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Actor networks around catenary hybrid trucks in central Europe: An analysis over time

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Summary

As one type of electric road system (ERS), catenary hybrid trucks (CHT) can contribute to the decarbonisation of heavy road transport. As a technological niche, CHT represent an alternative to the currently dominating regime technology of diesel-powered trucks. For the successful growth of this niche, growing actor networks are considered a key element in the multi-level perspective (MLP) and strategic niche management (SNM). This paper shows that the actor network around the technological niche of CHT in Germany and Europe has grown and become denser since the initiation of the field trials in Germany but that some network bottlenecks remain.

1 Introduction and Research Questions

Catenary hybrid truck (CHT) systems represent one electric road system (ERS) concept that can contribute to decarbonise heavy road transport [1]. CHT are operated with electricity from overhead lines and combine an electric engine with an internal combustion engine. CHT systems can be an economically viable solution for heavy-duty trucks, provided that the catenary infrastructure has been pre-financed and is well-utilised [2]. The infrastructure is provided by Siemens and is called eHighway. Since 2016, the technology has been demonstrated in Sweden, California and Germany. In Germany, three field trials for testing CHT systems are currently planned or carried out.

Besides ERS concepts, there are further options to decarbonise heavy road transport, either independent or integrated with ERS. This includes drive systems with combustion engines (using for example diesel or electrofuels) or fuel cell and battery electric drive systems [1]. The distinctive feature of ERS is the high necessary initial investment in infrastructure.

How technological innovations develop vis-à-vis established and competing technologies can be analysed based on theories of transitions in socio-technical systems. In the multi-level perspective (MLP) framework, technologies, which are nurtured in niches, can become a part of or overthrow a current regime, which represents the dominant socio-technical configuration [3]. Here, CHT systems represent the niche and the currently dominant system around diesel trucks represents the regime in heavy-duty road transport. Strategic niche management (SNM) is a research strand with the aim to support such developments, especially for sustainable technologies. The growth of actor networks, including powerful actors, and the alignment of expectations are considered key elements for the growth of niches [4].

It is, hence, crucial to analyse whether more actors have joined the technological niche of CHT systems over time, how well-connected these actors are, and whether there are any critical bottlenecks, such as single actors in important bridging functions, in the network. This way, a pre-assessment can be made regarding the

chances of the technology to diffuse beyond the trial projects. The aim of this paper is therefore to track whether there has been a growth in the actor network in the niche of CHT over the last years and how the network structure has changed. Because there is a high proportion of transit traffic in Germany [5], we take a European perspective. Thus, Germany will be the focus of the analysis (due to the active field trials) but actors in neighbouring European countries will also be taken into account.

This leads us to the following research question:

- How has the actor network around the technological niche of CHT systems in Germany and Europe developed since the initiation of the field trials in Germany and are there any critical bottlenecks?

2 Methodology

To analyse the characteristics of the actor network around CHT, a social network analysis (SNA) was carried out. The network was identified and analysed for two points in time: (1) in the announcement phase of the German trial projects and (2) in the current phase, in which one trial is running, one is ready to run, and one is in the building phase. Subsequently, the differences between these two snapshots of the network were analysed.

Data collection

Actors, defined as private or public organizations, were identified for both points in time.[1] For each time frame, the data was aggregated into one network, presenting a snapshot in time. Data sources are presented in Table 1.

	Actor network 1	Actor network 2
Time frame of data collection	2013 - 05/2018	06/2018 - 01/2020
Data sources	Newspaper articles, publications (LexisNexis), grey literature (Google)	Newspaper articles, publications (LexisNexis), grey literature (Google)
Countries	Germany, Sweden, USA	Germany, Sweden, France, Italy, Poland, Czech Republic, Netherlands, Belgium, Switzerland[2]

Table 1: Data sources for network data

The main data sources for both networks were newspaper articles and a Google search (see Tables A1 and A2 in Appendix A for an overview of the analysed newspapers). The used German keywords, translated into the relevant languages, were: Oberleitungs-Lkw, HO-Lkw, OH-Lkw, O-Lkw, Hybrid-Lkw, oberleitungs-gebundener Lkw, e-Lkw, elektr* Straße / Highway, and e-Highway.

Data analysis

Actors and connections identified in this way were additionally verified and supplemented. For the first network, this was done with the aid of a survey, in which actors themselves could indicate their connections with other actors around CHT in the timeframe 2013 - 2018 in a closed-ended roster. For the second network, this was done based on attendance lists of the relevant Electric Road Systems conference and of project meetings and workshops around the German trial projects and other CHT research projects.

