PERSPECTIVES OF INTEGRATED RESOURCE PLANNING AT LOCAL ELECTRICITY MARKETS IN POLAND ON THE EXAMPLE OF POZNAN POWER DISTRIBUTION COMPANY

Jerzy ANDRUSZKIEWICZ
Poznan Power Distribution Company, ul. Nowowiejskiego 11, 60-967 Poznan, PL

Mieczyslaw KWIATKOWSKI
Polish Power Grid Company, ul Mysia 2, 00-496 Warszawa, PL

1. RESTRUCTURING OF THE POLISH POWER SECTOR

1.1 Structural Changes Aimed at the Implementation of the Free Market Rules in the Sector

As a result of systemic changes in the Polish national economy, which commenced in 1989, the power sector was divided into three subsectors, dealing respectively with power generating, transmission, and distribution. The first subsector comprises 36 public utility power plants and combined heat and power (CHP) plants of the gross available capacity of 32963 MW as at the end of 1998. The sole enterprise responsible for the transmission network operation is the Polish Power Grid Company (PPGC). Distribution is performed by 33 distribution companies. Presently, the vast majority of those companies are joint stock companies owned in 100% by the State Treasury.

The principles of wholesale electricity trading adopted in 1989 were based on the purchase of electric energy by PPGC from the generating sources, its transmission via the national power grid and resale to distribution companies on the basis of wholesale tariffs agreed annually between the subsectors and confirmed by the minister responsible for the operation of the power sector. On the motion of the same minister, the tariffs of charges for end users were subject to acceptance by the Minister of Finance; the latter was responsible for the control of the inflation level in the country.

The foundation for the liberalisation of trade in electric energy was coming into force in December 1997 of the Energy Law and associated secondary provisions. One of the key modifications was the creation of the Power Sector Regulatory Office (PSRO) whose tasks include:

- issuing concessions for the generation, transmission, distribution and trade in power sector,
- approval of tariffs for electricity and its transmission (including tariffs for end users) submitted by enterprises dealing with power generation, transmission and distribution in the field of regulated electricity trading,
- approval of development plans for meeting the customer demand for electricity submitted by transmission and distribution companies for their areas of operation, as required by the Energy Law,
- settlement of possible disputes between companies of the power sector and protection of end users against monopolistic practices.

The new Power Law introduces gradual liberalisation of trade in electric energy and freedom of access to the power grid for electricity consumers. In August 1998, the right of access was granted to consumers purchasing more than 0.5 GWh per year and is due to extend onto all 14.5 million consumers by December 5, 2005. This plan is being carried out on the basis of the principle of the so-called negotiated third party access to the transmission and distribution network (nTPA) in accordance with the energy transmission tariffs prepared by a particular power company rendering the service and approved by PSRO. Until the year 2005, the access will be granted only for electricity generated in Poland. Within the same time limit, electricity prices for end users should be freed and the solutions fully adjusted to the EC Directive no. 96/92/EC in connection with Poland's plans to join the European Union.

The legislation introduces new notions of in power sector: system market and local markets. The system market covers the 220 kV and 400 kV network, while the local markets relate to the network of 110 kV and lower voltage. As far as the power system market is concerned, apart from bilateral long-term contracts (covering 65% of demand for electricity), a spot transaction market (pool) will be created in 1999. As for local markets, regional distribution companies should take the lead. New legal regulations practically give distribution companies freedom to decide on their sources of supply of electricity for the remaining 35% of end users. It may be the national grid, any power station, neighbouring distribution companies and local sources such as CHP plants, autoproducers or sources of renewable energy.

Such a state of affairs is quite new to distribution companies and requires a different approach to planning activity. So far, planning mainly focused on the development of technical infrastructure; now, the development strategy analyses should concentrate on the structure of the own portfolio of electricity purchases in order to minimise the operating expenses, where costs of purchase of electric energy account for 60-70% of total original (prime) costs. Bearing in mind that in some distribution companies the revenues are over hundreds of millions USD, the issue is fundamental to the future competitiveness, even more so as new power trading enterprises are expected to appear in the same area.

The scope of the development plans for satisfying the customer demand for electricity, which are required by the new Energy Law, meets the criteria of Integrated Resource Planning (IRP) since it deals with the search for an optimum method of covering the demand taking into consideration the demand and supply options. Therefore it has been decided that the possibility of implementing that methodology in distribution companies should be analysed.

