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PHYSICAL AND TECHNICAL ENERGY PROBLEMS

SMALL HYDROPOWER IN LATVIA AND INTELLECTUALIZATION OF ITS OPERATING SYSTEMS

A. Mahnitko, J. Gerhards, O. Linkevics, R. Varfolomejeva, I. Umbrasko

Riga Technical University, Institute of Power Engineering,
1 Kronvalda Blvd., Riga, LV-1010, LATVIA
e-mail: mahno@eef.rtu.lv

The authors estimate the potential for power generation from water resources of small and medium-sized rivers, which are abundant in Latvia. They propose the algorithm for optimal operation of a small-scale hydropower plant (SHPP) at the chosen optimality criterion in view of the plant's participation in the market. The choice of SHPP optimization algorithm is made based on two mathematical programming methods – dynamic and generalized reduced gradient ones. Approbation of the algorithm is illustrated by an example of optimized SHPP operation.

Keywords: *small-scale hydropower, smart grids, optimization, operating algorithm, income.*

1. INTRODUCTION

In the last decade the interest has increased in the development of renewable energy resources, both non-traditional (solar, geothermal, wind power) and traditional – first of all the hydro-energy of rivers. This energy will continue in use since the demand structure is becoming ever more complicated, which is explained by the economic development of the territories covered by centralized supply. Therefore, consumers seek for independent small-capacity generators which would operate on local energy resources, especially on hydro-resource of small rivers [1-6].

The favourable conditions for economic incentives of the consumers as to the installation of personal generating capacities promote the development and improvement of renewable energy technologies and small energy generation – so-called "distributed generation". This term defines different energy sources of limited size, renewable energy resources and conventional ones, which are connected directly to the distribution network [3, 7]. The main advantage of distributed generation is reducing the operating and capital costs while providing the peak loads, the power quality improvement, and the possibility to increase the time for technical renovation of the power systems (PSs); besides, the transmission losses are smaller, the power supply reliability is higher, etc. [8].

The EU Energy Policy envisages increase in the share of renewables for energy production. According to Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of renewable energy sources and the amending and subsequently repealing Directives 2001/77/EC & 2003/30/EC, the target set for Latvia (one of the highest in EU) is to raise by 2020 the renewable energy share in the gross final consumption to 40 %.

2. THE POWER INDUSTRY CONCEPT

The modern concept of power industry development is based on the creation of smart grids and meters, multilevel generation control, as well as on distribution and consumption of electricity, the use of digital technologies, etc. [2, 4, 5, 9-12].

In Europe, the Smart Grid concept is associated with the integration of renewable energy of power systems and the formation of active and adaptive qualities of distribution networks (e.g. self-diagnostics and self-recovery). In addition, emphasis is placed on the accounting devices that are to be connected to a single information network, which allows optimizing the energy consumption for different time of a day.

The Smart Grid concept is intended to reach the following key objectives:

- to increase the reliability of supply in a PS;
- to improve the energy efficiency;
- to protect the environment.

The key development segments of Smart Grid technologies are:

- energy accounting;
- automation of distribution networks;
- management and monitoring of electrical equipment;
- automation of the main electric networks and substations;
- control of the flows;
- distribution intelligence and consumer engagement;
- non- conventional and renewable energy sources.

3. SMALL HYDROPOWER ENGINEERING

As compared with other conventional forms of electric power engineering, modern hydropower engineering is the most economical and environment-friendly way of generating electricity, with small hydropower going even further. Currently, no unified worldwide criteria exist for adding hydropower plants (HPPs) to the category of small ones (SHPPs). Moreover, in some countries these criteria change over time. The range of installed powers which sorts out an HPP to the category of SHPPs is quite wide in different countries – from 0.1 kW to 30 MW [6, 13]. In Latvia, the HPP is considered small if its capacity is ≤5 MW.

In the world, many factors exist that contribute to increased attention paid on the development of small hydropower engineering, but the main factor is the already achieved high level of the mastered part of hydropower engineering resources which are used for the construction of large HPPs [6].

An SHPP preserves the natural landscape and does not affect the environment – neither during the exploitation nor in the process of construction.

No negative impact on the quality of water occurs, so it fully retains its natural properties: fish remains in rivers, water can be used to supply population.

Unlike other renewable energy sources such as sun and wind, small hydropower engineering is almost independent of weather conditions and is able to provide stable supply of cheap electricity to consumer.

