How Technology Relations foster or inhibit Innovation and Exnovation in the Energy Sector

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Workshop *„Accelerating Technological Sustainability Transitions by Overcoming Adoption and Diffusion Barriers in Energy Transitions“*

Session A: *“Barriers for Sustainability Transitions at the Demand Side“*

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Agenda

1.) Introduction

2.) Technology Relations - Insights from Biological Ecosystems

3.) The Case of the German Energy Transition

4.) Further Research Agenda

5.) References

1.) Introduction: Technological Innovation Systems as Analysis Tool in Innovation Studies

Innovation Studies aim at illuminating the “black box” of technological progress in Neoclassical modelling:

Innovation System: “The network of institutions in the public and private sectors whose activities and interactions initiative, import, modify, and diffuse new technologies.”

(Freeman 1987: 1)

The objective of innovation systems is “the interaction in the production, diffusion and use of new and economically used ‘knowledge’.”

(Lundvall 1992: 2)

Technological Innovation System (TIS): “[…] A dynamic network of agents interacting in a specific economic/ industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology.”

(Carlsson and Stankiewics 1991: 93)

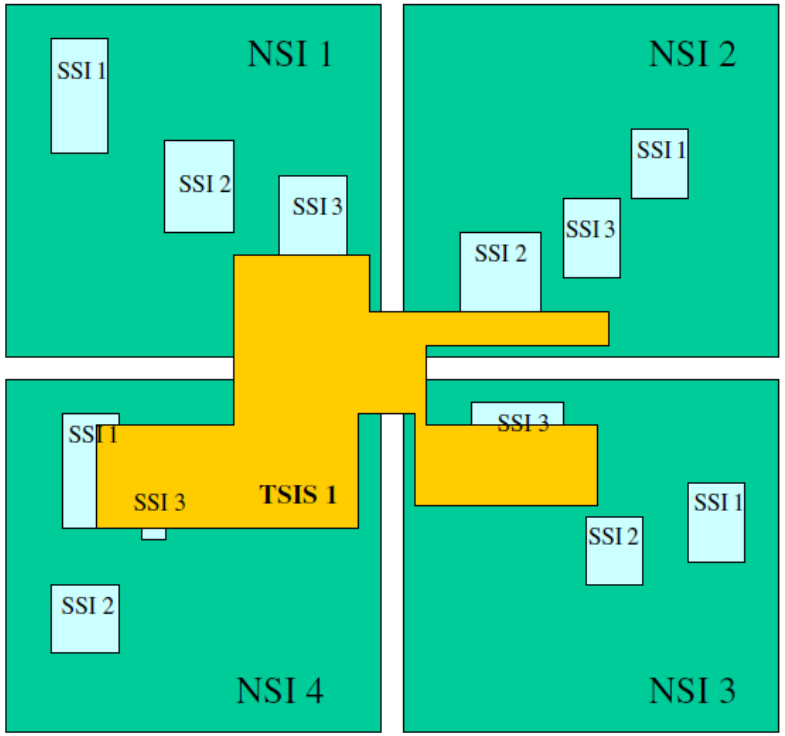
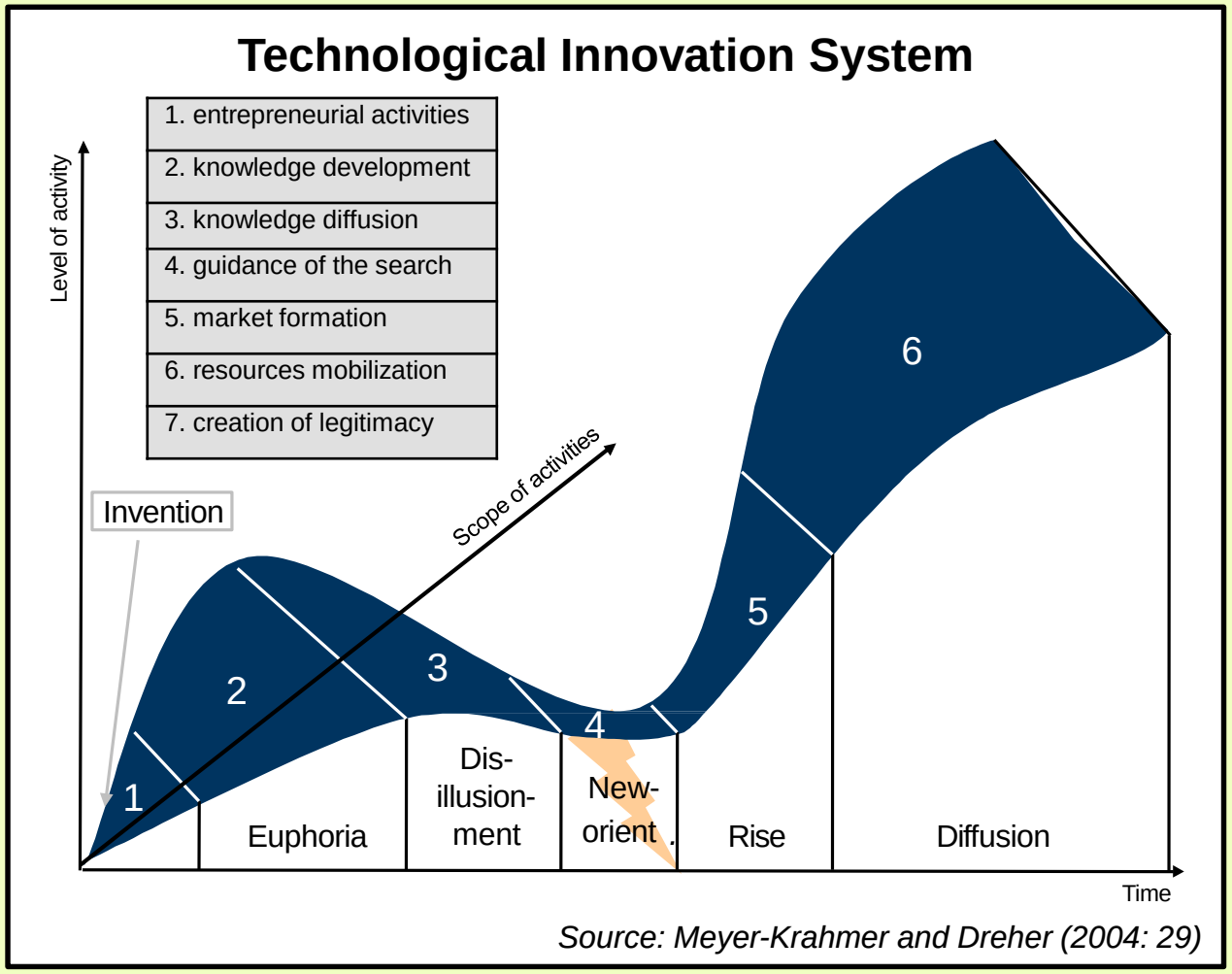


