ՀՀ ԳԻՏՈՒԹՅՈՒՆՆԵՐԻ ԱԶԳԱՅԻՆ ԱԿԱԴԵՄԻԱՅԻ

ԻՆՖՈՐՄԱՏԻԿԱՅԻ ԵՎ ԱՎՏՈՄԱՏԱՑՄԱՆ ՊՐՈԲԼԵՄՆԵՐԻ ԻՆՍՏԻՏՈՒՏ

Աֆրա Մոսթաֆայի

ՔԱՄՈՒ, ԱՐԵԳԱԿԻ և ՄԱՐՏԿՈՑԻ ՀԻՄԱՆ ՎՐԱ ԷՆԵՐԳԻԱՅԻ ԳԵՆԵՐԱՑՆՈՂ ՀԻԲՐԻԴ ԲԱՇԽՎԱԾ ՀԱՄԱԿԱՐԳԻ ԷՆԵՐԳԱՍՊԱՌՄԱՆ ԿԱՌԱՎԱՐՈՒՄԸ ՀԱՇՎԻ ԱՌՆԵԼՈՎ ՄԱՐՏԿՈՑՈՒՄ ԷՆԵՐԳԻԱՅԻ ԿՈՒՏԱԿՄԱՆ ԷՖԵԿՏԸ ԱՐԵՑ ՈՒ ՔԱՄՈՒՑ ՍՏԱՑՎԱԾ ԷՆԵՐԳԻԱՅԻ ԳԾԱՅԻՆ ԿԱՆԽԱՏԵՍՄԱՄԲ

Ե.13.05 - «Մաթեմատիկական մոդելավորում, թվային մեթոդներ և ծրագրերի համալիրներ» մասնագիտությամբ

Տեխնիկական գիտությունների թեկնածուի գիտական աստիճանի հայցման ատենախոսության

ՍԵՂՄԱԳԻՐ

ԵՐԵՎԱՆ – 2016

NATIONAL ACADEMY OF SCIENCES OF ARMENIA

INSTITUTE FOR INFORMATICS AND AUTOMATION PROBLEMS

Afra Mostafaei

ENERGY MANAGEMENT OF HYBRID DISTRIBUTED GENERATION SYSTEM, WIND, SOLAR AND BATTERY WITH REGARD TO MEMORY EFFECT ON THE BATTERY AND LINEAR PREDICTION OF WIND AND SOLAR

ABSTRACT

For obtaining candidate degree in technical sciences in specialty 05.13.05 "Mathematical modeling, numerical methods and software complexes"

YEREVAN – 2016

Ատենախոսության թեման հաստատվել է ՀՀ ԳԱԱ Ինֆորմատիկայի և ավտոմատացման պրոբլեմների ինստիտուտում:

Գիտական ղեկավար`            տեխ.գիտ.դոկտոր        Մ.Վ.Մարկոսյան

Պաշտոնական ընդդիմախոսներ`   տեխ.գիտ.դոկտոր        Հ.Հ.Հարությունյան
                            տեխ.գիտ.թեկնածու       Ա.Ռ.Համբարյան

Առաջատար կազմակերպություն`  Հայաստանի ազգային պոլիտեխնիկական
                            համալսարան

Պաշտպանությունը կայանալու է 2016թ. Մարտի 30-ին, ժ. 16:00-ին ՀՀ ԳԱԱ Ինֆորմատիկայի և ավտոմատացման պրոբլեմների ինստիտուտում գործող 037 «Ինֆորմատիկա և հաշվողական համակարգեր» մասնագիտական խորհրդի նիստում, հետևյալ հասցեով`0014, Երևան, Պ. Սևակ 1:

Ատենախոսությանը կարելի է ծանոթանալ ՀՀ ԳԱԱ ԻԱՊԻ-ի գրադարանում:
Սեղմագիրն առաքված 2016թ. Փետրվարի 29-ին:

037 մասնագիտական խորհրդի
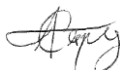գիտական քարտուղար, ֆ.մ.գ.դ.                               Հ.Գ.Սարուխանյան

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The subject of the thesis has been approved in Institute Informatics and Automation problem of NAS RA

Scientific advisor:         Doctor of technical sciences       M.V.Markosyan

Official opponents:         Doctor of technical sciences       H.H.Harutjunyan
                            Candidate of technical sciences    A.R.Hambaryan

Leading organization:       National Polytechnic University of Armenia

The defense of thesis will take place on 30 March, 2016 at 16:00 in Institute for Informatics and Automation Problems of NAS RA, during the session of the specialized council 037 "Informatics and Computing Systems", address: 0014, Yerevan, P. Sevak str. 1.

The thesis is available in library of IIAP of NAS RA.
The abstract is sent on 29 February 2016.

Scientific Secretary of the specialized council
Doctor of phys. math. sciences                           H.G.Sarukhanyan

# GENERAL CHARACTERIZATION OF THESIS

**Actuality of the subject:**
New energies sources due to multiple benefits are growing. These renewable systems are used in two kinds of connected to the network and separate from the network. Along with the many benefits of renewable energy systems, there is a fundamental problem, which is the reliability of such systems. Since renewable energies such as wind, solar, wave etc., have variable nature, so the reliability of these sources is a fundamental problem. To resolve this problem and utilization of new energies to generate power, hybrid systems are used, which are often combined with one or more renewable sources along with the backup system to compensate times of lack of power.

Among the most commonly used combination systems, systems consisting of wind turbines along with other sources of energy and in this context, many works have been carried out with different views. A number of hybrid systems that can be named include wind - diesel or wind - solar with backup systems and so on. Due to the widespread use of these systems in power generation, energy management issue in these systems is desired. In this thesis, a hybrid system consisting of a wind - solar with battery support was first modeled and then either fully and partially has been studied. Then, because of their variable nature, a prediction method (linear prediction) has been studied and finally, the main part of work (energy management this system) and energy management constraints including economic optimization and load management (with the method of cutting load) has been studied thoroughly. Electrical load management (ELM) is one of the most basic and most important branch of demand side management (DSM). Energy management in the proposed system is done by load management. Since, the main purposes of combining wind and solar units are to provide more reliable load consumption under different conditions of climate and on other hand, reduction of required system costs and also effects of load management on the economic and energy management issue, this study focuses on a detailed examination of the costs of a wind-solar hybrid power plant of the independent from over a 20 year period. Storage system used is a lead - acid battery bank and in addition to the cost of production and storage units, costs related to power electronic equipment is such as battery systems and charger and DC/AC inverter are considered in the calculations. Choosing the optimal combination of power plant was conducted using particle-bunch optimization algorithm. A condition that in the process of problem solving has always been considered is full coverage of the load in all year in two mode of without management and with load management. It seems that, since the new algorithm is used and the effects of various factors are considered, this work is unique in its kind. Features of this algorithm include simplicity, speed and convergence to the global optimum point.

**Purposes and objectives of work:**
The purpose of this thesis is combination selection from among of existing commercial equipments of the hybrid system studied for complete coverage of the load for a period of 20 years. Selection of the best combination is a compound that has the lowest cost during the choosed period. For this reason, the following objectives are formulated and solved:
- Load management and methods of its application,
- Modeling and simulation of system performance photo Voltaic PV photovoltaic /WG wind generator,
- Minimizing costs using intelligent algorithms PSO Particle Swarm Optimization,
- Influence of Environmental effect on energy management of system.

The noted tasks are solved with consideration and development of new algorithm and implementation of appropriate software package.

**The subject of research:**

Defining work principles of PSO; Minimization problem using PSO; Studying its metrics and limitation.

**Methods of research:**

The research was based on the study of literature and the experience of creating systems restores energy. Studies were conducted based on mathematical modeling techniques using PSO algorithms and software package MATLAB 7.1

**Scientific novelty:**

This thesis has the following innovations:

-The new optimized algorithm for hybrid system of the wind-solar with battery backup, which is a reliable and usable system in isolated areas of the network with having a convenient geographic location.

-This hybrid system to supply power has the capability of the variation in the sources number.

