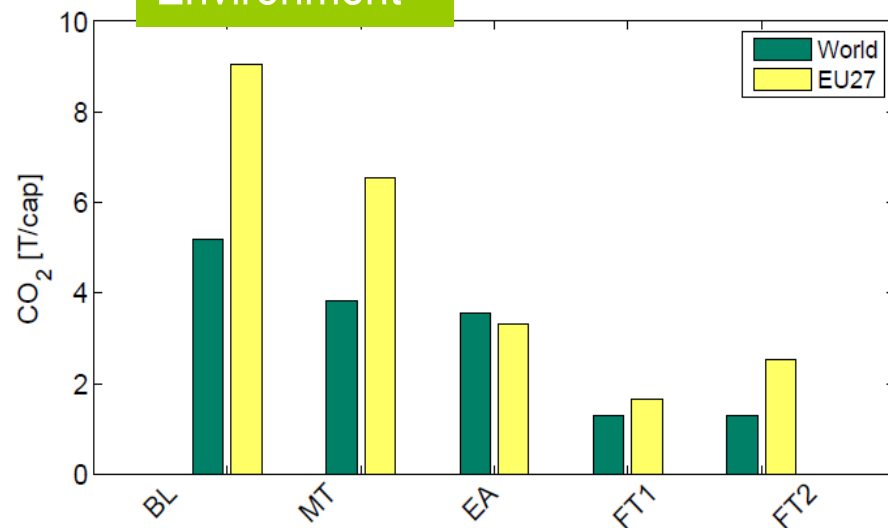


	Criteria / Indicator	Description	Unit	Source
ENVIRONMENT	CO ₂ Emissions World	Worldwide CO ₂ emissions per capita	t CO ₂ / capita	POLES
	CO ₂ Emissions EU 27	EU 27 CO ₂ emissions per capita	t CO ₂ / capita	POLES
ECONOMY	Energy Expenditure World	Worldwide energy expenditure per Gross Domestic Product (GDP)	USD / GDP	POLES
	Energy Expenditure EU 27	EU 27 energy expenditure per Gross Domestic Product (GDP)	USD / GDP	POLES
SOCIAL	Severe Accidents	Risk from severe accidents		
	Average Number of Fatalities	Cumulated expected number of fatalities from severe (≥5 fatalities) accidents worldwide in fossil (coal, oil, gas), hydro and nuclear energy chains	Fatalities / year	PSI
	Consequences of Worst Accident	Maximum fatalities from severe (≥5 fatalities) accidents worldwide in fossil (coal, oil, gas), hydro and nuclear energy chains	Fatalities	PSI
	Oil Spills	Oil spill risk is assumed to scale linearly with the amounts of oil used, so the indicator scales with the amount of oil used globally	Mtons	PSI
	Terrorism Risk	Cumulated terrorism risk for EU 27, based on attack scenarios for a European Pressurized Reactor (EPR), hydropower dam, refinery and Liquefied Natural Gas (LNG) Terminal	Fatalities	PSI
SECURITY OF SUPPLY	Diversity EU 27 Consumption	Shannon-Wiener diversity index of EU 27 gross inland energy consumption (Mtoe) for the different energy carriers	Factor	POLES
	Share of energy imports EU 27	Ratio of Primary Production (Mtoe) / Gross Inland Consumption (Mtoe) in EU 27	Factor	POLES
	Diversity of Resources	Shannon-Wiener diversity index of net exporters from 23 world regions in oil, gas and coal markets		
	Diversity World Oil Market	Shannon-Wiener diversity index of net oil exporters (Mtoe) from 23 world regions in POLES	Factor	POLES
	Diversity World Gas Market	Shannon-Wiener diversity index of net gas exporters from 23 world regions in POLES	Factor	POLES
	Diversity World Coal Market	Shannon-Wiener diversity index of net coal exporters from 23 world regions in POLES	Factor	POLES

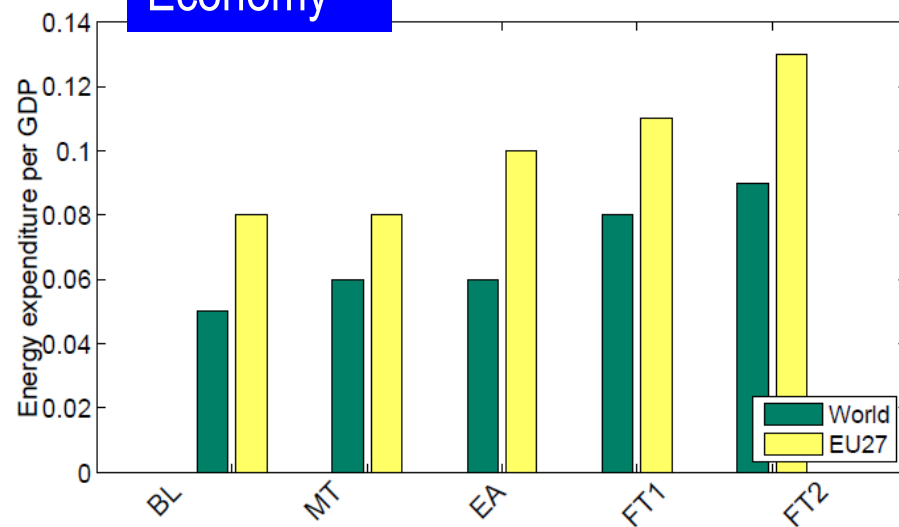
Main Scenarios	Baseline (BL): NO climate policy	Muddling through (MT): Copenhagen forever	Europe alone (EA): Climate policy with target of reducing GHG emissions by 60% in 2050 compared to 1990 levels only in Europe	Global regime -Full trade (FT 1& 2): a global climate regime with two sub scenarios
Nuclear accident Subsequent phase out of nuclear power	BL Nuc	MT Nuc	-	FT Nuc
Fossil fuel price Shock	BL Sh	MT Sh	EA Sh	-
No carbon capture & storage	-	MT CCS	EA CCS	FT CCS

