RIGA TECHNICAL UNIVERSITY

Faculty of Engineering Economics

Institute of Labour Protection and Civil Defence

Department of Labour Protection and Civil Defence

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METHODS OF EVALUATION ECONOMIC EFFECTIVENESS OF FIRE PROTECTION SYSTEM IN LATVIA

Summary of the doctorate paper

Riga 2011

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DOCORATE PAPER

PUT FORWARD IN RIGA TECHNICAL UNIVERSITY

FOR THE ACQUISITION OF DOCTOR'S DEGREE IN ECONOMIC SCIENCES

The doctorate paper is elaborated in Riga Technical University, Department of Labour Protection and Civil Defence. The doctorate paper for the acquisition of Latvia Republic doctor's degree in economic sciences will be defended in public in RTU P-09 at Promotion Council of Economic and Management Sciences on 09.05.2011, in Riga Technical University Falucty of Economic Engineering, in Mezha Str. 1/7, room 209, at 10.00.

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DECLARATION OF INTEGRITY

With this I declare that the doctorate paper elaborated is submitted for consideration in Riga Technical University for the acquisition of doctor's degree. Doctorate paper is not submitted to any other university for the acquisition of scientific degree.

Jelena Sulojeva 01.04.2011.

The doctorate paper is written in the Latvian language. Total volume of the paper, not including appendices, is 125 computer printed pages. The paper includes 23 tables, 20 pictures and 12 appendices. The list of bibliography consists of 101 information source.

One can gain an insight into the doctorate paper and its summary in the Scientific library

of Riga Technical University

References about the doctorate paper can be sent to the secretary of Promotion Council RTU P-09, Professor, Dr.habil.oec.Anatolij Magidenko. Riga Technical University, Mezha Str. 1/7, Riga, LV – 1048, Latvia. Fax:+371 67089490 E-mail: rue@rtu.lv

GENERAL CHARACTERISTICS OF THE PAPER

TOPICALITY OF THE THEME

Ensuring the fire protection of objects of different significance is connected with definite work and material expenses. The important factor characterising the effectiveness of these expenses is the volume of economic loss caused by fire.

Getting and using complete and secure information about the effectiveness of fire protection system functioning in separate objects as well as in state in general and the information about the volume of economic loss caused by fire allows to find well-grounded solutions about ensuring fire protection of objects, protection of nature and people from unhealthy influence of fires. At the same time it gives the possibility to perform economic evaluation of the use of fire protection system, as well as to plan the distribution of resources directed towards ensuring the fire protection of objects of different significance and functioning of fire protection brigades as basic element of state fire protection system. This information gives the possibility to reasonably show the connection of fire protection with social and economic development of the state.

Every year in the world as a result of fires, explosions and accidents more than two million people die and more than ten million people get poisoned and are injured. Only direct material loss (not counting indirect social and ecologic loss) makes 0.3% from inner gross product. Specialists evaluate direct and indirect loss up to 5% from inner gross product.Every year there take place more than 13 thousand fires in the state. Fire destroys more than 4000 building of different significance, as a result of fire more than 200 people die and almost as many get injured. It incurs economic loss not only to stateconomy, but also to environment.

Despite LR Ministry Cabinet normative documents on the fire protection requirements about the necessity of objective evaluation of economic loss caused by fire, as it is not possible to carry out the evaluation of economic effectiveness of fire protection system (including also fire protection system as its element), there are no systematised researches on the theme in the state.

Absence of the methodology of defining economic effectiveness of fire protection system in general, as well as of its elements does not allow specialists practitioners

choose the most suitable fire protection variant, evaluate the level of its economic effectiveness, as well as calculate the expenses for fire protection of protected system all chain element. Without solving the above mentioned economic problems one cannot perform the optimisation of protection system, as economic optimisation is in terms of quantitative corelation between effect and expenses which defines its acquisition.

The author of the paper sees the way out of present condition first of all in the elaboration of fire protection system and its element effectivity definition methodology. This is why one has to elaborate the methodology, methods, ways of evaluation of various loss caused by fire and their theoretical substantiation. So the author has made an attempt to elaborate the bases of complex of fire protection system effeciveness evaluation methods as one of possible variants of solving the problems of Latvian fire protection.

RESEARCH AIMS AND OBJECTIVES

The aim of the paper is, taking into account the already amassed experience of scientists and practitioners, to elaborate the theoretical basis and complex of evaluation methods for economically effective fire protection system of populated areas and national economy objects that will allow to make reasoned decisions about ensuring fire protection of private and state property, substantiate the investments necessary for system development, as well as plan and divide the resources for fire protection.

To achieve the aim of the paper the following **objectives** has been examined and solved:

- to study the present approach to definig economic loss caused by fire and applying these criteria to evaluation of economic effectiveness of fire protection system;
- to evaluate the role and meaning of fire protection system in the evaluation of loss caused by fire and their structure;
- to define the interdependency of the most important factors for constructing economic and mathemathic model;
- to elaborate the evaluation ratio of loss caused by fire components (indirect - connected with people loss and injuries or loss inflicted to environment);
- to elaborate the methods of economic effectiveness evaluation for fire protection system and its basic elements;

- to substantiate the choice of criteria for offering optimal fire fighting station number to State fire fighting and protection service.

RESEARCH OBJECT, SUBJECT AND RESTRICTIONS

Research object is fire protection system that consists of organisational, economic and technical activities meant for well timed detection of fires, restrictions of their spreading and complete liquidation.

Research subject is economic methods for rising the effectiveness of all fire protection system and its elements.

Taking into account that fire protection is a complicated system, but objects protected have different fire security, following **restrictions** have been defined in the paper: basic elements of fire protection system that influence most the reduction of loss caused by fire in Latvian populated areas and national economy objects have been examined. Further, in the doctorate paper the costs connected with the introduction of fire protection activitiess on the enterprise level have not been examined.

Methodological basis of the research

Methodological and theoretical basis of the doctorate paper is the works of Latvian and foreign economic scientists and fire protection researchers, the results of special researches, the materials of scientific conferences and seminars. The biggest part of the works used in the theoretical chapters of given doctorate paper is the books and publications of Eastern and fire protection specialists. The research has been performed in several stages, each of them has been logically included in common research. The materials have been studied and gathered after making enquiries about Latvian problem situation, compulsory laws and other normative documents, fire protection policy, monitoring, economic tools and development plans. Simultaneously, the author studied the experionce of other countries in the sphere of fire protection and using economic methods. During the period since 2003 the accent in researches has been made on the experience of Eastern countries, approbating it on Latvian statistic data.

In performing the research were used:

1. Published and unpublished information of Latvian Republic Ministry of Inner Affairs State fire protection and rescue service, International association of Fire Protection and rescue services and Latvia Central Statistic Board, data bases of State Fire Protection and Rescue Service,
2. Publications of scientists and specialists,
3. Latvian Republic fire protection regulating laws and other normative documents, normative documents and methods of European Union and other countries,
4. Electronic resources, data bases, publications in mass media including periodicals,
5. Results of author's own research.

Research methods

In elaborating the doctorate paper scientific research was performed on the basis of system analysis and using such research methods:

a) Scientific analysis (analysing the influence of fire protection system on reducing possibility of direct and indirect loss, including scientific researches and publications);

b) Synthesis (examining the interaction of economics and fire protection system);

c) Evolutionary analysis (examining the element of fire prosystem in its historical development, including the number of fires and loss caused by fire, programmes, declarations, concepts);

d) Induction (examining the methods of defining fire protection system economic effectiveness in other countries);

e) Comparative analysis;

f) Sociological inquiry analysis (analysing experts' opinions about the methods of defining economic effectiveness of fire protection system);

g) Mathematical modelling (comparing and analysing the factors of fire protection effectiveness);

h) Experts' (studying the reports, requirements, suggestiions, opinions of competent authorities, performing the inquiries of independent experts);

i) Mathematical methods (calculating the necessary number if fire stations in Latvian Republic).

SCIENTIFIC NOVELTY OF THE DOCTORATE PAPER

The scientific novelty of the doctorate paper is the following:

- To achieve the aim put forward within the doctorate paper, the author suggests to elaborate one complex methodology which includes calculation of the expenses for separate fire protection elements, as well as the methods of calculating yearly economic effect of fire protection activities performed,
- for the first time in Latvian researches connected with fire protection, the structure of economic loss caused by definite fire which additionally includes ratio connected with people loss and injuries, as well as with ecological loss,
- theoretical statements have been formulated and methods of evaluation of economic effectiveness of populated areas and national economy objects fire protection system have been formed,
- methods of defining the damage averted with the help of fire protection system have been suggested,
- the bases of research methods for rising the economic effectivity of fire protection system have been elaborated,
- subject «Environmental ecology» has been supplemented with new section «Fire protection economics».

