Introducing DER in Latvian Power System

I. Oleinikova, A. Mutule and A. Sauhats

Abstract - **The major issues influencing implementation of Distributed Energy Resources (DER) in Latvia are observed in the Paper. This process considerably depends on the technical and organizational characteristics of the investigated power system. Potential clients of DER in electricity and heat markets, tariff system, organization of electricity and heat market are considered, among others issues. The aspects of practical implementation of distributed energy resources are analyzed for specific CHP power plant. Main problems of implementation are concerned here too.**

Keywords - **Distributed Energy Resources, Distribution Networks, Electricity market.**

I. Introduction

The electricity market in Latvia is regulated by the Law on Electricity Market adopted on May 5, 2005 (further on in the text the Law). The Law regulates the operation of electricity market branches, including transmission and distribution networks, the functions of traders and providers of services required for electricity trading. It also establishes the frames of competence for the Ministry of Economics and Public Services Regulatory Body [1].

In accordance with the Law, every electricity market participant reserves the right to use transmission and distribution networks for electricity transportation in compliance with the system service rates (tariffs). The consumer connected to a distribution network has the right to change the supplier by forwarding at least three months before a notice to him and to the system operator who is in administrative charge for the network connections. The Regulations adopted by the Cabinet of Ministry on electricity trading and consumption determine the procedure by which electricity is supplied/not supplied to the consumer, the rights and obligations of electricity traders, system operators and consumers in the sphere of electricity supply and use as well as the accounting procedure for the services provided. The Regulations define the procedure of a trader's shift or rotation. Annual electricity tariff in Latvia for relevant electricity users consists of the following components: electricity price, network tariff and component of support provided by domestic electricity producers.

Since 2008 amendments to the Law have been adopted, which envisage the obligatory involvement in the liberalized electricity market of electricity users - the enterprises with 50 and more employees or those with turnover per year not less than seven million Latvian lats (LVL).

The transmission network operator is liable for administration of a market participant's electricity balance for the users connected to a transmission network, whereas the distribution network operator deals with the users connected to a distribution network.

All market partners/participants have the right to use transmission and distribution lines for electricity transportation.

Since 2007 the electricity market in Latvia is 100% opened and all Latvian enterprises are eligible to make a free choice of the electricity supplier.

II. Electricity Trade Transactions

It is important for consumer that it can consume electricity in an amount and at a time it needs. At the same time electricity cannot be stored in big amount economically. Therefore, in power system electricity has to be generated as much as it is consumed at every moment. For this reason electricity generators and buyers conclude agreements in the market where generation company undertakes to generate, but consumer undertakes to consume certain amount of electricity at a certain point of time (hour) in the future [1]-[3].

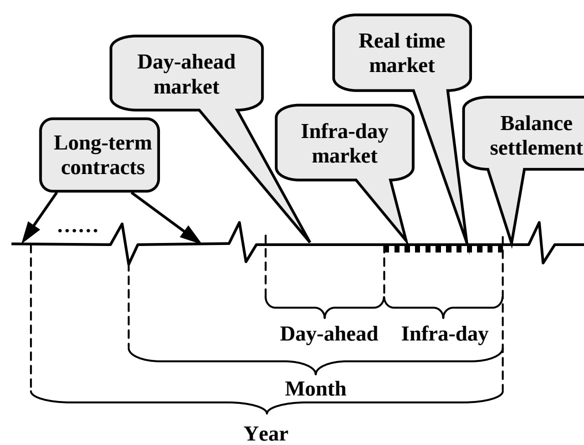

Fig. 1. Electricity trade takes place before delivery

Electricity trade between market participants within liberalized energy markets takes place by concluding different type of long term (year and longer), middle term (month and weeks) and short term (day-ahead, hour) agreements (Fig. 2). Choosing of type of agreement is up to market participant and it might depend on power plant type or consumption pattern, trade strategy and risk management policy.

