Department of Electrical Power Engineering

College of Engineering

University of Diyala – IRAQ

SHORT TERM LOAD FORECASTING

Lecturer

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Short Term Load Forecasting Content

- **Overview of Short term load forecasting**
  - **Introduction**
  - **Definitions**
  - **Importance of Short-term load forecasting**
  - **Impute data and system parameters required for load forecasting**
  - **Concept of STLF model Development**
  - **Major load forecasting techniques**

  Statistical methods
  - **(Multiply liner regression,**
  - **stochastic time series e.t.c)**

Short Term Load Forecasting Content

- **Artificial Neural Networks**
- **Support Vector Machine**
- **Fuzzy logic and evolutionary programming**

Overview of Short Term Load Forecasting (STLF)

Introduction

- **Three types of load forecasting:**
  - **Long term (e.g. 20 years)**
  - **Medium term. (e.g. 3-8 weeks)**
  - **Short term (e.g. one week)**

Introduction

- **The electrical load increases about 3-7% per year for many years.**
- **The long term load increase depends on the population growth, local area development, industrial expansion e.t.c.**

Introduction

- **The building of a power plant requires:**
  - **10 years (Nuclear)**
  - **6 years (Large coal-fired)**
  - **3 years (combustion turbine)**
- **Typically the long term forecast covers a period of 20 years**
- **The electric system planning needs the forecast of the load for several years.**

Introduction

- **The medium term load forecast covers a period of a few weeks.**
- **It provides the peak load and the daily energy requirement**
- **The planning of maintenance, scheduling of the fuel supply etc. calls for medium term load forecast .**

Introduction

- **The number of generators in operation, the start up of a new unit depends on the load.**
- **The day to day operation of the system requires accurate short term load forecasting.**

  The short term load variation depends on weather, local events, type of day (Weekday or Holiday or Weekend) e.t.c.

Introduction

- Typically the short term load forecast covers a period of one week
- The forecast calculates the estimated load for each hours of the day (MW).
- The daily peak load. (MW)
- The daily or weekly energy generation. (MWh)

Definitions

- **The short term load forecasting provides load data for each hour and cover a period of one week.**
- **The load data are:**
  - **hourly or half-hourly peak load in kW**

Definitions

- **The short term load forecasting is performed daily or weekly.**
- **The forecasted data are continuously updated.**

Importance of Short-term Load Forecasting

- **Provide load data to the dispatchers for economic and reliable operation of the local power system.**
- **The accuracy of the data affects the cost of operation.**
  - **Example: The increase of accuracy of the forecast by 1% reduced the operating cost by £10M in the British Power system in year.**

Importance of Short-term Load Forecasting

- The forecasted data are used for:
  - Unit commitment.
    - selection of generators in operation,
    - start up/shut down of generation to minimize operation cost
  - Hydro scheduling to optimize water release from reservoirs

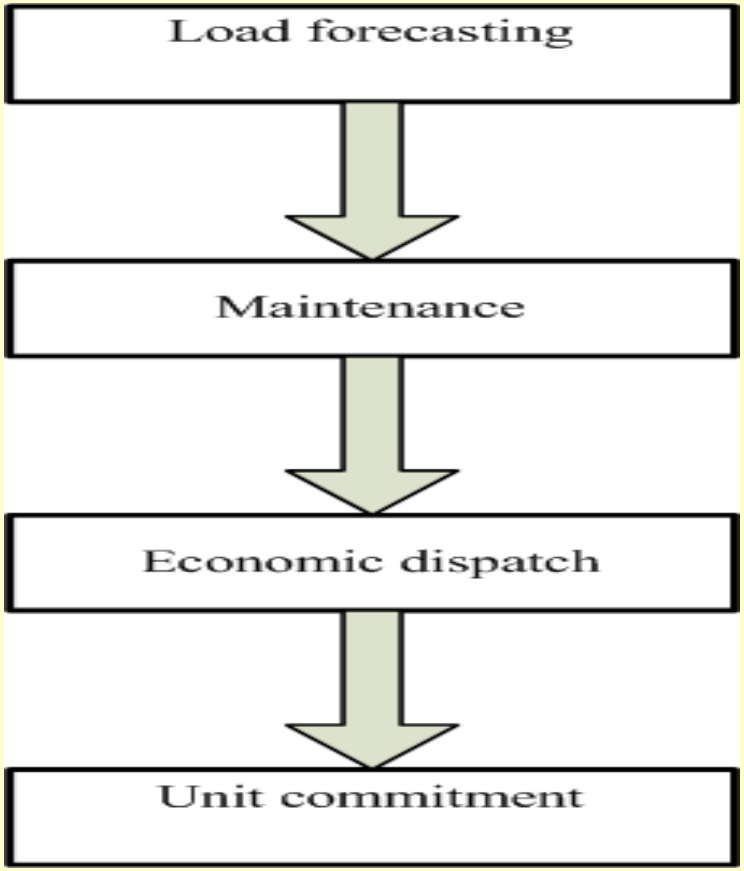
Importance of Short-term Load Forecasting

- The forecasted data are used for:
  - Interchange scheduling and energy purchase.
  - Transmission line loading
  - Power system security assessment.
    - Load-flow
    - transient stability studies

Importance of Short-term Load Forecasting

- Maintenance

  – load shedding,
  – starting up of peak units,
  – switching off interconnections,
  – increase spinning and stand by reserve


Load forecasting
Maintenance
Economic dispatch
Unit commitment

Impute Data and System Parameters for Load Forecasting

- The system load is the sum of individual load.
- The usage of electricity by individuals is unpredictable and varies randomly.
- The system load has two components:
  - Base component
  - Randomly variable component

Impute Data and System Parameters for Load Forecasting

- The factors affecting the load are:
  - economical or environmental
  - time
  - weather
  - random events

Impute Data and System Parameters for Load Forecasting

Economical or environmental factors

- Service area demographics (rural, residential)
- Industrial growth.
- Economical trends (recession or expansion)
- Change of the price of electricity
- Demand side load management

Impute Data and System Parameters for Load Forecasting

Time Factors affecting the load

- **Seasonal variation of load (summer, winter etc.). The load change is due to:**
  - **Change of number of daylight hours**
  - **Gradual change of average temperature**
  - **Start of school year, vacation**
- **Calls for a different model for each season**

