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Research paper

Providing passive defense solutions for the stability of the electricity distribution network in the snow crisis (case study: Iran-Koohrang city, Chaharmahal and Bakhtiari province)

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Abstract

Considering that electric energy is a strategic and vital energy in daily life, the need for the stability of this energy in crises is a necessity. The most important solution to deal with crises caused by natural disasters is to put passive defense in the operation of electricity distribution networks. By using analytical techniques, it provides a platform for informed decision making in crisis. In this article, while examining the non-operating defense in the electricity distribution company of Chaharmahal and Bakhtiari province, we will provide a solution to overcome the crisis of heavy snowfall in Koohrang city. By implementing these solutions, we will compare the amount of undistributed energy in medium and weak pressure feeders in the critical months of Koohrang city and check the reliability of the network.

Introduction

The electricity industry, which is responsible for providing reliable and stable electricity to customers, taking into account the priority of sensitive centers, is one of the most important infrastructure technologies in the administration of the country's affairs. The importance of electricity industry infrastructure in economic, social and service development (health and treatment, communication, transportation, financial affairs, etc.) cannot be denied [1,2]. From this point of view, concerns about malicious attacks on power system infrastructure such as adverse weather conditions have increased in recent years. Therefore, the implementation of non-agent defense is essential [3]. Passive defense in the electricity industry includes criteria such as: supplying sensitive loads of the power grid in all conditions, reducing unwanted power cuts of public subscribers and preventing social dissatisfaction, reducing the cost of operating the power system and decentralization using distributed generation [4, 5].

Koohrang city is located 90 km from the center of Chaharmahal and Bakhtiari province with an altitude of 2365 above sea level. Koohrang city is one of the coldest and rainiest regions of Iran. This city has 5 feeders and a 63/20 distribution substation. This city has sensitive places such as: Imam Javad Hospital, governorate, police command, health centers, telecommunications. Due to the size of this city and the presence of a distribution post, by disrupting one of the feeders, it causes a power cut in the rest of the cities and villages of this city. Heavy snowfall in this city will block the roads and disrupt the electricity distribution network, therefore, according to the weather conditions of this city, passive defense solutions are presented as follows to overcome the crisis and maintain the stability of the electricity distribution network:

- Use of scattered production in Birgan region
- Full implementation of the AMI smart measurement system to receive subscriber information
- Construction of a solar power plant in the electricity department of Koohrang city
- Use of motorized smart boards in public posts
- Increasing maneuver points between cities.

Doi:

PASSIVE DEFENSE

A set of unarmed measures that increase deterrence, reduce vulnerability, continue essential activities, promote national stability, and facilitate crisis management against threats. Crisis management, which is one of the main issues in non-agent defense, consists of five stages, which are: crisis prevention, crisis reduction, crisis preparation, crisis intervention [6]. Distribution systems as the last sub-system in the power system have a very important position because it has the important task of distributing energy to subscribers. The main features of the distribution network, which include the importance of non-operating defense discussions in this section, are:

- Expansion and complexity of distribution networks
- Importance of load in distribution networks
- Many consumers
- Social effects

On the other hand, the access to the distribution system (its council structure) is much less compared to the production and transmission systems. Therefore, it is necessary to evaluate and improve non-functional defense indicators in this part of the power system. Non-operating defense minimizes costs, reduces losses, voltage quality, and non-technical constraints including environmental and social constraints by providing planning of distribution systems [7].

PASSIVE DEFENSE SOLUTIONS TO OVERCOME THE CRISIS

Overcoming the heavy snow crisis of Kohrang city and maintaining the stability of the distribution network, five solutions are presented as follows:

COMPLETE IMPLEMENTATION OF AMI SMART MEASUREMENT SYSTEM TO RECEIVE SUBSCRIBER INFORMATION

When a crisis occurs, by cutting off the feeder, operational teams will establish the corresponding subscribers by maneuvering with another feeder. But most of the time due to the high load and length of the feeder, it causes voltage drop and causes consumer dissatisfaction. By installing smart metering systems, electricity distribution companies begin to identify non-priority subscribers and remove this category of subscribers from the circuit and help the stability of the feeder. We use zigbee technology to implement this idea. This technology is a new wireless technology that is guided by the personal network standard IEE 802.15.4. This technology is used to control the power consumption of the AMR wireless mesh network. This structure is superior in many ways such as very low power consumption, high network security, high reliability, flexibility, expandability, use of free frequency band, relatively short range communication, etc. In this design, the combination of zigbee mesh networks and Gprs network is used [8]. The whole area is divided into smaller geographical areas, each of these areas has a central node to collect the data read from the meters of that area. The meters in each area are connected to each other with a zigbee mesh network and send their read data to the central node in their area through a network. In the central points, using a microprocessor and a Gprs modem, the data collected in the Gprs platform are transferred to the server of the electricity department.

The AMR network consists of three main parts, namely the transmitter part (connected to the meter), the central points part and the receiver part (server of the electricity department). The transmitter part includes a digital meter, a microcontroller to control the reading, a non-volatile RAM memory to store meter information, a chipzigbee to wirelessly send data to central points. The block diagram of the transmitter is as follows:

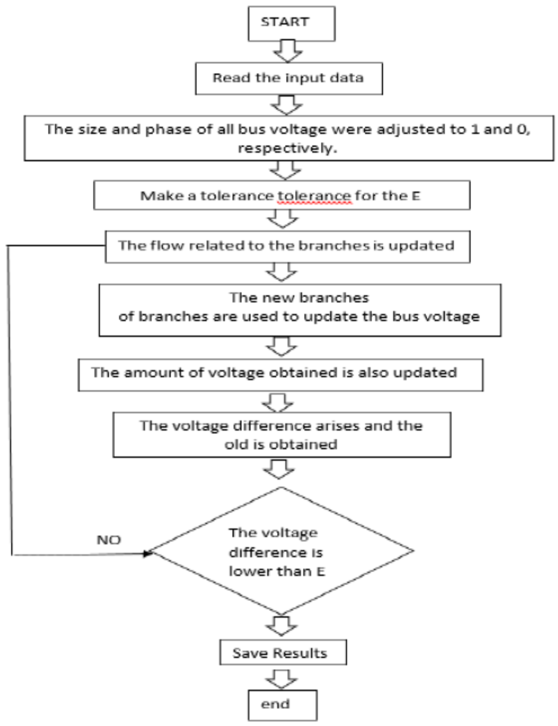


Fig.1: Block diagram of the transmitter section

The central part or collector, which is responsible for sending the information collected from the controls of that area on the GPRS platform to the server of the electricity department, includes a zigbee chip that is programmed as a coordinator, a modem with wavecom fastrak m136b model, which is responsible for sending It has the information and a microprocessor that is responsible for sending the command to the transmitter part is used. The block diagram of the central part is as follows.

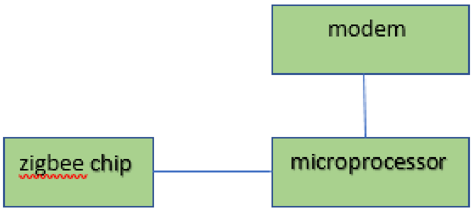


Fig.2: block diagram of the central part

In the receiver part, it is connected to the server of the electricity department by a modem, and the server is connected to the modem connected to the microprocessor in the central part by using this modem, and after establishing the connection, the information is transferred to the server.

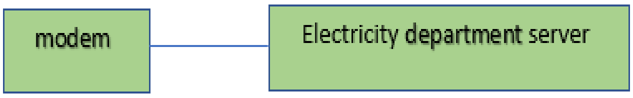


Fig.3: block diagram of the receiver section

USE OF SCATTERED PRODUCTION IN BIRGAN REGION

Heavy snowfall in Birgan region does not block the roads and does not allow the operation forces of the Electricity Department to fix the voltage drop and improve the power of the feeder. To solve this problem, use scattered production in the region. For optimal placement, we use genetic algorithm (GA) and check the results to improve the voltage profile and power of the feeder. In this method, positioning is done with the aim of reducing the losses of the entire network and improving the voltage profile. This method has been implemented on IEEE 30 bus network. In order to determine the losses of the mentioned network, the following information is entered and the wind part is implemented using the Newton-Raphson method with the genetic algorithm.

