[The "Current" Battle of the Currents: AC vs. DC – An Applied Lock-in- and System-Good Economics Approach]

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Overview

In this paper, we apply the approach of historical industrial network economics deployed by David (1985) on typewriter standards ("QWERTY-economics") to another, very topical field: The choice of standard electricity supply between alternating current (AC) and direct current (DC). The dynamics of the standardization pathway is even more complex than David's typewriter history (where once standardized, a technology that later turned out to be inefficient (the QWERTY keyboard) seems to prevail forever): After the invention of DC by Thomas Edison around the 1880s, and its rapid diffusion, AC networks have taken over in the period of late 1880s and following, driven by the ease of AC in transporting electricity over longer distances and the capacity of designing complex networks, thus leading to pervasive network effects (Hughes 1993). However, recently we observe a resurrection of DC-networks, sometimes called "mini-grids" or "swarm grids", that are used for the first state of electricity access in the global South, where over 1.5 bn. people still lack access to electricity; parallel to the DC grid, new DC appliances (such as refrigerators and welding machines) are developed in what is expected to become a booming market (Groh et al. 2014). We trace the long-term history of AC-DC electricity supply, then focus on the recent trends in DC, and finally offer some suggestions on the further development of this pathway-laden piece of historical, industrial network economics.

Concerning the recent, resurrected importance of the currents' contest, a lot of literature dealing with technological aspects were published recently. Technological requirements, advantages and disadvantages of both currents are some of the most popular topics of these papers, but it seems to lack of economic specification relating i. a. organizational models and further network economical classification. Since effective infrastructure policy necessarily depends on both technological and economic examinations, the core methods of this paper contribute a *system good* based analysis to the discussion with regards to network effect exploitation and lock-in effects.

Methods

The supply of an complex good consists of a broad range of services that are required for being capable of providing the respective good. Therefore, various services the good includes lead to the necessity of coordination between these segements. Electricity Supply as a complex system according to this definition, is subsequently considered as a system good. Figure 1 is based on the method of Beckers, Gizzi, and Jäkel (2012) and presents important elements and links with respective examples related to this paper's topic.

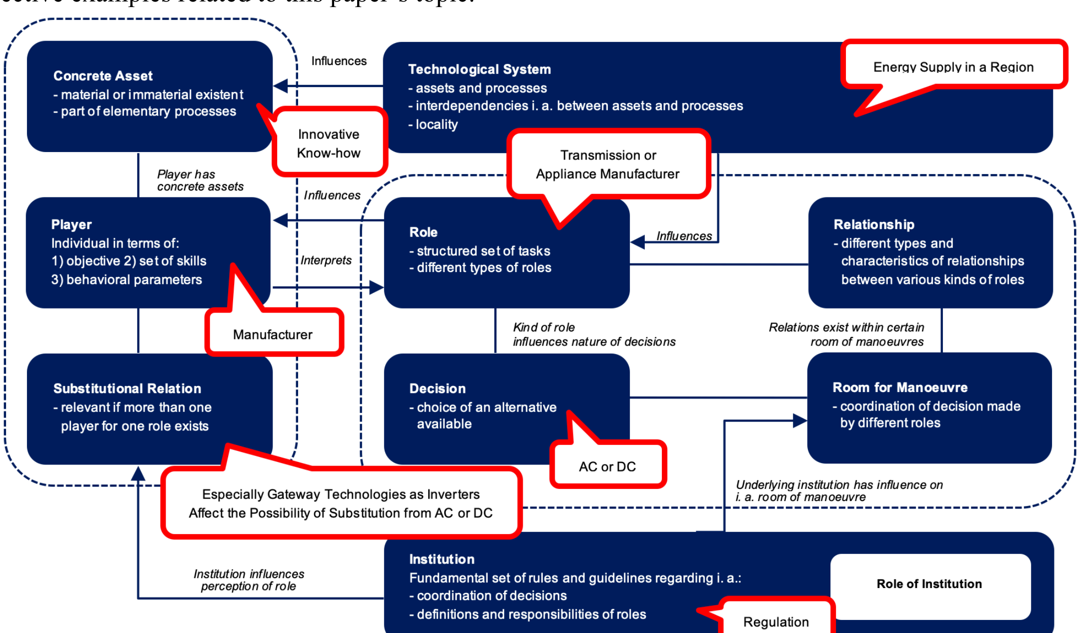

Figure 1: Elements of a System Good Based Analysis and Important Links (Based on: Beckers et al. (2012))

Lock-in as such means the direct and indirect advantageous effects of a certain good or technology, which prevents another good's or technology's progressing diffusion within a market. According to North (1990) following factors determine the "Grade of Lock-In": Technological dependancies, scale effects and irreversibility of investments. More specific, technological dependancies mean restricitions based on already installed technolgies while the other two factors should be familiar as common used terms. All parameters in the Figure 1 illustrating the energy supply as a system good, could benefit or suffer from lock-in effects.

Proceeding with the application of the preceding theorectical principles, it is necessary to design an organization model for being able to distinguish between different states with rating on the basis of especially transaction costs. Different states in this context mean a variation of elements in the model presented in Figure 1. The underlying methodolody of complex goods and subsequent definitions, of course, refer to both infrastructurally differentiated regions.

Preliminary results and conclusions

The value added of this work especially lies within the methodology, which provides an adapted approach with specific parameters that can and need to be observed from an "bird's-eye perspective" on the complex issue of AC/DC economics. Results of the complex system analysis identifies parameters and inferfaces, which have direct influence on the aggregated transaction costs if the currents used are varying. In case of non infrastructural constrained regions, grid operation and share of AC- and DC sockets in buildings are only two of a lot of these parameters in the organization model that definitely affect the amount of transaction costs incurred, due to significant differences concerning technological as well as architectural simplicity.

In addition to these advantages in the global north, in rather global southern areas as Sub-saharan Africa or Bangladesh, fixed costs for power inverters simply let the project implementation costs rise to a level, where the it becomes not feasible at all. Therefore, clear differences between the two currents can be located and a few constraints for the choice between the two are not hard to identify, once certain conditions of the observed system are classified. The examination if either supply, demand or both are the drivers of the "pro DC development", which could ultimately result in at least an equivalenve of the two currents, especially identifies the demand side as more propellent. Crucial for this finding is on the one hand the nonexistency of motivation based on the supply perspective, but way more important and as illustrated above is the perception, that the actual decisive constraints depend on the demand side (a lot of appliances are DC based anyway, transmission efficiency becomes more important, and fixed as well as transaction costs for countless conversions and inversions between AC and DC all over the system could be reduced too). Supporting that thesis is the clear preference of DC appliances in regions, where no lock-in and/or not already sufficient infrastructure exists and increasing potential of a rather DC based system especially in combination with residental solar-pv energy generation and storage devices as further literature like Vossos et al. (2017) suggests.

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