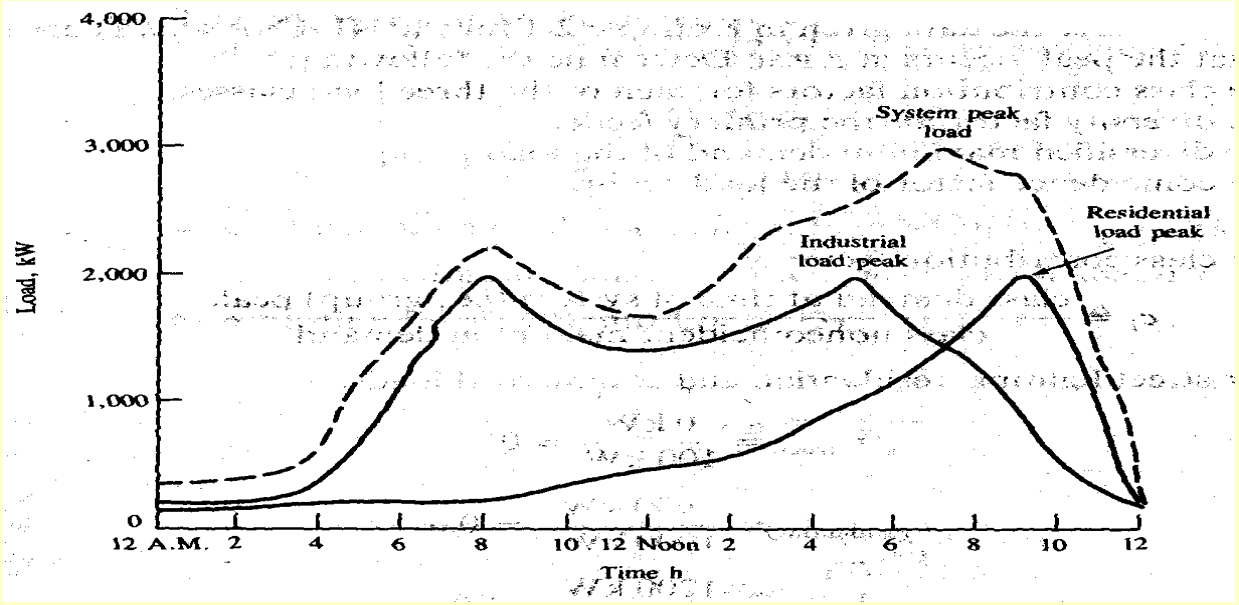
Impute Data and System Parameters for Load Forecasting

Typical Seasonal Variation of Load

Impute Data and System Parameters for Load Forecasting

Time Factors affecting the load

Daily variation of load. (night, morning,etc)



Impute Data and System Parameters for Load Forecasti

Time Factors affecting the load

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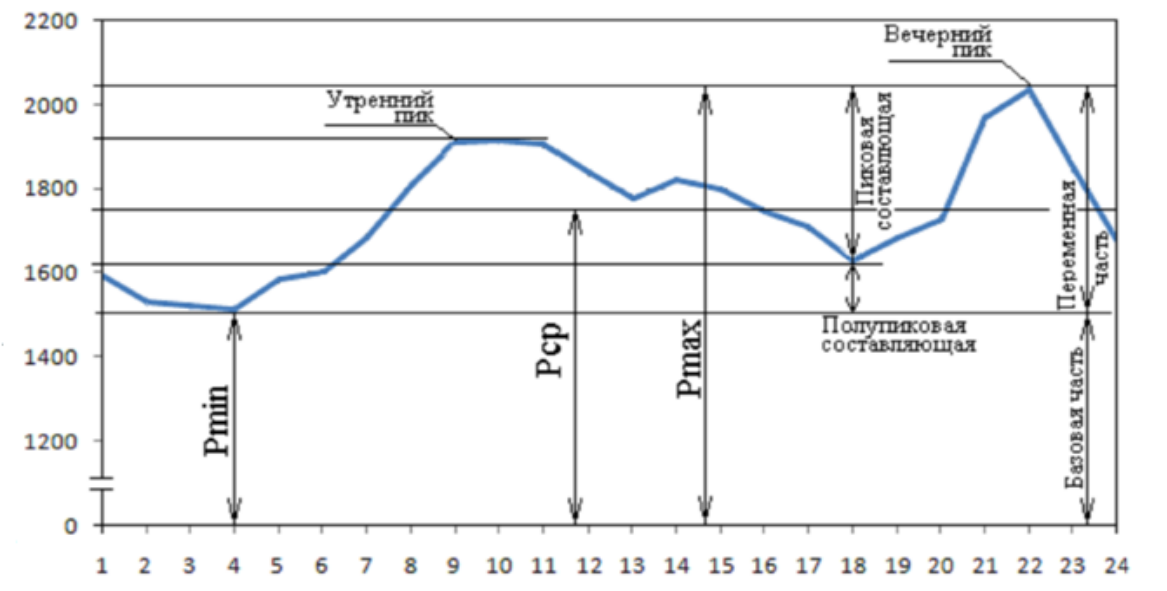
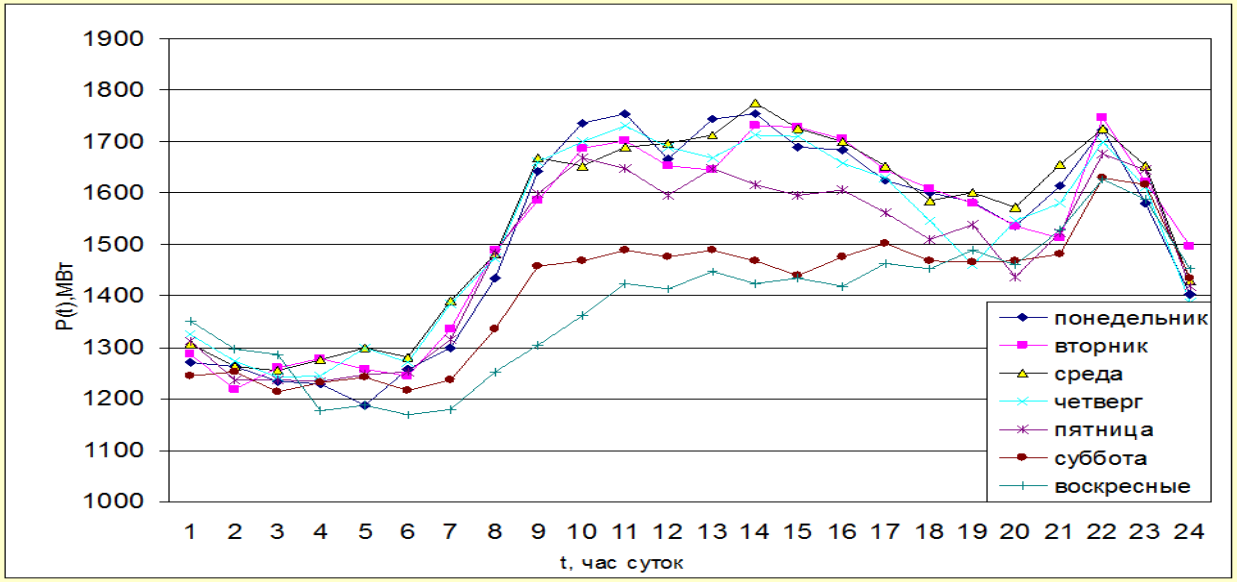


