Sustainable Energy Action Plan of Municipality Gradiška

- SEAP -

- Gradiška February, 2012 -

SUSTAINABLE ENERGY ACTION PLAN OF MUNICIPALITY GRADIŠKA

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Publisher
Municipality Gradiška, with support of the Development Program of United Nations (UNDP) of Bosnia and Herzegovina

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Content

Introduction

Climate on planet Earth is changing. Increasing concentrations of greenhouse gases in the atmosphere caused the growth of the average annual temperatures, which contributes to changes that are present on the entire Planet. Signs of climate changes can be noticed on our territory as well, where temperatures in winter seldomly go below zero, and summers are variable with frequent extreme weather characteristics such as tropical heat or rainy and chilly summers.

Percentage of growth of greenhouse gases emission is a result of personal use of energy of each individual. Some of the sources of these emissions are public transport, heating and cooling of the premises, water heating, use of house appliances, lighting and similar. The most significant gas of all greenhouses gases that pollute atmosphere and damage the ozone layer is carbon dioxide (CO_2). Beside the emission of harmful gases as side-effect of using energy in households, one more problem is creating waste which due to poor habits of population ends up on the wild depots.

Fight against climate changes also started the Administrative service of municipality Gradiška, in preparation of the Development sector, when it has in April 2011 signed the Covenant of Mayors. By this act Municipality obliged to prepare within one year time a *Sustainable Energy Action Plan*.

This key document shows that local authority will attain reduction of CO_2 emission for 20% till 2020, which will be the result of increase in energy efficiency for 20%, as well as increase of share of renewable energy sources for 20%. In this way Municipality has shown to accept the fact that local and regional authorities share responsibility regarding fight against climate changes together with national authorities. SEAP document will also contain measures/activities for reducing emissions till 2020, and they have been planned in private as well as in public sector on the territory of municipality. Some of these measures are improvement of energy efficiency at existing facilities by installment of saving lighting fittings, use of renewable energy sources through implementation of heating systems on biomass, reconstruction of public lighting, use of bio-diesel in public transport, construction of bicycle tracks, afforestation of the barren land and similar.

By efficient use of energy and water, as well as by the wise consumer choice, we can reduce our personal emissions of greenhouse gases for around 20% or for one tone per year. Most of people of this and other developed municipalities have probably already taken certain steps in order to save energy, money and to protect environment. However, challenge of reducing the emissions of greenhouse gases for 20% asks from us to engage even more.

1. Covenant of Mayors

After accepting climate and energy packages of European Union measures in 2008, European Commission started the Initiative **Covenant of Mayors**, to which so far joined over 3.350 cities signatories from all parts of Europe. In this way, countries members of EU obliged themselves to reduce the emissions of the greenhouse gases for 20% until 2020. Local authorities have the key role in mitigation of climate changes, because spending energy and emission of CO_2 are mostly caused precisely by activities in cities. The European Commission holds that it is possible to achieve these goals only with active participation of much wider number of participants such as local authorities, local investors, citizens and their associations.

Covenant represents response of the advanced European towns on challenges of global climate change and also the first and most ambitious initiative of European Commission which directly aims on local authorities and citizens through their active participation in fight against global warming. By signing Covenant, Mayors oblige to implement concrete measures of energy efficiency whose final result will be reduction of CO_2 in all of these citizens for up to 20% till 2020, as well as increase of part of renewable energy sources for 20%.

As European movement, Covenant of Mayors includes local and regional authorities which voluntarily want to work on increase of energy efficiency and use of renewable energy sources on each territory. Signatories of Covenant have the aim to satisfy or even top up the requests of European Union for reduction of CO_2 emissions for 20% till 2020. (*Covenant of Mayors, 2011*)

One of the obligations which cities undertake by signing Covenant is elaboration of Sustainable Energy Action Plan - SEAP. During the elaboration of Action plan for municipality Gradiška, thirteen towns approached to Covenant of Mayors in B&H. Sustainable Energy Action Plan is a document in which municipalities in B&H for the first time analyze theirs energy consumption and emissions of greenhouse gasses on each territory.

Experience says that such analysis of energy consumption is especially important because many of these municipalities have no control over energy sector. Besides, in the Action plan for the first time are defined measures and activities which are feasible and applicable in specific local conditions and whose application leads to decrease of emission of exhausting gasses for 20% or more till 2020.

2. Sustainable Energy Action Plan - SEAP

According to data of European Statistical Institute (*Eurostat, 2011*) urban areas in European Union are responsible for 80% of energy consumption and corresponding CO_2 emissions with annual trend of increase of 1,9%. Ambitious aim of decreasing emissions of greenhouse gases for more than 20% in relation to baseline year is possible only with active engagement and participation of town authorities, numerous stakeholders and citizens of greater number of European citizens. Together with state authority, town, local and regional authorities of European countries equally share responsibility and overtake the obligations for fight against global warming by conducting different programs and projects.

Sustainable Energy Action Plans of cities after elaboration need to be delivered to European Commission within a period of one year. Action plan represents ground document which on basis of collected data on current state within the baseline year identifies and gives precise directions for conducting measures and activities of energy efficiency and use of renewable energy sources on town level, and which will result in reduction of CO_2 emission for 20% till 2020.

Main aims of elaboration and implementation of the Action plan are:

- CO_2 emission reduction in all sectors by implementing measures of energy efficiency, using renewable energy sources, managing consumption, education and other measures,
- Contribution to safety and diversification of energy supply of town, decrease energy consumption in sector of construction engineering, transport, public lighting and similar,
- Increasing the share of the produced energy from renewable sources,
- Providing transformation of urban into ecological sustainable areas.

Action plan is focused on long-term transformations of energy systems within cities and gives measurable aims for reducing energy consumption and corresponding CO_2 emission.

Obligations from Action plan refer to the entire area of municipality, on public and private sector. It needs to be in all of its segments coordinated with institutional and legal framework on the level of EU, national and local legal regulations, and it should cover the period till 2020.

Fundamentally, Sustainable Energy Action Plan contains measures/action from following fields:

- Civil engineering, including new buildings and basic revitalization,
- Municipal infrastructure (town heating, public lighting, etc.),
- Use of land and urban planning,
- Decentralized sources of renewable energy,
- Public and private transport and town traffic,
- Participation of society, citizens,
- Smart use of energy by citizens, consumers and economy.

Besides energy saving, results of activities and measures stated in the Action plan are viewed in creating new working places which in future will not be centralized, healthier environment and improved quality of life, increasing economic competitiveness and bigger energy independency.

Measures stated in the Action plan do not cover all possibilities of reducing emissions, but they cover most important sectors and activities necessary for implementation in order to achieve set aims.

One of the important activities in the aim of the energy sustainable development of municipality is duly informing and continuous education of citizens and other participants on this area on need of energy saving and reducing CO_2 emissions.

In the implementation phase of Action plan, cities need to submit to European Commission periodical reports on implementation and progress of achieving set aims.

3. Methodology of elaboration of Sustainable Energy Action Plan

Initiative of Covenant of Mayors determines the process whose main results are the following:

1. Signed Covenant of Mayors,
2. Accepted and delivered Sustainable Energy Action Plan,
3. Delivered reports on implementation of Action plan.

Before signing ***Covenant of Mayors,*** it is necessary to perform set of preparatory actions in order to create an atmosphere and ensure support of initiatives whose aims are very ambitious. Support of local authority understands existing of political will for constant reduction of CO_2 emissions and other greenhouse gases, but also existing of awareness on need for installment of changes for whose implementation is necessary to ensure other assumptions such as human and financial resources, coordination and including other interest groups without whom implementation of plan would be impossible.

After the Covenant is signed, local authority within one year from signing must deliver Sustainable Energy Action Plan. Primary task in elaboration of Action Plan is preparation of Baseline Emission Inventory. Baseline Emission Inventory requires collecting and analysis of data on energy consumption in different sectors for defined baseline year (a year from which begins monitoring of CO_2 emission and in relation to which the reduction of emission is planned).

According to recommendations of European Commission, sectors are divided into construction engineering, transport, public lighting and optionally other sectors which can be chosen depending on the need.

Gathering data is an especially challenging task, since that data are frequently unavailable or scattered into several institutions and companies, or the structure of the data is insufficient for them to be use.

Final result of Baseline Emission Inventory represents input data for elaboration of measures/activities which make the most important part of the Action plan.

Signing Covenant of Mayors implies minimum reduction of CO_2 emission for 20% in relation to the baseline year. Mayor and Municipal Assembly reach Decision on adopting the Initiative of Covenant of Mayors and targeted reduction of emissions which can be bigger than prescribed.

By recognizing the biggest emitters of CO_2, local authority acquires the insight into priority sectors in which should be acted upon to reduce the emission. Most of the proposed measures in Action plan have time and financial dimension which local authority can manage during implementation, but also estimated energy and emitted savings in order to have an insight into efficiency of measures. For each measure it is possible to use set of financial resources which are available to municipality and other stakeholders.

Sustainable Energy Action Plan must be approved by Municipal Assembly, after that it is necessary to be delivered to Office of Covenant of Mayors. After approving Action Plan, its implementation follows which lasts till 2020. Each measure defined in Action Plan can represent individual project or even program made of several projects. As Action Plan contains relatively great number of measures which are often necessary to implement at the same time, implementation of program represents financial and organizational challenge for local authority. Formation of work group in charge of the implementation of measures with coordinator on top is a reference founded on good practices of other cities. Working group is made of employed associates, whose profile and position corresponds to measures which are necessary to be implemented.

Monitoring and reporting on implementation of Action plan is necessary to be done continuously. According to request of the Office of Covenant of Mayors, report on implementation of Action plan is necessary to deliver to Office minimum each two years. Since two years are relatively long period of time, and for implementation of Action Plan has remained eight years, working group will prepare report for each year.

Annual report is just one component of continual monitoring of project implementation. Preparation of annual reports provides insight in real results, i.e. effects of implementing the measures. Review of emissions, as the only relevant indicator of progress and success of implementing the measures needs to be stated every two years. For each new review of emissions, it is important to apply identical methodology of elaboration to one which is applied in elaboration of baseline review.

Organization of implementation consists of Municipal service for monitoring of implementation of SEAP, local team coordinator and professional team for elaboration of SEAP. Operational implementation of program will be assigned to local team coordinator. Coordinator will in its everyday work coordinate the work of several working groups in charge for individual sector. The need for coordination will be shown in the process of planning, operationalization, supervision and adjusting each measure in Action Plan.

Coordinator is an official whose working function is related to energy problematic, but also it has good review of functioning of Administrative service and knowledge in the area of project management. In operational implementation of measures will be included managing departments, town companies and agencies whose representatives will be in charge of sectors in accordance with stipulated obligations from Contract.

Board for monitoring the implementation of Action plan adopts strategic resolutions, makes changes of activities in certain measures (such as Resolution on capital investments, priorities, mode of financing and similar), and communicates with other participants outside Administrative service.

Industrial sector is only partially covered by this Action plan, so it is in future necessary to work on more active engaging of industrial representatives.

Professional team for implementation of Action plan consists of experts from individual sectors, but also other employees of Municipality whose role is important in the process of project implementation; such as representatives of Administrative service, representatives of managing department's of town companies "Toplana", "Elektrodistribucija", Police station for traffic safety, "Jelšingrad" and non-governmental sector. According to needs, for each of measures from Action plan, professional team will include other representatives' volunteers.

Use of the successfully conducted process of elaboration, implementation and submitting of the Action plan is multiple for Municipality and its citizens but also for strengthening the political power of municipal authority, which will by successful implementation of entire process contribute to following: demonstration of its determination for energy sustainable development of municipality on principles of environment, energy efficiency and renewable energy sources as imperative of sustainability of 21st century; establishing foundations for energy sustainable development of municipality, starting new financial mechanisms for moving and implementing measures of energy efficiency and use of renewable sources of energy in municipality; ensuring long-term energy supply of municipality, increase of quality of life of its citizens (improvement of air quality, reduction of traffic jam and similar).

4. Inventory of CO_2 emissions

Sources of aero-pollution in urban areas are mostly result of human activities and can be classified into three groups, and those are stationary sources, movable sources and sources of pollution from closed space. In pollution sources from the group of stationery sources are agriculture activities, quarry, industry, burning communal waste, individual fire boxes, open grills etc. In the group of movable sources are vehicles with motors with internal combustion. In the group of pollutions from closed space are smoking cigars, biological pollutions (pollen, maggots, mould, yeasts, insects and microorganisms) emissions from different matter such as vaporizable organic commixtures, lead, radon, asbestos, different synthetic matters etc. (*Institute for protection, ecology and informatics, 2011*)

Inventory of CO_2 emissions (*Baseline Emission Inventory*) represents fundamental document based on which are calculated and stated CO_2 emissions made after consumption of all energy-generating products in sectors on the area of municipality Gradiška.

Municipality Gradiška has determined that the quantities of emissions from 2005 will represent the baseline quantities. Selection of this year as baseline resulted from analysis of all available data based on which inventory of emissions of greenhouse gasses have been stated. According to the recommendations stated in the *Guidebook* made by Office of Covenant of Mayors (*CoMO*), Inventory can except emissions of CO_2, contain also emissions of other greenhouse gasses, such as methane (CH_4) and nitrogen-oxide (N_2O). In this overview of emissions only quantities of CO_2 emissions have been processed.

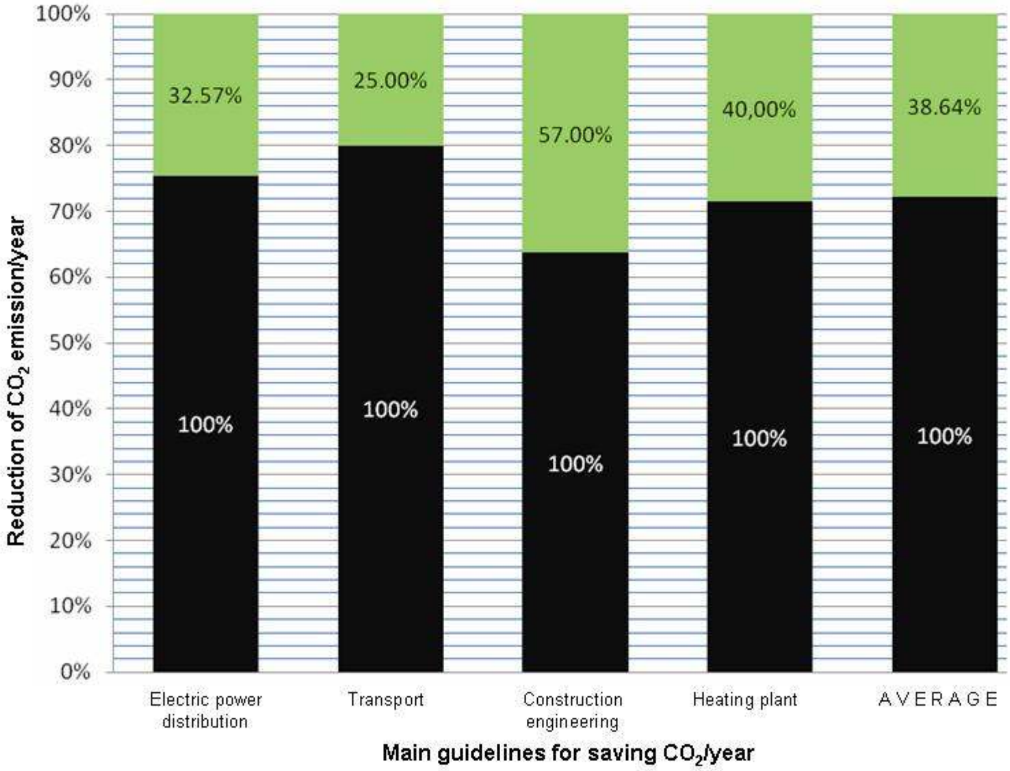
Inventory of CO_2 emissions is an instrument which enables local authority to measure efficiency of defined and proposed measures/activities. This monitoring of emission quantities, shows progress in implementation of this Action plan and gives information or signs of warning on attaining the set objectives. Inventory can serve also as motivation for all participants who participate in program of reducing and contribute to the attaining the set objective.

In accordance with the results of conducted energy analysis on the area of Municipality for sectors of construction engineering, transport, heating system, power engineering and public lighting, forestry and agriculture as well as potentials in the area of renewable energy sources, measures for energy efficiency whose implementation will result by reduction of CO_2 emission on the level of municipality for 20% till 2020 in relation to baseline 2005 are identified.

In order to determine priority activities with the aim of reducing greenhouse gasses, inventory of emissions for baseline year within main sectors has division onto following sub-sectors, which are: administrative buildings and other buildings in authority of Municipality Gradiška, buildings which are not in the authority of Municipality and residential buildings.

Total potential of emission reduction of all identified measures amounts to around 63.000 tons, i.e. 28% of CO_2 emissions from 2005, which is more than planned objective of 20%. From this reason, for achieving objective will not be necessary implementation of all analyzed measures, but the selection of certain measures according to possibilities of implementation (time, organizational and financial) will be possible. Some measures will require constant engagement of town structures, while some measures will have the character of the projects with limited time duration.

Action plan will present planned savings of carbon-dioxide, which can be achieved by emissions reduction in the sector of construction engineering (savings of 57, 00%), than in heating sector (savings of 40, 00%), power engineering sector and public lighting (savings of 32.57%) and in sector of transport (savings of 25, 00%). Summary review of emission and savings of carbon-dioxide are shown in the following table.



Picture 1. Chart of main sources –CO_2 sink

Gradiška is a municipality characterized by developed forest and agriculture wealth and as such it has huge potentials for creating CO_2 sink. By observing book insights, analyzing domestic and foreign literature, gathering information on field and processing collected data, we get certain projects whose implementation would contribute to the elimination of carbon – dioxide from environment. In the work, all sectors will be processed separately, where will be shown possible savings of CO_2 by implementing certain measures i.e. by implementation of projects.

Even without implementation of all interesting projects, municipality Gradiška can satisfy basic aim of reduction of CO_2 for 20%. By implementing all other measures, sink for carbon-dioxide would become bigger, and therefore the greenhouse effect would reduce.

Emissions of carbon-dioxide in the world have increased for 45 per cent and reach record of 33 billions of tons in previous twenty years. Although in many countries now are used renewable energy sources and nuclear energy, the biggest increase of emission of harmful gasses is recorded in the countries whose economies grow fast, like China and India. Trend of emissions increase is recorded in leading economies such as EU, USA, Japan and Russia. In European Union, emissions of carbon-dioxide are still lower in relation to time before the beginning of economic crisis in 2008, but they are approaching to that level. (*Euractiv, 2011)*

European Commission obliged to recognize and promote towns included in Covenant of Mayors. Commission had formed and financially supported opening of the Covenant of Mayors Office, whose aim is to provide technical and promotional support including implementation of instruments for monitoring and supervision, mechanisms that support exchange of know-how between towns and regions, as well as instruments of copying and multiplying of successful actions/measures.

Municipality Gradiška should in accordance with the undertaken obligations in period till 2020 reduce emissions of greenhouse gasses for more than 20% in relation to the baseline year, for which 2005 has been chosen. Reduction of greenhouse gasses emissions with simultaneous planned economic development will represent great technological and economical challenge for B&H. The framework convention of UN on climate change (UNFCCC) and Kyoto Protocol leaves to parties to individually or together with other parties define strategy, politics, programs and measures whose implementation will achieve final objective.

Through adopting strategic documents and decision from area of efficient use of energy, replacement of conventional technologies with „cleaner“, education of citizens, Municipality contributes to achievement of objectives as well as on local and state level. Through implementation of different measures and projects, local authority creates foundations for further development and positive influence on environment.

When we speak of future, aim is achieving economy and development based on the less carbon-dioxide, i.e. such development with which is reduced energy intensity in all activities. Research shows that there are some indicators of sustainability, even some target values in relation to sustainable town, but still they have to be supported by empirical proofs. As joint starting point stands the definition that the towns mainly have destructive influence (regionally and globally), and which can be seen in a way of exhaustion of natural resources and pollution of the land, water and air.

Sustainable town is the one considered to be compact and preserve land, has good accessibility and reduces the need for traveling, which is socially and economically balanced, uses clean and renewable energy sources and recycles all waste. As such, it in contact with its surrounding cannot sustain as self-sustaining category. So there is a need for defining the term **ecological footprint**, which represents the quantity of a land necessary for production of means for maintaining quality life, and it serves for measuring the ecological minimum of sustainability.

Ecological footprint as an input unit represents effective heuristic tool for measuring current consumption of resources by people. Everyone leave ecological footprint behind, and usually they are not aware of that or they do not know how to influence on that individually. Although the problem of reducing the ecological footprints before all refers to the most rich countries, it entirely must be accepted in the economically less developed part of the world and in that way to be known that towns themselves can provide many potential solutions.

5. Analysis of energy consumption by sectors

General data on space

Municipality Gradiška is placed on the area that spreads from 44°057’ to 54°014’ of North latitude and from 16°055’ to 17°028’ of East longitude. It is in the Western part of the Republic of Srpska and it spreads on its northern-central part. It consists of lowland part of Lijevče field and on the south part it is bordered with the foothills of northern part of Potkozarje and small part of the mountain area of Kozara and Prosara. On west, it is bordered with eastern Prosara and northern Kozara, which closes it from the south-west also. On the south, border goes through a part of Lijevče field, and on the east parallel with the river Vrbas to the river Sava.

Territory of municipality Gradiška takes the shape of irregular rectangle with the surface of 762,27 km^2. Neighboring municipalities with which municipality Gradiška borders in the Republic of Srpska: on north-east Srbac, on north-west Kozarska Dubica, on south-west Prijedor, on south-east Laktaši, on south Banja Luka and on north it leans onto the bank of the river Sava in the length of 58,78 km which is also the state border with the Republic of Croatia. Bordering municipalities from the Republic of Croatia are: Vrbje, Davor and Stara Gradiška in County of Slavonski Brod-Posavina and Jasenovac in County of Sisak-Moslovina.

Vertical range of municipality goes from 89 AMSL which is also the lowest point and it is in the river Sava, on east of the settling Orubica, all up to 863 AMSL which is the highest point on the mountain Kozara. The area of Prosara has the maximum altitude of 367AMSL (part of the Lupeška Krčevina). Hillsides of these mountains are slightly setting down towards valley where the altitude is only 92AMSL, where spreads fertile Lijevče field. Climate that dominates on this area is mildly continental.

Climate

Gradiška is placed in the center of the mild zone (45°09' N latitude and 17°15' E longitude), in the area of low Posavina in which is, due to the specific distribution of field of high and low atmosphere pressure, present the influence of intensive exchange of tropical and polar air masses and significant cyclone activity especially on the Adriatic sea in the winter period. Therefore it can be said that general climate characteristics of Gradiška are in great measure conditioned by characteristics of atmosphere circulation of macro proportions.

On the other hand, the area of Gradiška is completely open towards north-east and north-west and it is especially in winter exposed to influence of the cold air masses that reach from north quadrant and form strong Siberian anti-cyclone, while high mountain chain of Dinarides on the south which spreads along the Adriatic sea prevents significant influence of Mediterranean on the climate of this area.

From the above stated reasons Gradiška has mildly continental climate with significantly rough winters and warm summers, which significantly modifies morphological characteristics of the terrain and other local factors. Gradiška is placed in the alluvium sand plain on the north-west border of the macro-bottomland of Lijevče field, immediately along the right bank of the Sava, on 94m of altitude. Lijevče filed spreads between the branches of Prosara (367m) on north-west, Kozara (978m) on southwest, Laktaši cliff on south, river Vrbas on east and Sava on north.

On east, above the right bank of Vrbas rises a low flysh mountain Motajica (652m), while on north on the left bank of Sava rises low mountain Požeška gora (616m), Psunj (984m) and Papuk (958m). These mountains with their appearance and position along river and swamp surfaces, complexes of green surfaces and urbanization, significantly influence on the climate of Gradiška, especially on a meso and microclimate characteristics of analyzed area.

Air temperature

According to the characteristics of thermic regime of atmosphere, it is seen that the area of Gradiška is in the zone of mildly continental climate with average annual air temperature of 10,9°C. It should be emphasized that due to the global warming of climate in the 20th century, an increase of temperature in wider region of Gradiška is noted, where the average annual temperature had been increased for 0,8°C in the last 100 years. The biggest temperature growth in Gradiška has been recorded during the last decade of the 20th century, and 2002 year was the warmest with average temperature of 12,9°C.

Average daily air temperatures are only in January negative and they are around minus 0,5°C. In the warmer part of the year, from April to October, average temperatures are above 10°C and they are in the range of 10,9°C to 20,7° C. Absolute maximum of air temperature is registered in August of 2000 and 2003 and it was 39,2°C, and absolute minimum in January of 1963, which was minus 28,1°C.

Stated annual fluctuation of air temperature from 21,2°C, as well as high amplitude of absolute extreme air temperatures (67,3°C for Gradiška) reflects high degree of continentality of climate of the analyzed area.