Another advantage of the small hydropower engineering is the economic efficiency. Under the conditions when natural sources of energy (oil, natural gas, coal) are due to be finished and are constantly becoming more expensive, the use of cheap and affordable renewable energy of rivers, especially small ones, allows producing cheap electricity. In addition, the construction of SHPPs (compared with large hydropower facilities) costs less and pays back quicker. An SHPP can be put into operation within 15-18 months [14]. Reservoir is not typical for SHPP, which means the least impact on water. Construction of a dam is only necessary in some cases for the accumulation of resources (water) or for the creation of hydraulic pressure in the areas with flat topography.

An SHPP does not cause significant environmental damage, even in the case when an artificial reservoir is created to regulate the water level in the upper part of a river. Water behind the dam is filled with air using special equipment, which results in increased oxygen content of the water. To control the movement of fish the screens and barriers are used (including acoustic ones). Special fish conductors (meant for migratory fish species) are made that allow fish to move upstream. In general, the impact of small hydropower engineering on the fish and aquatic ecosystems is negligible provided special protective measures are taken.

It should be noted that the negative impact on environment typical of large HPPs (violation of thermal, hydraulic and climate conditions of the area) is not characteristic of SHPPs, which in most cases use natural pressure of water without the need of large-scale construction of hydro engineering structures.

It is easy to notice that the development of the above listed key segments of the modern concept of energy is directly related to small hydropower engineering.

4. WATER RESOURCES IN LATVIA

The problem of using water resources in Latvia has always been relevant, regardless of its economy [13, 15-17]. According to the data of [6], the theoretical* and technical** potentials of small hydropower engineering of the Baltic region are respectively 6.1 and 2.4 billion KW/h. The use of the technical potential of water resources is limited due to shortcomings of the existing technologies and equipment for electricity production using the water flow of rivers. This potential is therefore rising with improvement of the equipment and development of new technologies. The economic*** (commercial) potential of water resources is so far even smaller, which can be explained by economic, environmental, social, legal, and other constraints.

* the maximum possible capacity of energy resource

** part of the theoretical potential which can be practically used at the current level of science and technology

*** part of the technical potential the development of which is economically feasible under present conditions, at the current level of prices for equipment, materials, labour, and competing energy resources

Nowadays, to set the total economic potential of small hydropower engineering in Latvia is almost impossible because of the lack of reliable technical and economic indicators of all conditions for construction of SHPPs. Currently, research of cost-effective technical solutions for SHPPs is being conducted and requires the development of relevant methods and energy schemes for the use of small rivers. Since the main directions of small hydropower engineering development for the next 10-15 years are to be the re-entry and recovery of decommissioned SHPPs and mills as well as the modernization and reconstruction of existing facilities, this issue is still open. Now it is hotly debated, and the final decision is being delayed by the "green" who argue about inevitable environmental hazards. In turn, those who adhere to the use of river resource potential remind about the economic loss to be caused by the lack of electricity. In particular, to halt the construction of the Daugavpils HPP was the worst decision, which had a negative impact not only on the development of hydropower engineering, but on the entire economy of the country [17].

According to the Directive 2009/28/EK, the EU countries have to work out supporting programmes of their own, which would promote the use of renewable energy sources. In Latvia, a number of relevant regulations and rules have been issued; however, they do not allow finding a compromise between two irreconcilable parts of society – the SHPP-owners and the "green". As a result, since 2003 the SHPPs have been restored only partially.

Latvia possesses more than 200 medium-size and small rivers, with ~547 sites suitable for construction of SHPP [13, 15, 16]. At present, the number of SHPPs exceeds 144. These SHPPs can sell their electricity at a price higher than the average: e.g. in 2011 this price was 3.7 times higher than average for buying.

Currently, small-scale hydropower plants give 1% of electricity in Latvia [13]. With technological improvement of the power generation by SHPPs, this value can be raised by 10-20%, whereas the potential of small and medium-sized rivers for power generation in Latvia is at least four times higher.

4. GENERAL INFORMATION ON THE SHPPs

As far as known, the energy of water in the nature exists in three forms: mechanical, thermal and chemical. The mechanical power implies the ability of falling water to do work. Its amount is determined by the production of the falling water mass and the covered distance *S*:

$$A_p = m \cdot S, \quad kgm. \tag{1}$$

Depending on the water conditions (rest or motion) there are two types of energy state: potential and kinetic. Potential (or rest energy) is characteristic only for the water raised state. Particularly, this refers to standing water (lakes, ponds, swamps) in relation to lowlands. The lowest level – at which the potential energy is determined – is the average level of the mouth relatively to the sea. Raised water on high ground – due to its circulation in nature – accumulates the energy of the Sun (in the form of potential energy). Once the water is flowing, it does work.