I. Oleinikova, Institute of Physical Energetics, Latvia, Ph.: +37167558616 (e-mail: irina@edi.lv),

A. Mutule, Institute of Physical Energetics, Latvia, Ph.: +37167558616 (e-mail: amutule@edi.lv), and

A. Sauhats, Riga Technical University, Latvia, Ph.: +37167089930 (e-mail: sauhatas@eef.rtu.lv)

978-1-4244-2235-7/09/$25.00 ©2009 IEEE

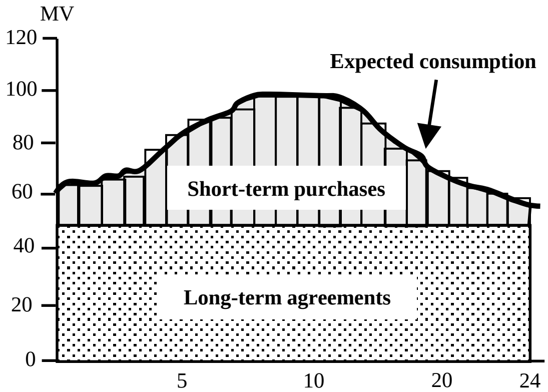

Fig. 2. Industrial consumer can purchase part of clearly needed electricity with long-term agreement (year or several years ahead) and the rest can be bought with short-term (day-ahead) agreements after more precise consumption forecast is available

Balancing deliveries

In market electricity is bought in accordance with pre-agreed hourly fixed delivery schedule according to consumption forecast. By consuming electricity according to customers' needs, actual electricity consumption will never precisely match with previously purchased electricity amount with fixed delivery schedule because forecasted consumption will always be smaller or bigger than actual electricity consumption. Therefore, imbalance occurs between previously purchased electricity and actually consumed (metered) electricity amount, and supply of unscheduled deficit electricity (previously not purchased) to consumer or purchase of unscheduled surplus electricity (previously excessively purchased) from consumer is called balancing (Fig. 3.). Prices for balancing deliveries usually are less favorable than prices for previously scheduled and purchased electricity deliveries therefore consumers usually are incentivized to plan their consumption accurately.

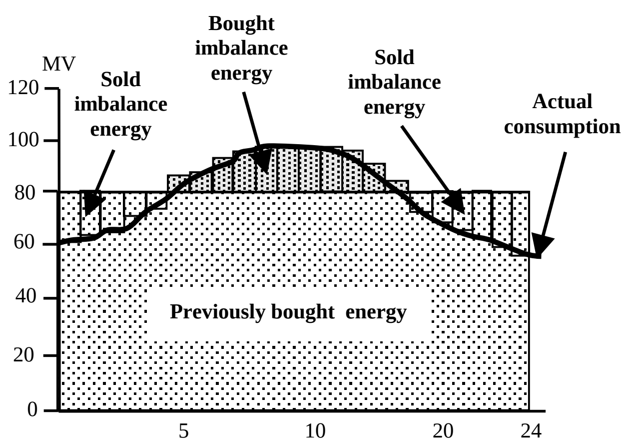

Fig. 3. Balancing of consumers' daily consumption

TSO is responsible for power balance in the power system - balance between supplied and consumed electricity.

Competition - a keystone of effective market

The goal of electricity market liberalization is to create benefits by introducing incentives for higher efficiency and more innovation. Effective incentives are created by introducing competition between market players. Competition exposes market players to the risk of losing market share, or even going bankrupt, if they are not sufficiently efficient and innovative. But it also provides rewards for taking risks and performing better than one's competitors. Failure to introduce effective competition can undermine the benefits of liberalization in terms of lack of efficiency improvements and perhaps even deteriorating efficiency.

The philosophy of full electricity market liberalization is to introduce competition and choice in as many parts of the value chain as possible - from generation to consumption of electricity.