Medium monthly air temperatures in Gradiška during summer months are equable and go from 19°C in June, to 21°C in July. During summer, open Posavina warms up less than closed vallies, therefore the maximum air temperatures are somewhat lower than the temperatures in vallies. So, for example, absolute maximum of temperature in Banja Luka valley is 41,4°C, while the biggest value of air temperature registered in Gradiška is significantly lower and it amounts to 39,2°C. Summers have, during a thirty years period, become drier and very warm with average air temperature of 20-22°C (in period 1961-1990 average summer air temperature in Gradiška was 19,6°C).

Autumns are slightly warmer than springs. Average autumn air temperature is around 11,3°C, and average spring air temperature is around 11,0°C, which is the consequence of weaker maritime influence on this area.

Middle minimal and middle maximum monthly air temperature on observed area have very similar spatial division as well as average monthly air temperatures and show that in average in Gradiška during a year air temperature is in the range of minus 5°C to plus 28°C.

Precipitation

Spatial division of annual quantities of precipitation shows that on the analyzed wider area of Gradiška in the coastal of Sava during one year in average precipitates 823-940mm of water residue, while in the surrounding mountain areas during year precipitates from 1000-1300mm of water residue.

Precipitations are proportionally frequent and in average they appear on every third day. Accordingly, middle annual number of days with precipitation of ≥0,1mm in Gradiška is around 105 days. However, in most cases those are the days with precipitation of weaker intensity, while the number of days with precipitation of stronger intensity (over 10mm) is less and it is annually around 30 days, i.e. in average 2-3 days a month.

Regarding the characteristics of precipitation regime, analyzed area is in the border zone of transition from continental to maritime pluviometric regime with maximum in November (83,4mm). Because of the maritime influence, on the analyzed area the quantity of water residue is quite equable. So that share of winter precipitations in total annual quantity of precipitation on the wider area of Gradiška is 22%, spring 25%, summer around 28% and autumn around 25%.

Because of the global climate changes, during the last decade of the 20th century, a change in the seasonal distribution of precipitation has been noticed. According to the data of maximum daily quantities of precipitation for Gradiška, it is noticed that absolute daily maximum of precipitation in June and August exceeds the average monthly quantities of precipitation and reaches the value of 100,7mm and 77,3mm.

It should be mentioned that according to the results of climate estimates in this region the increase of intensity of rains of short duration is expected, so this factor is necessary to be considered while dimensioning hydro-technical facilities for measures. For the purposes of dimenzionising hydro-technical facilities and estimates of risks of flooding, landslides, water erosions etc, it is necessary to know the likelihood of maximum rains of short duration for certain reversible period.

The likelihood of maximum daily precipitation is determined on the basis of 50-year string of maximum daily annual quantities of precipitation for station Gradiška. Value of maximum daily rain for station Gradiška which appears once every ten years is 71,9 mm, while maximum daily quantity of precipitation which appears once in every 50 and 100 years is 106,8 mm and 126,9 mm respectively.

Absolute maximum daily quantity of rain of 100,7 mm had been registered in 1951 u Gradiška, and it is slightly lower than the theoretical value of maximum daily quantity of precipitation for reversible period of 50 years. In many places of Balkans and entire Europe, as a consequence of climate changes, frequency of the transcendence of maximum daily rains, even for reversible period of 100 and more years is more and more common.

Average number of days with snow cover on the area of Gradiška is around 40 days and it appears mostly in period from November till March, and very rarely in April, May and October. Considering that Gradiška belongs to low Posavina, snow cover is unstable and after short duration it melts down, and forms again, so during winter months practically 50% of days are without snow cover.

During last decades in the moderate geographical latitudes of Northern hemisphere, as a consequence of global warming of air temperature, a trend of reduction of days with snow cover is present, as well as reduction of the total mass of snow, and similar trend had also been registered on the area of Gradiška. Average maximum height of snow cover in the coastal of Sava is around 30-40cm, with maximum of 82cm which is registered in 1963.

Pedagogical characteristics

On formation of land on the territory of Municipality Gradiška dominant role had relief, geological base, climate and human. Municipality Gradiška according to geologic – pedagogical map belongs to different geologic – pedagogical formations.

The biggest part of the area of municipality lies in the Lijevče field, and by smaller part it attains hillsides of Kozara and Prosara. Therefore most spread are the valley fields, and by smaller part rugged.

Valley fields, except in Lijevče filed are found in the valleys of Jablanica, Vrbaška, Lubina and other rivulets. Upon geological base, i.e. substrate on which they were developed, all of them can be divided into two basic groups: soils with gravel and sand and soils with clay and loam.

Soils on gravels were created on most part on the older and younger alluviums of the river Vrbas, and theirs effective and potential fertility depends mostly on the depth of the land to the gravel. The bigger the depth the bigger the fertility i.e. value for herbal production. They are spread the most in the central part of the Lijevče field, in wider area around Nova Topola, where are somewhat older, so carbonates from surface layer are washed out. Soils on sands sporadically appear. They have similar characteristics, but in most part they are deeper and therefore more fertile. The most commonly are found around Sava area.

Soils on clay and loam cover the biggest part of the Lijevče field, as well as vallies of the rivulets that ran from Kozara and Prosara. They differentiate by physical and chemical characteristics, which affects also on their position in relief. Namely even though micro relief is flat, there is still higher and lower terrain. Lower terrains are commonly under the influence of the underground waters, many have been flooded, before construction of the defense melioration systems.

Differences in chemical characteristics are related in one part with the creation of these soils as well as for their age. Those that were created from alluviums of Vrbas and Sava had been flooded in near past by those rivers, they are rich with herbal nutrients, and some of them are carbonate. On contrary, those in somewhat higher positions, are poor with nutrients and mostly are acidified. Among these two last is the wider area around Cerovljani and one zone in the area of Kočićevo-Mokreš.

In physical characteristics there are significant differences, which are conditioned mostly by mechanical content. The most suitable in that sense are light loamy, but dried soils. On contrary, clay soils which mostly were created on lower terrains where flooding waters stagnated, for example in the area of Liman.

Rugged soils are of smaller significance for agriculture, and the most common are podsolised-pseudogley terraced and separated soils, spread around Trebovljani and Podgradaci, and on some other places. The brown degraded soils on clays are spread on the hilly terrains of Potkozarje.

Distric cambisols developed on the hillsides of Kozara and Prosara and they represent the characteristical forestry land. On these mountains, on the west part of the range, as a consequence first of all of basic substrate and terrain configuration, soils of the type luvisol and eutric cambisoles on gabbro with exclusively suitable land formations for development of highly valuable forest vegetation were developed. Soils of luvisol type developed in the zone of Jurkovica where were found also the soils of pelosol type.

Allocation of space

Geological structure of the terrain, climate characteristics, values created by antopogenic work, as well as contemporary demographic movements affected existing use of land.

Municipality Gradiška has total surface of 76.174ha, of which agricultural surfaces cover 50.547ha or 66.36%, and forestry land is 20.877ha or 27.40% and infertile land 4.750 or 6.24%.

Agricultural land is the main resource of municipality; it in basics attains two mutually different areas – plains and hills. Plain area attains Lijevče field, vallies of bigger rivulets: Jablanica, Vrbaška, Lubina and others. In the Lijevče field the most represented is the production of tilling and vegetable cultures as well as production of fodder plants.

Hilly area of attains hillsides of Kozara and Prosara, where most representing is the fruit production. It has been planted 1.330ha of orchards on the area of municipality, where it is produced around 70.000 tons of fruit, with pointer of constant increase of production.

Contemporary demographic processes and development of activities of people i.e. individual resident construction have led to turning significant surfaces of the most quality agricultural land into construction land (exp. *New settlement Rovine).*

The forest holding „Gradiška“ manages with the greatest part of the forestry land on the territory of municipality Gradiška, it operates within the Forestry economic enterprise „Posavsko“. It comprehends the area of three forest holding units, and these are: „Kozara-Vrbaška”, „Kozara-Banjalučka” and „Prosara”, with around 15.053,89ha of woods, including the barren surfaces i.e. meadows and pastures. In private property is around 6.700ha. (*Information development project center, 2001*)

Considering all three forest holding units in FH „Gradiška”, beech-tree is the dominant kind of around 7.139,70ha, right after beech-tree come woods of Durmast oak which comprehend the surface of 3.345,75ha, and on the last place with 2.765,90ha are mixed woods of beech, fir and spruce-trees.

Kozara and Prosara are extremely forestry areas, of exquisite ecological potentials for development of forest vegetation, and as such represent one of the most significant resource for development of this area.

Vegetation characteristics

According to Stefanović's (*1986*) ecological-vegetation regionalization of B&H, the area of municipality Gradiška is within the Pre-panonne area i.e. north Bosnian area.

Vegetation on the area of municipality is very diverse and it is characterized by great variety of herbal communities. It is a consequence of variety of natural conditions for development of vegetation.

Real forestry vegetation of Gradiška is clearly differentiated into two groups, and those are: plain (hygrophilous) stands and highland (mezofilne) stands.

Plain phytocenoses are mostly represented by remaining groves of pedunculate oak and hornbeam (Carpino betuli-Quercetum roboris) and pure pedunculate oak (Genisto elatae-Quercetum roboris). In the east part of the municipality (Laminci), where it had not been performed massive reparcelling and regulation of land, highly valuable stands of European ash remained (Leucoio-Fraxinetum angustifoliae). On the recent fluvisols, on the area between Sava and embankment, the stands of the White Willow (Salicetum albae) and white and black poplars (Populetum albo-nigrae) developed. On the wetlands and mostly along the chanels, the stands of black Adler (Alnetum glutinosae) developed.

Climategenic communities of Durmast oak and chestnuts (Querco-Carpinetum), are found on the hillsides of Banja Luka's Kozara (Miljevići, Jurkovica, Vilusi) and on the more acidophil position are pedunculate oak and chestnut (Querco-Castanetum). The presence of chestnut (Castanea sativa) as Atlantic flora element it is one of the specificities of this area. On Prosara this zone is much bigger. To this zone, on Kozara connects powerful zone of hill Beech (Fagetum montanum), on which while climbing Kozara connects the zone of beech and fir-trees, as specificity of Pre-panonian mountains, in wider frame that is rare on such altitudes.

Pure beech-tree woods in economic sense are at the same time the most significant absorbers of CO_2 because of their surface, supply of wooden mass and yield, but they are also the main economic resource of forestry on the territory of municipality Gradiška.

5.1. Sector of construction engineering

For the purposes of analysis, electricity consumption in the sector of construction engineering of municipality Gradiška is divided into following sub-sectors:

1. Buildings of public purpose in property or authority of municipality Gradiška
2. Buildings of public purpose which are not in property or authority of municipality Gradiška
3. Residential buildings and houses.

Buildings of public purpose in the property or authority of municipality Gradiška are divided into following categories:

1. Buildings for local and territorially competent authority
2. Buildings of companies in property or authority of municipality
3. Buildings for educational activity
4. Buildings for cultural activity

Buildings of public purpose which are not in property or authority of municipality Gradiška are divided into following categories:

1. Buildings for territorially competent authority
2. Buildings of companies which are not in the property or authority of Municipality
3. Buildings of health care
4. Buildings for educational activity
5. Buildings for cultural activity

Residential buildings are divided into following categories:

1. Residential buildings for collective housing
2. Residential buildings for individual housing

Methodology of data gathering

Data are collected by going on the site, and than they were inserted into surveying lists. Part of data for number of facilities is extracted from Spatial plan of municipality Gradiška for period 2005 – 2020. Data for electricity consumption are received from authorized company for electro-distribution, while data for consumed heating energy are received from town heating plant.

Complexity of process of data gathering on existing construction fond of municipality lies in the absence of registry of facilities, and absence of system for collecting data. Due to absence of the new census, of households and apartments, as well as due to the inconsistent data from the last census from 1991 (results on number of apartments per settlement were published) it is not possible to talk about qualitative characteristics of housing fond (structure of residential units, average size of the apartments, installation furnished, age of the housing fond etc.).

War happenings at the beginning of the 90ies of XX century, on the area of former SFRY significantly affected on stagnation in construction of material goods. During war, a part of residential fond had been ruined and damaged. Level of ruin and damage is hard to determine, due to the variety of data from individual sources, as well as due to the different methodology. Migration of population (mass moving out as well as mass moving in) on the territory of municipality Gradiška has stopped development of town, but also caused intensive construction at the beginning of XXI century. After-war construction has been directed towards residential facilities – family buildings and houses, buildings for collective housing and business-trade buildings.

Existing form of buildings is far from energy efficient. Currently in the Republic of Srpska more than 40 – 50% of total energy needs go to building, which exactly makes this sector the biggest potential for savings. Existing facilities according to the manner of building, materials and elements do not satisfy the optimal energy, economic and ecological characteristics of residential facilities in EU. Trends of designing and construction are directed towards creating ideal internal conditions, comfort, maximum energy use and minimum negative influence onto the environment. Analysis of the investment costs in improving heating protection in most cases proved the economic justification of investment.

ADMINISTRATIVE AND OTHER PUBLIC FACILITIES IN AUTHORITY OF MUNICIPALITY

The process of data gathering for the administrative and other public facilities in the authority of municipality Gradiška was complex and long-lasting. Complexity of data gathering surely lies in the absence of system for data gathering on the level of municipality which says that individual data are received on the basis of evaluation or assumptions.

Facilities in the authority of Municipality refer to all facilities of authority, facilities of culture, three high-schools, two kindergartens, facilities of „Gradska čistoća", Fire brigade and „Vodovod"[1].

Number of facilities used by the Administrative service of municipality Gradiška is two, total surface of 2.122m^2.

There are 18 centers and territorial offices on the area of municipality Gradiška in the authority of Municipality, total surface of 6.852m^2. From total surface of facilities heated is 2.055m^2.

In the settlement of Gradiška are found two kindergartens of total surface of 1.387m^2.

On the observed area are found three high-schools: Grammar school, Professional and Technical High school and Technical school of total surface of 10.238m^2.

From public and cultural institutions in the authority of Municipality are following facilities: KP „Vodovod" a.d. with six facilities, than KP „Gradska čistoća" a.d, Professional unit Gradiška and Cultural center. Total surface of listed facilities amounts to 6.997m^2, and of those it is heated 6.829m^2.

On the basis of the gathered data for facilities in the authority of Municipality Gradiška, following parameters have been acquired:

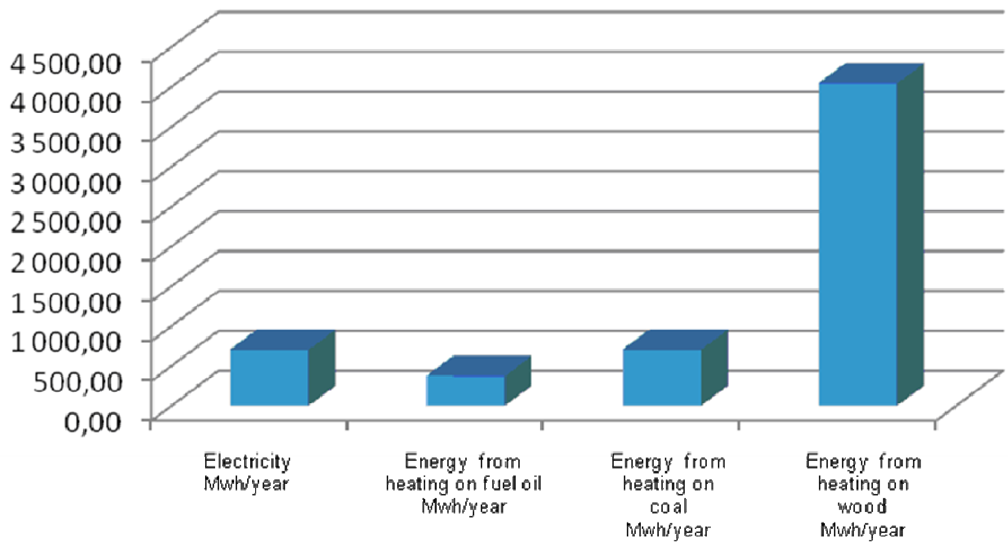
- General data on facilities (description of facilities, construction, isolation and degree of vacuum)
- Total surface of facilities in m^2
- Number of facilities of sub-sector
- Total consumption of electricity for the purpose of heating
- Total consumption of heating oil/fuel oil for the purpose of heating
- Total consumption of coal for the purpose of heating
- Total consumption of wood for the purpose of heating

[1] Regarding the services and insitutions on the level of B&H, on the area of Gradiška are found Customs branch office and smaller facility of State border service of B&H. In settlement of Gradiška exist also local branch offices of following institutions: Republic Employment Bureau, Basic court, Pension and disability insurance Fund of RS and Fund for health insurance of RS. The only entity institution on the area of municipality Gradiška is Anti-heil protection of RS, which has its regional radar center in settlement Nova Topola .

Total number of facilities in the authority of municipality Gradiška amounts to 34 facilities, total surface of 27.596m^2, of which is heated 22.631m^2. Total annual consumption of energy for heating in these facilities is 0,26 MWh/m^2.

Table 1. Structure of consumption in public facilities in the authority of Municipality[2]

Administrative and other public facilities in the authority of municipality Gradiška	
Energy-generating products	**MWh/year**
Electricity	710,00
Energy of heating from fuel oil	378,08
Energy of heating from coal	709,73
Energy of heating from wood	4 050,00
TOTAL	**5 847,81**
TOTAL MWh/m^2 year	**0,258**



Picture 2. Graphical display of consumption structure in public facilities in the authority of Municipality

PUBLIC FACILITIES WHICH ARE NOT IN THE AUTHORITY OF MUNICIPALITY

On the area of municipality Gradiška, exist two levels of health care, and these are primary and secondary. Primary level of health care is expressed through existence of Health center and ambulances, and secondary level through existing General hospital in the settlement Gradiška.

General hospital Gradiška has net surface of 6.568m^2, Health center Gradiška has net surface of 2.874m^2 and 16 branch ambulances which have net surface of

[2] Of total 378,08MWh/year town Heating plant „ Toplana" had delivered 90.45MWh/year

1.070m². Total net surface of health care facilities on the area of municipality Gradiška amounts to 10.500m².

On this area there are also 35 centers and local offices which are not in the authority of Municipality, total surface of 9.193m². From the total surface of facilities heated is 3.064m².

Public security center Gradiška has total surface of 2.500m² .

In public services from sector of education and culture which are not in the authority of Municipality are elementary schools. There are in total seven central elementary schools and more branch divisions (eight-year and four-year). Total surface of facilities of elementary education on the area of municipality Gradiška amounts to 25.129m². Also one elementary music school is on this area, whose surface is 465m².

In the analysis are included also six companies and public facilities of total surface of 93.742m². From this total surface is heated 72.200m².

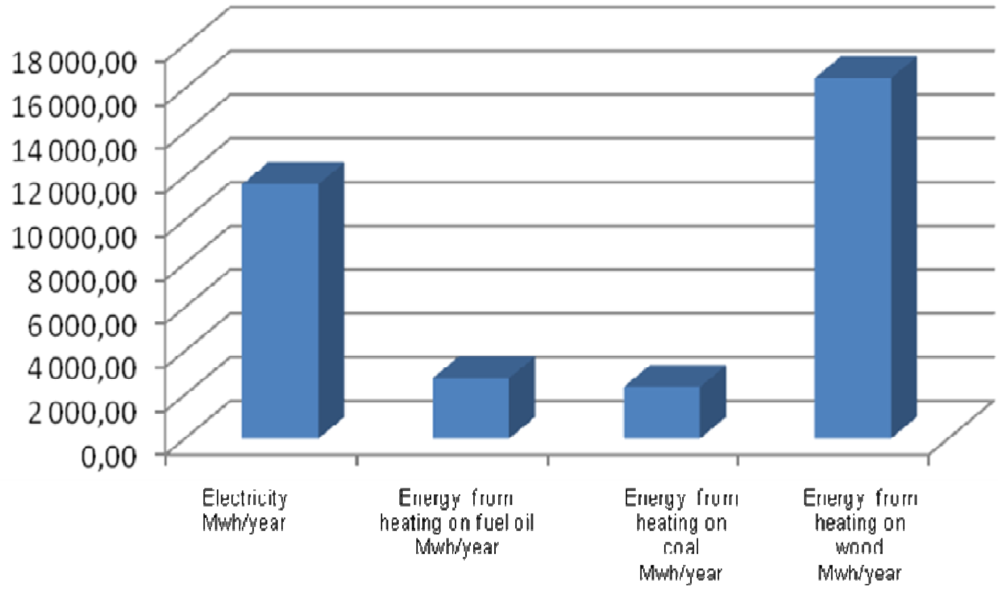
Total surface of public facilities which are not in the authority of Municipality amounts to 141.529m². From this total surface of public facilities, it is heated 113.858m².

Total number of public facilities which are not in the authority of municipality Gradiška, and which are taken into analysis amount to 52 facilities, of total surface of 141.529m², from which is heated 113.858m². Total annual consumption of energy for heating in these facilities is 0,29MWh/m².

Table 2: Structure of consumption in public facilities which are not in the authority of Municipality[3]

Public facilities which are not in the authority of municipality Gradiška	
Energy – generating products	**MWh/year**
Electricity	11.640,00
Energy of heating from fuel oil	2.771,10
Energy of heating from coal	2.364,78
Energy of heating from wood	16.485,00
TOTAL	**33.261,88**
TOTAL MWh/m² year	**0,29**

[3] Of total 2.771,0MWh/year town Heating plant „ Toplana” had delivered 448,98MWh/year.



Picture 3. Graphical display of consumption structure in public facilities which are not in the authority of Municipality

RESIDENTAL FACILITIES FOR INDIVIDUAL AND COLLECTIVE HOUSING

Number of households on the area of municipality Gradiška for period of 2005 is 16.212. Participation of apartments in collective housing facilities in total residential fond is around 8,6%.[4]

Total surface of facilities for collective housing is 122.039m^2, and number of residential units in collective housing is 1.384.

Total number of individual residential units is 14.828.

Total surface of individual housing units is 2.248.073m^2. [5]

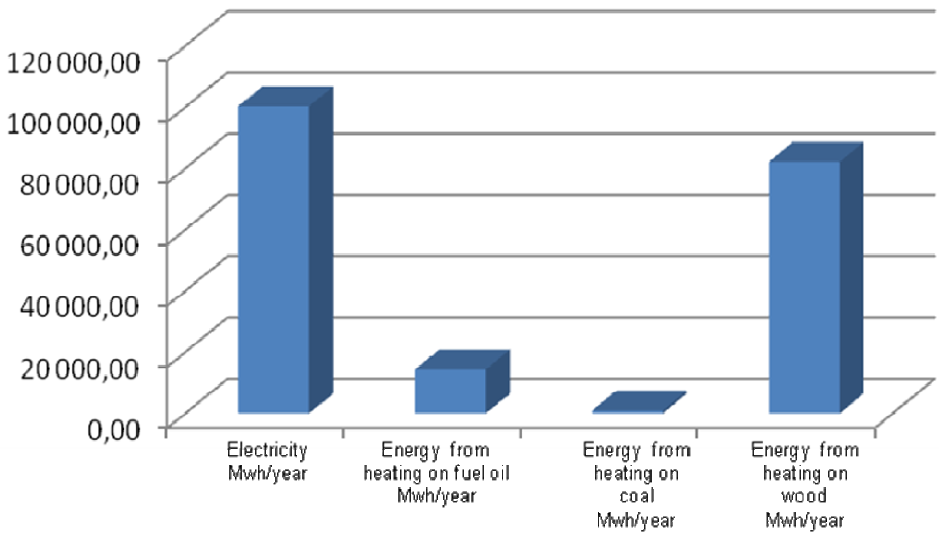
Total surface of facilities for individual and collective housing amounts to 2.370.112m^2, of which is heated 1.572.231m^2.

Total annual energy consumption for heating in these facilities is 0,13MWh/m^2.

[4] The business facilities in the ground-floor of buildings are included in the total surface of facilities for colletive housing.
[5] On the basis of the conducted surveys for the purposes of data gathering for individual residental facilities, acquired results state that the average surface per facility is 151,61m^2.

Table 3. Structure of consumption in the facilities for individual and collective housing

Facilities for individual and collective housing	
Energy-generating products	**MWh/year**
Electricity	100.330,00
Energy of heating from fuel oil	14.389,45
Energy of heating from coal	901,42
Energy of heating from wood	82.158,54
TOTAL	**197.779,41**
TOTAL MWh/m² year	**0,13**



Picture 4. Graphical display of structure of consumption in facilities for individual and collective housing

5.2. Sector of district heating system and sector of waste

District heating

Local district heating plant is constructed till 1982, when it began to work. Basic principle of district heating system in Gradiška is hot water pipeline for district heating with temperature of 110/73°C while water is heated in one central place (heating plant) and through distribution network is indirectly distributed to consumers.

JKP „Toplana“ Gradiška delivers heating energy for heating to consumers only during heating season. Depending on the metrological conditions, the heating season mostly begins on October 15th and ends on April 15th. According to available data „Toplana“provides for 35% of households, commercial and administrative facilities on the town area, with total surface of 148.000m².

