ISSN 1407-7345 POWER AND ELECTRICAL ENGINEERING 2007-7345
ENERĢĒTIKA UN ELEKTROTEHNIKA

ENERGY SYSTEMS AND THE ENVIRONMENT
ENERGOSISTĒMAS UN VIDE

SOLAR ENERGY FOR HOT WATER SUPPLY IN LATVIA

SAULES ENERĢIJAS IZMANTOŠANA KARSTĀ ŪDENS PIEGĀDEI LATVIJĀ

Dagnija Blumberga, Professor, Dr.Hab.Sc.Ing.
Riga Technical University, Institute of Energy Systems and Environment
Address: Kronvalda Boulevard 1, LV1010, Riga, Latvia
Phone: 371+7089908, Fax: 371+7089923
e-mail: dagnija@btv.lv

Ivars Veidenbergs, Professor, Dr.Hab.Sc.Ing.
Riga Technical University, Institute of Energy Systems and Environment
Address: Kronvalda Boulevard 1, LV1010, Riga, Latvia
Phone: 371+7089908, Fax: 371+7089923
e-mail: ivars@eef.rtu.lv

Andra Blumberga, Ass.Professor, Dr. Sc.Ing.
Riga Technical University, Institute of Energy Systems and Environment
Address: Kronvalda Boulevard 1, LV1010, Riga, Latvia
Phone: 371+7089908, Fax: 371+7089923
e-mail: andrab@latnet.lv

Introduction

The main goal of the European Union in the energy sector is to decrease energy consumption in the energy end user side. A huge research work is done to find border values which are taken as the basis for issuing directives. To complete EU goals, each country has to develop policy for both energy efficiency improvement and extensive use of renewable energy sources. In this case, questions on the use of solar energy get a wider sounding and application.

There are several ways to apply solar energy use in buildings, from which the most popular are the following:

- Solar energy absorption and transmission through the constructive elements of the building (windows, walls and roof);
- Solar energy absorption with specific equipment, e.g., solar collectors.

At present, passive solar energy is being used because of the fact that heat energy consumption in buildings directly depends on the influence of solar radiation to the building. In this case there are several factors which affect the impression of solar radiation to annual heat energy consumption of buildings. Some of them depend on elements of territorial planning and others on constructive solutions of building: Passive solar energy use indicators and features which have high importance are the following:

- the orientation of building towards cardinal points;

- the way how building is glazed -- the larger the surface of area of windows, which is guided towards south, the lower consumption of heat energy will be used;
- the largeness of the part of the building, which is placed in the shade.

Other consumer of heat supply, which does not depend on the influence of solar radiation to the building construction, is the consumer of hot water. The amount of heat energy for hot water systems depends on the technological solutions of solar collectors: parameters, elements of solar system etc. At present in Latvia it is possible to ensure ~ 60% of all hot water supply and 10% of thermal energy consumption to cover heating needs in buildings by use of solar collectors.
The research of solar energy use continues at the Institute of Energy Systems and Environment of Riga Technical University. The objective of this research is to increase the proportion of available solar energy for heating in single family houses. The main goal of this moment is to achieve solar energy use in the heating system around 50% from the total heat energy use of building.
Although the technological solutions of solar energy's use for hot water supply (in the range of 50 … 60%) are available, in Latvia there are less than 20 solar collector systems mounted. One of the reasons why they are not widely used is that the costs of solar collectors remain high. Today environmental aspects are becoming more and more important and therefore economical issues could be partly replaced by climate supporting schemes, for example green investment scheme.

The indicators for the use for solar energy for hot water supply

It is necessary to use specific indicators for valuation the consumer of heat energy, its influence on the environment and climate, for comparing the data of energy consumption with both other similar consumers and normative and standard values. Indicators are helpfull for defining the activities not only for energy consumption decrease, but also for the potential usage of renewable energy.
Different aspects are exercised to present the advantages and disadvantages of solar energy use. The classification of indicators of solar energy usage includes conditions of application [1].