Fig. 1. Boundary relations between National, Sectoral, and Technology Specific Innovation Systems.

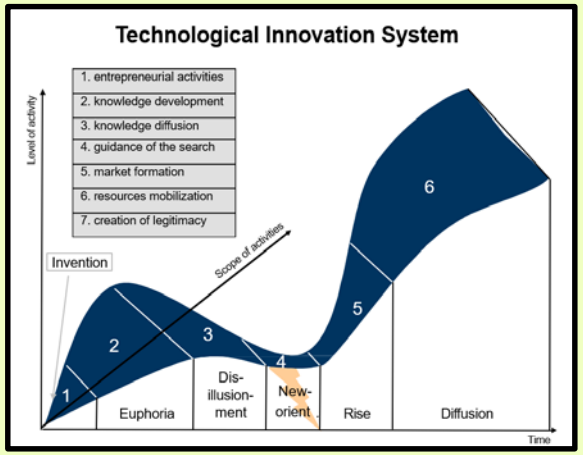
Source: Hekkert et al. (2007: 417)

Relations of Technological Innovation Systems and its contextual structures



Source: Meyer-Krahmer and Dreher (2004: 29)

Technology Relations

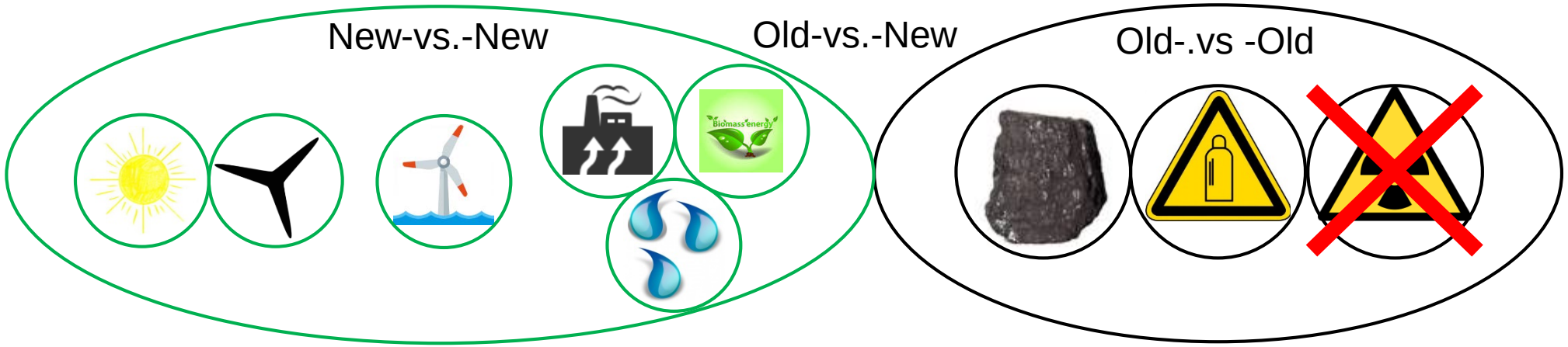


Contextual Structures:

- Technological context
- Sectoral context
- Geographical context
- Political context

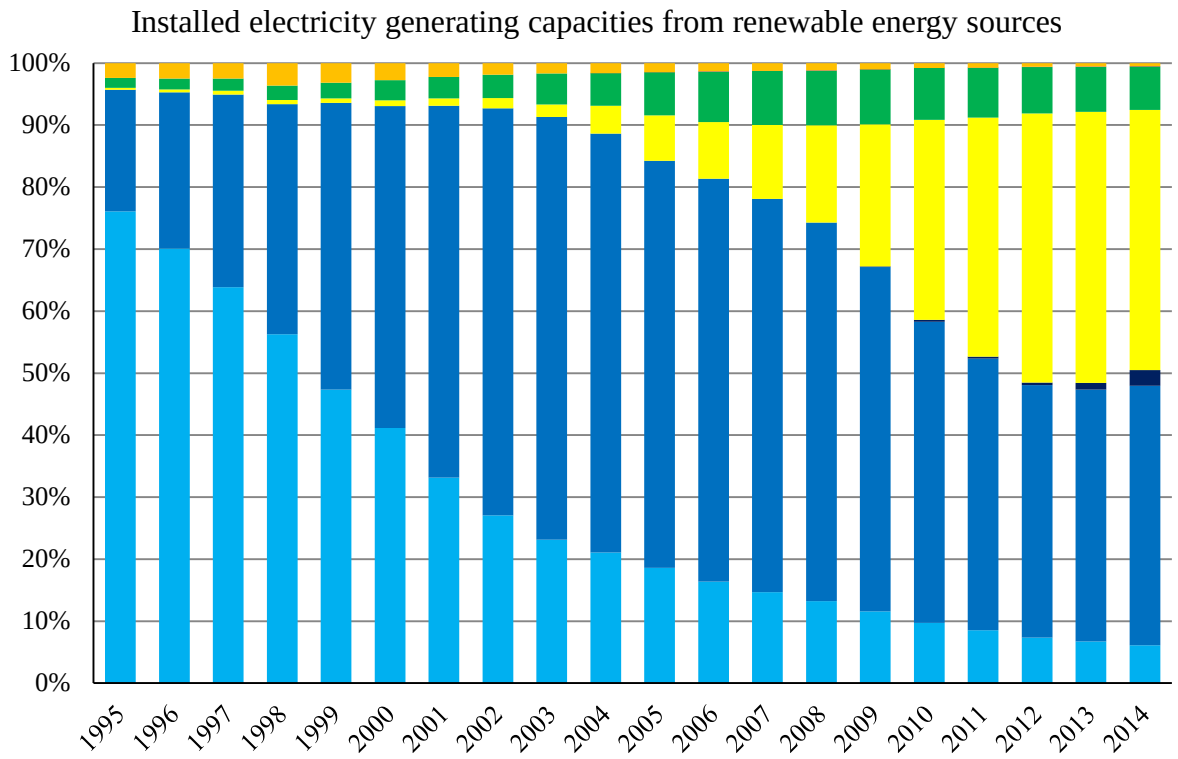
Bergek et al. (2015)