Annual efficiency of different parts in the chain of production and distribution of heating energy amounts:

- Utilization level of boilers and efficiency of heating energy production 82%
- Water loss in season 2010/2011 amounts to 3.829m^3
- Heat losses due to the loss of hot water amounts to 185,07MWh
- Heating energy losses from network 2.410,1MWh.
- Annual average of heat losses from network 10-14%

Total efficiency in relation to produced energy against energy delivered to consumers from system of „Toplana" is around 60% in comparison to European standard, which is 80%. Aside from water losses and heating energy losses in network, there is a problem in calculation of delivered heating energy which is not measured, and services are charged per m^2 for housing and business space.

Complete modernization, reconstruction, expending of capacity of heating system and installment of devices for measuring of produced and delivered heating energy – calorimeters, would contribute to savings in fuel consumption, water and electricity.

Technical description of district heating system

District heating system of JKP „Toplana" Gradiška is made of the following units:

- Boiler - with spaces, devices and equipment for receiving, storage and preparation of fuel oil, chemical preparation of water and boiler units for production of boiling water
- Hot water pipeline district heating network – with equipment, devices for circulation, piping lines and connectors for heating stations
- Heating substations – from which the heat from hot water pipeline network is submitted to house plants
- House pipeline network – used for distribution of heat in individual heating bodies (consumers of heat).

BOILER

Current state

Hot water boilers are of following technical characteristics:
Two boiler units of power 11,8MW produced by „Đuro Đaković" Slavonski Brod, in 1979 and 1980 for production of hot water are installed in the boiler room.

<u>Basic data:</u>

Type of boiler ....Steam block S1800-„Đuro Đaković" Slavonski Brod
Burner..Vanson B4-„Đuro Đaković" Slavonski Brod
Working pressure of boiler... p = 6bar
Fuel consumption ....B=1.200kg/h
Nominal capacity 11,8MW
Maximum working pressure 16bar
Type of motor fuel is middle weight heating oil (fuel oil)
Fuel consumption (season 6 months) in season 2010/2011...1.593t
Average price of fuel for season 2010/2011 ....992,6KM/t without VAT
Costs of fuel, additives, salts and water in the season 2010/2011 ....1.698,212KM
Costs of production on the threshold of the boiler room for season 2010/2011....1.935,002KM

Technical data of boiler:

Heated surface 315m²
Boiler length 7.100mm
Proportion of boiler with isolation 3.300mm
Space for pipe exchange 4.500mm
Total net weight when p=10bar 38t
Drive weight with water 54t
Water connection.. NO300
Oil connection.. NO50
Chimney connection 700/900mm

In the heating system, boiler units are connected so that one is operating and the other is back up in case of break down, repair or similar. Boiler units are constructed without proper circulation of water, and circulation is provided through centrifugal pumps in hot water network which is during operating mode of boiler plant adjustable and that is thermally unfavorable for work of boiler and there is great risk of thermal overloading. It is necessary to construct new contemporary boiler unit for safe work of heating system.

Pumping station for circulation of fuel from reservoir till boiler plants has the capacity 1300kg/h and it has the role to provide sufficient amount of fuel with certain temperature i.e. viscosity for boiler plants. Pumping station for delivery of fuel up to boiler units is of small capacity and can satisfy only one boiler unit, while the other boiler unit can be only reserve. It is necessary to have this in mind while elaborating the project of modernization and expending of boiler plant.

The reconstruction of boilers had been made in 2003 (from steam to hot water) and utilization level is increased to 82%. In 2009 it has been installed frequency regulation of electromotor for circulation pumps and air ventilator for fire-box and with that electricity consumption is reduced for 10%. These works are finances from the funds of „Toplana“.

Boiler capacity of 11,8MW does not satisfy the needs. By reconstruction of pipeline and regulation in boiler-room, the reserve boiler could be turned into working one. With that we would get new capacity of 23,6MW. There are no funds for this investment.

Plan of modernization of boiler room

The expending of boiler room and significant improvements in production of heating energy in boiler room are stipulated by the plan of modernization till 2020. The following activities have been stipulated by project:

- Expending of boiler room and purchase of new boiler on solid fuel
- Plan of replacement fuel oil with wooden bio-mass, for 60%
- Installment of automation and thermometer on boilers
- Installment of thermometers on the boiler exit into the hot water network.

The aim of conducting the modernization:

- Production of heating energy from wooden bio-mass, which would have a positive effect on lower price of produced heating energy
- Decrease of emission of harmful gasses and combustion products in atmosphere from boiler room by using wooden bio-mass instead of fossil fuels
- Decrease of maintenance costs
- Improvement of safety of boiler system

HOT-WATER HEATING NETWORK WITH CIRCULATION

Current state

Distribution of heating energy from boilers to heating sub-stations is preformed by hot-water heating network whose initial temperature regime is 110/73°C.

For the purposes of water circulation three centrifugal pumps have been installed in hot-water network and boiler units, with following characteristics:

1. KK 40–20 „Jugoturbina" Karlovac with Q=90l/sec and H=40 mVS,
2. KK 50–15 „Jugoturbina" Karlovac with Q=80l/sec and H=55 mVS,
3. SPS 88/A „Jastrebac" Niš with Q=4.800 do 7.200l/min and H=56-44 mVS.

All pumps are produced and installed in the period from 1980 till 1983. Pumps have been installed without equipment for parallel work and they can be used only individually. There is no regulation of temperature of starting water in the hot water network, and the same is performed directly in boiler unit.

Maintenance of hot water network is performed by "Toplana". Maintenance costs for primary distributive network are borne by "Toplana", and maintenance costs of housing installations in buildings and other facilities are borne by owners.

The length of constructed hot water network is 10.000m. System of inlaying the pipeline is partially in concrete channel with isolation – mineral wool with coating of tar paper, and the other part with the pre-isolated pipes. Smaller part of connecting pipes is made in "plubit"–mass.

Most part of the hot water network is constructed in the period from 1980 till 1985. Due to the old age (lifetime of network is around 30 years) network is in a very bad shape. Due to the old and bad isolation, the network is exposed to corrosion, which leads to thermal and water losses.

Pipeline network set in concrete channel in isolation of glass wool, tar paper is during the heating season due to the high underground waters flooded often and as such has heat losses of 1.402,1MWh. Isolation of pipeline network with pre-isolated pipes is in a very poor state, so heat losses are 1.008MWh. Pipeline network on some parts does not have capacity for covered heating consumption in the total length of 1.830m. The shape of the network is radial that is consumers are provided with hot water only from one line.

Plan of modernization of hot-water network

Due to the old age of the network, damaged isolation and corrosion on the hot-water network, losses are big and current state of the network is not capable to satisfy the present consumption. All the bigger affluence of population on the area of town caused intensive construction, and with that also the possibilities of connecting new consumers.

Reconstruction plan stipulates the following activities:

- Reconstruction of the existing network
- Replacement of pipes, vents, forks ...
- Installment of automatics for regulation and measuring of flow
- Reconstruction of concrete channels of hot-water lines
- Expending of hot-water network.

The aims of the reconstruction plan of hot water network are:

- Reduction of losses of heating energy and water
- Reduction of maintenance costs
- Improvement of quality of heating energy to the consumers
- Connection of new consumers by expending hot-water network

HEATING SUB-STATIONS

Current state

Current number of heating stations which are used in the season 2010/2011 is 112, whose total power is 15.150kW. 12 heating stations have the possibility of measuring, while other 100 do not have the possibility of measuring energy.

There is no regulation in most of the heating stations. Automatic regulation of temperature of heated water of manufacturer SIEMENS has part of the residential buildings (installed while repairing and starting heating system) and newly connected buildings. For users in private houses, regulation of temperature had not been performed. The equipment for measuring heat consumption exists only partially and for the users in private houses and in part of the business facilities. All heating stations own instruments for measuring parameters of heated water (temperature and pressure).

From 2003 till 2010 the replacement of pipe spiral exchanger with laminar exchanger of better characteristics had been performed by proper funds of „Toplana“ in all facilities except in heating stations of private houses where still are used piping heat exchangers made by „IMP” Ljubljana and „Sava” Stara Gradiška. Circulation pumps of „IMP” Ljubljana in heating stations are without frequent regulation.

In heating substations, by heating exchangers, the submitting of heat from primary (hot water) circle into secondary (hot water) circle whose integral part is installation of central heating in the heated area of consumer.

Installed capacity of heating stations is 15.150kW, and the capacity of installations which are connected to district heating system is 16.229kW. This shows that current capacity of boiler room, in relation to the connecting capacities of installations, cannot satisfy the needs of users for heating energy. Also connection of new users is not possible.

Modernization plan of heating stations

The modernization of all active substations is planned by the plan of reconstruction and modernization of heating system as well as installation of new substations for potential consumers by the plan of expending of district heating system.

During the realization of this part of project it is necessary to perform:

- Replacement of valves and installation of automatic regulation
- Installment of water flow meter
- Installment of distributed heat meter
- Installment of automation form district heating system supervision and regulation into all substations

The aims for conducting the modernization are:

- Cost savings
- Improvement of service quality for consumers in delivery of heating energy
- Measuring the energy consumption by installment heating energy meters in every facility

Stipulated modernization of heating stations of facilities, implementation of obligatory automatic regulation and measuring of heating energy for all facilities. Implementation of these measures would provide savings in fuel of 8-12%.

FACILITY USERS BUILDINGS AND THEIR ENERGY EFFICIENCY IN RELATION TO HEATING ENERGY

In municipality, 124 buildings are connected on district heating system.

Thermal protection of buildings is one of the most important topics in the energy efficiency because of the potential savings. Insufficient thermal isolation leads to increase of heat losses in winter i.e. during heating season.

Heating such, thermally non-isolated facilities requires bigger amount of energy which leads to increase of price of using and maintaining such facilities, as well as increase of price of produced heating energy, which directly affects environment pollution.

By improving thermal-isolation characteristics of buildings, it is possible to achieve the reduction of total losses of building for average from 40 to 80%.

Average old buildings annually spend more than 200kWh/m^2 of heating energy, standard isolated facilities below 100, contemporary houses around 40, and passive 15kWh/m^2. With energy which is spent during heating season in average building, 3-4 low energy houses can be heated. Existing buildings on the area of town connected on the district heating system of JKP „Toplana“ Gradiška represent great energy and ecological potential of savings due to the high percentage of buildings with non-satisfactory thermal protection.

One of the problems which „Toplana“ faces with is in great number of complaints of user's on non-adequate, i.e. weak heating during heating season. By surveying and measuring heating energy delivered from substations, it has been determined that there is enough heating energy according to prescribed standards and that inability of heating the premises in buildings appears due to the poor heating-isolation characteristics of facilities and poor windows on older facilities, as well as lack of heating bodies in newly built facilities.

In order to solve these problems i.e. to reduce losses in heating energy, reduction in fuel consumption for its production, which directly affects on reduction of negative influence on environment, it is necessary to approach to elaboration of repairing project of old buildings as well as change in regulations in civil engineering and their adjustment with standards of the European Union.

From totally consumed energy in building, taking into account since building and through entire period of using, 15% is energy for building while over 80% is a share of energy necessary for functioning of building.

Heating system of residential facilities needs to be centralized and propose solution which will result with the smallest energy consumption with the acceptable financial indicators of investment. It is necessary to consider the possibility of producing heating energy from renewable energy sources such as wooden biomass as the most perspective source of energy when it comes to the town district heating on the area of municipality Gradiška.

The most of facilities (95 facilities) built in the period from 1970 to 1987 are connected on the town district heating system. Characteristical for these facilities is, from the point of heating protection and energy savings, that they do not have any energy concept and that energy saving is very unsuitable. Most common are pre-fabricated concrete parapet panels, with no heating protection, and filling between the bearing structures is usually made as carpenter’s element with poor thermal characteristics.

Basic characteristic of building in this period, considering the heating protection, is adoption of the first regulation on thermal protection and beginning of modest use of thermal isolation, and on the other hand building of static, lean, thin constructions, with big glass surfaces and actually in heating sense very poor facilities.

In order to solve this problem, it is necessary to start analysis on state of the buildings in relation to thermal characteristics and their repair during which would be made thermal isolation on buildings of minimum 10cm, for facilities which possess no thermal isolation as well as repairing the external joinery on facilities. For achieving low-energy standard of building, the thickness of isolation of external wall should be from 14 to 30cm.

The second group of 25 buildings that are connected on district heating system consists of newly built facilities. Characteristics of these facilities are that they are built on all available materials on market, but without regulations and norms for quality and manner of building.

Table 4. Construction facilities connected to network of town heating according to the year of building

Facilities	Number of buildings	Quadrature (m^2)	Installed power (kW)	Installed power per kW/m²
1	2	3	4	4/3
Facilities constructed before 1970	1	233,77	29,16	0,125
Facilities constructed in a period 1970 - 1987	95	73.588,05	10.203,85	0,139
Facilities constructed after 1987	3	9.652,33	1.182,51	0,122
New - building	25	46.378,23	4.513,71	0,097
TOTAL:	**124**	**129.852,38**	**15.929,23**	**0,123**

Basic data of „Toplana“ for baseline year 2005:

- Capacity of boiler room 11.8MW
- Utilization level in boiler room 80%
- Length of network 15.000m
- Annual losses of hot water 4.000m^3
- Annual losses due to the poor isolation 2.000MWh
- Utilization level on network - estimate 85 -88 %
- Number of heating substations- without measuring 88 total power 14.0MW
- Number of users 1.400
- Surface of heated space 110.830m^2
- Heating quantity of consumers 13.7MW
- Consumption of fuel (fuel oil) 1.342 t
- Produced energy from fuel 14.929MWh.

Table 5. Delivered quantity of heat per facility in the baseline year 2005

Baseline year 2005	Surface in m²	Delivered power in MWh
Residental space in residental buildings	66,233	8.346
Business premises in residential buildings	12.386	2.071
Public, industrial, production facilities and private houses	32.211	4.512

Only two offices in “Crvena zgrada” building, which used Municipal Assembly of administrative premises of Municipality, were using services of „Toplana“ in 2005 and to them were delivered 90,45MWh of heating energy. From residential facilities (apartments in buildings and private houses), it has been heated 1.288 apartments of total surface 66.130,32m², delivered heating energy 13.512,43MWh and 64 private houses for which were delivered total power of 149,45MWh in 2005. Business premises which were heated in 2005 are 296 with total delivered energy of

727,69MWh. From industrial plants only enterprise „Jelšingrad“ used services of „Toplana“ in 2005 and delivered heating energy amounted to 265,20MWh. To hospital had been delivered 183,78MWh.

5.3. Transport sector

While elaborating the Action plan, indicator analysis had been performed for 2005, and on that occasion the state in the sector of transport of municipality Gradiška had been determined.

PUBLIC TRANSPORTATION

Bus transportation

Transportation of passengers on the area of municipality Gradiška performs „Autoprevoz“ Gradiška. During 2005 this company owned 22 buses which performed transportation of passengers on the area of municipality and transportation of passengers to Banja Luka.

Aside from these vehicles that transported passengers, services of passenger transportation and arrival to the area of municipality during one day also used in average 75 buses. These buses are in each arrival or departure from platforms of bus station in Gradiška passed around 21 km.

According to indicators of engine fuel consumption for these buses, we have that they in average use 30l of diesel fuel. This consumption, according to monitoring of the consumption, during summer and winter is the middle value.

Cargo transportation

Cargo transportation on the area of municipality Gradiška during 2005 had been performed by around 110 cargo vehicles of different manufacturers and different production years. According to monitoring of fuel consumption, that individual transporters performed for their cargo vehicles during 2005, they have come to the indicator that the average consumption was around 37l per 100km.

- **Mercedes Actros2543LS(2001)**
  37,5 l /100km at 72,2km/h (53,7 l /100km at 54,2km/h)
- **Mercedes Actros 2546LS (2003)**
  39,8 l /100km at 71,9km/h (58,7 l /100km at 54,2km/h)
- **Renault Magnum 440.19 (2001)**
  35,9 l /100km at 74,7km/h (51 l /100km at 55,3km/h)
- **Volvo FH12-460 (2003)**
  40,1 l /100km at 74,5km/h (58,4 l /100km at 57,3km/h)
- **Volvo FH16-610**
  36,4 l /100 km at 75,4 km/h (46,9 l /100 km at 60,6 km/h)
- **Scania R124-470**
  37,9 l /100km at 75km/h (55,8 l /100km at 58,1km/h)
- **DAF XF95.530 (2005)**
  37,4 l /100km at 76,3km/h (47,7 l /100km at 59km/h)
- **Iveco Stralis AS540** 6x2
  37,7 l /100km at 73km/h (52,2 l /100km at 61,6km/h).

First data refer to the average consumption at average test speed, and the other to the demanding highland-spiral roads, consumption at average speed, but with the loaded maximum bearing capacity.

Town administration

During 2005 Administrative service of municipality Gradiška possessed 18 vehicles, and 15 of them used petrol as their engine fuel, and the 3 of them used diesel. Average consumption of these vehicles is around 11,5l per 100km, and average age of vehicles is around 9 years.

DATA FOR ALL VEHICLES DURING 2005

During 2005 on the area of municipality Gradiška around 17.250 vehicle units had been actively registered, among which were passenger vehicles, cargo vehicles, buses, mopeds, motorcycles, working machines and connecting vehicles.

According to the processed pattern, average age of the vehicle was around 14 years, and it is assumed that the reason for that was the allowed import of vehicles with no limitation on production age.

Average consumption of engine fuels is different, i.e. amount of the consumed engine fuel per 100km significantly differs from driving on open road and in town area. For observed period these vehicles used averagely around 10,5l on 100km.

The type of engine fuel also had been determined on the observed pattern of vehicles, i.e.:

- 53% of vehicles used diesel fuel, and
- 47% of vehicles had used petrol fuels.

OTHER

International border-crossing Gradiška as one of the biggest crossings is on the area of municipality Gradiška, and over which during 2005, using the part of the traffic that go through municipality Gradiška, had crossed (entered and exited) certain number of vehicles, and these are:

- Passenger vehicles: around 1.107.000
- Cargo vehicles: around 135.000
- Buses: around 23.670

Aside from the fact that great number of vehicles has passed over traffic roads that are on the territory of municipality (which means that they have passed at least around 20km), during the weekend days and often during the working days and on holidays columns of cargo vehicles are formed and wait for the State border for few hours. In these waitings of 30 minutes up to the two hours, vehicles are often on the place of standing with engine on, especially in days when it is used system for maintaining temperature (heating – cooling).

5.4. Sector of forestry and agriculture

BALANCE OF SURFACES

Table 6. Ratio of agricultural and forest surfaces (Katastar, 2005)

No	Type of surface	State sector		Private sector		Total	
		Surface	*%*	*Surface*	*%*	*Surface*	*%*
1	Agricultural surfaces	12.358	24.4	38.189	75.6	50.547	100.0
2	Forests	13.870	66.4	7.007	33.6	20.877	100.0
3	Unfertile land	3.880	81.7	870	18.3	4.750	100.0
Total		**30.108**	**39.5**	**46.066**	**60.5**	**76.176**	**100.0**

Contemporary demographical processes have led to leaving rural areas in significant measure, which caused succession of vegetation towards pioneer forest communities. On the other hand, demographical processes have led to inflow of great number of citizens to town, which resulted in great scope of the non-controlled building, mostly on agricultural land, and partially on forestry.

Table 7. Structure of agricultural land of municipality (CORINE, 2005)

No	Categories of agricultural land	Stated in %
1	Arable land	16.25
2	Orchards	2.46
3	Pastures	2.27
4	Cultivated land	60.63
5	Other agricultural land	18.3
Total		**100.0**

Table 8. Structure of forest surfaces of municipality Gradiška

Categorization of woods and forestry land	State forests (ha)	Private forests (ha)	Total (ha)	Stated in %
Tall forests with natural life extension	13251	2536	15787	72.55
Tall degraded forests	0	0	0	0
Forest cultures	841	2	843	3.87
Coppice forests	769	4096	4865	22.36
TOTAL	14861	6634	21495	98.78
Surfaces suitable for foresting	129	33	162	0.74
Surfaces non-suitable for foresting	63	34	97	0.45
Usurpation	6	-	6	0.33
OVERALL SURFACES	15059	6701	21760	100.00

5.5. Electric power sector

On area of municipality Gradiška electricity supply is performed through electro-distributive networks and it comes from power and electricity generation plants in B&H. As it has been already stated, the biggest emissions of CO_2 occur by combustion of fossil fuels, that is coal for production of electricity in thermal power plant in B&H.

For calculation of CO_2 emissions based on the total consumption of electricity it is necessary corresponding emission factor (t/MWh), which contains:

- National/European emission factor,
- Local production of electricity,
- Certified 'green energy' spent on the area of municipality.

Decrease of CO_2 emission by increasing the energy efficiency and projects of local production of electricity from renewable sources are the priority of Covenant of Mayors.

This criteria is based on the assumption that locally produced electricity from smaller plants is used for local needs and that local authority has competences over those facilities, and having the possibility to implement measures with the aim of reduction of emissions. Big power plants are used for wide distributive network and they are in state authority.

On the area of municipality Gradiška in 2005 there were no plants for local production of electricity, nor from fossil fuels or renewable sources such as power of wind, solar energy and hydro-energy.

Local community can use also certified *green energy* for providing electricity. That certified energy can be purchased and it has to satisfy certain criteria according to the Directive 2001/77/ES and Directive 2009/28/EC. On the area of municipality in 2005, there was no purchase of certified energy.

Electricity Emission Factor for municipality Gradiška is EFE=0,831 (tCO_2/MWh).

Table 9. Consumption of electricity on the area of municipality in 2005

Consumption of electricity per sectors	Stated in GWh
Consumption of electricity in administrative and other facilities in the authority of Municipality	0,71
Consumption of electricity in facilities which are not in the authority of Municipality	11,64
Consumption of electricity in households	100,33
Consumption of electricity for public lighting	1,55
Consumption for economy, which is measured on high - voltage	26,27
TOTAL	**140,50**

6. Plan for reduction of CO_2 emission till 2020

Plan consists of measures and activities that need to be implemented on the area of municipality Gradiška in order to achieve the desired reduction of CO_2 emission till 2020. Measures are described upon sectors and represent integral part of Sustainable Energy Action Plan of municipality Gradiška, with stated estimates of expected energy savings and estimates of investment costs for implementation of activities.

Most of measures require necessary investments in every sector, but local authority will elaborate the models of financing which can represent some kind of incentives or facilities. Since estimated total costs of incentives go beyond financial possibilities of local authority, part of funds will have to be provided from available sources of financing of domestic and foreign investors. Stipulated global growth of prices of energy-generating products and electricity in future will additionally motivate citizens and stakeholders to invest in projects for increase of energy efficiency and reduction of energy consumption.

For some measures are used estimates founded on the estimates of similar or same measures in other countries or other cities, and some of them are the result of legal obligations prescribed on the level of EU or B&H.

6.1. Sector of construction engineering

Energy savings in housing are achieved first of all by improving thermo-isolation of walls, avoiding thermo-bridges, improving the tightness of buildings, improving the quality and tightness of joinery, as well as by use of passive and active systems. Increase of energy efficiency in buildings is one of the most cost-effective ways of reduction of harmful gasses into environment, as well as decrease of costs for energy.

Good thermal isolation of external walls of housing and other facilities is just a part of measures for increase of energy efficiency and foundation for contemporary management of energy resources, as well as protection of environment. Only with that measure heat losses are reduced for 50 – 80%.

Since residential buildings and other housing facilities represent the biggest individual consumers of energy, potential energy savings in construction engineering will be bigger than in any other sector. Investment in reconstruction of existing facilities, as well as satisfying standards (low-energy buildings in EU) in construction of new facilities, in the aim of increase of energy efficiency, are considered as the only right approach in satisfying the requests for decrease of emission of green house gasses. Aside from the energy savings and improvement of quality of life of citizens, reconstruction increases the market value of facility.

Possible energy savings i.e. orientation values which can be achieved while performing different repairs are following:

- 20cm of roof isolation represents approximately 11% of savings
- 8-10cm of external wall isolation represents approximately 15-25% of savings
- 6 cm of floor isolation of ground floor represents approximately 6% of savings
- Replacement of windows with energy saving glasses 20% of savings.

In ***water supply*** the savings measures are mostly achieved by installation of frequent regulators in waterworks stations and wells where would be reduced peak load while starting every motor of pumping stations and their work would be reduced to just necessary amounts of electricity. In this way each motor of pumping station would be additionally protected because it would have easy start (so-called *softly start*), and with all that would be achieved electricity saving of 20-30%.

Immigration of population during civil war had speeded up the construction of residential houses which are not completely finished. Energy consumption in individual residential facilities represents a significant part in total consumption of energy on the territory of municipality Gradiška. Current consumption of energy for heating in existing facilities on annual level is around from 100 to 250KWh/m^2.