The EU-27 Member States have committed to implement an energy route map, with a first milestone by 2020

→ 20 % reduction of GHG emissions (when compared to 1990 levels)
→ 20 % of renewable energy sources in the EU 27 energy mix (to-day 6.5 %)
→ 20 % reduction in the primary energy used (saving 13 % when compared to 2006 levels)

III. DER Penetration

Economically feasible implementations of DER depend on many factors. Each individual case should be studied separately to identify its business attractiveness, taken into account local climatic and wind conditions, availability of engineering infrastructure (for example gas networks), environmental requirements. The main requirement for DER efficient implementation is necessity of potential user:

- Potential consumers (especially households), who are in need for connection to electrical network, but who are located in a long distance from the network (high interconnection costs, potential place for installation of autonomous DER).
- Consumers who would rather increase its security of power supply (who need emergency power source).
- Small dispersed consumers, who are supplied through power network of high capacity rating with high power losses (decentralization / disconnection option).
- Consumers, who plan to increase its power demand, but who could not be satisfied (without substantial distribution investments) due to bottlenecks in the network.
- Consumers, who simultaneously consume electricity, heat and / or cooling (cogeneration / trigeneration).
- Consumers (usually industrial or commercial), who would rather be independent from the centralized power supply and prefer to have their own base-load generator. Such consumers remain connected to central power supply to exchange a surplus (top-up) and deficit (back-up, usually to cover its peak load demand) of power.
- Distribution system operators, who may be interested in enhancement of power quality (especially voltage problems).

- Isolated consumers / energy systems (such as oil derricks, islands, etc.).
- Complicated energy systems, which aims to increase total efficiency of energy supply:
    - Heat supply system with cogeneration, heat accumulator, electric heating boiler, heat pumps.
    - Power supply system with wind generators and hydro or battery storage technologies.

IV. Analysis of Heat Market in Latvia

During the last decade demand in centralized district heating (DH) systems has substantially decreased due to decentralization and network poor efficiency measures. With regard to decentralization, the usual consumer choice instead of centralized DH system was installation of individual / local gas-fired heat only boilers. It usually happened in the low heat density areas or when consumers were far from the heat sources. In both cases there were substantial heat losses and inefficient DH system. Probably in some of these DH decentralization cases DER could be preferable instead of heat only boilers. Potential market for cogeneration DERs is also centralized district heating systems of small cities. Motivations for development of cogeneration DERs are:

- Obtaining additional profits from electricity sales,
- Replacing obsolete old equipment (heat only boilers) with low efficiency by very efficient modern cogeneration units,
- Optimization of heat capacity of cogeneration units to the real level of heat loads. Due to decrease of heat loads in some district heating systems generating capacities do not match the heat load any more and could not operate efficiently.
- Cutting off long distance district heating pipes with high heat losses and replacing central heating points by cogeneration plants.

Besides the district heating systems, where heat is provided for space and water heating (usually for residential customers) there could be some demand for exhausted steam, as conditioning or cooling in industrial and commercial sectors. In Latvia potential clients of these products could be food industry, light industry, pharmaceutics, transit of oil and chemical products, wood / timber processing and potentially pulp and paper industry.

V. Matching of DER to Electricity and Heat Demand

Usually characteristics of demand curves for electrical power and heat are very different.

Heat demand curve of centralized district heating consumers is quite variable on seasonal basis illustrates variation of power and heat energy demand by example of Latvian power and Riga district heating systems. In summer, when space heating is switched off, average heat energy demand during a week could be approximately 10%-15% of maximum heat demand during the coldest week of the year. In average, during a heating period, weekly heat demand could be approximately 60%-70% of the coldest week's demand.

Variation between maximum and minimum power demand is not so great: usually during summer minimum weekly energy demand is about 50-60% of power system maximum demand, but during spring and autumn average demand is approximately 70%-80% of maximum week's demand (Fig.4).

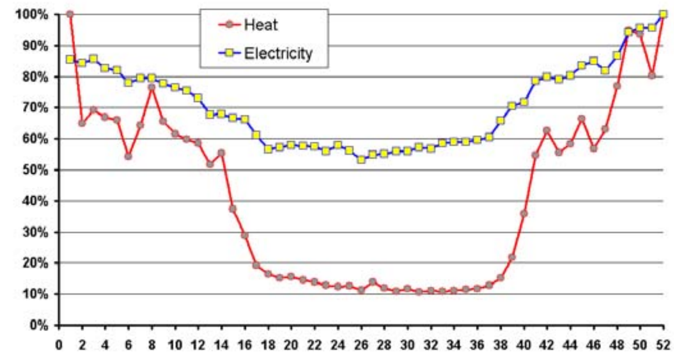

Fig. 4. Seasonal variations of electric and heat energy demand by week

However during a day, the picture is totally different; observe it on the Fig. 5. Heat load demand is quite stable, changing in the range of 10%-20%, whereas power demand is very fluctuating (up to 40%).