Source: LEPII/POLES

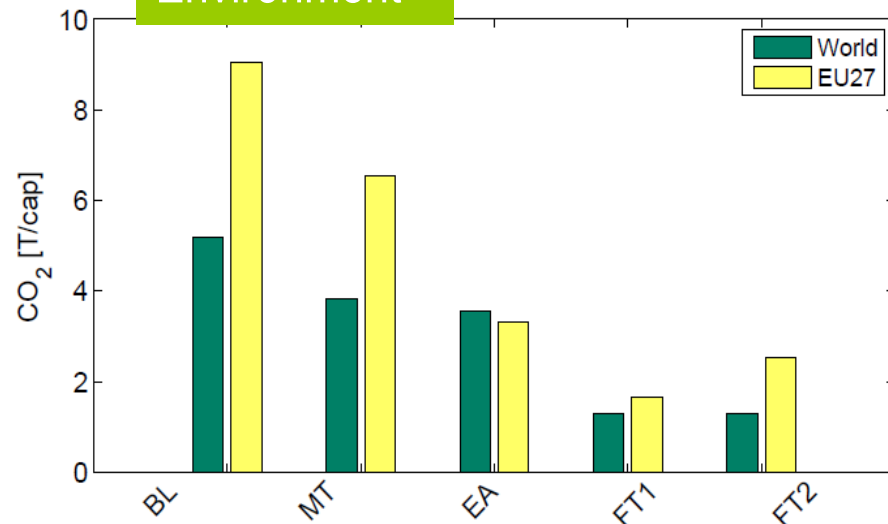
Environment



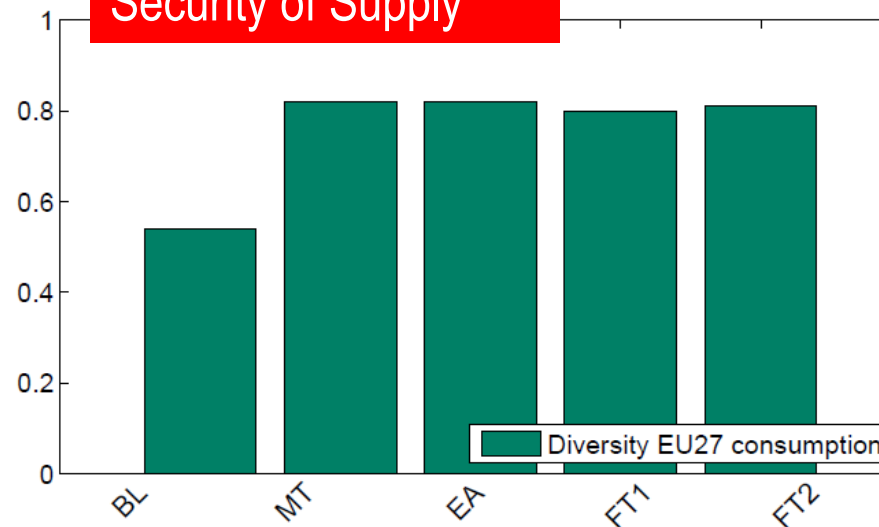
Economy



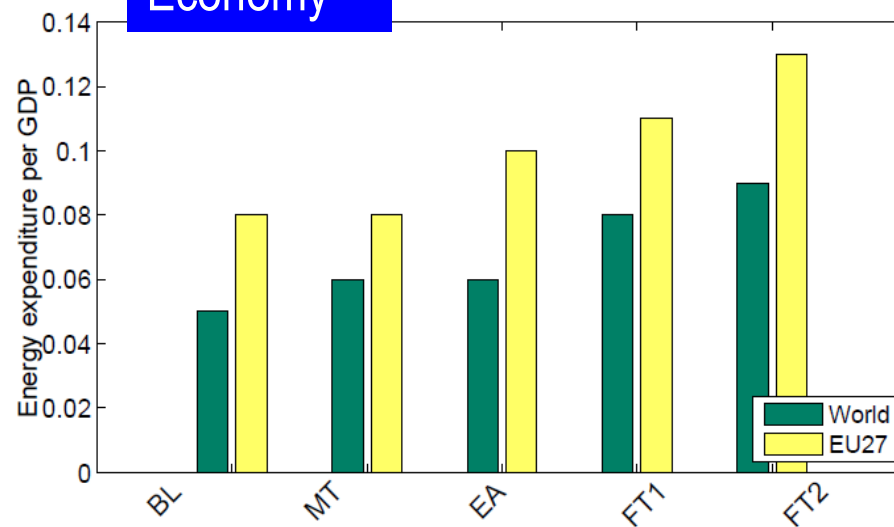
Environment



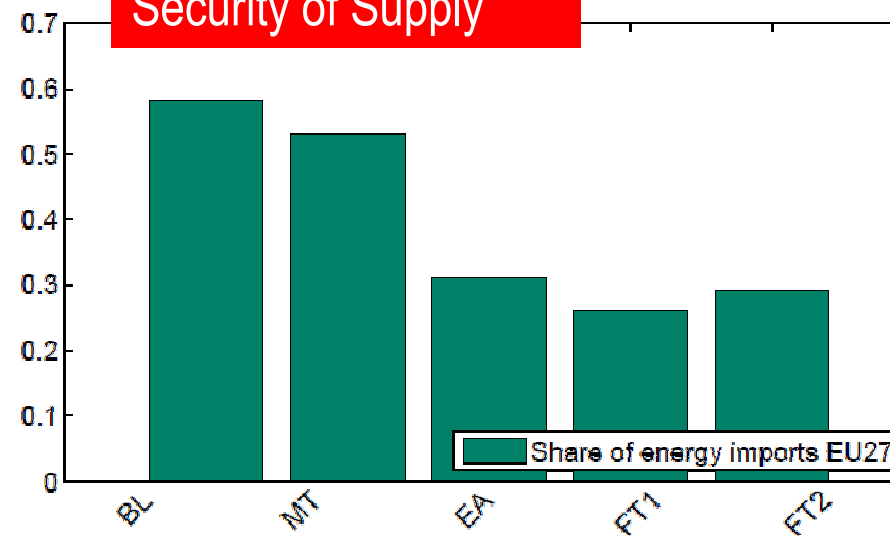
Security of Supply



Economy



Security of Supply



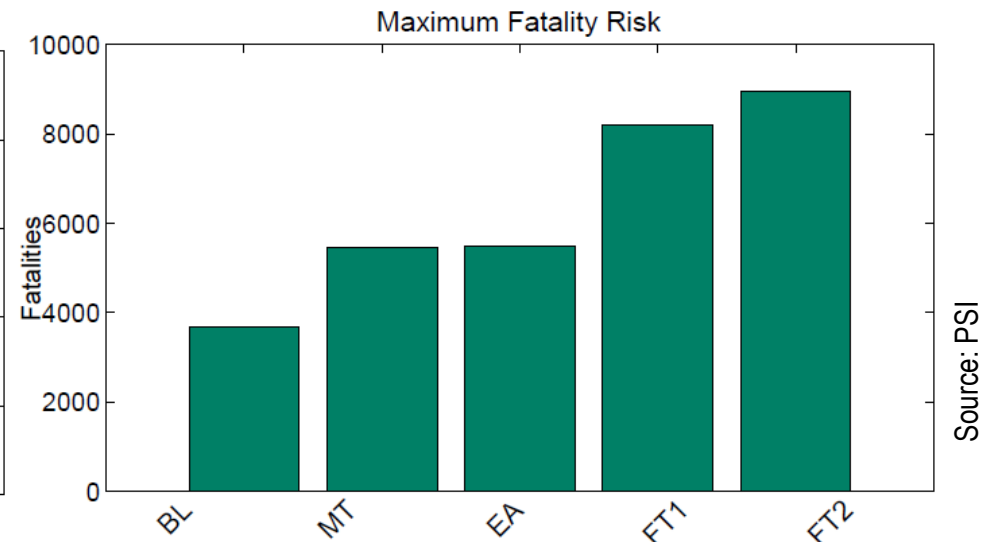
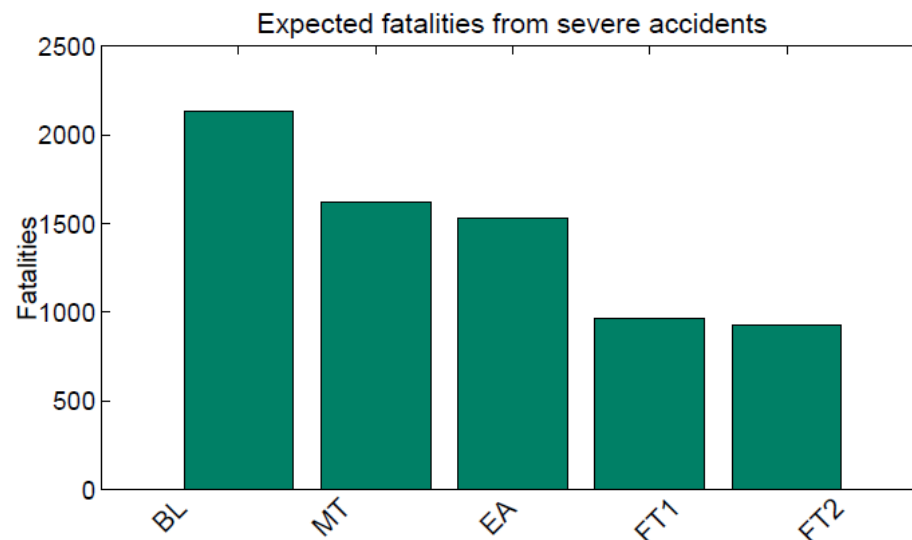
Source: LEPII/POLES

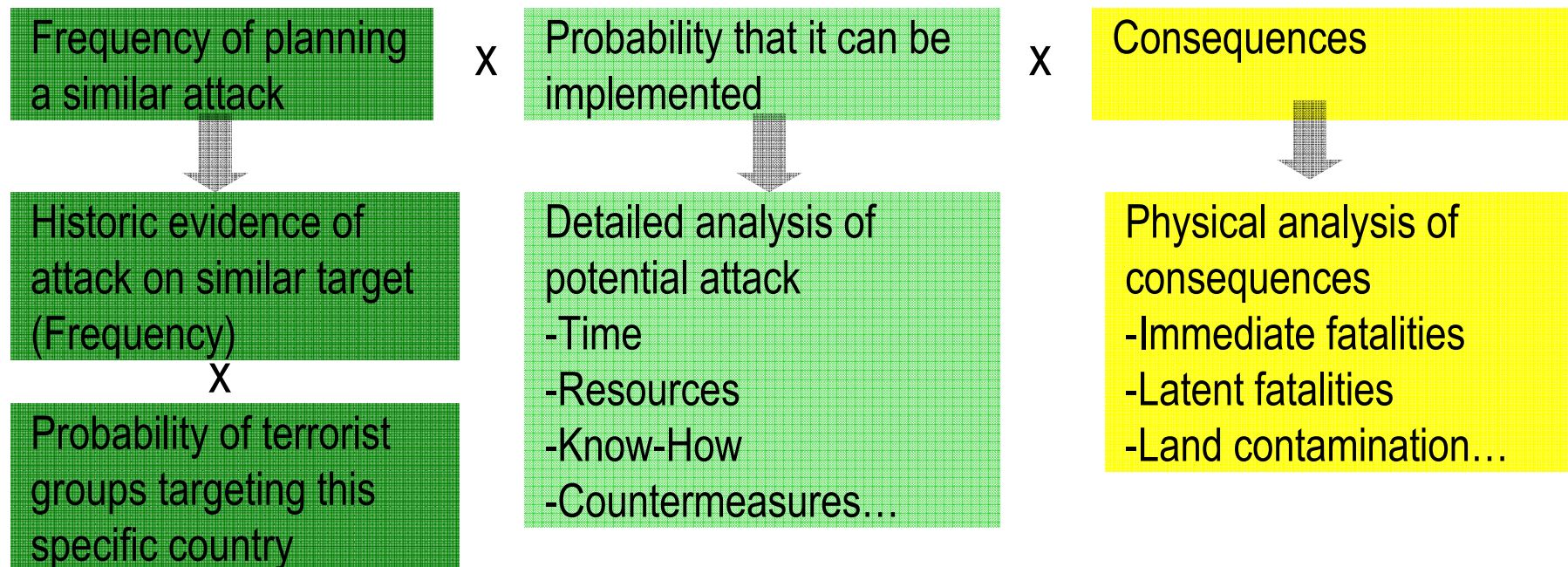
2 indicators:

- Fatalities from average accidents worldwide (severe accidents ≥ 5 fatalities)
- Fatalities from „worst case“ worldwide

Scaled for each scenario with scenario specific energy consumption

	Expected fatalities per Mt _{oe}	“maximum accident”	
Coal	0.17	434	Immediate fatalities
Gas	$5 \cdot 10^{-2}$	234	Immediate fatalities
Oil	0.16	2700	Immediate fatalities
Nuclear	10^{-5}	28000	Latent fatalities
Hydro	10^{-2}	10000	Immediate fatalities





- Full quantification of risk -> Frequencies for various levels of consequences
- Integrates uncertainty of assessment
- Consistent assessment methodology for wide range of targets
- Possibility to integrate expert judgment
- Formalized assessment and iterative process -> helps to develop realistic scenarios
- Analysis with Monte Carlo simulation
- Implemented in user friendly, visual tool

