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Evaluation of resource alternatives as carboneous feedstock for the production of platform chemicals: Eco-efficiency considerations and challenges associated with diverse boundary conditions

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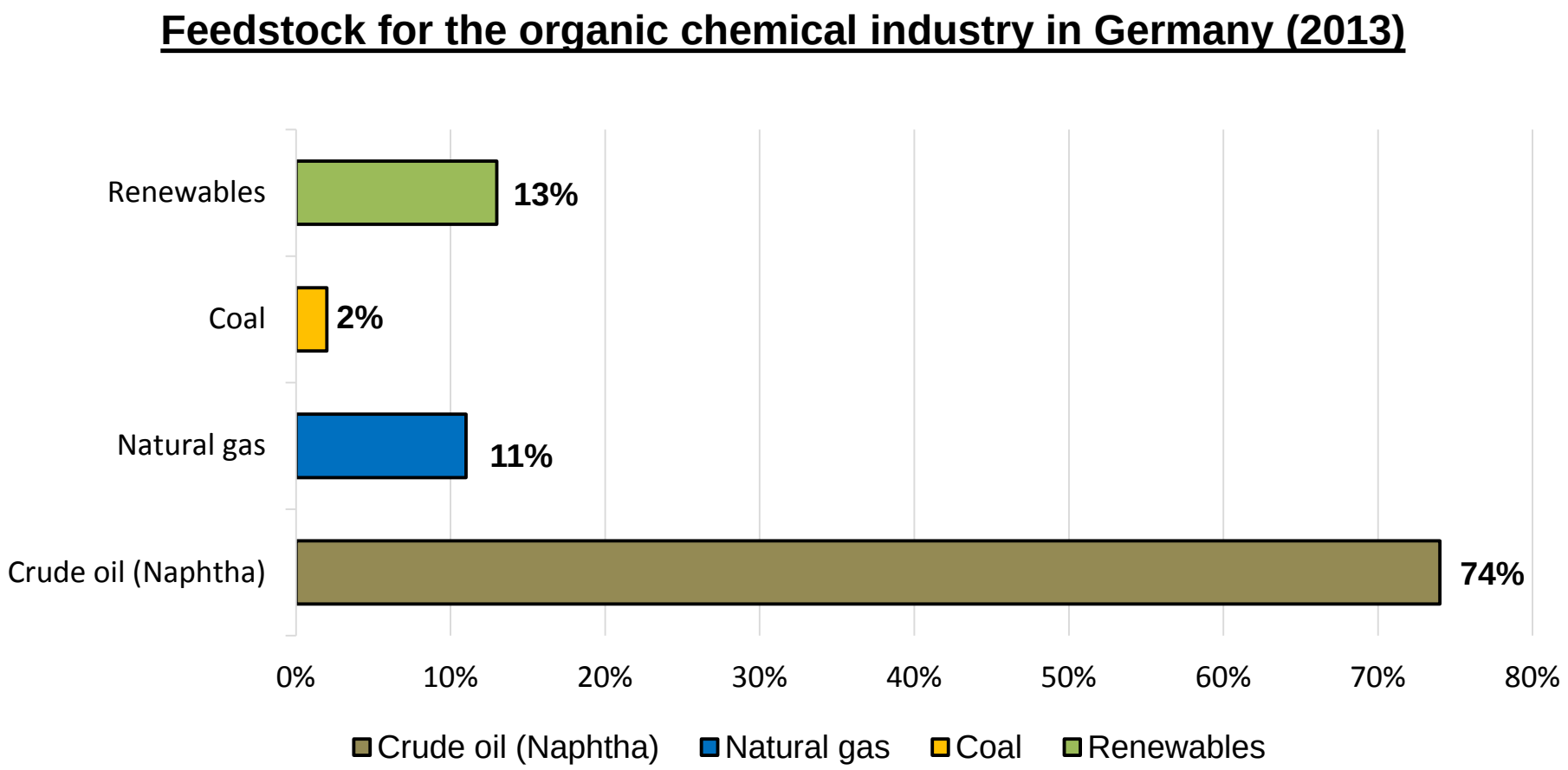
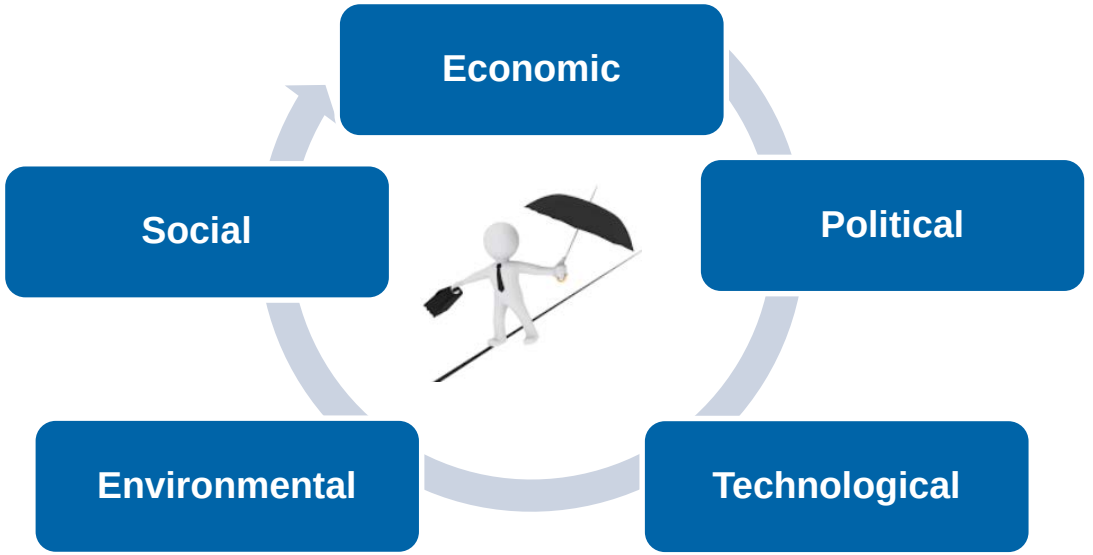
Content

Feedstock For The Chemical Industry: Current Stand in Germany



Source: VCI, 2016

Business as Usual?