- Technological indicators present various data both for energy end user, and equipment and also solar radiation.
- Efficiency indicators illustrate the efficiency of operation and maintenance of system.
- Social indicators show both the influence to employment/ unemployment and also the increasing of imported goods and services, for example, solar energy will replace a part of imported fossil fuel.
- Economic indicators include both investments for solar collector system and savings by reduction of energy costs for hot water consumers.
- Environmental and climate indicators define the necessity both to evaluate reduction of greenhouse gas (GHG) emissions and hazardous air pollutants and to estimate the cost efficiency of decrease of GHG emissions and also to make the life cycle analysis of solar collectors.

The number of those indicators is large. That is reason why the most important indicators are chosen and called the title indicators [2]:

- heat energy costs of hot water preparation, Ls/ m^3;
- heat energy costs, which include cost efficiency of reduction of GHG emissions Ls / kWh;
- energy efficiency: heat energy produced from solar collector, which is installed for building , kWh / m^2 ;

- accessibility and availability of solar energy.

Model for analysis. Algorithm

The model for analysis of solar energy use for hot water supply in state level includes three modules:

- technological module;
- economical modules;
- climate module.

The technological module consists of two types of information: estimation of heat energy consumption for hot water supply and solar technologies available to cover those needs.
The economical model takes into account two groups of outcome/income issues: from one hand investments needed for installation of solar collectors and operation and maintenance costs and from other hand – savings from solar energy use (solar energy is for free).
The climate model brings in evaluation of reduction of GHG emissions, which will be reached through increase of solar energy use. The Kyoto mechanisms allow to participate in different emission trading schemes in such cases and therefore the climate model could predict amount of additional finances from heat energy generation by renewable source.

Heat energy consumption for hot water supply. Potential

The historical data of heat energy consumption in Latvia are used for estimation of potential of heat energy consumption for hot water supply. Analysis of the existing situation and tendencies of development of hot water supply are based on the following aspects:

- analysis of structure of heat energy supply in Latvia;
- estimation of potential of hot water consumptions;
- evaluation of available solar radiation in different conditions.

Hot water supply is organized in several ways in Latvia. The most popular scheme today is the use of efficient boiler houses with connection of energy end users to district heating systems. Individual hot water supply scheme includes main element: boiler or heaters in houses or flats. The analysis of structure of use of heat energy shows that part of hot water supply is different for DH and individual energy systems. 25 ... 30% from the total consumption of district heating systems are used for hot water supply. Less heat energy is used for hot water supply in case of individual heat supply systems (20 ... 25%).

