# Renewable And Distributed Sources Within Smart Energy Regions

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## I. ABSTRACT

The concept of smart energy region is supposed to be supplied with renewable sources integrated into smart grid. Connection issues of renewable sources impose new challenges and tasks for the smart/distribution grid regardless of source and connection type within regions. Efficient integration of renewable sources either concentrated or distributed along smart region stand as one of the main tasks for the reliable customer supply. In order to fulfil this requirement, a smart grid is provided with various measurement data generated from many locations within region. This paper presents different approaches in integration of renewable sources. Not predictable and intermittent nature of renewable generation, wind or solar power, influences on voltage fluctuation and consequently on power quality in a smart grid. Vast amount of measurement and forecast data are supposed to inform all "players" in smart grid to use electricity in efficient manner with minimum storage and export to distribution grid. The great potential in solar power can be utilized either for water heating or electricity production what can depend on subsidy policy (feed in tariffs). A household in countries with fair feed in tariff can have benefit of produced electrical energy from photovoltaic cells at annual level.

***Keywords: Smart Grid, Distributed Renewable Integration***

## *II.* INTRODUCTION

Before introducing a Smart Grid concept, households were consuming electricity in old fashioned manner. Electricity consumption management was limited to choice to either higher or lower electricity tariff, only. Power Utilities used this method to initiate users to consume electrical energy during peak off hours in order to decrease peak in a power system. The fast development of information and telecommunication technologies (ICT) along with introduction of renewable sources in the last decade of 20th century has revealed opportunity to distribution system operators and consumers to use electricity efficiently. Installation of many metering systems at both distribution grid and consumers side makes household consumers are being smart users and not only passive load but also active electricity producers. Transforming the grid into a "Smart Grid" is not only enabling energy efficiency and deployment of dispersed renewable resources but it provides to the Distribution System Operators (DSOs) many other opportunities: improving the business of the outage management, asset management, reducing operational costs and supplying several services to different vendors of electricity and aggregators [1]. Technical system transformation into smart grid has to be followed by the regulatory authorities with proper regulations and subsidies. From the consumer point of view, Smart Grid concept will be approved if there are power supply improvement and decrease in electricity bills.

## III. SMART GRID

Integration of ICT and renewable sources within power sector impose new challenges to DSOs and gives more opportunities (services) for the power grid users (consumers and producers). In such power grid, consumers are supposed to have options to choose electricity retailer and organize (optimize) their own consumption. Furthermore, passive consumers are encouraged, in a manner of feed in tariff, not to be passive more but active. Consequently, participation of market, renewable sources and various metering data make such power grid much more "complicated" and transform it into "Smart Grid". Also, it can be explained that besides regular electrical infrastructure (hardware) Smart Grid comprises and information infrastructure (software) in parallel [2]. Besides new opportunities, Smart Grid has to preserve main performances, typically divided into two parts: continuity of supply and voltage quality.

Smart Grid concept is seriously recognized from the highest authorities in European Commission (EC), so many actions and projects have been supported by EC. One of these is Smart Grid Task Force (SGTF) - European Task Force for the Implementation of Smart Grids into the European Internal Market, set up by the Commission at the end of 2009. The ultimate goal of the SGTF Work Programme is to jointly produce a set of regulatory recommendations and to identify projects of common interest to ensure EU-wide consistent, cost effective, efficient and fair implementation of Smart Grids, while achieving the expected services and benefits for all network users. The work and initiatives on Smart Grids have been growing in number, participants and scope during the last years in Europe. But the implementation of Smart Grids at a

European level has been fragmented since the beginning of the decade and not accelerated as expected. The main reasons were/are the uncertainties regarding consumer acceptability, new retail market models, business models for investors, the global investments needed and, to some extent, the technology needed [3].

There are many definitions of Smart Grid concept and one of these is that: Smart Grids can be described as an upgraded electricity network enabling two-way information and power exchange between suppliers and consumers, thanks to the pervasive incorporation of intelligent communication monitoring and management systems [4]. Graphical explanation of such definition is presented (fig. 1.) where Distributed Energy Resources are added as the additional part of Smart Grid.