Source: PSI

Environment



Security of supply



Economy



Social



CO₂ world



CO₂ EU27



Diversity EU27 consumption



Share of energy imports EU27



Diversity of resources



Diversity oil market



Diversity gas market



Diversity coal market



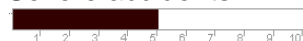
Energy expenditure world



Energy expenditure EU 27



Severe accidents



Average number of fatalities



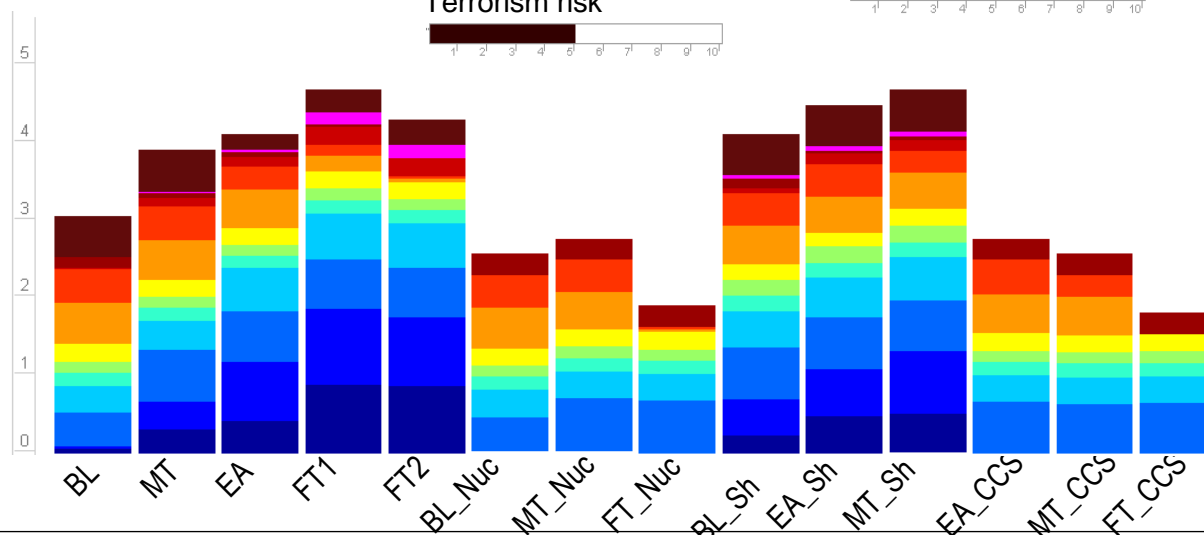
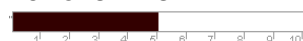
Consequences of worst accident



Oil Spills



Terrorism risk



- CO₂ world
- CO₂ EU 27
- Diversity EU27 consumption
- Share of imported energy EU27
- Diversity world oil market
- Diversity world gas market
- Diversity world coal market
- Energy expenditure word
- Energy expenditure EU27
- Average number of fatalities
- Consequences of worst accident
- Oil spills
- Terrorism

Source: PSI

Environment



Security of supply



Economy



Social



CO₂ world



CO₂ EU27



Diversity EU27 consumption



Share of energy imports EU27



Diversity of resources



Diversity oil market



Diversity gas market



Diversity coal market



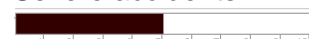
Energy expenditure world



Energy expenditure EU 27



Severe accidents



Average number of fatalities



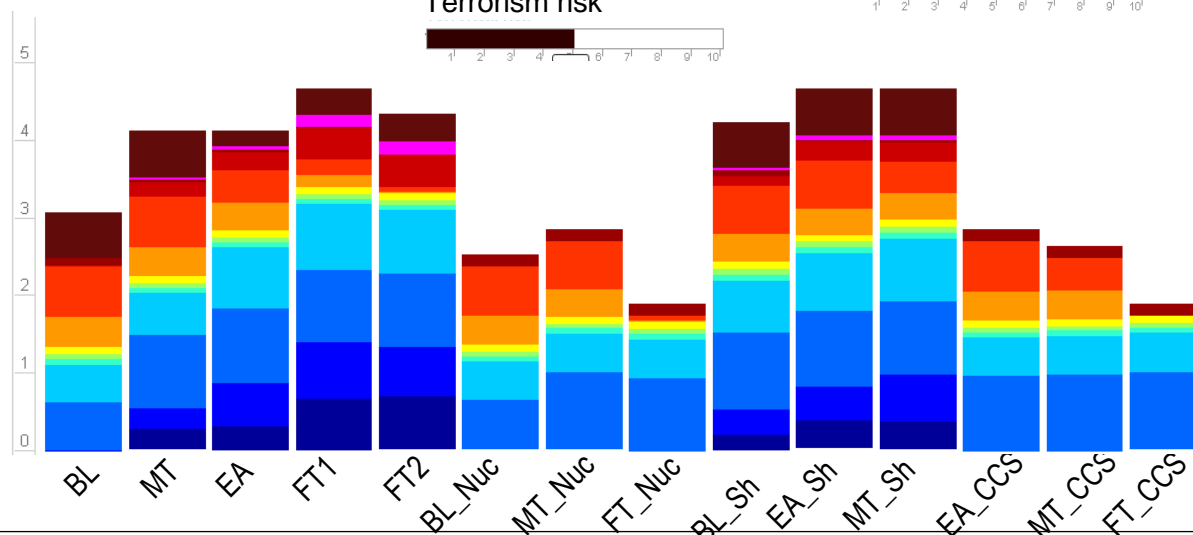
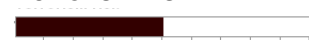
Consequences of worst accident



