ETH zürich

Uncertainty in the public perception of new technologies: The case of energy resources

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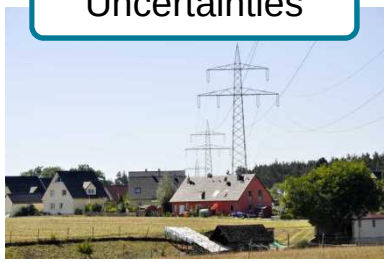
Importance of communication with the public

- Public perception has strong impact on policy making (Burstein, 2003), and thus major determinant of a country's energy portfolio, e.g.,
  - CCS project in Barendrecht (NL), 2010
  - Restarting nuclear power generation in Italy, 2011

- Energy technologies related to uncertainties and risks

Environmental & health hazards



Uncertainties

Concerns about supply

- ➢ Communication with the public is necessary
- ➢ To be able to communicate, the public's perception should be known (Bruine de Bruin & Bostrom, 2014)

Communication based on knowledge & beliefs

Coal-to-Gas

(CO_2 is captured)

How it Works: This is the same plant described in *"Coal-to-gas, CO_2 released"*. But in this plant, additional equipment is added to capture the CO_2

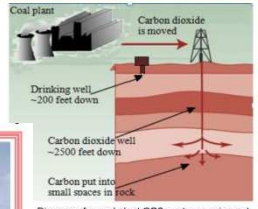


Diagram of a coal plant CO2 capture equipment.

Wind

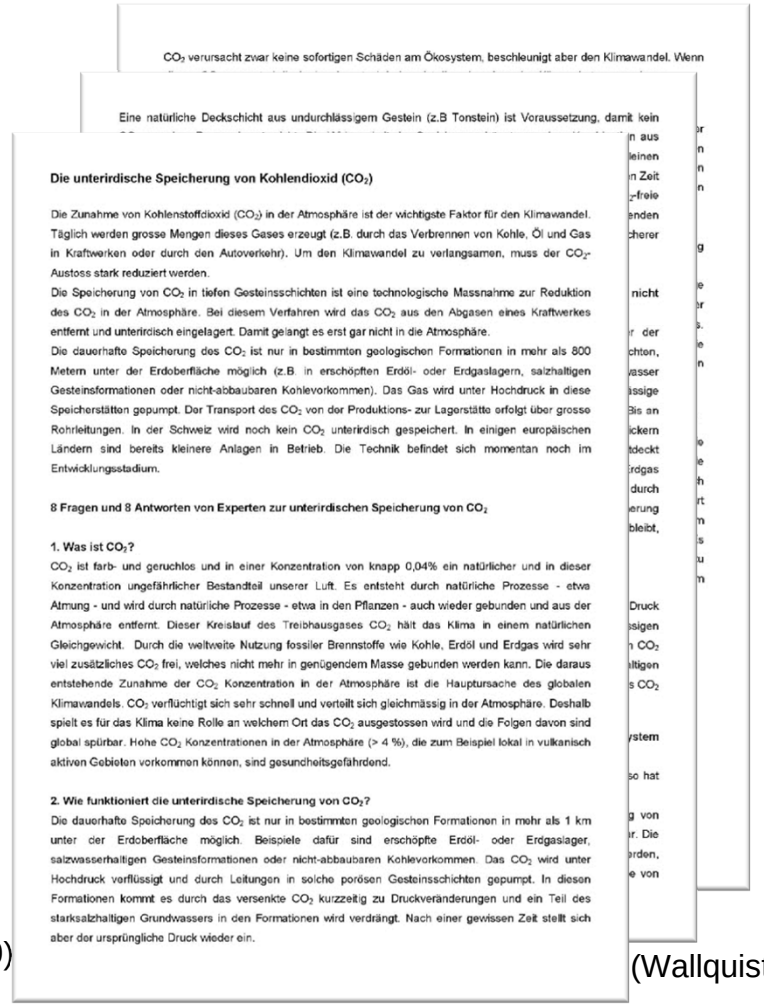
How it Works: Modern wind machines are much larger than the old windmills in Holland, or the metal windmills that pumped water for cattle in the American West. They are often between 100 and 300 feet high. That is about as tall as a 10 to 30 story building. The machines have blades that look like an airplane propeller. The wind turns the blades, and this runs a generator to make electricity.