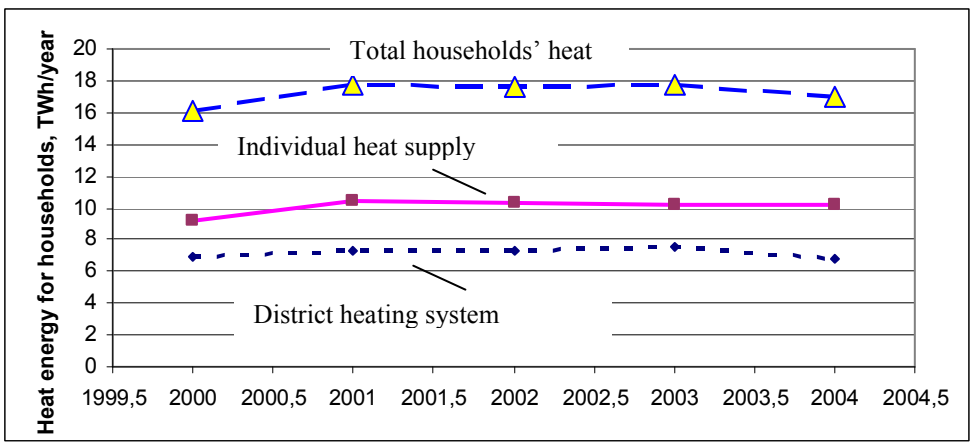

Fig. 1. Heat energy consumption in household

According to statistical data of the Investment and Development Agency of Latvia and the Institute of Statistics of Latvia [2] (see Figure 1), the consumption of heat energy from disrict heating systems slightly decreases in late years. It means that the amount of individual heat exchangers increases. Those features could be taken into account for forecast of heat energy consumption to cover hot water supply needs. The total use consumption of heat energy for hot water supply is estimated 3..4 TWh/year.
The integration of the annual data of solar radiation and hot water users was conducted during simulation and modeling of potential of solar energy for hot water consumption. Results of calculations present potential of heat energy consumption in range 1 … 1,1 TWh/year (see Figure 2).

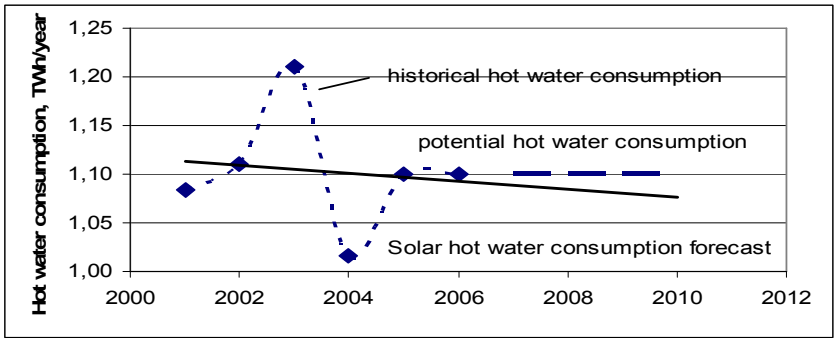

Fig. 2. Potential of solar heat energy consumption for hot water

The average solar radiation in Latvia is 1100 kWh/m^2. It is a little bit more than in Denmark (1020 kWh/m^2), Sweden (1040 kWh/m^2) and Finland (1000 kWh/m^2). An important question is solar radiation in autumn, winter and spring, because nobody doubts of use of the solar energy for hot water supply in summer. The values of intensity parameters of solar radiation are obtained from State Hydrometeorology Agency [3] and their changes are shown in Figure 3. The average month solar radiation intensity data are gained by summing daily values in a month period. As data presented in Figure 3 show heat energy generation for hot water supply depend on the position of solar collectors: it is possible to gain different amounts.
Assumptions for calculations of solar energy usage potential in the determination model are based on practical experience in Latvia. Available solar radiation is 400 kWh/ m^2 per year and solar collector gains energy during 1700 hours per year. The experimental data testifies that the real numbers of hours are more, for example, in April 2007 a private house solar system worked 240 hours in Jelgava.
Results of calculations present total surface of solar collector, which is necessary to install in Latvia. Total surface is 2,75 km^2. Affordability of data justified with comparison of data from Germany: in 2003 the total surface of installed solar collectors were 4,76 km^2.