In this case, the potential energy accumulated in the mass of water is released and converted into the kinetic energy:

$$A_k = \frac{m \cdot v^2}{2}, \quad kgm, \tag{2}$$

where v is the falling speed (movement speed) of water, m/s.

Conversion of the mechanical energy of free-flowing river water into electricity is performed at hydropower plants.

Hydropower is the mechanical energy of water. Its amount is expressed by the known formula:

$$A_p = \gamma \cdot W \cdot H, \tag{3}$$

where A_p is the potential energy, kgm; W is the water volume, m^3; γ is the water volume density (γ = 1000 kg/m^3); and H is the water drop height ($H = h_1 - h_2$), m.

The main expression of the hydraulic energy can be written in kgm as

$$A_p = \gamma \cdot Q \cdot H \cdot t \tag{4}$$

where Q is the used water amount during the time interval (s); t is the time interval (s) in which the total amount of water (W, m^3) is used.

The amount of the work completed per time unit is called capacity:

$$P = 1000 \cdot Q \cdot H, \text{ kgm/s} \tag{5}$$

and could be expressed in kW (1 kW=102 kgm/s):

$$P = 9.81 \cdot Q \cdot H \tag{6}$$

The capacity of a hydro-unit is determined by the expression:

$$P_{SHPP} = 9.81 \cdot \eta_{HA} \cdot Q \cdot H \tag{7}$$

where η_{HA} is the efficiency factor of hydro-unit: $\eta_{HA} = \eta_{turb} \cdot \eta_G$, η_{turb} being the turbine efficiency factor; η_G is the generator efficiency factor (all the parameters are given in relative units).

In general, η is the function of pressure H and used amount Q of water, i.e.

$$\eta = \eta(H, Q). \tag{8}$$

This function is formulated either in the form of a graph or a polynomial approximating dependence (8). In the exact model it is necessary to take into account that the pressure H (mainly due to changes in the level of the lower river) depends on the water flow in a given time and the water consumption in the preceding intervals (due to changes in the level of the upper river).

In the regime calculation of any HPP the information on its hydraulic units is required which is contained in the characteristics of hydraulic turbines [18-19]. Universal characteristics of hydraulic turbines (efficiency in dependence on the shaft power and pressure) and the specifications are provided by the manufacturer;

these are obtained in the model laboratory tests of hydraulic turbines or their real tests at an HPP.

The efficiency of an SHPP in market conditions is determined by the profit received during the billing period. This parameter is derived for the operation at which the maximum total hydroelectric power generation and the highest sale price in the market are reached for a definite water inflow in a given period. The corresponding algorithm for optimal operation of an SHPP at the chosen optimality criterion allows solving the problem.

5. DESCRIPTION OF THE ALGORITHM

By its nature, the optimization algorithm determines the system's regime control of an SHPP that does not have reservoir and is running by the natural flow of water. In designing the optimization algorithm a classic monograph by V. M. Gorshtein [18] was used along with the algorithm for dispatch schedule and filling a reservoir drawdown a large hydropower with parallel operation of the thermal power plants in the PS [20, 21]. The algorithm is based on the method of dynamic programming (DP), whose ideas and ways of its implementation are described in detail in [22]. The DP method belongs to the class of so-called multistep (multistage) processes of decision-making: for each interval the trajectory (strategy) is found which is optimal (the best one) in terms of the income – in a given time interval and in all previous ones.

The DP method provides a global solution to the optimization task. Such properties of the objective function as linearity, non-linearity, etc., are unimportant here; it is only necessary to determine the value of this function at different points. The only condition is the requirement of additivity regarding the objective function for optimization of the whole process. Its value should be equal to the algebraic sum of incomes at each stage (interval). An example of implementation of the DP method for solving the tasks of optimal network development is given in the well-known monograph by V. A. Dale, *et al*. [23]. Other examples of solving the power industry problems by the DP method are provided in [19, 21, 24].

6. SHPP MANAGEMENT SYSTEM

The variety of possible types of a technological SHPP as source of energy creates some difficulties while developing its control system. It is required that this system ensures the optimum operational condition, monitors the equipment condition, distinguishes the abnormal and pre-emergency situations at SHPP and prevents their development, providing with the necessary information the operative staff at the control centre of a distributive network as well as the consumers. The intellectual basis of the modern control systems and dispatching is the software and the algorithm complex that enable optimum working conditions of a SHPP online under varying load of a consumer. Besides, the mandatory should be registration of the temporal, daily and seasonal weather changes and the climatic conditions. In opinion of experts (see, e.g. [4, 11, 12]), the entire basic functionality of smart control systems should be provided at the program level.