Modern wind turbines in Somerset, PA

Availability	Wind farms work well when built in windy areas. PA has lots of wind on hilltops in the center of the state. However, even the best wind farms in PA only make 28% of the power that would be possible if the wind was always blowing. They cannot make 100% because sometimes the wind is not blowing. Wind farms are often located far away from where people live, since this is where it is the windiest. It is expensive to transmit the wind electricity across long distances.
Reliability	• Wind varies in strength, which can make it less dependable for making electricity. Because of this, wind farms cannot consistently make electricity. Natural gas plants must be built to "back up" or fill in electricity during times when it is not windy. In the future, we might use very large batteries to store electricity from wind, but that is very costly to do today. • On average, a newly built wind farm in PA can make about 0.5 TWh of electricity over the course of the year. The natural gas plant built to fill in electricity when it is not windy will have to make about 1.2 TWh over the course of the year.
Limits to Use	If many wind farms are built, there will be a lot of CO_2 released by the "back-up" natural gas plants. The more wind farms you build, the more indirect CO_2 that is released to the air. So wind farms can only be used to make up 28% of the additional electricity needed for PA if we want to reduce the CO_2 released from all new plants by 50%. This would be about 16.5 TWh of the 60 TWh.
Current Use	There are more than 100 wind farms working in the U.S. today.
Environmental Impacts (*Read Note Below)	• There is almost no solid waste from wind farms. • Wind farms with many machines require hundreds of acres. If the machines are built on farm land, most of it can still be used for farming. In forests, trees must be cleared to build the machines. This can disturb the plants and animals. On mountain ridges, wind farms can be very visible. • Wind farms make some low noise. It is less than the noise from most other power plants. But, since wind farms are in the country, the noise is often more noticeable. • The blades of wind machines sometimes strike and kill birds and bats. New wind machines are being located away from bird (migration) flight paths. Less is known about how to prevent bat deaths.
Safety	Wind farms present very few risks to people.

** Note: Health, Water and Land Impacts are shown on a Separate Sheet*

(Fleishman et al., 2010)



Die unterirdische Speicherung von Kohlendioxid (CO_2)

Die Zunahme von Kohlenstoffdioxid (CO_2) in der Atmosphäre ist der wichtigste Faktor für den Klimawandel. Täglich werden grosse Mengen dieses Gases erzeugt (z.B. durch das Verbrennen von Kohle, Öl und Gas in Kraftwerken oder durch den Autoverkehr). Um den Klimawandel zu verlangsamen, muss der CO_2-Austoss stark reduziert werden.

Die Speicherung von CO_2 in tiefen Gesteinsschichten ist eine technologische Massnahme zur Reduktion des CO_2 in der Atmosphäre. Bei diesem Verfahren wird das CO_2 aus den Abgasen eines Kraftwerkes entfernt und unterirdisch eingelagert. Damit gelangt es erst gar nicht in die Atmosphäre.

Die dauerhafte Speicherung des CO_2 ist nur in bestimmten geologischen Formationen in mehr als 800 Metern unter der Erdoberfläche möglich (z.B. in erschöpften Erdöl- oder Erdgaslagern, salzhaltigen Gesteinsformationen oder nicht-abbaubaren Kohlevorkommen). Das Gas wird unter Hochdruck in diese Speicherstätten gepumpt. Der Transport des CO_2 von der Produktions- zur Lagerstätte erfolgt über grosse Rohrleitungen. In der Schweiz wird noch kein CO_2 unterirdisch gespeichert. In einigen europäischen Ländern sind bereits kleinere Anlagen in Betrieb. Die Technik befindet sich momentan noch im Entwicklungsstadium.

8 Fragen und 8 Antworten von Experten zur unterirdischen Speicherung von CO_2

1. Was ist CO_2?

CO_2 ist farb- und geruchlos und in einer Konzentration von knapp 0,04% ein natürlicher und in dieser Konzentration ungefährlicher Bestandteil unserer Luft. Es entsteht durch natürliche Prozesse - etwa Atmung - und wird durch natürliche Prozesse - etwa in den Pflanzen - auch wieder gebunden und aus der Atmosphäre entfernt. Dieser Kreislauf des Treibhausgases CO_2 hält das Klima in einem natürlichen Gleichgewicht. Durch die weltweite Nutzung fossiler Brennstoffe wie Kohle, Erdöl und Erdgas wird sehr viel zusätzliches CO_2 frei, welches nicht mehr in genügendem Masse gebunden werden kann. Die daraus entstehende Zunahme der CO_2 Konzentration in der Atmosphäre ist die Hauptursache des globalen Klimawandels. CO_2 verflüchtigt sich sehr schnell und verteilt sich gleichmässig in der Atmosphäre. Deshalb spielt es für das Klima keine Rolle an welchem Ort das CO_2 ausgestossen wird und die Folgen davon sind global spürbar. Hohe CO_2 Konzentrationen in der Atmosphäre (> 4 %), die zum Beispiel lokal in vulkanisch aktiven Gebieten vorkommen können, sind gesundheitsgefährdend.