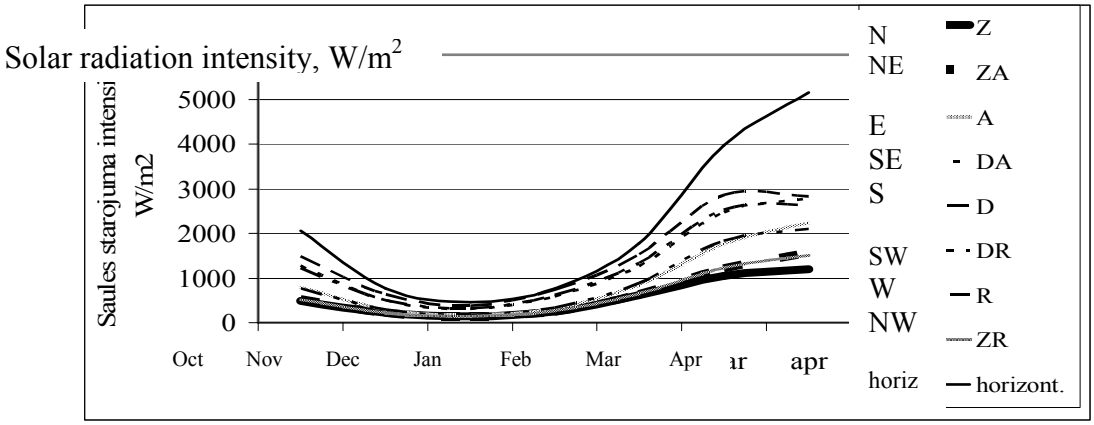

Fig. 3. Solar radiation intensity per month on the horizontal and differently vertically oriented surfaces.

Analysis of economical indicators

The economical justification depends on the one hand on the investments for solar collector systems and their operation and maintenance costs and on the other hand - savings, what are formed from the elimination of fossil fuel costs and reduction operation and maintenance costs in energy sources (boiler houses).

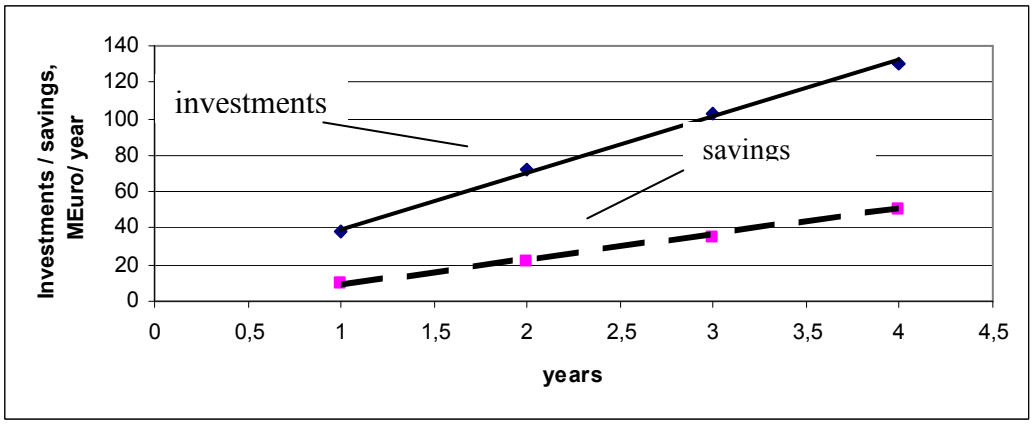

Fig. 4 Analysis of investments and savings

There are assumptions made in the economical modeling of solar collector use for hot water supply in Latvia. The expanses for solar collectors change through years, because the technologies are improved, new collectors are made, and today's collectors will cost less in few years. It is assumed in calculations that a credit for 10 years will be taken; the project of solar collectors will be carried out in four years period, starting in 2008, the fossil fuel (the price for it will increase for 7 %.) will be replaced. Figure 4 shows the calculations for annual loan repayments and savings in this state project, in which every citizen in Latvia could take part. The results show that difference between investments needed and savings obtained becomes larger and larger through years. It means that support from other sources have to be used.

The Ministry of Environment has carried out "The strategy of renewable energy sources for 2006- 2010". In chapter 6 of the document proposes the versions of financing for the alternative energy sources (including solar energy) to improve their competitiveness with fossil fuel. Besides other actions for attracting EU financing, the necessity to add activities and undertakings for renewable energy source development is mentioned to have to be put in the strategic document 2007-2013 operational programs. In this document is defined implementation of pilot projects of renewable energy sources by the governmental financial support for elaboration, introduction and

implementation of the new products and innovative technologies, especially in the field of solar energy.
An interesting idea is about the governmental financing investment, that is set for the efficient and environmentally friendly consumption of the renewable energy sources by use of financial support from green investment scheme in the international emission trade.