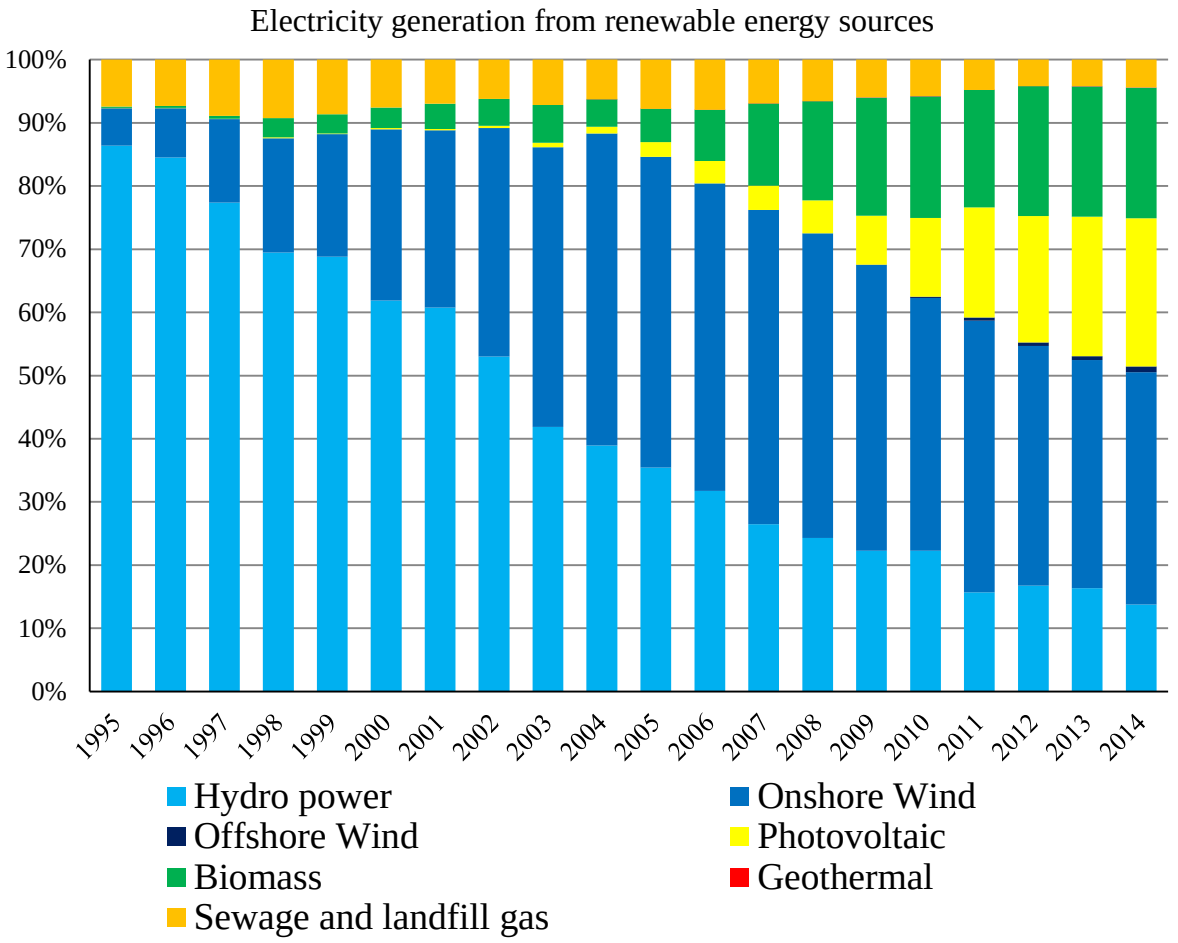
Technology Relations in the Electricity Market



Dreher, Kovac and Schwäbe (2016), Zundel et al. (2005)