Objectives:

1) **Comparative technological-economic-ecological evaluation of five carbon feedstock**

1) **Extend evaluation to include upstream factors in production pathways**

1) **Consideration of boundary conditions**

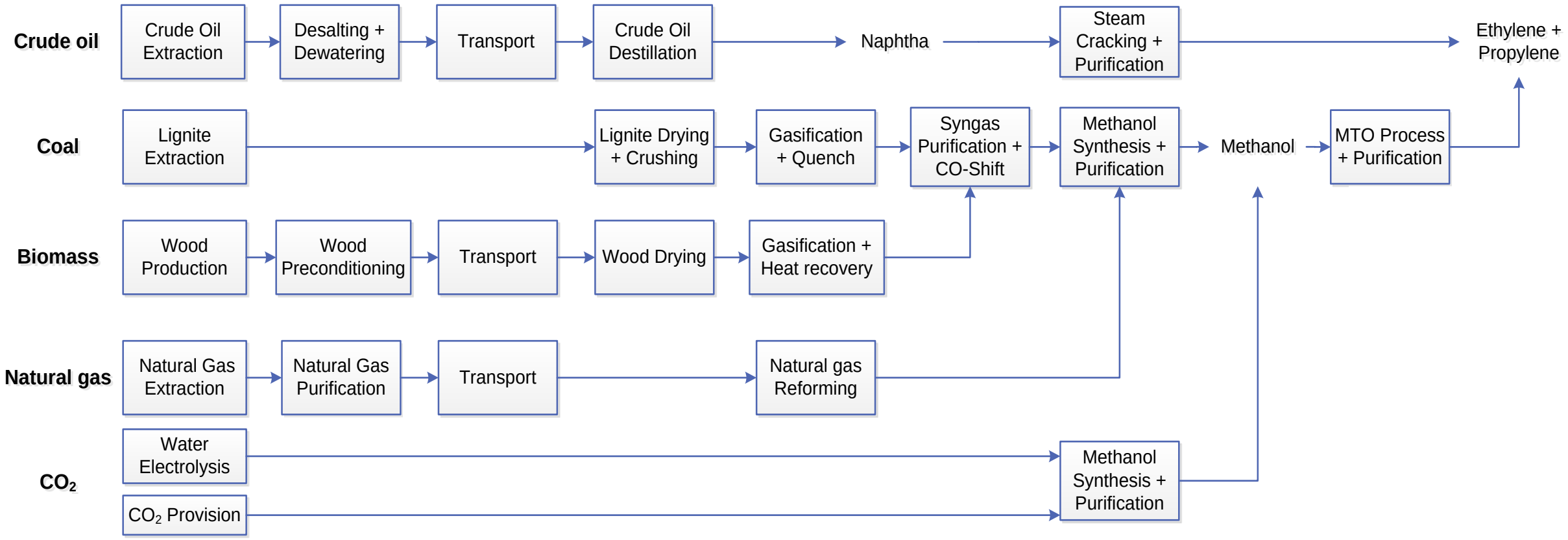
Content

Case Study: Olefins Production From Alternative Feedstock

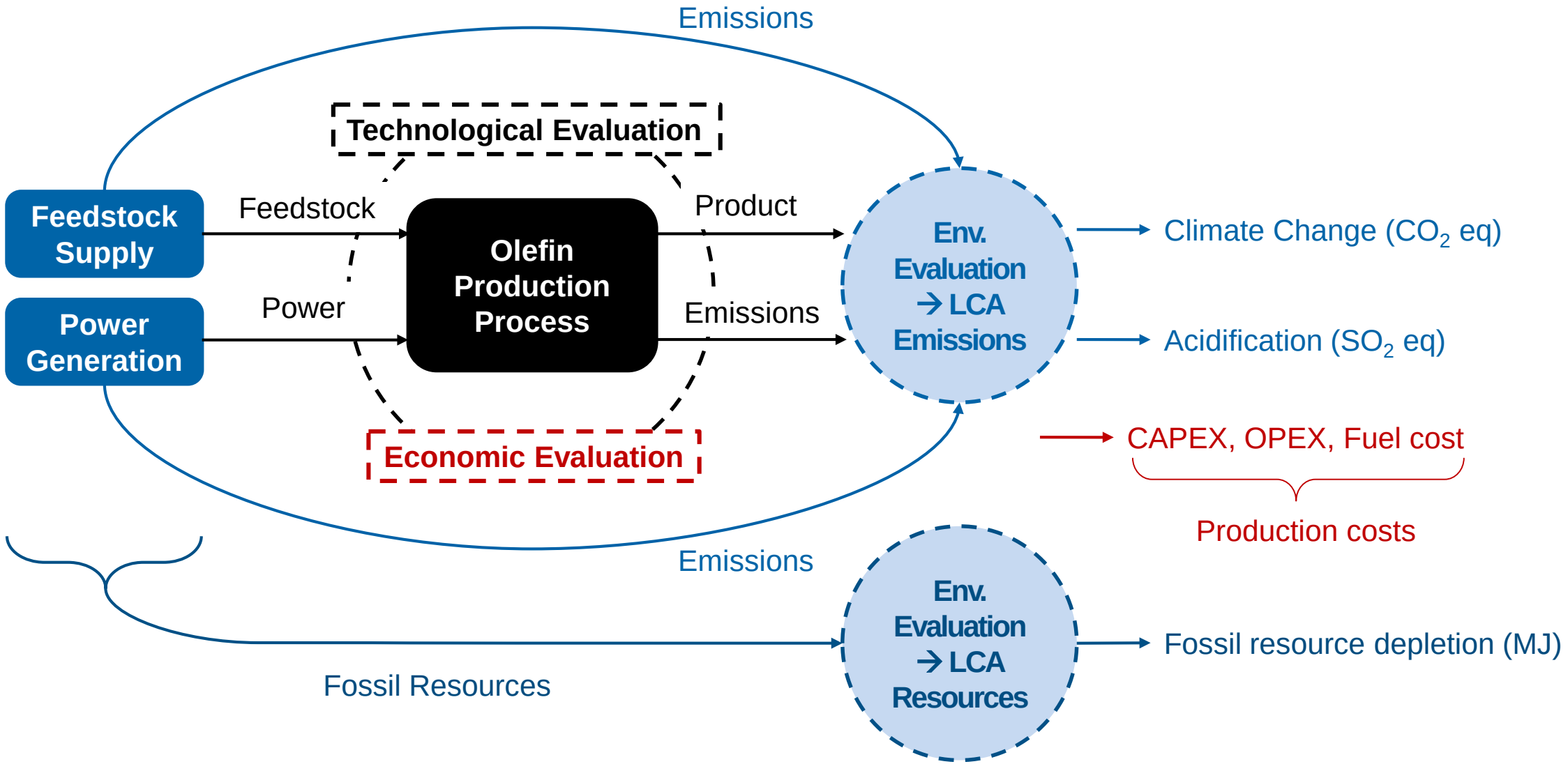
Baseline Framework

Where:	Germany
Product:	- Olefin production at 1 Mio t per year → approx. 9 Mio ton ethylene and propylene in 2014 in Germany
Feedstock Alternatives:	- Domestic feedstock → Lignite & Biomass (wood) - Imported feedstock → Crude oil & Natural Gas - CO_2 as waste material from chemical plant (high purity, low pressure)
Power Generation	Germany 2015 power mix → 42 % coal (lignite and bituminous), 30 % renewables (incl. 14 % wind, 8 % biomass), 14 % nuclear, 9 % natural gas → *Changing power mix will lead to other scenarios*
Transportation:	- Lignite processed near extraction location - Biomass collected over larger area - Crude oil and natural gas imported via pipelines - Chemical plant based CO_2 processed near extraction location → exhaust CO_2 from - power plant not considered

Alternative Production Routes



Methodology



LCA – Life Cycle Assessment

Framework Conditions

Technological Evaluation

- Uniform total plant capacity
- Polymer-grade olefin production (ethylene > 99.9 %, propylene > 99.5%)
- Recycling of side-products if possible (material or energetic use) or sold (sulfur, power)
- Excess steam converted to electric power