28 April 2010

Impute Data and System Parameters for Load Forecasting

Weekly Cyclic Variation

- **Saturday and Sunday Significant load reduction**
- **Typical weekly load pattern:**



Impute Data and System Parameters for Load Forecasting

Time Factors affecting the load

- **Holidays (Christmas, New Years)**
  - **Significant reduction of load**
  - **Days proceeding or following the holidays also have a reduced load.**

Impute Data and System Parameters for Load Forecasting

- Weather factors affecting the load
- The weather affects the load because of weather sensitive loads:
  - air-conditioning
  - house heating
  - illumination

Impute Data and System Parameters for Load Forecasting

Weather factors affecting the load

The most important parameters are:

- **Forecasted temperature**
- **Forecasted maximum daily temperature**
- **Past temperature**

Regional temperature in regions with diverse climate

Impute Data and System Parameters for Load Forecasting

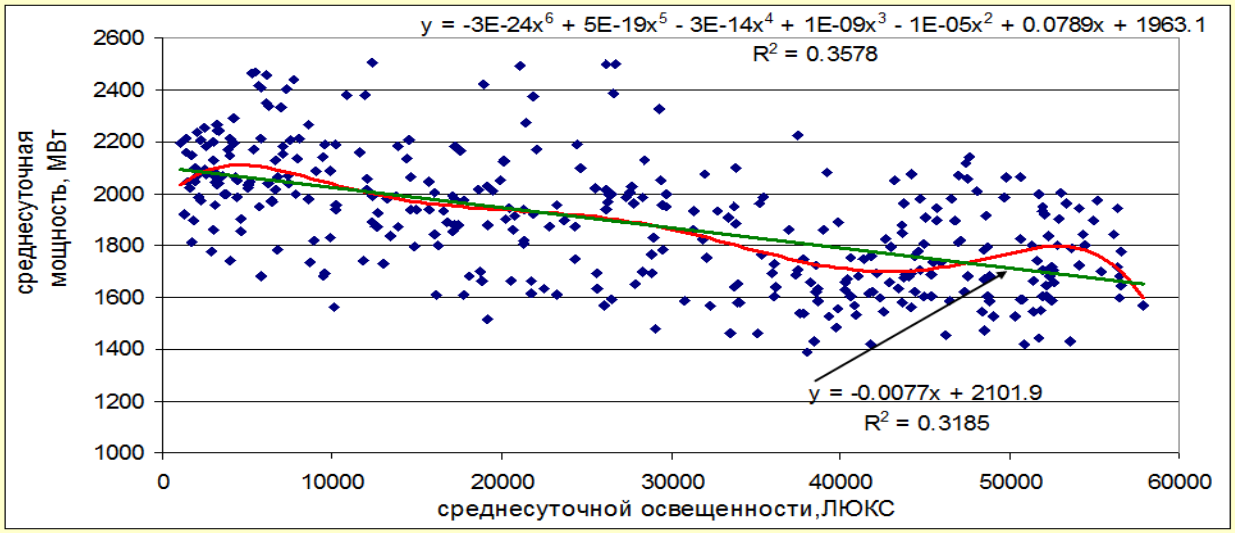
Weather Factors Affecting the Load

The most important parameters are:

- **Cloud cover or natural lighting.**
- **Humidity**
- **Wind speed**
- **Rain, fog, snow**

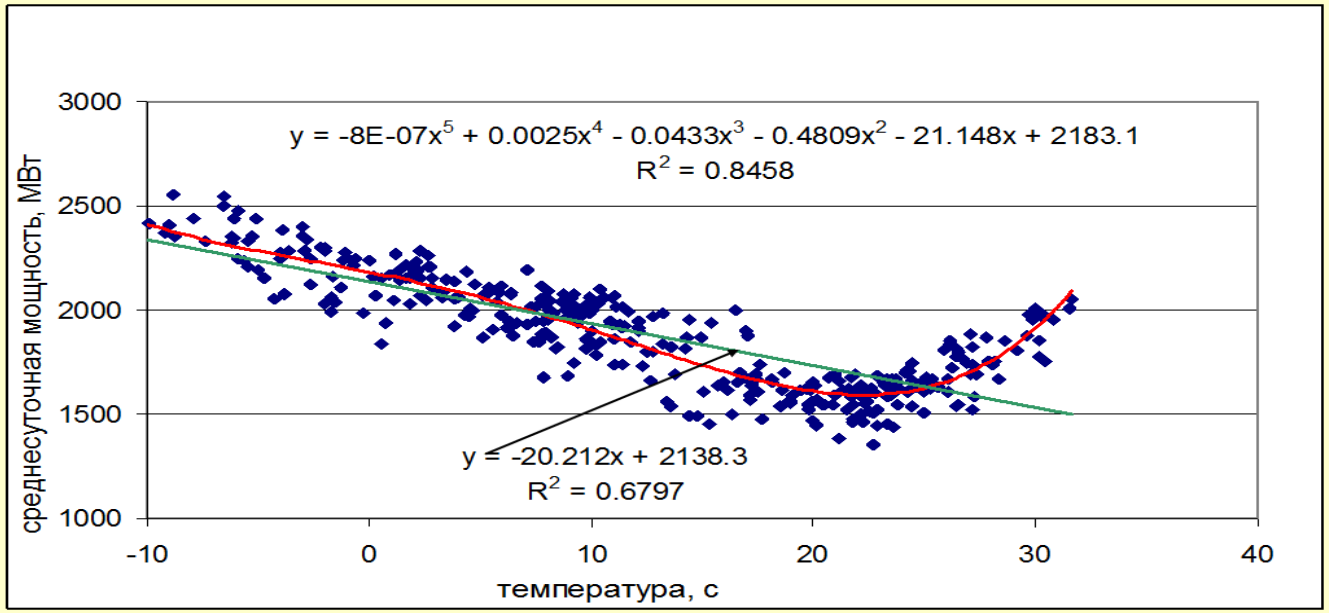
Impute Data and System Parameters for Load Forecasting