Research materials of the doctorate paper can be used for making decisions on the State Fire Protection and Rescue Service further development, planning of Latvian economic sectors development, in learning process (in lectures, seminars) - activities of general education and in study courses «Environmentas ecology», «Environmental economy», «Civil defence».

STRUCTURE OF THE DOCTORATE PAPER

To achieve the aim put forward in the paper the author struktures the layout of paper problems solution in four chapters. While structuring the paper the principle of theory and practice linking entirety has been observed.

In the first chapter of the paper the problem positions are given - theoretical bases of defining economic effectiveness of fire protection system, as well as the role and place of fire protection economy in the system of economic sciences are formulated. Main conditions of fire protection economic effectiveness are studied. Characteristics are given and corelation is defined that state economics as well as social development depend on the effectiveness of fire protection system.

In the second chapter of the paper an analytical insight into functioning of fire protection systems within state economy is given. Ability for action of State Fire Protection and Rescue Service is analysed and evaluated, as well as normative documents and European Union directives have been analysed. The author also gave an insight into voluntary fire-fighting forces and economic evaluationof their work in Latvia and abroad. In addition, the evaluation of economic effectiveness of using automatic fire detection and extinguishing systems was performed.

In the third chapter the system of evaluation of fire protection economic effectiveness is elaborated, as well as fire protection system elements are defined and on the basis of the above mentioned the basic indices of fire protection economic effectiveness calculation in Latvian Republic are worked out.

Also in the chapter the significance of social and technical criteria in calculating the loss caused by fire is shown. With the help of aim and activity construction and a group of experts the damage averted is economically evaluated.

In the fourth chapter the suggestions for optimisation of the dislocation of fire-fighting brigades are elaborated with the aim to rise the effectiveness of fire-fighting, as well as the map of optimal location of fire-fighting brigades is offered.

In the final part of the paper the most significant conclusions and suggestions are formulated.

The problems defined for the paper are solved and the aim is achieved.

APPROBATION OF RESEARCH (DOCTORATE) RESULTS

A wide circle of interested persons is acquainted with main elaborations of the paper. To achieve this aim different techniques were used. During the period from 2000 till 2010 the author of the doctorate paper aprobated the results of the research in 3 projects as a researcher-executive and in 3 research works as an executive:

- 2008 . MES - RTU Project R7364 „VUGD efektīvai darbībai nepieciešama materiāli-tehniskā un finansiālā nodrošinājuma zinātniskais pamatojums ” (Scientific Substantiation of Material, Technical and Financial Guarantee Necessary for SFRB Effective Operation), researcher - executive.

- 2007. MES - RTU Project R7219 „Pieļaujama ugunsgrēka riska zinātniskais pamatojums Latvijā” (Scientific Substantiation of Admissible Fire Risks in Latvia), researcher - executive. (105 hours/13 hours a month).

- 2006. MES - RTU Project U7112 ”Ugunsgrēka riska kvantitatīva vērtējuma metodikas» (Methods of Quantitative Evaluation of Fire Risks), researcher - executive.

- 2002. Scientific research paper "Ēku un būvju ugunsgrēku radīto materiālo zaudējumu aprēķināšanas metodika" (Methods of Calculating Material Loss Caused by Fire for Buildings and Constructions), executive RTU IEF (executive persons - PhD student J.Sulojeva and others), agreement Nr.6645 from 15th October, 2002 with IeM.

- In 2001 ordered by LR Ministry of Internal Affairs „Latvijas valsts standarta projekta “Ugunsdrošība. Vispārīgas prasības” izstrāde” (Elaboration of Latvian State Standard Project “Fire Protection. General Requirements”), agreements nr. 6644, 15th September, 2002 and nr. 6566, 19th October, 2001 (executive persons - PhD student J.Sulojeva and others)

- Year 2000 project of Latvian science council Nr.98.897 «Methods of economic substantiation of innovations during transition period (executive persons - PhD student J.Sulojeva and others).

A positive reference on scientific redearch performed was received from LR IeM State Fire Protection and Rescue Service.

As well as a number of research results are reflected in 15 scientific publications. 7 articles aout of those are published in generally recognised scientific publications under review:

Generally recognised scientific publications

1. J.Sulojeva, V.Jemeļjanov, R.Buls. Sprādzienbīstamības un ugunsbīstamības riska faktoru novēršana.//Scientific Papers of 50 RTU International Scientific Conference. – Riga: RTU, 2010. p.36-44.
2. J.Sulojeva, V.Jemeļjanov, M.Ziemelis. Uguns dzēšanas līdzekļi un to efektivitātes paaugstināšanas paņēmieni.// Scientific Papers of 50 RTU International Scientific Conference. – Rīga: RTU, 2010. p.44-53.

3. J.Sulojeva, M.Ziemelis, V.Jemeļjanos. Uguns dzēšanas ar ūdeni efektivitātes paaugstināšana// Tehnogēnās vides aizsardzības zinātniskās problēmas. Starptautiskās zinātniski praktiskās konferences zinātniskie raksti. – Rīga: RTU, 2008. – p.36- 43.

4. J.Sulojeva, V.Jemeļjanovs V.Edins. Bīstamo zonu ģeometrisko parametru noteikšana gāzu, šķidrumu tvaiku, putekļu sprādzienu gadījumos// Tehnogēnās vides aizsardzības zinātniskas problēmas. Starptautiskās zinātniski praktiskās konferences zinātniskie raksti. – Rīga: RTU, 2007. p.83-89.

5. J.Sulojeva V.Jemeļjanovs, N.Kabanovs. Ugunsdzēsības depo skaita optimizācija un sabiedrības drošība// Cilvēktiesības un sabiedrības drošība. Starptautiskās zinātniski praktiskās konferences zinātniskie raksti. – Rīga: LPA, 2004.g. – p.65 - 70.

6. J.Sulojeva,V.Jemeļjanovs, J.Puškina, K.Didenko (ar līdzautoriem). Ugunsgrēka radīto tiešo zaudējumu aprēķināšanas pamatprincipi // Ekonomika un uzņēmējdarbība. RTU Zinātniskie raksti, 3. sēr., 5. sēj. – Rīga: RTU, 2002. p.81-85.

7. J.Sulojeva, V.Jemeļjanovs, A.Jemeļjanovs. Inovatīva pieeja ugunsgrēku izraisīto zaudējumu novērtēšanai Latvijas lauku rajonos // Ekonomika un uzņēmējdarbība, RTU zinātniskie raksti, 3.sēr. , II.sēj. Rīga: RTU, 2001. p.44- 50.

Other scientific publications

8. Сулоева Е., Зиемелис М., Емельянов В. К вопросу повышения эффективности тушения пожаров // Сборник трудов второго международного конгресса (Четвертой международной научно-технической конференции) «Экология и безопасность жизнедеятельности промышленно-транспортных комплексов», т.4. – Tolyatti: ELPIT, 2009. – p. 125-130.

9. Сулоева Е., Зиемелис М., Емельянов В. Проблемы определения категории помещений по взрывопожароопасности и зон взрывопожароопасности// Международные научные чтения «Белые ночи – 2008», ч.2. – St.Petersbourgh: МАНЭБ, 2008. – p.456- 460.

10. Сулоева Е., Иевиньш Я., Емельянов А., Емельянов.В., Диденко К. Обоснование допустимого уровня пожарного риска и управление им в Латвии// Международные научные чтения «Белые ночи – 2008», ч.2. – St.Petersbourgh: МАНЭБ, 2008. – p.461-468.

11. Сулоева Е., Зиемелис М., Емельянов А., Емельянов В., Иевиньш Я. Проблемы определения категории помещений по взрывопожароопасности// Сборник трудов первого международного конгресса (Третий международной научно-технической конференции) «Экология и безопасность жизнедеятельности промышленно-транспортных комплексов», т.3. – Tolyatti: ELPIT, 2007. – p.265- 268.

12. Сулоева Е., Иевиньш Я., Емельянов А., Емельянов В., Диденко К. Обоснование допустимого уровня пожарного риска в Латвии // Международная научная конференция „Экология и безопасность жизнедеятельности промышленно - транспортных комплексов», т.3. - Tolyatti: ELIPT, 2007. – p.118 - 124.

13. Сулоева Е., Иевиньш Я., Емельянов А., Емельянов В. Оценка состояния техногенной безопасности города Рига и ее комплексное обеспечение в контексте развития города// Международная научная конференция «Экология и безопасность жизнедеятельности» (Известия Самарского научного центра Российской академии наук.), т.1. – Tolyatti: special edition ELIPT, 2005. – p.94 - 98.

14. J. Sulojeva, A.Maģidenko, L.Ribickis, K.Didenko, G. Ketners, V.Kozlovs, K.Ketners un citi. Inovāciju ekonomiskā pamatojuma metodoloģija pārejas periodā// LPZ Ekonomikas un juridiskās zinātnes galvenie pētījumu virzieni 2000.gadā, 6. sēj. Riga: ŪZZ tipogrāfija. 2001. – p.81-88.