The analysis will utilise previous experience and computer tools used in PPGC.

1.2 The Importance of Development Analysis for Distribution Companies Operating in Market Conditions

New legal regulations attach importance to the efficiency of electric energy acquisition and its rational use. Therefore one should consider the implementation of new technologies both in electricity generation, with particular emphasis on renewable resources, and its utilisation.

The general aim of the development planning activities in distribution companies is the implementation of strategic objectives in the most efficient way, taking into account the limitations related to the existing resources and the environment. Due to the specific nature of operations of distribution companies, the main area subject to analysis is the electricity supply. The activities undertaken in new legal and economic conditions should result in a competitive offer for a product of a required quality at a reasonable price. Taking into consideration the capital-intensive nature of investment projects in the power sector, the decisions made in that field need to be well grounded.

In view of the circumstances mentioned above, the main strategic objectives of a distribution company are:

- ensuring the coverage of the electric energy demand in a given area with maintaining the suitable level of energy reserve,
- ensuring the required quality of supplied energy,
- creating conditions for the efficient use of electricity, as well as generation and transmission equipment.

In the traditional planning process applied so far, distribution companies tried to ensure the cover for the electricity demand through the purchase of suitable quantities of energy from the PPGC grid and through the development of the distribution network on different voltage levels for the reliable supply of good quality electricity to its utilisation areas.

The planning process was divided into the following stages:

- demand forecast in various time horizons,
- development of technical means of distribution and auxiliary equipment enabling supplies of electricity to consumers,
- ordering suitable quantities of energy ensuring coverage of demand in the area serviced by a particular company.

The process must now be substantially changed to reflect the change in the operating conditions. The most crucial changes are:

- possibility of purchasing energy on the local market, not only from PPGC but also directly from CHP plants and power plants,
- shaping of the tariff system for end users by the distribution company itself,
- occurrence of local initiatives in the field of high-performance combined generation of electric energy and heat using gas,
- establishing standards for the reliability and quality of power supply to be maintained under pain of economic sanctions,
- separation of trading activities performed by distribution companies from activities in the power grid development and operation and the need to justify investment in technical infrastructure (co-ordination of the development plan with ERO),
- competition in trade in electricity on the area serviced by a particular company,
- creation of the market of system services (load control).

The changes listed above force the companies to introduce changes in the planning process. The regulation, which specifies the principles for tariff shaping, introduces the obligation to purchase goods and services, including power, on competitive markets. Therefore, companies need to examine the possibility of covering the power demand from various sources so that the power supply is carried out at the lowest possible cost. A distribution company faces the following new development options [1,2]:

- construction of own, highly efficient sources of energy and power in the serviced area,
- demand control for serviced consumers in order to minimise costs connected with the coverage of natural peak load from own or external sources,
- undertaking activities aimed at rationalisation of power consumption at the consumers' premises,
- optimisation of activities related to ordering of power and electric energy taking into consideration the implemented distribution system optimisation aimed at achieving lowest possible costs of supply while maintaining relevant standards.

The outcome of the development planning process should be a development programme for the company. Such a programme would ensure the selection of projects, which are most effective for the achievement of intended objectives. This will allow for the presentation of proposals related to a sequence of aims, specify the assumptions for their implementation and, after approval, mark out the stages of the company's overall activity. The idea will be to find framework solutions, which will then be reflected in the solutions included in the development plan.

The plan should form the basis for the activities of the company, especially those, which are ultimately to be regulation free, i.e. in trade, services and possibly generation. This is especially important because of the presence of competitors in the three areas; the adopted strategy must serve the purpose of maintaining the company's presence on the market. The advantage of distribution companies is their knowledge of final consumers in their respective areas, which competitive energy suppliers will initially lack.

Entities trading in energy will use the plan as the basis for the evaluation of contracts for the purchase of electricity. Development of certain demand control programs is a natural area of activation of the labour market of the services division of the company, allowing for employment of a considerable number of employees providing information service to customers and concluding contracts.