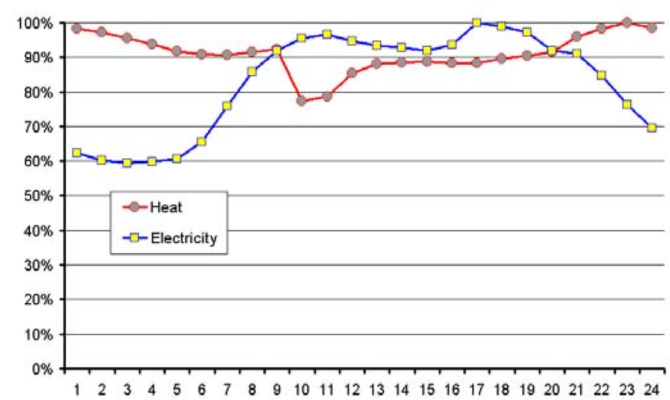

Fig. 5. Daily variations of electric and heat load demand

The above-mentioned graphs illustrate impossibility to cover consumer's power and heat demand by pure base-load CHP systems. Peak units, such as hydro or simple cycle gas turbines should be used during the day to balance power demand, whereas heat only boilers are operated at winter maximum heat loads.

An attempt to equalize power demand peaks was made by introducing differential tariffs. Unfortunately, this measure was not so efficient, due to insufficient difference of price levels and inadequate elasticity of power as a commodity. None of special Demand Side Management methodologies could be applied to manage heat load peaks, because, they primary depends on outside air temperature. One of the measures to deal with this problem is installation of heat accumulators. To increase heat demand during the summer period a possibility to develop cooling system should be analyzed. However it is necessary to admit, that trigeneration system is still not so widely used.

Also wind generators alone could not be used to cover power demand of consumers. Preferably it should be operated in couple with storage technologies. However storing power is costly. It adds from 30% to 100% to the price of production in wind generators. This gap should be compensated by adequate tariffication mechanism, which does not exist in Latvia. The problem is, that peak of wind generation is not necessary coincide with peak of demand and represent operation of wind park, located in the western coast of Latvia and demand of small city directly supplied by the mentioned power plant. The surplus / deficit are balanced by power network. Just in several hours the system is being changed from surplus to deficit (Fig. 6,7).

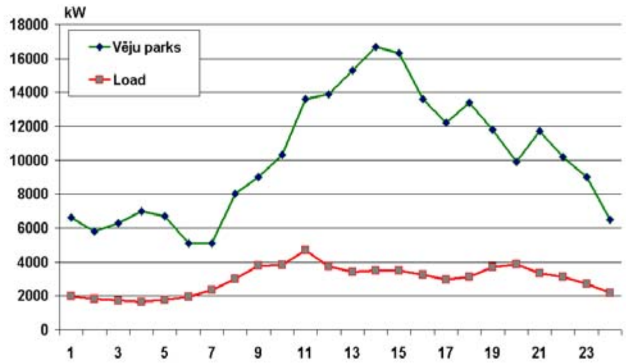

Fig. 6. Load of local consumers and generation of wind park 26.10.2004

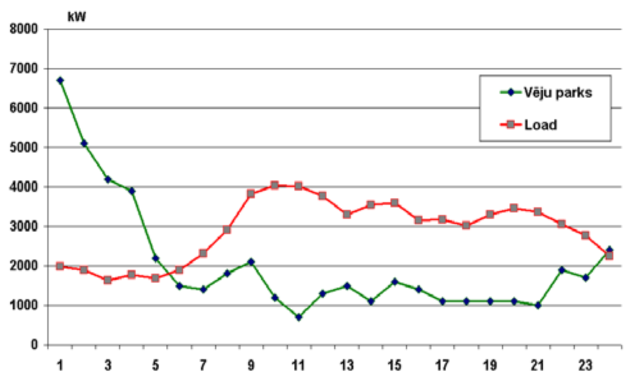

Fig. 7. Load of local consumers and generation of wind park 27.10.2004

The important question is about the choice of optimal capacity of new cogeneration DER. Usually it is determined by available or so called useful heat load. It is very important to estimate available heat loads as much precisely as possible, taking into consideration all possible factors influencing its increase or decrease during the planning period.

