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A novel concept for a renewable network within municipal energy systems

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ABSTRACT

Renewable energy sources are amongst the more widely acceptable options for the future transformations of existing energy systems. The complexities of such transformations call for various comprehensive preparatory actions. Amongst them, the organisation of a multifaceted renewable value-chain into a renewable network may well be crucial for the successful utilisation of renewable energy sources in the future. This paper proposes a novel concept for renewable network covering entire renewable value chain with division on supply, demand and technology sections. In the past, each section has been addressed separately. The organisation of renewable network covering all sections is deemed to be vital for accomplishing the optimal distribution and deployment of renewable energy sources. Constant technological advancements within the renewable sector indicate the significance of a technology section within a renewable network. The appropriate arrangement of various stakeholders involved throughout the entire value-chain, which includes all sections of a renewable network, is therefore crucial for the further development of a renewable sector. The proposed concept of a renewable network would support the effective operation of a renewable value-chain within a municipality through the establishment of local virtual energy cooperatives aimed at fulfilling energy needs and supporting the development of the community. The applicability of the proposed concept is demonstrated through the development of a biomass network within the municipality of Cirkulane, Slovenia.

1. Introduction

State-of-the-art energy systems rely to a large extent on fossil fuels and are therefore amongst the major contributors to greenhouse gas emissions. Renewable energy sources (RES) could contribute both towards the reduction of greenhouse gas emissions and to any progress towards the sustainability of future energy systems [1–4]. The share of RES reached 16.7% of the global total energy consumption in 2010 [5].

Further increase in the RES share regarding final energy consumption requires significant transformations of the existing energy systems. Decentralisation of energy systems, for example, could decrease dependence on foreign suppliers and contribute to better integration of local energy resources [6,7]. Municipalities, for instance, could follow ambitious objectives towards implementing entirely renewable and self-sufficient energy supplies. This is pertinent particularly for those rural municipalities with substantial RES potentials due to abundant natural resources.

Various energy models based entirely on renewable resources are reported in the literature [8–11]. Also, several analyses supporting the integration of RES in the energy systems [12–17], methodologies for RES deployment [18] and studies of electrical smart grid [19–23] may be found. Nevertheless, significant problems have been reported regarding the deployment of RES. The more serious problems include the integration of RES within existing energy systems and the provision of sufficient storage systems. Various studies have been conducted regarding this field [24–27].

Successful integration of RES within existing energy systems requires the consideration of various aspects. The renewable network (RES network) covers the supply, demand, and technology sections. In the past, the main focus was on advances in the supply section [28–32]. The demand sections' management has also been analysed in some studies [33,34], whilst the technology section has been discussed in certain papers [35–39]. However, the importance of the technology section may have been underestimated in the

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past. The main resources of complexity regarding RES networks seem to have been within the technology section. This may be to some extent attributed to the fact that the technological solutions to the traditional energy systems are in the mature deployment phase and are typically operated by economically and technologically mature and centralised utility companies. On the other hand, those technologies utilising renewables are continually evolving as even more innovative technologies become available. These rather complex technologies are expected to be operated within less centralised and technologically aware environments. Advantages beyond the simple return of investment may therefore be pursued within the RES networks. Nevertheless, a lack of overall renewable value-chain (RES value-chain) organisation is noticeable regarding the supply, demand, and technology sections.

A novel concept of RES network to be commenced within a municipal energy system is proposed in the paper. The concept of this RES network covers the complete value-chain that is assumed to include the supply, demand, and technology sections. One of the major goals of the proposed concept is to accelerate the integration of RES throughout existing and future municipal energy systems. Additional goals include more efficient usage of energy, more optimal functioning of energy systems, utilisation of local resources, enhanced self-sufficiency, and last but not least, connecting all the related stakeholders. Various parameters within specific documents and studies have to be considered in order to achieve this. These documents, amongst others, include feasibility studies of different RES, energy audits, local energy concepts (LEC), and spatial plans. Virtual energy cooperatives are proposed as newly-developed forms for implementing intelligent energy management systems. The proposed concept has been implemented as a biomass network within the municipality of Cirkulane, Slovenia, and confirms the applicability of the proposed novel RES network.