In activities subject to regulations, the plan may be a starting point for the network development, taking into account the most profitable sources of supply of electric energy.
Introduction of the planning rules presented above will be in place once the reforms in the power industry are effected and new working conditions for distribution companies established. At present we should focus on preparatory work, which will enable us to implement new, planning procedures.
This study is an attempt to systematise planning analyses for a distribution company in the scope of covering future electricity demand with the application of IRP methodology developed in PPGC over the last few years. Development analyses were performed on the example of Poznan Power Distribution Company (PPDC), the third biggest retail seller of electricity in Poland.

2. INTEGRATED RESOURCE PLAN FOR POZNAN POWER DISTRIBUTION COMPANY

2.1 Assumptions and Input Data

Applied methodology

The analysis, aiming at the specification of optimum electric energy purchases structure until 2010 from the point of view of cost minimisation, was performed with the use of IPM model developed by ICF Resources Inc. [3] and used the following methodological simplifications:

- area of operation of PPDC is treated as a „spot" power minisystem separated from the National Power System (NPS); for that reason, the spatial arrangement of elements within the minisystem is not taken into account,
- peak load and electric energy demand in the area of operation of PPDC, corrected after taking into account the results of the DSM programs selected in the optimisation process, is covered by local sources of energy (existing and selected future ones) and contracts (existing and selected future ones) for the purchase of power and energy from the power system market and neighbouring distribution companies,
- the development of transmission and distribution subsystems, and specifically the costs of power output lead from new sources, remain outside the scope of this analysis,
- exchange of load and electric energy with the rest of NPS is modelled as contracts for the purchase/sale of electric energy from outside the examined system; by connections with neighbouring distribution companies one understands here the 110 kV lines linking the networks of distribution companies and connections with the PPGC network are made in the highest voltage network nodes,
- optimisation calculations are made with the use of the IPM model and according to the IPM methodology (objective function: the aggregate costs of covering the forecasted load and energy demand discounted for the basic year with assumed external constraints),
- the criterion of reliability in the form of reserve margin is assumed,
- in order to decrease the risk connected with forecasting mistake, calculations are made for two alternatives differing in power and electric energy demand forecast,
- calculations are made on the gross level of a distribution company, i.e. without the auxiliary needs of generation sources and transmission losses, but including distribution losses,
- the division of the load duration curves into segments shall be the same as for the analyses conducted within the framework of the so-called Second Loop of the Integrated Resource Plan for Poland (IRP-2) [4] prepared in PPGC,

Macroeconomic assumptions

For the needs of integrated resource planning for the area of operation of PPDC, the following macroeconomic assumptions were made:

- planning horizon: the years 1995-2010,
- the analysis is made in Polish Zloty (PLN) with the assumed fixed prices as of 1995,
- discount rate of 10%,

Peak load and energy demand forecast. Load curves

In 1996, a case study [5] was prepared by Energoprojekt Consulting SA (EP-C SA) for PEDC. The study presented two alternative forecasts for peak load and electric energy for the area of operation of PEDC in the years 1995-2010.
This material was the basis for the regional development programme of PEDC.
As a result of consultations between the representatives of PPDC and PPGC, the demand for electric energy in the years 1995-1997 was corrected in accordance with the statistical values. For the years 1998-2010 the amounts of energy were corrected according to the change trends forecast by EP-C SA.
The assumed variant of the peak load and electric energy demand forecast in the area serviced by PPDC is shown in Figure 1.

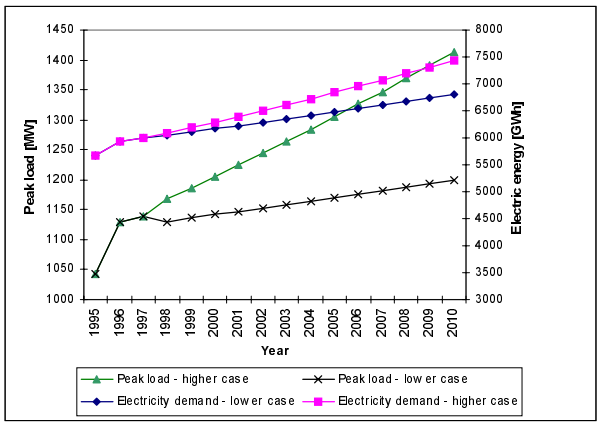

Figure 1. Power and electric energy demand forecasts assumed for calculations of the regional development programme for PPDC

Purchase of capacity and electric energy from the transmission grid and from neighbouring distribution companies

PPDC is connected with the national transmission grid belonging to PPGC through five network nodes operating on 220 kV and one operating on 400 kV. From those nodes electric energy is transmitted through the 110 kV and lower voltages network belonging to PPDC to the entire area serviced by the distribution company. Apart from the existing connections, the analysis foresees also the opening of a new network node working on 220 kV. The first output leads of 110 kV from the mentioned node are to be assumed in the year 2000. In the calculations made with the use of the IPM model, this connection is subject to optimisation and becomes an alternative for new local electricity generation sources.