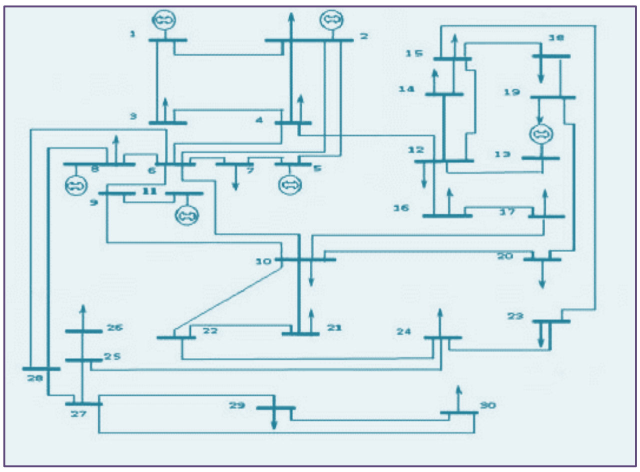


Fig.4: Network 30 with three IEEE

The characteristics of this network, load and lines are shown below:

```
basemva = 100; accuracy = 0.001; maxiter = 50;
%   IEEE 30-BUS TEST SYSTEM (American Electric Power)
  busdata= [1   1   1.06   0    0     0      0   0    0   0   0
            2   2   1 .04  0   21.7 12.7  0   0 -40  50  0
            3   0   1      0   2.4  1.2     0    0    0    0  0
            4   0   1 .06  0   7.6   1.6     0    0   0    0   0
            5   2   1 .01  0   94.2   19  0   0   -40   40   0
            6   0   1 .0   0    0   0    0    0     0       0     0
            7   0  1 .0   0    22.8   11    0    0    0        0
            8   2   1.01  0    30   30   0   0   -10   60   0
            9   0    1.0   0    0    0   0     0     0     0   0
           10   0    1.0     0     5.8   2  0   0   -6   24   19
           11   2    1.08   0     0   0    0    0     0    0     0
           12   0    1.0     0    11.2 7.5   0    0   0   0     0
           13   2    1.07   0    0     0     0   0    -6   24    0
           14   0    1      0    6.2    1.6   0    0   0   0     0
           15   0    1       0    8.2   2.5   0    0   0   0      0
           16   0    1    0    3.5   1.8    0     0    0   0      0
           17   0    1      0    9   5.8    0     0     0   0      0
           18   0    1     0    3.2   0.9    0     0    0   0      0
           19   0    1     0    9.5   3.4    0     0    0   0      0
           20   0    1    0    2.2  0.7     0     0     0   0      0
           21   0    1    0   17.5 11.2   0     0     0   0      0
           22   0    1     0    0     0     0   0     0     0       0
           23   0    1     0   3.2     1.6    0   0    0   0      0
           24   0    1    0   8.7   6.7    0     0    0   0     4.3
           25   0   1    0   0     0     0    0     0   0        0
           26   0   1   0   3.5     2.3    0    0     0    0      0
           27   0   1     0   0     0     0    0.0     0   0      0
          28    0   1    0   0    0    0    0    0       0       0
          29    0   1     0   2.4      0.9    0   0    0   0      0
          30    0    1    0   11   1.9   0    0       0   0     0];
```

The simulation results of the voltage profile and losses after 11 repetitions are as follows:

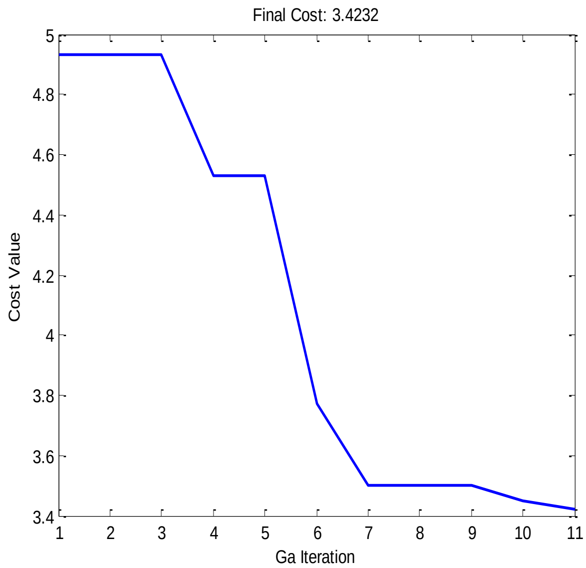


Fig .5: Loss optimization

According to the above figure and the slope of the graph, it can be seen that after repeating 11 times in each stage, he tried to improve the optimal solution. In order to show the effect of applying DG on the grid voltage, the results before and after the application of distributed generation in each of the gases are as follows.

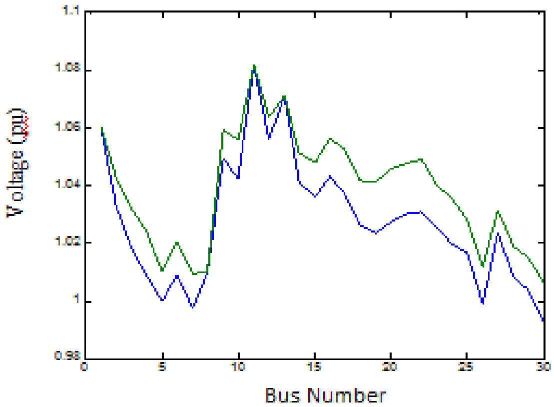


Fig.6: Voltage profile before applying DG

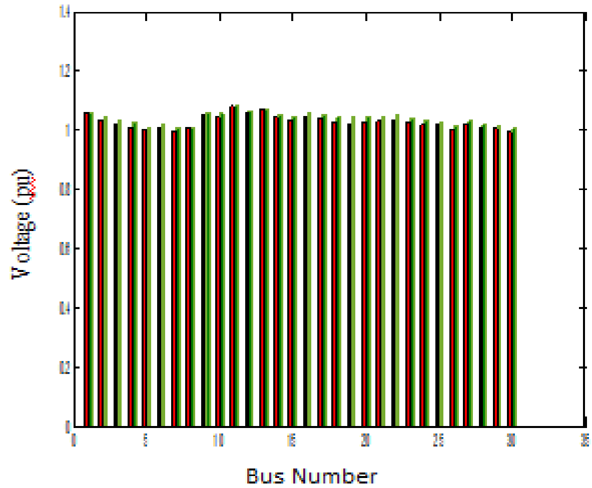


Fig.7: Voltage profile after applying DG

CREATION OF MANEUVERING POINTS WITH FEEDERS OF NEIGHBORING CITIES

In fact, the fault in the electricity distribution network causes a forced shutdown, which is far from the mission of the electricity distribution companies. Changing the arrangement of feeders is done through switching at the points called maneuver points, the existence of these points in the filters is an important factor in increasing the reliability and distribution of electrical energy. Therefore, maneuvering points are one of the important and fundamental parameters of the electricity distribution network because the distribution network is designed radially. Koohrang city has four maneuvering points with Shahrekord-Farsan and Ardal cities, which are as follows.

-MANEUVER POINTS WITH SHAHREKORD AND KOHRANG CITIES:

The maneuver point of the cities is between the feeders of 12 Kurang and 6 Shahrekord at the coordinates of x=439407 and y=3600613.