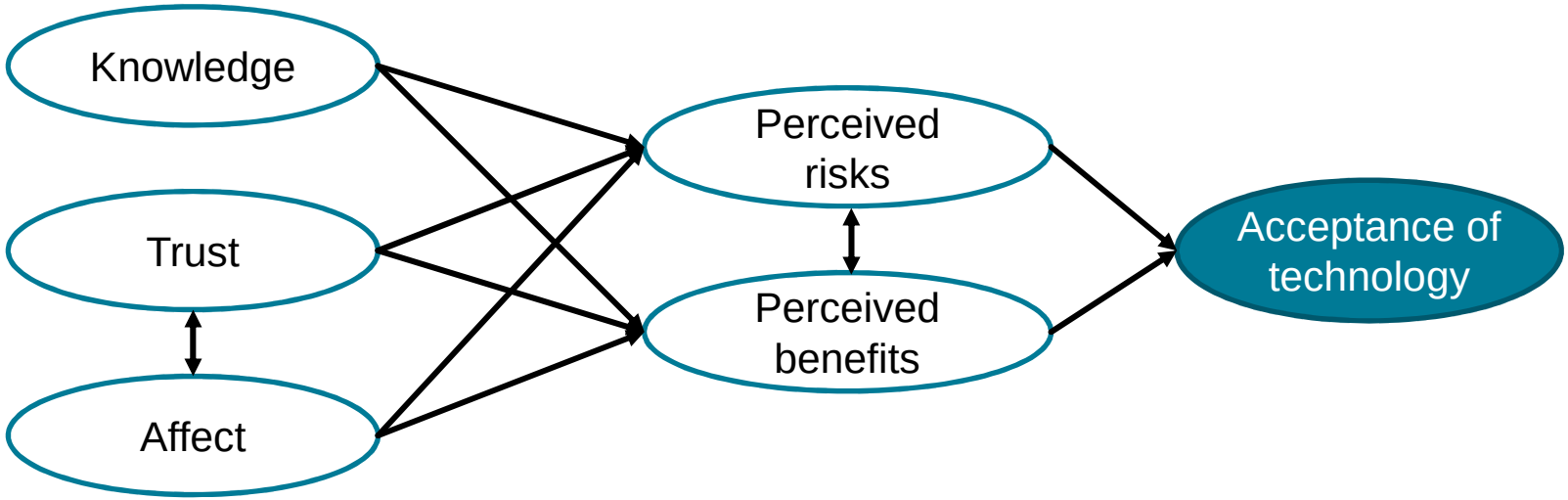
2. Wie funktioniert die unterirdische Speicherung von CO_2?

Die dauerhafte Speicherung des CO_2 ist nur in bestimmten geologischen Formationen in mehr als 1 km unter der Erdoberfläche möglich. Beispiele dafür sind erschöpfte Erdöl- oder Erdgaslager, salzwasserhaltigen Gesteinsformationen oder nicht-abbaubaren Kohlevorkommen. Das CO_2 wird unter Hochdruck verflüssigt und durch Leitungen in solche porösen Gesteinsschichten gepumpt. In diesen Formationen kommt es durch das versenkte CO_2 kurzzeitig zu Druckveränderungen und ein Teil des starksalzhaltigen Grundwassers in den Formationen wird verdrängt. Nach einer gewissen Zeit stellt sich aber der ursprüngliche Druck wieder ein.

(Wallquist et al., 2011)

- Targeted communication materials >> more informed decisions, but require a lot of elaboration and effort!

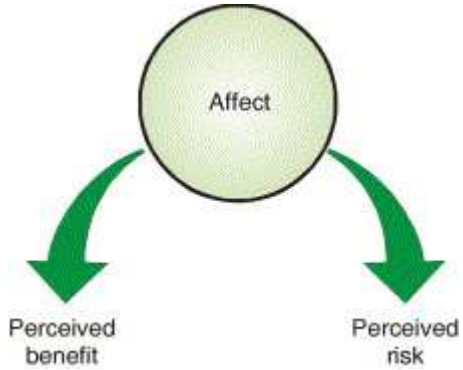
What determines acceptance of a technology?