Oil Spills



Terrorism risk



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Source: PSI

Environment



Security of supply



CO₂ world



CO₂ EU27



Diversity EU27 consumption



Share of energy imports EU27



Diversity of resources



Diversity oil market



Diversity gas market



Diversity coal market



Economy



Social



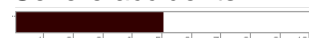
Energy expenditure world



Energy expenditure EU 27



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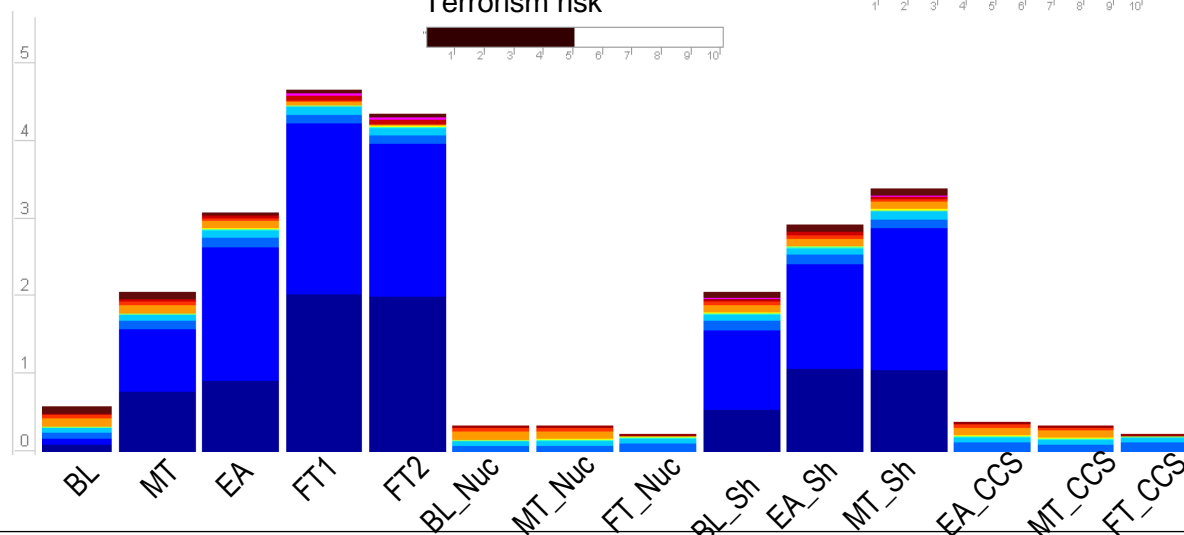
Consequences of worst accident



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Security of supply



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CO₂ world



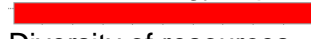
CO₂ EU27



Diversity EU27 consumption



Share of energy imports EU27



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Diversity oil market



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Energy expenditure world



Energy expenditure EU 27



Severe accidents



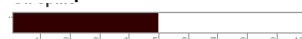
Average number of fatalities



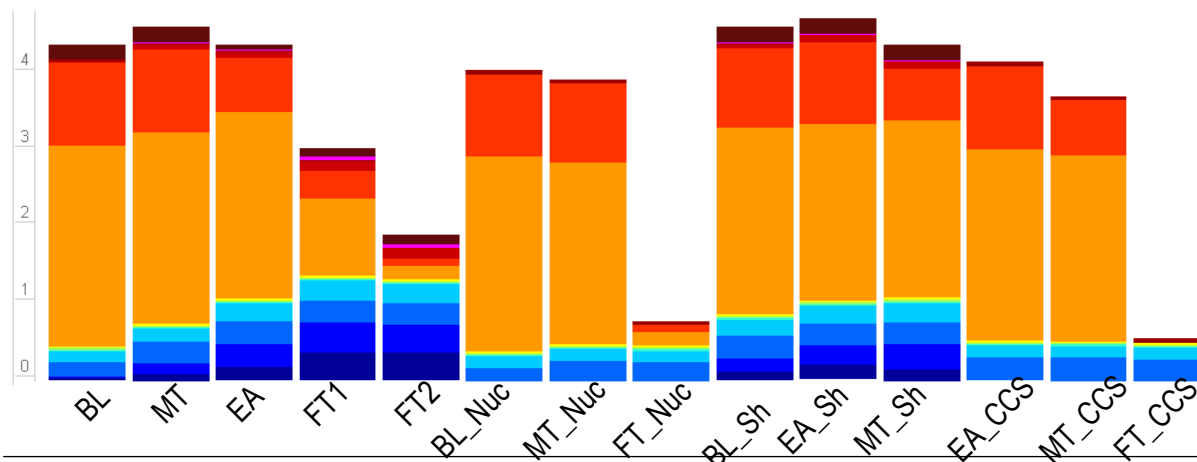
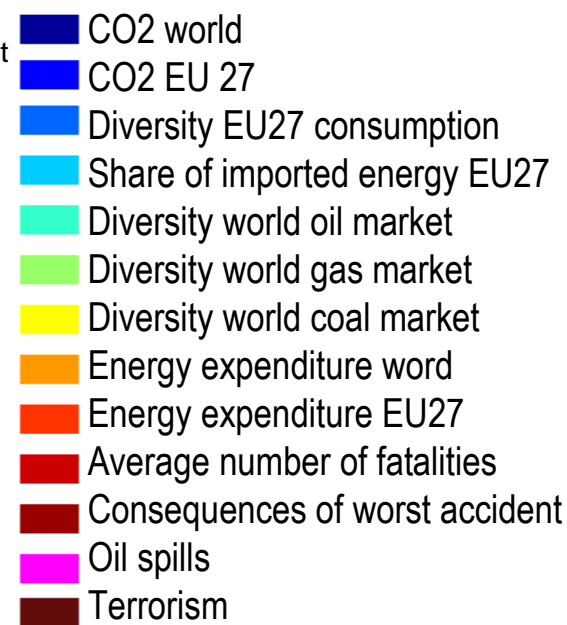
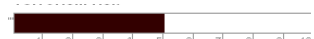
Consequences of worst accident



Oil Spills



Terrorism risk



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Environment



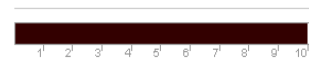
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CO₂ world



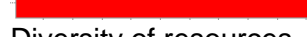
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Diversity EU27 consumption