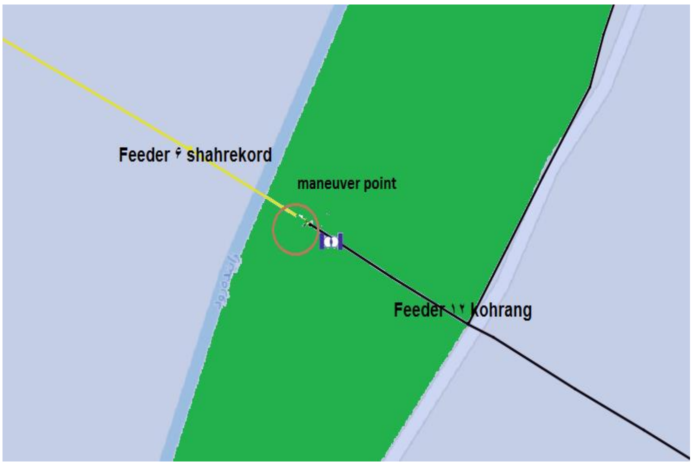


Fig.8: Maneuver points with Shahrekord and Kohrang cities

- Maneuvering point between Kohrang city and Ardal city:

The maneuvering point of the cities is between the feeder of Chahar Dashtak and Chahar Kohrang at the coordinates of x=426972 and y=356853

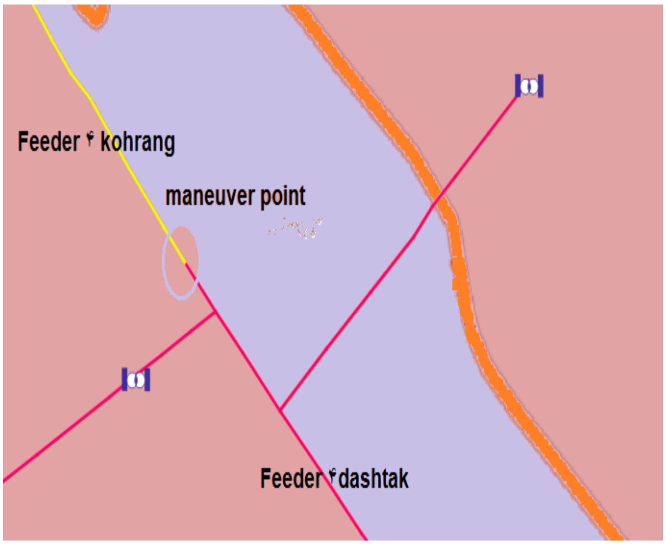


Fig.9: Maneuvering point between Kohrang city and Ardal city

- Maneuver point between Kohrang and Farsan cities:

The maneuvering points of the cities are between feeder 7 of Farsan and 4 of Kohrang with coordinates y=3582761 and x=438444 [10,11].

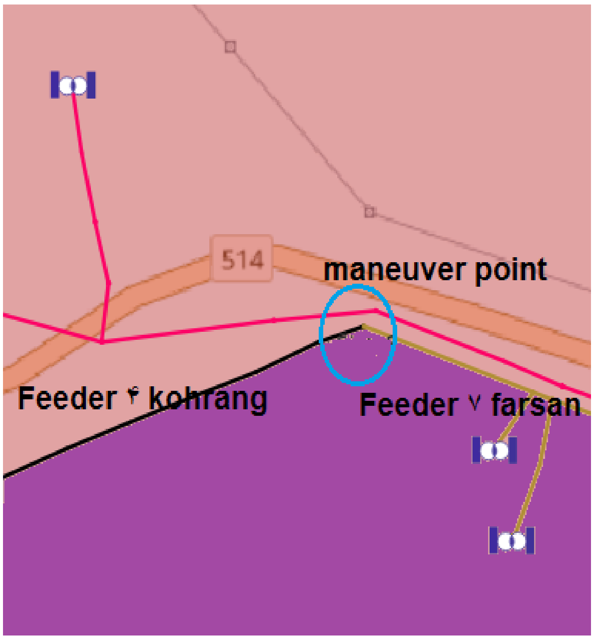
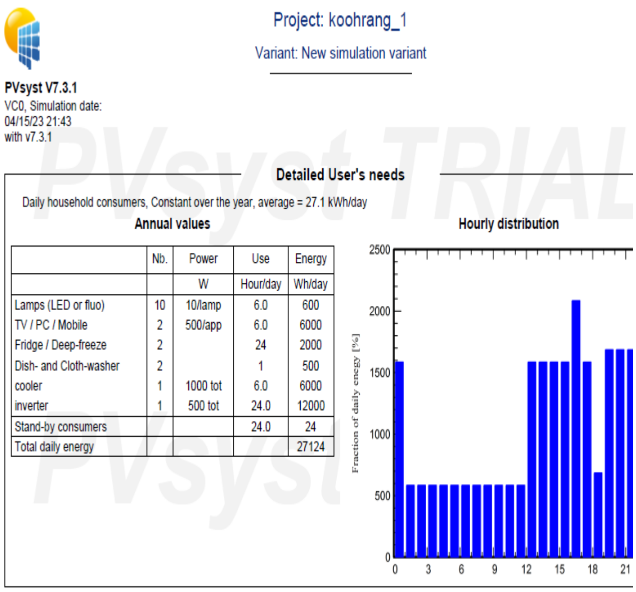