Technologically least demanding and the most cost-effective methods of increase in energy efficiency and reduction of CO_2 emission are isolation of facades, attics and lofts (or final floor). Quantity of emission reduction depends on dynamics and scope of conducting the reconstruction of the facilities.

Solving issues of energy efficiency of facilities aside construction also include the areas of economy and law. Implementation of regulations on improved heat protection of existing and new facilities is quite complicated. Owners of residential facilities while selling should own energy certificate which provides information on estimate of energy efficiency of facility in accordance with defined norms. All facilities that are in the possession of Municipality should satisfy the stipulated criteria on heating isolation, in order to serve as an example in promoting energy efficiency in construction engineering.

Measures for achieving greater energy savings, and reduction of emission of carbon- dioxide:

- Elaboration of plans for conducting energy inspection of facilities, especially public facilities: institutions, schools, kindergartens
- Projects of reconstruction of public facilities with the aim of improving energy characteristics of facilities
- Elaboration of study on usage of alternative and renewable energy sources for heating the facilities on territory of municipality
- Intensive exertion of construction regulative of Administrative service of municipality which is totally adjusted with the requests of EU Directive on energy characteristics of buildings (2002/91/EC)
- Continuous monitoring of legal regulative from the area of building and simultaneous implementation of these measures
- Elaboration of projects from the area of energy efficiency in building and participation in projects of international and non-governmental organizations

- Formation of fund for energy efficient projects on the area of municipality
- Incentives for individual households for connecting on district heating system
- Incentives for improving thermal characteristics for facilities of collective housing
- Optimization of district heating system
- Installment and implementation of system for measuring the consumption of heating energy from district heating system for all facilities
- Initiation of obligation for possessing energy certificate while purchasing, renting and reconstructing the facilities
- Education of employees in public facilities on energy efficiency
- Campaign on raising awareness of citizens on energy efficiency
- Promotion of projects of energy efficiency through professional gatherings, info-stands, leaflets and other
- Introducing citizens with possibilities of heating on bio-mass, installment of solar collectors, construction of passive and low-energy house
- Installment of frequent regulators in waterworks stations and wells.

Beside the reduction of emission of greenhouse gasses and reduction of human influence of environment by implementing overall program of improving thermal isolation of residential facilities, tenants would achieve significant savings in energy for heating, and while implementing the program there would be need for opening new working places which would increase the market value of reconstructed facilities. With such measures it is possible pay respect to world trends to reduce the emission of greenhouse gasses for 20% till 2020 and to provide the energy in the amount of 20% from renewable sources.

6.2. Sector of district heating system and waste

DEVELOPMENT PLAN OF FUTURE HEAT CONSUMPTION FOR A PERIOD TILL 2020

Possibility of using the most convenient fuel on the area of municipality Gradiška

Engine fuel for boilers in boiler-room of JKP„Toplana“ Gradiška is heating oil middle heavy – fuel oil. Existing plant for reloading, storage and supply of fuel oil can provide safe operation of boiler-room of current capacity 11,8MW for one working boiler, while the other boiler is reserve. Capacity of boiler room of 11,8MW does not satisfy the current needs.

During the season of 2010/2011 total consumption of fuel oil for heating the connected consumers of 16.229KW amounted to 1.593t. By analyzing the fuel price in 2005 which was for fuel oil 0.55KM/kg and with the suggestion of development plan of heating system, it has been determined that the price of natural gas on market in the region is 0,30KM/m^3. Based on these data the conversation from fuel oil to natural gas had been stipulated.

Even though the conversion of the engine on natural gas seemed like the most suitable from the aspect of investment comparing to existing engine on fuel oil, significant lower costs of exploitation during the remaining working time of the plan and suitable ecological effects justify the conversion, but still this plan was abandoned due to the increase of price of natural gas on market in the period after 2005. By stipulated plan of activities till 2020, due to the increase of price of fuel oil on market, which was in May of 2011 and in the period of elaboration of this study amounted to 1.22KM/kg, a replacement of fuel oil with wooden bio-mass was stipulated.

By analyzing available fuels on the area of municipality Gradiška during 2010, it has been determined that the most promising use of wooden bio-mass is in the form of forest waste. The replacement of part with fuel oil with bio-mass for 60% (40% fuel oil and 60% of bio-mass) was stipulated by development plan till 2015, and in the period from 2015 to 2020 it would switch entirely to wooden bio-mass. In order to provide the use of bio-mass it is necessary to invest in installment of the boiler on solid fuel of corresponding capacity, construction of storage facility for collected brushwood etc.

Also it should determine the quantities and types of wooden waste on the area of municipality, quantities of forest waste, quantities of wooden waste from the processing in the saw-mills, quantities from cutting orchards, quantities of wooden bio-mass created by cleaning non-categorized land that is shaggy, quantities of wooden waste which is disposed on depots (old house furniture, wooden waste from industry and similar), as well as possibility of plantation growing of wooden bio mass in form of fast growing wooden plants (willows, aspens, polars) for the needs of town heating.

According to available data, gathered from authorized services of Municipality Gradiška, 100.000m^3 of round wood is cut on the area of municipality annually. Around 25% of this quantity or 25.000m^3 is considered to be waste wood, which is used as wood for heating, as well as 15.000m^3 of the unused brushwood that remains on Kozara after forest exploitation. This quantity of brushwood is more than significant for town heating, because the purchase of two new boilers (of total power 12MW), which would use per season in total 6.000m^3 of this brushwood, is planned.

Benefits of using the wooden bio-mass as one of the renewable sources of energy aside ecological advantages that are seen in fact that wooden bio-mass is neutral regarding CO_2 (because emission of CO_2 which is released in the process of combustion of wooden bio-mass is equal to quantity which plant uses during its period of growing), there are also economic benefits of lowering import of fossil fuels, safety of energy supply and opening of new working places.

If the project of constructing the heating plant on wooden biomass starts, Gradiška would become the first municipality in the Republic of Srpska which uses this source of energy, and therefore it would be energy independent in relation to prices of energy-generating products.

6.3. Transport sector

The biggest source of air pollution in cities is automobile traffic. It is considered that around 60% of total world pollution comes from fuel combustion in automobile motors.

Exhausting automobile gasses, which result from combustion of petrol in motor, contain around 20% carbon-dioxide, 27% hydrocarbon and 34% nitro oxide. To some kinds of petrol lead is also added, so it also finds its way to atmosphere. If it is known that carbon-dioxide in atmosphere causes greenhouse effect and global warming, and that lead and hydrocarbon are dangerous poisons which damage lounges and respiratory organs and cause tree dieback, and that nitro oxides cause acid rains, it is clear that the damage caused by automobile gasses is very big.

Elimination of causes for aero-pollution refers to installment of new *cleaner* technologies in the production process and using *cleaner* fuels. One of the examples is also development of motors that use lead-free petrol, which contributed that one source of pollution by lead to be eliminated totally.

Reduction of quantity of exhausted polluting material is today's basic way of air protection. Special group of air protection measures represent the actions of making green the area in which aero-pollution appears. Resistant trees and herbaceous plants are of significance for all residents of polluted town environment. They constantly create new amounts of oxygen, spend harmful carbon-dioxide, absorb particles of grime and dust, also with their green tree tops they absorb great amounts of sun radiation, which decreases temperature and create better conditions for life. Also, they reduce the town noise which in some parts of town can be intolerable. On Gradiška area, there are lands which can be used for parks, tree lines and green surfaces which would aside the functional role could contribute to esthetic look of town.

Finishing works on construction of high-way Gradiška-Banja Luka, which by its greater part goes through area of municipality Gradiška, and since the beltway from Čatrnja to Gradiška is planned, it is desirable to plan also the expansion of green areas in form of parks, alleys, hedges and lawns.

Bicyclism and construction of bicycle tracks

Bicycle is a transportation mean that does not pollute the environment, and it is at same time the most economic and exquisitely useful for health of citizens. That is the reason why public transportation, bicycle or even healthier to go afoot should be used instead of the car. The aim of promoting such ways of moving is in accordance with the sustainable development of town i.e. giving chances to future generations to live healthy and safe.

Data from 2004 state that citizens of Europe posses 214 million of automobiles or 38% more than in 1990. According to certain researches, each automobile annually emits three times more harmful ingredients than its weight, which causes death of hundred of thousands of people.

In conditions of town traffic, automobile and bicycle are moving approximately the same average speed. When using special bicycle track, bicyclists often move faster than automobiles on distances below 10 km.

Facts that contribute to bicycles:

- 5% of all moving in Europe (all kinds of transpiration) is done today by bicycle, which is five times more than all traveling by train and 50 times more than traveling by airplane,
- Driving bicycle only 30 minutes a day (going and returning from school/work), lowers the risk of cardiovascular diseases for 50%, improves heart work and cardiovascular system (especially blood circulation in peripheral blood vessels),
- Therapeutically usage of driving bicycle reduces the level of stress hormone (cortisol), and increases the level of hormone of happiness (serotonin), as well as natural opiates (endorphin) – effects are good mood and life joy,
- Therapeutically usage of driving bicycle contributes to regeneration and rehabilitation of foot joints,
- Bicycle is a cheap transportation mean, which is easily and simply serviced,
- In some cities there is a possibility of renting a bicycle (Rent-a-Bike),
- Cargo transportation on special bicycles/threecycles (cargo bike) or in trailer,
- Driving licence is not necessary for driving bicycle,
- There are no registration costs or any tax for using bicycle,
- There is no problem with parking space,
- It does not use the fuel, but human power of muscles as drive,
- Special bicycle „Pedelec"(electric bike) with assistant electric motors makes easier the peddling, and energy which releases while braking is used (with help of regenerative function of motors) for charging the batteries.

Analysis and estimates in Europe show that by intensive development of bicycle infrastructure and restrictive politics towards cars in cities, level of CO_2 can be reduced for 4%.

This is reason why in cities all over the Europe and world rigorous restrictions for using cars are implemented, such as:

- charging for going through town center,
- restrictive system (pair-no-pair),
- high prices of parking (and fines),
- narrowing the streets and slowing down the traffic (special facilities, barriers),
- speed limitation,
- enlargement of pedestrian space (expending pedestrian zones),
- use of individual traffic tracks on road for the needs of bicyclists.

Main strategy of these cities is directed towards development of public town transportation. Ecological means of public transportation (Metro, LRT, trams and trolleybus) more and more replace classical buses. Vehicles with hybrid engine are introduced (electric and engine on natural gas), as well as for public town transportation also for delivery of goods in town. Effects of these measures have in last decades led to multiple energy savings, reduction of cramming and pollution in town, reduction of traffic accidents, improvement of health of children and adults.

Activities on the area of municipality Gradiška

Bicyclism is one of the most important traffic means on the area of municipality Gradiška whose use is economically acceptable, especially from the aspect of price of engine fuels, use of parking space (which are charged per hour for motor vehicles), and costs of vehicle maintenance etc.

For continuation of use of such alternative transportation means, it would be necessary to create certain conditions which will contribute to increase of safety of bicyclists in traffic.

In the following period, it is necessary to plan the construction of bicycle tracks, i.e. to plan the costs for their construction on the following sections of the road:

- Dubrave-Gradiška (length around 6km),
- Čatrnja-Gradiška (length around 5km),
- Kozinci-Gradiška (length around 2,5km).

It is necessary to consider the possibility of turning part of the Vidovdanska street into pedestrian zone, in order to reduce traffic jam in center of the town, and at the same reduce aero-pollution and noise which burden residents of residential and catering facilities in this street. Based on the data received from annual counting of traffic loads that have entered or exited St. Vidovdanska and St. Kozarskih brigada, from 2010, number was around 900 vehicles, and there are two semaphores and five pedestrian crossings.

Construction of bicycle tracks on stated parts would first of all provide bigger safety for bicyclists in traffic, as participants of traffic, who are on every day basis and in all weather conditions participants of traffic using the magisterial roads, sidewalks, edges and streets and similar for moving, and surely the number of bicyclists that would travel to school, work etc. would significantly increase.

How much popular bicyclisms on the area of municipality Gradiška, shows also the example of maintaining the manifestation *„Biciklijada“,* which is organized every year in May. Number of bicyclists which participate in the traditional bicycle race is from 1.000 to 1.400 bicyclists of all age. This number increases every year.

Alternative fuels

Due to the restricted reserves of oil, political instability in the area where are the biggest producers and exporters of oil, increase of price of oil and its derivates on world market and harmfulness of oil derivates for health of people, the use of energy-generating products which will successfully replace oil derivates is constantly considered.

Alternative fuel must be technically suitable, economically concurrent, based on the renewable raw materials, ecologically suitable and easily accessed. One of such fuels is the product of chemical modification of herbal oils and animal fats by reaction of transesterification with which glycerol is replaced most commonly by methanol, known as bio-diesel. Bio-diesel is biodegradable, non-toxic and inflammable; it burns fully due to the oxygen in the structure (10–11%) and has smaller emission of harmful gasses in comparison with fuels of mineral origin.

Bio-diesel degrades in 21 days for 98%, and mineral diesel in the same period degrades for 50%. In this way, danger of pollution underground waters is decreased. This characteristic of bio-diesel justifies its wide use, and especially in national parks, natural reservation as well as on agricultural areas.

Bio-diesel is liquid fuel produced from herbal oils or from used oils and fats.

Bio-fuels do not require production of new cars i.e. new car engine. This compatibility with existing engines has pushed many countries to turn to bio-fuel, convinced that in this way they will be able to reduce consumption of fossil fuels. European Union has determined the goal to use bio-diesel for twenty per cent till 2012, which means ten times increase of cultivation of oleaginous plants.

Gas is also used as drive of motor vehicles, and the types of gas are:

- Liquid oil gas (Liquefied Petroleum Gas) (propane butane) whose abbreviation is LPG and
- Compressed natural gas with abbreviation CNG.

Auto gas should become one of the primary fuels in auto industry due to the more and more demands for environment protection and rigorous norms for concentration of harmful gasses in air.

Because of its characteristics auto gas is the fuel which is *the biggest friend* of environment. Vehicles with auto gas drive in relation to diesel motors do not emit smoke, solid particles and sumpore oxides. In relation to petrol motors they do not exhaust lead, produce less carbon dioxide and non-degradable carbon hydrates. Use of gas as motor fuel greatly reduces the emission of harmful gasses into atmosphere and so nitrogen oxides less for around 20%, CO_2 for around 15%, non-burned carbon hydrate for around 50%.

LPG while burning reduces the emission of CO_2 in relation to petrol for around 15%, a CNG reduces emission of CO_2 in relation to petrol for around 25%.

Electric vehicles

For activation of electric automobiles are used electro-motors which do not have harmful gasses that are emitted into atmosphere. Energy necessary for their work usually is used from batteries that are placed in the cars. Their charging is stipulated to be performed at home or on specialized stations equipped for this type of vehicles. Different manufacturers of cars have different technological solutions that are used, and because of that it depends how many kilometers can you go with one charging of the battery, but also that depends from the type of the battery.

These vehicles are very efficient in ecological sense, there is no emission of harmful gasses, and the price of the passed kilometer is very low.

Hybrid vehicles

Hybrid vehicles combine two or more different technologies; usually there are classical petrol motor with internal combustion and electric motor. Most of hybrids today use motors with internal combustion in order to charge batteries that are used for work of electric motors. Motors which use diesel fuel or other kinds of fuel also can be used in combination with electric motors. This technology is used in small town cars, classical cars and even in buses and locomotives.

This combination at hybrid vehicles increases the fuel efficiency, and significantly reduces the emissions of exhausting gasses. When car stops, motor is automatically turned-off. While starting or braking, kinetic energy is used for charging of the batteries. One of the biggest advantages of hybrid car is that it is not necessary to build new infrastructure for fuel loading.

Economic use of fuel

A few years ago a statement that it is possible to make a car that spends three liters of fuel per 100 kilometers would sound amazing. Members of Greenpeace have proved the opposite when they succeeded with technical improvements to reduce the consumption of fuel by half.

Today there are few models on market – each of them use fuel very efficiently.

Control of exhausting gasses

Content and color of exhausting gasses on motor vehicles are defined by *Law on safety basics of traffic on the roads in Bosnia and Herzegovina*, as well as in *Rule-book on dimensions, total weight and axle weight of vehicle, on devices and equipment that vehicles need to have and on basic conditions which they must fulfill and equipment in traffic on roads*. Control is performed in accordance with European directive 2003/26/EC, where maximum values of individual polluting material in exhausting gasses of motors had been defined.

PROPOSAL OF MEASURES:

- Use of alternative fuels in town and suburban traffic means use of bio-diesel, bio-ethanol as engine fuel for vehicles of town and suburban transportation. Aside from these measures it can also be planned use of taxi vehicles which will use auto gas as engine fuel, even hybrid vehicles,
- In the sense of reduction of emission of harmful gasses in atmosphere on the area of municipality, it can be planned in the following period to purchase hybrid vehicles for the purpose of the Administrative service. Considering that these vehicles usually combine electric energy and petrol motors, they would be very popular for town area where they would use electric energy, and on open roads they can use petrol motors or other kinds of motors,
- For the purpose of the Administrative service, plan the purchase of electric vehicles with solar panel for charging which would be used by workers of inspections, and who would in this way promote the use of these vehicles on the area of municipality,
- Considering that on the exit from the Republic of Srpska towards border crossing with the Republic of Croatia columns of passenger and cargo vehicles that are waiting to cross the state borders are formed, it is

necessary to plan putting the switching traffic signalization which will enable faster flow of vehicles,

- To plan stimulations for purchases of newer vehicles of *pure technologies,* which emit very small amounts of harmful gasses in the atmosphere, in accordance with future normative of emission of harmful gasses,
- Planting trees i.e. avenues and parks, placing the lawns, placing the green hedges, along the highway, main and auxiliary roads in town and suburban area,
- To plan turning the St. Vidovdanska from the crossroads with the St. Kozarskih brigada and St. Mladena Stojanovića into a pedestrian zone.

6.4. Sector of forestry and agriculture

Activities and measures of reduction of CO_2 emission in forestry can be seen through following project proposals:

- Afforestation of productive, barren forestry land
- Use of biomass for production of heating energy
- Expending forest surfaces that will be nurtured by spacing
- Sustainable management of forests
- Parks and allies in the narrow and wider town center

Afforestation of productive, barren forestry land

Under the afforestation is considered artificial or hand rising of the forests by planting the seedlings or by planting the seeds on the surfaces that are for a very long time without forests.

On the area of municipality, the surfaces that are suitable for afforestation amount to 162ha or 0,74%. They represent the surfaces on which afforestation will be performed by corresponding types of trees in accordance with the natural and ecological conditions, which contributes to significant increase of surfaces on which will be performed regular production of necessary and quality forest wood assortments in future, and in that way influence on the reduction of CO_2 emission on local level.

Kyoto protocol on reduction of emission of harmful gasses that affect on the atmosphere orders that 10% of annual amount of carbon from surroundings should be used through biomass or increase forest biomass for 1% per year through afforestation. The reason is in fact that 1 hectare of forestry surfaces a year absorbs equal quantity of CO_2 emitted by burning 88.000l of heating oil or 134.000m³ of natural gas. (*Šljivac, 2011*)

Increasing the forest cover can affect on reduction of CO_2 emission, which is one of the most important tasks in the future. Carbon-dioxide is the fundamental factor of photosynthesis and its herbal production. Herbs spend a lot of carbon – dioxide, 50% of organic material is composed of carbon. It is spent around 820m³ of carbondioxides for production of 1m³ of wood. By the process of photosynthesis, forests perform assimilation of the CO_2, which aside other gases significantly affects on creation of the greenhouse effect. During linking each gram of carbon-dioxide it releases 0,75 grams of oxygen. On the whole Earth during year, terrestrial herbs (of which more than 50% make forests) bind 64,8 billions of tons of CO_2, while releasing 50,9 billions of tons of oxygen. (*Govedar, 2011*)

Forest holding „Gradiška“ in a period from 2001-2010 had a string of activities where the afforestation of bare forestry land was performed. The biggest actions were performed in G.J. „Prosara“ where it has been afforested 60,8ha, but the afforestation had not been performed in 2004, 2005 and 2008. In G.J. „Kozara-Vrbaška“, it has been afforested 62,5ha, but in 2001, 2005 and 2006 no afforestation had been done. The tree types that were used for planting on the surfaces that were not afforested were: maple, oak, spruce, ash and black pine.

In 2012, according to Afforestation plan with the forestry cultures, filling up of the places where seedlings dried out will be performed. Plan stipulates the following areas: G.J. „Prosara“ section 25/2, G.J. „Kozara-Vrbaška“ section 28, G.J. „Kozara-Vrbaška“ section 32. (*Information development project center, 2001).*

Bigger interventions of afforestation on the places where it has not been performed before are not feasible because of the negligence of the land and growing of the pioneer kinds. Before planting on such areas, clearing and preparation of the land should be performed, this would increase the price of the afforestation process. This is the reason why sustainable management is a priority in GO „Gradiška“, and in future intensifying the afforestation process is planned.

Use of biomass for production of heating energy

Biomass is the most complex form of renewable energy sources, because as a raw material it includes forestry and agricultural biomass, and it can be grown on the energy plantations. As final product in form of energy, biomass can serve as renewable source for production of thermal energy.

Tree represents the most significant energy source on the area of municipality Gradiška. According to data with which GO „Gradiška“ disposes average annual accrual of wooden mass is around 150.000m³, while average annual allowable cut was 100.000m³. Average annual accrual of wooden mass for 2011 was 112.129m³, while average annual allowable cut was 93.603m³. The quantity of waste which is made while exploitating wood is 25.000m³ which is used as wood for heating, while 15.000m³ falls to brushwood which goes down the waste in forest. Aside the forest waste, there is also the waste made on the saw-mills while processing wood and it amounts to 15.000m² per year (while processing wood it is lost around 35-40% from entering raw material in the production process, and the quantity of waste for some products such as parquets is up to 65%).

Today in world the use of biomass for energy production is conducted by respecting the principle of the sustainable development, it is used exclusively the wooden mass which was made as side-product or waste in forestry and wood industry, such biomass is used as fuel in the plant for production of thermal energy.

Municipality Gradiška has a potential which is insufficiently used in regard of using forest and saw-mill waste, certainly it is necessary to start the plant for production of pellets and briquettes, considering that on the area of municipality Gradiška there is no such plant, and that would in an economic and rational way solve the problem of forest and saw mill waste.

Use of biomass would provide employment of people (opening new and maintaining the existing working places), increase of local and regional economic activity, as well as achieving additional income in forestry and wood industry through selling biomass as fuel.

Biomass market in B&H is still underdeveloped, while on the area of European Union there is already established market with formed prices of biomass. Total price of biomass for heating and production is concurrent to the price of fossil fuels because 2,5kg of wood for heating in average contains the energy as 1l heating oil, and with bigger increase in price of raw oil, biomass will be even more cost-effective.

Expending forest surfaces that will be nurtured by spacing

Cleanings which precede the spacing are the only breeding measures which we can implement in the even age stand of trees. From the breeding point of view, it is necessary to conduct the spacing in order to grow more resistant and produce more quality trees. The high spacing contributes to that the most, because in that way only the most beautiful developed trees are freed up and improved and all trees that are poorly developed are removed, such as: crooked, forked, very branched, damaged and trees with any other faults that decrease their technical value and endanger their health state. This at the same time raises health state of the stand of trees, so they become resistant to external factors, especially wind and snow.

Only with spacing we can regulate the proportion of state in the existing stands of trees and in that way favourize the kind of tree we want to expend. This is of special significance for mixed stands of trees of beech, fir and oak in which the state can be fixed on behalf of the kind that is most cost-efficient. The most quality stand of trees managed by FH „Gradiška“ are: woods of beech and fir-tree in GJ „Kozara-Vrbaška“ with surface of 2.118ha, oak-tree woods in GJ „Kozara-Vrbaška“ with surface of 309,80ha and GJ „Prosara“ with surface of 3.035,95ha, beech-tree woods in GJ „Kozara-Vrbaška“ with surface of 316,8ha (*Govedar, 2011*). Space and cleaning needs to be conducted on all places, in all woods in order to breed more valuable stand of trees, because they have for sure great role in reduction of emission of greenhouse gases on the territory of municipality Gradiška.

At average conditions of environment, trees and herbs of forest eco-systems from the surface of 1ha spent annually in average around 4 tons of CO_2, which they extract from approximately 18 million cubic meters of air (*Jones and Curtis, 2000*). Mature beech tree give every hour 1,7kg of oxygen, and daily it produces oxygen sufficient for 64 human beings. During its life a medium large beech purifies 50 millions of cubic meters of air and contains around 400 thousand of liters of water (*Govedar, 2011*).

Sustainable management of forests

Forests and forestry land are goods of general interests and as such they enjoy special care of society as whole. The term sustainability designates the relation between the cutting the forests and afforestation. Forests that are sustainably managed are not exploited more than they are afforested by new seedlings. In that way a new accrual of forests is provided, and at the same time habitats are intact. Principle of sustainability is very simple, it is necessary to cut only the number of trees that is the same as the number of new seedlings planted.