-The proposed method of energy management of this system with controlled load

**Reliability of results:**

The algorithm used to optimize the problem is PSO that in terms of categories, it is among the intelligent algorithms. This algorithm is a relatively new and presented at 1995. This algorithm is based on Social Intelligence of the organisms that live in mass. Not only PSO algorithm very quickly reaches the optimal point, but also the possibility of trapping in local extremes is very low. What will be applied in the present study, is a simple algorithm PSO using the inertia weight that to ensure optimized solutions obtained, the problem will be addressed in several times and with different initial populations (multi start technique ).

**Main points presented for the defense:**

- The optimum angle for solar panels installation;
- Optimum combination of mixed plant Wind – Solar;
- The results of energy management and optimization with application of load management;
- Estimation of influence the Environmental effect of energy management.

**Practical significance of results:**

The results are important for the organization of works in real environments, such as:

- providing more reliable load consumption under different conditions of climate;
- reduction of required system costs;
- reducing effects of load management on the economic and energy management issue;
- choosing the optimal combination of power plant using the particle-bunch optimization algorithm.

**Implementations:**

The proposed method and algorithm is taken for use in power plant in northwest region of Iran (Ardebil) for simulated management of distribution of energy of wind and solar generators.

**Approbation of the thesis:**

- The first international Scientific-Research conference 2014 Nanotechnology Applications of Electrical and Computer Engineering.Azad Sama university of Zanjan (Abhar);

- The first international Scientific-Research conference 16-17 September 2011, ISSN:1829- (Computer Science and IT), pp. 211, poster, Yerevan ,Armenia;

- The first international scientific-Research conference 2014 (computer science and IT) Azad
 university of Zanjan  (Abhar);

-In scientific seminars of YeTRI and IIAP of NAS RA.

**Publications:**
The main results of thesis have been published in 6 scientific publications, which are listed in the end of the abstract.

**Structure of dissertation:**
The thesis contains introduction, five chapters, conclusion, bibliography with 50 references and 2 appendixes. The main text includes 143pages, 73 figures, 13 tables and 109 formulas. The full text of theses with appendixes includes 154 pages.

## THE MAIN CONTENT OF THESIS

**In Introduction**, the actuality of the work is justified.

**In Chapter 1** the purposes and objectives of work, as well as the main points presented for the defense are formulated; the practical significance of results, the scientific novelty and the functional and structural features of renewable energy hybrid systems are presented.

**Section 1.1** in the wind power turbines, wind kinetic energy is converted into mechanical energy and then into electrical energy. A wind energy conversion system is shown schematically in Figure 1.3.
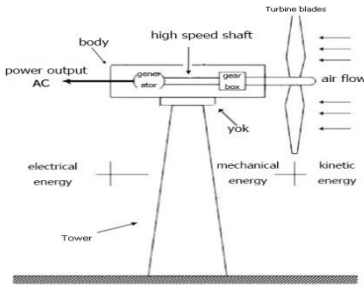
Figure 1.3: Schematic
block diagram of
a wind energy conversion system.

**In Chapter 2** according to the name of the thesis (Energy management of the wind and solar hybrid system with storage battery, which must be the wind and radiation are anticipated and to be considered battery memory effect) the project is divided into two general sections and two general points.

**Section 2.1** the system configuration is shown in Figure 2.1. An induction generator with variable speed wind turbine with the blade pitch angle control as the initial stimulus is moved for the production of electrical power is used. AC output voltage of the generator ( with the variable frequency ) is first rectified and then in an inverter to AC voltage with frequency of 50 Hz is converted. For use in situations of the separate from the network, each compensator capacitor banks are required to set up the induction generator but in applications of the connected to the network, capacitor bank can be removed from the system.
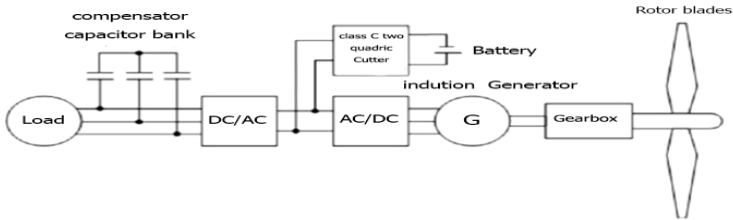
Figure 2.1: Block diagram of the turbine system and the generator separated
from the network with the battery storage.

**Section 2.2** in following the relations that were discussed in Chapter I for the solar cell, in this section, a complete model of a photovoltaic array and module is provided with full their relations. Then, we

5

obtain the different curves of a module under standard conditions and to compare with the curves given by the manufacturer. We will also change the inputs and the results to compare with the theories presented in Chapter II, thereby performance accuracy of the models is confirmed.

**Section 2.3** power electronic interface circuits are an integral part of hybrid systems such as those in this study are examined. This section presents rectifier models AC/DC, converters DC/DC and inverter DC/AC and their results. It should be noted that the purpose of this study is not a detailed examination of converters, their switching status and various power electronic converters and their advantages and disadvantages. **Section 2.4** in this section applies two solar radiation inputs to the photovoltaic system and their results will be discussed.

**Section 2.5** to solve the memory effect on the battery, there are special charging procedures, which dead houses will return to the first case. The most important defect that occurs on the batteries with condensed pages is mode of being ineffective or weak of the number of pages that occurs due to not participate in the charge and discharge.

**In chapter 3** in this study, the linear prediction method is used. Since these predictions for 2.5 seconds later and using 10 data of wind speed have done in the past, should be very fast, so the results can be used to control turbine. The proposed method may not be the best option but considering the urgent need to high speed in the prediction, this method can be very efficient. The linear prediction model respectively shows time series of signal samples during the specified time interval.

$$y(t + T) = a_1.y(t) + a_2.y(t - T) + \cdots + a_m.y(t - (m - 1).T)$$

**Section 3.1** the prediction error that is obtained from the difference between the predicted wind speed and its actual value must be minimized.

$$Error(\%) = \left\{ \frac{Predicted\ Value - Real\ Value}{Real\ Value} \right\} \times 100\%$$

**Section 3.1.1** the mean absolute percentage error (MAPE) and the mean square error is defined as follows (MSE):

$$MAPE = \frac{1}{N}\sum_{k=1,\ldots,N} \left| \frac{V_{actual} - V_{predicted}}{V_{actual}} \right| \times 100 \qquad MSE = \sqrt{\frac{1}{N}\sum_{k=1,\ldots,N} \left| V_{actual} - V_{predicted} \right|^2}$$

Using linear prediction method for various lengths of modeling window and different orders

| length of modeling window | Order model , m | | | | | |
|---|---|---|---|---|---|---|
| | m = 2 | | m = 4 | | m = 6 | |
| | * | ** | * | ** | * | ** |
| 20 | 22.30 | 4.81 | 20.53 | 4.56 | 19.12 | 5.28 |
| 60 | 23.08 | 4.35 | 21.32 | 3.89 | 20.21 | 3.92 |
| 100 | 21.07 | 4.23 | 19.72 | 3.60 | 18.20 | 3.56 |

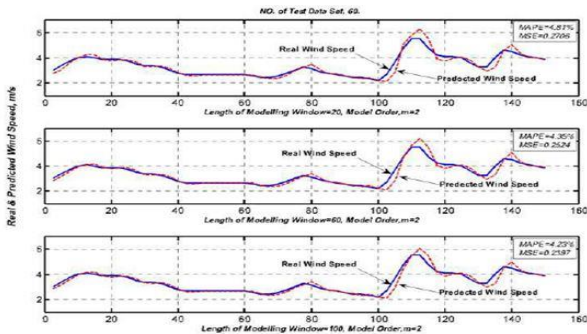* maximum prediction error, ** mean absolute percentage error



Figure 3.1: Prediction of 60 data on wind speed with modeling window length of variable and model of equal to 20

**In chapter 4:** The best combination is a compound that has the lowest cost during the study period. These costs will include the cost of investment and maintenance. Optimization variables are the number of PV modules, number of WG turbines and battery capacity needed. The algorithm used to optimize the problem is PSO algorithm.