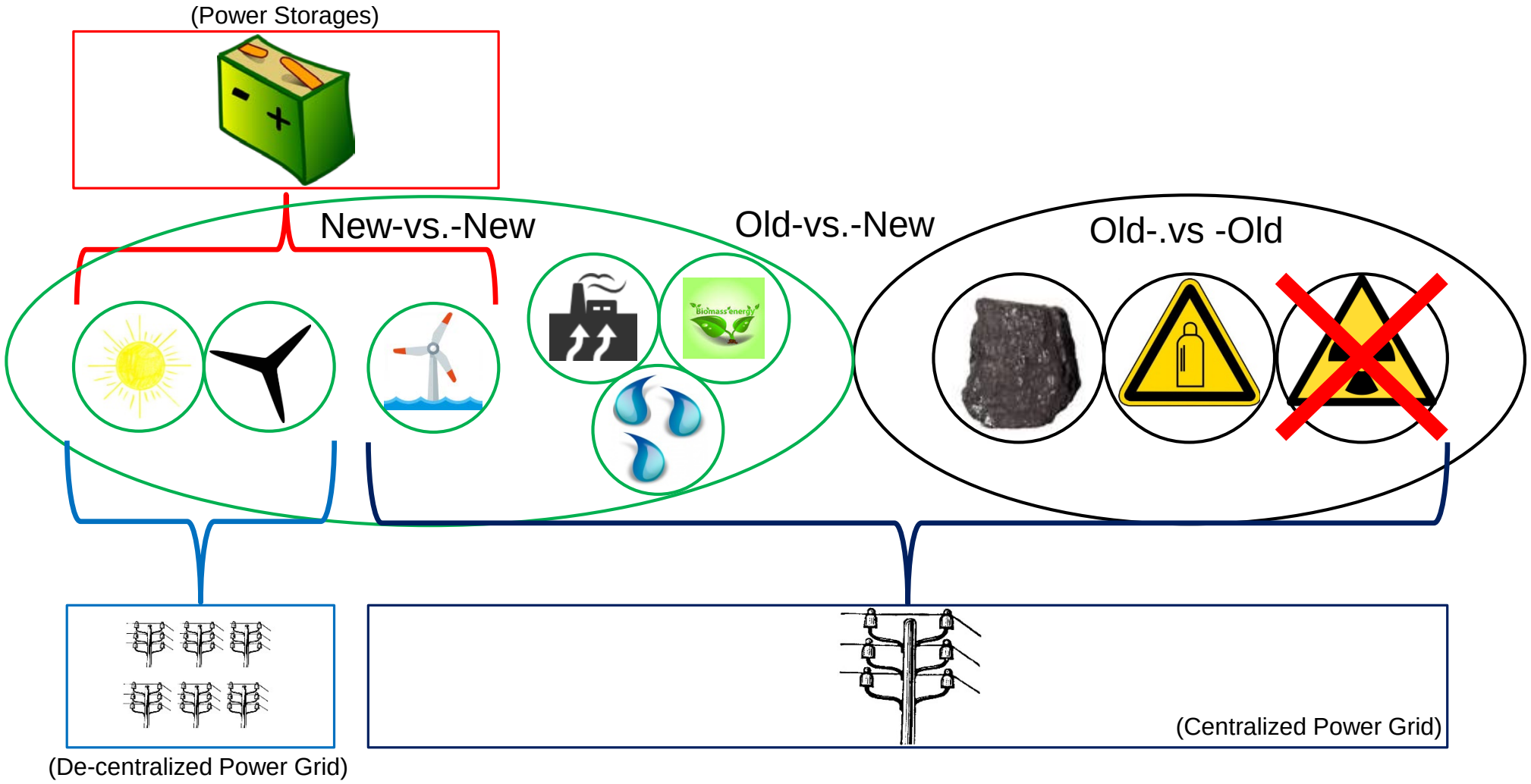
Relevance of technological context structures: Renewable Energy Capacities vs. Generation





Source: AGEE-Stat (2015), own calculations

Relevant Technology Relations in the German Energy Transition



Dreher, Kovac and Schwäbe (2016), Zundel et al. (2005)

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Technology Relations – Objectives and conceptual challenges

Objectives	Conceptual Challenges
➢ Deeper understanding of technology relations apart from competition and complementarity	➢ Identification of all relevant relations between technologies via inductive case study research *Eisenhardt and Graebner (2009)*
➢ Criteria to support and accelerate adoption and diffusion in an technological ecosystem ➢ Conclusions for firm decisions and innovation policy makers facing the dynamic co-evolution of technologies	➢ Built-up of “Middle-Range Theory” ideas on the different technology relation types *Merton (1962)*
➢ Validation of the Technology Relations Concept in order to demonstrate its relevance for decisions for firms and policy makers	➢ Systematisation of quantitative innovation indicators for the analysis of technology relations ➢ Methodology for the qualitative assessment of technology relations by interviews with relevant actors

2.) Technology Relations beyond competition and complementarity – Insights from Biological Ecosystems

Biological Ecosystem considers several modes of relations between life forms:

Relationships amongst and across functional groups

- Within one specie: ...
- Across species: ...
- Across functional groups: ....