VI. Study Case Description

For the Baltic States the more perspective type of DG penetration is apartment housing area. A *Single-family house* is a structure that provides living space for one household or family. It can be attached or detached and is not divided into multiple housing units and has an independent outside entrance. Stand-alone houses, townhouses, row houses and duplexes are considered single-family housing units, as long as there is no household living above another one within the walls that go from the basement to the roof to separate the units.

Needed Data:

- Data about energy consumption of each consumer.
- Electrical equipment of each consumer.
- Actual subscribed power of each consumer.

Possible Technology:

Every technology that can run in a "stop and go" mode and better with CHP application. It can be reciprocating engines, micro-turbine (eventually a turbine for large sites). The case of reciprocating engine will be further studied as it is the best suitable technology from an economic point of view.

From the point of view of the customers: Be provided by electricity and heat at a lower price in exchange of a higher constraint on its end-usages.

From the point of view of the energy supplier: Be able to sell energy at lower prices by minimizing the factors that increase cost of electricity provided by the grid (production cost, transportation cost and cost due to penalties).

In case any potential producer has not been qualified to receive the support, it always could construct its power plant and sell electricity at market prices. However, one can predict almost for sure, that there will not be so many "enthusiasts" that will decide to build a "green" power plant on condition like that. At the same time, those power plants, which have lately received the license / allowance, may have possibility to consider the issue.

VII. Conclusion

The Paper presents the main implementation issues of Distributed Energy Resources in Latvia. This study is based on real-life examples with observing practical aspects and theoretical approach taking into account Latvian market condition. In this paper opportunities are figured out, through experiments and simulation studies, including CHP application technology that can be further on developed in order to support DER expansion in Distribution Networks in Baltic States.

VIII. References

[1] G. Junghans. Operation of power system in liberalized market conditions. Riga: 2008, p. 40.

[2] A. Dolgicers, A Sauhats. Possible development strategies for thermal plant "V". FP6 Project: SES6-CT-2003-503516. 2008.

[3] I. Oleinikova, A. Dolgicers, A Sauhats. BM for thermal plant "V" RTU. FP6 Project: SES6-CT-2003-503516. 2008.

IX. Biographies

Irina Oleinikova was born in Riga, Latvia, on September 16, 1974. She received the BSc, E.E., MSc and Dr.sc.ing. degrees from the Riga Technical University, in 1994, 1995, 1997 and 2000 respectively. She is senior researcher in the Laboratory of Electric Power System Simulation at the Institute of Physical Energetics. Her main research interests include Methods for Mathematical Modelling of Electrical Networks and Systems; Methods for Development of Power Systems Planning; Dynamic Optimization Methods and Decision Systems. She is author of 86 papers, including 2 books.

Anna Mutule was born in St. Petersburg, Russia, on December 16, 1975. She received the BSc, MSc and Dr.sc.ing. degrees from the Riga Technical University, in 1999, 2002 and 2005 respectively. She is senior researcher in the Laboratory of Electric Power System Simulation at the Institute of Physical Energetics. Her main research interests include Methods for Mathematical Modelling of Electrical Networks and Systems; Methods for Development of Power Systems Planning; Dynamic Optimisation Methods and Decision Systems. She is author of 56 papers.

Antans Sauhats received Dipl.Eng., Cand.Techn.Sc. and Dr.hab.sc.ing. degree from the Riga Technical University (former Riga Polytechnical Institute) in 1970, 1976 and 1991 respectively. Since 1991 he is Professor at Electric Power Systems. Since 1996 he is the Director of the Power Engineering Institute of the Riga Technical University.