In so far use of natural resources in FH „Gradiška“, dominant role had production and use of wood, while other possibilities of use of forests and forest complexes have not been considered. Such relation is not understandable especially in current conditions of business, when circumstances demand use of all available resources that are available in forestry.

Some of the possibilities of use of forestry surfaces are recreational, tourist and health functions and role of woods. Such possibilities have derived from the needs of contemporary human being burdened with the town environment and hard work in order to recreate and take care of his health. Nature and woods provide him with that. Because of the proximity and position of wood complexes in relation to municipality, area of one part of Prosara can be arranged as park-woods which would have active recreational character, with pedestrian and trim tracks, sports fields etc.

Contemporary pharmaceutical, cosmetic and food industry in newer times more and more uses self-sown herbs, fruits, mushrooms and other forest products in the technological process of production. Redemption price of side-wooden products provide, with good organization, rational collecting, distribution and additional earnings in forestry.

Parks and allies in the narrow and wider town center

One of the aims of spatial and urban planning, among other things should be adjustment of development and social needs with demands of different pretendants on locations in space. When considering planning of the town structures, for healthier environment among other things it is very significant the presence of the woods, i.e. parks, due to their very suitable influence on urban ambience.

System of green areas has complex functional structure. Elements which form system are different in their purpose, aims which they try to achieve, and also in manner of composition. Basic functions of greenness are improvement of sanitary-hygienic conditions, than creation of suitable micro-climate conditions, as well as increase of ambience values of the space. Green surfaces, i.e. their regulation as a component of settlement urbanization, have extraordinary significance in life and work of people, so they need to be treated as important infrastructural component.

Significance of urban woods in the process of preserving healthy environment and health of people is great. Parks in the town area absorb great amounts of carbon-dioxide from atmosphere, in certain percentage they influence on air humidity and temperature creating positive micro-climate, prevent erosion of the land, are important for preserving bio-diversity and similar. Urban woods can be also of preserving character, for example they separate the zone of narrow town area from industrial zone.

Observed area has characteristics of insufficiently regulated green matrix and it is in great part represented by courtyards of facilities of individual residence.

In the observed period of baseline 2005, there were two parks. According to Urban project „Manjurevi-Toplana-Stadion“ from 2003 that is a central park which is even today in the urban part of town and with its surface does not satisfy the needs of population, due to its reduction because of the intensive building.

Also the park next to Town stadium, small surface of 21.293m^2 and frequently very unkempt, and because of the closeness of a regional road and lack of accompanying content it was not visited very often, and situation is not much better today. Park next to Bus station, surface of 20.067m^2 is since 2009 in the phase of rejuvenation and adjustment to Children Entertainment Park with wooden furniture. In a period of baseline year this park had reduced function of aero-refinement, due to the old age and negligence of tree tops.

Based on the data taken from Regulation plan „Gradiška istok“ which was elaborated in 2009, the park area of around 25.000m^2 had been planed, and from Regulation plan „Gradiška zapad“ from the same year, that is the surface of park of around 26.000m^2 and other one in the near proximity of around 38.000m^2.

Because of the intensive building, natural potentials such as parks become more precious and that conditions the finding of the new solutions in reaching first of all qualitative, then quantitative changes in representation and manner of using and regulating these areas.

Allies refer to all elements of landscape composition which are found along the streets, between construction lines and edges of the pavements, as well as those between lanes. Functions of well formed allies is seen in providing penetration of fresh air masses, mitigation of temperature extremes during summer heats, absorbing certain quantity of carbon-dioxide, reduction of noise level. Existing state of allies on the territory of municipality is not satisfactory; there should be plantation of new allies along the roads whose profiles allow that. It is also necessary to perform replacement of old deteriorated trees, with new seedlings, while as a seedling material can be used: Tilia platiphylos, Fraxinus lanceolata, Liriodendron tulipifera, Acer platanoides with occasional adding and some other sorts adjustable to urban conditions.

Reduction of CO_2 emission in agriculture can be viewed through following measures and activities:

- Utilization of biomass,
- Production of biogas,
- Production of bio-diesel.

Utilization of biomass

Biomass is biodegradable part of the product, waste and remains of agricultural production (of herbal and animal origin), forest and other industries. Main advantage in use of biomass as energy source are abundant potentials, not just plants that are for that purpose planted but also the waste material in agricultural production.

Advantage of biomass in relation to fossil fuels is also non-comparably smaller emission of harmful gasses and waste materials. It is calculated that the overloading with CO_2 while using biomass as fuel is negligible, since the quantity of emitted CO_2 while burning is equal to amount of absorbed CO_2 during growing of the plant, in case that the cutting and accrual of the wooden mass are in the sustainable relation. (*Šljivac, 2011*)

Arable land on the territory of municipality Gradiška amounts to 50.547ha (66.36%), and surely the biggest part is agricultural land, therefore great significance on the territory of municipality Gradiška could have remains from agriculture i.e. agricultural biomass (corn remains, sunflower stems, straw, shells, pips, remains from pruning orchards and vineyards and similar).

Experiences of developed countries in Europe show that it is a valuable energy source which should not be neglected. After corn harvest on cultivated land remain corn stems, stems with leaves, corncob and shuck. Since the average ratio of grain and mass (so-called harvesting ratio) is 53%:47%, iz supervenes that amount of biomass is close to the amount of grain. If you separate the corn stems and corncob, than their ratio is averagely 82%:18%, i.e. on the amount of 1t of produced corn grains you get 0,89t of biomass of corn which makes 0,71t of corn stems and 0,18t of corncobs. It is undoubted that biomass must first of all return in soil, the ploughing is recommended between 30 and 50% of that mass, therefore for energy use remains at least 30%.

Energy value of biomass is equal to quality brown coal, with calorific value of 14.000 to 18.000KJ/kg, without sumpore and low content of ashes (2-6%).

Content of humidity in straw is around 10%, but its content in corn stems is somewhat unsuitable 25% and more, which in technical sense is not unsolvable problem.

Aside the remains and waste, there is a great number of herbal sorts which can be cultivated so-called *energy plantation* with great yield. Municipality Gradiška does not have clear strategy of buying up the agricultural biomass, it should be worked on establishing buy-up station, since that there is no such station on the territory of municipality.

Production of biogas

Biogas obtains from organic materials, and it is produced and used mostly from reasons of economic management of manure, for optimization of yield per hectare of arable surface, protection of human environment and working environment and for the purpose of supplying farms with their own energy.

Origin of raw materials for biogas can vary, from cattle waste, harvesting surpluses, remains of vegetable oil to organic waste from households. Biogas is a mixture of gasses which results from fermentation of biodegradable materials in the environment without oxygen. It is the mixture of methane CH_4 (40-75%), carbon-dioxide CO_2 (25-60%) and roughly 20% of other gasses (hydrogen H_2, sulphar-hydrogen H_2S, carbon monoxide CO).

Biogas is about 20% lighter than air without smell or color. Combustion temperature is between 650 and 750°C, and it often burns with blue flame. Its calorific value is around 20MJ/Nm^3 and it burns with around 60%-effectiveness in conventional biogas furnace. (*Šljivac, 2011*)

The biggest potential for production of biogas from manure on the territory of municipality Gradiška has "Farmland" a.d. from Nova Topola which practices the cattle farming and milk production. With over 3.500 of existing heads of cattle, it disposes with great amounts of manure. Aside "Farmland" there is also "Agroeksport" from Gradiška which practices the cattle fattening, and currently it has over 2.000 heads.

According to some data when talking about cattle unit (500kg of live weight) daily you can get from 25kg (pigs) to 43kg excrement, which according to researches provides biomass in amount of 950 liters (dairy cow) to 3140 liters (poultry), i.e. gas with 56-70% methane, whose bottom thermal power is 20-25MJ/m^3.

Based on these data, it is easy to calculate for example that for 1m^3 of biogas with 62% of methane in thermal power replaces 0,66m^3 of natural gas or 0,48kg propane gas or 0,61l heating or diesel fuel or 0,72 petrol or 6,11kWh electric energy.

Produced biogas can be used for:

- Heating premises, production of hot water in house needs by direct combustion;
- For production of electric energy, this would be used on farm or would be included in energy system of municipality.

In the process of obtaining biogas occurs fermented manure, which by its physical and chemical content can be used as excellent basic manure, because it contains after the fermentation all mineral materials, nitrogen, calcium and phosphor. Use of the fermented manure would contribute to significant saving of mineral fertilizer and foreign currency funds which are used for their import.

For the economically costs-effective plant on biogas it is calculated that it is necessary manure of 100 cattle or 1.100 pigs or 12.000-14.000 chicken. There are 55 cattle farms, 10 pig farms and few chicken farms with these capacities that are currently registered on the territory of municipality Gradiška. All so far attempts for production of biogas here did not give satisfactory results. Still optimal technical-technological solution for manure treatment has not been found. Delay in development of cattle-breeding is one of the factors which do not stimulatively act on development of this energy-generating product.

Production of bio-diesel

Bio-diesel is a commercial name for *methil-esther,* without added mineral diesel fuel, found on the market of liquid fuels and sold to end-users. Standardized is liquid mineral fuel, non-toxic, biodegradable replacement for mineral fuel and it can be produced from herbal oils, recycled waste of edible oil or animal fats by the process of esterification, during which the glycerol occurs as side-product.

Choice of basic raw material for production of bio-diesel depends on specific conditions and opportunities in concrete countries, in Europe for production of bio-diesel is mostly used oil of oil rape (82,8%) and sunflower oil (12,5%), while in America is mostly used soy oil. Advantage of bio-diesel is in fact that it is equal to regular diesel by its energy characteristics, it has much better lubricity, therefore significantly extends the work of motor.

The most significant are its characteristics regarding reduction of environment pollution. Total CO_2 emission equivalent of bio-diesel depends on used raw material: for bio-diesel from sunflower around 50g/km, for bio-diesel from oil rape around 110g/km. For comparison, at classical diesel total CO_2 emission equivalent amounts to 220g/km. Also it is necessary to emphasize that the reduction of CO emission occurs for 42, 7%, carbon-hydrates for 56, 3%, solid particles for 55, 3%, toxins for 60 to 90% with total elimination of sulfates. *(Šljivac, 2011)*

The production is also possible at home. Transportation of bio-diesel is almost completely safe for environment, because it degrades after 28 days if it gets on the ground. If oil during manipulation or transportation gets into water, one liter pollutes almost million liters of water, while at bio-diesel such pollution does not exist, because it degrades absolutely in the water just after few days.

Lacks of bio-diesel are seen in possibility of clogging the injectors, spreading the smells of fried oil from exhausting tube, smaller energy value of 37,2MJ/l (oil 42,0MJ/l) and bigger consumption.

While producing bio-diesel from oil rape, a whole set of profitable side products becomes, such as rape meal, which is highly valuable protein additive to cattle food, we also get glycerol which is used as raw material in cosmetic and pharmaceutical industry. At the end of the technological process, as side-product we get oily mud, which is used as high quality fertilizer for vegetable cultures in ecological agriculture.

Due to its numerous positive characteristics, bio-diesel found its widest application just in ecological agriculture, where it is, according to international criteria the only energy-generating product. Without use of bio-diesel, today in EU you cannot get the certificate on pureness of ecologically produced agricultural products. Use of arable land for production of oil rape on the territory of municipality Gradiška should be thoroughly examined, due to the fact that on the area of municipality there is less and less arable land, and the production on non-arable agricultural land is recommended.

6.5. Electric power sector

Based on the received data for baseline year 2005, as well as on the basis of Development strategy of municipality Gradiška, Program of capital investments for period 2011-2015, LEAP document of municipality, the activities and measures which could contribute to reduction of emission of harmful gases into atmosphere are suggested:

Installment of saving lighting fittings

In the administrative and other facilities which are in the authority of Municipality, it is necessary instead of existing light bulbs with filament or standard neon lighting fittings to install saving light bulbs and lighting fittings. Standard lighting fittings of older generation should be replaced by saving lighting fittings which spend less electricity and have better technical characteristics.

For realization of this aim, it is necessary to replace conventional (standard) lighting fittings with saving lighting fittings of better technical characteristics.

Effects of savings that would be achieved in this way would amount to 97,65MWh and reduction of emission of CO_2 for 81, 15 tons.

For **facilities which are not in the authority of municipality**, it is also necessary to perform the replacement of old with new kinds of lighting fittings which can be found on the market, and in the aim of CO_2 reduction in this sector.

Effects of savings which would be achieved in this way would amount to 240MWh, and reduction of CO_2 emission would be 199, 44 tons.

For **residential facilities of households,** it should also perform the installment of saving lighting fittings. Effects of savings which would be achieved in this way would amount to 6621,79MWh and reduction of CO_2 emission would be 5502,70 tons.

Public lighting

Timely management of public lighting implies that public lighting should be turned on only in the period when there is no day light. In summer period public lighting should be turned on one hour later, and turned off one hour earlier than in winter period.

In order to implement such measures it is necessary to install automatic management of working of public lighting from one center.

Effects of savings which would be achieved in this way would be 310,1MWh, and reduction of CO_2 emission would be 257,70 tons.

Reconstruction of public lighting implies that standard lighting fittings of older generation should be replaced by saving lighting fittings, which spend less electricity and have better technical characteristics.

For implementation of this measure it is necessary to reconstruct public lighting and install saving lighting fittings of better technical characteristics and longer period of lasting, as well as installment of lighting with LED diodes. The following equipment that comes with saving lighting fittings should also be replaced within this measure.

Effects of savings which would be achieved in this way would amount to 321MWh, and reduction of CO_2 emission would be 266,75 tons.

Modernization and reconstruction of electro distributive network

To modernize and reconstruct electro distributive network, with transition to 20kV voltage on the whole territory of municipality. Distributive losses would be reduced for 7% by reconstruction.

For implementation of this measure it is necessary to replace all 10kV cables and equipment with 20kV cables and equipment; to reconstruct distributive substations on 20kV voltage, to build necessary substations; install measuring in all substations.

Effects of savings which would be achieved in this way would amount to 8.430MWh, and reduction of CO_2 emission would be 7.005,33 tons.

Establishing solar systems

Implementation of project of **putting solar cells** on roofs of few facilities, as well as on roofs of facilitates in the authority of municipality Gradiška.

For implementation of this action, it is necessary get engaged in gathering information on positive experiences of already finished similar projects financed by EU, in order to provide technical support for this kind of project, and in aim of better preparation of project documentation.

Solar energy from photovoltaic systems which would be used for production of electricity on the area of municipality Gradiška.

Municipality is placed in the continental zone, but no matter that production of solar energy should not be neglected. Primarily, this refers to production of hot consumable water for the needs of households, as well as use of sun energy for installment of photovoltaic systems for production of electricity.

This use of solar energy could contribute to annual savings of 1.760MWh and reduction of CO_2 emission for 1.462,56 tons.

6.6. Renewable energy sources

Considering bigger and bigger consumption of energy, one of the options is the use of renewable energy sources. Alternative sources of energy (solar energy, wind energy, hydro energy, energy of biomass, etc.) are considered to be suitable choice in the aim of improvement of energy use precisely because of their low influence on environment.

Information on estimated energy needs i.e. quantity and kind of necessary energy should be looked for and compared with available resources on local level in order to determine the choice of technology. Even though technologies for renewable energy sources finds the way for more and more applications in energy sector, for example heating water in heating system, still there is huge unused potential. Choice of technology in great measure depends on the availability of local resources.

Systems of solar energy, wind energy, heating pumps and biomass today are used where it is possible to do so.

One of the characteristics of renewable energy sources is that they are *clean* sources of energy because they contribute to reduction of air pollution, water and land and they are cyclic rejuvenated. To renewable energy sources belong energy of sun and wind, hydro energy, geothermal energy and energy of biomass.

Development of renewable energy sources is important from several reasons:

- They have very important role in reduction of CO_2 emission into atmosphere
- Increase of share of renewable energy sources increases the energy sustainability
- They help improving safety of delivery of energy in way that they reduce dependency on import of energy raw materials
- Share of renewable energy sources in future needs to be increased significantly because unrenewable energy sources are decreasing, and their harmful influence is more and more obvious in the last few decades.

Biomass and its potentials on the area of municipality Gradiška

Due to its general-beneficiary functions and economic significance, forests and forestry land are of general interest and have special care and protection by state. Protection, improvement, use and management of forests and forestry land and other potentials of forests and forestry land are achieved under the conditions and in a manner determined by Law on forests.

It has been regulated by Law that forests are kept, rejuvenated and used so that their value is preserved and increased as well as their general beneficence, to provide lasting yield and constant increase of yield.

Alternative energy sources on the area of municipality Gradiška have potential which is insufficiently used. This especially refers to biomass. Biomasses are wooden waste and waste from agricultural production. Very small part of wooden waste is used for energy purposes in households and plants for treatment of wood, and most of the waste ends up on undedicated locations and it represents important ecological problem. Also the biomass from agriculture is not used.

Biomass is in great quantity present on the area of municipality Gradiška. First of all, this is a consequence of raw material base, expressed in wood expanse, existing of wood processing and significant herbal and animal production.

In highland area of municipality there is a great number of orchards. In orchards during pruning, significant quantity of bio-waste is produced and burned, which states the fact that there is no system of organized collecting which could provide valorization of this potential energy resource.

On the area of municipality Gradiška, it is planted 1.330ha of orchards, these capacities are spreading every year, and the fact that in the last few years 620ha of new orchards had been raised proves that. The density of planting refers from 3.500 to 6.500 trees per hectare, and by newer methods of planting it goes to 18.000 trees per hectare.

According to the data of the Republic institute for statistics on evaluation of potentials of biomass from agriculture, apple and pear trees after pruning give from 1,2 to 1,8kg per tree of brushwood, and plum from 5,1 to 9,9kg per tree. Based on these data it is possible to calculate the quantity of wooden biomass from fruit-growing and it is in average around 9.300t per pruning.

Also the amounts of wooden biomass resulted from cleaning non-categorized shaggy land (channels, lawns etc.) should be used. Aside the great amounts, wooden waste is not collected on the area of municipality for energy purposes or making briquettes and pelleting, and that would represent the basic manner or rational and economic use of biomass.

Waste from agricultural production, of herbal and animal origin, remains and waste from herbal agricultural production and animal remains and waste, can be used for production of biogas, while agricultural cultures such as oil rape, corn and soy can be used for production of bio-diesel and bio-ethanol. Beside the great quantity of herbal and animal waste from agricultural production, as well as significant production of oil rape, corn and soy, on the area of municipality the production of bio-gas, bio-diesel and bio-ethanol had not been recorded.

The surface of arable land on the area of municipality amounts to 50.547ha (66.36%). The biggest parts in agricultural land have plough land and gardens from 59%. Energy use of tillage remains can be counted into the estimate of potentials, but it changes every year due to the agricultural laws. With annual changes of locations, such biomass has small energy density which makes harder to list it into the energy planning. According to data used for elaboration of Development strategy of energetics in the Republic of Srpska, potentials of harvesting remains are left out from estimate of potentials. (*Government of the Republic of Srpska, 2009*)

Estimate of potentials of biomass from tillage on municipality Gradiška should be focused on hiring non-cultivated agricultural surfaces for the needs of energetics. That would not change existing agricultural politics, because non-cultivated areas would be used for growing energy crops, where should be considered the simplest crop sequence of three years and choose most effective crop per hectare for energy needs, depending whether the crop will be used for production of bio-diesel, bio-ethanol, biogas or used as bio-fuel.

Cost-effectiveness of production of bio-diesel, if agricultural surfaces are used, should be thoroughly inspected. If we take that the surface of cultivable land on the area of municipality is 50.547ha (66.36%) and that whole surface is seeded with oil-crops necessary for production of bio-diesel, the need for diesel of population will be satisfied by 40%, and lack of food will appear, due to the lack of cultivable surfaces. From these reasons it is recommended cultivation of agricultural cultures for the needs of production of bio-diesel on non-cultivated agricultural surfaces.

The possibility of repair of wild depots on the area of municipality as well as possibility of recycling, removing and treating bio-waste (waste of herbal origin) produced on public, recreational, agricultural surfaces, wood industries, private households can be achieved by founding **bio-compost plant** on local level, within town Communal company.

The composting process would give the product of compost, precious for agriculture, and as one hundred percent organic fertilizer which would in the aim of repair and recultivation of damaged surfaces had use on agricultural and town surfaces. (*Babić, 2010*)

Biogas and potentials of its production on the area of municipality Gradiška

In agriculture, when considering production of biogas from agricultural plants, first position belongs to “Farmland” a.d. from Nova Topola which is into cattle-breeding.

“Farmland” from Nova Topola aside its capacities can serve also as centralized company in which smaller farmers will deliver the surplus of manure from livestock farming in aim of protecting environment (underground and on the ground waters, emissions of greenhouse gasses and similar). It is assumed that “Farmland” with its own raw materials will have the potential of 0.5MW per plant for production of biogas.

When considering the potential of biogas production, it is important to have in mind that it is counted as mono-digestion based on manure while in practice biogas is produced through co-digestion of different substrates where manure represents the foundation and has lower values while generating biogas from maximum 90m^3 per ton of manure, while from waste fats (waste from cheese processing, bakery waste, old bread, corn silage) can get from 451 to 874m^3 biogas per ton of substrate.

From this reason it is necessary to extract the organic friction from communal waste, which is currently transported to regional depot in Ramići on the area of Banjaluka and use it for the purposes of biogas production. Potential of organic waste from household can be estimated according to number of population, where it is taken that one resident produces 0.7-0.9kg of waste. With that, annual production of communal waste on the area would be around 48t. Than we can assume that from organic waste from depots can be acquired around 20.000m^3 of depot gas per year.[6] Opening companies and factories which would deal with storage and recycling of waste would represent the possibility of opening new working places, but also and income through industry of recycling.

On the municipality Gradiška there are no cattle farms which produce biogas not even for their own purposes, and reason for that is mostly of financial nature. The price of constructing biogas plant for processing manure of 500UG costs around 900.000,00KM of that 650.000,00KM for facilities and 250.000,00 for machines and equipment. Amortization of facility is 30 years, and of machines and equipment 10 years. Great costs which burden biogas plant on annual level and based on which will be calculated price of 1KWh of produced electricity.

[6] According to data on quantitiy of organic waste per inhabitant, overtaken from the Strategy of development of energetics of RS till 2030, the quantity of waste from household on the area of municipality is calculated, and based on that data the quantity of depot gas was acquired.

Bigger costs on annual level:

Biogas plant does not work for approximately 33 days on annual level, i.e. uninterrupted production lasts around 332 days a year, so for that period annual estimate of production of energy is calculated.

The price of 1kWh of produced electricity amounts to: 65.366,67KM/508.889,6kWh=0,1284KM/kWh

Average annual price of electricity in RS is 0,13KM (VAT included), so it can be concluded that the price of electricity produced from biogas is somewhat lower than the market price (for 0,0016KM/kWh), i.e. for a year an income could be achieved: 508 889,6kWh x 0,0016KM = 814,22KM

Of course, there is a great quantity of heating energy, which has not been considered in previous calculation.

Daily production of heating energy is: 2.329,6kWh
For one year (332 days) it is produced: 773.427,20kWh = 773,5MWh

Part of the heating energy is used for heating the fermentor (around 15%), remaining heating energy is more than enough for satisfying all needs of the farm (heating production space, offices, hot water and similar), so that surplus can be used for heating residential buildings, houses and other consumers that are close to biogas plant.[7]

While calculating cost-effectiveness, all produced electricity can be used either for satisfying proper needs or by return (selling) to energy network; however the situation is a bit different with heating energy because it will be possible to be used only in winter period.

For farms without additional consumers of heating energy, from totally produced 773,5MWh, useable is around 232,05MWh.

Current price of 1MWh of heating energy on market (JKP „Toplana" Gradiška) is 117,95KM.

Market price of usable heating energy is: 232.05MWh × 117,95 = 27.370,29KM.

This amount represents savings of the farm for one year. Amount is necessary for paying annual heating needs of the farm (buying heating-oil, woods, gas and similar), and after construction of biogas plant all these needs can be settled by heating energy produced in it.

Geothermal energy

Geothermal energy has numerous advantages comparing to traditional sources of energy based on fossil fuels. The biggest advantage of geothermal energy is that it is pure and environment safe. Method used for creating electricity does not create harmful emissions. Reduction of using fossil fuels also reduces the emission of green

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[7] Calculation performed on the basis of data overtaken from Strategy of develoment of energetics of RS till 2030.

house gasses. Other advantage is available energy supplies to us. Supplies of geothermal energy are practically inexhaustible.

Existence of hydro-geothermal system, even though research and appearance of thermal surface sources in surroundings on neighboring municipalities Laktaši and Banja Luka, south of municipality Gradiška, determined existing of hydro-geothermal system such as appearance of thermal water on the territory of Republic of Croatia in Lipik, north from municipality, for area of municipality Gradiška there is not data on its existence. It is recommended to approach to elaboration of project research and use of geothermal energy on the area of municipality, first of all for the purposes of heating people and industry, and as first research work, the elaboration of geothermal bore of 3000 m depth is recommended.