The hydrolycity of the natural water flow in a river is not the same as, e.g. that of electricity consumption, etc.; therefore, a need for redistribution of the natural flow could arise in its regulation. For an SHPP running on natural water flow the period of regulatory regime is 24 h. Consequently, one of the conditions to meet the proposed operational condition of SHPP is to spend during the period of regulation a definite water amount (equal to the inflow). The water pressure variation has to meet definite requirements – for example, requirements of related fields (fishing, agriculture, water supply, etc.). Consequently, the change in the water level should be limited by the H_{min} and H_{max} values, i.e.

$$H_{min} \le H \le H_{max} \tag{9}$$

The water pressure change in the SHPP is caused by the upstream and downstream water levels (i.e., due to the consumption of water flowing through SHPP turbines).

7. ALGORITHM FOR SHPP TO GAIN THE MAXIMUM INCOME

Mathematically, the task of gaining the maximum income from an SHPP at the already known water inflow and forecast of price on the market can be formulated as maximization of the function:

$$I(P_1, P_2, ..., P_j) = \sum_{j=1}^{J} I_j(c_j, P_j) \to max \tag{10}$$

under condition (2) and considering the balance of water drawdown during the regulatory period of the SHPP:

$$\sum_{j=1}^{J} Q_j \cdot Dt_j = W_j \, . \tag{11}$$

In (10), $I_j(c_j, P_j)$ is the income from sale of electricity produced at the SHPP during time interval Δt_j at the known market price c_j [25], €; T is the regulation cycle duration: $T = \sum_{j=1}^{J} \Delta t_j$; Q_j is the water flow through the SHPP in the time interval *j*, m^3/s; W_j is the set amount of water that could be passed through the SHPP per regulation cycle (day, week, etc.).

Electricity production by SHPP in interval Δt_j is $P_j \cdot \Delta t_j$. Knowing the domestic inflow (natural usage of river flow) W_j, we determine the water use of SHPP in each interval of the regulatory period by pressure change ΔH in a predefined range and the known mirror surface of the river.

Taking into account a relatively small change in the water pressure (a few cm) in the observed SHPP, it is possible to restrict it with a small step *h*. The pressure levels may be labelled H_j^i, where the subscript index *j* indicates the number of the time interval of the regulatory cycle ($j = \overline{1,\ 24}$), and superscript index *i* – the number of pressure value which depends on the chosen discretization step of pressure.

8. APPROBATION OF OPTIMIZATION ALGORITHM

The efficiency of the developed algorithm can be illustrated by the example of optimizing the regime of an SHPP (Berzes river). The initial data are [26-28]: installed capacity 300 kW, efficiency 0.85 rel. units; the maximum water level before the dam 8.2 m, the minimum acceptable level of the SHPP pool 7.9 m (in accordance with the environment protection regulations of Latvia); the average annual flow of the river 2.4 m^3/s; river basin surface 274000 m^2. To control the level of water and in order to find the value of the water pressure in a specified range the microcontrollers are used. In addition to the initial data on SHPP, the graphs of variation in the market prices for a given period are employed [26].

To assess the influence of the step value for the considered SHPP this was taken 0.025 m and 0.01 m. The values of these steps are to be considered at the end of time interval (from the 1st to the 23rd) – 13 and 30 discrete marks of water level, respectively. Figures 1, 2 show the changes in the river water levels before dam obtained by the DP method for different values of steps.

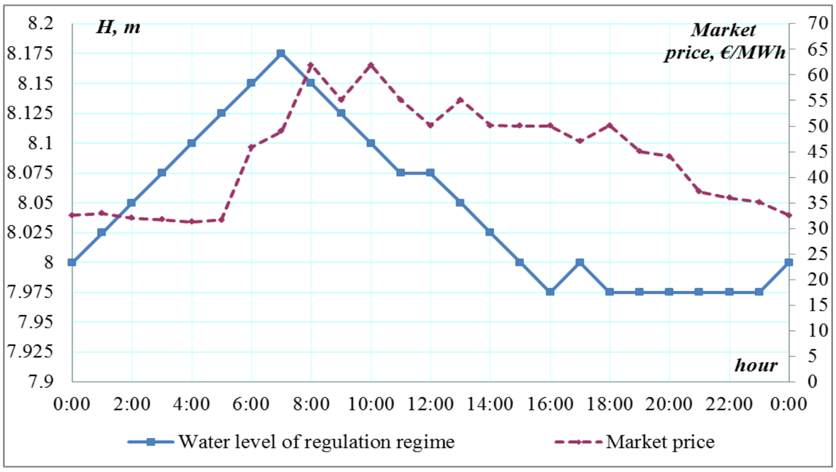

Fig. 1. Water level before dam obtained at optimization using DP method (step 0.025m).