15. Е.Сулоева, В.Козлов. Экономическая оценка эффективности затрат на обеспечение пожарной безопасности // Inženierekonomikas nozīme uzņēmējdarbības attīstībā: Starptautiskās zinātniski praktiskās konferences materiāli – Riga: RTU, 2000. – p.56.

The author of the doctorate paper also practically approbated the results of the research **at 8 international, scientific and scientifically practical conferences:**

1. Round table «Проблемы обеспечения экономической безопасности хозяйствующих систем в современных условиях», ГПС МЧС России Санкт-Петербургский университет 2010 г. 15-18 февраля. Пути повышения эффективности тушения пожаров в Латвии. Сулоева Е.с соавторами.

2. Второй Международный экологический конгресс, в рамках Четвертой научно-технической конференции „Экология и безопасность жизнедеятельности промышленно-транспортных комплексов ELPIT - 2009", Тольятти, 2009.г. 24.-27.сентября. К вопросу повышения эффективности тушения пожаров. Сулоева Е. с соавторами.

3. RTU – 50th International Scientific Conference. Riga, RTU, 2009 October 15-16. Brīvprātīgo ugunsdzēsēju formējumi un viņu efektivitāte. J.Sulojeva ar līdzautoriem.

4. Starptautiskā zinātniski praktiskā konference „Tehnogēnās vides aizsardzības zinātniskās problēmas" Rīgā, 2008.gada 9.- 10.oktobrī. Uguns dzēšanas ar ūdeni efektivitātes paaugstināšanas, J.Sulojeva ar līdzautoriem.

5. Starptautiskā zinātniski praktiskā konference „Tehnogēnās vides aizsardzības zinātniskas problēmas" Rīga, 2007.gada 30.martā. Bīstamo zonu ģeometrisko parametru noteikšana gāzu, šķidrumu tvaiku, putekļu sprādzienu gadījumos. J.Sulojeva ar līdzautoriem.

6. Международная научная конференция „Экология и безопасность жизнедеятельности ELPIT - 2005", Тольятти, 2005.г., Оценка состояния техногенной безопасности города Рига и ее комплексное обеспечение в контексте развития города Сулоева Е. с соавторами.

7. Starptautiskā zinātniski praktiskā konference «Cilvēktiesības un sabiedrības drošība", Rīga, LPA, 2004.gada 26. - 27.augustā. Ugunsdzēsības depo skaita optimizācija un sabiedrības drošība. J.Sulojeva ar līdzautoriem.

8. Международная научная конференция «Стратегия выхода из глобального экологического кризиса», С.-Петербург, 2001.года июнь. Деятельность аварийно-спасательных служб по международным стандартам качества. Сулоева Е. с соавторами.

The volume and structure of the doctorate paper

The doctorate paper is written in the Latvian language. The paper consists of an introduction, four chapters, doctorate paper conclusions and suggestions, bibliography list and appendices.

The total volume of the paper, not including the appendices, is 125 computer written pages. The paper contains 23 tables, 20 pictures and 12 appendices. 101 information source is included in the bibliography list.

Theses broughts forward to presentation:

Studying the main conditions of economic effectiveness of fire protection activities, it is necessary to summarise and formulate the theoretical bases of defining economic effectiveness of fire protection system as well as the place and role of fire protection economics in the system of Latvian economic sciences supplementing it with a new section «Fire Protection Economics».

Economics as well as social development of Latvia depend on the effectiveness of fire protection system, as the united complex of methods elaborated, which includes the calculation of costs for separate fire protection elements as well as the methods of calculation of annual economic effect from fire protection activities performed, helps to define the structure of economic loss caused by fire more precisely. Additionally, in this structure, for the first time in Latvian researches, the coefficients connected with human death and injuries, as well as with ecological loss, are included.

The substantial precondition of rising the capability of Latvian State Fire Protection and Rescue Brigade is to work out the proposals on the optimisation of fire-fighting units location as well as to offer the map of optimal disposition of fire-fighting units on the basis of the analysis of European Union normative documents and directives.

To evaluate the overall economic effectiveness of fire protection system, one has to compare three directions of basic activity: the effectiveness of Latvian State Fire-Fighting and Rescue Brigades, economic evaluation of voluntary fire-fighting units and their work, as well as to present economic arguments for using automatic fire detection and extinguishing system in the Republic of Latvia.

1. METHODS OF EVALUATION OF ECONOMIC EFFECTIVITY OF FIRE PROTECTION IN LATVIA AND IN THE WORLD

Rising the level of fire protection is an indisputable necessity dictated by significant moraland material loss that fires incur to society. In the system of rising fire protection of populated areas and state objects the economic substantiation of fire protection ensuring methods is of great importance. Additionally, it is very important to prove scientifically the interconnection between fire protection expenses and possible loss caused by fire. In its turn it is closely connected with resource limitations for further fire protection development, including its most important element - fire protection systems.

Methods of defining the economic effectiveness of fire protection system in general and its separate elements substantiated by innovative approach to this complicated and significant problems helps to solve this problem.

Economic theory studies social production in general, forms of expression of economy laws and their operation mechanisms in national economy.

General feature of any theory studying national economy is examination of economic processes and material wealth, its exchange, consumption and distribution appeared in the process of production. However, economy theory does not particulary study the specific forms of the expression of general economy laws in several spheres of national economy. This is the subject of research of sectoral economics disciplines - industrial economics, agricultural economics, transport economics, etc.

Fire protection economics can be in the same way referable to tha category of sectoral economics disciplines. Sectoral economics and fire protection economics as well studies the action and forms of the expression of economic laws in the mentioned sphere of sectoral economics, special economic regularities characteristic for the sphere mentioned, study conditions and factors under which influence the laws can operate with greater effectiveness.

Thereby, fire protection economics is economic relationships that appear in the process of fire protection ensuring system formation, introduction and expluatation, the peculiarities of expression in the sphere of objective economic laws functioning, in the system of fire protection ensuring in general and methods of effectiveness rising of its separate elements.

Fire protection economics is closely connected with particular economic disciplines that study the methods of analysis and calculation of economic activity, economic effectiveness, evaluation methods of economic substantiation of different organisational and technical activities (with statistical, managerial economics disciplines, national economics sectoral economics disciplines, etc.).

In its turn fire protection economics directly cooperates with special technical disciplines - fire-fighting equipment, automatic fire-extinguishing, fire-extinguishing water supply, fire-fighting preventive disciplines, fire-fighting tactics, bases of management of state fire-fighting and rescue service. It is known, that the equipment used in enterprises strongly affects all the spheres of economics. Simultaneously, economics defines the of scientifically technical progress, evaluates new equipment taking into account its ability to ensure the rise in labour productivity - the most important ratio of social productivity effectiveness.

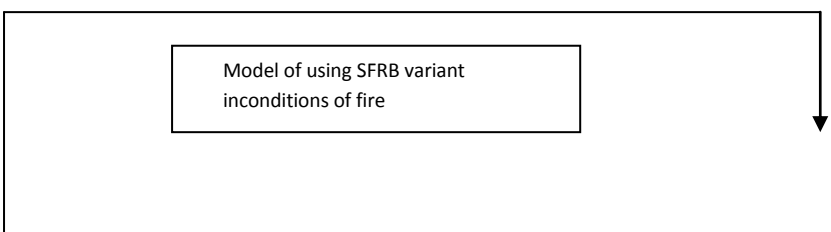
Today one can declare with certainty that in economically developed countries the expenses on fire protection system maintenance, engineering activities and direct loss caused by fire make about 1% from yearly gross domestic product. If one takes into account indirect loss caused by fire, social and environmental damage, then social expences become at least twice as great. This is why it becomes obvious that fire protection has turned into independent and very important sphere of economics.