**Section 4.1:** Energy management in the proposed system is done by load management. With regard to the descriptions in this section, we can say that load management techniques are the three main categories of load shading, valley filling and load shifting.

**Section 4.2:** Modeling and simulation of system performance PV/WG are presented. In the study conducted, system performance is simulated with time steps of 1 hour for one year. Characteristics of the current – voltage and power - voltage of a PV array from each production unit which is shown in Figure 4.7 is composed of parallel modules NP and series modules NS.
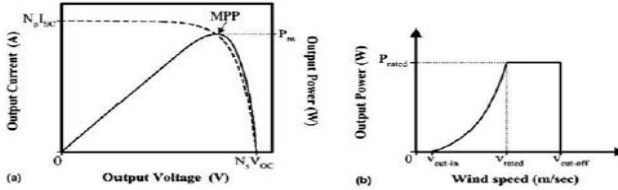


Figure 4.7: The output power characteristics WG and PV: (a) current - voltage and power - voltage characteristic of the PV module and (b) power characteristic based on the wind speed WG.

The output power measured from a PV array and the corresponding maximum obtainable power for a business charger battery that is not equipped with the MPPT[1] are shown in Figure 4.8. During bulk charging, PV array is connected directly to the battery bank. Available solar radiation during the period of measurement is changed from 0 to 900 W/m2. Average obtained for the conversion factor **n2** will be approximately 70 percent.
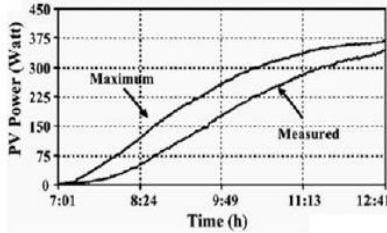


Figure 4.8:  PV array output power deviation from maximum obtainable power in the conditions of non-use MPPT

Battery bank with the nominal capacity $c_n(A\ h)$, is only allowed to be discharged to a limited extent. Maximum allowable depth of discharge (DOD) (%), by system designer and at the beginning of optimization process is determined.

$$c_{min} = (1 - DOD).C_n$$

Based on energy produced PV and WG and power required load, state of battery charge (SOC) in during the simulation is calculated as the cumulative and from the following equation:

$$c^i(t) = c^i(t-1) + n_B \frac{P_B^i(t)}{V_{BUS}} \Delta t \qquad\qquad C^i(24) = C^i(0)$$

The number of batteries in series, $n_B^S$, depends on the DC busbar nominal voltage and the nominal voltage of each batteries, that is calculated as follows: $\qquad n_B^S = \frac{V_{BUS}}{V_B}$

The equations presented above are used in a simulation process to determine whether the responses obtained from the optimization will provide the required load during the year or not. The flowchart of this case is shown in Figure 4-9. The algorithm inputs include solar daily radiation on a horizontal

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[1] - Maximum power pointer Tracker

plane, average hourly ambient temperature and wind speed, the power required load during the year and specifications of the equipment's used in the system. However, the calculations time step is considered equal to 1 hour. First, the total transmitted power from PV and WG to the battery bank, $P_{re}^i(t)(W)$, during the day of ith $1 \le i \le 365$ and hour of t-th $1 \le t \le 24$, is calculated from the following equation:

$$P_{re}^i(t) = N_{PV}.P_{PV}^i(t) + N_{WG}.P_{WG}^i(t)$$

Then, input power of DC/AC converter, $P_L^i(t)(w)$, using the power required load is calculated as follows:

$$P_L^i(t) = \frac{P_{Load}^i(t)}{n_i}$$

The remaining capacity of the battery, with respect to calculation of the production power and consumption load will be achieved.

- If $P_{re}^i(t) = P_L^i(t)$, then the battery capacity will remain unchanged.
- If $P_{re}^i(t) > P_L^i(t)$, then extra power for charging the battery bank is used.
- If the battery SOC reaches 100% of the allowable SOC, then the remaining power available will remain unused.
- If $P_{re}^i(t) < P_L^i(t)$, then the fraction of the power, $P_B^i(t) = P_{re}^i(t) - P_L^i(t)$, to meet the required load must be supplied by the battery.
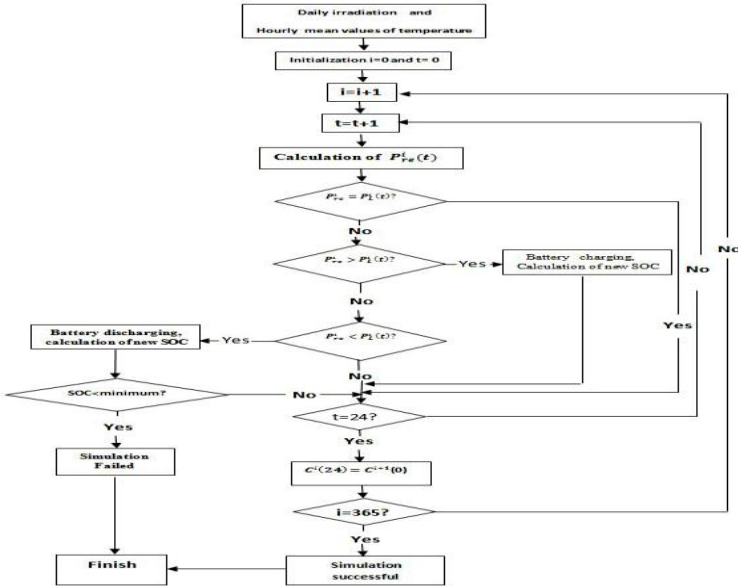


Figure 4.9: Flowchart of the algorithm used to simulate the system performance

The above steps are repeated until either the simulation time range is finished at the 24 hours on the 365th days, which will indicate the successful performance of the system, or the battery is discharged to a value less than the minimum allowable range defined in Equation 4.10. In such a situation, the system performance is considered unacceptable and the plan is rejected because it does not guarantee reliable performance of the system.

**Section 4.3:** PSO is a population algorithm, where members search for a desired area. In this bunch of the population, swarm and each member is called particle. Each particle moves with adjustable

speed in the search space and keeps the best previous position itself in its memory. In the whole space of the algorithmic search, the best position achieved by the whole series is to inform all other particles. For a hypothetical n-dimensional search space, $S \subset R$ and a group consisting of N-particles, the position of particle i-th under the influence of n-dimensional position vector is:

$$X_i = (x_{i1}, x_{i2}, \dots, x_{in})^T \in S$$

Also, the velocity vector of this particle is n-dimensional vector: $\quad V_i = (v_{i1}, v_{i2}, \dots, v_{in})^T \in S$

The best previous position obtained for the i-th particle is spot in S that is displayed as follows:

$$P_i = (p_{i1}, p_{i2}, \dots, p_{in})^T$$

Suppose that g is index used for the particle which so far has achieved the best position among all particles of the bunch and t is the repeat counter. Then, the new position of the bunch particles are defined according to the following equations:

$$V_i(t+1) = V_i(t) + cr_1\big(P_i(t) - X_i(t)\big) + cr_2(P_2(t) - X_i(t))$$
$$X_i(t+1) = X_i(t) + V_i(t+1)$$

One of the negative aspects of this type of PSO is the lack of a mechanism to control the speed that may lead to the explosion of the bunch. To deal with this problem, we can set an upper limit for the speed amount of each particle, $V_{max}$. Although, reforms made can not alone make a significant impact in improving the algorithm work. Closely observing the performance of this algorithm shows that although, PSO finds the area where optimal point is located in it, faster than other evolutionary computation methods, but to reach this area, the speed of the algorithm progress is reduced. This is due to the inability of the algorithm to adjust the size of the steps in the algorithm in order to continue the search in the more appropriate space.