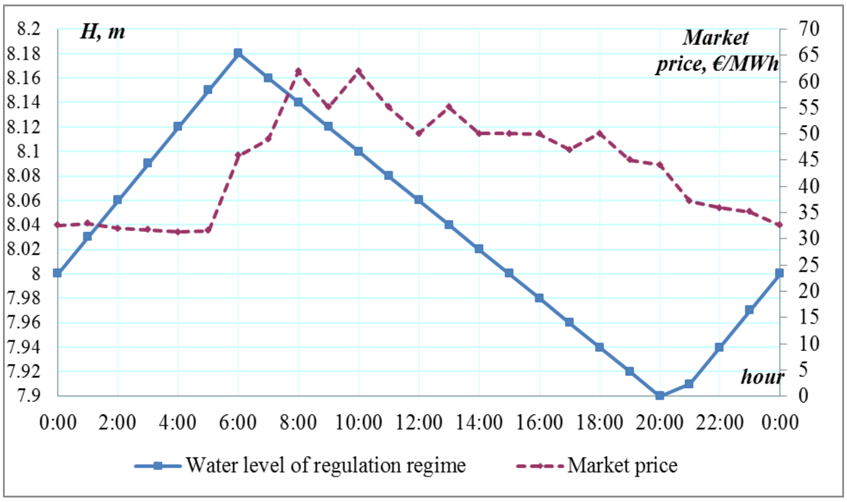

Fig. 2. Water level before dam obtained at optimization using DP method (step 0.01m).

Figures 3, 4 illustrate the power changes using the proposed algorithm for the control of SHPP operation depending on the pressure change at the end of each hour in a 24-h period. It is seen that the SHPP income due to optimization by DP with the selected step 0.025 m is 192.23 €, while at a 0.01 m step the SHPP regime is more optimal and the income is 196.86 €. In turn, in Figs. 5-6 the optimization results are presented for SHPP and control system's operation at using the generalized reduced gradient (GRG) method. The SHPP income with GRG optimization is 217.83 €, which is greater than at using the control algorithm obtained by DP method. It is easy to see that in the latter case the results are more consistent with the SHPP technological process: considering the limitations on the amount of water used during a day, the plant in some hours is not in the running condition and accumulates water. The last circumstance allows making the required preventive works at the SHPP.

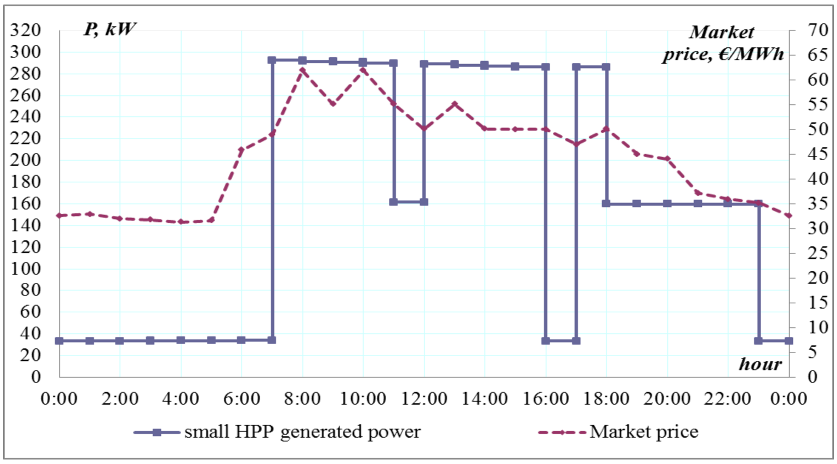

Fig. 3. The market price and generated power obtained at optimization using DP method (water level step 0.025m).