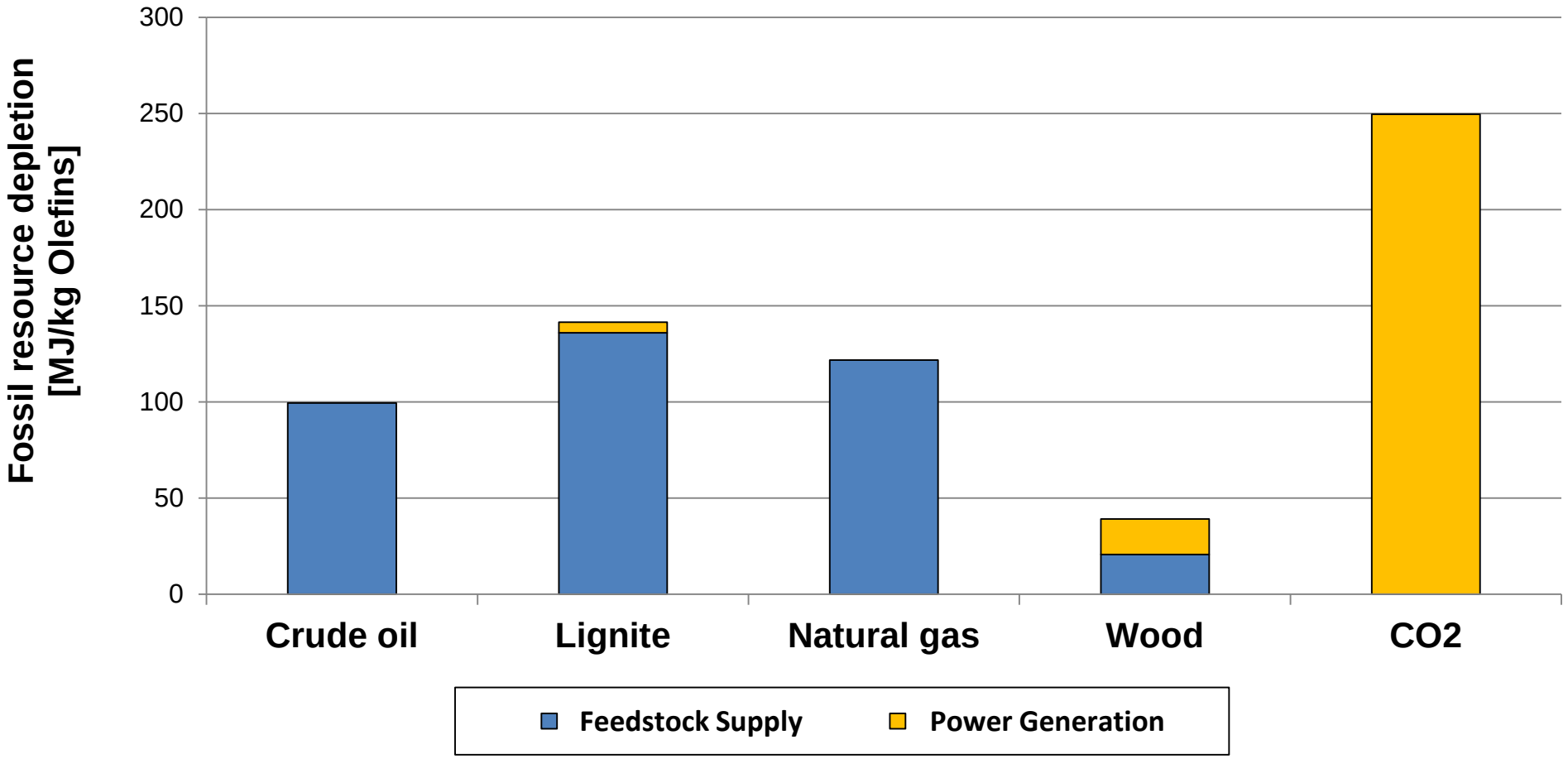
Economic Evaluation

- CAPEX based on scaling of reference facilites (capacity, time)
- OPEX includes fixed and variable operation costs, personnel
- Production cost include side-products (sulfur, power) and financial costs (interest rates)

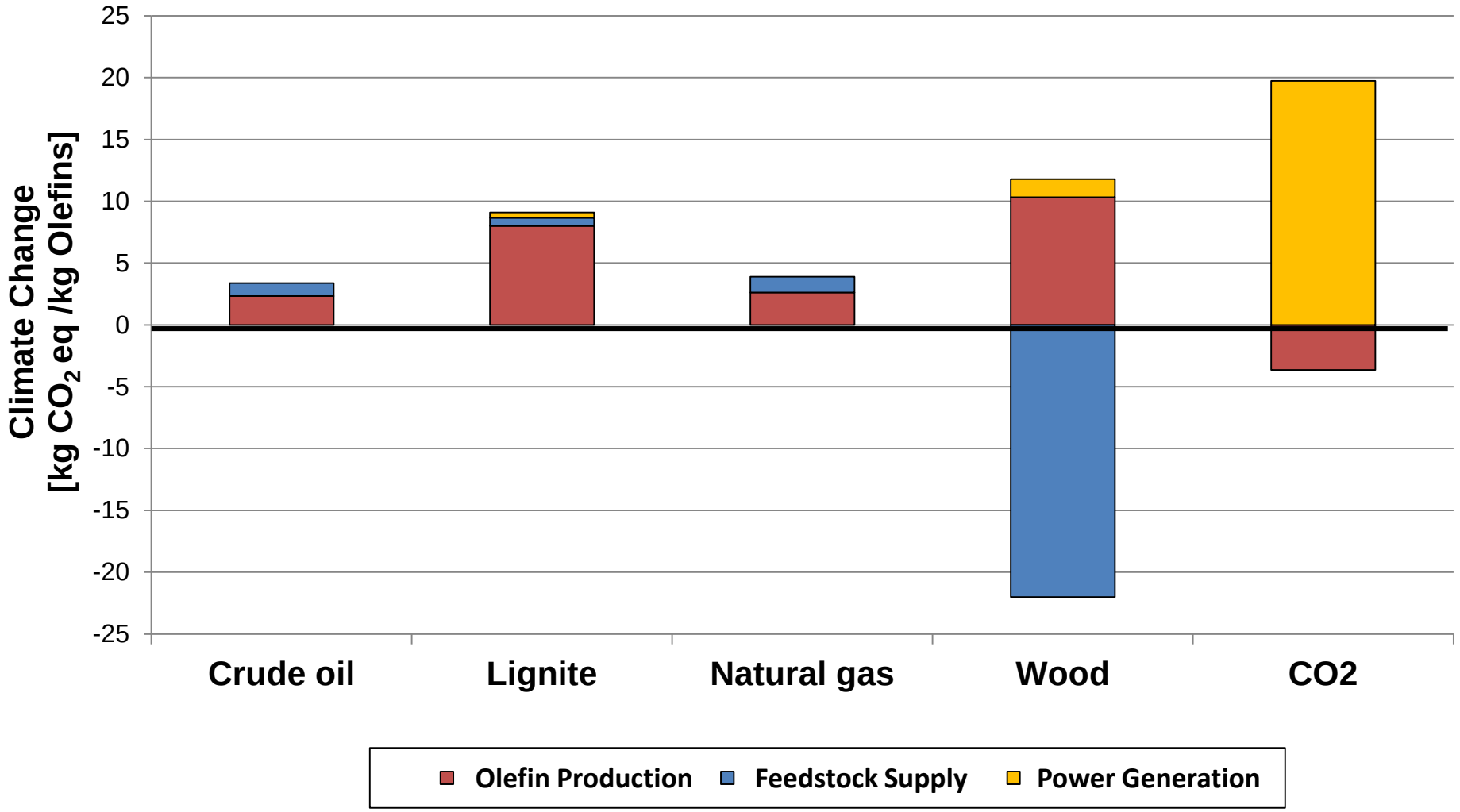
Ecological Evaluation

- Life Cycle Assessment, CML 2001 baseline methodology
- Cradle-to-gate approach
- Construction of production facilities not considered