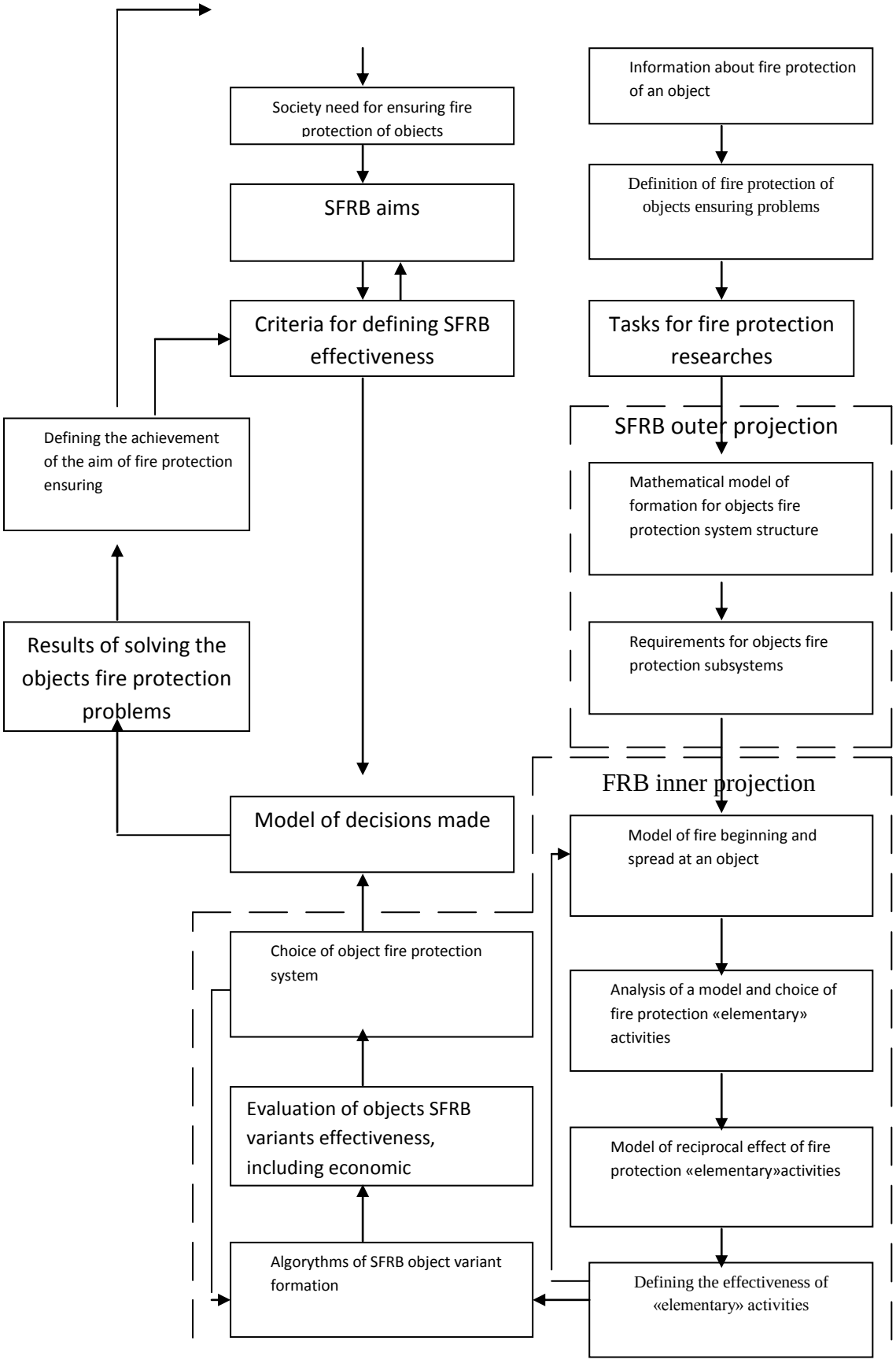
Appropriation of financial resources to ensuring fire protection on the one hand and the necessity of their economic evaluation on the other hand determines the necessity to elaborate the methods for definition of economic effectiveness of fire protection system ensuring and the methods of thair optimisation.

One should conclude that fires, especially those that develop into emergency situations and disasters, principally influence the implementation of state development topical programs, economic conditions, ecology and society.

So there appears the necessity to improve the fire protection system in which great meaning is applied to the subsystem of loss caused by fire volume reduction - fire protection, which can be considered a system as well.

Further on general economic evaluation of this system functioning substantiated by the analysis of fire protection is given.





Pict. 1. The scheme of object fire protection ensurance system

One should make the substantiation of fire protection ensuring activities effectiveness in each object observing the probability of fire beginning and the volume of loss caused by probable fire as well as the value of an object, investments (I) and current expenses (E) for ensuring fire protection.

For solving this problem one should, first of all, define the optimal balance between expenses on fire protection ensuring and the volume of possible loss caused by fire taking into account the probability of its beginning.

The author's opinion is that for economic expenses for ensuring the fire protection system of an object there should be created the fire protection system able to liquidate the fire before reaching its critical moment.

Analysing the data by International Association of Fire-Fighting and Rescue Services (further in the text ISFRS) from 2006 till 2010, the number of fires in the most developed European Union and world countries is great. It is reflected in table 1.

Table 1

ISFRS data for years 2006-2010

COUNTRY	AVERAGE ANNUAL NUMBER OF FIRES	NUMBER OF FIRES PER 1000 INHABITANTS
Germany	184628	2,24
France	359126	5,56
Italy	224717	3,86
Sweden	27374	3,03
England	462868	7,62
USA	1587400	5,27
Russia	227058	1,61
Latvia	11537	5,1
Lithuania	18066	5,05
Estonia	12127	9,04

During this period, there started at an average 184,628 fires a year in Germany, which makes 2.24 fires for 1000 inhabitants, in France - 359,126 fires, 5.64 fires for 1000 inhabitants, in Italy – 224,717, 3.86 for 1000 inhabitants; but in Sweden – 27,374, which at an average makes 3.03.fires for 1000 inhabitants a year, in Englang it is 462,868 fires, which makes 7.62 fires for 1000 inhabitants, in its turn, in the USA - 1,587,400, which makes 5.27 fires for every thousand of state inhabitants. In Russia there are 227,058 fires, 1.61 fire for 1000 inhabitants. Baltic states do not get behind the most developed world countries in these figures. In five years time, from 2006 till 2010, there started at an average 11,537 fires a year in Latvia, which makes 5.1 fire for 1000 inhabitants, in Lithuania it was 18,066 fires, which makes 5.05 fires for 1000 inhabitants, but in Estonia it was 12,127 fires, which makes the biggest number of fires for 1000 inhabitants in Baltic states - 9.04.

Table 2

ISFRS data for years 2006 - 2010

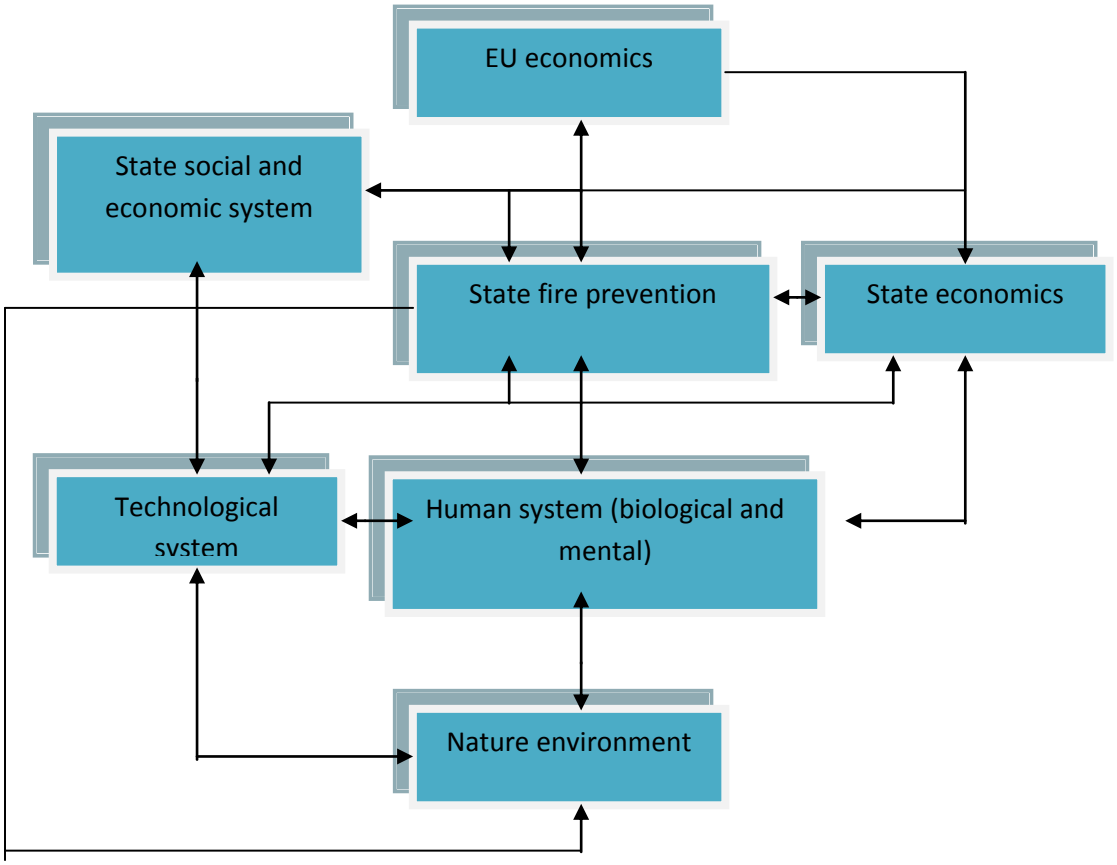
COUNTRY	AVERAGE ANNUAL NUMBER OF DEAD	NUMBER OF DEAD PER 1000 INHABITANTS
Germany	461	0,56
France	434	0,68
Italy	101	0,17
Sweden	97	1,07
England	512	0,84
USA	3635	1,21
Russia	17974	12,21
Latvia	227	10,04
Lithuania	277	7,76
Estonia	140	10,45

The number of people lost in fires during this period of time, from 2006 till 2010, is very big in the above mentioned countries. In Germany 461 person was lost in fires, which makes 0.56 people for 1000 thousand inhabitants, in France it is 434 people, 0.68 for 100 thousand inhabitants, in Italy 101 person was lost, which makes 0.17 people for 100 thousand inhabitants, in its turn, in Sweden it is 97 people, which makes at an average 1.07 people a year for 100 thousand inhabitants. In England it is 512 people, 0.84 for 100 thousand inhabitants, in its turn, in the USA it is 3635 fires, which makes 1.21 person for every 100 thousand state inhabitants. In Russia there are 17,974 lost people, which makes 12,21 people for 100 thousand inhabitants. In Baltic states during the period of five years, from 2006 till 2010, there is great proportion of people lost in fires. In Latvia there are 227 people lost in fires, which is 10.04 people for 100 thousand inhabitants, in Lithuania it is 277 people, 7.76 for every 100 thousand inhabitants, in its turs, in Estonia it is 140 people, 10.45 people lost in fires for 100 thousand inhabitants.