(Siegrist & Cvetkovich, 2000; Visschers & Siegrist, 2008)

What determines acceptance of a technology?

Affect heuristic



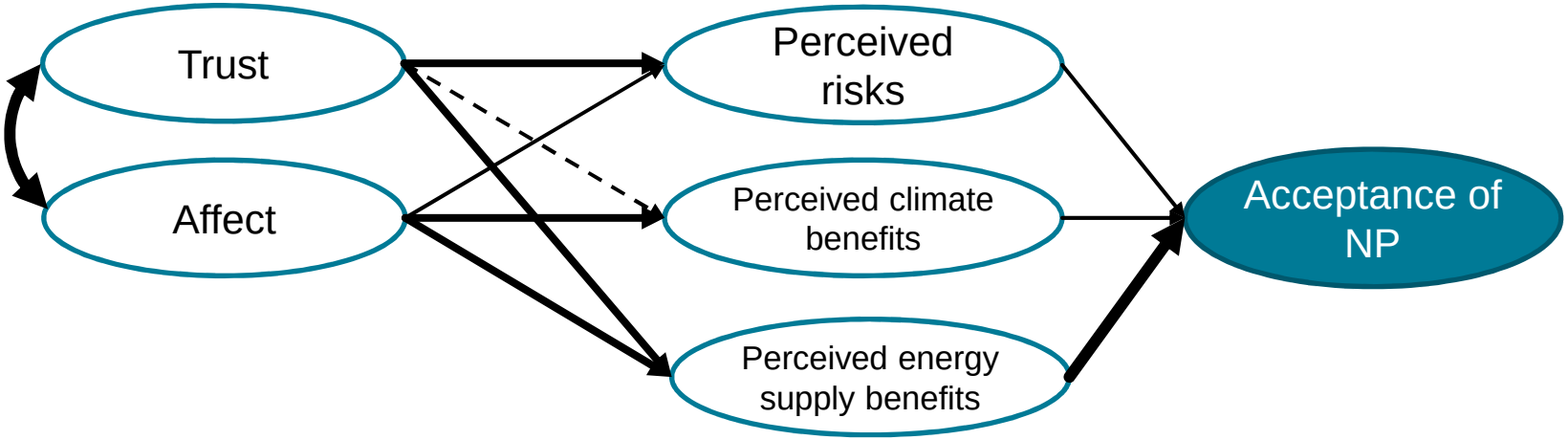
(Finucane et al., 2000)

Trust as heuristic

(Siegrist et al., 2000)

- Feeling-as-information: affect guides judgments and decisions and motivates behaviour (Damasio, 1994; Kahneman, 2003; Schwarz, 2011)

Explaining acceptance of nuclear power stations



- Affect and trust are important in explaining acceptance of nuclear power.

(Visschers et al., 2011)

Explaining acceptance of various energy technologies

	solar power			nuclear power			hydro power			gas power			wind power		
	B	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*
Constant	4.15		3.89; 4.41	3.46		3.08; 3.83	4.22		3.91; 4.52	1.97		1.72; 2.21	2.89		2.62; 3.16
Positive emotions	.26	.33	.22; .31	.26	.22	.18; .33	.23	.32	.19; .28	.37	.29	.30; .43	.41	.49	.37; .46
Negative emotions	-.43	-.28	-.51; -.36	-.24	-.26	-.30; -.18	-.27	-.23	-.34; -.21	-.23	-.56	-.27; -.18	-.34	-.22	-.41; -.27
Trust	.24	.34	.20; .29	.27	.33	.21; .33	.21	.28	.16; .26	.38	.42	.34; .45	.25	.28	.20; .30
	R^2 = .52			R^2 = .49			R^2 = .41			R^2 = .56			R^2 = .62		

(see Visschers & Siegrist, under review)

