REGIONALLY DIFFERENTIATED PHOTOVOLTAIC FEED- IN TARIFFS IN SUPPORT OF A COST OPTIMAL SYSTEM INTEGRATION- CASE STUDY FOR AUSTRIA

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(1) Overview

According to the IPCC "Special Report on Renewable Energy Sources and Climate Change Mitigation" the consumption of fossil fuels causes the majority of greenhouse gas emissions; thus the most severe impacts of climate change can be avoided by a transformation of the energy system (IPCC, 2011) from being carbon intensive and low-efficient to being carbon constrained and highly efficient (Huberty and Zysman, 2010). Several countries or regions have targets on renewable energies and emissions. One example is the European Union with the Renewable Energy Directive (Directive 2009/28/EC, 2009), which sets the target to increase the share of renewable energy in the gross final energy consumption from 8.5% in 2005 to 20% in 2020. In its Energy Roadmap 2050, the European Commission explores scenarios achieving at least a share of 55% of renewable energy in the gross final energy consumption (European Commission, 2011). In the European Strategic Energy Technology Plan (SET-Plan) the European Commission states that photovoltaic energy (PV) is one of the key technologies to meet the 2020 targets (European Commission, 2007). According to the European Photovoltaic Industry Association, in the European Union the photovoltaic systems could supply up to 12% of the electricity until 2020 (EPIA, 2011).

The large scale deployment of distributed renewable energy systems such as rooftop photovoltaic systems has effects on the distribution grid. Depending on the amount of PV installed in the distribution grid, the supply load profile, the load profile of the demand, the current electricity infrastructure, system upgrades are required for power to flow from the distribution feeder back to the transmission system (Paatero and Lund, 2007; Liu and Bebic, 2008) and voltage rise needs to be taken care of (Widén et al., 2009).

In the Austrian Energy Strategy, it is stated that the largest potential of a large scale photovoltaic deployment lies in building integration (Federal Ministry of Economy, Family and Youth and Ministry of Life, 2010). Austria, until 2009 had 53 MW of installed photovoltaic energy systems, in 2010 it increased to 154MW and 317MW in 2011\ (Eurostat, 2013). In 2013, the feed- in tariffs allocated for PV amount to 8Million € in total, varying between 16.59 €Cents for freestanding and 18.12 €Cents for building integrated and rooftop photovoltaic systems. Next to the feed- in tariffs there is a 30% investment subsidy of maximum 200€ per kW. Additionally, there are 18Million € in feed- in tariffs available distributed between photovoltaic energy, wind energy and small hydropower plants (Federal Ministry of Economy, Family and Youth, 2012).

Feed- in tariffs have recently had a big impact in increasing renewable electricity deployment. The additional fee is usually included in the network tariff (European Commission, 2008). Feed-in tariffs are generally the same over the country; they can differ by installation size but do not consider location specific differences. There are areas where a large scale integration of PV causes more problems than in others. In this paper we assess the if there are benefits in economically incentivizing photovoltaic deployment in areas where it does not pose negative impacts on the electricity system. We study the extent to which regional feed in tariffs can allow reaching the same deployment effects with lower overall costs. As the general public is paying for the feed- in tariffs, reaching the targets in a cost- optimal way is highly relevant and we feel that there is a gap in the literature exploring this option.

(2) Methods

To estimate spatially explicit load-profiles, we use a pool of 800 measured household load profiles from April 2010 to April 2011 with a time resolution of 15 minutes (Energieinstitut Linz et al., 2012) . For each grid cell of one km^2, the load-profiles are combined with data on the number and type of households (Statistik Austria, 2012) and the number of employees (Statistik Austria, 2001). We divide the pool of households load profiles into building types. We bootstrap from the household load profiles pools depending on the composition of the grid cell. As we do not have measured commercial load profiles we construct residual load profiles with the pool of measured household load profiles assuming that the residuals behave similarly. We use a standardized load profile for commercial consumers