Fig.10: Maneuver point between Kohrang and Farsan cities

CONSTRUCTION OF A SOLAR POWER PLANT FOR THE ELECTRICITY DEPARTMENT OF KOHRANG CITY

The building of the city's electricity department is one of the sensitive points because all maneuver operations start from the center of this department. The solar power plant in this office is used to generate energy and store it on the days when the city's feeders are cut off to power up the building, charge wireless devices, operate tablets, etc. The capacity of this power plant is considered to be 10 kW and its design is done with PVSYST software and the results are as follows:

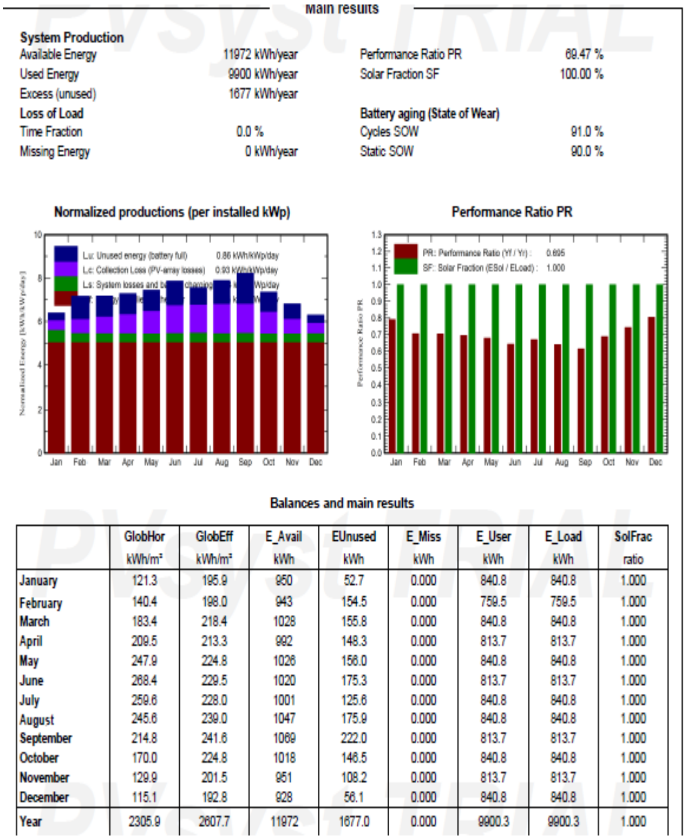
16 panels of 335 watts and 17 batteries of 48 volts, 120 amps in parallel and a charge controller of 1000 watts full sine mppt have been designed. The consumers and the daily consumption chart are as follows:



	Nb.	Power	Use	Energy
		W	Hour/day	Wh/day
Lamps (LED or fluo)	10	10/lamp	6.0	600
TV / PC / Mobile	2	500/app	6.0	6000
Fridge / Deep-freeze	2		24	2000
Dish- and Cloth-washer	2		1	500
cooler	1	1000 tot	6.0	6000
inverter	1	500 tot	24.0	12000
Stand-by consumers			24.0	24
Total daily energy				27124