The figure shows example of daily power consumption dependences on daily natural light of operating zone of the Rostov dispatcher control during the year, it is clear that correlation for linear and non-linear models show weak correlation between the power consumption and natural light .

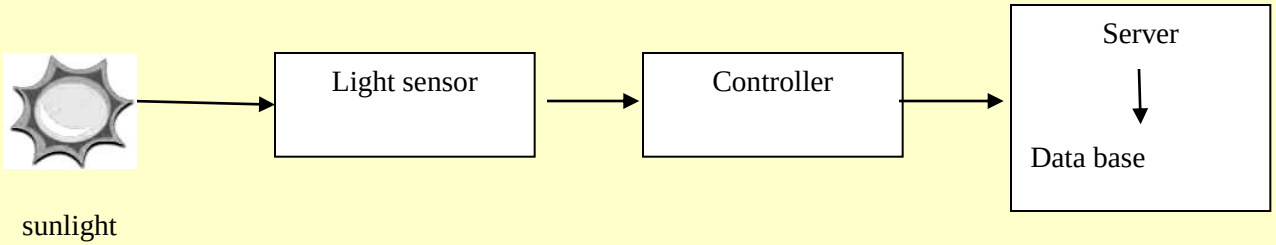


Impute Data and System Parameters for Load Forecasting

The figure shows example of daily power consumption dependences on daily temperature of operating zone of the Rostov dispatcher control during the year, it is clear that correlation for linear and non-linear models show weak correlation between the power consumption and temperature.



Impute Data and System Parameters for Load Forecasting



Block diagram of natural lighting control station.

In a five-minute light exposure values determined hourly. When selecting installation locations of stations taken into account three main factors: a) the differing climate; b) the concentration of population.

Impute Data and System Parameters for Load Forecasting

Impute Data and System Parameters for Load Forecasting

Random Disturbances Effects on Load

- Start or stop of large loads (steel mill, factory, furnace)
- Widespread strikes
- Sporting events (football games)
- Popular television shows

Impute Data and System Parameters for Load Forecasting

- **The different load forecasting techniques use different sets of data listed before.**
- **Two -three years of data is required for the validation and development of a new forecasting program.**
- **The practical use of a forecasting program requires a *moving time window* of data**

Impute Data and System Parameters for Load Forecasting

- **The data requires for forecasting:**
  - **Data covering the last 3-6 weeks**
  - **Data forecasted for the forecasting period, generally one day or one week.**

Impute Data and System Parameters for Load Forecasting

- **The selection of long periods of historical data eliminates the seasonal variation**
- **The selection of short periods of historical data eliminates the processes that are no longer operative.**

Impute Data and System Parameters for Load Forecasting

- **The forecasting is a continuous process.**
- **The forecaster**
  - **prepares a new forecast for everyday and**
  - **updates the existing forecast daily**
- **The data base is a moving window of data**

Major Load Forecasting Techniques

- Similar-day approach
- Statistical methods
- expert system
- Artificial Neural Networks
- Fuzzy logic
- Support vector machine
- Evolutionary programming
- expert system
- Combination of the above methods

Major Load Forecasting Techniques

- In my work concentrates on load forecasting methods using neural networks, support vector machine, fuzzy logic and Evolutionary programming .

Concept of STLF Model Development

- Model selection
- Calculation and update of model parameters
- Testing the model performance
- Update/modification of the model if the performance is not satisfactory

Concept of STLF Model Development

- **Model selection**
  - **Selection of mathematical techniques that match with the local requirements**
- **Calculation and update of model parameters**
  - **This includes the determination of the constants and**
  - **selection of the method to update the constants values corresponding to behavior of power demand)**

Concept of STLF Model Development

- **Testing the model performance**
  - **First the model performance has to be validated using 2-3 years of historical data**
  - **The final validation is the use of the model in real life conditions. The evaluation terms are:**
    - **accuracy**
    - **ease of use**