(Bundesverband der Energie- und Wasserwirtschaft e.V, 2000) which is available for three days and seasons and bootstrap from the residual load profiles depending on the composition of the grid cell. We aggregate the household and commercial loads in each grid cell. This determines the total load per grid cell over one year. We use hourly data on solar PV output per km^2 and kWp installed for the same year (Huld et al., 2008). We assume that each single family household installs 1kWp on the roof, in total this amounts 1762 MWp, representing around 12% of the capacity in Austria in 2010 (e- control, 2011). Aggregating the demand load profiles with the PV load profiles per grid cell gives us the net demand load profiles, showing the reverse load flows per 15 minutes. We use the mean deepest function (López-Pintado and Romo, 2009) to analyze the statistical significance of the results in the single grid cells. We then divide the grid cells into five groups with no to high system impacts which would result from a large scale PV deployment. In a next step we study how to best allocate the budget dedicated to feed- tariffs and investment subsidies in order to give priority to areas where the system integration is feasible at least costs. For this we use the JRC EU TIMES technology optimization energy system model to find the optimal PV- feed in tariffs to allocate the PV deployment in the most cost- effective locations for the energy system. In JRC EU TIMES we model several scenarios for the energy system of Austria from 2005 until 2020 reflecting different allocation of the feed-in tariffs and subsidies overall budget across regions. We use the JRC EU TIMES model to estimate the system costs differences between these different regional budget allocation and conclude on the advantages (or not) of considering regionally differentiated feed-in tariff schemes.

(3) Results

As there is no PV production during the night we analyze the results between 5am and 7pm. Over all, demand in the grid cells exceeds supply on average in 9% of the hours; however, the variation between grid cells is high and lies between 0% to 60%. If only the load generated by households, i.e. excluding companies, is considered, we observe reverse load flows on average in 23% of the hours. Fig.1 shows the percentage of grid cells with a reverse load per month and hour. The overproduction is highest in July peaking at 9am and lowest in December. Figure 2 shows the mean commercial demand load profile, the mean household demand load profile and the mean photovoltaic production over all days and grid cells per hour. Over the entire year the demand load profiles exceed the PV production, and the commercial load profile is the highest, except for the evening. This proves the importance of spatially explicit analysis: the differences between regions are considerable using mean values for an entire country can generate misleading conclusion.

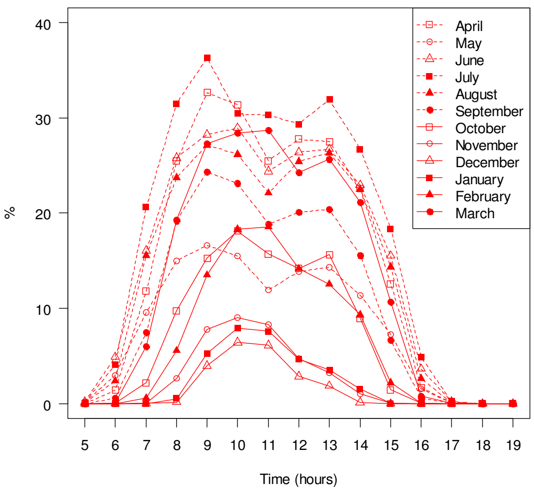

Fig. 1: Percentage of Grid Cells showing Reverse Flows

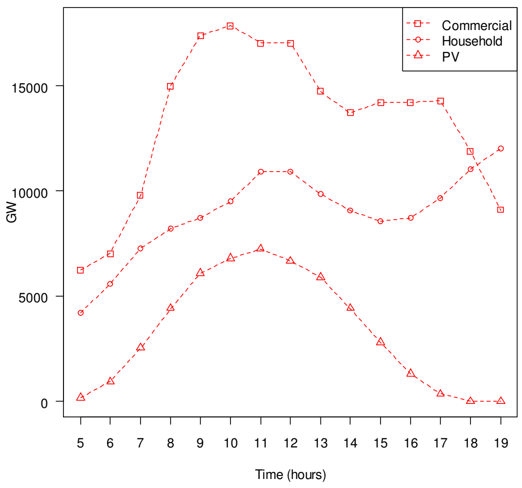

Fig. 2: Mean hourly values of the commercial, households and PV load profiles

Expected results from integrating the data into the JRC EU TIMES energy system model are the optimal region specific feed- in tariffs minimizing system costs for 2020 and impacts in the remaining Austrian energy system.

(4) Conclusions

The methodology allows modeling the spatial and temporal distribution of reverse flows by taking into consideration the location specific consumer composition. We show that when only modeling load profiles of households, the amount of decentralized PV which can be integrated without causing problems on the system may be underestimated. In grid cells which contain a low share of single houses and high share of commercial units, the commercial consumption absorbs the photovoltaic electricity. Our results demonstrate that there are significant location specific system integration differences. From the results of the JRC EU TIMES energy system model we will be able to explore the possibility of regional feed- in tariffs to give priority to decentralized PV development in areas where system integration does not pose problems. We will assess if regional feed- in tariffs can allow reaching the same deployment effects with lower overall costs.

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