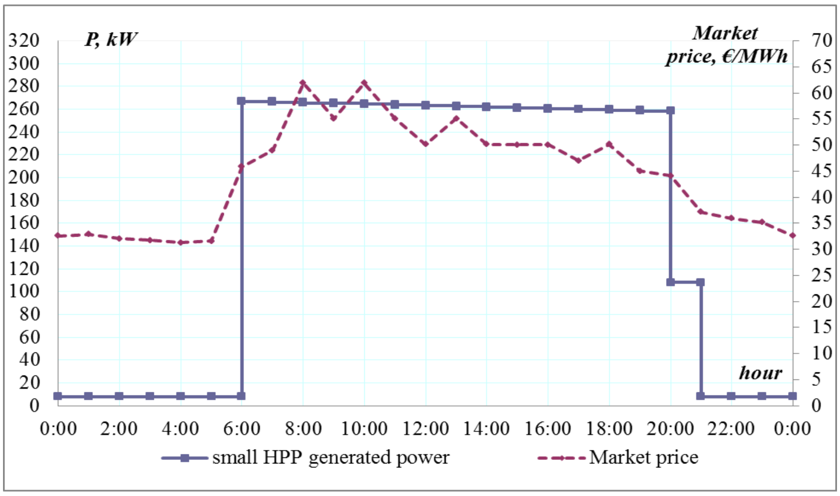

Fig. 4. The market price and generated power obtained at optimization using DP method (water level step 0.01).

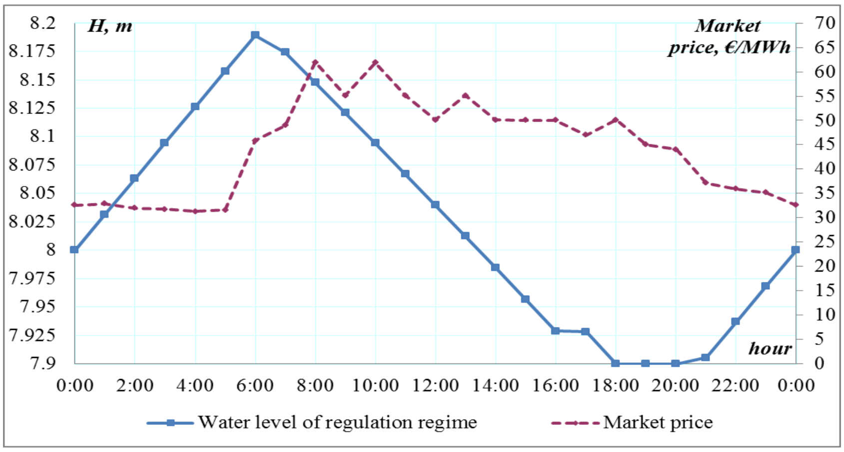

Fig. 5. Water level before dam obtained by optimizing with generalized reduced gradient method.

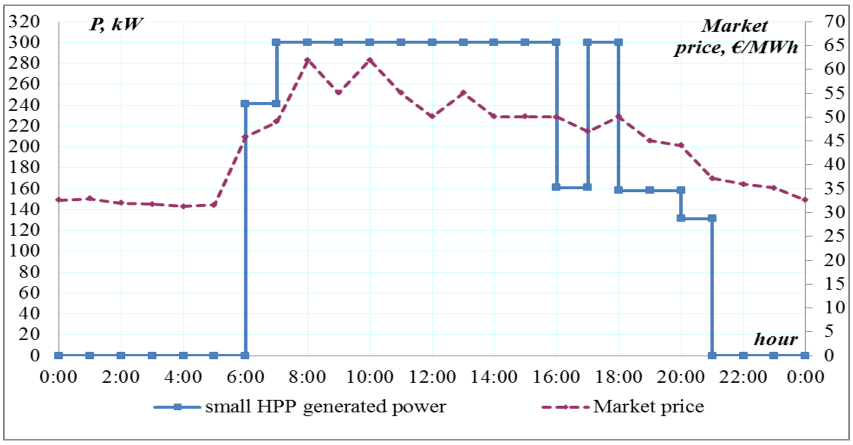

Fig. 6. The market price and generated power obtained at optimization using the GRG method.

The obtained results clearly show the influence of the control algorithm for an SHPP on the optimization of its regimes. Calculation of SHPP capacity and the use of the water flow in each interval should be in compliance with its dependence on the specific change in the water pressure but not on the average pressure value. In this regard the authors of the present paper have serious doubts as to the adequacy of the SHPP power calculation in each time interval of the regulatory period according to the formula given in [28]:

$$P = g \cdot \eta \cdot Q_i \cdot \frac{(H_i + H_{i+1})}{2} .$$

This is easy to verify by simple calculation. We will assume that at the end of each interval of the regulation cycle (except the last, where the final pressure of level is set H_k) there are three states of pressure: H_o, H_{min} and H_{max} (H_o=3 m, H_{min}=2 m and H_{max}=4 m). Taking the last interval only, it is easy to see that the mentioned formula from [28] is valid only in the case, when the pressure at the end of the penultimate interval in the optimal SHHP schedule is equal to the initial pressure H_o, which itself determines the incorrectness of the final result of optimization, which that does not allow us to consider that at the beginning of the next period of the SHPP regime management the water pressure will be equal to the initial value H_o. As a result, the volume of sold electricity determined using the above formula of capacity for SHPP is not true. It is clear that this fact does not comply with the Smart Grid concept of energy resources. In addition to the already mentioned facts, it is necessary to indicate the inconsistency of the illustration in [28] with the essence of dynamic programming, which evidences that the calculation scheme in that work is not fitted for the implementation of this method.