Geothermal energy is not used on the area of municipality Gradiška; hence a detailed research of possibilities of usage of thermal pumps for the needs of exploitation of geothermal energy is suggested.

No geothermal researches of potentials of Republic of Srpska have not been performed till 2010, so the estimates of potentials have been given on the basis of previous, geothermally relevant researches (geological, hydro-geological, geo-physic, seismic and other research). On the basis of the stated researches it can be determined that municipality Gradiška is on the hydro-geothermal foundings in alluvium sediments whose energy can be used with thermal pumps.

Available data base shows that on the certain parts of Lijevče field can form geothermal sources of thermal power of 50-100MW. The biggest potential of use of geothermal energy is found in the agro-culture, and communal activities such as heating of settlements. The possibility of use includes heating of buildings, herbal plantation in greenhouses, drying crops, heating water in fishponds and industrial processes.

Temperature of hydro-geothermal system in alluvium sediments below territory of municipality is not sufficient for production of electricity.[8]

Solar energy and possibility of its use on area of municipality Gradiška

Technology of sun thermal collectors is old few decades and in principle it has not been significantly changed so in future we cannot expect significant improvements of efficiency of these systems. Considering that there is no significant solar production of energy in the Republic of Srpska, as well as in the rest of the region, the prices of devices are pretty high because they are based on the import from Western countries and Middle East.

[8] Strategy of development of energetics of RS till 2030 and Geothermal potentials of hydrogeothermal resources on the area of Banja Luke in the aim of their use for heating and other purposes, Faculty of Mining and Geology of the Belgrade University, Institute for hydrogeology.

Speaking in numbers, daily on Earth reaches from Sun around 960 billions kW of energy, i.e. around 1,36kW/m². By using sun energy which is free, it is possible to save up to 80% per year of necessary energy for preparation of sanitary hot water.

Application of solar energy in households on the area of municipality Gradiška is small from the above stated reasons (high price of costing and small offer of systems), and use of sun energy is reduced to individual cases. It is mostly used for preparation of hot water.

On the facilities which are connected to district heating system, additional installment of solar systems requires complex works and it is not financially cost-effective. The biggest cost-effectiveness of solar systems for heating water are reached in the facilities which are intensively used during all 24 hours, such as houses, hotels, health institutions, sports departments. Installment for facilitates such as schools and kindergartens which during summer do not work or work with reduced intensity, the installment of such technology is in economic sense questionable.

Installment of photovoltaic panels on the area of municipality is not cost-effective because of the price and short period of use only during day and their inability to work at night. Installment of solar collectors is recommended for heating water in which heath would be accumulated and available over night and in that way electricity would be saved for heating sanitary water as well as possibility of heating premises in facilities which are not connected on the district heating system, such as farms and facilitates in the distant parts of municipality.[9]

Hydro-energy and possibility of its use

Hydroelectric power plants are energy plants where potential energy of water is turned into mechanic (kinetic) energy by turbines, which is in an electric generator used for production of electricity. Use of energy of water potential is economically concurrent to production of electricity from fossil and nuclear fuels, that is why hydro-energy is the most significant renewable energy source (it represents 97% of energy produced in all renewable sources).

Hydro-energy still significantly stagnates in production because of the fact that use of hydro energy has important technical and natural restrictions. Main restriction is the demand for existing abundant source of water throughout whole year. In order to avoid oscillations of water level on certain locations it is necessary to build dams and accumulation lakes. Construction of accumulation lakes frequently demands flooding great parts of vallies, and sometimes whole settlements. Aside that in this way the price of building is increased; there is also problem of raising the level of underground waters around accumulation. Level of water affects herbal and animal world, there are also changes of relation of sedimentation and erosion inside the river beds. This points to the fact that hydro energy is not completely harmless for environment. Hydro-energy, unlike other manners of use of renewable energy sources, does not have problems with lack of necessary technology but lack of necessary locations.

Basic watercourse of municipality Gradiška is the river Sava. Inflow of waters from area of municipality is in the direction of the rivers Sava and Vrbas and to each

[9] Podaci obrađeni u skladu sa pojedinim segmentima Strategije razvoja energetike RS do 2030. godine.

of these rivers belong corresponding surface of confluence. Surface of the confluence has its lowland and hilly parts. Total surface of municipality is 762km², from that surface on the confluence of Sava goes 657,7km² (86,31%), and on the confluence of the river Vrbas 104,3 km² (13,69%).

This area does not have bigger rivers and lakes, and relief is mostly plain. There is great number of affluents of Sava: Jablanica, Jurkovica, Borna, Osorna, Gašnica. These affluents due to its watertight basis close to the sources have conditions for development of smaller accumulation lakes and possibility of construction of mini hydro power plants. All that can be implemented with the maximum preservation of eco-systems, and therefore these resources would be used in energy purposes.

Hydro energy in rivers on the area of municipality do not posses bigger falls, so this potential is not expressed in such measure as it is the case with the other areas of RS. Certain potential for construction of mini hydro power plants is present in the upstream flows of Jablanica, Vrbaška and Lubina. Ministry of economy, energetics and development of the Republic of Srpska for the area of municipality has given one concession for construction of mini hydro power plant on the upstream flow of Jablanica. (*Administrative service of municipality Gradiška, 2007*)

Energy of wind and possibilities of use on the area of municipality Gradiška

Investment in wind-power plants depends on the size of plant and choice of the manufacturer of wind-aggregate. Also significant influence on price can have the need for construction of the necessary infrastructure as well as distance from connecting point.

Main cost for construction of wind-power plant goes to wind-aggregates which amount up to 75% of total investment. Since that price on market depends on supply and demand and that since 2005 demand for wind-aggregates was in constant growth, which was not monitored in significant measure by new production capacities, the price of equipment in accordance to these trends and changed market relations also went up.

Wind potentials for the purposes of wind-power plant on the area of municipality are not thoroughly inspected and only regional climate data which refer to periodity and intensity of wind are available. Proportionally high frequency of silence shows that on this area during year around 15-20% days are without wind. The biggest average wind speed is from around 3,0m/s at south and southeast winds, which by their frequency are not dominant winds.

Basic meteorological data says that on the area of municipality Gradiška there is no potential for using wind energy due to small wind speed and frequent silences. If we take into consideration the meteorological data and technical data for wind-power plants which need the minimum wind speed of 3-4m/s, it can be concluded that on this area there is no possibility of bigger use of wind-power plants as alternative source of energy.

It is necessary to perform thorough speed and frequency measuring of wind, on different zones of municipality in order to seriously approach to the possibility of use wind as source of energy. With this analysis it is possible to use global data of spatial division of average annual speed and power of wind which are the result of use of global model of atmosphere, i.e. regional atlas of wind, regional wind atlas *Regional Reanalysis*, and which uses meteorological data. It should be considered that obtained results by use of this model are not verified by measuring on the ground. However, results obtained in this way can be sufficiently representative for selection and micro-locating of the area for construction of wind-power plants. On the basis of the obtained data from regional atlas of winds, municipality Gradiška does not count in potential locations for construction of wind-power plants. (*Administrative service of municipality Gradiška, 2007*)

6.7. Sector of promotion and raising public awareness

Prepared Sustainable Energy Action Plan will be presented to public and it will be proceeded to public debate. The success of implementation of SEAP in great measure depends on engagement of stakeholders and citizens, and the task of local authority of municipality Gradiška is to motivate citizens on participation as more as possible.

Having in mind that the aim of SEAP is reduction of emission of CO_2 gases till 2020, it is necessary that certain changes in current state and habits of citizens occur. Successful achieving of these aims depends on implementation of innovations in the area of mitigation of climate changes and their transfer to bigger number of residents of municipality. Public should be notified in due time on planned activities so it can effectively participate in their achievement.

As the closest legal institution to citizens, local authority of municipality will, in accordance with the defined measures in SEAP, work on activation of citizens via local media. Besides local authority, there are also non-governmental organizations and associations of citizens which should further work in the field of energy efficiency and mitigation of climate changes, as well as actively publish articles in local newspapers on theirs activities from these and similar areas, so that wider public would be introduced to their work. Working on networking and establishing partnership of public and non-governmental sectors (such as private sector, enterprises and non-governmental organization) would be one of the ways to activate community on action in the aim of improving environment, with greater engagement and personal contribution. (*EUROPE AID, 2012*)

Chances for success of implementation of any measure from Action plan on level of local community are greatly increased if there is a good cooperation between local authority and organizations of civil society, which is very good in municipality Gradiška so far. Notifying associations and citizens on necessary conducting of activities will be performed by adds, advertisements, leaflets, brochures, and different posters and other promotional material. Further more, non-governmental sector could participate with one part in spreading the ecological awareness in way that it would gather citizens via forums, workshops and round tables and activate them to action and volunteering.

Therefore, it is necessary during all phases of SEAP implementation to provide and maintain good communication between local authority, non-governmental organizations and all stakeholders engaged in the implementation. In the end, it is the most important that citizens of local community are aware of the fact how big contribution they can give to preservation of environment, by adopting some new habits and knowledge.

Promotional activities, which can affect on citizens of municipality Gradiška so they all would contribute to the local and global reduction of emission of greenhouse gases, are following:

- Installation of info-box on energy efficiency in the Counter-service hall of the Administrative service of municipality Gradiška
- Continuous informing consumers on possibilities of energy savings through short messages on the back of the bills for electricity
- Implementation of thematical campaigns for raising awareness of citizens on energy efficiency in buildings and local communities, such as :
  a) How to build energy efficient house?
  b) Introduction of energy certificates – while building new residential units, implementation of energy consumption as market category while purchasing or selling residential units
  c) How to achieve energy efficiency in household – advantages of installment of thermostatical valves, solar systems for heating water, installment of energy efficient joinery, purchase of electric appliances for households of A category
  d) Installment of internal saving lighting
  e) Advantages on heating on biomass
- Conducting lectures in elementary and high schools of municipality, on energy efficiency
- Organizing education for key actors and employees in public facilities on technical-technological aspects of improvement of energy efficiency and given methods and means of project action
- Organizing traditional manifestation „Day without cars“ each year, so that drivers would at least for one day contribute to reduction of emission of harmful gasses. Within this manifestation leaflets would be prepared on significance of reduction of emission of harmful gases and potential contribution of citizens to this reduction, with emphasis on advantages of vehicles on alternative fuels (electric energy, natural gas, bio-fuels etc.)
- Organizing the action „Week of town regulation“, which is traditionally organized in April in municipality Gradiška, and in this way animate as more as possible citizens, employees from Administrative service, students from elementary and high schools to give theirs contribution to regulation of town
- Organizing "Biciklijada" (bicycle race) once a year with the aim to increase the number of bicyclists every year. In the announcement for bicycle race, prepare information video on advantages of driving bike as alternative transportation vehicle in everyday life, its positive effect on human organism and environment
- In cooperation with NGO organize workshops and round tables on topic of reduction of emission of greenhouse gases and measures which citizens can apply themselves in order to achieve energy efficiency in their own home
- Work on reconstruction of individual or group of facilities, and with aim of improvement of energy efficiency, reduction of operative costs and possible energy sources.

7. Emission Inventory of CO_2 for municipality Gradiška

In the process of elaboration of *Sustainable Energy Action Plan,* integral and necessary part is calculation of carbon-dioxide emissions. By Analyzing certain sectors that affect emission of carbon-dioxide, as well as on the basis of the recommendations for elaboration of Action plan, Expert team for elaboration of SEAP (hereinafter Team) had divided municipality Gradiška on certain sectors and sub-sectors. In further work, these data will be applicable for monitoring the implementation of measures that Municipality is obliged to fulfill. By implementation of measures recalculation of emissions of will be done and also comparison and analysis of obtained data.

Necessary data for calculation of carbon-dioxide emissions are gathered from individuals of the Team for the sector that was entrusted to them. All data which is included into calculation is collected for the adopted baseline year 2005.

By agreement of the Team for implementing Action plan, following sectors had been defined:

- ✓ Electric power
- ✓ Transport
- ✓ Heating ("Toplana")
- ✓ Construction engineering
- ✓ Forestry and agriculture
- ✓ Renewable energy sources

To perform the calculation of the carbon-dioxide emissions, necessary data which is collected according to Guidelines had been converted into energy expressed in MWh or smaller SI units. After that they have been calculated according to given formulas and adopted coefficients. It is important to mention that the calculation had been performed according to recommendations in document *How to develop a Sustainable Energy Action Plan* i.e. *Guidebook for* SEAP, issued by Office of Covenant of Mayors. According to principles of IPCC the standard emission factors for each kind of energy-generating product had been adopted. Generally speaking, it is necessary to turn overall energy for certain sectors into energy of MWh and multiply it with certain adopted coefficients according to formula.

Team for implementation of SEAP of municipality Gradiška has decided to adopt standard emission factors for each energy-generating product separately as it has been recommended in the Guidelines.

Obtained results are expressed as $\frac{tCO_2}{unit\ of\ time}$

Sectors included in baseline review of emissions

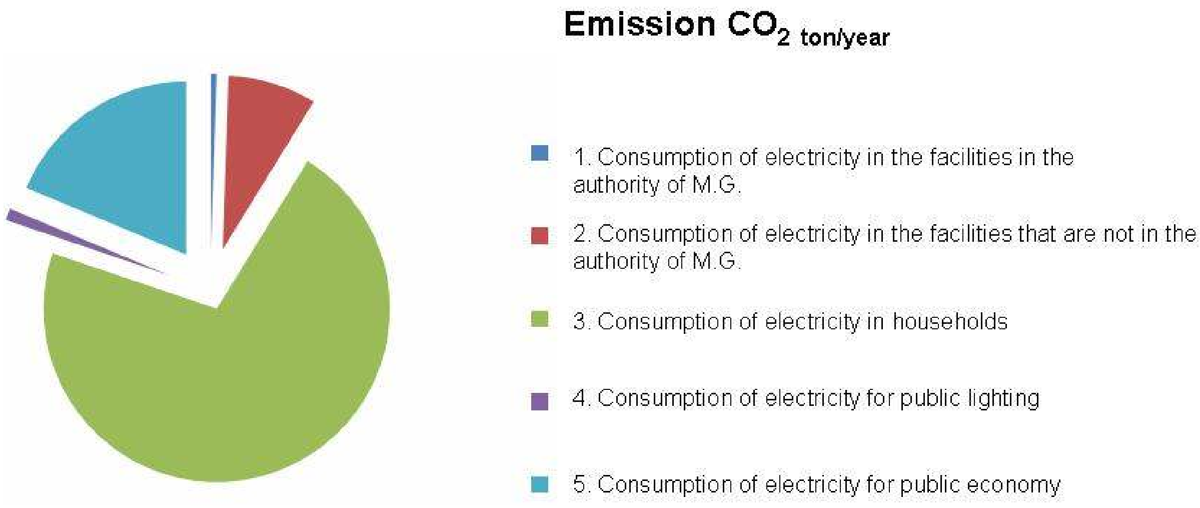
Sector	Subsector	Explanation
Power engineering	Energy delivered to construction engineering	Distribution of energy to subsectors had been performed after gathering data. Exact insight into distribution had been performed on the basis of the state of delivered energy determined in record-keeping.
	Energy of public lighting	
Transport	Cargo motor vehicles	Data had been collected from books of technical review, as well as from SIB Gradiška. Energy had also been divided according to type of fuel and as such separately had been calculated (petrol-diesel fuel). After that calculation had been made. Emission of CO_2 itself for transport is bigger due to the existence of border crossing in the municipality.
	Bus Transportation	
	Car Transportation	
	Transportation of border crossing Gradiška	
Heating plant	Energy delivered to construction engineering	Necessary data had been gathered from evidences on fuel consumption for baseline year. Heating plant of municipality Gradiška exclusively burns fuel oil.
	Energy savings of CO_2 by reconstruction of plant and transition to bio-fuel	
Construction engineering	Administrative and other public facilities in the authority of municipality Gradiška	Construction engineering belongs to the biggest cause of CO_2 emission on the area of municipality Gradiška. Gathering data had been performed from land registers, cadastre, urbanism and surveying lists gathered by field work. Influence of CO_2 emission had been calculated from registered consumed energy (from electro sector, Heating plant and other manners of heating/cooling)
	Public facilities which are not in the authority of municipality Gradiška	
	Facilities for individual and collective housing (households)	
Renewable energy sources	Afforestation	Great surfaces suitable for afforestation are found on the area of municipality Gradiška. Surfaces suitable for afforestation had been defined by field research and insight into Land registers. In that way progressive sink of carbon-dioxide had been calculated proportional to quantity of afforested surfaces.
	Solar energy	Gradiška is a municipality with non-polluted sky, and therefore posses great amount of sun energy. Quantity of saved energy had been calculated for heating collectors that serve for heating the water. The assumption is that water is most commonly heated by electric energy; therefore it had been proportionally calculated.
	Energy which can be produced in agriculture	On the area of municipality Gradiška are found well developed agricultural branches, and therefore there is possibility of using products while producing and processing different agricultural raw materials.

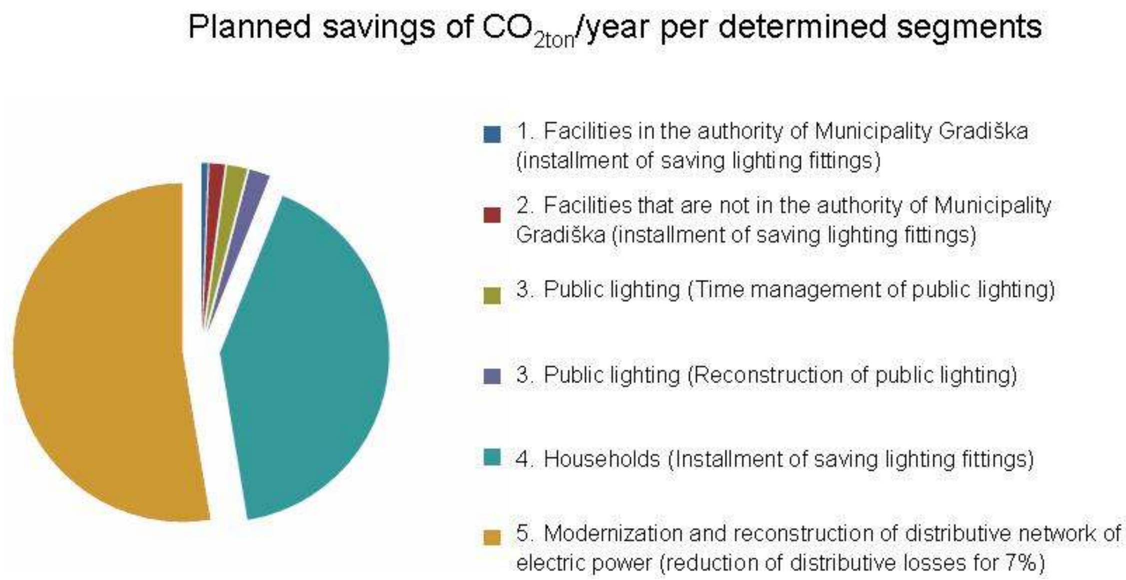
Distribution of electric power

After analysis of data that were gathered by responsible person for sector of power engineering, the charts had been formed which show the quantity of emitted carbon-dioxide on the area of municipality Gradiška for sectors which use this kind of energy.

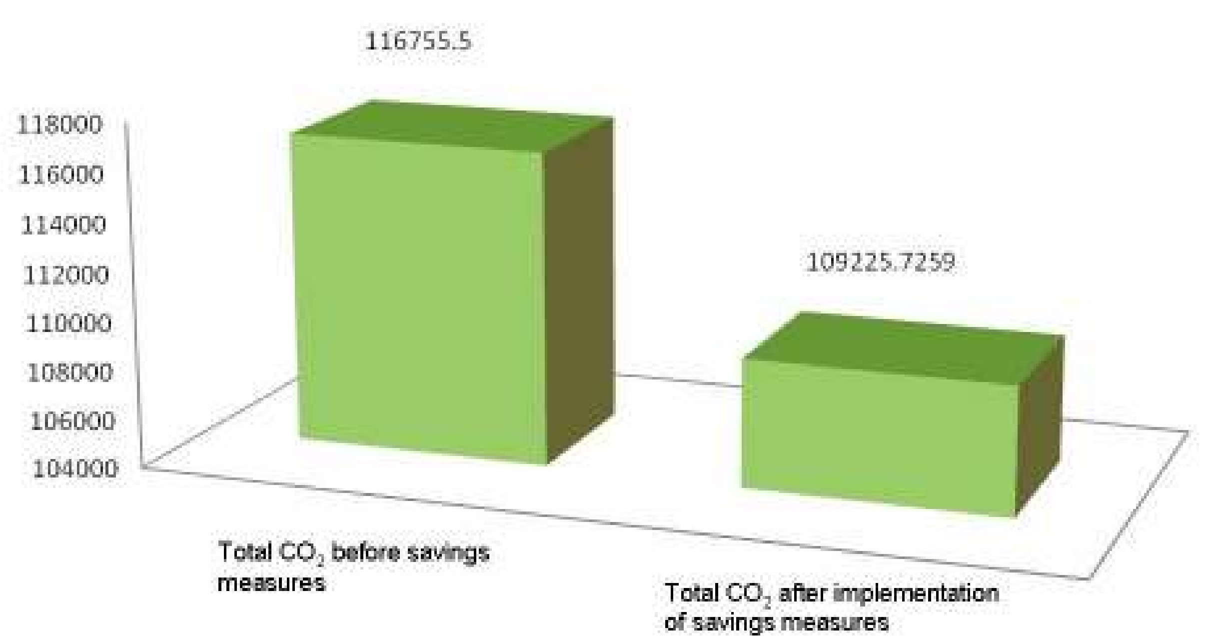
After calculation of emissions of carbon-dioxide, the saving measures have been planned through:

- ✓ Installment of saving lighting fittings
- ✓ Time management of public lighting
- ✓ Reconstruction of public lighting
- ✓ Modernization and reconstruction of distributive network of electric power.





After careful division of distribution of electricity on energy that belongs to construction engineering and energy of public lighting, we have the following chart which shows the relation of carbon dioxide before and after implementation of savings measures regarding public lighting. Planned savings are around 7-8%.

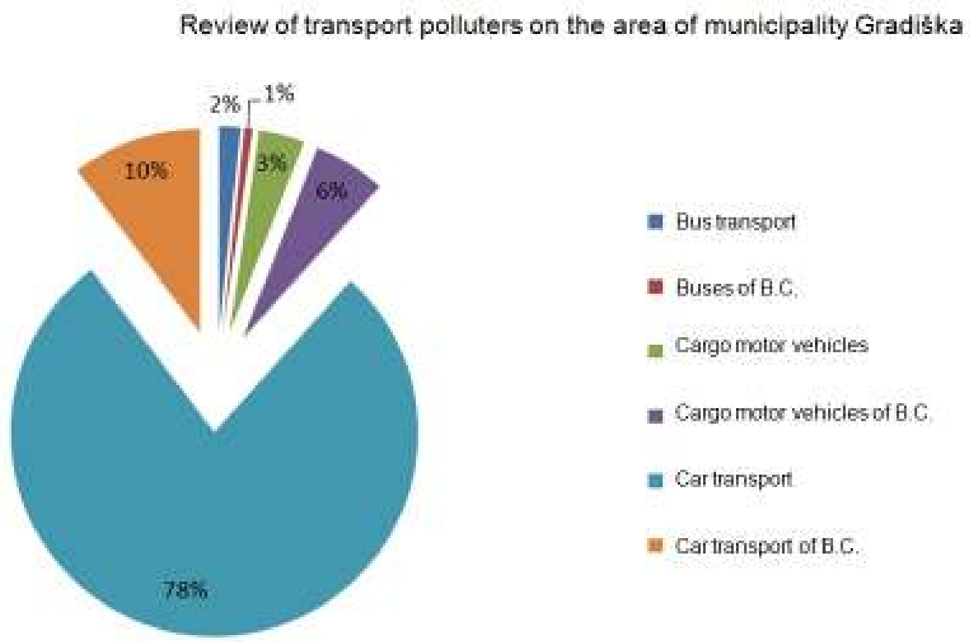


Transport

Aside basic transportation vehicles on the area of municipality Gradiška is also State border crossing. Frequency of transport during surveyed baseline year is not negligible, regarding pollution i.e. emission of harmful carbon-dioxide gas.