The aim of hte research was chosen on the basis of main Euripean Union directives in the sphere of fire protection, as well as taking into account resources and other kinds of supply data of State Fire Protection and Rescue Service, as one of the most important subsystems of Latvia national wealth fire protection, as well as using other data connected with ensuring technical safety in the state.

The analysis of foreign scientific sources showed, that the problem of ensuring fire protection, as well as technical safety in general, is of an explicit international character and it causes serious agitation in the world.

The questions of country's national wealth conservation are tightly connected with common develoment of national economy. The simplified structure of this connection, taking into account Latvia's membership in European Union, is demonstrated in picture 3.



Pict. 3. The place of State fire protection in system hierarchy

For accounting of these interconnections the results of Latvian Republic, as well as of foreign scientists' researches were used.

In the study of the influence of physical volume of state industry national income, solving fire protection problems, the work in connection with forecasting the increase in national economy causes great interest. At the same time the growth of national economy is connected with fire protection system, building, modernisation, modernisation of objects.

On the basis of the analysis of fire conditions performed in Latvia, taking into account the opinion of experts, as well as model of accounting succession heaviness (loss) based on recurrent analysis of regress, examined in this chapter, as well as analysis of literary sources, data placed in the Internet and the analysis of fire protection normative

documents, the aim, basic tasks and methods of the research, that will be described further on, have been formulated.

As substantiation for making decisions about the choice of fire protection ensuring system or the best variant of activity social or economic index are accepted. The forst of them allows to evaluate the correspondence of actual characteristics to definite social norms, the second one - the economic resul achieved. In cases when the implementation of fire protection ensuring activity is substantiated by the necessity solve ecological and other important problems, the substantiation of the activity and its variants can be performed according to non-economic considerations taking into account econmic evaluation.

2. ANALYSIS OF FIRE-FIGHTING ORGANISATIONAL AND TECHNICAL VARIANTS

The notion «fire protection system» was introduced in Latvia by standard LVS 38-93 “Fire Protection and Definitions”. It was defined in the standard that «fire protection system» is an engineering technical and organisational campaign to avert the influence of dangerous factors of fire, spreading of fire and not to allow or limit the damage caused by fire.

From definition of the notion «fire ptotection system» the structure of the system, as well as its requirements are formed.

This system includes such organisational and technical activities:

- organisation of corresponding fire protection (professional, voluntary, of an object), definition of its size and technical equipment;
- involving the society into solution of fire protection ensuring problems (the voluntary);
- using fire extinguishing and protection automatic equipment;
- using materials and equipment that ensure limitation of fire spreading;
- using nonflammable agents and fire-resistant colours;
- organisation of timely evacuation of people;

- establishment of necessary conditions at objects for fighting fires with sufficient effectiveness;
- ensuring collective and individual protection of people against dangerous factors of fire.

Unfortunately, one should conclude that the role, possibilities and significance of disaster and rescue services in life protection and ensuring of populated areas in town and in the country are little examined. In fact, this process begins only now.

The service area of fire protection brigade is of great importance. In Riga these areas are larger than in other towns. It can be clearly seen in table 4, where the density of Riga fire-fighting brigades stations in comparison with other world cities is given.

Table 4

Density of Riga fire-fighting brigades stations in comparison with other world cities, years 2009-2010

City	Number of inhabitants, thousands	Space, m^2	Number of fire stations	Average space of service area, $км^2$	Average number of inhabitants for one station, thousands
Riga	830	307	11	27,9	92,22
Kopenhagen	460	90	9	10	51
London	7000	1600	114	14	34
New York	7300	790	217	3,6	34
Tokio	10000	720	229	3,1	44

LBN 201-07 272. clause defines the size of Fire-fighting brigade service zone according to the following criteria:

272.1. it should be possible to arrive to the objects within the territories of towns of the Republic not later than five minutes after receiving an application;

272.2. it should be possible to arrive at objects in territories in towns and in the country with population density 10 and more people per square kilometre not later than 15 minutes after receiving an application;

272.3. it should be possible to arrive at objects in the country with population density less than 10 people per square kilometre not later than 25 minutes after receiving an application. Calculating the possibilities of accomplishment of the criteria mentioned in clause Nr.274 of this building normative, the condition, position and kind of streets and roads, possible speed of movement, technical and organisational ensuring of fire-fighting and rescue brigades explosive risk and inflammability of an object, as well as conctructional peculiarities of buildings are taken into account.

Factors dangerous for people and caused by fire begin their formation together with the beginning of fire, and average statistic numbers and observations testify that minimal time of their formation is about 5-10 minutes. Admitting that a telephone call about a fire follows after 1.5 minutes after a fire starts and gathering and departure of a fire-fighting brigade takes 1 minute, there are only 2.5 minutes left for driving to an object and till the moment of formation of critical concentration of dangerous factors.

In conditions of Riga, where the speed of task transport does not exceed 30 kmph, fire-fighters can effectively serve and protect the inhabitants before the appearing of dangerous factors effects within a radius of 1.25 km, i.e. a 4.9 square kilomentes wide territory. That is why in 2009 out of 57 people lost in fires 48 (or 74%) were dead already before the fire-fighters arrived, as at an average 10.49 minutes were spent for arriving, i.e. two times more that it is set in normatives.

In 2010 the city fire-fighting brigades could arrive at an object before the moment of appearing of dangerous factors only in 14.15% of cases, i.e. at 346 fires out of total number of 2300 fires. In 3.23% cases brigades could arrive at an object only in 20 minutes.

In rural areas the situation is even worse. 15 minutes normative time, within which a fire-fighting brigade should arrive at the location of fire, is absolutely unacceptable from the point of view of people's health and life protection. In many Latvian regions this time is strongly exceeded. In 2010 average time of arrival of fire-fighting brigades to the location was: in Daugavpils district - 20.82. minutes and during this time 8 people were lost, in Gulbene district - 26.41 minutes and 6 people correspondingly, in Riga district - 15.16 minutes and 8 people, in Rezekne district - 15.12 minutes and 7 people. Similar situation was also in other districts of the state.

All the above mentioned facts testify that in conditions of Latvia new solutions for prevention of technogenic accidents and liquidation of their results should be searched for. This complicated problem should be solved in complex on the basis of systematic analysis.

The results summarised for year 2010 show that in Latvia fire-fighting brigades arrived at fire locations at an average in 7.3 minutes in urban and in 25 minutes in rural areas.The analysis of fires shows that the critical values of factors dangerous for people is achieved in 5-10 minutes time from fire starting moment, destruction of metallic constructions begins in 10-15 minutes, but effective work of fire-fighters begins only in 19 minutes (including 11 minutes spent on the way).

Analysing the activities of voluntary fire-fighting brigades in the above mentioned countries in general, the brigades can be conditionally divided into two groups:

the first one – formations of voluntary fire-fighting brigades, whose activity is directed to avertion and extinguishing of fires;

the second one – voluntary fire-fighting brigades whose activities are directed not only to the avertion and extinguishing of fires, but also to providing aid in all emergency conditions and taking part in liquidation of results of natural disasters.

Taking into account limited financial possibilities, for the consolidation of Latvian State fire-fighting and rescue brigades as the most important element of fire protection system, one should admit that correct and scientifically substantiated organisation and training of voluntary fire-fighting brigades in general will give the country significant economic effect and allow to rie the level of fire protection.

One must mention that investments into voluntary fire-fighting brigates have high effectiveness. Treir maintenance, as researches show, is 2-4 times cheaper than the maintenance of professional brigades. In many cases the means not only from state budget, but also from the income the voluntary societies themselves get for fire-fighting works done, from insurance companies, patrons and other sources can be used.

