Abstract: One of the EU energy policy goals is development of utilization of renewable and small local power sources. Local balancing of power production and consumption is aimed due to power transmission loses minimization. In other words all energy consumed in separated small area (cottage, town, commune) should be produced within this area. Research it has been done so far shows that it is very hard, in particular using unstable renewable power based on solar and wind energy, to reach the aim with keeping very high quality factors, high efficiency and low costs. One of the solutions could be local microgrid connected or not to power system. The microgrids can be realized as AC or DC current. There is DC current microgrid idea presented in the paper. In authors opinion such microgrid using power electronics converters and advanced control systems allows easier effective connection of different power sources as AC microgrid. In particular there are no problems like reactive power control, voltage and current distortion, reactive loses etc.

Keywords: distributed generation, renewable power sources, microgrids, power electronic converters.

1. INTRODUCTION

Strategic aims of EU clearly describe the role of distributed generation (DG) and renewable energy resources (RES) in power production. Experts are unanimous that DG participation in production will be raising also due to economical reasons. Unfortunately it will cause necessity of some changes in power system. Current centralized solutions have to be transformed [5]. The transformation is forced by another EU aim – power quality raising.

From opposite direction EU main goal is sustainable development. In case of power it means increasing of efficiency, RES utilization and local energy balancing.

Local balancing means that almost all energy consumed in separated area needs to be produced within this area using local primary carriers. Such solution allows to minimize power loses connected with power transmission and power distribution and encourages investment in local small production units.

Goals and development directions described above require transformation of current distribution networks of medium and low voltage. It is necessary to introduce possibility of local control of power flow. Protection systems need to work with bidirectional energy flows. There is no data communication subsystem necessary to control all components in current distribution network. In consequence the idea of microgrids was come into being. Microgrid means small, balanced power system which connect distributed power stations and consumers located on not big area. Description of different AC microgrids can be found in references [4][6].

The principle of microgrid operation is balancing of production with consumption. In case of stand-alone microgrid system has to be balanced all time. In case of subsystem connected to power system has to be constructed in the way the power interchange should be planned like in case of big power plants.

Unfortunately, a disadvantage of microgrids is problem of voltage and frequency control (reactive and active power flow). It is clear that there will also problems with voltage distortion due to wide utilization of power electronic converters.

Authors propose to use DC current microgrids as a solution which avoids most of problems described above. The solution allows to keep low costs in many cases and makes easier some issues connected with control of quality parameters. Problem of quality in DC systems is reduced to keep voltage or current in required range.

2. AC CURRENT MICROGRIDS

Microgrid conceptions described in references concern AC current systems. Two interesting examples can be found in [4][6].

The [6] concerns technical solutions allowing wide and safe introduction of uncontrolled energy sources into public grid. The aim of project was to analyse of reliability and cohesion of AC microgrids. There were significant amount of installed power in renewable power sources. The next aims were research on system properties with decentralized control and collecting experience in exploitation.
To reach the aims fragment of 20 kV distribution network was chosen. Structure of the network is shown in fig. 1.

Fig. 1. AC microrid structure [6].

There were two main conclusions. The first one was there is no significant technical difficulties to construct such system. But an adequate level of reliability and availability of the microgrids elements have to be kept. The second one was it is necessary to develop data communication subsystem which will connect all sources into virtual power plant (fig. 2).

Fig. 2. Concept of virtual power plant [6].

Different in its idea is system described in [4]. It is stand-alone microgrid built on an island (fig. 3).

Fig. 3. AC stand-alone microgrid presented in [4].

Unfortunately AC current based solutions have many disadvantages. Wide usage of not big sources extracts introducing of many power electronic converters – in-verters – to convert power into AC 50 Hz current at required voltage level from DC or AC frequency variable current. As a result system of many inverters connected in parallel will be coming into being. Assurance of proper parameters of energy supplied by microgrid will depend on strategy of control of the inverters and on how the problem of changing the leading inverter will be solved. Leading inverter needs to be changed in case the current leading source loses its production capacity.

There are not trivial problems and more research is still required [3][5]. It is particularly important introducing such control strategy which allows to avoid voltage drops and frequency changes. Other difficulties are caused by problems with reactive power and shape control.

3. DC CURRENT MICROGRID STRUCTURE

An idea, which is a base of DC current microgrid conception, is realization of postulate of local balancing of production with consumption like in case of AC microgrid. In addition high quality parameters will be kept. Thanks to introduction of DC current there will not be such problems like frequency, shape, reactive power control. Block diagram of the system proposed by authors is shown in fig. 4. DC current microgrid principle of operation is based on conversion of all kind of produced power into DC current. In case of generators with variable frequency the conversion is always applied. Connection with power grid is also realized by rectifier and inverter. All power balancing and control functions are performed in DC circuit.

Fig. 4. DC microgrid concept.

Consumers are connected by inverters. If connection needs to be bidirectional it has to be done by bidirectional converter or parallel connection of rectifier and inverter.

Problem of power quality in the microgrid is reduced to voltage level control. It is obvious consumers need to be joined to the AC 50 Hz sources. So, there are inverters which produce 50 Hz sinusoidal voltage. Due to the power control is executed in DC circuit, if the DC voltage are kept higher then minimum threshold value, the output AC voltage will meet all requirements. It is particularly interesting that voltage in DC circuit does
not have to be kept with very high precision. Modern inverters can keep stable sinusoidal waveform with relatively wide changes of DC input voltage.

Described solution can have a few variant depending on number of inverters and their power and localization. The border solutions are the one inverter supplying all consumers on one side and individual inverters for each consumer on the second side. The second possibility allows for instance to measure energy in DC circuit. It could be interesting approach in the light of current “trade” problems in Poland.

As in microgrids presented in [4][6], the critical problem is data communication subsystem and proper control strategy. The strategy will have direct impact on power quality, power sources utilization, balancing level etc. In consequence it will have crucial influence on energy costs in the microgrid.

4. AUTHORS’ RESEARCH

Team leaded by authors is experienced in hybrid power production systems [1]. Particularly in DC current systems. We have also very good experience in remote supervising and control systems [2]. A model of DC current microgrid is constructed (fig. 4) in laboratory of Chair of Power Plants and Power Economy.

Intensive research is done on all components of the microgrid. Fig. 5 shows an example of results. It is a chart of power flow in hybrid production system based on solar source and PEM fuel cell. As it can be seen both sources covers energy demand together depending on current production in photovoltaic array. The experiment were done on solar power plant and PEM fuel cell system developed at Warsaw University of Technology (fig. 6 & 7).

Fig. 7. PEM fuel cell supply system developed at Warsaw University of Technology.

5. CONCLUSIONS

Common utilization of small power units, often unstable and unpredictable, will be causing necessity of build networks subsystems called microgrids. Microgrids, according to EU strategic goals, will cover all energy demand in area they will built using local primary carriers. It is political aim which has to be realized. It will increase power safety and life level by increasing of power availability, efficiency and quality.

Intensive research is performed on microgrids all over Europe. Authors propose, as their own contribution, DC current microgrid. The DC microgrid allows:

- avoid many difficulties with control of energy parameters,
- simplification of control strategy and control units,
- costs reduction,
- transmission loses reduction,
- developing of new method of energy measurement,
- introducing load active control methods.

Technical realization of the DC microgrid is possible and quite simple at present timewith relatively low costs. It is the result of sudden development of power electronic converters and data communication equipment and significant their costs reduction.

6. REFERENCES