Fig.11: consumers and the daily consumption

The simulation results of the power plant are as follows:



	GlobHor	GlobEff	E_Avail	EUnused	E_Miss	E_User	E_Load	SolFrac
	kWh/m²	kWh/m²	kWh	kWh	kWh	kWh	kWh	ratio
January	121.3	195.9	950	52.7	0.000	840.8	840.8	1.000
February	140.4	198.0	943	154.5	0.000	759.5	759.5	1.000
March	183.4	218.4	1028	155.8	0.000	840.8	840.8	1.000
April	209.5	213.3	992	148.3	0.000	813.7	813.7	1.000
May	247.9	224.8	1026	156.0	0.000	840.8	840.8	1.000
June	268.4	229.5	1020	175.3	0.000	813.7	813.7	1.000
July	259.6	228.0	1001	125.6	0.000	840.8	840.8	1.000
August	245.6	239.0	1047	175.9	0.000	840.8	840.8	1.000
September	214.8	241.6	1069	222.0	0.000	813.7	813.7	1.000
October	170.0	224.8	1018	146.5	0.000	840.8	840.8	1.000
November	129.9	201.5	951	108.2	0.000	813.7	813.7	1.000
December	115.1	192.8	928	56.1	0.000	840.8	840.8	1.000
Year	2305.9	2607.7	11972	1677.0	0.000	9900.3	9900.3	1.000

Fig.12: Energy consumption per year

In the above table, the amount of energy consumed is 9900 kilowatt hours per year. The system is designed with the lowest losses, and the amount of losses in each section is as follows: [12]

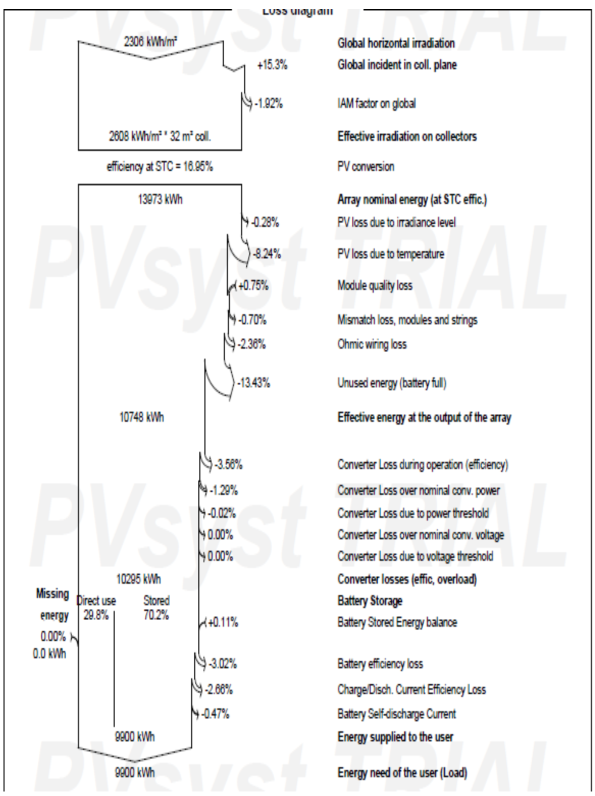


Fig.13: The amount of casualties

USE OF MOTORIZED SMART BOARDS IN PUBLIC POSTS

Public substations are responsible for distributing energy between consumers and providing street lighting. Disturbances in these panels cause blackouts and power outages for customers. In Kohrang city, due to the huge amount of snow, the distribution boards are buried under the snow and it causes disruption in the distribution of electricity between subscribers.

Fig.14: The distribution board falling under the snow

To control and optimize energy, automatic motorized switches are used, which have advantages such as: simultaneous coupling, disconnection and connection of load in order to optimize energy cost, replacement of normal power supply, backup by changing the status to a power supply. An alternative to save and optimize energy costs is to disconnect and connect the automatic switch in the form of remote control. The performance of the automatic key motor during the simultaneous coupling and starting of the motor locally, central function and automatic control is specified and used. Disconnecting and connecting or resetting compact automatic switches by connecting with the motor mechanism is one of the important and main applications of the automatic switch motor. The control and coordination of the connection of the motor mechanism is done by connecting to the network and it is necessary to perform this function. that the BSCM switch position control module and the NSX wire are installed and started. Connecting the BSCM module to the network using the NSX wire is done with the aim of receiving the disconnection and connection command and requesting a reset or reset, as well as transferring the automatic switch to the OFF and ON states [13].

