Combining flexible biogas and a PV system to answer fluctuating load demand through a Virtual Power Plant

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Introduction

During some recent years, flexibility and reliability to control either electrical load or generated power has been considered as a solution to match electrical load demand and generated power. However, sometimes intermittent renewable energy sources such as PV or wind power plant cannot meet this requirement alone. Generated power from PV power plant, changes during a day, is not preferable to cover basic load. Battery storage then is used as an energy buffer and a complementary component which maintains power availability from PV power plant to cover load when the solar radiation is not available (Freris, L.; Infield, D. (2008), Farret, F. A.; Simões, M. G. (2006)). But, there is still a gap when battery storage and PV power could not cover specific conditions of fluctuating load such as at short time of peak period. The recent development of biogas power plant has enabled biogas to generate flexible gas based on certain controls and conditions. This flexibility gives a chance to answer residual load from PV or wind power plant (Iberdrola, J.; EDF, J. (2009)).

Apart from that, the combination of intermittent energy sources and flexible energy generation, however creates a new concern on the operational of the electricity system. Thus, power management is required in order to manage the energy exchange of the components as well as optimization tool to find techno/eco/environmentally optimum configuration. Last but not least, the implementation of advanced Information Communication Technology (ICT) is also taking part on this issue. This ICT implementation is recently called as Virtual Power Plant (VPP). Within a VPP, all stakeholders (consumer, producer, prosumer, system operator, etc) are able to control load demand or generated power and to adapt some changing like price of the electricity (EI Bakari, K.; Myrzik, J. M.A.; Kling, W. L. (2009)). Implementation of power management of a VPP is unique and depends on services that would be provided by a VPP such as to enable active participation of VPP stakeholders in the electricity market (You, S. (2010)).

This project is mainly focused to find the technical possibility and constraints/limitations of combined flexible biogas power plant and PV power plant to cover fluctuating load demand through a virtual power plant. The experimental part of this research is approached in three parts. The first part is hardware development including flexible biogas, battery storage, and VPP infrastructure. The second part is software development including control for biogas and battery system, optimization tools and user interface of VPP. The third part is testing and optimizing VPP performance in several scenarios in order to find the limitations of this combined power plant.

PV-system and load demand of Aschaffenburg

An installed PV-system to answer load demand of Aschaffenburg (Bayern-Germany) is used. The percentage of PV power compared to load demand is to be found about only 1 %. Forecasting of produced PV power and load is conducted as part of VPP.

Battery storage system

The battery capacity of minimum 1 kWh is chosen to represent contribution of energy storage in a VPP. Forecasted power availability of battery is built based on data from power received and delivered by battery over a specific time frame.

Flexible biogas power plant

Development of flexible biogas in this research is based on adaptation of controllable biogas (Ganagin, W.; Loewe, K.; Loewen, A.; Wallmann, R. (2011)).

Control algorithm and forecasted biogas production model are built with considering Anaerobic Digestion (AD) state and residual load. These components are then applied to Programmable Logic Controller (PLC) S7-1200. Gas analyzer, gas bags, and data logger are installed to monitor and store biogas parameters e.g. CH_4 concentration.

VPP design

Design of VPP consist of three groups, which are: ICT, energy generation and energy storage. Power management of VPP, monitor-control process of VPP and forecast models are parts of ICT group. While, generation group consists of power plants from intermittent sources (PV) and flexible energy sources (flexible biogas). Battery is used as an energy storage of VPP.

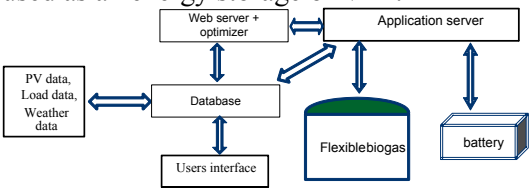

figure 1. Simplified VPP design

Tools and techniques applied

Some techniques and tools applied for this projects are:

- server-client communication
- artificial intelligent e.g. Fuzzy logic and Artificial Neural Network
- PLC S7-1200 ,SCADA, and data logger
- gas analyzer and optimization tool
- development software for control and user interface e.g. Java Script, TIA portal Step 7 and OPC server.

Expected outcome

Finding in the first year of this project is that by calculation using an optimization tool, combining flexible biogas and a PV system is technically able to follow fluctuating load demand. The next step is to check the hardware ability of flexible biogas and a PV system to follow load based on the calculation which is previously done. Another expected result is finding the limitations of power plants of this combination system on a VPP.

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