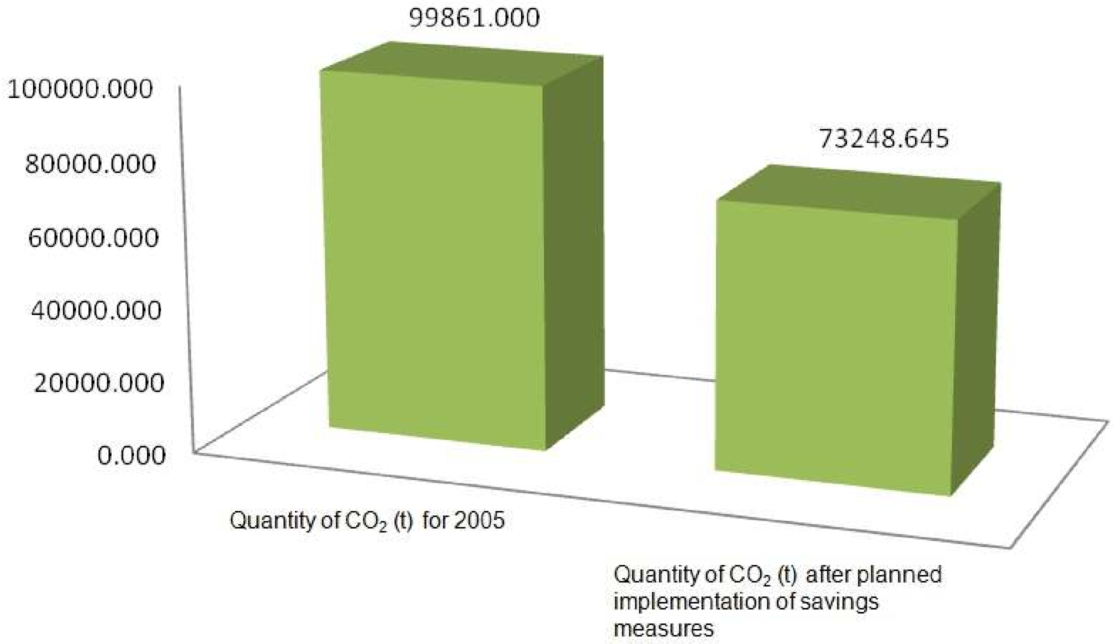
The following subgroups of vehicles had been defined by gathered data on quantity and kind of transportation on area of municipality Gradiška:

Type of transport	CO_2 ton / year
Bus transport	1679,950
Buses of border crossing	663,588
Cargo motor vehicles	3592,815
Cargo motor vehicles of border crossing	5733,858
Car transport	77874,710
Car transport of border crossing	10316,088



Planned savings of CO_2 emissions refer to:

- ✓ Transition of cars onto ecological fuels
- ✓ Increase of number of cars with euro-motors
- ✓ Opening section of high-way Gradiška - Banja Luka
- ✓ Construction of bicycle tracks on stipulated sections

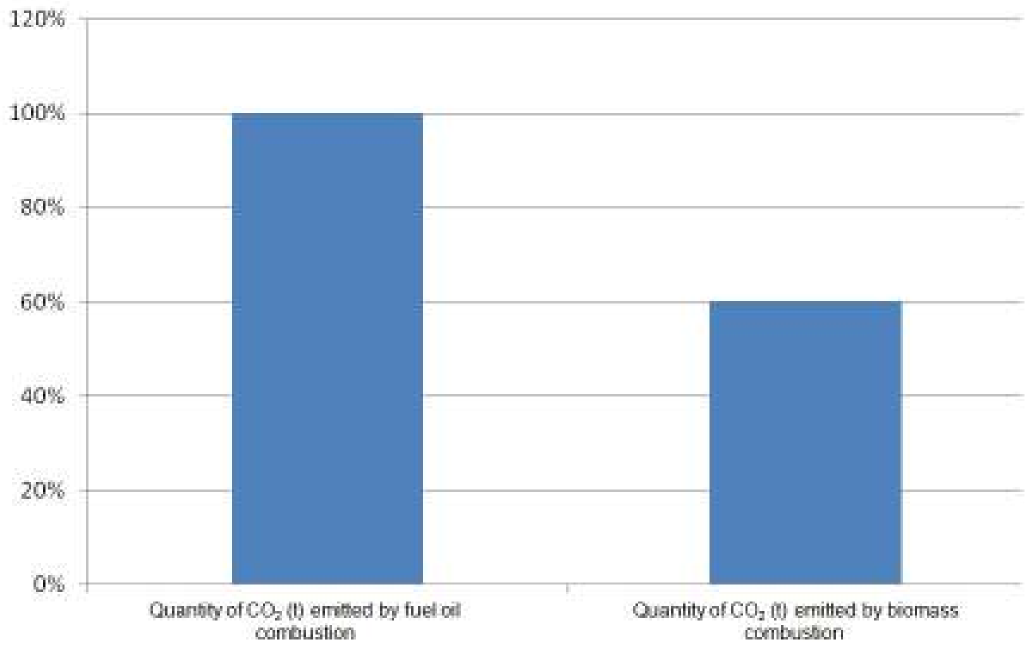


Heating plant

Heating plant is production unit which exclusively serves for heating households, different facilities, and business premises i.e. in general construction engineering. Total produced energy (not including internal losses) is delivered to construction engineering. Savings measures which are directly related for production unit – Heating plant influence on the reduction of carbon-dioxide. That percentage is calculated as delivered energy before and after planned measures of reconstructions and planned combustion of biomass instead of fuel oil.

According to calculation total savings of Heating plant as production unit can be up to 40%. This affects reduction of emission of carbon-dioxide in production of energy which is delivered to construction engineering.

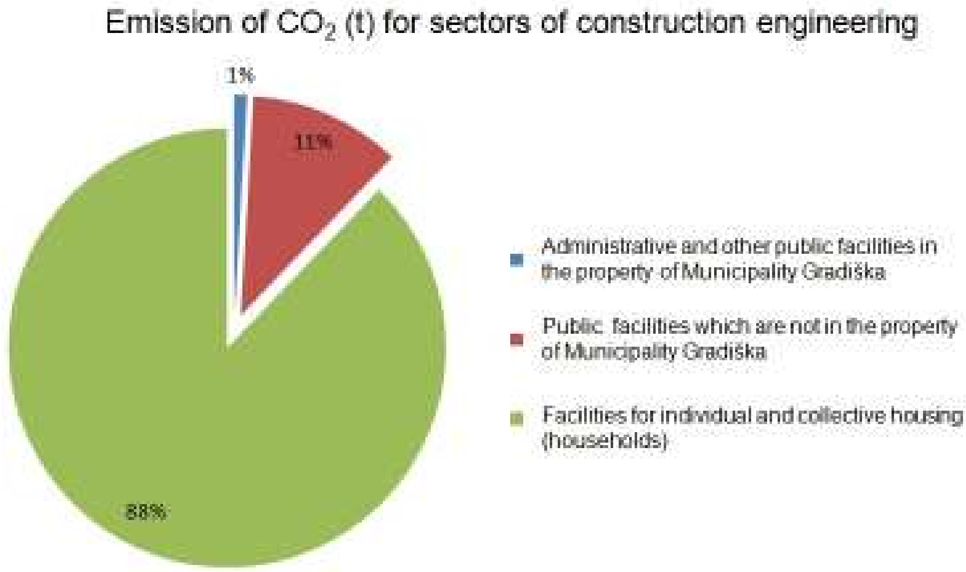
The chart shows savings of emissions of carbon-dioxide for possible use of biomass instead of conventional types of fuels, by implementing measures and adjusting production unit itself:



Construction engineering

A special attention needs to be paid to construction engineering as one of the biggest emitters of carbon-dioxide. By analyzing gathered data for baseline year, the results on consumption of energy-generating products related to heating, cooling and other kinds of consumed energy were established.

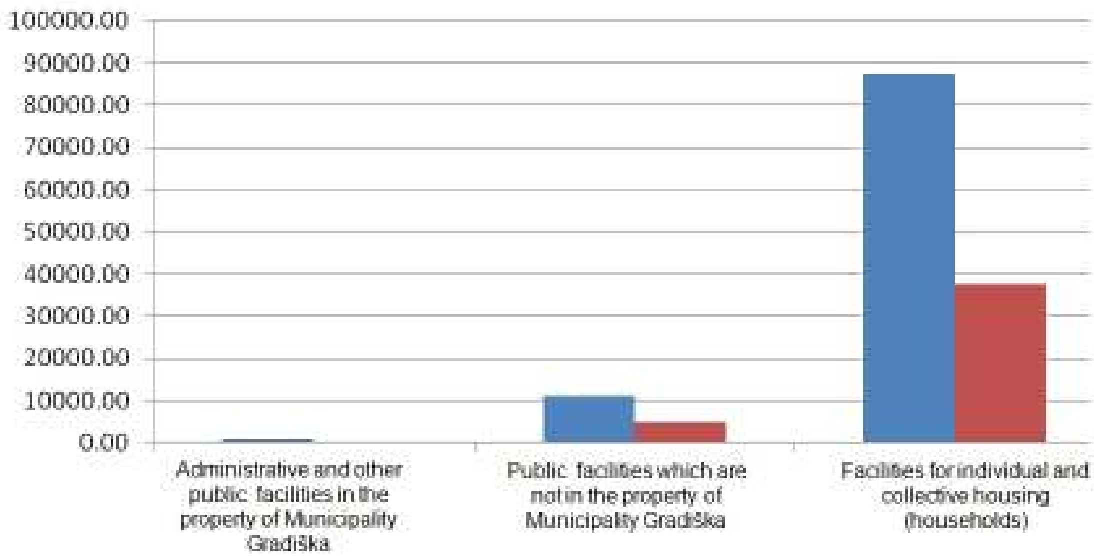
This energy had been converted into MWh by careful division and after summing up through sectors, a simple chart had been created in which can be seen the biggest consumers of energy and therefore the biggest emitters of carbon-dioxide.



By agreement of the Team, planned savings measures of emission of carbon-dioxide related to construction engineering refer to following activities:

- ✓ Roof isolation
- ✓ External walls isolation - facading
- ✓ Isolation of ground floor
- ✓ Replacement of existing windows with saving joinery

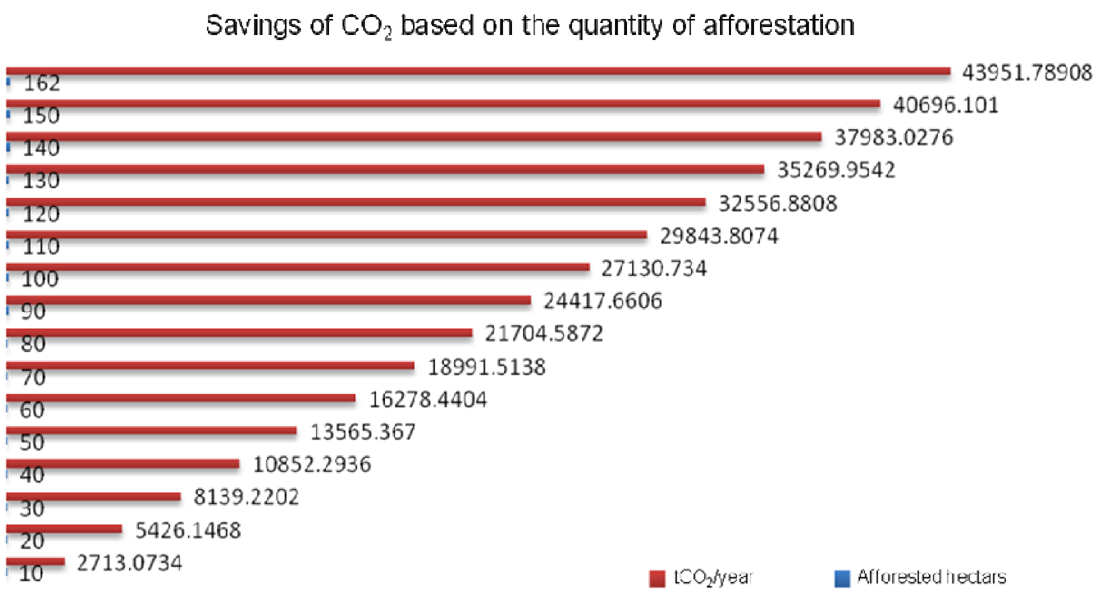
Total savings which can be achieved by implementing these measures are around 57%, which can be seen in table:



Renewable sources

Afforestation

By collecting data on surfaces that are suitable for afforestation, savings measures for emission of carbon-dioxide which directly refer to planned afforestation of those surfaces are defined. From the following chart we can see the relation of saving carbon-dioxide in regard of afforested surfaces in hectares.



Creation of park surfaces

On the basis of the data overtaken from Regulation plan „Gradiška istok“ which was elaborated in 2009, two park surfaces of around 26.000m² and 38.000m² had been planned.

	Surface (ha)	Sink (t) CO_2 / year
Park surface 1	2,6	705,399
Park surface 2	3,8	1030,968

Biomass from forests

By observing renewable energy sources from forests on the area of municipality Gradiška, we have following segments:

- ✓ Biomass from forests – waste brushwood (around 15.000 m³/year)
- ✓ Biomass produced by saw-mill processing of wood (around 15.000m³/year).

On the basis of heating power of the most common trees at us beech-tree, we can conclude that by using this biomass significant quantity of energy would be saved and by that also the emission of carbon-dioxide.

The following table shows the relation of quantity of biomass and energy which could be saved:

Type of biomass	m³/year	MWh/m³	Total MWh/year
Biomass from forests – waste brushwood	15.000	3.064	45.974.25
Biomass produced by saw-mill processing of wood	15.000		45.974.25

Obtained energy can be used as equivalent energy to standard fuels in the plant for production of heating energy. In the case of the municipality Gradiška, it is fuel oil.

Emission of CO_2 for combustion of wood biomass does not count, because it can be considered that tree during its growth absorbs equal quantity of CO_2 which is emitted by its combustion.

Solar energy

It has been determined by certain analysis and calculations that by putting solar collectors on certain facilities in the area of municipality Gradiška[10] would save significant amount of energy. This energy would be used for heating hot water, and as replacement electricity.

By positioning the solar plant for production of electricity for the purposes of one average four-member household in Gradiška it would be saved 6,248MWh a year. To this quantity corresponds to the quantity of emitted CO_2 in the value of 5,19t CO_2.

If we wanted to ensure the energy which served for heating the water for one four-member family for one year than we would have saved 2,01873 of spent MWh for heating the water would reduce the emission of CO_2 for 1,67 t CO_2.

Considering the following table on produced heating energy we can see the quantity of emitted carbon-dioxide for equivalently produced electricity in a classical way. This way of saving would be achieved if the solar panels are installed in certain facilities[11] stated in the table:

Name of the facility	Amount MWh/year	Amount of emission CO_2 (t)/year
1. Residential units in the property of Grammar school	5,61884	4,67
2. Houses for abandoned children and children without parental care	10,37971	8,63
3. Building of the Administrative service of Municipality	4,03748	3,36
4. Grammar school Gradiška	12,54346	10,42
5. Technical school in Gradiška	11,09614	9,22
6. Professional and technical high school in Gradiška	12,41368	10,32

[10] Paper which shows *Possibilities of use of solar energy on the area of Gradiška* is in the Annex of Sustainable Energy Action Plan of municipality Gradiška. Detailed overview of paper on using solar energy is in the data base of Municipal service for monitoring the implementation of SEAP.

[11] Detailed overview of Paper on installment of solar systems on certain facilities on the area of municipality Gradiška is in the in the data base of Municipal service for monitoring the implementation of SEAP.

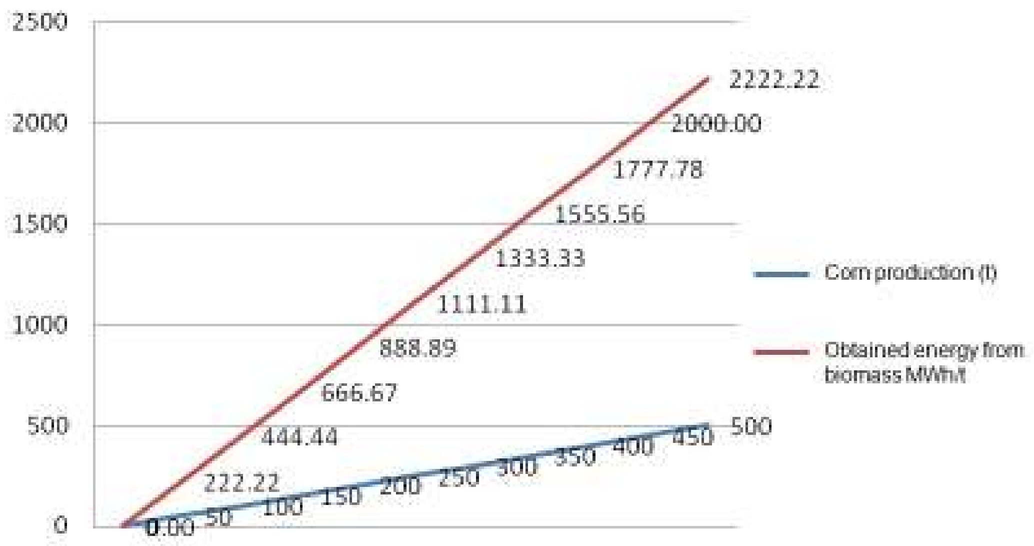
Calculation had also been made for two observed households on the area of the municipality:

Name of facility	Amount MWh/year	Amount of emission CO_2 (t)/year
1. Household 1 (St. Kozarskih ustanika)	1,57523	1.31
2. Household 2 (St. M. G. Nikolajevića)	1,80184	1.5

Agriculture
-Biomass-

The richness of Gradiška region with agricultural land, does not exclude the possibility of using remains of plants' cultivation and their processing. The ration between produced corn grains and remains of biomass have been taken for observation of saving carbon-dioxide. Part of the remains of harvesting corns must be ploughed, but it is estimated that the rest of 30% could be used for biomass.

On the following chart we can see the ratio of produced corn grains and obtained energy from biomass made by their production. Acquired energy linearly grows so it can be adopted for any amount produced of corn grains:

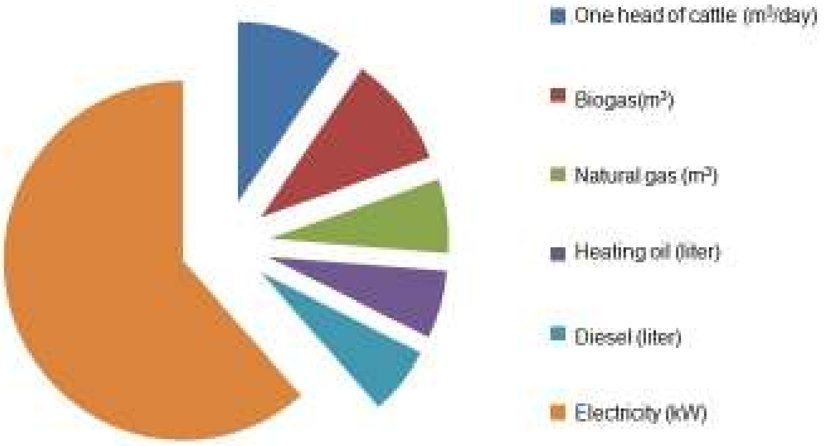


The savings of carbon-dioxide depend on the sector that uses this biomass i.e. energy which it would replace.

Agriculture
-Biogas-

On the basis of the data received from the sector of agriculture, the relation between the energy created from biogas of one unit of head of cattle. Savings of carbon-dioxide depend on the usage of energy gained from biogas produced in this way:

Relation of quantities of energy of biogas and other kinds of fuel					
Biogas (m^3)	Biogas produced from cultivating one head of poultry (m^3/daily)	Natural gas (m^3)	Heating oil (liter)	Diesel (liter)	Electricity (kW)
1	0.95	0.66	0.61	0.61	6.11



Considering that Municipality has two big farms for cattle breeding with the number that overpasses 5.500 heads of cattle, it can be concluded that there is a great potential for production of biogas.

8. Time and financial framework for implementation of measures and activities

Most of the proposed measures in the Action plan has time and financial dimension through which local authority can manage with the process of implementation, but also with the estimate of energy and emission savings in order to acquire insight into the effectiveness of measures. For each of measures it is possible to use a lot of sources of financing that are available to Municipality.

Implementation of measures will require significant investments. Some of the sources of financing that are currently available, are not sufficiently used such as pre-accession funds dedicated to countries candidates and also to countries with the status of the potential candidate for membership in EU, as well as public-private partnerships merged for more economic and efficient business whether it is production, providing services or similar.

Maybe the most important source of financing for project activities during the implementation period would refer to continuous research of possibilities of financing and co-financing of project activities through European funds, including donor funds and suitable credits from different international institutions.

These funds are just some of the sources of financing which would significantly contribute to revival of investment activities.

No.	Projects	Estimated costs (KM)	Estim. reduction of emissions CO_2 (t)	Cost of reduction (KM/ t)	Project duration									
					2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	CONSTRUCTION ENGINEERING, PLANTS / INSTALLATIONS AND INDUSTRY	**38,050,000.00**												
	Administrative and other facilities in authority of Municipality	*2,840,000.00*												
1	Improvement and promotion of building energy efficient existing buildings and new facilitates	1,800,000.00												
2	Installment of saving lighting fittings	200,000.00	81,15	2.464,57										
3	Installment of systems for measuring water and heating energy consumption for facilities in the authority of Municipality	100,000.00	-	-										
4	Implementation of Energy Management Information System (EMIS)	140,000.00	-	-										
5	Installment of thermostatic valve sets on radiators in buildings in the authority of Municipality	200,000.00	-	-										
6	Installment of sensor taps, pissoirs and kits in toilettes, light and ventilation detectors of presence in public facilities	100,000.00	-	-										
7	Energy certification on local level	300,000.00	-	-										
8	Establishing plan on local level for energy review of facilities	xxx	-	-										
	Facilities which are not in the authority of Municipality	*2,460,000.00*												
9	Installment of saving lighting fittings	500,000.00	199,44	2.507,02										
10	Installment of solar systems for heating water in schools	60,000.00												
11	Improvement of energy efficiency of existing buildings	1,000,000.00												

12	Installation of photovoltaic panels for electricity production in schools	200,000.00												
13	Installment of energy highly efficient windows in schools	500,000.00	-	-										
14	Installment of sensor taps, pissoirs and kits in toilette, light and ventilation detectors of presence in public facilities	200,000.00	-	-										
	Residential facilities	*13,700,000.00*												
15	Installment of saving lighting fittings	2,000,000.00	5.502,70	363.46										
16	Installment of thermostatic valves in residential buildings	500,000.00												
17	Installment of house heating system on renewable energy sources with boilers of new generation	5,000,000.00												
18	Installment of solar systems for heating hot water in households	1,500,000.00												
19	Installment of thermal pumps that use heat of underground waters for households needs	700,000.00	-	-										
20	Improvement of energy efficiency of existing residential facilities	4,000,000.00												
	Public lighting	*19,000,000.00*												
21	Modernization and reconstruction of electro-distributive network	17,000,000.00	7.272,08	2.337,71										
22	Time management of public lighting	2,000,000.00	257,70	7.760,96										
	Other: Inspection of energy efficiency in buildings	*50,000.00*												
23	Energy reviews	-	-	-										
24	Installment of frequent regulators in waterworks stations and pools	50,000.00	-	-										
	TRANSPORT	**1,545,000.00**												
	Vehicles of town authority	*40,000.00*												
25	Eco inspection in hybrid or vehicles on electric engine	40,000.00	-	-										

	Public transport	*170,000.00*												
26	Use of bio-diesel in buses of town and suburban transport	150,000.00	67.20											
27	Improvement of logistics of bus network (posting time-table on all bus stations)	20,000.00	-	-										
	Private and commercial transport	*460,000.00*												
28	Construction of bicycle tracks	400,000.00	778,74											
29	Improvement of existing bicycle transport	50,000.00	-	-										
30	Promotion of *car-sharing* and *carpooling* models	10,000.00	-	-										
	Other: *1. Control vehicles* *2. Transport of Border crossing Gradiška*	*875,000.00*												
31	Emergency control of exhausting gases and technical check of vehicles	-	-	-										
32	Displacing of border crossing	700,000.00	668.54											
33	Modernization of traffic signalization on border crossing	100,000.00	83											
34	Installment of device for measuring exhausting gases on border crossing	75,000.00	-	-										
No.	**Project**	**Estimated costs (KM)**	**Estimated reduction of emissions of CO_2 (t)**	**Reduction costs (KM/ t)**	**Project duration**									
					2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	LOCAL PRODUCTION OF ELECTRICITY	**6,400,000.00**												
	Hydro energy	-	-	-										
	Solar energy	*3,500,000.00*												
35	Installation of photovoltaic panels for production of electricity	2,500,000.00	1.462,56	1.709,33										
36	Placing solar panels on roofs of residential, commercial buildings and building of Administrative service	1,000,000.00												