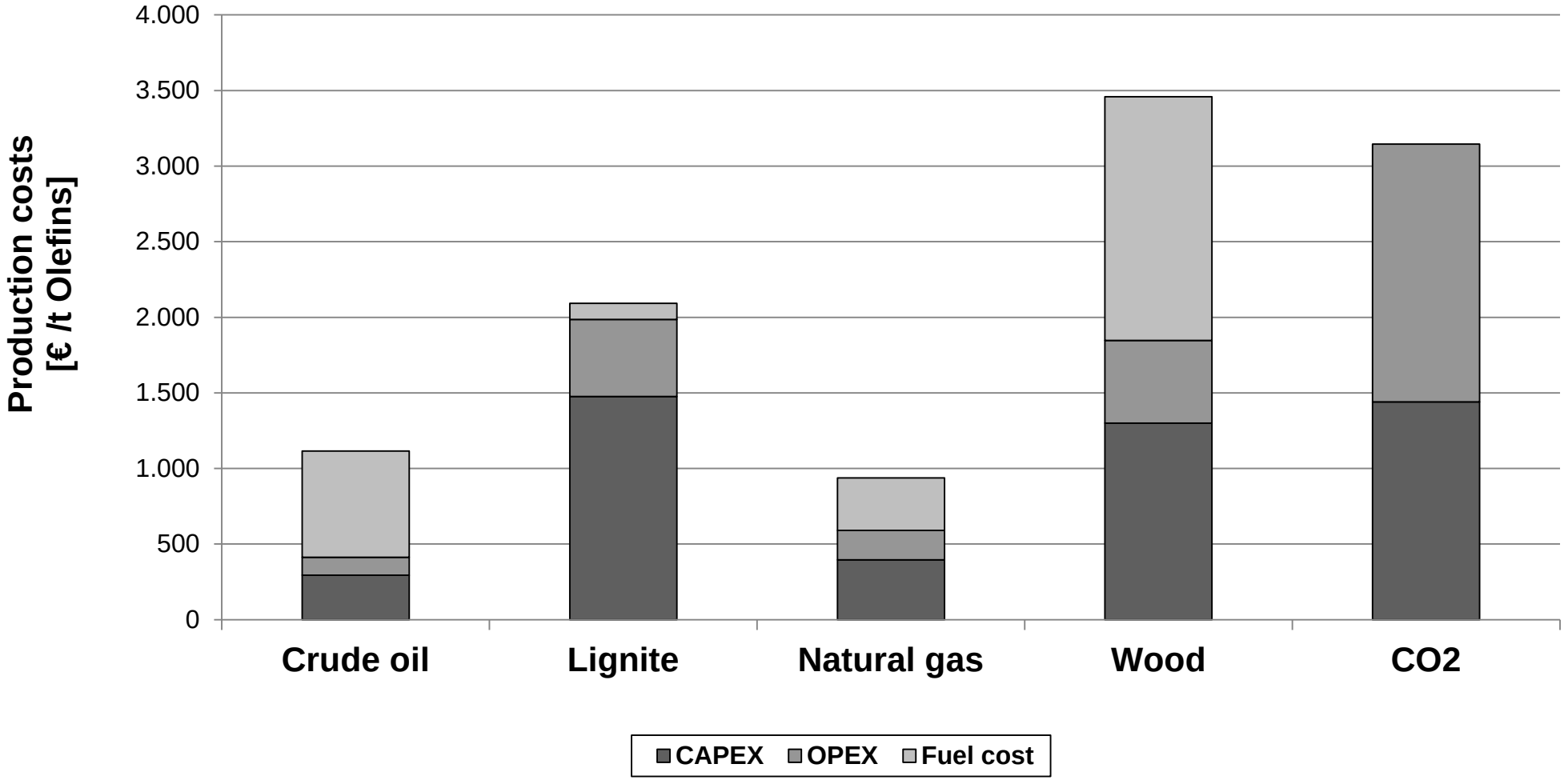
Environmental Evaluation: Fossil Resource Depletion



