Autonomous life support using intelligent analysis in Kazakhstan

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***Abstract*—The Republic of Kazakhstan has chosen a fundamentally new path for the development of society with the adoption by of the "Strategy "Kazakhstan 2050" and the Concept of transition to a "green" economy. One of the central points in the gradual transition to a green economy is energy efficiency. The use of modern neural network technologies in this area is a promising and relevant area of research. In this paper, we propose a model consisting of two similar perceptrons, one of which is applicable for predicting the hourly load profile of a working day, the other for a weekend or holiday. It was developed the software "Smart House Energy Management System". The software product includes four main blocks: Measurement data; Power indicators; Generation and consumption of electricity; and predictive model. The demo example predicted the current drawn by the load for two connected devices. It is possible to play different scenarios, disconnect and connect devices. We can adjust the work of alternative energy sources (we have solar panels) depending on the forecast.**

***Keywords*— smart house, intelligent analysis, energy efficiency**

I. Introduction

Now much attention all over the world and in Kazakhstan in particular is paid to the issues of energy saving and energy efficiency. This topic has been relevant for many years. This shows the presence of publications devoted to this issue, for example [1-11]. Particular attention is paid to solving the problems of uninterrupted power supply of residential buildings. The Republic of Kazakhstan has chosen a fundamentally new path for the development of society after the adoption of the "Strategy "Kazakhstan 2050" and the Concept of transition to a "green" economy. According to the Concept, the focus of state policy on reducing environmental impact, resource conservation and achieving a high level of quality of life for the population will play a key role. Kazakhstan has significant opportunities for improving energy efficiency in industry, energy, housing and communal services and transport [12]. Energy efficiency is one of the central points of a phased transition to a green economy.

The aim of the study is to develop software for regulating the energy consumption of a residential building using, along with the traditional source of an alternative energy source - solar panels.

We have discussed this problem in detail during Hungarian Science Festival 2020 by Óbuda University, 12.11.2020 [13]. After the study, we came to the conclusion that the topic is practically significant and very relevant.

II. Modeling

We propose a model consisting of two similar perceptrons, one of which is applicable for predicting the hourly load profile of a working day, the other for a weekend or holiday. In the proposed model, the learning processes for workdays and weekends (or holidays) were separated, i.e., four matrices of synaptic weights were calculated (two for each perceptron). The architecture of the neural network includes three layers: Input, Hidden and Output. (see Figure 1).

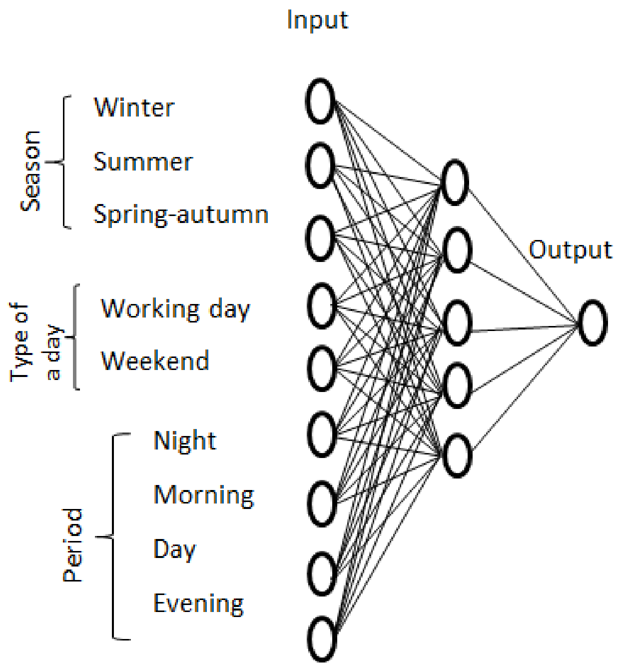

Fig. 1. The architecture of the neural network

Input layer consists from 3 groups:

1) Season (winter, summer, spring-autumn),

2) Type of a day (weekend or working day) and

3) Period (night, morning, daytime, evening).

