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Direct Current Grids in Urban Planning for More Sustainable Urban Energy and Mobility

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Abstract : The energy transition towards renewable energies and drastically reduced carbon dioxide emissions in Germany drives multiple sectors into a transformation process. Photovoltaic and on-shore wind power are predominantly feeding in the low and medium-voltage grids. The electricity grid is not laid out to allow an increasing feed-in of power in low and medium voltage grids. Electric mobility is currently in the run-up phase in Germany and still lacks a significant amount of charging stations. The additional power demand by e-mobility cannot be supplied by the existing electric grids in most cases. The future demands in heating and cooling of commercial and residential buildings are increasingly generated by heat-pumps. Yet the most important part in the energy transition is the storage of surplus energy generated by photovoltaic and wind power sources. Water electrolysis is one way to store surplus energy known as power-to-gas. With the vehicle-to-grid technology, the upcoming fleet of electric cars could be used as energy storage to stabilize the grid. All these processes use direct current (DC). The demand of bi-directional flow and higher efficiency in the future grids can be met by using DC. The Flexible Electrical Networks (FEN) research campus at RWTH Aachen investigates interdisciplinary about the advantages, opportunities, and limitations of DC grids. This paper investigates the impact of DC grids as a technological innovation on the urban form and urban life. Applying explorative scenario development, analyzation of mapped open data sources on grid networks and research-by-design as a conceptual design method, possible starting points for a transformation to DC medium voltage grids could be found. Several fields of action have emerged in which DC technology could become a catalyst for future urban development: energy transition in urban areas, e-mobility, and transformation of the network infrastructure. The investigation shows a significant potential to increase renewable energy production within cities with DC grids. The charging infrastructure for electric vehicles will predominantly be using DC in the future because fast and ultra fast charging can only be achieved with DC. Our research shows that e-mobility, combined with autonomous driving has the potential to change the urban space and urban logistics fundamentally. Furthermore, there are possible win-win-win solutions for the municipality, the grid operator and the inhabitants: replacing overhead transmission lines by underground DC cables to open up spaces in contested urban areas can lead to a positive example of how the energy transition can contribute to a more sustainable urban structure. The outlook makes clear that target grid planning and urban planning will increasingly need to be synchronized.

Keywords : direct current, e-mobility, energy transition, grid planning, renewable energy, urban planning
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