Energy on the Roof

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Abstract: At Budapest Tech an Energy Park (EP) developed for the real investigation and education of the REN and DG techniques. The park contains wind turbine, fuel cell, photovoltaic panels and heat collectors too. Beyond the investigation of the individual characteristics also different microgrid structures can be developed. The most promising formation is the virtual microgrid.

Keywords: Renewable energy, demonstration energy park, microgrids

1 Introduction

1.1 Scientific and Technological Objectives

Although EU directive for increasing the REN share in the portfolio have existed for long time, the practical application is retained in the countries having poor REN resource and poor REN culture.

The power Engineering Department of Budapest Tech, Faculty of Electrical Engineering is highly involved in the dissemination of the REN and DG culture, in the region that is why a project has been started with the following objectives:

1 Setting up a laboratory test environment for the REN/DG tools where the students can physically investigate the characteristics of these units.

2 Disseminate project findings in educational institutions. The future generation of power engineers should have sufficient knowledge on RE applications. In order to include project findings in the curriculum instructors in major educational institutions should be adequately informed.

3 Share existing knowledge on REN integration. The REN is hot topic in all European countries and many parallel operated research centres can be found.

The project aims to make use of existing knowledge in this field instead of duplicating research efforts. It may include inducing other Central European Countries setting up similar projects in the future using the project findings.

4 Visibly decrease obstacles to application of REN resources. There is continuous development of the basic REN unit (wind turbine, micro water turbine, solar unit, heat pump, etc. but all these tools can be purchased on the market. In spite of the commercial possibility, the penetration in Central Europe is really low. Increase the physical penetration rate is beyond the time frame of this project but it should contribute to decreasing the numbers of identified barriers.

5 Create support information for electric utilities in order to handle REN related issues. The attitude of electric utilities is crucial to the success of integrating RENs. The project targets them by organizing a forum for exchanging ideas (conference) and by providing them with written information (booklet) on the project findings.

6 Increase awareness and raise interest of RENs for the small scale users. For lack information concerning the technical requirements, the legal requirements and the pros and cons of REN resources. In order to make them aware of the potential of this energy source they should be supplied with adequate information on the subject. The activity of professional associations and new targeted publications can contribute to the achievement of this objective.

7 Foster wider application of REN units in the low penetrated countries, mainly in Central Europe.

At Budapest Tech one of the most current educational topic is the renewable energy application. For years runs theoretical investigation of these different techniques from fuel cells to wind turbines. Nowadays these equipments are off-the-shelf tools, one can get billion pieces of information in this area. The present value is not the simple information, but the filtered knowledge can be used at a real application case. This is why Budapest Tech made decision not to theoretical, but practical handling of these machines. An Energy Park (EP) developed for the real investigation and education of these techniques.

1.2 Setting up Test Environment

We started the realisation of a "*mini REN park*" on the top of the college. The REN units are mass products that can be applied by any small customers. This project is the test area of our work regarding the intelligent control of the small units and the development of the grid connections (utility contracting, measurement, etc.).

The REN park includes heat collector, photovoltaic unit, wind turbine and prospectively fuel cell, too. The units get a common intelligent measuring and controlling system. The small energy system will be connected to the central building heating system and to the electric utilities' system too.

2 The Renewable Park on the Roof

The Budapest Tech is located in Budapest in urban area. We set up the energy park on the roof of a college (PV, Wind and Heat collector). This is not the optimal place for the energy generation, but the best place for the educational and investigation purposes.

2.1 Photovoltaics

The task is to get detailed information about the generable energy with the local meteorological climate. We applied the low cost amorphous silicon technology panels (2-3 USD/W). (Fig. 2.1.1 and Fig. 2.1.2) Characteristics:

- Nominal power: 40W
- Nominal voltage: 44,8V
- Nominal current: 900mA
- Free running voltage: 62,2V
- SC current: 1150mA
- area: 0,8 m^2

Running investigations are:

- Definition of operational efficiency
- Find the optimal position angle
- Effects of the dispersed light
- Aging features
- Planning the best mounting accessories
- Make help for the architects to plan more PV application

Figure 2.1.1
The Photovoltaic test site

Figure 2.1.2
The DS 40 solar panel

2.2 Windturbine

We apply a 400W AIR-X 401 turbine. The electronics, the load (night illumination) and the National Instrument measurement system was built by students (see Fig. 2.2.1 and 2.2.2) Main characteristics:

- Rotor diameter: 1,15 m
- Voltage: 12 V
- Cut in speed: 3 m/s
- Nominal power: 400 W/11,5 m/s
- Maximal output: 520 W/18 m/s
- Built in charging controller

Figure 2.2.1
The AirX401 wind turbine

Figure 2.2.2
The turbine installation

2.3 Fuel Cell

Figure 2.3
The fuel cell

The 20 W FLEXIVA fuel cell unit transforms pure hydrogen into electricity (see Fig. 2.3). The produced heat is dissipated by air cooling fan. The energy is stored recently in 12 V accumulator.