Environmental Evaluation: Climate Change Potential

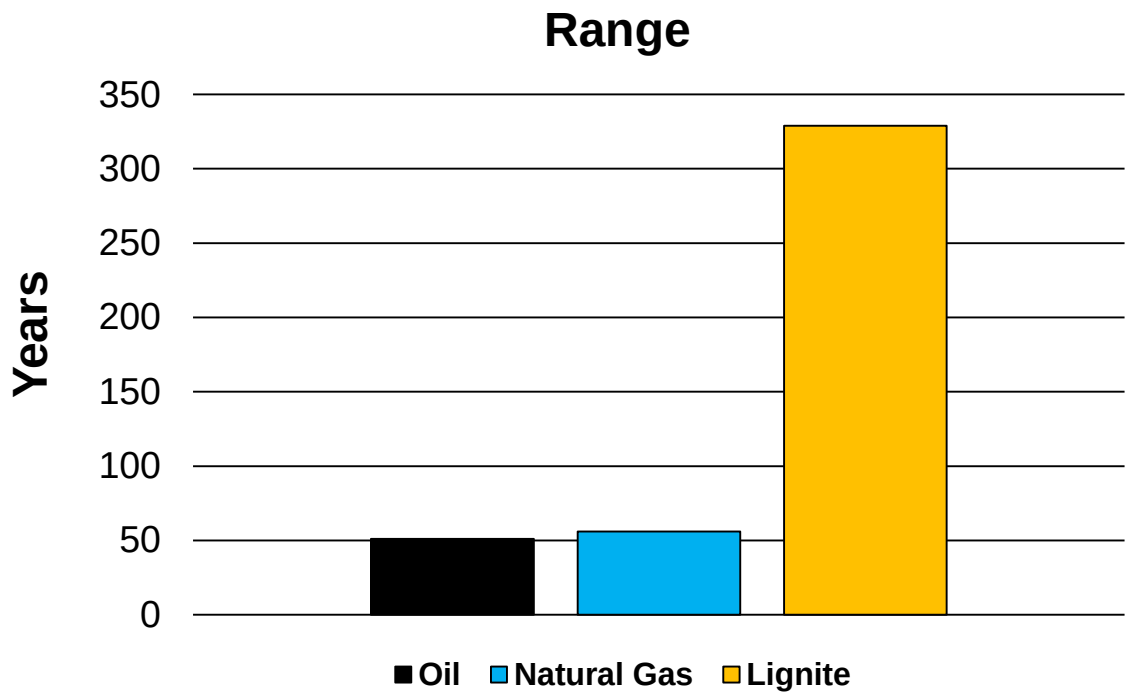


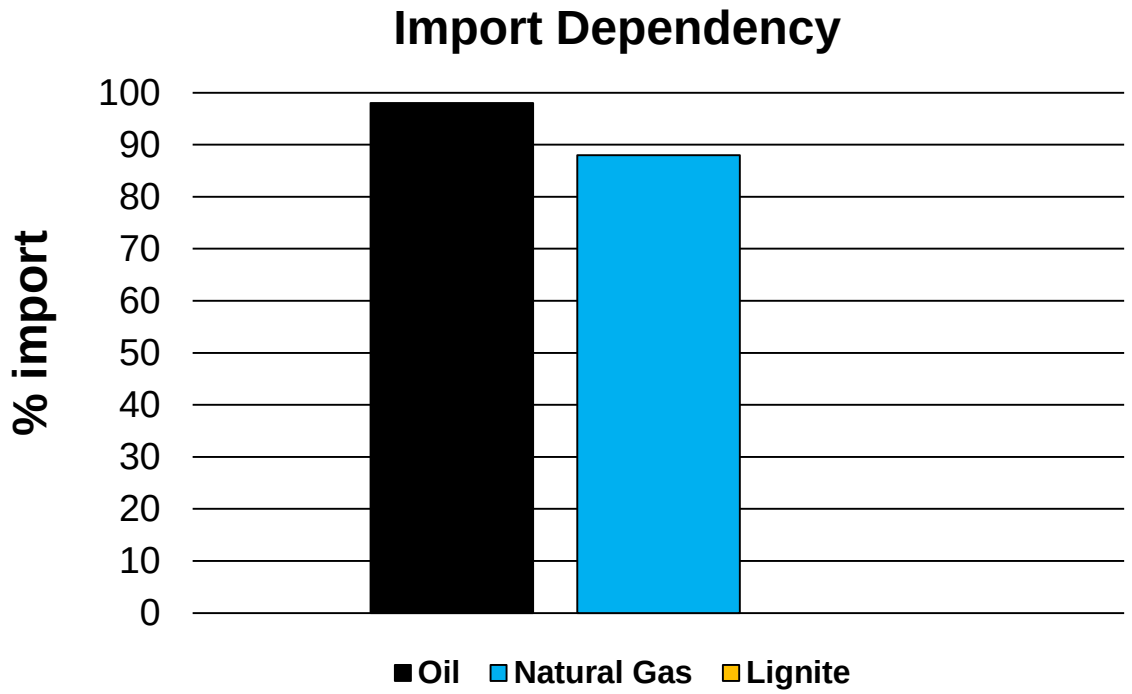
Economic Evaluation: Production Costs Estimation



Content

Two Key Considerations: Range & Import Dependency





Germany: 232 years
(31 years in mining areas approved till end 2009)

Germany: 65% import dependency for biomass for the chemical industry

Sources:
BGR Energiestudie 2015, S. 34
Prognos 2011: Bewertung der Primärenergieträger zur Stromerzeugung, S. 14
http://www.bgr.bund.de/DE/Themen/Energie/energie_node.html
VCI 2016: Daten und Fakten – Rohstoffbasis der chemischen Industrie: S. 4

Reduction Of Import Dependency Via Domestic Feedstock?

Transition?

Motivators

- Reduce import dependency
- Storage potential
- Social benefits → employment etc.

COAL

- Significant domestic resources
- Continuous extraction
- High carbon yield
- Price stability
- …

BIOMASS

- Renewable carbon resource
- New materials & products
- …

Risks

- High investment costs
- Dependence on socio-political frameworks & developments → High uncertainty

COAL

- Socio-political, market & community acceptance issues
- Environmental impacts e.g. landscape destruction
- Social impacts e.g. emissions