Above problem is reduced by applying a weighting parameter to the particle previous speed. The following equations to calculate the new position of each particle are used:

$$V_i(t+1) = \omega V_i(t) + C_1 r_1 + C_1 r_1\big(P_i(t) - X_i(t)\big) + C_2 r_2(P_g(t) - X_i(t))$$
$$X_i(t+1) = X_i(t) + V_i(t+1)$$

**In subsection4.3.2** In the proposed method, the outputs of the optimal sizing using the algorithm PSO are the number of WGs, modules PV and batteries. The number of variables must be optimized in such a way that ultimately 20-year cost of the system is equal to the lowest possible value.

The total cost of the system $J(X)(\$)$ is the sum of capital costs $C_c(X)(\$)$ and maintenance costs $Cm(X)(\$)$. $\qquad \min_x\{J(X)\} = \min_x\{C_c(X) + C_m(X)\}$

Therefore, the aim of this multi-variable optimization is minimizing a function including the initial and ongoing 20-years costs of each of the parts used in the system.

$$
\begin{aligned}
J(X) = &\, N_{PV}.(C_{PV} + 20M_{PV}) + N_{WG}.(C_{WG} + 20M_{WG}) \\
&+ N_{BAT}.[C_{BAT}.(y_{BAT} + 1) + M_{BAT}.(20 - y_{BAT} - 1)] \\
&+ N_{ch}^{PV}.[C_{ch}^{PV}.(y_{ch}^{PV} + 1) + M_{ch}^{PV}.(20 - y_{ch}^{PV} - 1)] \\
&+ N_{INV}.[C_{INV}.(y_{INV} + 1) + M_{INV}.(20 - y_{INV} - 1)]
\end{aligned}
$$

According to the conditions:

$N_{PV} \geq 0 \qquad ; \qquad N_{WG} \geq 0 \qquad ; \qquad N_{BAT} \geq 0$

$$P_{Supply}(i,t,X) \geq P_{Demand}(i,t) \quad for \begin{cases} i = 1,2,3,\dots,365 \\ t = 1,2,3,\dots,24 \end{cases}$$

The number of inverter replacement frequency during system lifetime (20 years) is equal to lifetime of the system divided by the mean time between failures of the power electronic converter. (Note that the initial installation is considered as a replacement.

The last condition is about to review the ability or inability of the composition obtained for system to meet the load demand. This condition is tested at each step of the simulation and even if in one step, it fails then the composition obtained is known inappropriate and will be removed from the possible plans.

**Section 4.4** This plant is simulated based on data related to wind and radiation survey of the East region of Iran .It should be noted that the costs obtained are based on the existing prices and based on

the dollar ($) and load profiles under study to test the reliability of a variable load profiles with a maximum value is 20Kw. Annual profiles of wind speed, which is sampled at a height of 40 meters and a 1-hour intervals, an average of 24 hours in a 52-week year is shown in Figure 4.10.

In conclusion, the results of the simulation
 in terms of working with the weekly average will have more credibility than the results obtained from the simulation with exactly duplicate data. Second, instead of the simulation during time step 8760 (one year of 365 days is assumed to be equal to 8760 hours ), the simulation can be done in time step 52×24=1248 (one year is equal to 52 weeks and each week will also include a 24 hour profiles).

Thus, the volume and time of computations and memory requirements are reduced about 7 times. Profiles of blowing and horizontal-vertical radiation of the wind and load consumption during the one year that are obtained by taking the average of 24 hours over 52 weeks are shown in Figures 4.10 and 4.11.
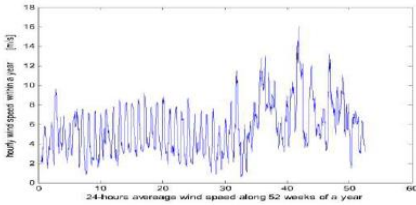


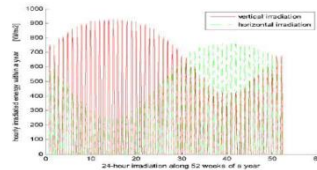Figure 4.10: 24-hour average of the wind over the 52 weeks of the year

Figure 4.11: 24-hour average of the horizontal and vertical radiation over the 52 weeks of the year

**In subsection 4.4.1:** As can be seen in Figure 4.11, radiation survey data in both horizontal and vertical direction are measured. Thus, the vertical radiation is related to the rate of energy radiated by a horizontal plane with dimensions 1×1 m and the horizontal radiation is related to the rate of energy radiated by a vertical plane facing south with dimensions 1×1 m. The rate of energy radiated (W/m2) by a solar panel that is installed at an angle $\boldsymbol{a}$ with respect to the horizon in every moment can be calculated from the following equation:

$$G^i(t,\alpha) = G_V^i(t).\cos(\alpha) + G_h^i(t)\sin(\alpha)$$

The amount of energy radiated (Wh/m2) by the panel with an area of 1 m2 during the year, is obtained from the following equation:

$$E_G(\alpha) = \sum_{i=1}^{365}\sum_{t=1}^{24} G(t,\alpha)$$

The best angle $\boldsymbol{\alpha}$ is equal to the amount which gives the maximum possible value to the $E_G$. Figure 4.12 shows a $E_G$ amount calculated for $\boldsymbol{0 \le \alpha \le 90°}$ based on horizontal and vertical radiations annually obtained in the study site. This site is located in East of Iran, which is located at the longitude of 48°:17′ and latitude 38°:15′. As can be seen in Figure 4.12 the best angle for the installation of solar panels is $\boldsymbol{\alpha_{OPT} = 34.29°}$.
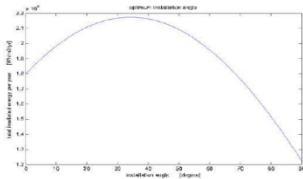


Figure 4.12: The amount of energy radiated by the solar panel during a year based on the angle of the panel installation

**In subsection 4.4.2:** Technical and economical characteristics of equipment's used in hybrid power plant studied are as follows:

- Wind turbines with nominal power 50000W, installation height 15m, low cutoff speed 2.5 m/s, nominal speed 11 m/s, high cutoff speed 24 m/s, price 200000$.
- PV module with nominal power 6000W, price 30000$.

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- Battery with nominal capacity 2000 Ah, DOD max = 80%, charge and discharge efficiency 85%, lifetime 3 years, price 6000$.

Annual maintenance cost of any equipment is considered to be equal to 1% of the initial cost of buying them.

To find the optimal combination of power plant desired, software in the MATLAB 7.1 programming environment is provided that comprises two main parts of simulation and optimization.

The main functions of the optimization are as follows:

**Generation production.**
**Compare the particles(compounds)-conditions.**
**Determine the suitability of each combination**
**Next generation production and repeat the above steps.**

The algorithm stops after producing a limited number of generations ( 100 generations ) and the best answer obtained is known as the most optimal possible combination.

In the simulation part, as its name implies, to simulate the compounds produced in each generation are paid, as desired combination for one year, with data on blowing, radiation and load shown in Figures 4.10 and 4.11 are simulated.

**In subsection 4.4.3** The above program runs with the initial population equal to 60 individuals and for 500 generations.run time of the above program is approximately 1.5 minutes on a Pentium V with 2024 MB RAM.5/40GHz. Figure 4.13 shows the trend of convergence of the above program in five independent execution. It can be seen that almost all executions in less than 150 generations will converge to the optimal answer.
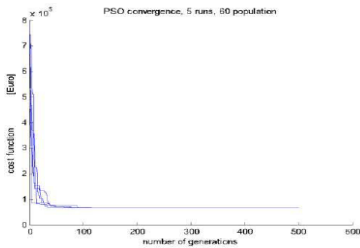


Figure 4.13: The convergence trend of the program written in five independent executions. (populations equal to 60 individuals and for 500 generations)

The interesting thing is that the program execution with population of 30 individuals and 100 generations to reach the optimal solution will suffice. This, with the previous same system ends in 60 seconds, just in order to ensure the convergence program to the global optimal answer, it is better that the program ran several times ( 5 times ) consecutively ( multistart technique ).

The last thing remaining is that, since the final composition should include correct arrays, it is better in the space surrounding the results obtained which are real and non-integer, the search is performed to obtain the best combination. Since, this problem has only three variables, it would be easy to do.