[1] In the first network, US American actors had also been included [6] but the trials around Los Angeles have since been stopped and beyond Europe no further practical implementations of CHT systems have taken place. We therefore excluded these actors for the comparison, and the analysis of the new actor network has focused on Germany and Europe from the start.

[2] All identified European actors entered the actor network around CHT systems after the aggregation date of the first network, justifying the addition.

For the SNA, all actors and their connections were entered into a binary matrix. Connections in the network were defined as communication and / or collaboration of the actors on the topic of CHT. Three main activities were identified as operationalisations of these two concepts: research project collaboration within (*intra*-project) and between projects (*inter*-project), joint event attendance (workshops, conferences, openings of test tracks), and individual communication and / or collaboration reported by the actors themselves. If a connection in one direction was reported and / or identified, the connection was assumed to be mutual, leading to a symmetric, undirected network.

Each actor in an SNA is represented by a node ("dot") in the network and each connection by an edge ("connecting line"). Subsequently, network metrics were calculated for individual nodes (degree, betweenness centrality) and the entire network (density, communities/cliques), allowing for comparisons between the two points in time and the identification of possible bottlenecks.

3 Results and Discussion

In this section, the first, older and the second, newer actor network around CHT systems and their differences are analysed, outlining the changes in the actor landscape around this technology.

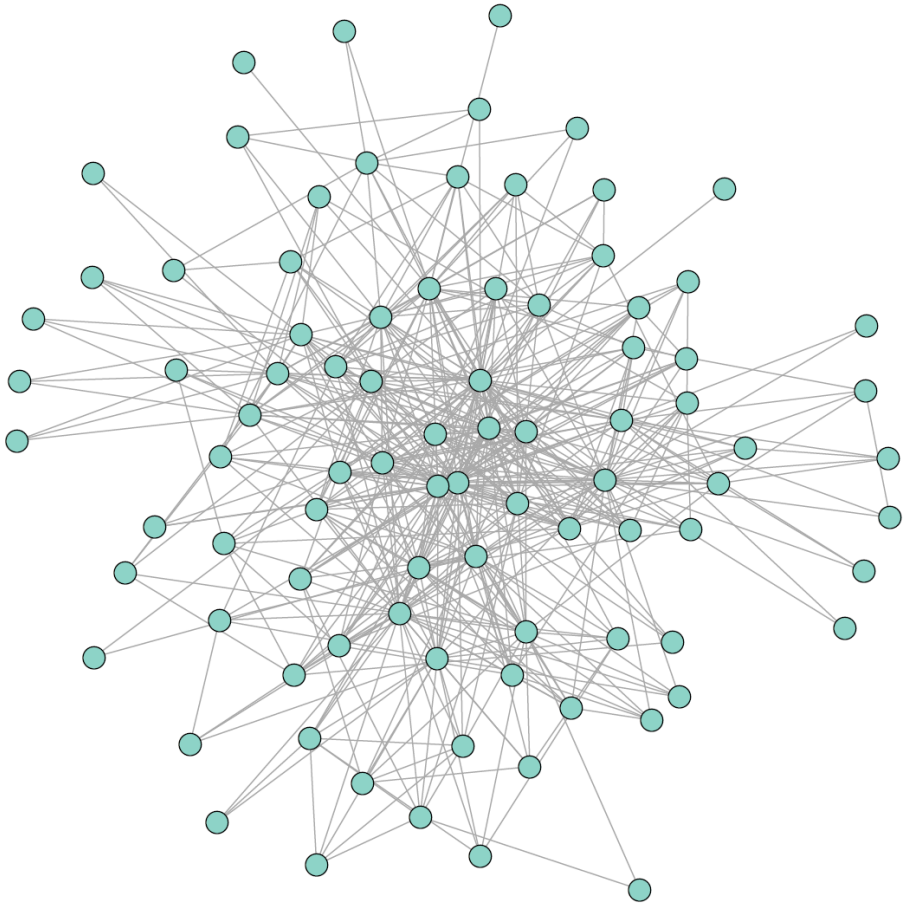

Figure 1: Actor network 1. Actor labels are excluded due to data protection.