BIOMASS

- Availability of arable land & food vs. fuel → acceptance issues
- Seasonal dependency
- Low carbon yield
- Price instability
- …

The Human Dimension

Challenge of Public Acceptability

- Direct Costs (delays, disruptions, cancellations…)
- Indirect Costs (loss of trust, frustration…)

Nuclear protest

Coal protest

Wind protest

2 Modes of Thinking

System 1

Associative
Link by experience to affect & emotions
Intuitive, fast, mostly automatic

System 2

Analytic, reason oriented
Logical and evidence based
Relatively slow, effortful, conscious control

System 1

System 2

- Experiential and analytic modes of thinking interact in a „***dance of affect and reason***“ *(Finucane et al., 2003; Slovic et al., 2004)*
- Unlikely that analytic thinking can take place without input from the affect somewhere along the line *(Slovic et al., 2014)*

Overview of Research Activities into Energy Preception & Acceptance

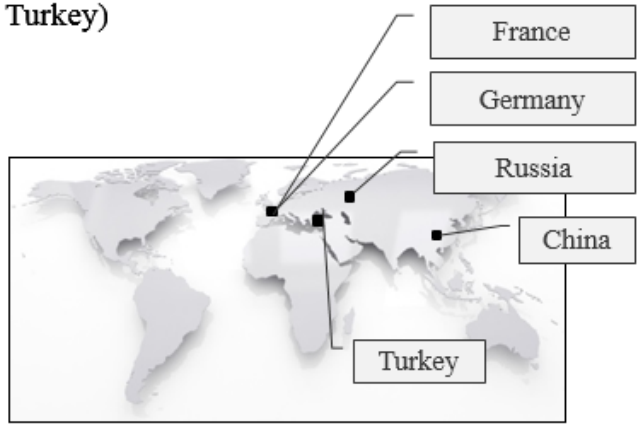
2010: Initial Study
(German university participants)

2011: Before & After Fukushima
(German university & non-university participants)

2012: International Studies
(China, France, Germany, Russia, Turkey)

2013: Mixed Methods Study
(France)