Explaining acceptance of various energy technologies

	solar power			nuclear power			hydro power			gas power			wind power		
	B	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*	*B*	*β*	*95% CI*
Constant	4.11		3.82; 4.41	2.13		1.54; 2.72	3.17		2.80; 3.54	1.67		1.30; 2.05	2.17		1.79; 2.55
Positive emotions	.15	.19	.10; .19	.14	.13	.07; .21	.11	.15	.07; .15	.17	.13	.11; .22	.22	.26	.18; .26
Negative emotions	-.30	-.20	-.38; -.23	-.11	-.13	-.17; -.06	-.11	-.09	-.17; -.05	-.14	-.16	-.18; -.10	-.17	-.11	-.23; -.11
Trust	.14	.19	.10; .18	.11	.13	.05; .17	.10	.13	.05 .14	.19	.20	.14; .24	.14	.16	.10; .18
Perceived benefits	.30	.34	.25; .35	.48	.43	.41; ;55	.46	.45	.41; .52	.58	.45	.51; .65	.49	.41	.43; .55
Perceived costs	-.14	-.16	-.19; -.10	-.09	-.10	-.17; -.02	-.16	-.21	-.20; -.12	-.14	-.13	-.19; -.09	-.15	-.15	-.19; -.10
	R^2 = .61			R^2 = .60			R^2 = .59			R^2 = .70			R^2 = .74		

(see Visschers & Siegrist, under review)

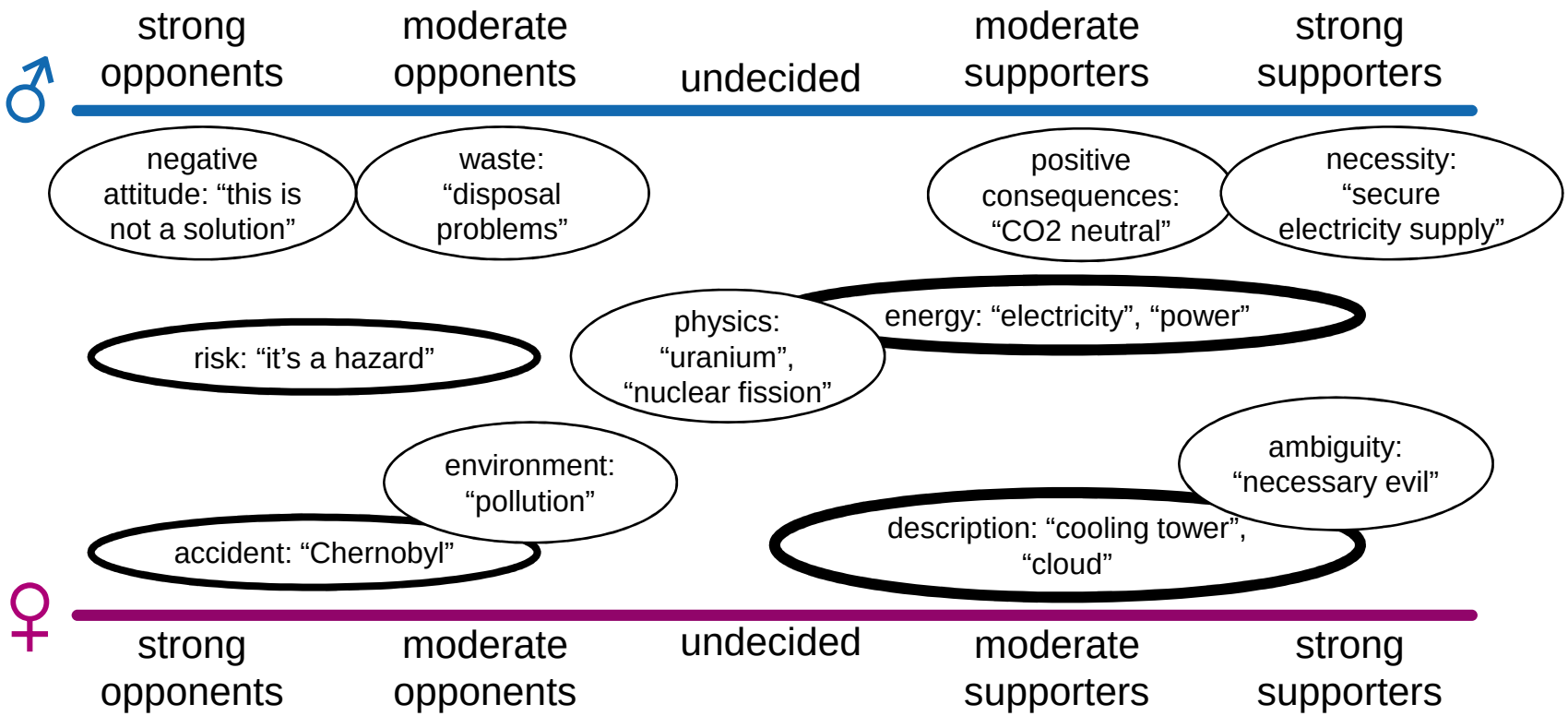
What underlies affect?