According to the input data which can be seen in the table below, the following result is obtained:

Table 4.1: The data used in the optimization algorithm

| Lifetime of the system | | 20 years |
|---|---|---|
| The power of each solar modules | | 6000 watts |
| The price of each solar modules | | 40000 $ |
| The cost of modules maintenance in a year | | 500 $ |
| Price per turbine | | 200000 $ |
| The cost of wind turbine maintenance in a year | | 2000 $ |
| Price per battery bank | | 6395 $ |
| The cost of  battery maintenance in a year | | 200 $ |
| Lifetime of the battery | | 3 years |
| The cost of DC/AC converter | | 51000 $ |
| The cost of  converter maintenance in a year | | 500 $ |

| Lifetime of the converter | | 4.5 years |
|---|---|---|
| The cost of charger battery | | 3000 $ |
| The cost of charger battery maintenance in a year | | 20 $ |
| Lifetime of the charger battery | | 4.5 years |

**In subsection 4.4.3.1:** Now, at the first, we observe results of the energy management and optimization without applying load management with respect to the algorithm described and data of the wind, sun and load which can be seen in the next figures and also table above, which are as follows:

Table 4.2:  Result of the energy management and optimization without applying load management

| Wind turbine | 3 pcs |
|---|---|
| Solar module | 13 pcs |
| Battery bank | 106 pcs |

For the load curve for a one-year is used from a load curve IEEE that its maximum power is 1 kW but the total diagram is multiplied by 20 to be proportional with the load demand that can be seen in Figure 4.14.
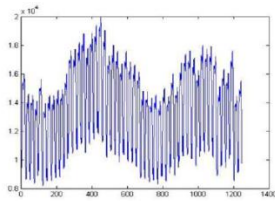


Figure 4.14: The annual load curves used based on average hours per week
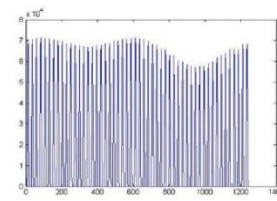


Figure 4.15: Curve of power generated by solar modules based on average hours per week

Power generated by wind turbines and solar modules are shown in Figures 4.15 and 4.16 ( in this case, regardless of the load shading ):
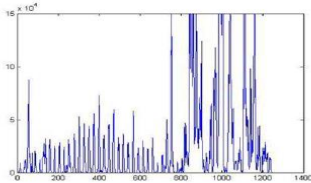


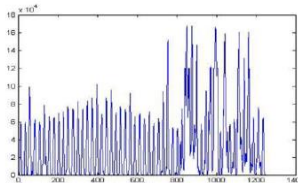Figure 4.16: Power generated by wind turbines based on average hours per week



Figure 4.17: Total productive power with respect to converter efficiency based on average hours per week

But total productive power with respect to the efficiency of the converter is shown in Figure 4.17. And, the battery SOC diagram in this case can be seen in Figure 4.18.
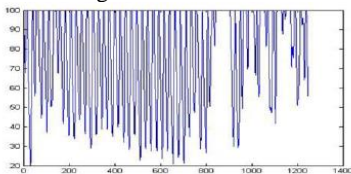


Figure 4.18: Battery SOC during the year based on average hours per week

The important point in this figure which represents the amount of remaining battery charges, is that to enhance reliability, we consider the minimum SOC battery to 20% in this algorithm But this case also has another advantage and that is that each month.

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**In subsection 4.4.3.2** Now, we observe results of the energy management and optimization with applying load management by the load shading method, with respect to the algorithm described and data of the wind, sun and load which can be seen in the next figures and also input table in the load management mode, which are as follows:

Table 4.3: Result of the energy management and optimization with applying load management by the load shading method

| Wind turbine | 2 pcs |
|---|---|
| Solar module | 14 pcs |
| Battery bank | 105 pcs |

Load curve in this case with respect to the load management in the peak consumptions is faced with load shading, which can be seen in Figure 4.19.
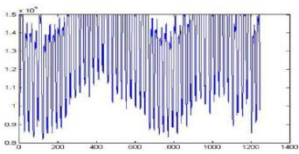


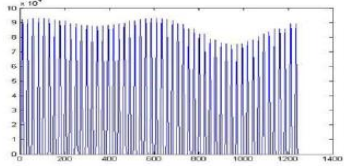Figure 4.19: The annual load curves usedbased on average hours per week



Figure 4.20: Power generated by solar modules based on average hours per week in the load shading mode.

Power generated by wind turbines and solar modules (in this case, with respect to the load shading) are shown in Figures 4.20 and 4.21.



Figure 4.21: Power generated by wind turbines based on average hours per week in the load shading mode



Figure 4.22: Total power generated with respect to the converter efficiency based on average hours per week in the load shading mode

But total productive power with respect to the efficiency of the converter is shown in Figure 4.22. And, the battery SOC diagram in this case can be seen in Figure 4.23.

Figure 4.23: Soc battery during the year based on average hours per week in the load shading mode

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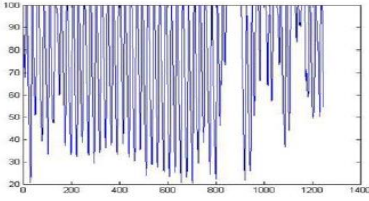
Description of the battery SOC is like the previous case.

**In subsection 4.4.3.3** Now, we observe results of the energy management and optimization with applying load management by the load shifting method, with respect to the algorithm described and data of the wind, sun and load which can be seen in the next figures and also input table in the load management mode by load shifting method, which are as follows:

Table 4.4: Result of the energy management and optimization with applying load management by the load shifting method.

| Wind turbine | 2 pcs |
|---|---|
| Solar module | 15 pcs |
| Battery bank | 108 pcs |

Load curve in this case with respect to the load management in the peak consumptions is faced with load shifting, which can be seen in Figure 4.24.
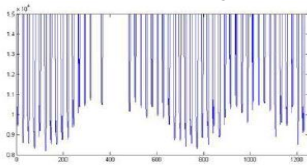


Figure 4.24: The annual load curves used based on average hours per week in the load shifting mode.
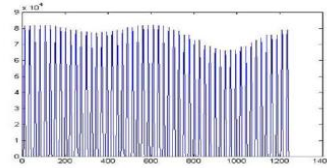
Figure 4.25: Power generated by solar modules based on average hours per week in the load shifting mode

Power generated by wind turbines and solar modules (in this case, with respect to the load shifting) are shown in Figures 4.25 and 4.26.
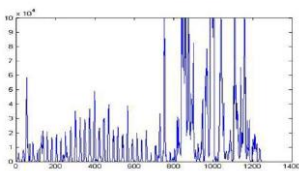


Figure 4.26: Power generated by wind turbines based on average hours per week in the load shifting mode.
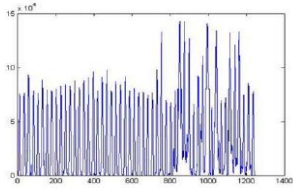
Figure 4.27: Total power generated with respect to the converter efficiency based on average hours per week in the load shifting mode

But total productive power with respect to the efficiency of the converter is shown in Figure 4.27. And, the battery SOC diagram in this case can be seen in Figure 4.28.

Figure 4.28: Soc battery during
the year based on average hours
per week in the load shifting mode

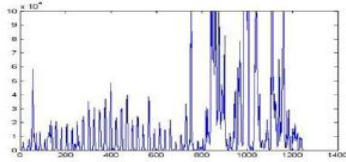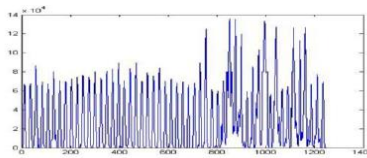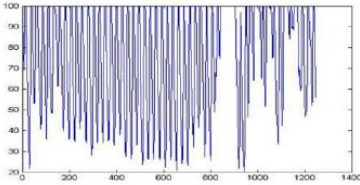Description of the battery SOC is like the previous case.