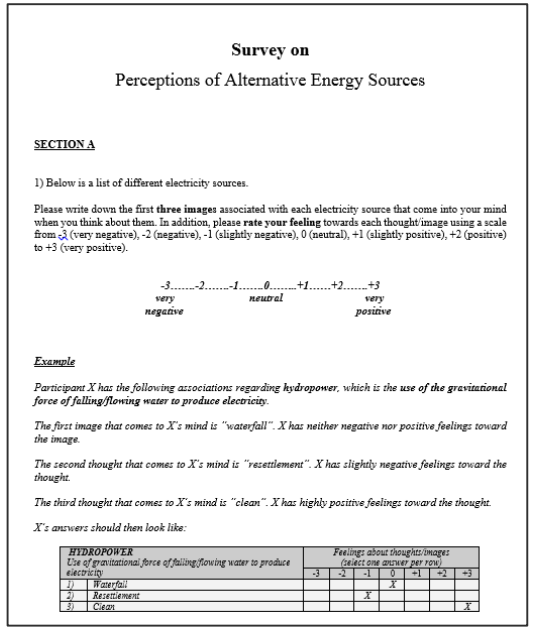
Oct 2013: Representative Study
(Germany)



Methodology

Quantitative Survey Study (paper/online)

- Affective perception
- Cognitive Beliefs
- Knowledge
- Preferences
- Demographics information



Survey on

Perceptions of Alternative Energy Sources

SECTION A

1) Below is a list of different electricity sources.

Please write down the first **three images** associated with each electricity source that come into your mind when you think about them. In addition, please **rate your feeling** towards each thought/image using a scale from -3 (very negative), -2 (negative), -1 (slightly negative), 0 (neutral), +1 (slightly positive), +2 (positive) to +3 (very positive).

-3……-2……-1……0……+1……+2……+3
very negative — neutral — very positive

Example

Participant X has the following associations regarding ***hydropower****, which is the* ***use of the gravitational force of falling/flowing water to produce electricity****.*

The first image that comes to X's mind is "waterfall". X has neither negative nor positive feelings toward the image.

The second thought that comes to X's mind is "resettlement". X has slightly negative feelings toward the thought.

The third thought that comes to X's mind is "clean". X has highly positive feelings toward the thought.

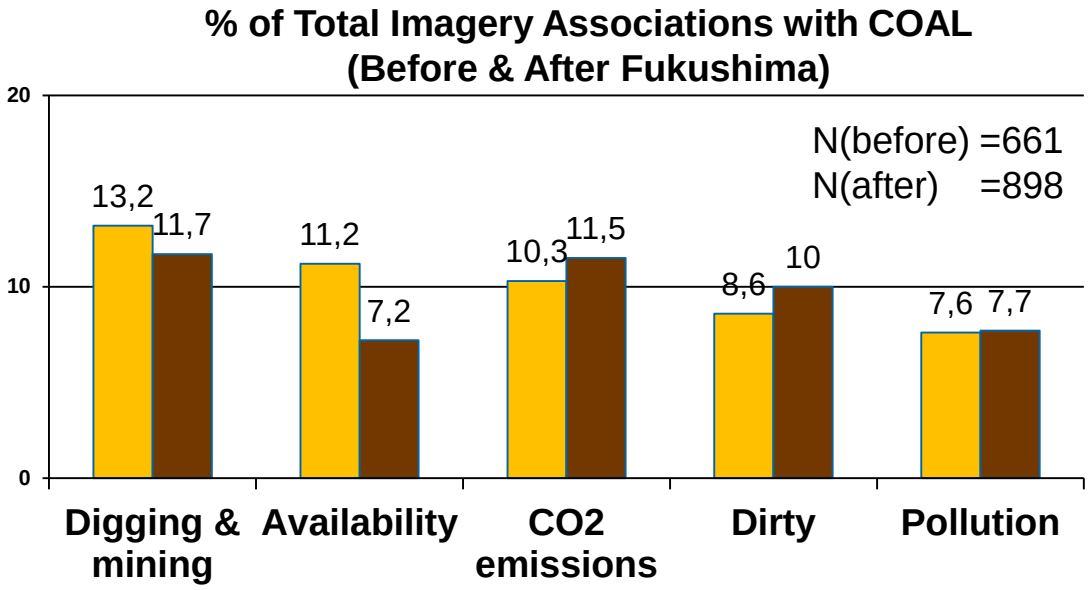
X's answers should then look like:

HYDROPOWER *Use of gravitational force of falling/flowing water to produce electricity*		*Feelings about thoughts/images (select one answer per row)*						
		-3	-2	-1	0	+1	+2	+3
1)	*Waterfall*				X			
2)	*Resettlement*			X				
3)	*Clean*							X

Qualitative Focus Group Discussions

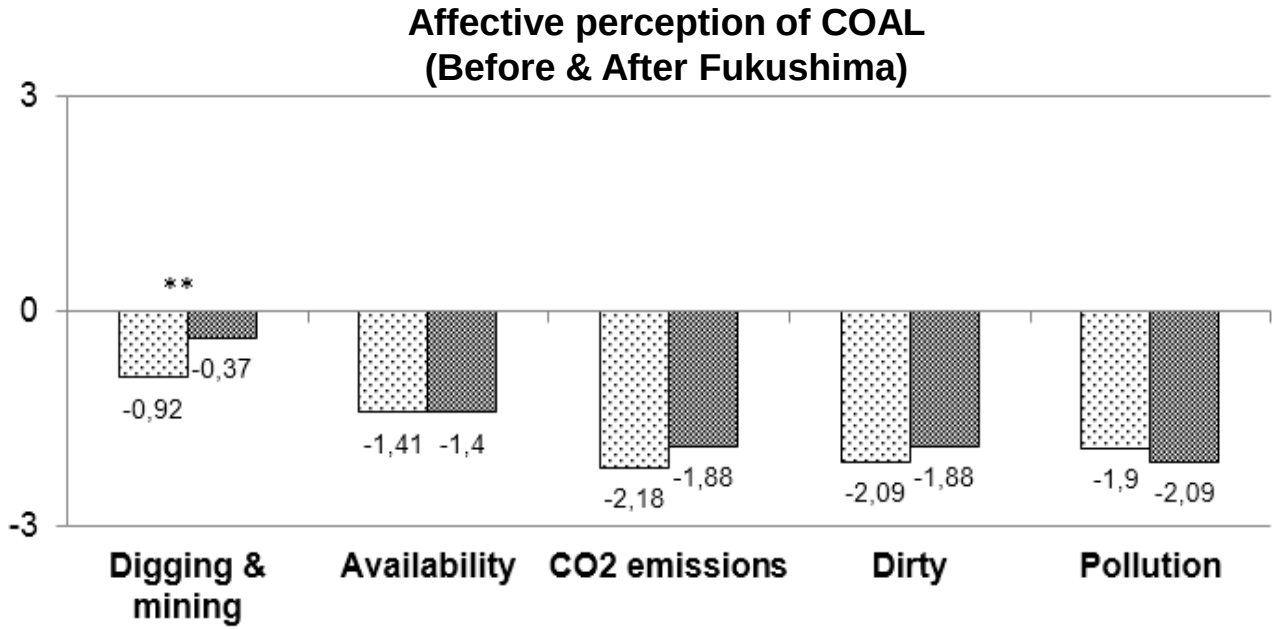
- Societal factors shaping how an energy source is viewed