- Affective imagery
- Method: two-steps
  1. Ask respondent for his/her spontaneous association with a stimulus
  2. Let respondent rate the affective quality of each association (i.e., on a scale from very negative to very positive)
- Associations are categorized
- Outcome measures: Frequencies and affective evaluations of categories

- Telephone survey in 2009
- Perception of nuclear power
- Frequencies of association categories related to acceptance of nuclear power.

(Keller et al., 2012; Slovic et al., 1991; Peters & Slovic, 1996)

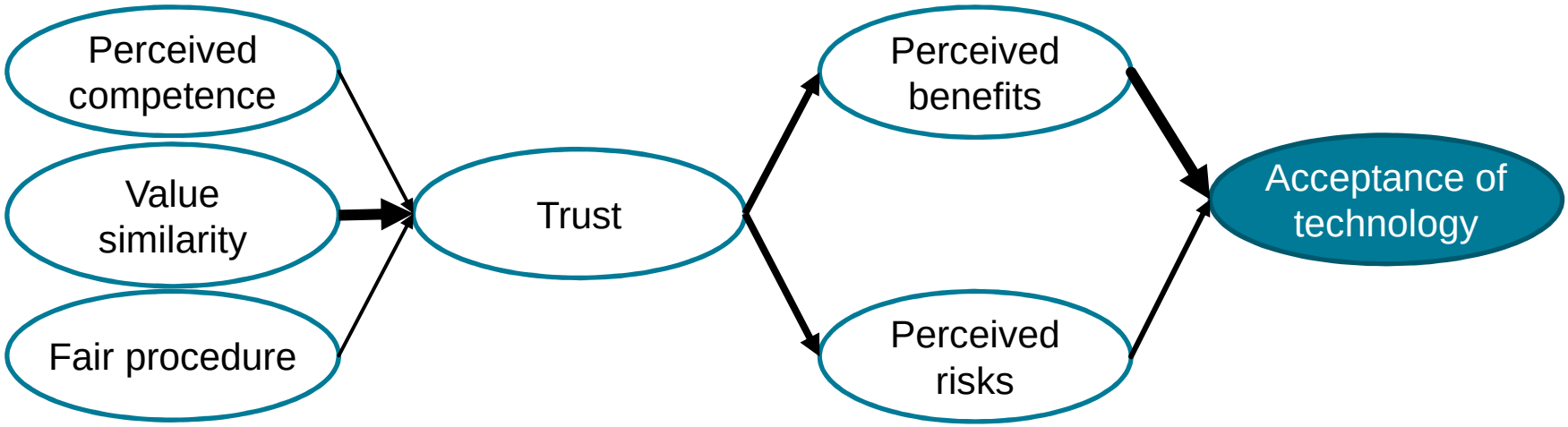
What underlies affect?



- Different levels of acceptance are related to different affective images: regarding content ànd concreteness.

(Keller et al., 2012)