PPDC is linked to the neighbouring distribution companies through currently nine 110 kV lines. In the IPM model, contracts for the purchase and sale of electric energy are reflected by means of, among others, change of connection capacity, amounts of energy exchange, availability of those connections, costs of energy for particular links and time zones into which every 24-hour period is divided.

The prices of electric energy from the network nodes of PPGC were prepared for the calculation needs in two following alternatives:

a) for the years 1995-1997 (same values for both cases) prices of energy for the evening peak, morning peak and the remaining hours of a 24-hour period were assumed to be average energy prices for each of those years according to the data provided by PPDC,
b) for the years 1998-2010 (different values for the two alternatives):

- projection of changes of energy prices in the years 1998-2010 prepared by PPDC presented in the study [5],
- change dynamics of average marginal costs for the entire power system in accordance with IRP-2 in the years 1998-2010.

Energy prices for connections with distribution companies were increased by the charges for energy transit services.

Existing and new local sources

In the area of operation of PPDC there are two public CHP plants (Garbary and Karolin I) and a number of facilities included in the group of autoproducers. The group contains mainly plants built for the needs of the food industry (sugar factories) and metallurgical industry (two metal foundries: (Srem and Poznan).

In the area there are also five small hydro power plants belonging to PPDC and ten private small hydro plants from which energy is purchased. For the coverage of the future power and energy demand increase, four generation technologies were chosen which may influence the power and energy balance of PPDC Those are:

1. gas turbine (163 MW)
2. steam-gas cycle 1 (466 MW)
3. steam-gas cycle 2 (205 MW)
4. hydro power plants (max. 0.5 MW by the year 2010).

DSM programmes

As an alternative to the construction of new connections and new generating sources, the analysis assumes the introduction in the area supplied by PPDC of the programmes, which are to reduce the demand for power and energy. Three such programmes were analysed which were previously used in the works connected with IRP-2. The valuation made by PPDC revealed that two such programmes may be adopted in the area of PPDC (compact fluorescent lamps – CFLs and water heaters).

The cost of introduction of DSM programmes was not examined in detail. For the purpose of calculations the values from IRP-2 were assumed: 23.8 PLN for the use of one CFL and 45.8 PLN for one water heater.

2.2 Analysis Results and Conclusions

The calculations produced four development variants, two for each demand forecast for the area of PPDC. Those are as follows:

a) low-case energy demand forecast and prices for electric energy according to EP-C SA (100N),
b) high-case energy demand forecast and prices for electric energy according to EP-C SA (100W),
c) low-case energy demand forecast and prices for electric energy according to IRP-2 marginal costs dynamics (200N),
d) high-case energy demand forecast and prices for electric energy according to IRP-2 marginal costs dynamics (200W).

For each variant, the following values were established for the years 1995-2010:

- electric load balance,
- electric energy balance with the structure of PPDC demand coverage,
- structure of costs connected with covering the demand.

Figures 3 and 4 present the hypothetical structures of energy demand coverage for variants 100W and 200W.

The performed analyses lead to a number of conclusions concerning the decisions on the future coverage of demand for electricity for the area of operation of PPDC From among the examined options, the most advantageous way of demand coverage is the construction of new combine steam-gas units.

With the assumed input data, the use of network connections with neighbouring distribution companies for the purchase of electric energy in case of demand increase seems less profitable. This applies to both alternatives of energy price change forecasts used for the calculations.