Selection criteria:

- Explanatory power to analyse relation and derive recommended actions
- Degree of difference to further relation
- Examples for technologies

Modes of relations

1. Mutualism (both benefit)
2. Commensalism (one benefits)
3. Parasitism (one benefits, one is harmed)
4. Interference competition (same application, different value-chains
5. Exploitation competition (same value chain and same application)
6. Apparent competition (different application, same value network)
7. Neutral

Source: Bascampte & Jordano (2007), Eppinger & Ehls (2007), Gamfeld et al. (2008), Gessner et al. (2004), Tiwari et al. (2017) Pistorius & Utterback (1997), Sanden & Hillman (2011)

Technology Relations: Three Types of Symbiosis

1. Mutualism: both benefit, two modes

1.1 obligatory: both need each other,

1.2 facultative: both may live alone but are better off together**.**

2. Commensalism: one benefits, the other is neither benefited nor harmed

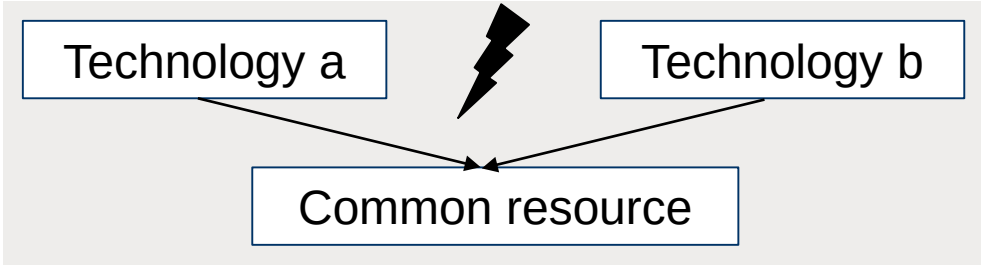
3. Parasitism: one benefits, the other is harmed

Source: Eppinger and Ehls (2007)

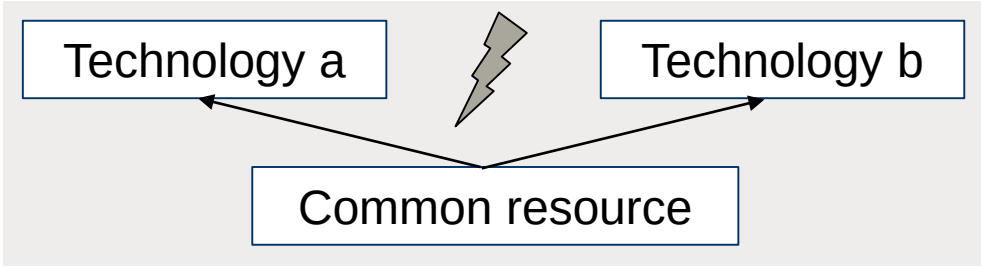
Different outcomes of competition and parasitism: exclusion, co-existence and mitigation

4. **Interference competition**: direct interaction in order to displace the competitor

5. **Exploitation competition:** indirect interaction via competing for common resources



6. **Apparent competition:** indirect interaction, not a “real” competition (e.g. both are a food source for same predators)



Source: Eppinger and Ehls (2007)

Relationships of Technologies: Co-existing and evolving over time

Technology Relations	Comment	Examples
1. Mutualism (both benefit)	Ideal relationship for both	Volatile renewable energies (wind, photovoltaic) with energy storage
2. Commensalism (one benefits)	Often pre-stage before it turns into parasitism	Centralised electricity grid with wind offshore, biomass or conventional energies
3. Parasitism (one benefits, one is harmed)	Pre-stage before it turns into a competition mode	Wind offshore benefits from technology development of wind onshore.
4. Interference competition (application)	Competing for same application field with different value chains, typical substitution mode	Conventional versus renewable energies
5. Exploitation competition	Competing for same application field with same parts of the value chain	Biomass energy and a decentralised grid which is less compatible
6. Apparent competition (value network)	Using (parts of) same value chain for different application fields (e.g. urban roof farming & photovoltaics)	Wind Onshore and Solar PV technologies as variable energy sources
7. Neutral	No benefits or disadvantages despite e.g. same application field or value system)	Energy storage and coal energy having no direct impact on each other