This equipment is capable for the independent auto (car) accumulator charging too, but we operate and measure it through a personal computer system.

2.4 Heat Collector

The communal energy usage can not be investigated only from the electricity side. The heat consumption has effect on the gas and electricity bills too, because heating and cooling can run by electricity and gas as well. For the education of the energy consciousness thinking we apply heat collectors too. The different types of

primary equipment (vacuum tube solar collector, flat collector – see Fig. 2.3.1 and 2.3.2) cooperate with the hot water system of the college building. The gas boilers heat the solar preheated water. The measurement system collects the data from the accumulated, stored and used heat. One must mention that the application of the heat collectors seems to be financially the most profitable investment into the renewable.

Figure 2.3.1
Flat collector in the laboratory before the mounting

Figure 2.3.2
Vacuum tube collector

3 Control and Measurement Scenarios

The energy park development is performed in the next steps:

I Setting up independent units, with independent measurement systems (see. Fig. 3.1)

II Unification of the measurement systems (see. Fig. 3.2)

III Set up a common AC microgrid network (see. Fig. 3.3)

IV Common load and generation control in the network (see. Fig. 3.4)

V Set up a virtual microgrid (see. Fig. 3.5)

3.1 Independent Units

The basic measurement task is to identify the characteristics of the different tools:

Photovoltaic panel:	sun radiation -> electricity generation
Wind turbine:	wind speed –> electricity generation
Fuel cell:	hydrogen consumption -> electricity generation
Heat collector:	sun radiation -> heat production

In this phase one can get acquainted with the energy transformation unit, can learn the application techniques, can compare the different types of products and brands.

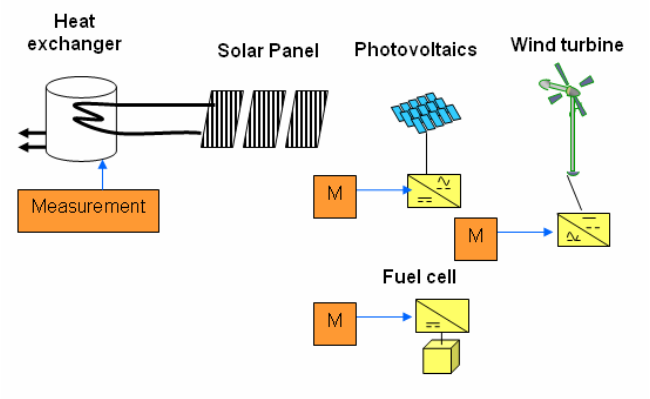

Figure 3.1
Step I: Setting up individual units with measurement

3.2 Microgrid Operation

The microgrids are small, mostly isolated – islanded electricity nets. It has growing importance for the renewable and distributed electricity generation. In this configuration all the power system phenomena can be investigated:

- Voltage control
- Load – generation balancing
- Frequency in the AC net
- Active/reactive power
- Harmonics
- Load management, etc.