Concept of STLF Model Development

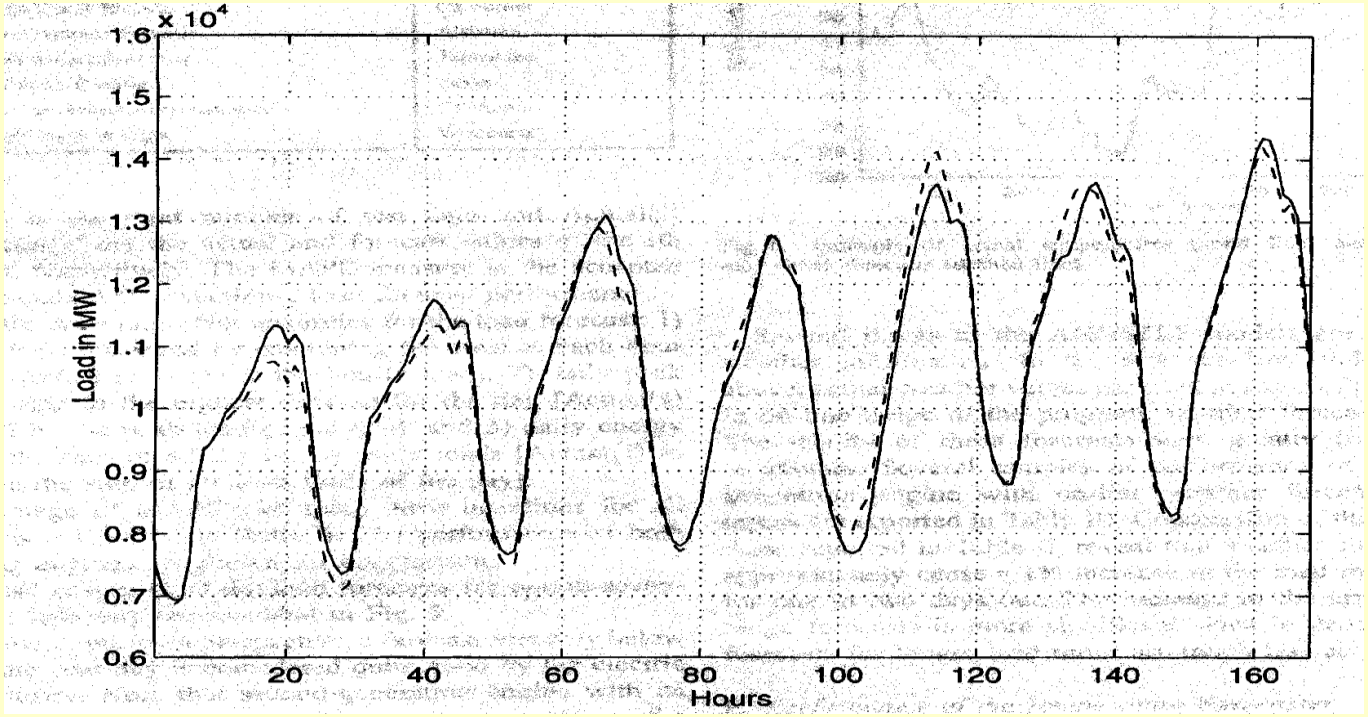
- **Update/modification of the model if the performance is not satisfactory**
  - **Due to the changing (decline of local industry etc.) the model becomes obsolete and inaccurate,**
  - **Model performance, accuracy has to be evaluated continuously**
  - **Periodic update of parameters or the change of model structure is needed**

Load Forecasting For Holidays

- **The load during the holidays has different patterns and is significantly reduced.**
- **The forecast is inaccurate because of the small number of historical data.**
- **The holiday is treated as**
  - **Sunday , Saturday.**