As to the building of fire-fighting stations, then from the point of view of rising the level of human protection, as well as from the point of view of reducing insurance risks, first of all, 5 more stations should be built in Ludza district where at present there is the lowest fire-fighting station ensuring coefficient (further on - EC) - 0.29 (the fire-fighting station ensuring coefficient EC is the correlation between present number of stations and the needed one). Similar situation is in several other districts, which is reflected in the following table 5.

Table 5

Number of stations needed in regions

Region	Number of stations needed	EC	
		For present number of stations	For necessary number of stations
Aluksne	3	0,57	0.64
Yekabpils	3	0,35	0,52
Ludza	**5**	0,29	0,56
Madona	4	0,46	0,59
Preili	6	0,47	0,54
Rezekne	7	0,34	0,58

The analysis of cases connected with insurance shows that equipment of residential objects with fire detection alarms can lead to the reduction of the number of people lost in fires up to 70-75%. Unfortunately, such kind of alarm is insufficiently used in dwelling sector. Automatic fire detection systems are more widely used in the

protection of other objects, and it helps to reduce material loss caused by fire as well as the number of dead people.

The analysis of statistic data performed shows that there still are reserves in raising the effectivity of fire-fighting brigades activities

Statistic data about fires testify that the activities performed, norms accepted and safety requirements in the country do not ensure the reduction of loss caused by fire. In standing normative documents fire prevention requirements are particularly formulated, but there are no normative documents providing ways and methods of solving these problems.

Analysing the experience of foreign countries, one should note that in conditions of market economy every state tries to solve the problem of fire protection of objects not with the help of extensive methods, which require additional material and human resources, but with the help of intensive methods based on scientifically technical progress and involving voluntary brigades (VFB) into operative service of fire-extinguishing.

The D part of objects being in operative service zone can be defined by using regressive equation acquired by the method of smaller squares:

$$D = 7{,}82.10^{-4}. N + 1{,}57.10^{-3}, \quad (1)$$

where N – number of fire-fighting stations.

At the objects where fire-fighting service cannot provide aid in case of emergency, it is offered to place autonomous fire-extinguishing systems. In gardening societies that are situated 20-30 km away from fire-fighting stations local extinguishing systems placed have already proved their effectiveness and perspective.

To evaluate the economic effectiveness of using automatic fire-extinguishing it is necessary to solve two problems. Firstly, the expedience of use of AFE at national economy objects should be economically substantiated if there are other fire protection systems (further in text - FPS), secondly, the most rational variant of the use of automatic fire-extinguishing equipment should be chosen.

At an object where there is no automatic fire-extinguishing system but there are other protection means of fire security system, the economic expedience of using automatic fire-extinguishing system can be defined by comparing the volume of loss reduction possibility if there is automatic fire-extinguishing equipment with present value of investments.

Calculation of present value of reduced expenses for automatic fire-extinguishing system construction (capital and operating expenses) usually does not cause special difficulty.

Using sufficiently precise statistic data about loss caused by fire at an object, one can define annual material loss caused by fire according to the following formula:

$$Z_{ie.m.z} = (Zt + Zn + Z\ b.t. + Z\ eco.)\ P, \qquad (2)$$

where Zt – average direct loss from one fire, Ls;

Zn – average indirect loss from one fire, Ls;

Zb.t. – loss from people's death and injuries, Ls;

Zeco – ecological loss, Ls;

P – probability of fire starting.

If there are no statistic data for evaluation of possible volume of loss caused by fire, then a mathematic model should be elaborated. The area of fire should be calculated and the part of material values destroyed should be defined according to this calculation.

On the basis of statistic materiāls, the part of material loss destroyed in a fire can be defined according to different types of objects if the object is or is not equipped with FPE, taking into account the frequency of fires. The numbers of calcualtion are reflected in table 6.

Table 6.

Part of material loss destroyed in a fire at different types of objects

Kind of object	Destroyed part of material values of an object C_1		Frequency of fires, a year f
	Not equipped with FPE (are other FPS means)	Eguipped with FPE	
Warehouses:			
Timber and woodwork	0,316	0,006	0,0394
Leather and leatherwork	0,235	0,004	0,0123
Technical rubberwork	0,314	0,006	0,0123
Fabrics	0,098	0,002	0,0104
Technical property	0,114	0,002	0,0094
Cellulose and paper products	0,204	0,004	0,0125
Chemical products	0,139	0,003	0,0123
Other products	0,206	0,004	0,0094
Production shops:			
Synthetic rubber and synthetic fibre processing	0,030	0,001	0,0265
Casting and melting	0,072	0,002	0,0189
Machine-shops	0,139	0,003	0,0060
toolshops	0,054	0,001	0,0060
meat and fish products processing	0,100	0,002	0,0153
hot metal rolling shop	0,065	0,002	0,0189
textile industry	0,060	0,001	0,0153
Electric power stations	0,314	0,006	0,0224
Commercial objects:			
Trade centres, department stores, stores	0,073	0,002	0,0097
public catering enterprises	0,035	0,001	0,0097

The value of object in FFRS station service zone and its area are known quantities for each object, so possible material loss caused by fire could be calculated according to the following formula:

$$Z_{ie.m.z.} = Co \cdot (C_1 + K_{net}) \cdot f\,, \qquad (3)$$

where Co – average rate of the area protected 1 m^2, Ls;

f – frequency of fires, a year (see.table 6);

C_1 – destroyed part of material values of an object (see Table 6);

K_{net} – ratio of indirect loss caused by fire ($K_{b.t.} + K_{eco}$).

Taking into account that new coefficients K b.t. and K eco. are first introduced in the paper, it is necessary to evaluate them quantitatively.

As K b.t. we accept the correlation between loss from human loss and injuries and direct loss from fire, i.e.,

$$K\ b.t. = \frac{Z\ b.t.}{Z\ t} \qquad (3.1.)$$

where $Z_{z.b.}$ – loss from peopleš death and injuries in one fire, Ls

Z_t – average direct loss in one fire, Ls;

As K eco. The author of the work accepted the correlation between ecological loss and direct material loss from fire, i.e.,

$$K\ ec\ o. = \frac{Z\ eco.}{Z\ t} \qquad (3.2)$$

where Z_{eco} - ecological loss caused by fire, Ls;

Z_t – average direct loss caused by one fire, Ls.

In researches devoted to the category of social and economic effectiveness, the emphasis is on the unity of social and economic results. As social results one should understand the characteristics reflecting the achievement of the aims put forward by society as a consumer and changes they make in a person. As economic results one should understand the achievement of aims put forward by society as the owner of production means and which show as profit.

However it is not enough with constatation of unity and particular characterisation of social and economic results of this unity for the integration of numerical evaluation of soocial and economic results. It is highly essential to avoid double calculation of expenses

and results in such kind of evaluation process, but it can be implemented if objectively conditional limits separating social and economic results are defined.

To characterise the mechanism of interaction between social and economic results of introducing new equipment into fire protection the following notions are defined: «source of social results», «sphere of realisation of social results», «object of social results impact».

Source of social results is any new technical solution of fire protection problems that possesses social parametres in all stages of its movement. Manufacturing environment and human working and recreation environment can be attributed to the sphere of realisation of social results. Manufacturing environment is the complex of all work application conditions in social manufacturing sphere including fire conditions. The sphere of human work and recreation is characterised as factors influencing and surrounding people and connected with fire security of places of work and recreation.

Social results influence people through their realisation spheres.

The calculation of economic effectiveness of fire protection system is used in performing such kinds of calculation:

- estimation of economic effectiveness ekonomiskās efektivitātes iepriekšējs aprēķins, sastādot gada un perspektīvos plānus, kā arī pamatojot jaunu tehnisko risinājumu ugunsdrošības aizsardzības jomā veidošanas variantus;
- calculation of expected economic effectiveness, executing scientifically technical jobs, as well as on the stages of elaborating technical tasks, technical project and working documentation;
- calculation of actual economic effectiveness introducing the results of scientific researches, starting commercial production of technical equipment, as well as evaluating technical equipment of top quality.

Calculation of economic effectiveness is performed by an enterprise (organisation) developer.

Evaluation of economic effectiveness is performed in following cases:

- assessing new and modernised fire-extinguishing technical equipment;
- taking fire-extinguishing preventive measures.

For calculation of economic effectiveness the following data are used:

- tasks anf sphere of application of a new product (technical solution);
- basic technical parametres of a new and basic product (technical solution);
- lifetime;
- running operating expenses;
- need for new fire-extinguishing technical equipment if national economy;
- costs and price of a new product (technical solution).