Input data of the neural network include information about seasons, type of a day and time of day (period). Output data present a profile of the power consumption: enough or not the energy from solar panel or we need additional energy.

18 daily load curves were selected, of which 16 formed a training sample, and 2 - a control one to train a neural network that predicts the power consumption of individual residential buildings. The initial synaptic weights were

chosen in such a way that before the training of the neural network, the relative load of a residential building with electric stoves during the morning peak in autumn will be 50%.

The backpropagation algorithm was used for training. Due to the limited training sample, it was necessary to repeat the training cycle. The cyclic loading of the training sample into the neural network in both cases was repeated until the root-mean-square change in the weights of neurons during the training cycle fell below 3%. For this, 12 cycles were enough.

III. THE EXPERIMENTAL INSTALLATION

The choice of generators for the experimental setup was dictated by the available equipment. Monocrystalline and polycrystalline photovoltaic modules were used in this installation. Once installed on the roof, they can be considered as built-in renewable energy sources.

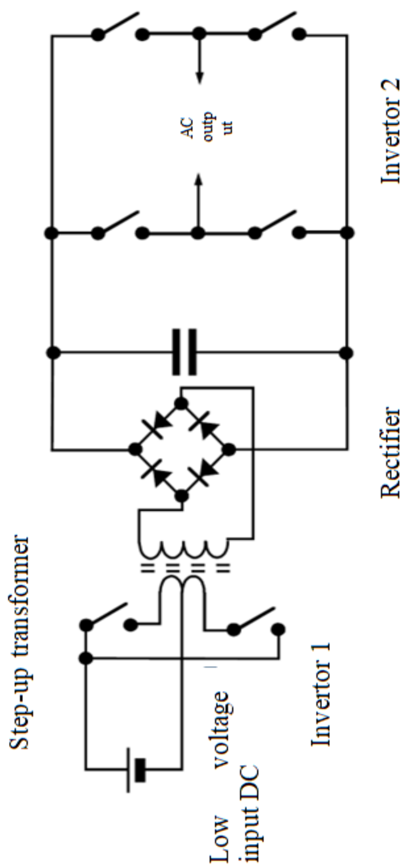

Fig. 2. The topology of the inverter

Equipment is needed to ensure interaction with the grid that converts direct current to alternating current and changes the voltage to the desired level, since batteries and photovoltaic modules operate on direct current, while the electrical network is 230 volts AC, 50 Hz. In other words, the use of an inverter is required. In the system under consideration, the inverter acts as a bridge between the part of the system containing generators and storage and the part containing loads.

As part of this work, a 550 W network inverter was designed and built. Let's define the basic connection diagram. The system will have two buses: a DC bus and an AC bus. All DC installations (photovoltaic, DWT, ballast load, batteries) are connected to the DC bus, and all AC installations (loads, mains) are connected to the AC bus. The inverter connects to both buses and links them together.

It is necessary to know the energy flow going from and to each installation object to connect measuring equipment. This flow, depending on the type of device, must either be measured or controlled to the desired value. The topology of the inverter used in the experimental setup is shown in Figure 2.

This part of the experimental setup consists of an inverter (in this case a breaker) followed by a transformer, which in turn is followed by a rectifier. Although it is more difficult, it has certain advantages. When the inverter output passes through a transformer, the transformer must be sized to operate with the inverter's output frequency.

The proposed system required some way to make electrical loads "smart" using fuzzy logic elements. The practical part of designing a Smart Plug device is discussed in detail and published in the materials of the AIS2020 symposium [13].

IV. SOFTWARE

The software consists of four main blocks: Measurement data; Power indicators; Generation and consumption of electricity; Predictive model.