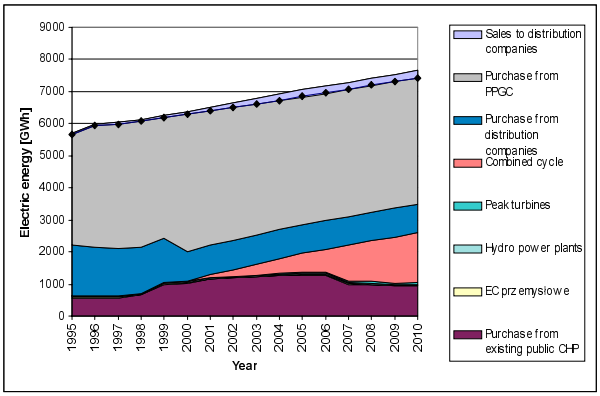

Figure 3. Structure of electricity demand coverage in the area of PPDC (high-case energy demand forecast and prices for electric energy according to EP-C SA)

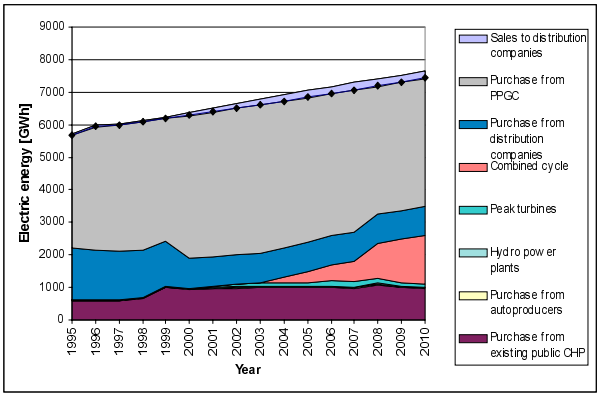

Figure 4. Structure of electricity demand coverage in the area of PPDC (high-case energy demand forecast and prices for electric energy according to IRP-2)

As follows from the performed calculations, the option of building a new network connection on the transmission system level as a source of additional supply is not an attractive business option for any of the four examined development variants.

Two DSM programmes diminishing the demand for power and energy were examined as solutions competing with the construction of new sources (peak turbines, steam-gas cycle or new connections).

The calculations revealed that the only programme applicable in the territory of PPDC is the use of CFLs. That programme is chosen for all calculation variants. The second programme (water heaters) was not chosen for any alternative due to correction in the input data connected with the elimination of the effects of that programme on the decrease of load demand in peak hours.

The economic calculations concerning the integrated resource planning for PPDC were then supplemented with financial calculations [6].

3. FINANCIAL ANALYSIS BASED ON INTEGRATED RESOURCE PLAN

The financial projections in the described calculations (consistent with the earlier developed IRP for PPDC) were made with the financial model MAF-L [7] on the basis of the methodology of revenue requirements on the following two levels:

- the „generation - area of PPDC" level, also referred to in the financial analysis as „consolidated producer", covering existing and potential local sources of electric energy in the area of operation of PPDC,
- the „distribution - PPDC" level concerning directly the activities of PPDC in the field of distribution of energy.

The analyses on the „distribution - PPDC" level take into account the calculation resulting from the „generation - area of PPDC" level as well as additional contracts for the purchase and sale of energy within the framework of operations of PPDC,

System financial data concern the adoption of scenarios of future income taxes and rate of inflation. They were based on statutory regulations, forecasts of the Ministry of Finance and independent economic organizations (see Table 1).

Table 1
Values of income tax and inflation rate in the years covered by the forecast range assumed for the purposes of the financial analysis

	1996	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Tax	0.4	0.38	0.36	0.34	0.32	0.32	0.32	0.32
Inflation	0.185	0.135	0.11	0.1	0.09	0.08	0.08	0.08

	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Tax	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Inflation	0.07	0.07	0.07	0.06	0.06	0.06	0.05

Forecasted financial parameters for the power sector for 1996-1998 partly reflect the actual state of affairs, hence the limitations connected with the non-market nature of the sector. The forecast is already based on assumed market expectations, particularly the acceptable return on equity (ROE is one of the crucial input figure to the model). Due to the prepared privatisation of power enterprises, the year 1999 takes into consideration the possibility of raising funds through the issue of stock.

Assuming the level of acceptable return on equity of PPDC for the years 1998-1999 practically means that the analysed development scenarios do not foresee any return in those years.

For each of the development variants, the following financial statements were prepared:

1) balance sheet,
2) profit and loss account,
3) cash flow statement,
4) revenue requirements,
5) required (total) capital,
6) path of averaging electricity price,
7) selected financial indexes.