Within Smart Grid consumers will be provided by information that helps them to make more sensible use of energy. If consumers can save energy, they can see the benefit directly as lower energy bills. The lower energy bills the less energy consumed and the lower impact on environment.

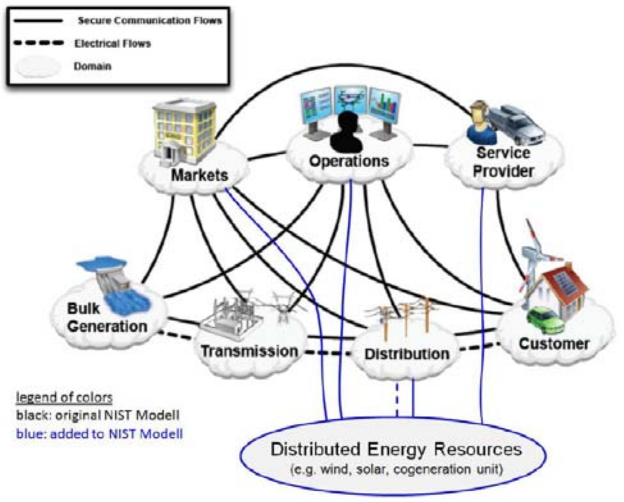


Fig 1. Smart Grid conceptual model [4]

Smart Grid concept stands as the one of the cornerstones for accomplishment of Smart Regions (Smart Buildings, Smart Cities). Smart Grid network, electrical and data network, are supposed to be key tools for efficient and reliable power supply of all consumers within Smart Region. All users (fig. 1.) have to be provided by necessary data and be ready to share data in order to be able to fulfill users' requirements.

## IV. DISTRIBUTED GENERATION

Before significant deployment of small scale renewable generation, at the end of last century, consumers have been supplied by power produced from concentrated large conventional units, by transmission and distribution grid. There were minor number of small scale hydro power units, but percent of these was negligible, comparing to nowadays and planned in future. Rapid development of renewable generation technology, followed by proper regulatory subsidy policies and electricity price increase, have motivated households to invest in small scale renewable generation unit, predominantly solar and wind power. It makes them less dependant on power supply on distribution grid; electricity produced can be either consumed for their own purposes or sell to distribution grid. The renewable generation technology is getting improved every year and the pay back of investment in such facilities is less, so many households've decided to invest in their own small scale renewable production. This trend influences on transmission and distribution grid, so a supplied region or city is not passive any more but active. Consequently, concept of power system is now changed and transmission and distribution system operators have to adopt new approaches in power system management. In this scenario, central power stations will continue to exist, but in addition there will be a large number of smaller, distributed systems. This change in structure demands the coordination of the operation of a large number of systems and the electricity networks. Thus, the importance of information and communication technology for energy systems will further increase [6].

A successful transformation of the current electricity system designed around large-scale centralized electricity generation towards a future electricity system with a large role of small-scale distributed electricity generation requires an efficient integration of distributed generation from two perspectives: market integration and network integration [5].

Generally, variable production from the renewable sources, either small scale distributed or large scale, requires additional efforts from power system operators to keep power system in stable operational point. Regardless, distributed generations have some advantages against large scale production units:

*1) failure in one small scale production units has less impact on grid stability, significantly,*

*2) higher electricity supply independence,*

*3) reduced transmission/distribution losses, electricity produced at local level is consumed in local,*

*4) reduced investment capital risk (no huge investments in large scale units),*

*5) energy management on local/regional level – everyone will be able control your consumption/production,*

*6) support local industry – components production and maintenance employment,*

*7) less independence on fossil fuels,*

*8) reduced environmental impact of electricity production, etc.*

Distributed renewable generation is supposed to be main energy sources within smart cities/regions. As the part of a smart grid, distributed renewable generation should improve supply security, reduce consumers' electricity bills and interact with distribution grid in effective manner. All these tasks and actions assume to be followed by adequate regulatory activities, such motivating feed in tariff and not complicated permission documents provision.

## V. Renewable Distributed Sources

Solar and wind power stand as the main renewable sources in smart regions. Depending on weather conditions, feed in tariff, investment possibilities, urban infrastructure, electrical connection issues, etc., the source type and size is chosen, usually. The single unit installed power are 5, 10, 15 kW, what is quite enough to provide electrical power for single household purposes and export to distribution grid in peak off hours.