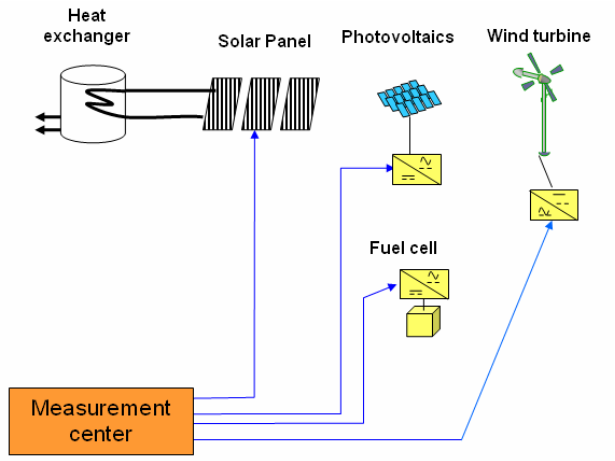

Figure 3.2
Step II: Setting global measurement system

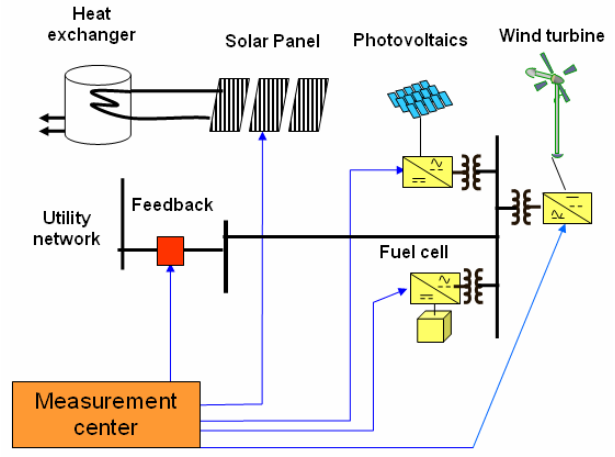

Figure 3.3
Step III: Setting up the microgrid

We are planning to feed back to the utility net too. This is the real test/demonstration of the Distributed Generation in the deregulated market environment.

The control unit will be based on a PC that controls the load and storage facilities too. The PC acts on switches and variable loads.

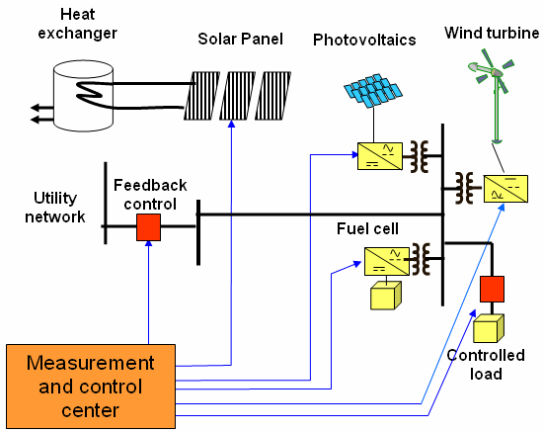

Figure 3.4
Step IV: Setting global control system

3.3 Virtual Microgrid Operation

Our further aim to build a virtual microgrid that can be widely realised in the country. In these applications the individual equipments are connected to the normal utility network, but participate in a control system that control specific elements. The control uses the existing Internet infrastructure.

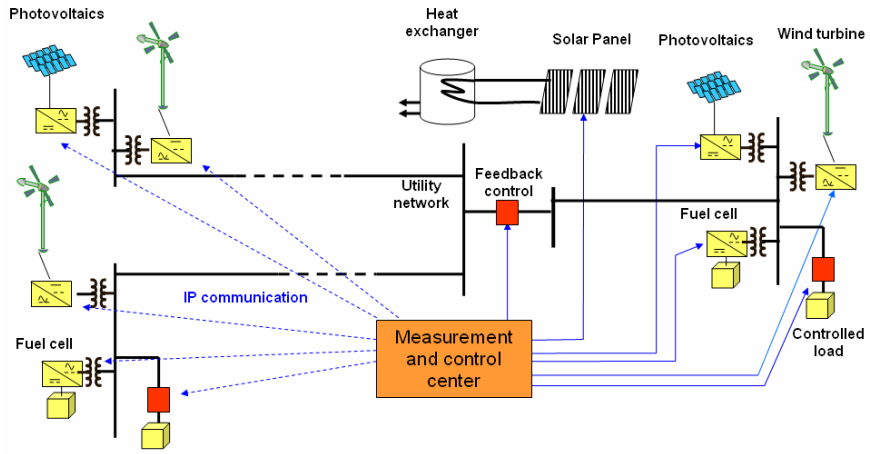

Figure 3.5
Step V: Virtual Microgrid enhancement

3.4 Controlling Strategies

After getting knowledge about the individual units complex strategies can be developed regarding the problems and expectations of the main grid's control.

Some problems that encourages our activities:

- The present network control philosophy does not accept with pleasure the small DG and REN units
- The wind power generation makes disturbances
- The cross border transfer capacities are overloaded
- The present DG units gas engines) are uncontrolled, etc.

Directions of the research

- Development of the cooperation control between gas engines and wind turbines.
- Development of IP controllable equipments: loads and generator as well.
- Making a household controller (maybe on fuzzy base) that optimize the load schedule.
- Enhancement of the AGC controller with DG control too (beside some great units, hundreds of small equipment could participate in the system), etc.

Conclusions

At the Budapest Tech a microgrid development project has been started. Photovoltaic, fuel cell, wind and solar collector units are installed. With this system different control structures can be investigated. This renewable/distributed energy park is practical education place far beyond the theoretical studies.

Acknowledgement

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