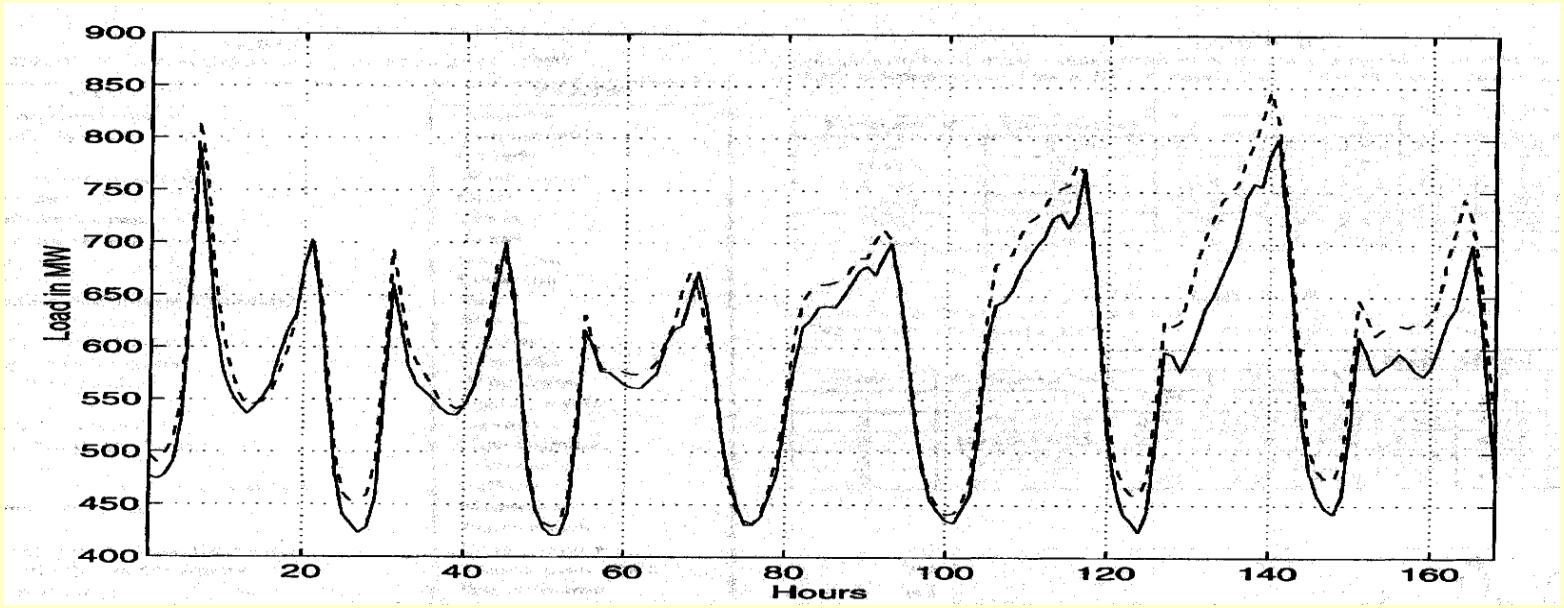
Load Forecasting Results

Comparison of forecasted and actual loads

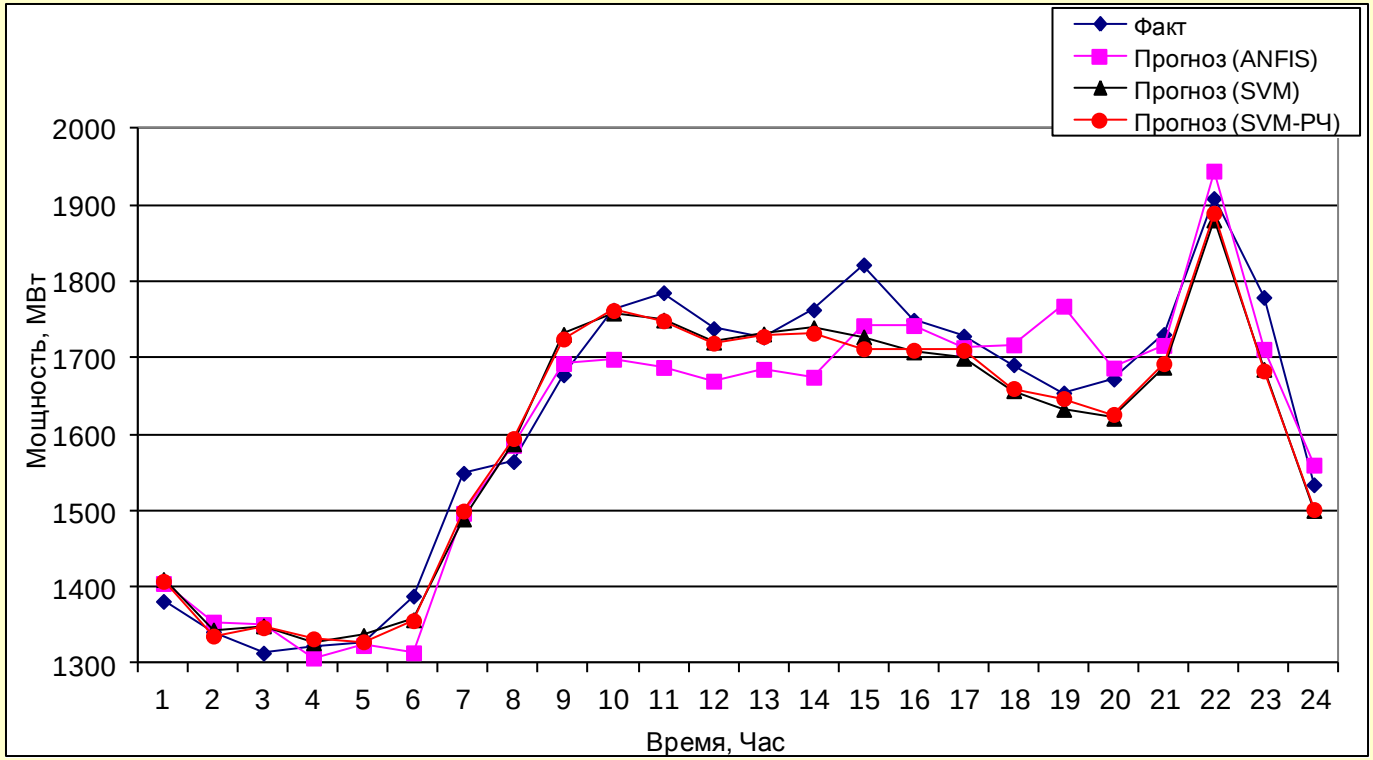


Load Forecasting Results

- **Accuracy less than 3% for the next days forecast is considered good**
- **The longer term forecast accuracy is less (7-8%)**