9. CONCLUSIONS

1. Latvia – owing to its geographical position – possesses more than 200 small and medium-sized rivers, and, consequently, a high hydro-energy potential for electricity production. With the improvement and development of new technologies, the Latvian energy economy can significantly raise the national energy supply and the level of energy independence by generating electricity using water resources.
2. Considering the adopted requirement for the use of local renewable energy, Latvia sooner or later will have to seriously discuss the issue related to using the potential energy of water resources of small and medium-sized rivers.
3. Smart basis for the control over small HPP operation should have a corresponding complex of algorithms and programs realized in the control devices (controllers and sensors). On the electricity market with participation of an SHPP appropriate devices are used to control its regime at a limited inflow of water, which allows reaching the maximum power generation and income from sale at the highest price.
4. The relevant mathematical programming methods allow the most appropriate algorithm to be chosen for controlling the SHPP operation at limited water resources.

REFERENCES

1. Фортов, В.Е., & Попель, О.С. (2011). *Энергетика в современном мире*. Долгопрудный, изд. дом " Интеллект ".
2. Фортов, В.Е., & Макаров, А.А. (2009). Направления инновационного развития энергетики мира и России. *УФН, 179* (12), 1337 – 1353.
3. Зайченко, В.М., Цой, А.Л., & Штеренберг, В.Я. (2008). *Распределенное производство энергии*. М.: БуКос.
4. Директор, Л.Б., Зайченко, В.М., & Майков, И.Л. Интеллектуальные системы управления автономными энергетическими комплексами в составе локальных распределительных сетей малой энергетики. *Известия РАН (Энергетика)*, (1), 38 – 48.
5. Чусовитин, П.В., & Ерошенко, С.А. (2010). Актуальные проблемы развития энергосистем. *Всероссийская научно-техническая конференция*: *Энергетика глазами молодежи*. Екатеринбург, УГТУ-УПИ, 7 – 13.
6. Михайлов, Л.П., Фельдман, Б.Н., Марканова, Т.К., и др. (1989). *Малая гидроэнергетика*. М.: Энергатомиздат.