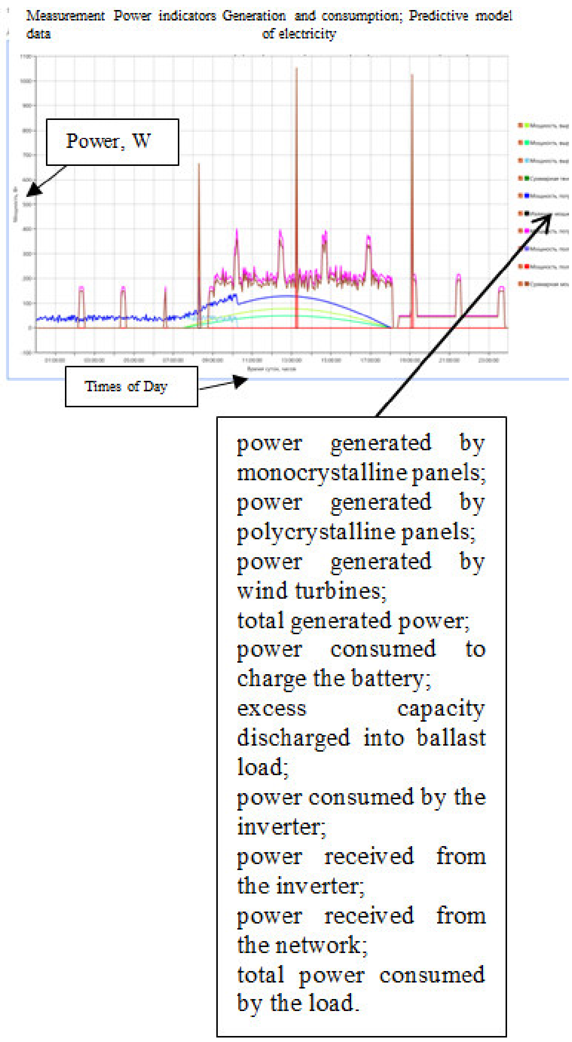

Fig. 3. Tab "Power indicators"

Figure 4 shows graphs for three indicators depending on the time of day:

- the power received from the inverter;

- power received from the network;

- the total power consumed by the load.

When we click on the button "Calculate the balance of electricity for the day" the calculation of the following indicators is calculate:

- generated by single-crystal panels, W*h;

- produced by polycrystalline panels;

- produced by wind turbines;

- total electricity generated;

- power consumed to charge the battery;

- consumed from the inverter;

- consumed from the network;

- total electricity consumption.

The figure shows an example of forecasting for two devices turned on simultaneously.

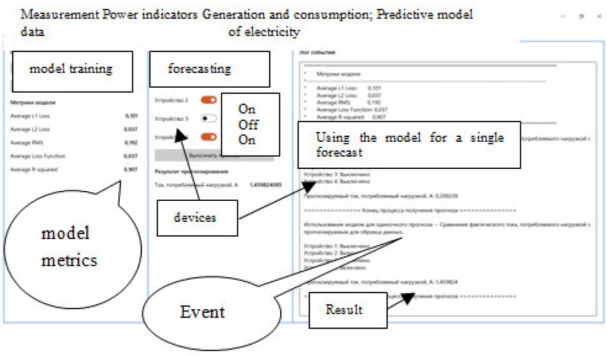

Fig. 4. An example of forecasting for two switched on devices and certificate of authorship for software

The software is implemented in the C # environment in accordance with the developed schemes and requirements. (see Figure 5).

Fig. 5. Certificate of authorship for software № 16772 from 14.04.2021 “Residential building intelligent energy management system ”Smarthouse”