The first network of 95 actors (= nodes), shown in Figure 1, exhibits a visible difference between a well-connected core and a less connected periphery and shows no isolated groups. The density of the network is 0.13[3]. The number of ties that individual actors have with others (= degree), ranges from 1 to 46. Six actors

[3] Density is "the number of ties in the network expressed as a proportion of the number possible" (Borgatti et al., 2013, p. 150).

possess high betweenness centrality scores (above 200) with a large gap to the rest of the actors, which means that they are brokers or links in the network and are therefore important for the stability of the whole network

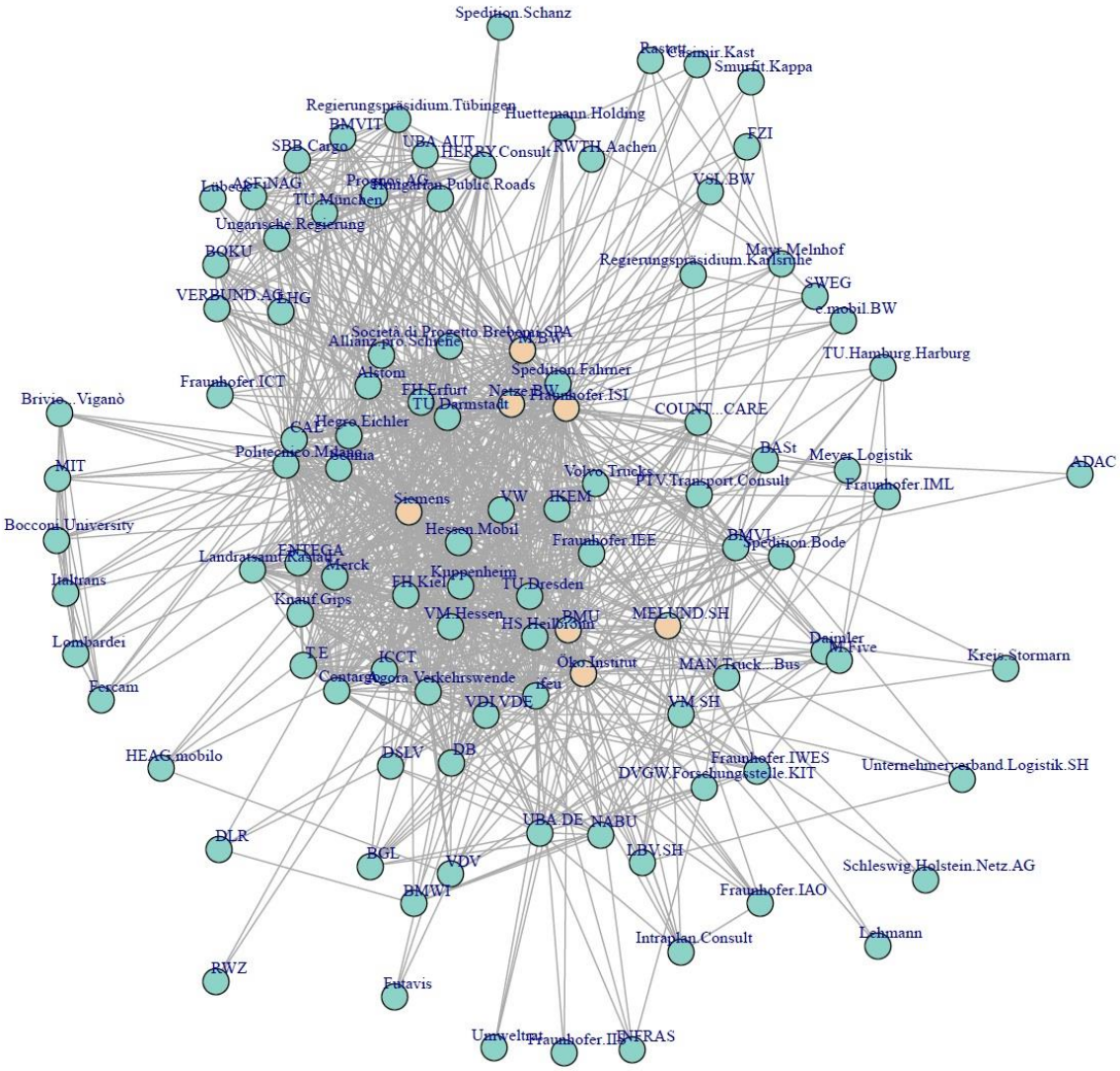

Figure 2: Actor network 2. Actors with the highest betweenness centrality are highlighted in orange.

The second network, shown in Figure 2, is visibly different from the first network. While a periphery of actors remains, its core is connected more strongly. The network has changed both regarding individual actors and regarding its overall characteristics. A group of Swedish actors was involved in a field trial from 2016 to 2017 on the highway E16, to test CHT as one type of ERS. The actors have since shifted their focus to try out other ERS, such as inductive solutions. They hence no longer appear in the new network. On the other hand, a growing internationalization within the EU is observable. Italian and Hungarian actors are planning trial projects and some French, Austrian, and a few Swiss actors have joined the discussion.