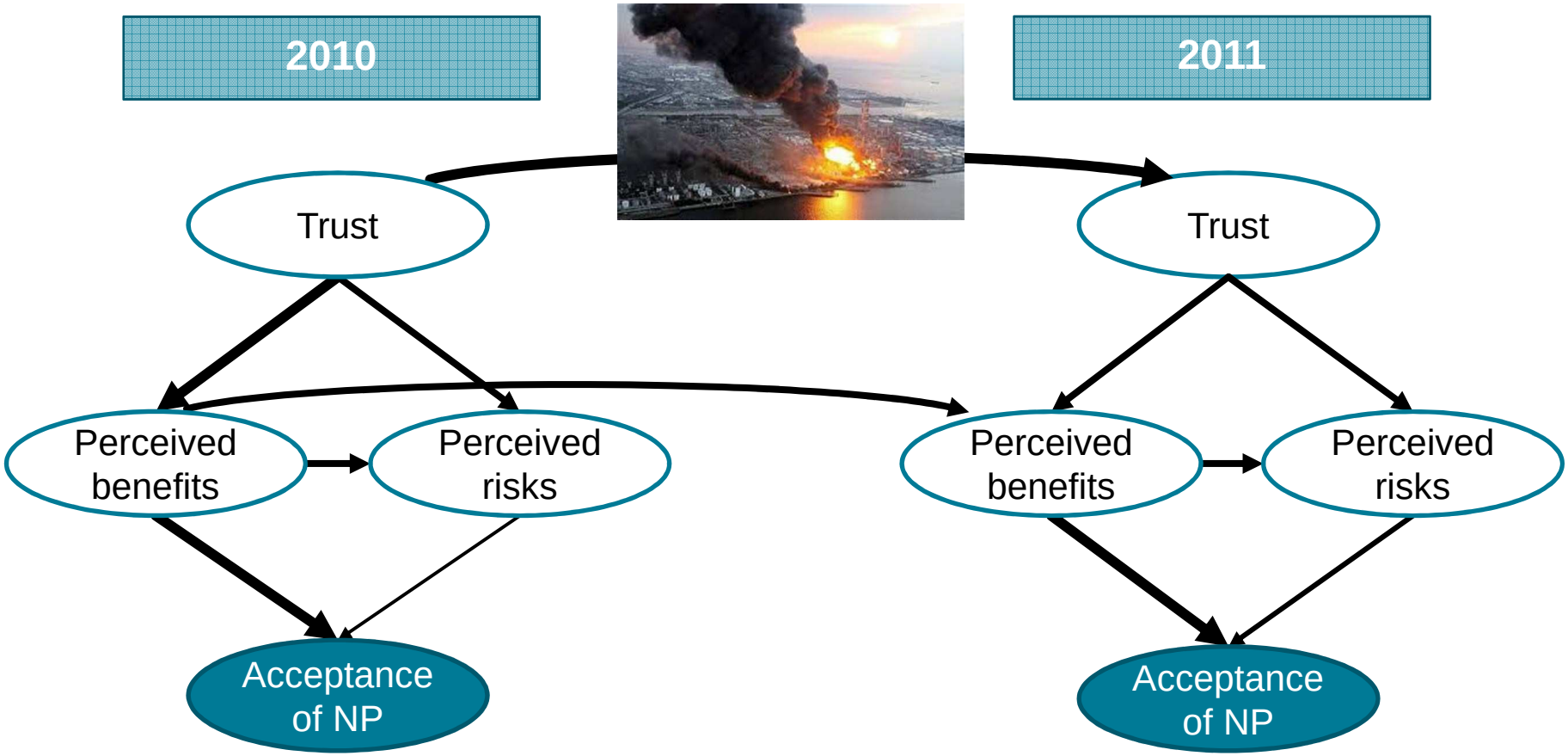
What determines trust?



- More expertise of stakeholder
- If the public can participate in the decision procedure
- Stakeholders that have similar values and goals as decision maker.

(Siegrist et al., 2000; Terwel et al.,2009; 2010; Wallquist et al., 2012)

Stable impact of trust on acceptance



- Trust remained important, even after receiving information about the nuclear accident and more knowledge was thus available.

(Visschers & Siegrist, 2013)

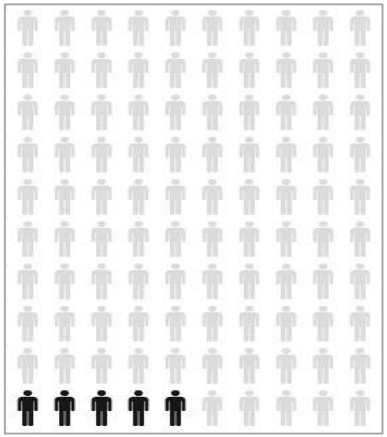
Communicating uncertainty – More about affect

- Integral affect induction, e.g. fear appeals and narratives/testimonials

(Schwarz, 2011; see Visschers et al., 2012 for an overview)

Communicating uncertainty – More about affect

- Incidental affect induction: indirectly induced by communication material or situation but connected to the hazard
  - Fluency: “chlorofluorocarbon” vs. “propellant”
  - Probability information:
    - Verbal vs. numerical expressions:
      “highly unlikely”, “very small chance” or “very uncommon” vs. “.001%”
    - Graphs vs. numbers:



vs. “5 out of 100”

(Schwarz, 2011; see Visschers et al., 2012 for an overview)

Communicating uncertainty: Impact on affect and trust

Probability information:

Two studies showed that the probability is X%.

Ambiguous information:

Two studies showed that the probability is between **X** and **Y**%.

- may reduce trust in the information source
- can make the source appear more honest or less honest (?)
- and increases aversion towards the hazard.

Conflicting information:

Study **A** showed that the probability is **X**%. Study **B** showed that the probability is **Y**%.

- reduces trust in the information source
- reduces the perceived competence of the source and the risk assessor
- may induce outrage
- and increases aversion towards the hazard.

(Johnson & Slovic, 1995; 1998; Markon & Lemyre, 2013; Smithson, 1999; Visschers et al., 2012)

Implications for communicating uncertainty

In general:

- Target content of your message to your public!