The interface of neural connections is presented below; each connection stores a weight and a pointer to a neuron (see Figure 6).

```
template <typename T>
class Neuron;


template <typename T>
class NeuralLink
{
public:
                                        NeuralLink( ) : mWeightToNeuron( 0.0 ),

mNeuronLinkedTo( 0 ),

mWeightCorrectionTerm( 0 ),

mErrorInformationTerm( 0 ),

mLastTranslatedSignal( 0 ){ };

                                        NeuralLink( Neuron<T> * inNeuronLinkedTo,
double inWeightToNeuron = 0.0 ) :
                                                                                mWeightToNeuron(
inWeightToNeuron ),
                                                                                mNeuronLinkedTo(
inNeuronLinkedTo ),

mWeightCorrectionTerm( 0 ),

mErrorInformationTerm( 0 ),

mLastTranslatedSignal( 0 ){ };

  void SetWeight( const double& inWeight ){ mWeightToNeuron = inWeight; };
  const double& GetWeight( ){ return mWeightToNeuron; };

  void SetNeuronLinkedTo( Neuron<T> * inNeuronLinkedTo ){ mNeuronLinkedTo =
inNeuronLinkedTo; };
  Neuron<T> * GetNeuronLinkedTo( ){ return mNeuronLinkedTo; };

  void SetWeightCorrectionTerm( double inWeightCorrectionTerm ){
mWeightCorrectionTerm = inWeightCorrectionTerm; };
  double GetWeightCorrectionTerm( ){ return mWeightCorrectionTerm; };

  void UpdateWeight( ){ mWeightToNeuron = mWeightToNeuron +
mWeightCorrectionTerm; };

  double GetErrorInFormationTerm( ){ return mErrorInformationTerm; };
  void SetErrorInFormationTerm( double inEITerm ){ mErrorInformationTerm =
inEITerm; };

  void SetLastTranslatedSignal( double inLastTranslatedSignal ){
mLastTranslatedSignal = inLastTranslatedSignal; };
  double GetLastTranslatedSignal( ){ return mLastTranslatedSignal; };
protected:
  double mWeightToNeuron;
  Neuron<T> * mNeuronLinkedTo;
  double mWeightCorrectionTerm;
  double mErrorInformationTerm;
  double mLastTranslatedSignal;
```

Fig. 6. Listing of the interface of neural connections

The neural network itself stores pointers to neurons organized in layers (in general, pointers to neurons are stored in vectors that need to be replaced with layer objects), includes an abstract factory of neurons, as well as a network learning algorithm.

It is not necessary to demonstrate all algorithms realized in the work.

Figure 7 shows the realization of neural network training.

```
template <typename T>
class NeuralNetwork;

template <typename T>
class TrainAlgorithm
{
public:
	virtual ~TrainAlgorithm(){};
	virtual double Train(const std::vector<T>& inData, const std::vector<T>&
inTarget) = 0;
	virtual void WeightsInitialization() = 0;
protected:
};

template <typename T>
class Hebb : public TrainAlgorithm<T>
{
public:
		Hebb(NeuralNetwork<T> * inNeuralNetwork) :
mNeuralNetwork(inNeuralNetwork){};
	virtual ~Hebb(){};
	virtual double Train(const std::vector<T>& inData, const std::vector<T>&
inTarget);
	virtual void WeightsInitialization();
protected:
	NeuralNetwork<T> * mNeuralNetwork;
};

template <typename T>
class Backpropagation : public TrainAlgorithm<T>
{
public:
		Backpropagation(NeuralNetwork<T> * inNeuralNetwork);
	virtual ~Backpropagation(){};
	virtual double Train(const std::vector<T>& inData, const std::vector<T>&
inTarget);
	virtual void WeightsInitialization();
protected:
	void  NguyenWidrowWeightsInitialization();
	void  CommonInitialization();
	NeuralNetwork<T> * mNeuralNetwork;
};
```

Fig. 7. The algorithm of neural network training

V. Conclusion

An intelligent system has been developed that allows to regulate uninterrupted power consumption from solar panels, supplementing this process with power supply from the AC network, to reduce the power consumption of a residential building. Moreover, the system gives preference to power from an alternative energy source - solar panels. The intelligence of the system lies in the selection of the ratio of alternative and traditional energy supply in favor of the alternative, i.e. more economical option. Uninterrupted power supply is also maintained during peak hours in case of insufficient power of solar panels.

All the considered methods and algorithms are implemented in a software package in the C # programming language.

We are going to continue the research and try to test our system in real conditions.

Acknowledgment

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