Analysis of climate and environmental indicators

Other support for use of renewable energy sources is under discussions for greenhouse gas emission reduction mechanisms in the post - Kyoto period. Each country has to provide information about possibilities to reduce GHG emissions, therefore it is important to foresee how much 1 ton of CO_2 reduced (called also cost efficiency) could cost and investigate availability for technological solutions. Solar energy use for hot water could replace the fossil fuel and electricity use in boilers and heaters.
Climate justification includes modeling of GHG emissions from combustion facilities, which could be replaced. Modeling includes different variables. Dependent variable is annual emission generation, which varies in time (days, months, year). Dependent variable depends from independent variables: energy generation, energy efficiency and emission factor. The energy generation per year is an independent variable $Q=f(\tau, B, \eta)$,. The energy efficiency is an independent variable from emission generation $\eta=f(Q)$, but it depends on the load of a facility. Other independent variable is emission factor, which depends from type of fossil fuel. Under discussion is independent variable, which express fossil fuel consumption $B=f(\tau)$. The analysis of data of emission trading operators in Latvia permits to define calculation of CO_2 emissions by following equation (1).

$$CO_2 = \int_0^{\tau} \int_{Q_1}^{Q_2} R \cdot Q(\tau) \cdot \frac{1}{\eta(Q)} \cdot d\tau \cdot dQ, \ \text{tCO}_2\text{/year}, \qquad (1)$$

where

Q - energy generation, MWh/year;
R - emission factor, tCO_2/MWh;
η - energy efficiency of combustion facilities;
Q_1, Q_2 - minimal and maximal energy load;
τ - time, year.

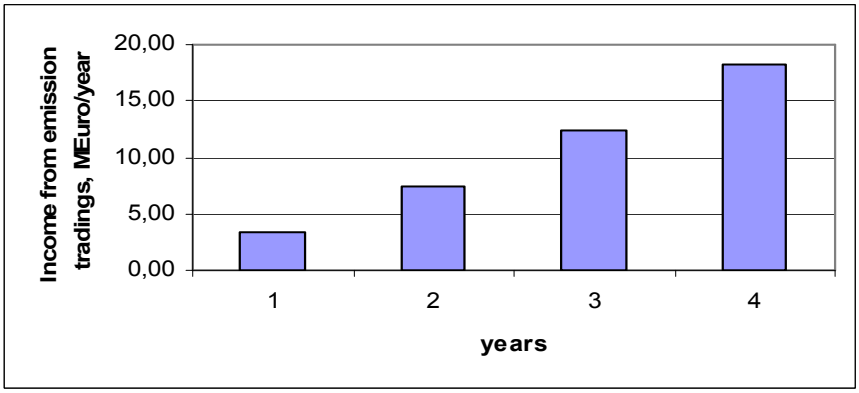

Fig. 5. Forecast of savings from emission trading scheme

Results of climate modeling of installation of solar collectors in Latvia in the next four years are presented through economical obtainings (see Figure 5). Assumptions are made for the following factors:

- selection of proportion of fossil fuels replaced (done according statistical data of 2006);
- greenhouse gasses emission price in the emission trade scheme;
- selection of emission factors for replaced kinds of energy sources and efficiencies.

According to the results of climate modeling (Figure 5.), emission trading for solar energy use could give benefit in range from 3 to 18 millions EUR in a year in Latvia.

Income from emission trading could cover part of the difference between investments and savings presented in Figures 4. and 5. According to assumption done in climate model emission trading input could be in the range of 25…35% of total difference between investments and savings.

Conclusion

1. A model for evaluation of potential solar energy consumption for hot water supply in Latvia is made. It is defined that governmental support is needed for solar energy use as a renewable energy resource. The model allows defining the amount of financial support, what could be reserved both from the EU structural funds and by making a special tax discount. Attention needs to be paid to the use of Kyoto mechanism schemes.
2. The analysis of potential gives a qualitative estimation, because a lot of assumptions have to be used. Some of them are based on the experience of previous energy efficient projects. However forecast of GHG emission prices in emission trading scheme is impossible to predict today.