Key Insights – Affective Imageries Associated with Coal



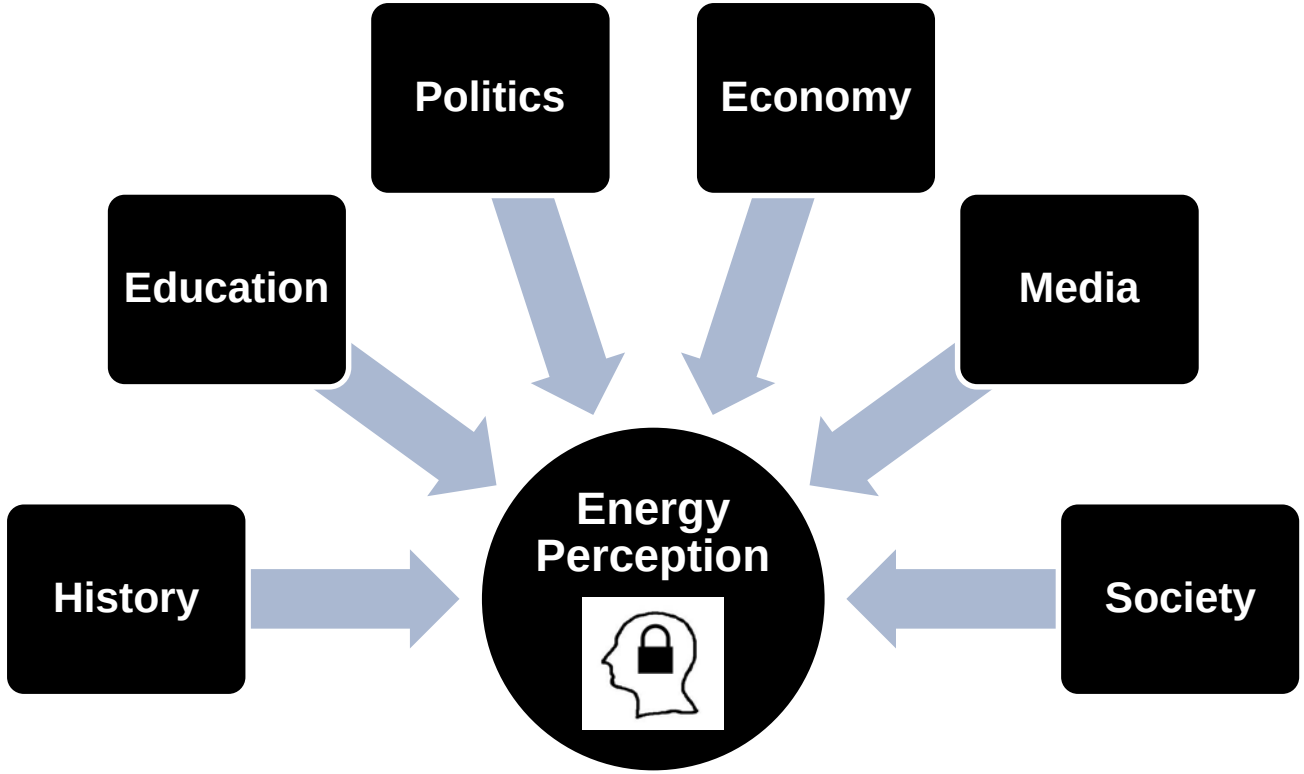
- Strong association of an energy source with specific imageries
- Stability of energy imageries

- Affect towards imageries differ → **an energy source is not simply GOOD or BAD**
- Relatively stable after Fukushima → **suggests lock-in of affective energy imageries**



Lee, R.P. (2015) Stability of energy imageries and affect following shocks to the global energy system: The case of Fukushima. ***Journal of Risk Research***, 18(7): 965-988.

Key Insights – „Lock-in“ Of Energy Perception



- **Energy perception deeply anchored → perceptual lock-in in a society**
- **Multi-prong approach as part of socio-technical systems change**

Lee, R.P., & Gloaguen, S. (2015) Path-dependence, lock-in, and student perceptions of nuclear energy in France: Implications from a pilot study. ***Energy Research & Social Science***, 8: pp. 86–99.

Outlook

Current Status:

1) Basis for further comparative evaluation of carbon feedstock alternatives and technologies
2) Quantification and integration of upstream process in production pathways
3) Consideration of qualitative and intangible boundary aspects e.g. public perception & acceptance

Next Steps:

1) Development of an integrated methodology for techno-economic-ecological-social evaluation
2) Extending baseline framework to alternative scenarios
3) Perception and acceptance of alternative utilization of carbon resources

THANK YOU FOR YOUR ATTENTION!

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