Share of energy imports EU27



Diversity of resources



Diversity oil market



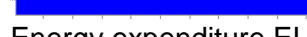
Diversity gas market



Diversity coal market



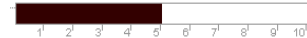
Energy expenditure world



Energy expenditure EU 27



Severe accidents



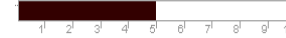
Average number of fatalities



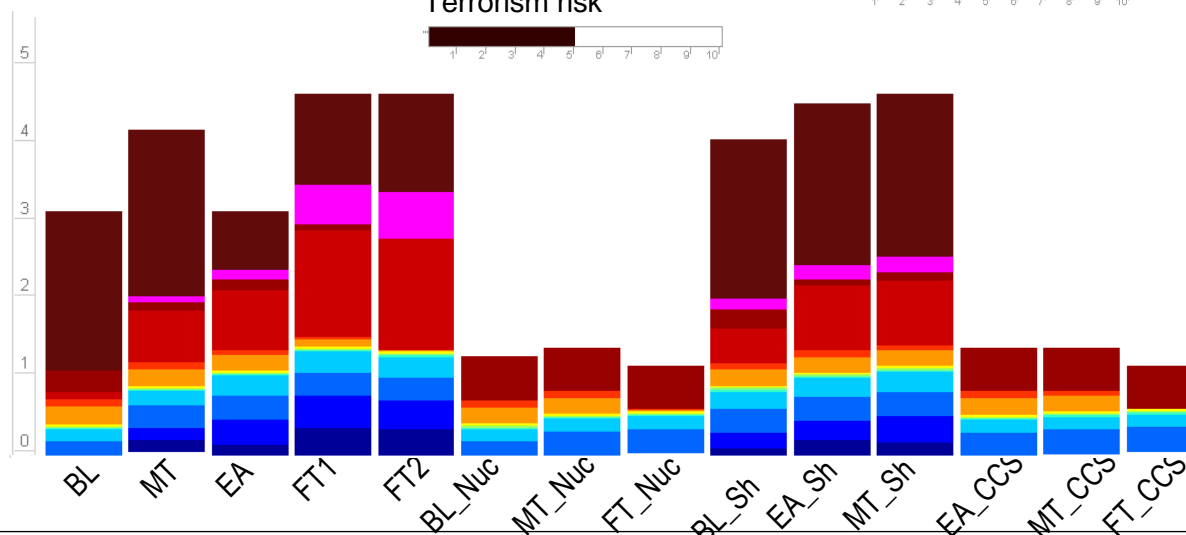
Consequences of worst accident



Oil Spills



Terrorism risk



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Source: PSI

Environment



Security of supply



CO₂ world



CO₂ EU27



Diversity EU27 consumption



Share of energy imports EU27



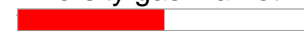
Diversity of resources



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Diversity coal market



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Social



Energy expenditure world



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Severe accidents



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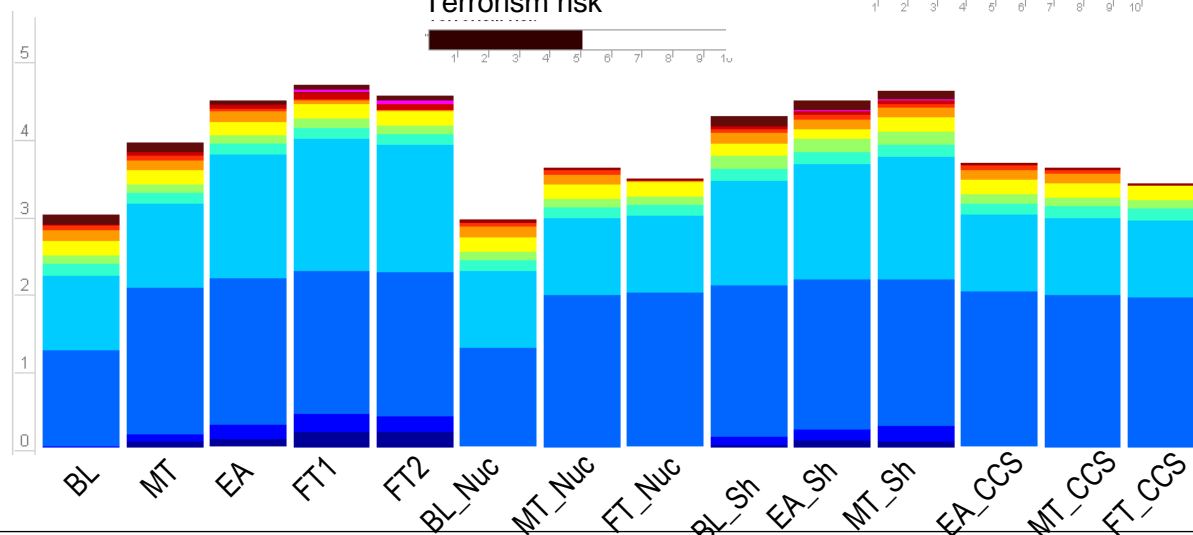
Consequences of worst accident