References

1. J.O. Dalanback Solar energy in building renovation. Energy and Buildings 24, Elsevier, p. 39-50. 1996

2. A.Blumberga Ēku energoefektivitātes izpēte. Ekonomiskā un ekoloģiskā optimizācija / Promocijas darbs. RTU 2001

3. Valsts Hidrometeoroloģijas pārvaldes atbilde RTU Vēstuli Nr. 11/13 (.2000. gada 08.maijā).

4. Latvijas Statistikas gada grāmata. 2006

5. D. Blumberga, A. Blumberga, V. Vitolins Energy audits in dwelling buildings in Latvia. Data collection /DYMASTEE conference, Proceedings, Athens, Greece, October 21-23, 2005

6. M.Suri, T.Huld, E.Dunlop Geographical and time variability of the solar electricity generation in Europe / Conference Solar Energy use in Eastern Europe countries. 2004. October 12 -14th, Ispra, Italy

Blumberga D., Veidenbergs I., Blumberga A. Saules enerģijas izmantošana karstā ūdens piegādei Latvijā.
Tagad Latvijā ir iespējams nodrošināt ap 60% no visa karstā ūdens apjoma un 10% no siltuma enerģijas pieprasījuma, izmantojot saules kolektorus.

Šī pētījuma mērķis ir palielināt pieejamās saules enerģijas īpatsvaru siltumapgādei vienģimenes mājā. Galvenā ideja ir palielināt saules enerģijas izmantošanu līdz 50% no visa siltumenerģijas patēriņa ēkā. Ir izveidots saules enerģijas izmantošanas modelis karstā ūdens nodrošināšanai Latvijā. Ir noteikts, ka ir nepieciešams valsts atbalsts saules enerģijas kā atjaunojamā enerģijas resursa izmantošanai,. Modelis ļauj noteikt finansiālā atbalsta lielumu, kas var tikt iegūts kā no ES strukturālajiem fondiem, tā arī ar speciālajām nodokļu atlaidēm. Jāpievērš uzmanība arī Kioto mehānismu shēmu izmantošanai.

Blumberga D., Veidenbergs I., Blumberga A., Solar energy for hot water supply in Latvia.
At present in Latvia it is possible to ensure ~ 60% of all hot water supply and 10% of thermal energy consumption to cover heating needs in buildings by use of solar collectors.
The objective of this research is to increase the proportion of available solar energy for heating in single family houses. The main goal of this moment is to achieve solar energy use in the heating system around 50% from total heat energy use of building. A model for evaluation of potential solar energy consumption for hot water supply in Latvia is made. It is defined that a governmental support is needed for solar energy use as a renewable energy resource. The model allows defining the amount of financial support, what could be reserved both from the EU structural funds and making special tax discount. An attention to use of Kyoto mechanism schemes have to be made.

Блумберга Д., Вейденбергс И., Блумберга А., Использование солнечной энергии для снабжения горячей водой в Латвии.
Сейчас в Латвии возможно обеспечить до 60% от всего объема спроса на горячую воду и 10% на отопление, применяя солнечные коллекторы.
Цель данного исследования увеличить удельный вес доступной солнечной энергии в общем балансе теплоснабжения односемейного дома.
Главная идея увеличить использование солнечной энергии до 50% от общего потребления солнечной энергии в здании. Разработана модель для использования солнечной энергии для нагрева горячей воды в Латвии. Определено, что поддержка государства необходима для использования солнечной энергии, как возобновляемого источника энергии. Модель позволяет определить размер необходимой финансовой поддержки, которая может быть получена как из структурных фондов ЕС, так из с помощью специальных скидок на налоги. Особое внимание надо уделить использованию схем механизмов Киото.