All the financial reports were presented in alternative versions: in fixed prices and in current prices. Figure 5 shows the results of calculations of averaging electricity price sold to customers by PPDC in the years 1996-2010 in current prices. The results of the projection are estimates and were prepared to illustrate the development of the

economic situation of the examined power plants in the area of PPDC which satisfy the current and future electricity demand of local customers. The analysis is an attempt to specify the influence of the changed manner of fixing the purchase price level from PPGC on the results of calculations.

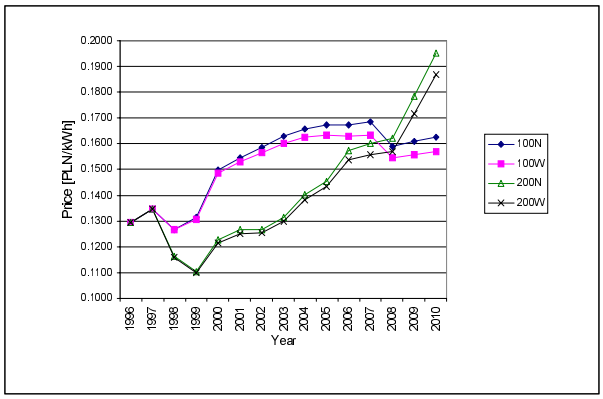

Figure 5. Averaging (current) prices of electricity for customers of PPDC for the four alternatives.

Derived for PPDC quantities for revenue requirement, i.e. average purchase prices and selling prices of electric energy show the change dynamics (trends) close to revenue dynamics. Electricity purchase prices are higher for the variants assuming quicker increase of demand and for the purchase of electricity from PPGC on the basis of marginal costs change dynamics. Selling prices do not show such a clear tendency to change under the influence of the factors analysed above.

4. SUMMARY

1. Due to the advancement of the market processes in the Polish power sector, distribution companies will face more competition and will be main animators of local energy markets. At the same time, there will be an increasing tendency to treat electric energy as any other commodities subject to trade.
2. The changing conditions in which distribution companies operate fundamentally influence their medium- and long-term development strategies. Since distribution companies participate mainly in electricity costs, this particularly applies to the choice of sources of supply for end users in the serviced area.
3. One of the possible manners of defining the so-called optimum purchase portfolio may be the application of IRP, which methodology was used on the example of PPDC. On the basis of assumptions and input data the alternatives of the optimum electricity purchase portfolio for end users by the year 2010 were outlined.
4. On the basis of the obtained results related to sources of purchase of electric energy, alternative financial forecasts for PPDC were prepared with the necessary revenue requirements method together with specification of the end user average price projection.
5. The forecasts, reflecting the influence of assumed input data, particularly the forecast concerning the changes in demand for peak load and electric energy, evidence the need of gathering data of that type in professional databases by distribution companies.

5.REFERENCES

[1] J. Andruszkiewicz, “Integrated Resource Planning at the Regional Level”, *Information Bulletin of the Polish Society for Transmission and Distribution of Electric Energy*, no 2/1995, pp. 12-21, (in Polish);

[2] J. Andruszkiewicz, “Opinion of the Polish Society for Transmission and Distribution of Electric Energy on the Study: Integrated Resource Plan of Electricity Generation Sources Assumptions and Preliminary Results of the Second Calculation Loop (ZPR-2)”, Warsaw (November 27-28, 1996), (in Polish);

[3] “Evaluation of the IPM Model Possible Utilization for Integrated Resource Planning at the Level of Distribution Companies on the Example of Poznan Electricity Distribution Company. PEDC & PPGC Report”, Poznan - Warsaw (1998), (in Polish);

[4] “Integrated Resource Plan of Electricity Generation Sources (ZPR-2)”, Development Department PPGC, Warsaw (1998), (in Polish);

[5] “Analysis of the Possibilities of Optimum Peak Load and Electric Energy Demand Coverage in Poznan Electricity Distribution Company by the Year 2010”, Energoprojekt Consulting SA, Warsaw (1998), (in Polish);

[6] “Evaluation of the IPM Model Possible Utilization for Integrated Resource Planning at the Level of Distribution Companies on the Example of Poznan Electricity PEDC & PPGC Report”, Poznan - Warsaw (1998), (in Polish);

[7] J. Sidlarewicz, T. Laski, “The MAF-L Financial Model, Reference Manual”, JES Energy Ltd., Warsaw (1998), (in Polish).