Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 99 (2016) 411 – 417

Energy Procedia

10th International Renewable Energy Storage Conference, IRES 2016, 15-17 March 2016, Düsseldorf, Germany

Power-To-Gas Concept for Integration of Increased Photovoltaic Generation into the Distribution

Chan Park*, Felix Bigler, Petr Korba

Zurich University of Applied Sciences, Winterthur, Switzerland

Abstract

According to the Energy Strategy 2050 set forth by the Swiss federal government, Photovoltaic (PV) energy shall make up one fifth of the nation's total energy production in 2050. Such a drastic expansion rate of PV and the resulting excess energy thereof can lead to so-called reverse power flow in the low voltage (LV) grid as demonstrated in previous studies. Power-to-Gas (PtG) represents a suitable storage solution to resolve the situation by absorbing the excess PV energy. This paper presents a qualitative and quantitative feasibility analysis of the PtG technology in the future Swiss LV grid. For this purpose, PtG is integrated in simulation into the grid for absorbing the excess PV energy while producing hydrogen. This hydrogen is assumed to be sold in the mobility sector. Three different operational scenarios are established with respect to the input energy source to the PtG plant, including the excess PV energy, curtailed PV excess energy and PV excess energy plus the energy from the grid. Summing up the results, it can be concluded that the PtG plant is still far from economically viable even though significant improvement can be accomplished to the hydrogen production costs by adopting the active PV curtailment and by purchasing additional energy from the grid. The future study to be undertaken by the authors, with respect to economical viability of the PtG, will include other sources of value, including production of methane as main product, production of oxygen and heat as by-products, and provision of services such as biogas upgrading, frequency regulation and voltage.

Peer-review under responsibility of EUROSOLAR - The European Association for Renewable Energy

Keywords: Power-to-Gas; Renewable energy; Distribution grid; Excess energy; Energy storage; Gas grid

1. Introduction

After the disaster of the nuclear power plant in Fukushima, Japan, in 2011, the Swiss federal government decided

* Corresponding author. Tel.: +41-58-934-4609;
E-mail address: park@zhaw.ch

Peer-review under responsibility of EUROSOLAR - The European Association for Renewable Energy
doi:10.1016/j.egypro.2016.10.131

to abandon the nuclear energy, which currently amounts to about 35% of the total electricity supply of the nation. According to the Energy Strategy 2050 subsequently set forth by the Swiss federal government, the deficit in the production of electricity as a result of this decision and other sweeping changes in the international energy arena will lead to major changes in the Swiss energy system. In order to fill the gap in electricity production after the phase-out of the nuclear energy, renewable energy sources (RES) represent the only possibility for Switzerland to produce self-reliant and CO2-emission free energy. With a share of 20% of the entire electric energy consumption, which equals 11 TWhel, Photovoltaic (PV) energy shall make up a fifth of Switzerland energy production [1].

As demonstrated in the already implanted systems around the world, PV represents a fluctuating energy source due to its innate dependency on diurnal, seasonal, and meteorological variations. These characteristics are anticipated to cause significant challenges to the existing electricity network. A previous study [2] was performed to illustrate the impact of the increased PV production in the low voltage (LV) grid in in a Zürich area by simulating the load flow through Powerfactory from DIgSILENT. The characteristics of the urban area are depicted in Table 1.

Table 1 Characteristics of the urban area

Description	Value
Maximum active power load	0.675 MW
Yearly load energy consumption	2.95 GWh
Maximum PV power	2.096 MWp
Yearly PV energy production	2.453 GWh

The result of the load flow analysis of the study is illustrated in Figure 1, in which the reverse power flow is anticipated beyond the maximum 630 kVA, causing problems characterized as voltage violation, line and transformer overloading, and N-1 violation.

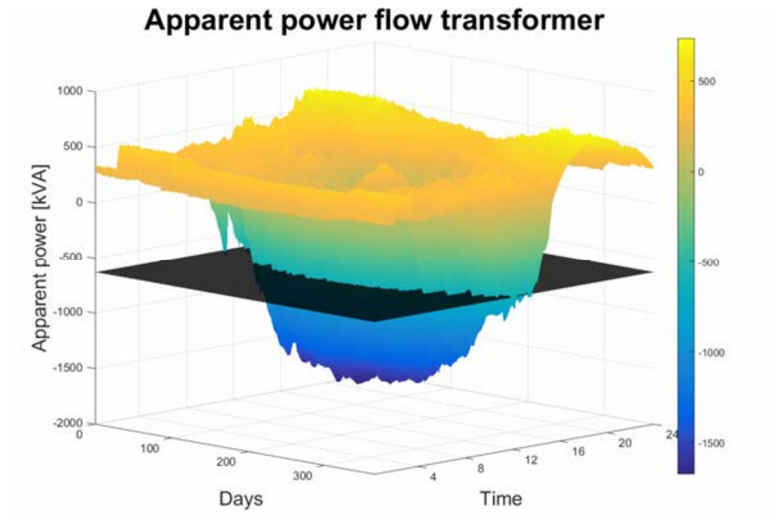

Figure 1. 3-dimensional plot of a transformer power flow of the case under consideration. For the z axis values, the area below the black plane indicates the reverse power flow, which occurs when the energy flows form the LV level to the MV level through the transformer

In order to prevent the existing electricity network form such violations, energy storage systems (ESS) will play an important role in the future. To operate the transformers in a safe range, for example, the previous study [2] indicated that a Battery Energy Storage System (BESS) is required to have a nominal power of 1.004 MW and a nominal capacity of 6.457 MWh. However, the size of the BESS seems unrealistic to implement, considering the