### *A. Integration of distributed renewable sources*

Integration of small scale renewable sources into electrical grid imposes fewer requirements comparing to large scale renewable sources integration. Small scale renewable units are connected to either low voltage (LV) or medium voltage (MV). Influences on power system stability and power quality are less significantly, since production variation or trip out of one small scale unit has local impact, only. Also, when connected within smart region, connection lines length between sources and consumers' loads are rather short what improves smart grid electrical stability. While, production variations of large scale unit have impact on whole power system stability and influences on all consumers. Consequently, there are fewer technical requirements, from regulatory bodies, and hence the procedure for production permission is much easier comparing to one for large scale units. Generally, from the supply quality point of view, either for small or large scale renewable production units, the main disadvantage of renewable production is power production variations. It is hard to expect constant sun radiation (for PV production) or constant wind sped (for wind turbine production) so power produced from such sources are not "clean" like from conventional sources. In order to decrease such "impurities" in some cases hardware interface is needed when connected to power grid, i.e. VAR compensators, AC-DC-AC convertors, STATCOM etc

Distributed renewable generation deployment is very dependant on subsidy policy of the regulatory bodies. Depending on feed in tariff, regulatory bodies can support solar or/and wind power production. For example in Australia, with abundant solar power, the feed in tariff for small scale photovoltaic (PV) units is in range 7.7 to 12.9 cents/kWh and average retail electricity price is 24.4 $/kWh [7]. In Japan, with strong support policy on solar production from small scale PV (up to 10 kW installed power), electricity paid to small scale PV is 42 ¥/kWh and retail electricity price is about 23 ¥/kWh [8, 9]. In Bosnia and Herzegovina, where regulatory agency has recently enacted feed in tariff to support small scale renewable generation, for PV units up to 50 kW installed power, produced power will be paid for 0.25 €/kWh and for wind power up to 10 000 kW installed power, produced power will be paid for 0.083 €/kWh. The average retail electricity price is 0.05 €/kWh.

### *B. Small scale wind power*

Serious wind utilization started in 1980s in Denmark. Since then, rapid development of wind turbine design has started for both small and large scale, in parallel. Nowadays, there are great offer of small scale turbines with different power, blade designs, for various installation sites, etc. Usually, small scale wind turbines are up to 50 kW of installed power. Selection of installation site in urban area is more complicated comparing in rural area, not just because of lack of proper space but also there is wind wake effect if installed close to buildings. So, inadequate site can make problems for optimal wind turbine operation and decrease energy extracted from wind. Urban sites are within built-up areas. They are likely to be quite close to buildings and other ground features [10].

When deciding install wind turbines within urban sites, there have to be considered possible visible and sound pollution what could be important factor to choose PV units instead wind power in urban sites.

### *C. Small scale PV and water heater units*

Recent improvements of solar power technology have made PV cells financially affordable and installation feasible for the small households. Assuming minimum sunny hours and with adequate feed in tariff one household can deliberate about supplying for its own purposes and export electricity to distribution grid. Installation of PV units in urban sites is not such demanding comparing to wind turbines. PV units could be installed on the roofs, walls, highway noise barriers (fig. 2.), etc. and be as the "natural part of construction". Also, PV units have minor visible effects on landscape no sound pollution at all, no rotating mechanical parts so installation and maintenance works is much easier comparing to wind turbines.

Fig. 2 PV highway noise barriers [11]

PV cells convert sunlight directly into electricity. PV generates DC voltage what has to be inverted to AC in order to connect to distribution grid. At the connection point with distribution grid it has to me measurement equipment able to measure electrical energy in both directions. These components make simplified grid tied PV unit (fig. 3.).