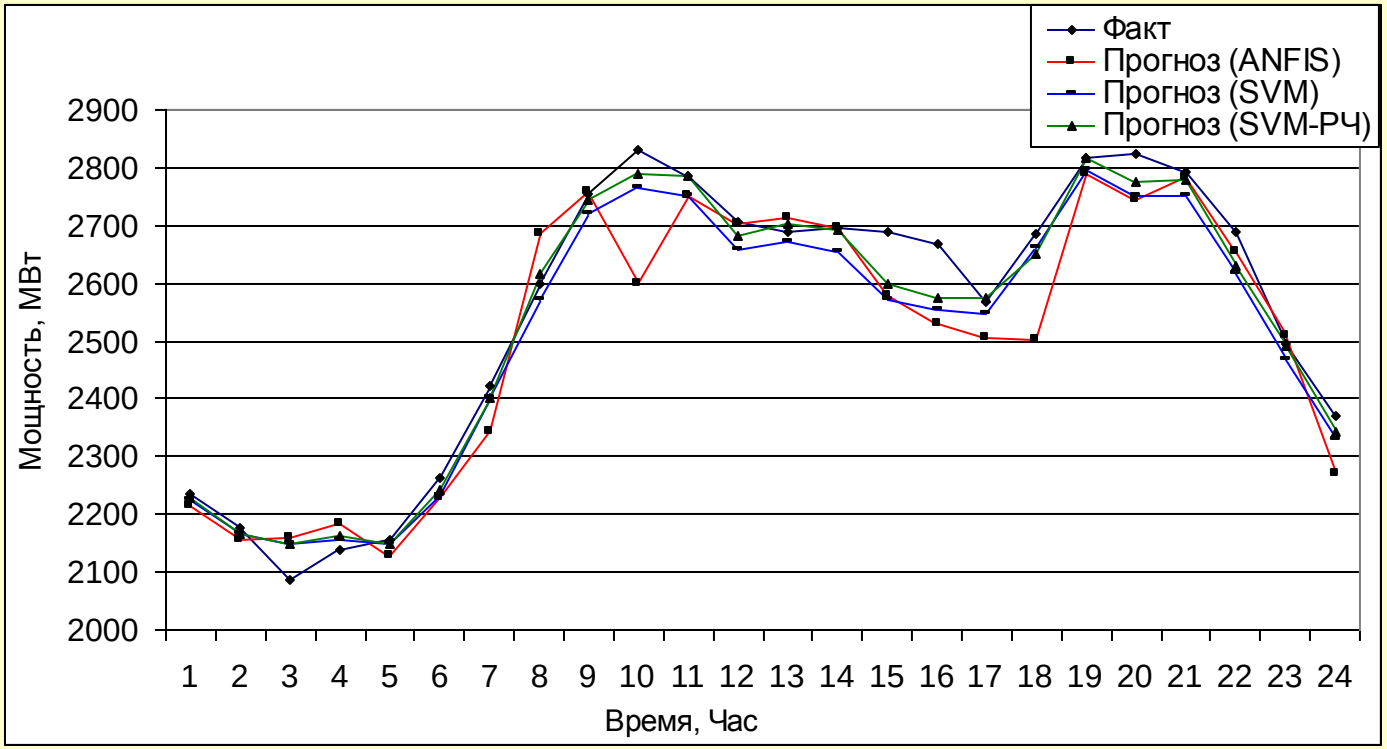


Load Forecasting Results



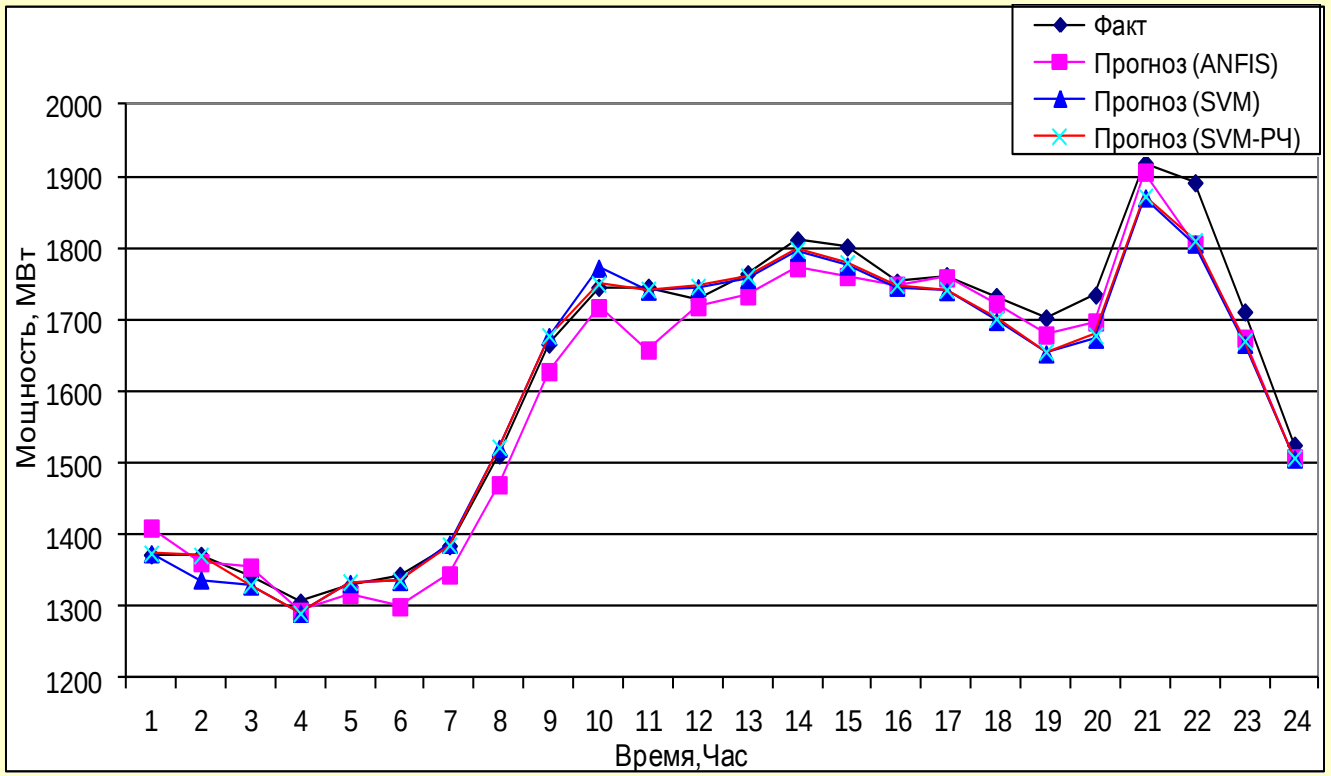
Actual and forecasting electrical load(Spring 31.05.2014)

Load Forecasting Results



Actual and forecasting electrical load (Winter 26.01.2014)

Load Forecasting Results



Actual and forecasting electrical load (Sumer 31.08.2014)

Load Forecasting Results

Date	Forecasting error , MAPE		
	ANFIS	SVM	SVM-PSO
01/11/2014	3.21	2.75	2.52
02/11/2014	2.48	1.54	1.53
03/11/2014	2.86	2.32	1.87
04/11/2014	3.46	3.05	2.14
05/11/2014	3.48	2.50	1.62
06/11/2014	4.77	3.80	2.51
07/11/2014	4.41	3.08	2.53
08/11/2014	3.23	3.11	2.71
09/11/2014	3.70	3.50	2.79
10/11/2014	3.19	2.78	1.79

Load Forecasting Results

11/11/2014	3.45	3.01	1.99
12/11/2014	3.79	2.50	1.60
13/11/2014	3.31	2.41	1.52
14/11/2014	4.03	3.22	2.53
15/11/2014	2.71	2.31	1.58
16/11/2014	2.18	1.82	1.37
17/11/2014	3.52	3.29	2.39
18/11/2014	2.21	2.04	1.73
19/11/2014	3.97	2.02	1.78
20/11/2014	3.27	1.29	1.25

Load Forecasting Results

Date	Forecasting error , MAPE		
	ANFIS	SVM	SVM-PSO
21/11/2014	2.05	1.69	1.56
22/11/2014	2.96	2.47	2.24
23/11/2014	3.37	1.54	1.42
24/11/2014	2.57	1.81	1.13
25/11/2014	3.55	2.87	1.94
26/11/2014	4.06	3.07	1.84
27/11/2014	4.51	2.11	1.86
28/11/2014	3.51	3.18	2.53
29/11/2014	3.20	2.15	1.80
30/11/2014	2.216	1.61	0.98

CONCLUSION

1. A model of short-term load forecasting for Electric Power Control Center, based on the method of support vector machine and particle swarm algorithm, characterized in that it as one of the affecting factors are taken into account natural light, which improves the accuracy of the modeling and forecasting

2. Models such as neural network, neuro-fuzzy and a regression model based on support vector machines have shown that the best approximating properties in solving the problem of short-term load forecasting, taking into account temperature and natural light for the Electric Power Control Center in Rostov has regression model based on support vector machine theory.