Fig.15: Photos of the motorized smart board

RESULTS AND DISCUSSION

By implementing the suggested solutions in Kohrang city in February 1401, the amount of undistributed energy was compared in two critical months of 1401 (February and March) and the results using Tazarv software are as follows:

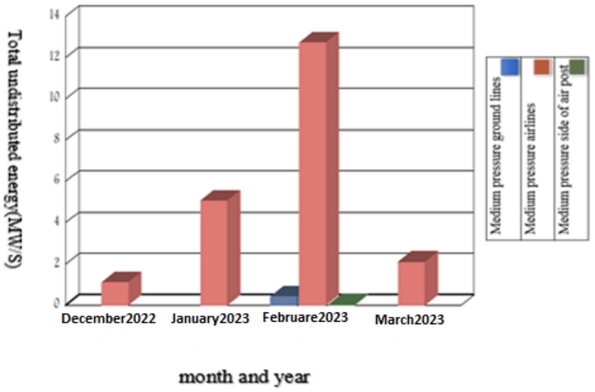


Fig.16: Undistributed energy medium pressure

According to the above statistics, in February with heavy snowfall, the amount of undistributed energy has reached 12 megawatts. The reason for this was the frequent blackouts of the city's feeders. By applying crisis management solutions under the same conditions in March, the amount of undistributed energy has been reduced to 2 megawatts. When the medium pressure feeder is cut off, low pressure distribution stations are unavailable and the amount of undistributed energy in low pressure lines increases. According to the statistics recorded in Tezro software in February 1401, the amount of undistributed energy of weak pressure lines has reached 62 kilowatt hours, which has been reduced to zero by applying non-active defense solutions. Also, in the subscribers' section, the amount of undistributed energy was 20 kilowatt hours in February, which decreased by 10 kilowatts in March.

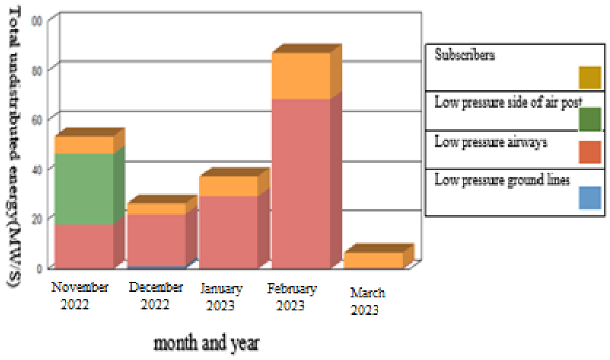


Fig.17: Undistributed energy of weak pressure

Reliability is desirable for a network that has less downtime. Therefore, the blackout duration has a direct relationship with the rate of undistributed energy. In February, the amount of undistributed energy rate was 38,462 kilowatt hours, and in March of this year, this amount became zero. It should be mentioned that this amount has decreased significantly in March compared to last year.

Table.1: Undistributed energy rate

Comparative report of undistributed energy rates of medium pressure network by month					
February		January		District	Row
Last year	Current year	Last year	Current year		
0.03	0.00	3.06	38.46	Koohrang	1
0.03	0.00	3.06	33.46	total	2

CONCLUSION

In this article, the solutions to overcome the crisis were discussed with the aim of implementing non-operating defense in the weather conditions of Kohrang city. By implementing these solutions, it has decreased by 1.6. Also, with the reduction of undistributed energy in the weak pressure sector, it has brought the level of customer satisfaction. By comparing the rate of undistributed energy in the critical months of the year, we conclude that the reliability of the distribution network has increased, which is an important goal in electricity distribution networks.

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