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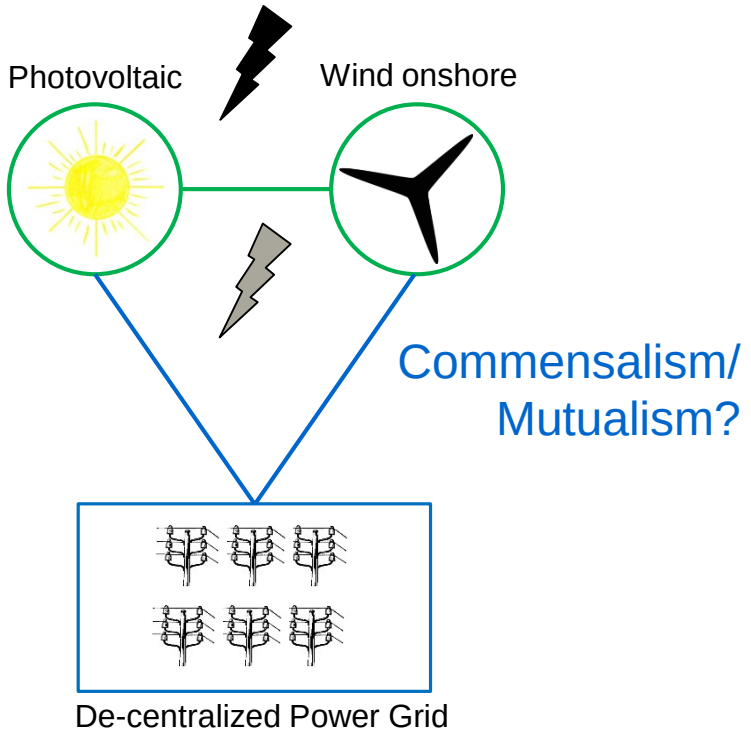
3.) The Case of the German Energy Transition at the Electricity Market

	Photovoltaic	Wind Onshore	Wind Offshore	Biomass	Coal	Energy Storage	Centralised Grid	Decentralised Grid
Photovoltaic								
Wind onshore	6. Apparent Competition							
Wind offshore	4. Interference Competition	4. Interference Competition						
Biomass	4. Interference Competition	4. Interference Competition	6. Apparent Competition					
Coal	4. Interference Competition	4. Interference Competition	6. Apparent Competition	6. Apparent Competition				
Energy Storage	1. Mutualism	1. Mutualism	1. Mutualism	7. Neutral	7. Neutral			
Centralised Grid	6. Exploitation Competition	6. Exploiting Competition	2. Commensalism	2. Commensalism	2. Commensalism	7. Neutral		
Decentralised Grid	2. Commensalism	2. Commensalism	6. Exploiting Competion	6. Exploiting Competition	6. Exploitation Competition	7. Neutral	No relation possible	

As it holds true for every typology – the exception proves the rule:

- Photovoltaic and wind onshore energy stand in a clear competition relation:
  Interference competition?

- But both are depending on a decentralised power grid feeding-in low-scale and volatile power sources:
  Apparent competition?



Preliminary Conclusions – Work in Progress

- A technology relation exists if one technology influences the other.
- Coexistence of different technology relations → also depending on contextual structures (geography/sector/political).
- Technology relation are subject of a dynamic co-evolution.
- Policy makers may influence a TIS directly, but also through influencing other related TIS or its technology relations. The same holds true for management decisions on the use of technologies in firms.

4. Further Research Agenda

- Do further relevant technology relations exist?

- How can qualitative methods (in particular expert interviews with concerned firms, policy makers or researchers) contribute to the analysis of technology relations?

- Which innovation indicators regarding the technology, the related markets, the value chain or the contextual structures are appropriate for the identification of technology relations?

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Thank you for your attention!

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Different outcomes of competition and parasitism: exclusion, co-existence and mitigation

4. **Interference competition**: indirect interaction, competing for common resources:

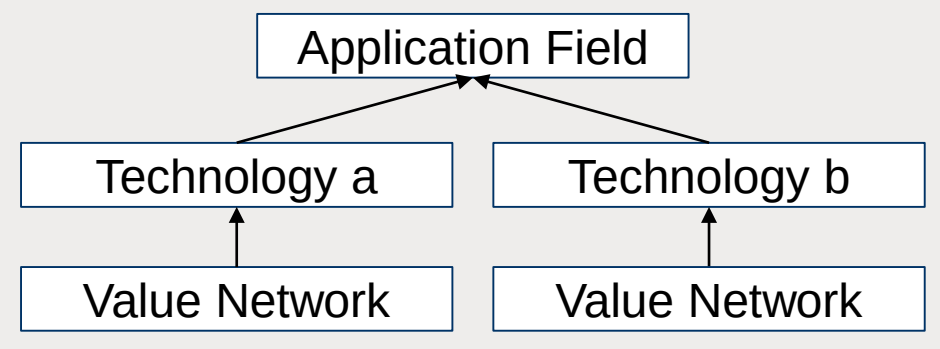
   competing for same application field with different value chains