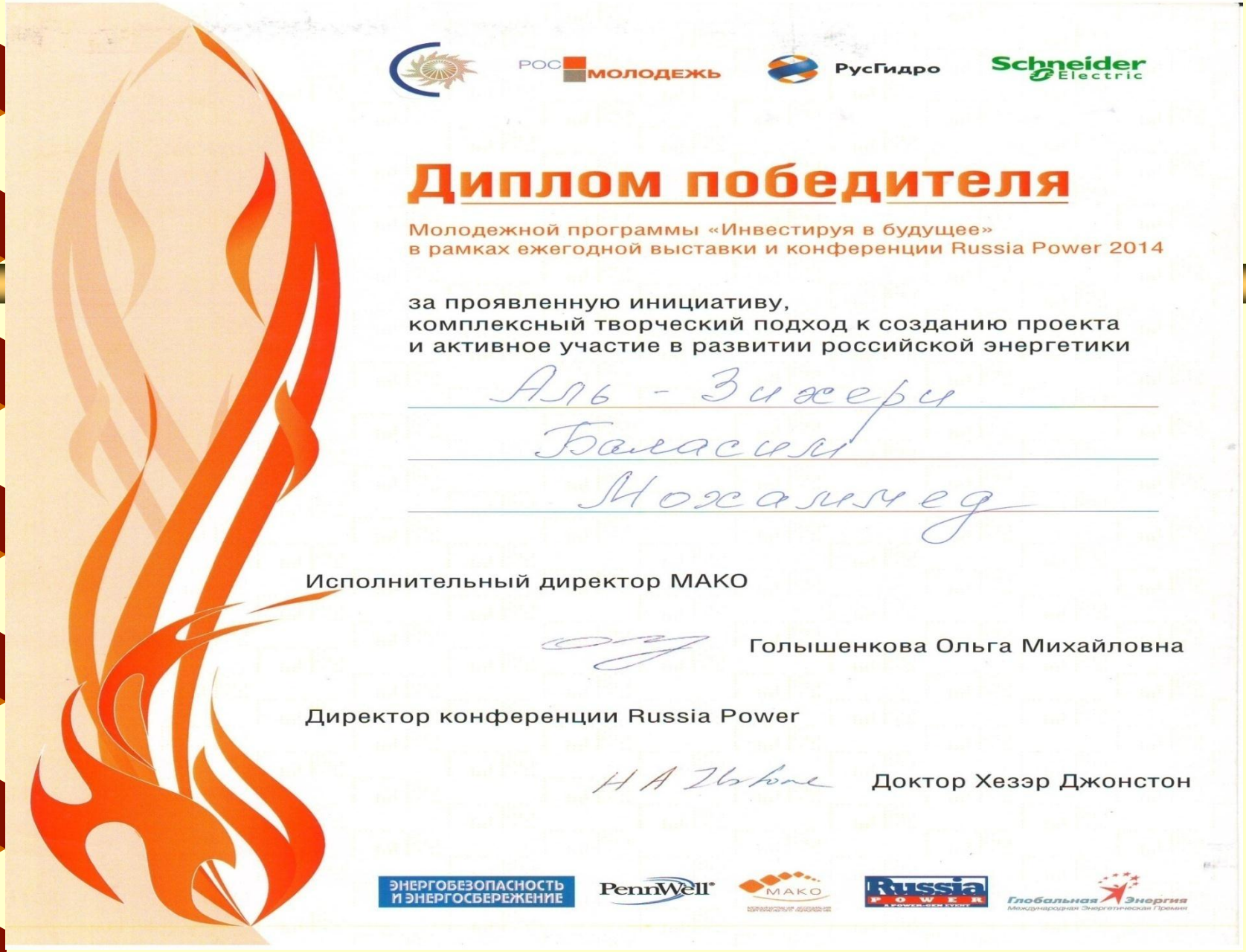
3. Improving of short-term load forecasting methods, develop in the direction of creating a combination models, using models such as neural networks, fuzzy algorithms and support vector machines with evolutionary algorithms to optimize the model parameters.

4. Clustering data into four seasons increase the prediction accuracy, but it has disadvantage of increasing load forecasting error at beginning and end of the season. More accurate results can be obtained if we replace fixed time intervals training sample to the “moving data window".

5. Previously models (neural network)for electrical power dispatcher control center in Rastov, which developed by Demura A.B. and Sergy C.O. give error in range [3.04 % - 4.78 %], but a proposed models in this work have the following errors:

•ANFIS - [2.21% - 4.21 %]; SVM - [1.29%- 3.22%] и SVM-PSO - [0.98%- 2.51%].

6. The results of this work is offered to use In electrical power dispatcher control center in Rostov and can be recommended for use in other regions.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Schneider Electric
Диплом победителя
Молодежной программы «Инвестируя в будущее»
в рамках ежегодной выставки и конференции Russia Power 2014
за проявленную инициативу,
комплексный творческий подход к созданию проекта
и активное участие в развитии российской энергетики
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ОАО "Системный оператор
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Южно-Российский государственный
политехнический университет (НПИ)
имени М.И. Платова

ДИПЛОМ

IV международной научно-технической конференции
«ЭЛЕКТРОЭНЕРГЕТИКА ГЛАЗАМИ МОЛОДЁЖИ»

НАГРАЖДАЮТСЯ

Надтока И.И.,
Аль-ЗихериБаласим М.

ФГБОУ ВПО «Южно-Российский государственный политехнический университет (НПИ) имени М.И. Платова», Новочеркасск

за подготовку актуального доклада по современным проблемам электроэнергетики и активное участие в работе конференции

Сопредседатель Оргкомитета
Проректор по научной работе
и инновационной деятельности *Ю.И. Разоренов*

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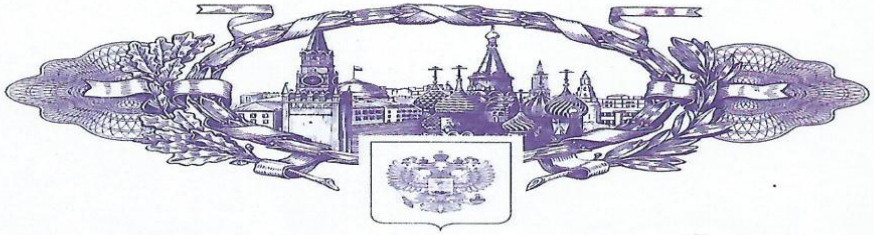
РОССИЙСКАЯ ФЕДЕРАЦИЯ



СВИДЕТЕЛЬСТВО

о государственной регистрации программы для ЭВМ

№ 2015614574

«Прогноз-ЭТО PSO SVM»

Правообладатель: ***Общество с ограниченной ответственностью научно-производственное предприятие «ВНИКО» (RU)***

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Врио руководителя Федеральной службы
по интеллектуальной собственности

Л.Л. Кирий


ЭНЕРГИЯ
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