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Management Summary

„We can do everything – even 100%" (Janzing, 2011) is a manifestation to accept challenges of unrestrained and unsustainable handling of electricity in society. The manifestation demonstrates a terrestrial project, the energy turnaround, intending to re-design an entire industry on economic, political, and social levels. The transition was nudged by environmental pollution or nuclear accidents in Fukushima questioning sustainability of electricity networks. The growing public awareness of electricity production and consumption starts to modify the acceptance of climate damaging production units as nuclear or thermal power plants are increasingly in the spotlight of critics. Recent undertaken efforts like the last climate conference in Paris in 2015 are signals and reinforcements to reduce CO2 emissions or to abolish energy forms (i.e. nuclear exit). These efforts are not solely concessions on paper which show the example of economic disinvestments initiative in coal (Henn & Dubois, 2015), respectively announcement of Allianz (Esser, Hua, & Morawietz, 2015). Big challenges are ahead due to decades of neglected care and attention.

The challenges cause ramifications on existing electricity industry and current vivid discussions demonstrate the need for a vision of future network as well to perform transition to the next stage. For that purpose, stakeholders define the concept of a Smart Grid. In general, it describes a synchronised production and consumption of electricity through advanced metering and digital information and communication technologies. The concept plans a vast scope of actions and for example intends a reconfiguration of the macro level (Verbong & Geels, 2010). Leaving electricity industry pretty much unchanged, on a micro level – mainly demand side contribution – experiences a radical change and is important to achieve strategic objectives (BFE, 2013). Thereby, the major objective is the integration of the black box "consumption" to build a holistic and continuous value network. To this end, technical connection and information exchange are central topics for sustainability, reliability, and performance. Initial ideas tackle integration by introduction load management programs to peak, fill, or shift demand and balance with production capacities (Bellarmine, 2000). However, load management is a single aspect and further views must be added.

The addressed 100% refers to a total electricity production from renewables redefining the regional value creation. This requires more advanced concept of micro-grids and implies a re-decentralisation and promotion of on-site production. With cellular structuring, a profound integration is expected and simultaneously promotes dramatic implications in the low-voltage network. The result is a complex, interconnected, interactive, and adaptive network. An essential driver is a recognisable decentralisation trend supported by internal technological developments in the electricity sector, e.g. photovoltaic, and external influx of information and communication technologies (ICT). The latter one introduces new possibilities of value creation but also implicate different mind-sets for innovation. Furthermore, value capturing opportunities expands to other participants e.g. communities (Nürnberger, 2015). Such novel factors implicate a commotion in the current electricity system causing a transition pathway of de- and re-align the supply chain (Verbong & Geels, 2010); thereby the de-alignment expresses the disengagement of traditional concepts and mind-sets. This kind of socio-technological transition is a continuously incremental approach rather an upfront planned schedule. In the emerging uncertainty, struggles for power is common and influence transition as stakeholders act in favour of own interests. An authoritative part has the

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suppliers' and distributors' side (later called also called electricity provider or only provider) defending their existing revenue stream of selling quantity. The opposing attitude of providers to the Smart Grid concept brings controversial contributes to discussions. Providers accelerate load management objectives to reduce electricity waste keeping influence of demand side under control. Simultaneously, an improved consumption behaviour cuts of lucrative stream and would throttle own profit. The willingness of profound alterations from provider side must be questioned.

Consequentially, present disputes are predetermined and lack on a sufficient consideration of future consumer role and accompanied duties and rights. The technological decentralisation entails that consumer strengthen their position in the value network by investments in production and storage equipment. By becoming a prosumer, temporary independency diminishes claims from the overall grid (Teufel & Teufel, 2014). Such an individual independency is greatly feared, but will undoubtedly occur. It would also be folly to state that there will be at one side independent individuals and at the other side the overall grid. It is likely that centralised and decentralised elements exist and incorporate for a sustainable network. Nevertheless, the appearance of prosumers permanently modifies the network and especially value creation because of a different behaviour contrary to business driven counterparts. New relationships and decision making patterns emerge and sharing of electricity and information reshape traditional constructs. Meanwhile, the dominance of intangibles, e.g. knowledge or internal structure, modifies value creation and stakeholders depend upon the connectivity to and among demand side. Thus, research from a prosumer perspective is highly recommendable.

For that reason, this dissertation elaborates on the new research field of Crowd Energy (Teufel & Teufel, 2014). Crowd Energy takes the micro-grid concept further and investigates upon so called intelligent generation-storage-load cells (iGSL) (Teufel & Teufel, 2014). These three cell functionalities provide a range for actions in regard to produce electricity surpluses and hence to sustain own demand or support neighbouring cells through delivering electricity. By pooling functionalities of several houses, collective effort creates a virtual crowd. This provides several advantages. First, a crowd approach improves resource allocation between surplus and shortage locations but also allocation through time. Furthermore, the local to local principle shortens the transportation distance and hence the losses for transformation. Secondly, the local flexibility of exchange provides reliability for the overall grid. In case of black outs, crowds can preserve availability through self-produced electricity. Additionally, crowd resources can provide storage space to balance load. These arguments proclaim an advanced technical, automated integration similar to the crowd sourcing methods but extend these approaches by including social related subjects. A last advantage of Crowd Energy is the consideration of human behaviour to influence cell functionalities and consequential the dynamics of a crowd. Subjects like sharing behaviour, decision making patterns or trust and commitments, are decisive for creating and maintaining crowd structures as well for completing successful demand side integration.

The bottom up approach of a Crowd Energy is a new research field and requires investigations to answer basic questions. A major area is designing the future electricity value network under a Crowd Energy paradigm. Important points are of peculiar interest: role description of prosumers, position in the value network, types of relationships and value creation through prosumers respectively crowds. Latter point contains several significances

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due to value creation through tangible and non-tangible assets and hence related quality of outcomes. Another question is potential outcome of crowds in terms of electricity production. There are several simulations of micro-grid contributions, mostly in the light of top-down views (Baños et al., 2011), but the crowd-based concept focuses on optimal exchange among members. So, the potential of exchange considers minimisation of transportation and is an indicator for independency of the crowd in the value network.

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