2. Concept of the RES network

An important role of the RES network is to provide strategic guidance towards the optimal organisation and functioning of all important stakeholders in the RES value-chain. Stakeholders are defined in the supply section as different suppliers, in the demand section as various end-users, and in the technology section as decision makers and other technology experts. Also, some other external organisations such as advisory service companies, public entities, universities, and other agencies could also be associated. A RES network may be grouped into the supply, demand, and technology sections, as discussed below. The proposed RES network concept offers appropriate organisation of each section, with the major emphasis being on a swiftly evolving technology section.

2.1. Supply section

Organisation of the supply section needs to be comprised of a database containing the present energy consumption, RES potentials, identification of potential RES suppliers, and the formation of special suppliers' groups. The main objective is to provide optimal organisation of the supply section in order to achieve effective functioning.

Planning the appropriate supply section corresponds to the requirements of the demand section. Therefore, the initial step is to recognise and analyse the present energy consumption. The local RES potentials are then defined on completion of the feasibility studies. The focus should lie on RES local resources' integration. Identification of the related RES suppliers and any connections between them is crucial for establishing an organisational supply infrastructure. In regard to this, the relationships amongst suppliers have to be defined, together with their roles within the RES network. The forming of specific suppliers' groups such as farmers, foresters, and utility companies, could provide a more efficient operation of the supply section.

The supply section should operate in unison with the demand section. Specific renewable options are more appropriate for certain groups of end-users than others. For instance, industrial demands and consumption patterns differ from those of households, as also do decisions based on distinguishing between proper renewable resources according to their availability, technical potentials, and even economic aspects. Specific parameters for energy supply have to be identified for different end-users, whilst accounting for end-user consumption patterns, demand requirements, and the availability of RES.

2.2. Technology section

The technology section demands for the constitution of a database covering available technologies for RES deployment. It is important for municipal energy systems that the constitutors become familiar with all the technologies. Only in this manner can they depict the most suitable solutions for particular RES installations. The main objective is to support decision-makers by providing knowledge of available renewable technologies for deciding upon optimal options. Therefore, technical and knowledge support from external experts is highly recommended. In addition, analyses of technology platforms, technology roadmaps are encouraged in order to provide connections to a variety of RES networks and clusters [40,41]. Distinctions between technologies should be stressed, plus the corresponding infrastructures for RES deployment. Both these things have to be considered during the decision-making process, as one cannot function without the other. During the decision-making process those technologies within 'research phases' also need to be considered, as renewable technologies are constantly evolving. Installation times differ according to the decision-making periods. After all, there are long-term investments on the horizon and cutting-edge technologies should be supported as implemented novelties. On the other hand, the economic aspect also has to be considered when making appropriate decisions for specific technologies. In practice, assessments of the various technological options have to be performed in order to find the optimal solutions.

2.3. Demand section

The main objective of the demand section is to form certain end-users' groups in accordance with their consumption patterns, and accelerate the deployment of RES. End-users have different consumption patterns regarding their requirements and preferences. Preparing action programmes targeted at specific end-users would be more successful in comparison with more generally orientated ones.

Firstly, the present energy consumption has to be analysed, together with proposals for decreasing energy consumption. In the LECs of municipalities and energy audits of different buildings are obtained information regarding end-users, energy consumption and possibilities for lowering energy consumption. Connections between all sections should be established in regard to some interrelated functions such as energy consumption analysis. Some energy needs are already being satisfied using existing renewable energy solutions. This proposed further step correlates with depicting the proper structures regarding renewable sources for certain groups of end-users, whilst considering technical limitations.

Division into certain end-users' groups with similar energy consumption patterns is proposed to obtain optimal functioning of the demand-side. Energy consumption patterns depend on the