The number of actors in the network has increased to 114. The degree now ranges from 2 to 72. Additionally, the network has become denser (density score = 0.20). The increased density can be explained by the fact that actors identified as working in individual research projects in network 1, have since collaborated and communicated in new formats such as the more widely attended annual ERS Conferences, regular networking meetings between the German research projects on the field trials, and a workshop on CHT systems between interested actors of different countries. Seven actors now possess high betweenness centrality scores above 200 - with 5 out of 6 actors staying the same and one Swedish actor being replaced by two German actors in Baden-Württemberg (see Figure 2).

Discussion and bottlenecks

Overall, the network has become more connected and despite some actors leaving the network, it has grown in size. This indicates that the advocacy coalition, i.e. the group of actors supporting the technology, in the niche of CHT has managed to grow and become stronger. An important reason are the field trials in Germany, which have now all been started or are about to start. For this reason, players involved in the operation of the test tracks are now part of the network and the involved players have become more connected. For a full assessment of the actor landscape, this could be contrasted with activities in the diesel regime and in niches around other alternatives for heavy road freight. In the current situation, which is characterised by multiple technologies developing in parallel, the positions and connections of actors are crucial to find out which alternatives might succeed in the socio-political sphere.

Some first bottlenecks could be identified. Critical bottlenecks in a network are, for example, actors who have a bridging function between different parts of the network. The idea is that if these actors would no longer participate, other actors would lose their connection. While the overall core of network 2 is well connected and has increased density compared to network 1, a few actors with comparatively high betweenness centrality scores were identified, indicating a bridging function. For the ongoing analysis, it remains interesting whether the network is more or less connected when splitting it into different functions such as financing or infrastructure building. Here, few actors are currently involved in central positions, such as the Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) or Siemens. We therefore expect that in individual functions, bottlenecks occur more strongly and will examine this aspect further.

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Appendix A

Country	Germany	Sweden	France	Italy	Poland	Czech Republic	Netherlands	Belgium	Switzerland
News-paper	FAZ (Frankfurter Allgemeine Zeitung) Süddeutsche Zeitung Die Welt Handelsblatt Taz (Die Tageszeitung) Die Zeit Der Spiegel Bild	"Svenska Dagbladet" Göteborgs-Posten Dalarnas Nyheter Aftondablet	Le Monde L'Équipe Le Parisien Ouest France Le Figaro	la Repubblica Corriere della Serra Il Sole 24 Ore Il Messaggero	Fakt Gazeta Wyborcza Rzeczpospolita	Blesk Mladá fronta Dnes Právo	De Telegraaf AD De Volkskrant metro	De Standard De Morgen De Tjid La Libre Belgique	AZ Nordwestschweiz Tagesanzeiger Blick Neue Züricher Zeitung

Table A1: Examined newspapers (part one).

Country	Austria	Denmark
News-paper	Kronen Heute Österreich Kurier kleiner Zeitung	Jyllsanders-Posten Berlingske Politiken

Table A2: Examined newspapers (part two).

References

[1] Gustavsson, M. G. H.; Hacker, F.; Helms, H. (2019): *Overview of ERS concepts and complementary technologies.* Retrieved from ri.diva-portal.org/smash/get/diva2:1301679/FULLTEXT01.pdf

[2] Wietschel, M., Gnann, T., Kühn, A., Plötz, P., Moll, C., Speth, D., . . . Mader, S. (2017). *Machbarkeitsstudie zur Ermittlung der Potentiale des Hybrid-Oberleitungs-Lkw*. Retrieved from http://www.bmvi.de/SharedDocs/DE/Anlage/MKS/studie-potentiale-hybridoberleitungs-lkw.pdf?__blob=publicationFile

[3] Geels, F. W. (2011). The multi-level perspective on sustainability transitions: Responses to seven criticisms. Environmental Innovation and Societal Transitions, 1(1), 24–40. https://doi.org/10.1016/j.eist.2011.02.002

[4] Smith, A., & Raven, R. (2012). What is protective space? Reconsidering niches in transitions to sustainability. Research Policy, 41(6), 1025–1036. https://doi.org/10.1016/j.respol.2011.12.012

[5] Eurostat (2020). Road freight transport statistics. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php/Road_freight_transport_statistics

[6] Scherrer, Plötz, van Laerhoven (in press). Power from above? Assessing actor-related barriers to the implementation of trolley truck technology in Germany. Environmental Innovation and Societal Transitions.

Authors

Aline Scherrer studied Liberal Arts and Sciences (BA) with a Major in Governance at the University of Freiburg. In her Master studies of Sustainable Development (MSc) at Utrecht University in the Netherlands, she used a basis of environmental and climate governance topics to focus on theories of socio-technical transitions. Since October 2018, she is a research associate in the Competence Center Energy Technology and Energy Systems at the Fraunhofer Institute for Systems and Innovation Research ISI. Her work focusses on the acceptance of new energy technologies, social networks, and the interface between acceptance and innovation research.

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