7. Akorede, M.F., Hizam, H., Aris, I., & Ab Kadir, M.Z.A. (2010). A review of strategies for optimal placement of distributed generation in power distribution systems. *Research Journal of Appl. Sciences, 5* (2), 137-145.
8. Gil, H.A., & Joos, G. (2008). Models for quantifying the economic benefits of distributed generation. *IEEE Trans. Power Systems, 23,* 327 - 335.
9. Costa, L.M., & Kariniotakis, G. (2007). A stochastic dynamic programming model for optimal use of local energy resources in a market environment. *Proceedings of Power Tech. Conf.* 1 -5 July, Lausanne (Switzerland).
10. Tsikalakis, A.G., Dimeas, A., Hatziargyriou, N.D. *et al*. (2006). Management of microgrids in market environment. *Intern. J. of Distributed Energy Resources, 2* (3), 177-193.
11. Freris, I., & Infield, D. (2008). *Renewable Energy in Power Systems*. John Wiley & Sons.
12. Baldinger, F., Jansen, T., Riet, M., & Volberda, F. (2010). Nobody knows the future of Smart Grid, therefore separate the essential in the secondary. – Developments in Power System Protection. *The 10-th IET Intern. Conf. (DPSP 2010)*. 29 March - 1 April, Manchester (UK) .
13. *Mazā hidroenerģētika Latvijā 2012.* Rīga: SIA Haidenfelde, Mazās Hidroenerģētikas Associācija (MHEA).
14. Соловей, А. И., Лега Ю.Г., Розен В.П. и др. (2007). *Нетрадиционные и возобновляемые источники энергии*. Черкассы: ЧГТУ.
15. Balodis, J. (1951). *Mazās hidroelektriskās stacijas*. Rīga: Latvijas valsts izdevniecība (in Latvian).
16. Magelis, L. (1994). *Mazo HES ierīkošanas iespējas Latvijā*. Rīga: Autora izdevnieciba (in Latvian).
17. Осипов, Б.В. (1988). *Альтернативы строительству Даугавпилсской ГЭС*. Рига: Зинатне.
18. Горштейн, В.М. (1959). *Наивыгоднейшие режимы работы гидростанций в энергетических системах*. М.: Госэнергоиздат.
19. Синьков, В.М. и др. (1976). *Оптимизация режимов энергетических систем*. Киев: Вища шк.
20. Mahnitko A., & Vorps, H. (1992). *Energosistēmu režīmu optimizācija.* Rīga: RTU (in Latvian).
21. Gerhards, J., & Mahņitko, A. (2005). *Energosistēmu režīmu optimizācija*. Rīga: RTU (in Latvian).
22. Беллман, Р., & Дрейфус, С. (1965). *Прикладные задачи динамического программирования.* М.: Наука.
23. Дале, В.А., Кришан, З.П., & Паэгле, О.Г. (1979). *Динамические методы анализа развития сетей энергосистем.* Рига: Зинатне.
24. Gerhards, J., & Mahņitko, A. (2007). *Elektroapgādes sistēmu optimizācija.* Rīga: RTU (in Latvian).
25. Nord Pool Spot home page: http://www.nordpoolspot.com/Market-data1/Elspot/Area-Prices/ALL1/Hourly/
26. Small Hydropower Association home page: http://www.mhea.lv/component/content/article/62/73-brzes-dzirnavu-hes.html/ (in Latvian).
27. Latvijas Vides, Ģeologijas un Meteorologijas Centrs home page: http://www.meteo.lv/en/ (in Latvian).
28. Mutule, A., unc. (2012). Mazā hidroenerģētika un brīvais elektroenerģijas tirgus. *Enerģija un pasaule, 72* (1), 74-76 (in Latvian).

PAR MAZO HIDROENERĢĒTIKU LATVIJĀ UN TĀS STACIJU VADĪBAS SISTĒMAS INTELEKTUALIZĀCIJU.

A. Mahņitko, J. Gerhards, O. Linkevičs, R. Varfolomejeva, I. Umbraško

K o p s a v i l k u m s

Darbā analizētas tradicionālo un pieejamo vietējo atjaunojamo energoresursu – mazo un vidējo upju hidroresursa izmantošanas iespējas Latvijas enerģētikā. Tiek sniegts faktiskais materiāls šajā jautājumā, kas iegūts, balstoties uz oficiālos avotos publicētiem citu autoru iepriekš veiktajiem pētījumiem. Tiek atzīmēts, ka teritoriju, kas atrodas mazo upju tuvumā un nav ietvertas centralizētās elektroapgādes sistēmā, saimnieciskā apgūšana rada apstākļus patērētāju stimulēšanai izmantot autonomus vietējos energoresursus, ieskaitot hidroenerģiju, izmantojošas mazas jaudas energoiekārtas. Atjaunojamās enerģijas tehnoloģiju un iekārtu pastāvīga attīstība un pilnveidošanās veicinās mazo upju plūsmas izmantošanas elektroenerģijas ražošanas efektivitātes paaugstināšanos.

Mūsdienu enerģētikas attīstības koncepcija, kas balstīta uz viedo tīklu (smart grids) izveidi, ļauj paaugstināt mazās hidroenerģētikas darbības efektivitāti, integrējot to elektroenerģētiskajā sistēmā. Mazo hidroelektrostaciju (MHES) darbības vadības sistēmas intelektualizācijas pamatā jābūt kompleksam algoritmam un programmām, kas ļauj tiešsaistes (online) režīmā nodrošināt izdevīgu MHES darbības grafiku (režīmu) maksimālā ienākuma gūšanai, balstoties uz zināmu elektroenerģijas cenas prognozi attiecīgajam laika periodam (diennaktij).

MHES darbības optimizācijas algoritma, kas pēc būtības ir tās vadības pamats, izstrāde tiek veikta, balstoties uz klasiskās matemātiskas programmēšanas metodes - dinamiskās programmēšanas metodi un vispārināto reducēto gradienta metodi.

Izstrādājot programmu kodus, kas realizē autonomā režīmā strādājošas MHES optimizācijas algoritmu, nepieciešams izmantot speciālas aprēķinu procedūras, kas ir adaptīvas pret konkrētiem MHES ūdens spiediena ierobežojumiem. Algoritma aprobācija veikta uz konkrētas MHES režīma optimizācijas piemēra.

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