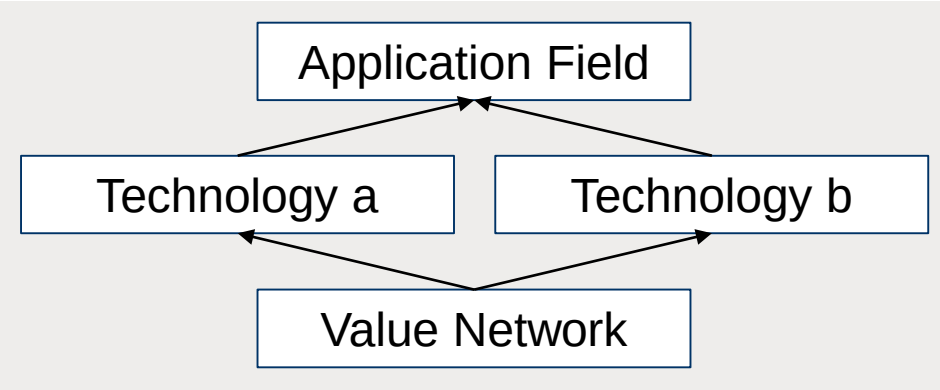
5. **Exploitation competition:** direct interaction, competing for common resources:

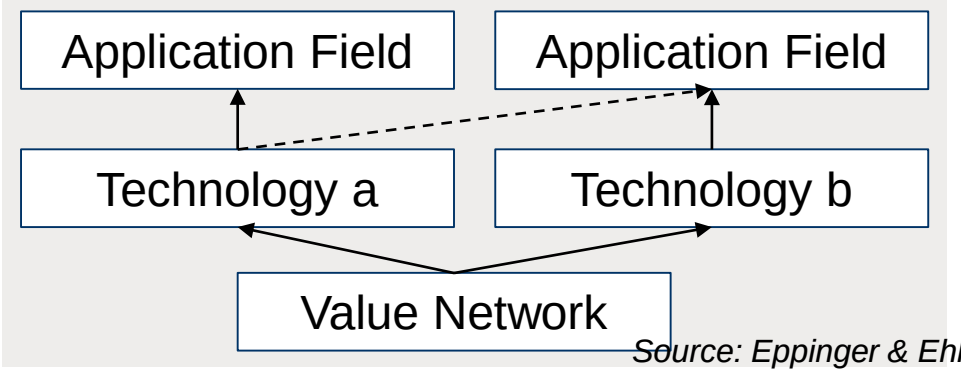
   competing for same application field with same parts of the value chain

6. **Apparent competition:** indirect interaction, not a “real” competition (e.g. both are a food source for same predators):

   using same value chain for different application fields







Source: Eppinger & Ehls (2017)

Relationships of Technologies: Co-existing and evolving over time

Technology Relations	Comment	Implications (if both aredesirable)
1. Mutualism (both benefit)	Ideal relationship for both, e.g. photovoltaics & smart grid	Preferred mode – try to keep mode (provide framework/ context)
2. Commensalism (one benefits)	Often pre-stage before it turns into parasitism	Try to keep mode (provide framework/ context)
3. Parasitism (one benefits, one is harmed)	Pre-stage before it turns into a competition mode, e.g. wind offshore benefits from tech development of onshore	Try to bring it back to commensalism/ nurture technology which is harmed
4. Interference competition (application)	competing for same application field with different value chains, typical substitution mode	Mitigate competition, e.g. find broader application fields/ increase markets
5. Exploitation competition (value network and application)	competing for same application field with same parts of the value chain	Mitigate competition, e.g. find broader application fields/ increase markets or integrate both
6. Apparent competition (value network)	using (parts of) same value chain for different application fields (e.g. urban roof farming & photovoltaics)	Mitigate competition, e.g., integrate both to reach commensalism or neutral stage, improve efficiency
7. Neutral	No benefits or disadvantages despite e.g. same application field or value system)	If time – try to get it to mutualism or commensalism

Source: Eppinger & Ehls (2017)