**Section 4.5** To create an energy plan codified in each country needs a comprehensive energy system consists of specific inputs for each country that suitable format for this case is RES graphical diagram which its input and output are consumption and carriers of the production in any country. But, since the efficiency and transfer matrices establish relationship between these two, we briefly explain it.

**Operation algorithm and computation**

In the energy balance of the country for the year 2010 that is given in Table 4.5, the first step is to change the type of the consumptions of each country and consumption amount of each of them and this is placed as input in the RES diagram. In next step, with respect to type of carriers will be determined producing share of each of the carriers at the consumptions type that in end of this step, we reach to the energy net available for the carriers.

$$a_1 = \begin{bmatrix} 0.2312 & 0.3156 & 0.9921 & 0.7096 & 0 & 0.4026 \\ 0.5945 & 0.5212 & 0.0075 & 0 & 0 & 0.4976 \\ 0 & 0.0207 & 0 & 0 & 0 & 0 \\ 0.0003 & 0 & 0 & 0 & 0 & 0.1009 \\ 0.0669 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0.1070 & 0.1424 & 0.0004 & 0.2904 & 1.000 & 0 \end{bmatrix}$$

In next step, we should calculate the losses in transmission and distribution sectors and also consumptions of the energy part as an efficiency matrix that at the end of this step, we reach to the energy net amounts plus losses.

$$V_1 = a_1 \times Consumption \quad Consumption = \begin{bmatrix} 379.3000 \\ 188.2000 \\ 254.3000 \\ 33.4000 \\ 2.5000 \\ 85.2000 \end{bmatrix} \quad V_1 = \begin{bmatrix} 457.3833 \\ 367.8865 \\ 3.8957 \\ 8.7105 \\ 25.3752 \\ 0 \\ 0 \\ 79.6859 \end{bmatrix}$$

Table 4.5: Energy balance of the country for the year 2010

| Description | Crude oil and petroleum products | Natural Gas | Coke gas and Blast Furnace Gas | Coal | Solid biomass | Hydro power | Renewable energies | Total electricity | Total energy |
|---|---|---|---|---|---|---|---|---|---|
| **Offer** | | | | | | | | | |
| Domestic production | 1615/1 (1) | 645/0 | 4/2 | 6/5 | 25/4 | 25/1 | 0/1 | -- | 2321/4 |
| Import | 80/3 (2) | 32/6 | -- | 2/6 | -- | -- | -- | 1/2 | 116/7 |
| Export | -1150/7(3) | -29/8 | -- | -0/2 | -- | -- | -- | -1/6 | -1182/3 |
| International ship fuel | -0/2 | -- | -- | -- | -- | -- | -- | -- | -0/2 |
| The total domestic energy available | 578/5 | 647/7 | 3/9 | 8/7 | 25/4 | 25/1 | 0/1 | -0/4 | 1289/1 |
| Conversion losses of the Oil refineries | -14/0 | -- | -- | -- | -- | -- | -- | -- | -14/0 |
| Gas and LNG plants | -11/9 | -- | -- | -- | -- | -- | -- | -- | -11/9 |
| Transformations (4) | -29/7 | -- | -- | -- | -- | -- | -- | -- | -29/7 |
| **Plants** | | | | | | | | | |
| Fuel Consumption | -59/6 | -220/8 | -- | -- | -- | -25/1(5) | -0/1(5) | -- | -305/7 |
| Electricity produced | -- | -- | -- | -- | -- | 9/5 | 0/04 | 104/7 | 104/7 |
| Transmission and distribution losses | -1/9 | -4/3 | -- | -- | -- | -- | -- | -19/0 | -25/2 |
| Energy Expenditure | -4/0 | -54/8 | -- | -- | 25/4 | -- | -- | -5/6 | -64/4 |
| The net available energy | 457/4 | 367/8 | 3/9 | 8/7 | 25/4 | -- | -- | 79/7 | 942/9 |
| **Consumption** | 457/4 | 367/8 | 3/9 | 8/7 | 25/4 | -- | -- | 79/7 | 942/9 |
| Domestic and commercial | 87/7 | 225/5 | -- | 0/1 | 25/4 | -- | -- | 40/6 | 379/3 |
| Industry | 59/4 | 98/1 | 3/9 | -- | -- | -- | -- | 26/8 | 188/2 |
| Transport | 252/3 | 1/9 | -- | -- | -- | -- | -- | 0/1 | 254/3 |
| Agriculture | 23/7 | -- | -- | -- | -- | -- | -- | 9/7 | 33/4 |
| Other Uses | -- | -- | -- | -- | -- | -- | -- | 2/5 | 2/5 |
| Non-energy uses | 34/3 | 42/4 | -- | 8/6 | -- | -- | -- | -- | 85/2 |

(1) It includes the production of crude oil, condensate and gas liquids.
(2) It includes crude oil swap transactions.
(3) It includes crude oil swap transactions, liquefied petroleum gas exports and condensate and gas liquids exports.
(4) Conversions are performed as a result of re-classifying products or due to change in the specifications and nature of a product or due to combine it with other products.
(5) Primary energy.

The third step is the separation of the total electricity from its manufacturer carriers, which share of each of the carriers, is characterized by a transfer matrix.

$$a_2 = \begin{bmatrix} 1.0129 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.1607 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1.0000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.3086 \end{bmatrix}$$

$$V_2 = a_2 \times V_1 \qquad V_2 = \begin{bmatrix} 463.2835 \\ 427.0058 \\ 3.8957 \\ 3.8957 \\ 8.7105 \\ 25.3752 \\ 0 \\ 0 \\ 104.2769 \end{bmatrix}$$

$$a_3 = \begin{bmatrix} 0.2272 \\ 0.6818 \\ 0 \\ 0 \\ 0 \\ 0.0907 \\ 0.0004 \\ -1.0000 \end{bmatrix} \qquad V_3 = a_3 \times V_2 \, (8) \qquad V_3 = \begin{bmatrix} 23.6917 \\ 71.0960 \\ 0 \\ 0 \\ 0 \\ 9.4579 \\ 0.0417 \\ 104.2769 \end{bmatrix}$$

The fourth step is a continuation of the third section, which converts the carrier amounts to produce electricity with considering its losses to the fuel used to generate it.

$$a_4 = \begin{bmatrix} 2.5056 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 3.0941 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 2.6427 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 2.5000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0000 \end{bmatrix}$$

In the fifth step, at first, we sum the total results of the first and fourth sections together then with a matrix can be obtained losses (efficiency) + losses of the refineries conversion + losses of the transfer and transformations of the total internal energy available

$$V_4 = a_4 \times V_3 \qquad V_4 = \begin{bmatrix} 59.3629 \\ 219.9753 \\ 0 \\ 0 \\ 0 \\ 24.9945 \\ 0.1043 \\ 104.2769 \end{bmatrix}$$

.

$$V_5 = V_2 + V_4 \qquad V_5 = \begin{bmatrix} 522.6464 \\ 646.9811 \\ 3.8957 \\ 8.7105 \\ 25.3752 \\ 24.9945 \\ 0.1043 \\ 0 \end{bmatrix}$$

$$a_5 = \begin{bmatrix} 1.1063 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1.0000 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1.0000 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1.0000 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1.0000 \end{bmatrix}$$

$$V_6 = a_5 \times V_5 \qquad V_6 = \begin{bmatrix} 578.2037 \\ 646.9811 \\ 3.8957 \\ 8.7105 \\ 25.3752 \\ 24.9945 \\ 0.1043 \\ 0 \end{bmatrix}$$

$$V_7 = \begin{bmatrix} 10770.4 \\ -2.8 \\ 0 \\ -2.4 \\ 0 \\ 0 \\ 0 \\ 0.4 \end{bmatrix} \qquad V_8 = V_6 + V_7 \qquad V_8 = \begin{bmatrix} 1648.6037 \\ 644.18 \\ 3.9 \\ 6.3 \\ 25.4 \\ 24.99 \\ 0.1 \\ 0.4 \end{bmatrix}$$

In the sixth step, we sum the result of the fifth section with the total exports and then we subtract it from imports until we reach to the total domestic production in any carrier available in the country.