There are four groups in the system of necessary ratio, meant for detailed evaluation of progressiveness and effectiveness of technical solutions introduced:

- the indicators characterising technical advantages (mass, dimensions, dynamic characteristics, etc.);
- the indicators defining expluatation results (durability, safety and precise operation, etc.);
- social and economic indicators characterising the level of mechanisation and automatisation, simplicity and safety of exploitation, convenience of repair work and maintenance;
- final indicators of comparative economic effectiveness (coefficient of comparative efficiency of capital investments, time limit for capital investments repayment, minimum of cut expenses, yearly economic effect).

Economic effectiveness is defined by comparability of capital investment complex science-production-consumptionand its operation expenses (current expenses), if necessary, taking into account the loss of national economy in fires.

Differences in the conditions of introduction of new technical solutions require different aptowards calculation of economic effectiveness.

To correctly substantiate and formulate the aims and objectives of the research, it is necessary to additionally examine main factors directly influencing the volume of loss (Z) caused by fire.

The loss caused by fire can be averted as a result of preventively performed fire protection system activities. Loss averted is the most important indicator of economic effectiveness of these activities. But in Latvia this indicator is not being used in

corresponding institutions and at national economy objects. Absence of corresponding methods can be considered to be the main reason of it. Taking into account that fire protection activities also include organiational and administrative activities, defining the volume of loss averted from usefulness of realisation of these activities, basing on structure - aim model, i.e. construction of aim and activities tree.

Before constructing aims and activities tree a group of expert performed expert evaluation using evaluation of individual experts and afterwards defining average evaluation. The way of performing group expert evaluation is easier and is the most widespread. In author's opinion, it allows to liquidate features of subjective uncertainty characteristic for individual evaluation. Here one can mark out three stages of examination: formation of a group of experts, investigation and processing of experts' report.

Consequently, the total economic evaluation of averted loss is 1,783,397 Ls, which is 56,7 % from total intended loss. If the question given is examined taking into account indirect loss (9 million. 426 thousand Ls), then the volume of averted loss will make 5,344,000Ls. It can be seen from calculation made that the sum of loss averted depends on how objectivelu direct as well as indirect loss are defined.

3. FORMATION OF ECONOMIC EFFECTIVENESS EVALUATION SYSTEM FOR FIRE PROTECTION

Calculation of economic effectiveness of fire protection system is used for performing such kinds of calculations:

1) preliminary calculation of economic effectiveness, preparing annual and prospective plans as well as substantiating the variants of new technical technical solutions in the sphere of fire protection formation;
2) calculation of prospective economic effectiveness, fulfilling technical scientific works, as well as on the preparation stage of technical tasks, technical project and workpapers;
3) calculation of actual economic effectiveness, introducing the results of scientific research, starting line production of technology, as well as certifying technology to the highest quality degree.

Determination of annual economic effectiveness is based on comparing cut expenses acoordint to the base as well as to a new technical solution. Cut expenses are the sum of cost and profit.

While calculating economic effectiveness, the determination of the degree of separate technical parametres improvement influence on economic ratio (value of technology, running operating expenses) is an important moment. The ratio reflecting this coherence is an equivalence ratio.

The equivalence ratio in each kind of technical solution is determined as weighted average arithmetic equratio.

As basic ratio for performing economic effectiveness calculations are accepted:

1) capital investments;
2) cost;
3) running operating expenses;
4) introduction volume.

Capital investments (C) are reproduction expenses for fixed assets. Determining the annual economic effectiveness for capital investments, all the simultaneous expenses, necessary for creation and application of technical solution are taken into account: direct

capital investments into technical solution which define its value, pre-production expenses and additional capital investments, realised in connection with the introduction of technical solution.

So, in the structure of State Fire Fighting and Rescue Brigades (further in the text - SFFRB) capital investments are included:

1) expenses for scientific research, experimental construction and designing, creation and testing of experimental samples, industrial testingthat are necessary for verification of results (only in the variant of a new technical solution);
2) expenses for purchasing, delivery, assembling, adjustment and acquisition of a new technical solution;
3) expenses for modernisation of equipment and making special (non-standard) equipment by enterprise's own forces;
4) expenses for supplementing circulation funds, connected with formation and application of a new technical solution;
5) value of necessary industrial area and other elements of basic funds connected with formation and application of a new technical solution;
6) if a part of replacable equipment, while introducing new technical solutions, is to be taken down, then the residual value (not including realisation sums) is charged up to capital investments according to a new variant;
7) expenses connected with purchase and delivery of fire-fighting means whose storage term is longer than a year;
8) expenses for other additional works necessary for the introduction of a new technical solution (building new fire-fighting stations and reconstruction of existing stations, building new access roads, etc.).

SFFRB capital investments into formation of new technical solutions are determined according to formula:

$$K_{vugd} = K_z + K_{r2}, \qquad (4)$$

where K_z - expenses for scientific research and experimental construction works, Ls/unit, a year;

K_{r2} - special capital investments into production funds for a new technical

solution, Lsa year.

SFFRB current expenses (E) are annual expenses connected with the exploitation of technical solution introduced and they are determined according to formula:

$$I_{vugd} = S_m + S_{da} + S_{kr} + S_e + S_r, \quad (5)$$

where S_m - expenses for materials, Ls a year;

S_{da} - expenses for salaries, Ls a year;

S_{kr} - expenses for overhaul, Ls a year;

S_e - expenses for technology exploitation, Ls a year;

S_r - expenses for wear of tyres, Ls a year.

Expenses for materials include expenses for fire-fighting means used for fire-fighting and teaching aims.

In economic effectiveness calculations are adjusted according to cut fire protection technology base variant expenses and current expenses.

Performing activities connected with fire-fighters' labour protection improvement, annual economic effect (E) can be calculated accordint to the following formula:

$$E = \sum_{n}^{i=1} Z_{ie.m.z.} - (K_{vugd} + I_{vugd}), \quad (6)$$

where $Z_{ie.m.z.}$ – possible material loss at the objects situated in SFFRB stations service area, Ls, a year;

K_{vugd} – capital investments of SFFRB stations a year, Ls;

I_{vugd} – SFFRB running expenses a year, Ls.

4. SUGGESTIONS FOR OPTIMISATION OF LOCATION OF FIRE-FIGHTING DEPARTMENTS WITH THE PURPOSE OF RISING FIRE PROTECTION EFFECTIVITY

In accordance with Latvian building standards LBN 201-07 "Fire safety of buildings" (further in the text – LBN 201-07), the size of fire-fighting station service area is defiend according to following criteria:

- so that a fire-fighting brigade could arrive to objects within the territory of a town not later than five minutes after receivinga notification;
- so that a fire-fighting brigade could arrive to objects in urban and rural areas with population density 10 and more people for square kilometre not later than 15 minutes after receiving notification;
- so that a fire-fighting brigade could arrive to an object situated in rural areas with population density less than 10 people for square kilometre not later than 25 minutes after receiving notification.

It can be seen from table 7 that, according to time standards mentioned before, seven Latvian towns are in 5-minute service zone, 25 Latvian regions are in 15 minutes service zone, 1 Latvian region - Ventspils region, where the density of population is lower that 10 people for 1 square kilometre (5.7 people for 1km2), is in 25-minutes service zone.

Table 7

Administrative division and density of population in Latvia in the beginning of 2009

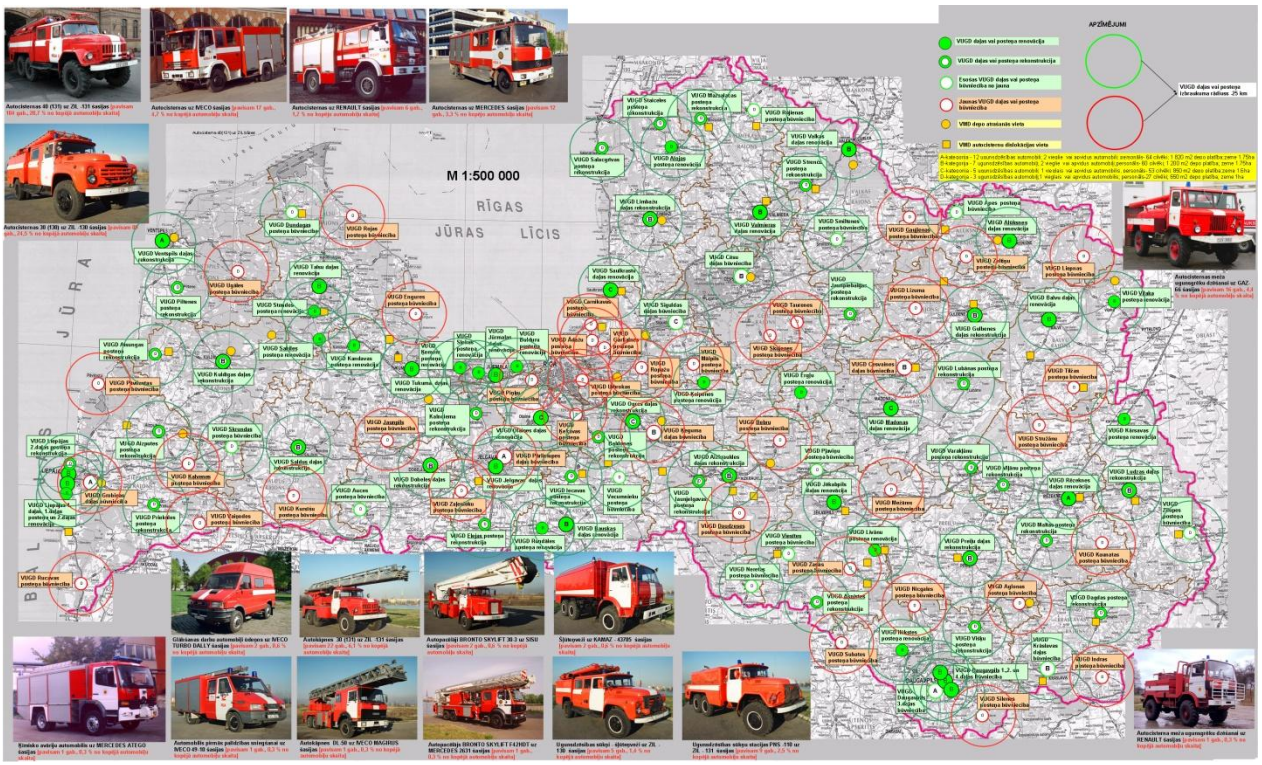
ADMINISTRATIVE DIVISION AND DENSITY OF POPULATION IN 2009					
2009	Number of towns	Number of areas	Number of rural districts	Space, km²	Density of population (people for 1 km² of territory)
Latvia	77	35	432	64 589	35.3