Oil Spills



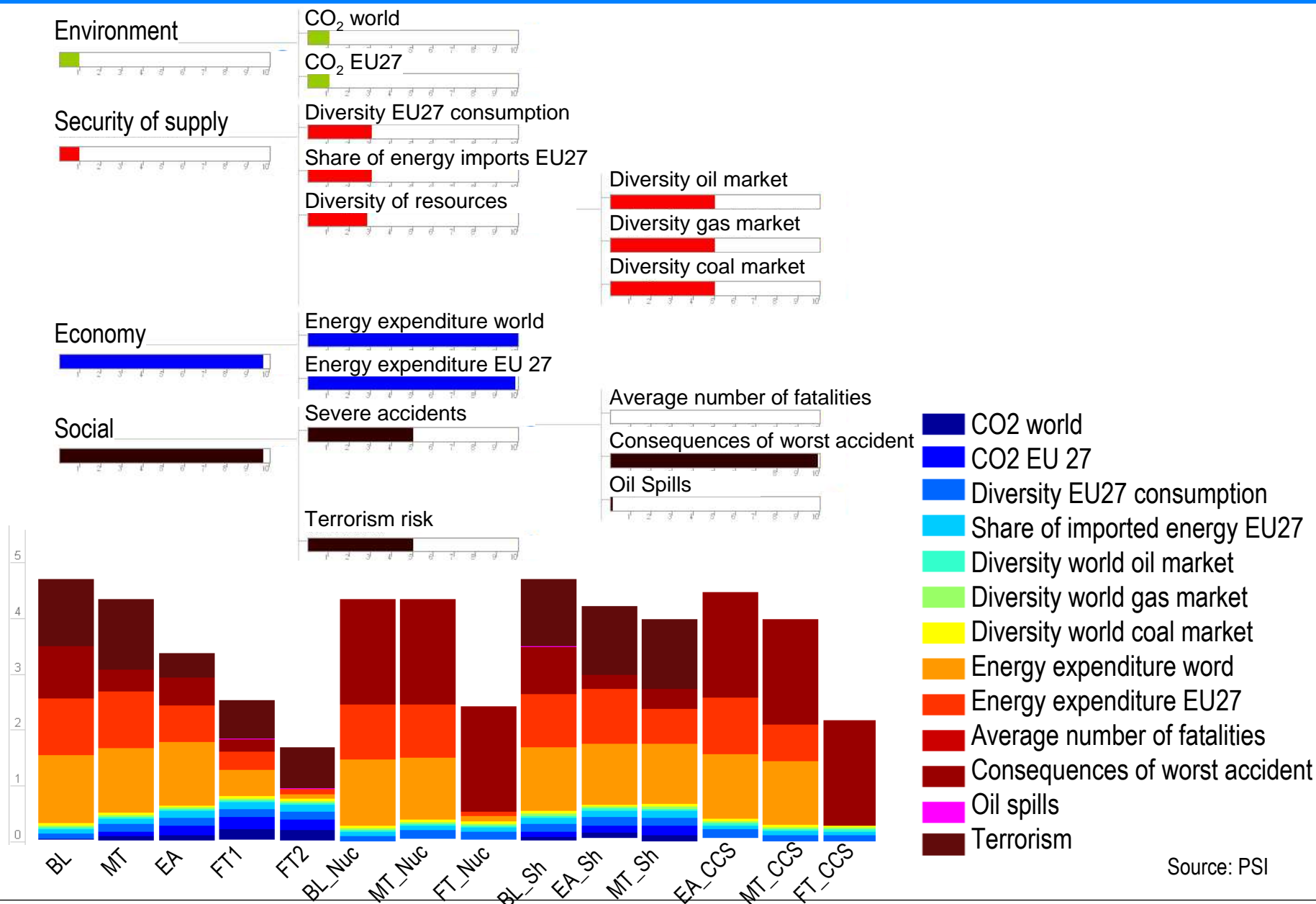
Terrorism risk



- CO2 world
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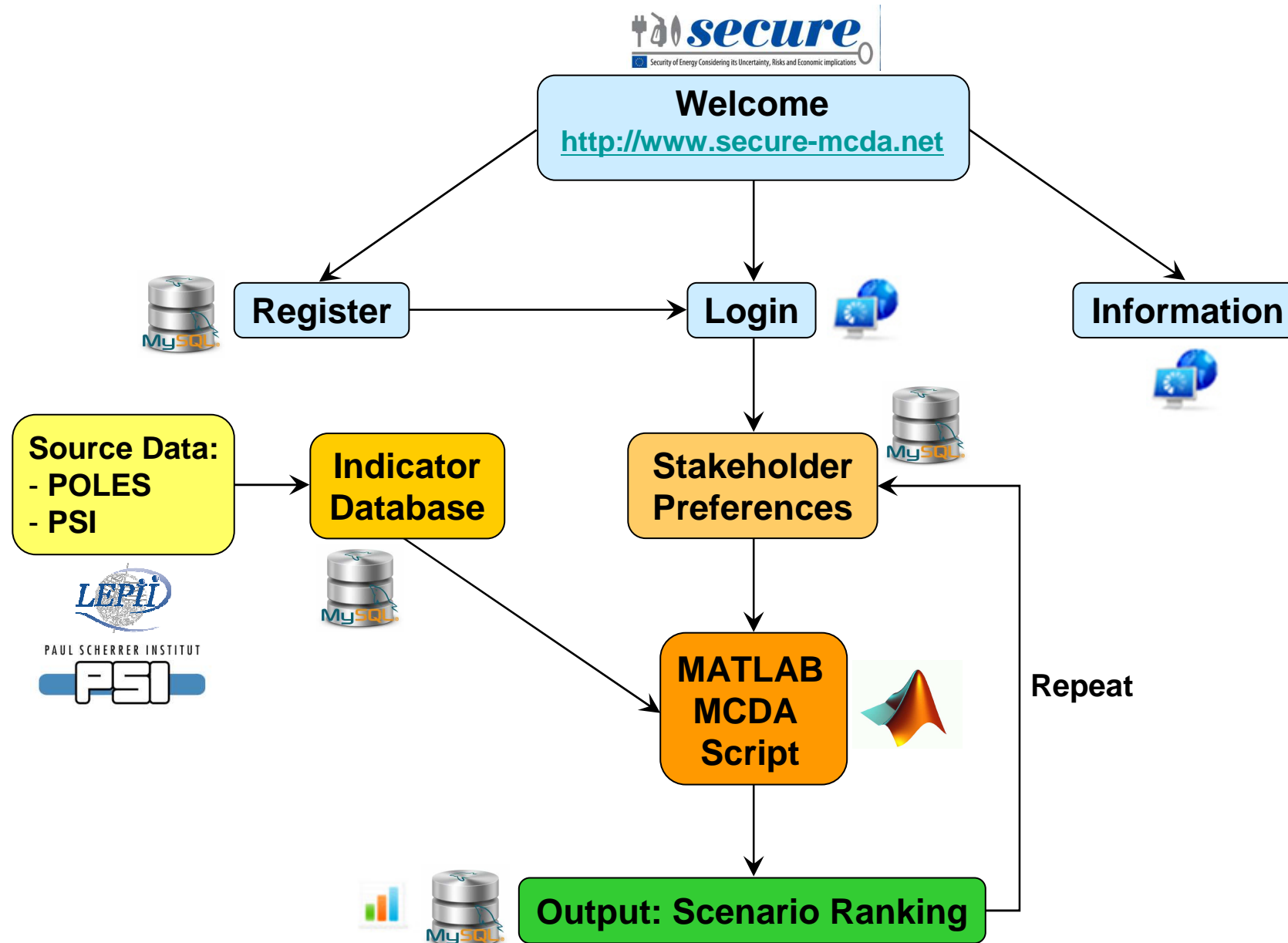
Source: PSI

When is Baseline top ranked?



Source: PSI

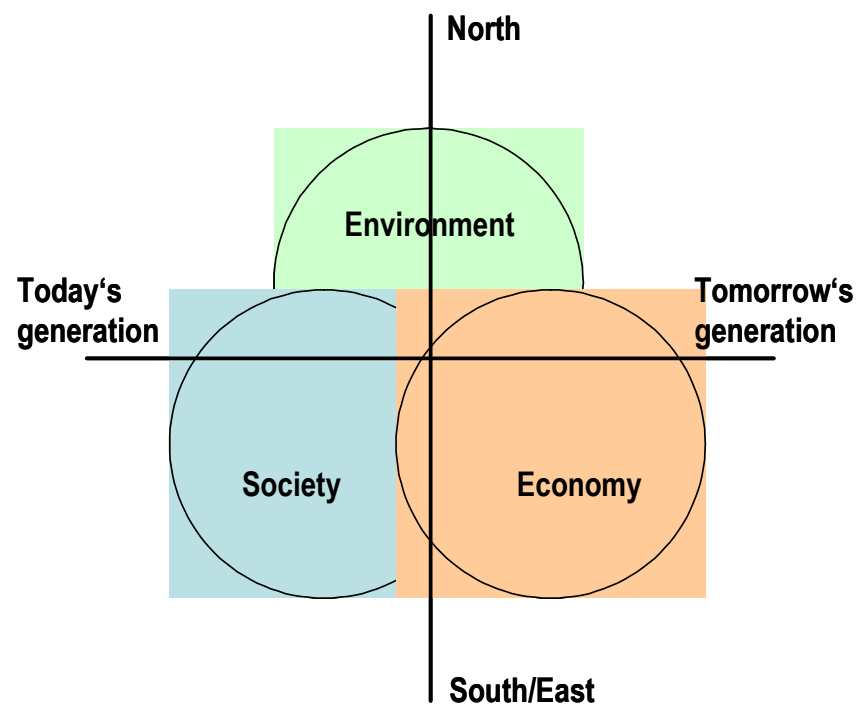
- No single scenario meets all sustainability and security of supply criteria used in SECURE; thus, trade-offs are inevitable,
- Given balance between environmental, economic, social and security of supply criteria, the global regime climate regime scenarios (without shocks) perform best while the baseline scenario is consequently worst.
- This result is with two exceptions quite stable with respect to the variations of preferences. The exceptions are economy-centered profiles and/or high importance assigned to the aversion towards worst consequences of severe accidents.
- Under the assumptions made in the SECURE project the global regime scenarios are highly vulnerable to shocks in form of a very severe nuclear accident and/or failure to implement carbon capture and storage on a large scale.
- There are clear synergies between protection of climate and security of supply. Meeting ambitious GHG-emission reduction goals by means of successful decarbonisation of the energy supply system through expansion of renewables, nuclear and CCS, combined with very extensive efficiency improvements, is also highly beneficial for security of supply.