As a result, sixth section is the same of RES[2] outputs that are obtained from the previous steps and input (consumption). Therefore, we have to supply matrix.

Now, according to the above process and given that our target system with the load profile intended in consumption year provides 16.959 megawatt hours, with respect to jules conversion coefficient ( FCR Jules ) to the barrels of crude oil, equivalent with 3129 barrels of crude oil will save money.

But according to the above steps, if this amount of production generated from the above carriers, it causes that environmental pollutants are generated as follows according to Table 5.6, which in result of the environmental pollutants reduction effect will be as follows.

Table 4.6: The reduction amount of environmental pollutant gases in year 2010 ( based on tons ).

|  | $No_x$ | $So_2$ | $Co_2$ | $SO_3$ | $CO$ | $CH$ | $SPM$ |
|---|---|---|---|---|---|---|---|
| Crude oil and petroleum products | 1/35 | 1/019 | 262 | 0/01 | 11 | 2/5 | 0/05 |
| Natural Gas | 0/3 | 0 | 269 | 0 | 0 | 0 | 0 |

Table 4.7: The reduction amount of environmental costs, thereby pollutants reduction effect.

| Billion rials | | | | | | |
|---|---|---|---|---|---|---|
| Division / gas | $NO_x$ | $SO_2$ | $CO_2$ | $CO$ | $CH$ | $SPM$ |
| According to studies by the World Bank and the Environment Organization | | | | | | |
| Domestic, commercial and public | 0/004 | 0/00001 | 0/50 | 0/1 | 0 | 0 |

**Section 4.6** Choosing the optimal combination of power plant was conducted using PSO algorithm. A condition that in the process of problem solving has always been considered is full coverage of the load in all year in two mode of without management and with load management. It seems that, since the new algorithm is used and the effects of various factors are considered, this work is unique in its kind. Features of this algorithm include simplicity, speed and convergence to the global optimum point.

Conclusions and Recommendations are given in **chapter 5**

### THE MAIN RESULTS OF THESIS

-The cost of energy is optimized by developing PSO algorithm with technique of EC.

-Proposed system of optimal choice of energy source taking into account the changing environment on the basis of linear prediction.

-Developed system for optimal distribution of energy sources on the basis of the package MATLAB 7.1 .

-It is proposed to optimize the control algorithms of energy sources using PSO algorithm

-Assess and reduce the cost of expenses, depending on the system requirements, as well as the economic consequences of the use of load and energy management through the PSO algorithm for 20 years.

-Simulation and consideration of our system is done for balancing of energy by the RES graphical software.

-With the help of a software package RES graphically reached mode with maximum energy production, minimal consumption of it and with minimal losses.

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[2] Graphical format for displaying the energy

-Estimation of the costs associated with power electronic equipment is modeled in such a system as a battery and charger, and a wind generator and solar panel and inverter DC / AC in the MATLAB software for the new hybrid power station.

-Shows that the prediction of wind speed, solar radiation, the use of battery-driven and appropriate management processes will lead to greater energy recovery and power

-The proposed algorithm has been implemented in real physical and virtual networks of the same. The differences between the real and virtual simulation are minimum.

-According to the research the proposed system increases the service life.

### List of the publication on the topic of the thesis

1. Afra Mostafaei, ''INTELLIGENT ENERGY MANAGEMENT IN DISTURBUTED GROUPS OF HOUSES''10 volume 3 number 3 Yerevan 2013,Proceedings of engineering academy of Armenia, pp. 580- 584
2. Afra Mostafaei, "Forecasting issues of wind speed and solar radiation" problems of economic development and management (iem), 2014, ISBN: 978-9939-9055-5-6, pp. 306-316
3. Afra Mostafaei, ''Basic concept of wind, solar and storage battery renewable systems ''11 volume ,number 3, Yerevan 2014, Proceedings of engineering academy of Armenia, pp. 629
4. Afra Mostafaei "Modeling The energy management system taking into account the load characteristics and economic performance", (Izvestia) ISSN 0002-306x, (information systems), pp. 384
5. Afra Mostafaei, ''Energy Management And Solar Energy In Intelligent House" 16-17 September 2011, ISSN:1829-3034, The first international Scientific-Research (computer science and IT), pp. 211
6. Afra Mostafaei, ''Modeling of hybrid system components" 25 February 2015 Nanotechnology Applications of Electrical and Computer Engineering Zanjan sama university(abhar) of Iran

## Աֆրա Մոսթաֆայի

### Քամու, արեգակի և մարտկոցի հիման վրա էներգիայի գեներացնող հիբրիդ բաշխված համակարգի էներգասպառման կառավարումը հաշվի առնելով մարտկոցում էներգիայի կուտակման էֆեկտը արնից ու քամուց ստացված էներգիայի գծային կանիսատեսմամբ

### Ամփոփում

Հողմային և արևային համակարգերը (գելիոուստանովկի) միմյանց հետ համադրելու հիմնական նպատակներն են՝ տարբեր կլիմայական պայմաններում ավելի հուսալի բեռնվածության սպառման ապահովումը, իսկ մյուս կողմից, անհրաժեշ֊ համակարգային ծախսերի, ինչպես նաև տնտեսական և էներգետիկ կառավարման վրա բեռնվածության կառավարման ազդեցությունների նվազեցումը: Սույն հետազոտությունն ուղղված է անկախ հողմ-արևային հիբրիդ էլեկտրակայանի 20 տարվա ծախսերի մանրամասն ուսումնասիրությանը: Օգտագործված պահեստավորման համակարգը կապարէ-թթվային մարտկոցային բլոկ է և արտադրության ու պահեստավորման բլոկների արժեքից բացի, հաշվարկներում նկատի են արնվել նաև ուժային էլեկտրոնային սարքավորումների, այդ թվում՝ մարտկոցների համակարգերի, լիցքավորիչի և

հաստատուն/փոփոխական էլեկտրական հոսանքի փոխակերպիչի հետ կապված ծախսերը:

Կատարվել է էլեկտրակայանի օպտիմալ համադրության ընտրություն՝ օգտագործելով մասնիկների խմբի օպտիմալացման ալգորիթմը: Խնդրի լուծման գործընթացում մշտապես դիտարկել ենք ողջ տարվա ընթացքում ծանրաբեռնվածության լիարժեք ծածկույթը երկու՝ առանց կառավարման և բեռնվածության կառավարման ռեժիմներում: Այս աշխատանքն իր տեսակի մեջ եզակի է համարվում, քանի որ օգտագործվում է նոր ալգորիթմ և ուսումնասիրվում են տարբեր գործոնների ազդեցությունը: Այդ ալգորիթմի հատկանիշներն են պարզությունը, արագությունը և ընդհանուր օպտիմալ կետին մոտեցումը:

## Հետազոտության նպատակը
-Ծանրաբեռնվածության կառավարումն ու դրա կիրառման մեթոդները,

-Ֆոտոգալվանային համակարգերի գործունեության մոդելավորում և սիմուլյացիա PV ֆոտոգալվանային /WG հողմաէներգետիկ

-Ծախսերը նվազագույնի հասցնելը, օգտագործելով խելացի ալգորիթմեր PSO[3]

-Համակարգի էներգիայի կառավարման համար շրջակա միջավայրի ազդեցության նշանակությունը

## Գիտական նորույթը
Սույն ատենախոսության գիտական նորույթներն են.

-Պահեստային մարտկոցով հողմ-արևային հիբրիդ համակարգի նոր օպտիմալացված ալգորիթմը հուսալի է և կիրառելի է ցանցից մեկուսացված վայրերում, այն պայմանով, որ դրանք ունենան աշխարհագրական հարմար դիրք:

-Հոսանք մատակարարող այս հիբրիդ համակարգն ունի մի շարք աղբյուրներից օգտվելու հնարավորություն:

-Վերահսկվող ծանրաբեռնվածությամբ այս համակարգի էներգիայի կառավարման առաջարկվող մեթոդը:

## Արդյունքների կիրառելիությունը
Արդյունքները կարևոր են իրական միջավայրերում աշխատանքների կազմակերպման համար, այդ թվում.

-Տարբեր կլիմայական պայմաններում առավել հուսալի ծանրաբեռնվածության սպառման ապահովում

-Համակարգի համար պահանջվող ծախսերի նվազեցում

-Տնտեսական և էներգետիկ կառավարման հիմնախնդրի վրա ծանրաբեռնվածության կառավարման հետևանքների նվազեցում:

-Էլեկտրակայանի օպտիմալ համադրության ընտրություն՝ մասնիկների խմբի օպտիմալացման ալգորիթմի կիրառմամբ:

## Պաշտպանության ներկայացվող դրույթներ
-Արևային վահանակների տեղադրման օպտիմալ անկյունը,

-Հողմ-արևային միացյալ կայանի օպտիմալ համադրությունը,

-Էներգիայի կառավարման և օպտիմալացման արդյունքները ծանրաբեռնվածության կառավարման կիրառման միջոցով,

-Գնահատման նշանակությունը Էներգիայի կառավարման բնապահպանական ազդեցությունների համար:

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[3] օպտիմալացում ըստ մասնիկների խմբերի

## ԱՏԵՆԱԽՈՍՈՒԹՅԱՆ ՀԻՄՆԱԿԱՆ ԵԶՐԱԿԱՑՈՒԹՅՈՒՆՆԵՐԸ

-Էներգիայի արժեքն օպտիմալացվում է PSO ալգորիթմի մշակմամբ:

-Էներգիայի աղբյուրի օպտիմալ ընտրության առաջարկվող համակարգ, հաշվի առնելով փոփոխվող միջավայրը, գծային կանխատեսման հիման վրա:

-Էներգիայի աղբյուրների օպտիմալ բաշխման մշակված համակարգ, MATLAB 7.1. փաթեթի հիման վրա:

-Առաջարկվում է օպտիմալացնել էներգետիկ աղբյուրների հսկման ալգորիթմերը, օգտագործելով PSO ալգորիթմը:

-Կախված համակարգի պահանջներից, գնահատել և նվազեցնել ծախսերը, ինչպես նաև բեռնվածության և էներգիայի կառավարման կիրառման տնտեսական հետևանքները, PSO ալգորիթմի միջոցով 20 տարիների ընթացքում:

-Մեր համակարգի մոդելավորումն ու քննարկումը կատարվել է էներգիայի հավասարակշռման համար, RES գրաֆիկական ծրագրային ապահովման միջոցով:

-Ծրագրային ապահովման RES գրաֆիկական փաթեթի օգնությամբ մենք ստացել ենք էներգիայի առավելագույն արտադրությամբ, նվազագույն սպառմամբ և նվազագույն կորուստներով ռեժիմ:

-MATLAB ծրագրային ապահովման միջոցով նոր հիբրիդային էլեկտրակայանի ծախսերի գնահատումը, կապված ուժային էլեկտրոնային սարքավորումների հետ, որոնք մոդելավորվում են այնպիսի համակարգերում, ինչպիսիք են մարտկոցը, լիցքավորիչը, քամու գեներատորն ու արևային վահանակը, ինչպես նաև հաստատուն/փոփոխական էլեկտրական հոսանքի փոխակերպիչը:

-Հետազոտության արդյունքները ցույց են տալիս, որ քամու արագության կանխատեսումը, արեգակնային ճառագայթումը, մարտկոցի վրա հիմնված և համապատասխան կառավարման գործընթացցները կխանգեցնեն առավել մեծ քանակությամբ էներգիայի վերականգնման և դրա հզորության:

Ըստ սույն հետազոտության, առաջարկվող համակարգը մեծացնում է ծառայության կյանքի տևողությունը:

**А.Мостафаей**

**Управление энергопотреблением гибридных распределенных систем генерации на основе энергии ветра, солнца и батареи с учетом эффекта памяти на батарее и линейным предсказанием ветра и солнечной энергии**

**Резюме**

Основными целями объединения ветровых и солнечных устройств являются, с одной стораны обеспечение более надежного использования нагрузки в различных климатических условиях, с другой стороны уменьшение требуемых затрат, а также влияния регулирования нагрузки на вопросы экономического и энергетического управления. Данное исследование фокусируется на детальном изучении затрат на ветро-солнечные гибридные электростанции за 20-летний период времени. Использованная система хранения – это свинцово-кислотный батарейный блок. Кроме расходов на производственные и складские устройства, имеются затраты на силовое электронное оборудование, такие как например: батарейные установки и зарядочники и преобразователь DC/AC (постоянного /переменного тока) учитываются в расчетах.

Выбор оптимального сочетания электростанции был осуществлен с использованием алгоритма оптимизации группы частиц. Условие, которое в процессе решения проблем всегда рассматривалась является Полная информация нагрузки в течение всего года в двух режиме без управления и управления нагрузкой. Кажется, что, так как новый алгоритм используется и влияние различных факторов рассматриваются, эта работа является уникальной в своем роде.

Особенности этого алгоритма включают в себя простоту, скорость и сходимость к глобальной оптимальной точке.

## Цель исследования

- Управление нагрузкой и методы его применения;
- Моделирование и имитация производительности фотогальванических PV[4]/WG[5] систем;
- Минимизация затрат с использованием интеллектуальных алгоритмов PSO[6];
- Влияние воздействия окружающей среды на энергетическое управление системы.

## Научная новизна

Данная диссертация содержит следующие нововведения:

- Новый оптимизированный алгоритм для ветро-солнечной гибридной системы с резервным питанием от батареи, которая является надежной и используемой системой в отдаленных частях сети при условии, что они имеют выгодное географическое расположение.
- Данная гибридная система для подачи питания наделена возможностью изменения количества источников.
- Предлагаемый способ управления энергией в этой системе – это способ с управляемой нагрузкой.

## Применимость результатов

Результаты важны для организации работ в реальных условиях, таких как:

- Обеспечение более надежного потребления нагрузки в различных климатических условиях;
- Сокращение необходимых затрат системы;
- Уменьшение влияния управления нагрузкой на экономическое и энергетическое управление;
- Выбор оптимального сочетания электростанции был осуществлен с использованием алгоритма оптимизации группы частиц.

## Нижеуказанные утверждения представлены к защите

- Оптимальный угол для установки солнечных батарей
- Оптимальное сочетание смешанного устройства Ветер - Солнце
- Результаты управления энергией и оптимизации с применением управления нагрузкой
- Оценка влияния окружающей среды на управление энергией.

## ОСНОВНЫЕ ВЫВОДЫ ДИССЕРТАЦИИ

- Стоимость энергии оптимизирована путем разработки алгоритма PSO.
- Предлагаемая система оптимального выбора источника энергии, принимая во внимание изменяющуюся среду на основе линейного прогноза.
- Система, разработанная для оптимального распределения источников энергии на основе пакета MATLAB 7.1.
- Предлагается оптимизировать алгоритмы контроля источников энергии с использованием алгоритма PSO.
- Оценить и уменьшить стоимость затрат, в зависимости от требований к системе, а также экономические последствия использования нагрузки и управления энергией через алгоритм PSO в течение 20 лет.
- Моделирование и рассмотрение нашей системы выполнено для балансировки энергии при помощи графического программного обеспечения RES.

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[4] фотогальванический

[5] ветровой генератор

[6] оптимизация по группам частиц

- С помощью программного обеспечения RES мы получили режим с максимальным производством энергии, минимальным его потреблением и с минимальными потерями.
- Оценка затрат на новую гибридную электростанцию с помощью программного обеспечения MATLAB, связанных с силовым электронным оборудованием, моделированным в такой системе, как аккумулятор и зарядное устройство, генератор ветра и солнечная батарея, а также инвертор DC/AC (постоянного /переменного тока).
- Результаты исследований показывают, что прогноз скорости ветра, солнечной радиации, использование процессов управления с аккумуляторными источниками питания и надлежащих процессов управления ведет к большей рекуперации энергии и мощности.

По данным исследования, предлагаемая система увеличивает срок службы.