- Perceived benefits strongest relation with acceptance of a technology
  - ➢ To influence acceptance, question or assure the benefits

- Increase trust in stakeholders by emphasizing similar values and goals >> image cultivation
  - If trust is high, an unexpected, salient event does not bring much damage

- Use people's affective images with the technology
  - To strengthen/emphasize affective images
  - To provide people with concrete affective images that are associated with acceptance.

Implications for communicating uncertainty - Probability

Regarding uncertain probability information:

- Carefully communicate this type of information, consider its effect on competence, trust and emotions

- Be aware of affect induction
  - Can be very persuasive, but morally acceptable?
  - Pretest communication material!

Thank you!

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Literature

Bruine de Bruin, W., & Bostrom, A. (2013). Assessing what to address in science communication. *Proceedings of the National Academy of Sciences, 110*, 14062-14068.

Fleishman, L. A., Bruine De Bruin, W., & Morgan, M. G. (2010). Informed public preferences for electricity portfolios with CCS and other low-carbon technologies. *Risk Analysis, 30*, 1399-1410.

Keller, C., Visschers, V., & Siegrist, M. (2012). Affective imagery and acceptance of replacing nuclear power plants. *Risk Analysis, 32*, 464-477.

Markon, M.-P. L., & Lemyre, L. (2012). Public reactions to risk messages communicating different sources of uncertainty: An experimental test. *Human and Ecological Risk Assessment: An International Journal, 19*, 1102-1126.

Schwarz, N. (2011). Feelings as Information Model. In P. A. M. Van Lange, A. W. Kruglanski & E. T. Higgins (Eds.), *Handbook of Theories of Social Psychology* (Vol. 1, pp. 289-308). London: Sage Publications.

Siegrist, M., & Cvetkovich, G. (2000). Perception of hazards: The role of social trust and knowledge. *Risk Analysis, 20*, 713-720.

Siegrist, M., Cvetkovich, G., & Roth, C. (2000). Salient value similarity, social trust, and risk/benefit perception. *Risk Analysis, 20*, 353-362.

Smithson, M. (1999). Conflict aversion: Preference for ambiguity vs conflict in sources and evidence. *Organizational Behavior and Human Decision Processes, 79*, 179-198.

Terwel, B. W., Harinck, F., Ellemers, N., & Daamen, D. D. (2009). Competence-based and integrity-based trust as predictors of acceptance of carbon dioxide capture and storage (CCS). *Risk Analysis, 29*, 1129-1140.

Terwel, B. W., Harinck, F., Ellemers, N., & Daamen, D. D. L. (2010). Voice in political decision-making: The effect of group voice on perceived trustworthiness of decision makers and subsequent acceptance of decisions. *Journal of Experimental Psychology: Applied, 16*, 173-186.

Visschers, V. H. M., Keller, C., & Siegrist, M. (2011). Climate change benefits and energy supply benefits as determinants of acceptance of nuclear power stations: Investigating an explanatory model. *Energy Policy, 39*, 3621-3629.

Visschers, V. H. M., & Siegrist, M. (2008). Exploring the triangular relationship between trust, affect, and risk perception: A review of the literature. *Risk Management, 10*, 156-167.

Visschers, V. H. M., & Siegrist, M. (2012). Fair play in energy policy decisions: Procedural fairness, outcome fairness and acceptance of the decision to rebuild nuclear power plants. *Energy Policy, 46*, 292-300.

Visschers, V. H. M., & Siegrist, M. (2013). How a nuclear power plant accident influences acceptance of nuclear power: Results of a longitudinal study before and after the Fukushima disaster. *Risk Analysis, 33*, 333-347.

Visschers, V. H. M., Wiedemann, P. M., Gutscher, H., Kurzenhäuser, S., Seidl, R., Jardine, C. G., et al. (2012). Affect-inducing risk communication: current knowledge and future directions. *Journal of Risk Research, 15*, 257-271.

Wallquist, L., Visschers, V. H. M., Dohle, S., & Siegrist, M. (2011). Adapting communication to the public's intuitive understanding of CCS. *Greenhouse Gases: Science and Technology, 1*, 83-91.

Wallquist, L., Visschers, V. H. M., Dohle, S., & Siegrist, M. (2012). The role of convictions and trust for public protest potential in the case of carbon dioxide capture and storage (CCS). *Human and Ecological Risk Assessment: An International Journal, 18*, 919-932.