Thank you for your attention!

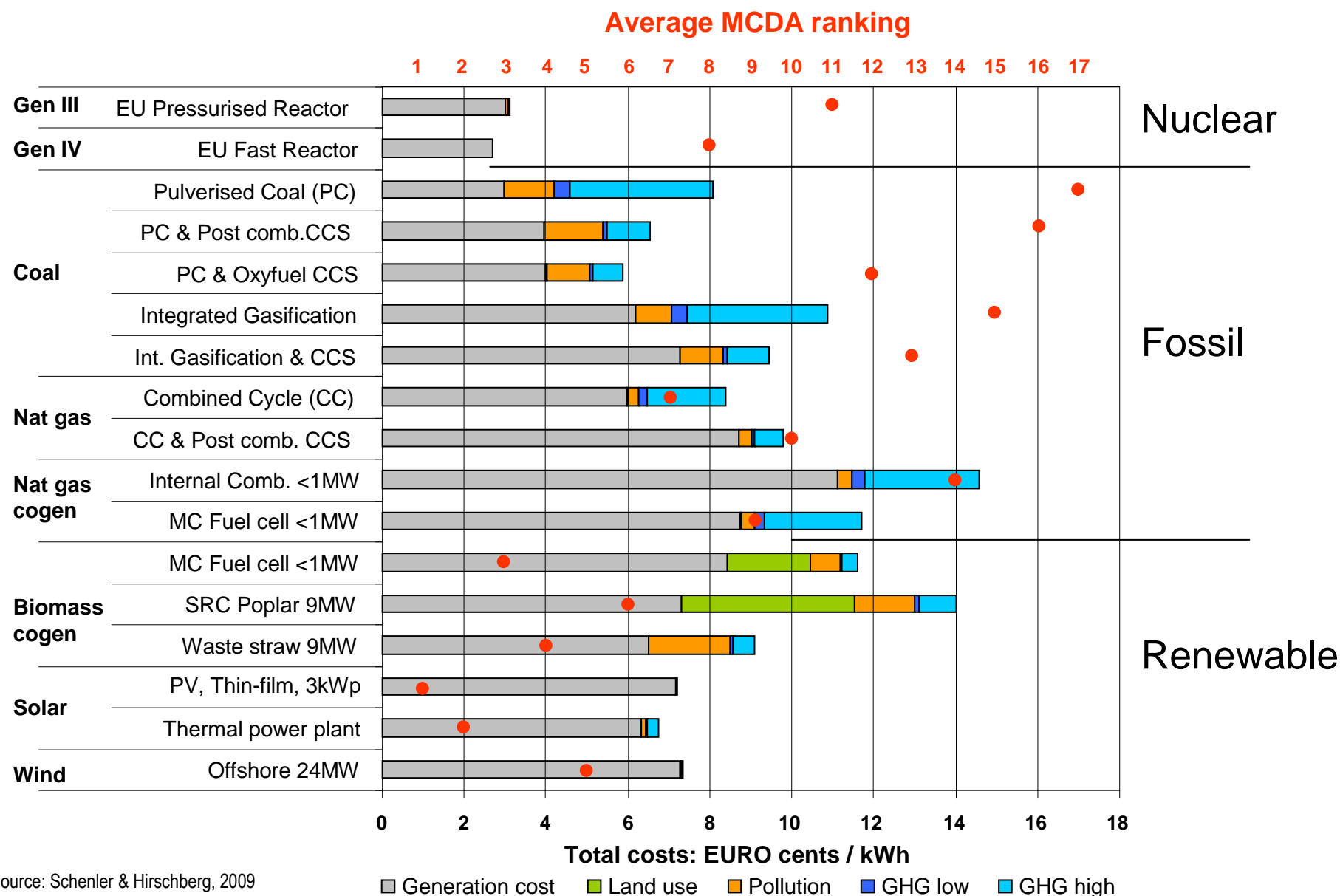


Sustainability Criteria



Criterion	
ENVIRONMENTAL DIMENSION	RESOURCES
	Energy Resources
	Mineral Resources (Ores)
	CLIMATE CHANGE
	IMPACT ON ECOSYSTEMS
ENVIRONMENTAL DIMENSION	Impacts from Normal Operation
	Impacts from Severe Accidents
	WASTES
	Special Chemical Wastes stored in Underground Depositories
	Medium and High Level Radioactive Wastes to be stored in Geological Repositories
ECONOMIC DIMENSION	IMPACTS ON CUSTOMERS
	Price of Electricity
	IMPACTS ON OVERALL ECONOMY
	Employment
	Autonomy of Electricity Generation
ECONOMIC DIMENSION	IMPACTS ON UTILITY
	Financial Risks
	Operation
SOCIAL DIMENSION	SECURITY/RELIABILITY OF ENERGY PROVISION
	Political Threats to Continuity of Energy Service
	Flexibility and Adaptation
	POLITICAL STABILITY AND LEGITIMACY
	Potential of Conflicts induced by Energy Systems.
SOCIAL DIMENSION	Necessity of Participative Decision-making Processes
	SOCIAL AND INDIVIDUAL RISKS
	Expert-based Risk Estimates for Normal Operation
	Expert-based Risk Estimates for Accidents
	Perceived Risks
SOCIAL DIMENSION	Terrorist Threat
	QUALITY OF RESIDENTIAL ENVIRONMENT
	Effects on the Quality of Landscape
	Noise Exposure

Source: Hirschberg et al., 2007&2008



Source: Schenler & Hirschberg, 2009