Riga region	1	-	-	307	2 353.4
Next-to-Riga region	19	15	47	10 134	36.8
Vidzeme region	16	3	105	15 257	15.8
Kurzeme region	16	4	83	13 600	22.5
Zemgale region	11	5	80	10 742	26.5
Latgale region	14	8	117	14 549	24.4
Riga	1	x	x	307	2 353.4
Daugavpils	1	x	x	73	1 480.7
Jelgava	1	x	x	60	1 100.9
Jurmala	1	x	x	100	554.1
Liepaja	1	x	x	60	1 424.6
Rezekne	1	x	x	18	2 019.2
Ventspils	1	x	x	55	791.7
Aizkraukle area	3	1	18	2 567	15.6
Aluksnes area	2	-	18	2 245	10.9
Balvi area	2	-	19	2 381	11.4
Bauska area	1	1	15	1 881	27.1
Cesis area	2	1	21	2 973	19.0
Daugavpils area	2	1	21	2 526	15.6
Dobele area	2	1	15	1 632	23.3
Gulbene area	1	-	13	1 876	14.0
Jelgava area	1	2	12	1 605	23.0
Jekabpils area	3	-	20	2 997	17.5
Kraslava area	2	1	23	2 288	14.6
Kuldiga area	2	-	17	2 500	14.3
Liepaja area	5	2	23	3 593	12.2

Limbazhi area	5	-	11	2 602	14.5
Ludza area	3	2	19	2 412	13.0
Madona area	4	1	17	3 349	12.8
Ogre area	4	4	11	1 843	34.8
Preili area	2	4	7	2 042	18.8
Rezekne area	1	-	28	2 809	14.4
Riga area	7	9	9	3 132	51.4
Saldus area	2	1	16	2 182	16.8
Talsi area	4	1	16	2 748	17.0
Tukums area	2	2	16	2 457	22.3
Valka area	4	-	17	2 441	13.0
Valmiera area	3	1	19	2 373	24.6
Ventspils area	1	-	11	2 462	5.7

The time from the beginning of fire till its detection, time of receiving notification and time of fire-fighters brigade arrival together form the of free spreading of fire when factors dangerous for people as well as material and ecological loss caused by fire arise.

The length of time from the beginning of fire till receiving a call in SFRB depends on several reasons and factors and at an average equals 8-12 minutes.



Pict.4. SFRB departments location map

CONCLUSIONS AND SUGGESTIONS

While elaborating the doctorate paper the theoretical and practical aspects of fire protection system economic effectiveness evaluation methods were studied. Author`s research gives the possibility to better understand and substantiate the necessity of fire protection system economic effectiveness evaluation methods to promote its introduction in modern Latvian economic conditions.

On the basis of this research the following main conclusions were made:

1. The results of the doctorate paper are connected with studying and improvement of the complex of methods of fire protection economic effectiveness evaluation to apply in corresponding organisations. With economic-mathematical model elaboration and adaptation in planning real fire protection activities and including in strategic plans, it would be correct from the point of view of economics to choose the way of using resources that would allow to achieve the highest effectiveness of their use.
2. On the basis of analysis of statistic data on fire extinguishing and economic loss caused by them, as well as taking into account the performed analysis of fire-prevention normative documents regulations the presence of great reserves for rising the effectiveness of fighting fires and, correspondingly, reducing social, metrial and ecological (in general economic) loss is established.
3. To find substantiated solutions for rising the economic effectiveness of fire protection system at national economy objects and in populated areas, basic factors, essentially influencing economic loss caused by fire, were defined with the help of regress analysis. To such factors the distance from fire location to fire-fighting station, the time of receiving a notification and arrival of fire-fighters to those, the ensuring of objects with effective fire-extinguishing means are related.
4. The methods of defining the averted economic loss caused by fire were elaborated and the structure of this loss was defined. The averted loss consists of direct and indirect loss, loss from people’s death and injuries, ecological loss. It is demonstrated that in Latvian State Fire-Extinguishing and Rescue Service only direct loss is listed at present, what does not give the possibility to objectively evaluate the real «price» of a fire and to correspondingly objectively evaluate the

volume of loss averted with the help of fire protection system. It must be considered suitable to continue the summary loss accounting, which, as researches have showed, is at an average 15 time bigger than direct loss.

5. The main criteria of SFRB effective activities is formulated and scientifically substantiated. Firstly, it would ensure the protection of people in fires. As such criteria medical and biological criteria can be accepted. SFRB brigades should arrive to the location of fire in time, which is shorter than the time when factors dangerous for people's life and health set in. The main meaning of SFRB is that it is a rescue service. Besides, SFRB has to ensure a real rescue of people not registration of the fact of people's death having arrived to fire location. In the researches it is found that in Latvian conditions medical and biological criteria is 4-5 minutes.
6. On the basis of analysis of fire protection system functioning in populated areas and at objects it is established that two contraty processes - disorganisation and stabilisation - simultaneously take place in protection system. Moreover, disorganisation discredits and lowers economic effectiveness of the system, but stabilisation is continuous and rises the effectiveness.
7. Rationing methods for ensuring resources existing in Latvian Republic for State Fire-Fighting and Rescue Brigades (further in the text - SFRB) troubles SFRB fulfillment of their functions. This circumstance does not allow to in full ensure in Latvia the effective operation of technogenic risks and risks caused by nature management system, as exactly SFRB is responsible for risk management system operation, takes part in evaluation of industrial risks, organises, performs and manages emergency rescue works and liquidation of results, takes care of the safety of inhabitants in cases of fires or accidents, as well as provides first aid.
8. The methods of defining economic effectiveness of basic elements of fire protection system for objects and populated areas (fire protection, automatic fire detection system, automatic fire-extinguishing facilities, reducing the time of free development of fire as a basic factor of reducing social and material loss) were elaborated.
9. On the basis of aim-activity tree (structure-aim model) the methods of economic evaluation of loss averted, using the realisation of basic activities of fire protection system, is elaborated.

10. The complex of the activities performed gives the possibility to rise the level of fire protection for national economy objects and populated areas on the basis of the complex of methods for defining economic effectiveness of fire protection system elaborated in the doctorate paper. As well it allows to supplement present normative fire potection base with significant but at present absent economic aspects.

Summarising the results and conclusions made from the research, the author proposed such motions:

1. SFRB to use methods of defining the economic effectiveness for basic elements of fire protection of objects and populated areas (automatic fire detection and extinguishing systems, reducing the time of free development of fire, as well as the necessary number of fire stations as basic factors of reducing social and material loss caused by fire).
2. The elaborated methods of defining averted economic loss caused by fire and defined structure of this loss is recommended for SFRB use.
3. To find substantiated solutions for rising the economic effectiveness of objects and populated areas fire protection system basic factors essentially influencing economic loss caused by fire were defined. To such factors the distance between fire location and fire station is related first. So the author advises that fire stations in Latvia shoul be situated for one station to have the possibility to serve 12 km² area of administrative territory. Additionally, the average time that a fire-fighting brigade spends for getting to location of fire cannot exceed 5 minutes.
4. Justifying the new approach to ensuring fire protection in such Latvian rural territory objects that are situated outside service area of fire brigades and really cannot be reached in time defined in standards, to equip such objects with local automatic fire detection and fire extinystems to reduce possible loss caused by fire.