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ScienceDirect

Procedia Manufacturing 8 (2017) 270 – 277

Procedia MANUFACTURING

14th Global Conference on Sustainable Manufacturing, GCSM 3-5 October 2016, Stellenbosch, South Africa

Demand side management within industry: A case study for sustainable business models

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Abstract

The transition of the German energy market is primarily based on RES. The main problem of RES like photovoltaic and wind power is volatile availability. This issue can be mitigated through enhanced flexibility of the demand. DSM can be an additional mechanism in smart grids. Energy intensive industry offers a high DSM potential that could be useful to the energy sector. New business models are required that combine economic viability with environmental and social benefits for various stakeholders operating in the energy sector and manufacturing industry. This research analyses opportunities for business model innovation through DSM in industry. The study presents two case studies in which the Value Mapping Tool was applied to identify failed value exchanges with respective stakeholders and DSM. The research proposes a new business model aligned with sustainable development principles that can help the industry to mitigate volatile energy availability in an economically sensible manner.

Peer-review under responsibility of the organizing committee of the 14th Global Conference on Sustainable Manufacturing

Keywords: Sustainable business models; Demand side management; Sustainable Manufacturing; Value mapping tool

1. Introduction

The energy consumption has a significant environmental impact and is a major reason for the increasing emissions of greenhouse gases (GHG). According to the IPCC, fossil fuel combustion and industrial processes contributed to about 78 % of the global CO_2 emission increase between 2000 – 2010 [1]. In Germany the energy sector and the

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Peer-review under responsibility of the organizing committee of the 14th Global Conference on Sustainable Manufacturing
doi:10.1016/j.promfg.2017.02.034

manufacturing industry caused 62 % of the total GHG emissions in 2014 [2]. As a result from the Kyoto Protocol agreements and the more recent nuclear incidents in Japan, Germany's energy market is transitioning towards a sustainable and climate-neutral system [3]. This transition aims to achieve a stepwise reduction in GHG emissions of 95 % by 2050 [4]. The goals include the reinforcement of renewable energy systems (RES) on gross electricity consumption from 50 % in 2030 to 80 % until 2050 as well as increasing energy efficiency [4]. The latter is measured by amount of reduction in primary energy and electricity demand additionally to the raise of energy productivity and combined heat and power (CHP) generation.

Changing the energy market is challenging, not only in terms of the regulations and operational processes, but also in regards to the structure of assets. The geographic characteristics of Germany create a "North-South" divide caused by the distance between the main location of the off-shore WP plants and the industrial centres [5]. Moreover, smaller PV and WP generation units are often deployed on the country side.

The urgency to replace and to reduce dependency on fossil fuels demands the prioritisation of integration of RES into the public energy grid [6]. However, the volatile availability becomes a driving factor for the increasing fluctuation of residual load in the grid affecting transmission and distribution grids. According to the legal regulations, the transmission grid operators in Germany are responsible for the ancillary services and especially for the frequency control [7]. The procurement of necessary capacities is realised by operating a balancing energy market [7]. The distribution grid operators monitor the voltage [7]. In case of an unbalance between demand and generation, the equalisation occurs with other local grids or aggregates at the upstream grid levels.

The conventional solution approach to these issues is grid expansion. However, in a smart grid decentralisation cannot only be focused on the generation side of the system. For a holistic approach of sustainable energy market a "smart customer" is also necessary. Demand Side Management (DSM) can be an additional important mechanism to pointedly use flexibility of the energy demand. Consequently, the transition of the energy market is linked to the technological developments as well as to reassignment of roles to the actors in the market. Furthermore, it establishes opportunities for new sustainable business models (BMs).

This research aims to show the opportunities of innovation concerning more sustainable BMs in the energy market. It uses two companies as case studies, a mid-sized polymer processing manufacturer and a distribution grid operator, both located in the state Hesse in Germany. The application of the Value Mapping Tool (VMT) [8] gives support to the evaluation of failed value exchanges between the analysed company and its stakeholders. This leads to identification of innovation opportunities towards more sustainable BMs. By applying this tool to both companies with focus on energy supply and demand dynamics, opportunity for a new BM is derived and discussed.

2. Literature background and theoretical context

In the following, the two main concepts used in this research are presented, bringing the main aspects regarding DSM and sustainable BMs in the energy sector. The DSM approach has its roots in the research of Gellings, who classified theoretically the measures for a strategic influence of the power load profile of electric utilities [9]. Currently, the raising energy costs are the main factor driving the industry to change the consumption behaviour. In Germany the annual peak load is a base parameter for billing grid usage expenses. In operating peak-load monitoring systems DSM is often used to smooth the load profile and is a part of internal energy efficiency strategies.

Due to the fluctuating energy generation driven by WP and PV plants, DSM can be also used as a measure for the grid operator to equalize the load profile of the grid. In case of over-generation with purpose of a secure supply the extreme situation could require a disconnection of the RES from the grid. To avoid this, the consumption can be increased as a negative DSM capacity. The opposite is the positive capacity, which implicates that the demand can be reduced or the electric power generation could be increased. In a scenario in which energy systems shift towards sustainability, the usage of RES generated electricity should be raised. Hence, the demand side should be managed. For this reason the focus of the present research is on the measures at the consumer´s side.

2.1. DSM potential within industry

Electric steel, metal and chemical processing as well as wood, paper and cement industries are sectors characterised by energy intensive processes with a potential for DSM of multiple hundred megawatts. In addition, the cross-sectional technologies for air conditioning, cooling and compressed air supply indicate a significant potential across all