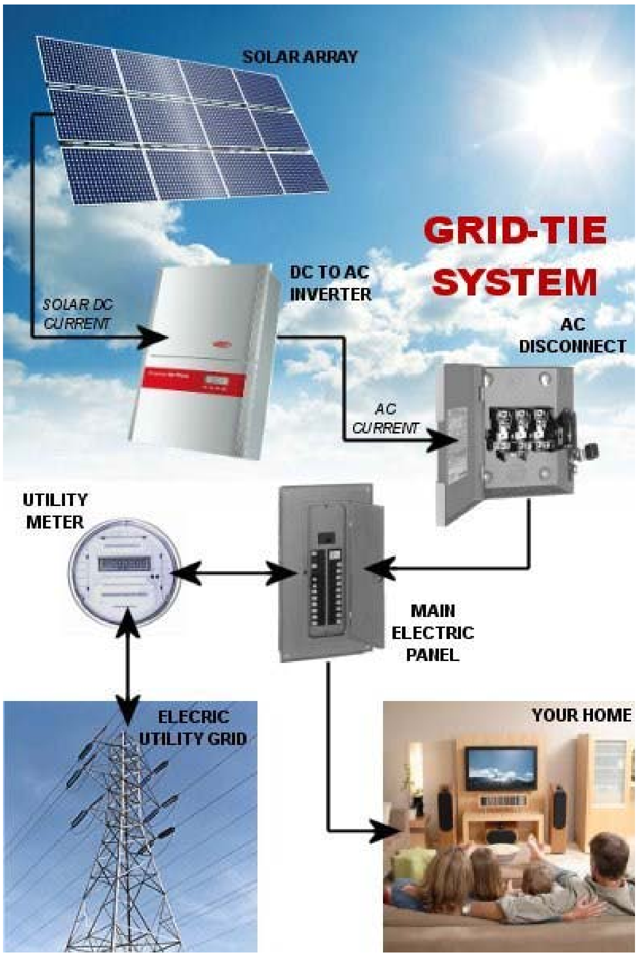


Fig. 3 Grid tied solar power system [11]

Another way to use solar power is solar water heating. More than 50 % of electricity consumed in households is for water heating, used either for space heating or everyday domestic purposes. Also, by this way no need to transfer solar power into electrical and electrical power into thermal when heating water, so no necessary energy transformation losses. Advantages of this system are very simple technology, much cheaper then PV units, no need to connect to distribution grid and simple installation. If no economically reasonable and technically feasible for PV installation, each Smart region/Smart city should consider installation of such solar hot water system. One such system is presented in Fig. 4.

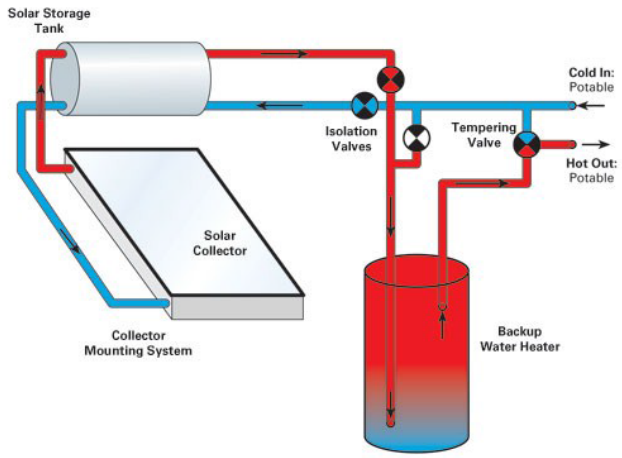


Fig. 4 Solar Hot Water System [11]

Solar collector is the part which catches up solar power and has to be exposed to sun radiation, while other parts can be located in a house. During winter cloudy days, the boiler with hot water has to be heated up by electric energy in order to have hot water. In the regions with not enough sunny days and average low temperature during winter this system might not be used.

## VI. Conclusion

Integration of renewable sources and ICT within exciting power network is the key factor for successful transformation of robust and nonflexible existing power grid into flexible and smart power grid. Within such smart grid, consumers should have possibilities for improvements of supply quality, lower electrical bills and less environmental impact. In such grid, consumers have opportunities to install own renewable production distributed along whole region/city. These renewable distributed renewable sources should be major power supply for smart grid consumers. When distributed, power productions have many advantages comparing to concentrate sources. These technical upgrades of power network have to be followed by proper support from regulatory bodies.

In urban area, solar power utilization has many advantages against wind power utilization. Solar thermal heater or PV units are easier for installation and maintenance, no sound pollution, usually less visual impact and no rotating parts. If not feasible to install PV units Smart region/Smart home should consider installation of solar water heater.

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