	Combined production of thermal energy and electricity	*1,600,000.00*												
37	Construction of plant for use of energy acquired from biogas, i.e. remains after cattle breeding	1,000,000.00												
38	Construction of plant for processing biomass in form of using the remains of herbal cultivation and their processing	600,000.00	-	-										
	Other: Agriculture Forestry	*1,300,000.00*												
39	Support through incentives to businessmen for growing energy crops	400,000.00	-	-										
40	Construction of Biocomposting plant within Town Communal company	100,000.00												
41	Formation of enterprise for collecting waste wooden biomass for purposes of heating	800,000.00	-	-										
42	Use of biomass in form of waste brushwood and wood from saw-mill processing for the purposes of heating	-	-	-										
	DISTRICT HEATING / COOLING, CHPs	**17,300,000.00**												
	District heating	*17,200,000.00*												
43	Installment of boiler on solid fuel and transition on wooden biomass of Heating plant	10,000,000.00	1.576,00											
44	Reconstruction and modernization of existing heating system	5,000,000.00	472,00											
45	Modernization of heating substations	1,000,000.00	-	-										
46	Installment of devices for monitoring the consumption of delivered energy in Heating plant	1,000,000.00	-	-										
47	Installation of measuring devices of heating energy in new buildings	200,000.00	-	-										

	Other: Geothermal energy	*100,000.00*												
48	Elaboration of study for using geothermal energy for purposes of heating the narrow area of municipality	100,000.00	-	-										
	PLANNING THE USE OF LAND	**680,000.00**												
	Strategic urban planning	*10,000.00*												
49	Integration of EU directive on energy efficiency in construction regulative of Administrative service	10,000.00	-	-										
	Administrative and other facilities in the authority of town	*400,000.00*												
50	Formation of alley network and placing lawns along main and auxiliary traffic lines	100,000.00	100,60											
51	Reconstruction of Vidovdanska street into pedestrian zone	300,000.00	31,00											
	Other: Afforestation	*270,000.00*												
52	Work on projects of afforestation of productive non-shaggy forestry land of FH "Gradiška"	70,000.00												
53	Expending surfaces under parks and allies in narrow and wider town center	200,000.00	868,00											

No.	**Project**	**Estimated costs (KM)**	**Estimated reduction of emissions of CO_2 (t)**	**Reduction costs (KM/ t)**	**Project duration**									
					2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	PUBLIC PROCUREMENT OF PRODUCTS AND SERVICES													
	WORK WITH CITIZENS AND STAKEHOLDERS	**534,000.00**												
	Advisory services													

54	Establishing business clusters for renewable energy sources and energy efficiency	-	-	-										
55	Technical support to preparation, submitting and implementation of projects by EU	-	-	-										
	Financial support and grants													
56	Funds of state and foreign funds as well as local funds of public and private partnerships	-	-	-										
	Raising public awareness	*364,000.00*												
57	Placing info box on energy efficiency in the counter-service hall of the Administrative service of municipality Gradiška	4,000.00	-	-										
58	Continuous informing consumers on possibilities of energy savings through short messages on the back of the bills for electricity	150,000.00	-	-										
59	Conducting theme campaigns for raising awareness of citizens on energy efficient lighting, certification of green building, biocomposting and other renewable energy sources	10,000.00	-	-										
60	Organizing education for key actors and employees in public facilities on technical-technological aspects of improvement of energy efficiency and given methods and means of project action	-	-	-										
61	Support to local bio-composting per households	-	-	-										
62	Support in co-financing of pilot projects from the area of ecology and renewable energy sources	200,000.00	-	-										
	Training and education	*170,000.00*												
63	Education in the area of improvement of energy efficiency in schools	5,000.00	-	-										

64	Organizing traditional manifestations Day without cars, Week of town regulation, “Biciklijada” – Bicycle race	150,000.00	100,60											
65	Preparation of manual for energy efficient designing	15,000.00	-	-										
66	In cooperation with NGO organize workshops and round tables on topic of reduction of emission of greenhouse gases and measures which citizens can apply themselves in order to achieve energy efficiency in their own home	-	-	-										
	OTHER SECTORS - specify	**90,000.00**												
67	Monitoring of air, land and water source quality	40,000.00	-	-										
68	Maintenance of greenhouse gases inventory for the area of municipality Gradiška	50,000.00	-	-										
	TOTAL	**64,599,000.00**												

9. Conclusions and recommendations

Elaboration of Sustainable Energy Action Plan of municipality Gradiška was developed with support of Development program of United Nations in Bosnia and Herzegovina. Action plan consists of greater number of necessary measures for reduction of CO_2 emissions for more than 20% till 2020, in accordance with the Strategy of European Commission and Covenant of Mayors.

Municipality Gradiška will work on activities which are directed towards change of behaviour of employed officials and citizens. Those are measures which according to experience of other countries can bring savings, and which do not require too much funds, but require constant engagement through educational activities, workshop organization, creation and distribution of leaflets and brochures.

Parallel to so-called *soft* measures, local authority will work on development of repair plan of buildings in the authority of Administrative service, town enterprises and institutions for which will be at the same time defined models of financing. In order to support measures for reduction of spent energy in private, service and commercial facilities, the proposal of model of co-financing for projects of repairment will be designed.

Data on energy emissions of CO_2 are collected on the basis of different energy sectors and categories for baseline year 2005. Action plan shows that the biggest consumer is sector of construction engineering with total emissions of CO_2 from 100.911.12 t, and than comes the transport sector with 100.298.92 t. Difference between these two sectors amounts to 612.2 t CO_2/year.

When talking about savings in emissions of CO_2, electric power sector with public lighting participates in small percentage in total planned quantities of reduction of CO_2 emissions, but financial savings are significant. This is a reason why municipality Gradiška still looks for development of this segment through further modernization by replacement of lighting fittings and regulation of light flux.

In the transport sector great role has further development of technology and increase of representation of electric and hybrid vehicles, replacement of old vehicles by modern types with small emissions of CO_2 as well as displacing Border crossing Gradiška from the narrow town center. Traffic infrastructure of municipality, even though it is well developed, still lacks a number of pedestrian and bicycle tracks, so citizens would use cars less. Because of that local authority already has started initiatives and projects which would result in development of alternative public transportation on principles of sustainable development.

Action plan contains also significant research on possibilities of using solar energy on area of municipality Gradiška. It is important to mention here that greater economic justification of constructing solar system for production of hot sanitary water and electricity, as well as in Gradiška and in the Republic of Srpska, would be in case if there was possibility of higher subsidies of state and good credit conditions. In that way shorter time period would be necessary for seeing the cost effectiveness of this plant.

Local authority, local investors, citizens and non-government associations together with their local and national authorities and European Union share responsibility of pollution. Therefore it is necessary to actively engage in fight against local and global warming, by programs of energy efficiency and renewable energy sources.

Literature

Administrative service of municipality Gradiška (2004): Develop*ment Strategy of municipality Gradiška 2005-2012*. University of Banja Luka, Faculty of Economics, Banja Luka.

Administrative service of municipality Gradiška (2006): *Local Ecological Action Plan-LEAP*. Agency for local development, Gradiška.

Administrative service of municipality Gradiška (2007): *Spatial plan of municipality Gradiška 2005-2020*. Urbanistical institute of the Republic of Srpska a.d., Banja Luka.

Administrative service of municipality Gradiška (2007): *Regulation plan area of town center „Izlaz na Savu" in Gradiška*. AD Projekt, Banja Luka.

Administrative service of municipality Gradiška (2007): *Urbanistical plan of Gradiška 2002-2017*. Proposal plan, Urbanistical institute of RS a.d., Banja Luka.

Babić, S. et. al. (2010): Biocomposting plant Gradiška-experimental phase. In: "*Program rada i zbornik sažetaka-I simpozijum ekologa Republike Srpske"*. Banja Luka, University in Banja Luka, Faculty of sciences, pp. 44.

Bulović, C. (2005): *Prošlost Gradiške*. Gradiška.

Covenant of Mayors [online]. Available on: http://www.eumayors.eu, content up to date 2012.

Đonlagić, M. (2010): "*Obnovljivi izvori energije"*. Study on renewable energy sources in B&H, Center for ecology and energy, d.o.o. Off-Set, Tuzla.

EEA-European Environment Agency [online]. Available on: http://www.eea.europa.eu, content up to date 2012.

EUROPEAID- European Commission [online]. Available on: http://www.ec.europa.eu, content up to date 2012.

EUROSTAT-European Commission [online]. Available on: http://epp.eurostat.ec.europa.eu, content up to date 2012.

FAO- Food and Agriculture Organization of the United Nations World [online]. Available on: http://www.fao.org/ag/agn/agns/jecfa_index_en.asp, content up to date 2012.

Govedar, Z. (2011): "*Gajenje šuma-ekološke osnove"*. Grafomark Laktaši. Banja Luka.

Town Banja Luka-UNDP (2010): *Sustainable Energy Action Plan*. Banja Luka.

Information development project center BL-IRPC (2001): "*Šumsko privredna osnova za period 2001-2010"*. Banja Luka

Institute for protection, ecology and computer science (2010): *Monthly report on results of control of aero-pollution on location Pumping station quay Gradiška*. Banja Luka.

Jones, M. H., Curtis, P. S. (2000): *Bibliography on CO_2*. E.f.f.c.t.s on vegatation and ecosystems. 1990-1999 literature, ORNL/CDIAC-129. Oak-RIDGE-national laboratory.

Jukić, E. (1953): "*Putopis i istorijsko-etnografski radovi"*. Svjetlost Sarajevo.

Krivokapić, B. et. al. (2008): "*Istorija Bosanske Gradiške i njene okoline"*. Gradiška.

Mihić, Lj. (1987): "*Kozara, priroda,čovjek-istorija"*. Dnevnik, Novi Sad.

Ministry for spatial planning, civil engineering and ecology of RS (2007): *Republic strategy for air protection with action plan for management of air quality 2010-2016.,* Draft, Banja Luka.

Ministry of environment protection, spatial planning and civil engineering (2006): *Techno-economic guidelines of sector programs for reducing emissions of greenhouse gases,* Draft. Energy and environment protection Institute, Zagreb.

Newman, P., Jennings, I. (2008): *Cities as sustainable ecosystems: principles and practices*. Island Press.

Municipality Gradiška [online]. Available on: http://www.opstina-gradiska.com, content up to date 2012.

Petrić, J. (2004): *Sustainability of the city and its ecological footprint*. Spatium.

Municipal Assembly of Gradiška (2009): "*Gradiški zbornik, časopis za društvena pitanja"*. Srpsko prosvjetno i kulturno društvo „Prosvjeta", Gradiška.

Official gazette of the Republic of Srpska (1996): *Law on space regulation*. Banja Luka, Official gazette of RS, No. 19/96, 25/96, 84/02, 14/03, 112/06, 53/07 and 55/10.

Official gazette of the Republic of Srpska (2010): *Law on space regulation*. Banja Luka, Official gazette of RS, No. 19/96, 55/10.

Stefanović, V. (1986): *Fitocenologija sa pregledom šumskih fitocenoza Jugoslavije*, Second expaned and amended edition. Sarajevo.

Strunić, M. (2008): *Privredni razvoj Gradiške opštine od 1945. do 1990. godine*. Gradiška.

Šimleša, D. (2010): *Ekološki otisak*. Institute of social sciences "Ivo Pilar", Zagreb.

Šljivac, D., Šimić, Z. (2011): *Obnovljivi izvori energije*. Society for shaping sustainable development, Zagreb.

Government of the Republic of Srpska (2009): *Development strategy for energy of the Republic of Srpska*, Initial report, Draft. Institute of Economics a.d. Banja Luka and Institute of Energy "Hrvoje Požar", Zagreb/Banja Luka.

Annex

Possibility of using solar energy on the area of municipality Gradiška

Content

INTRODUCTION

In the Annex is viewed possibility of installment of solar panels in the residential facility of one average four-member household on the territory of Gradiška. As output data will be given results on possibility of electricity production from solar panels, possible income of selling electricity to Elektroprivreda RS (for calculation of selling will be used two tariffs and the one currently valid and tariff upon proposal of Regulatory Commission for energetics of RS (REERS) which Government of RS still have not adopted) and the price of such plant.

Than it will be viewed the possibility of positioning solar collectors for preparation of sanitary hot water for one average four-member household in Gradiška. There as output data will be presented how much sun energy can be converted into heat, how much is the cost of one such installation and how much money can be saved by heating sanitary water in that way.

In the remaining part of this work, the possibilities for installation of solar systems for heating sanitary water on some facilities in the property of Municipality. Here also will be presented how much energy can be produced by such plants, how much is the money savings and how much is the price of such plant.

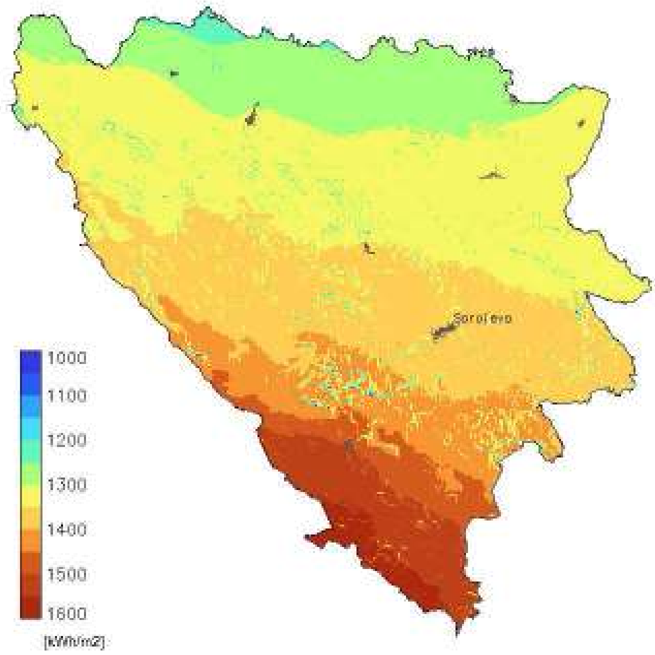
In the last part of the Annex it will be viewed how much solar energy was used in Gradiška in 2005.

Data on sun radiation for area of Gradiška

Very important climate element for converting sun radiation into certain form of energy is totally radiated sun energy onto the horizontal surface. By radiating horizontal surface with total sun radiation is defined total available energy that enters into the process of converting energy.

Data on quantity of solar radiation on the area of Gradiška are not available, i.e. most likely these measurings were not performed therefore in further analysis instead of Gradiška (due to the relative territorial proximity) the data on quantity of sun radiation on the area of Banja Luka were used. Those data were taken from the Study of energy sector B&H, Module 12 [1], which relates to consumption management, energy savings and renewable energy sources.

On picture 1. is shown the map of spatial division of annual irradiation on horizontal surfaces on the area of BiH by total sun radiation.



Picture 1. Annual irradiation of horizontal surface by total sun radiation [1]

Data that were taken from module 12 are given in table 1.

Table 1. Data on sun radiation for Banja Luka, and which were adopted for Gradiška also [1]

Month	Daily irradiation of inclined surface towards south by total sun radiation [kWh/m2/day]						opt. angle [°]	D/G	air Temp. [°C]	Degree days of heating
	Angle of slope									
	0°	15°	25°	40°	90°	opt. angle				
January	1,253	1,629	1,838	2,074	2,017	1,992	63	0,6	2,5	465
February	1,960	2,388	2,613	2,841	2,499	2,767	55	0,6	5	342
March	3,104	3,529	3,725	3,866	2,927	3,833	43	0,5	7,9	285
April	4,292	4,591	4,679	4,623	2,880	4,672	29	0,5	12,3	86
May	5,334	5,475	5,437	5,174	2,720	5,309	16	0,5	18	22
June	5,775	5,816	5,710	5,337	2,566	5,517	11	0,5	21,5	8
July	6,287	6,415	6,340	5.977	2,901	6,158	15	0,4	22,7	2
August	5,345	5,661	5,729	5,590	3,205	5,680	25	0,4	23,3	13
September	4,047	4,586	4,822	4,965	3,542	4,939	41	0,4	17,4	60
October	2,543	3,067	3,338	3,599	3,048	3,517	52	0,5	13,6	209
November	1,456	1,832	2,038	2,261	2,115	2,186	60	0,6	8,3	382
December	1,027	1,329	1,499	1,690	1,656	1,624	63	0,7	1,8	531
AVERAGE	3,544	3,868	3,988	4,006	2,673	4,023	34	0,5	12,9	-
TOTAL	1293,7	1411,9	1455,7	1462,2	975,8	1468,4	-	-	-	2405

Ratio D/G represents the share of dispersed in the total sun radiation.

1. POSSIBILITY OF INSTALLATION OF SOLAR PANELS ON RESIDENTIAL FACILITY OF ONE AVERAGE GRADIŠKA's HOUSEHOLD IN THE PURPOSE OF ELECTRICITY PRODUCTION

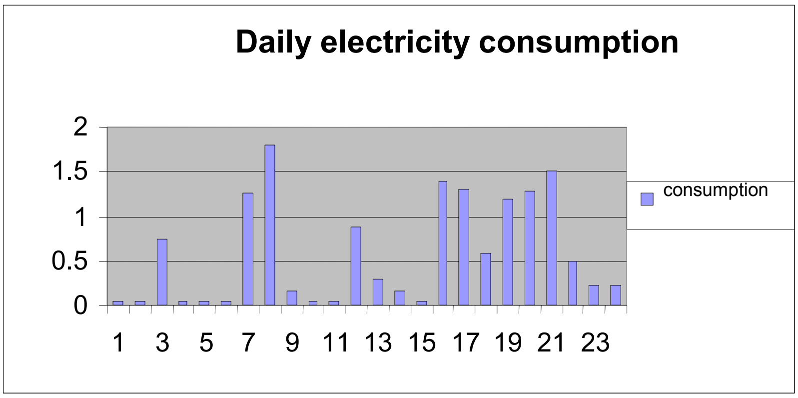
1.1. Balance of needs for electricity for four-member household

For dimensioning of the necessary size of solar panel, it is necessary to gain insight into the quantity of expected annual consumption of electricity of average four-member household [8]. For the purposes of this work, the results of researching daily consumption of electricity of average household is 13,853 kWh/day i.e. 5056,34 kWh/year, and they are given in table 12. These data are obtained on the basis of the reference of the Regulatory Commission for energetics of Republic of Srpska (REERS) [5]

Table. 2. Average daily electricity consumption in household in kWh

hours	00÷01	01÷02	02÷03	03÷04	04÷05	05÷06	06÷07	07÷08
kWh	0,042	0,042	0,742	0,.042	0,.042	0,042	1,267	1,799
hours	08÷09	09÷10	10÷11	11÷12	12÷13	13÷14	14÷15	15÷16
kWh	0,168	0,042	0,042	0,868	0,294	0,168	0,042	1,4
hours	16÷17	17÷18	18÷19	19÷20	20÷21	21÷22	22÷23	23÷00
kWh	1,302	0,588	1,197	1,288	1,498	0,504	0,217	0,217

On the following picture is show diagram of daily consumption of household where on X-axis are hours in which consumption had been measured, and on the Y-axis is consumption in kWh.



Picture 2. Diagrams of average hour consumption of electricity in household in kWh

1.2 Model proposal of using sun energy

By analyzing projects related to household which receive electricity from solar panels, and which are available on the internet, it is probably better to guide oneself with the ideas and project solutions which are in the immediate surroundings because climate conditions are much similar to Banja Luka area. Such projects which are in the surroundings are for example Solar roof Špansko in Zagreb [6] and Micro sun electricity plant Vincetić in Čakovac [7] and one dislocated residential facility on the Island Vis [8].

Upon these three projects, it has been adopted that these solar panels are used for one overage four-member household in the Gradiška area, to be made of mono-crystal silicon. The price of the mono-crystal silicon is higher than of poly-crystal and amorphous silicon, but it has higher degree of utilization and longer warranty period. Also, it has been adopted that solar panels do not use system for monitoring Sun, but to be fixed on the roof or on construction which is set on the ground. This is because, even though the system with monitoring of Sun is better because it absorbs bigger amount of daily sun light and therefore it produces bigger amount of electricity, but also its price is higher and according to [7] higher are the maintenance expenses.

According to data from table 1, it has been adopted that solar panels should be oriented towards south under the angle of $\beta=34^{o}$, which is optimal for work of fixed solar panels on this area, and which would work during whole year.

Since the household is connected to electricity network, it has been selected interactive photovoltaic network system where household uses electricity network as reservoir of energy. This means that household over day will submit into network extra produced energy, and take from it the energy in days when photovoltaic modules cannot produce enough quantity of electricity for example at night or during cloudy days. Because of the interactive use of network in this work it has not been stipulated use of battery for storage of electricity, even though in practices such systems are possible. In that way, investment costs regarding batteries and their charger had been avoided.

1.3. Calculation of necessary size of solar panel

While dimensioning the size and necessary number of modules, the idea was to use modules of similar power like in some examples from surroundings (Solar roof Špansko in Zagreb [6], facility on Island Vis [8] and Micro-sun electric plant Vincetić in Čakovac [7]). Therefore it has been adopted that total power of installed panel should be closely to $P_{uk}=6[kW]$.

In order to calculate the potentially produced quantity of energy, it is necessary to know how much the losses are in the system. The equipment is chosen from the catalogues of companies „Solaris Novigrad“[9] and „Solar projekt“ Split [10]. According to the catalogue of company „Solaris Novigrad“, the module type SLA240M whose maximum power is $P_{max}=240[W]$, surface $A_M=1,634[m^2]$ and coefficient of use of module $\eta_{fn}=0,147$ had been chosen.

Losses in this system are following:

- $\eta_M=0,147$ – coefficient of use of PV module;
- $\eta_g=0,8$ – share of utilization of power of PV module for 25 years of working life (considered had been stops, repairs and other);
- $\eta_{inv}=0,95$ – coefficient of utilization of inverter;

Once these data had been considered, the necessary number of modules is obtained by following procedure:

$$N_M = \frac{P_{uk}}{P_{max}} \qquad (1)$$

$N_M = \frac{6000}{240} = 25$ because of the easier arrangement of modules in space, it is adopted that necessary is N_M=24 modules.

Where it is:

- N_M – number of necessary modules;
- P_{max} – power of one module type SLA240M;
- P_{uk} – estimated total power of panel upon other such examples.

1.4. Calculation of daily irradiation of panels

Production of electricity from solar panels depends on the intensity of sun light which reaches onto the panel, taking into consideration that PV modules absorb aside direct also diffuse and reflected radiation [8], [14].

In order to know how much is the average intensity of Sun radiation on the inclined surface during each hour in one day for certain month, it is necessary to calculate how much are the daily irradiations of the horizontal surface during each hour in one day for certain month first. The simulation programHOMER [11] had been used for that purpose. This program is used for economic-energy simulation of work of hybrid systems of alternative energy sources. It had been used for discovering quantity of radiated energy for each full hour (for example 8÷9, 9÷10, 10÷11, etc. hours) averagely for each month and onto the horizontal surface, and all that on the basis of data on daily irradiation of horizontal surface from table 1. In the end, on the basis of those hour data on irradiation of horizontal surface, irradiation of inclined surface are calculated during each hour with the Liu and Jordan formula (2).

Such, a bit extended procedure, was necessary because there is no available data on hour irradiation of inclined surface on the observed area. That's why these data are obtained on the basis of data on hour irradiation of horizontal surface and with the expression (2).

Values of daily irradiation for each month, which are calculated with this simulation program, are given in the following table.

Table 3. Intensity hour irradiation on horizontal surface according to HOMER in kWh/m².

days\hours	05÷06	06÷07	07÷08	08÷09	09÷10	10÷11	11÷12	12÷13
15-Jan	-	-	0,013	0,072	0,136	0,198	0,210	0,221
15-Feb	-	0,001	0,045	0,117	0,198	0,261	0,315	0,318
15-Mar	0,0007	0,038	0,135	0,246	0,364	0,399	0,407	0,402
15-Apr	0,0002	0,031	0,130	0,245	0,351	0,420	0,524	0,511
15-May	0,014	0,096	0,206	0,349	0,426	0,514	0,567	0,588
15-Jun	0,029	0,121	0,235	0,346	0,438	0,539	0,620	0,655
15-Jul	0,0167	0,103	0,22	0,358	0,505	0,589	0,684	0,714
15-Aug	0,0007	0,051	0,168	0,306	0,415	0,516	0,586	0,613
15-Sep	-	0,01	0,099	0,209	0,346	0,438	0,508	0,522
15-Oct	-	-	0,029	0,125	0,213	0,333	0,340	0,365
15-Nov	-	0,001	0,050	0,119	0,182	0,224	0,234	0,223

15-Dec	-	-	0,016	0,065	0,121	0,168	0,184	0,177
days\hours	13÷14	14÷15	15÷16	16÷17	17÷18	18÷19	19÷20	20÷21
15-Jan	0,186	0,136	0,065	0,012	-	-	-	-
15-Feb	0,262	0,229	0,145	0,060	0,004	-	-	-
15-Mar	0,406	0,328	0,216	0,123	0,034	0,0002	-	-
15-Apr	0,533	0,497	0,409	0,313	0,210	0,099	0,012	-
15-May	0,606	0,542	0,506	0,431	0,277	0,153	0,051	0,001
15-Jun	0,665	0,579	0,51	0,427	0,309	0,195	0,088	0,012
15-Jul	0,723	0,663	0,596	0,465	0,329	0,216	0,091	0,009
15-Aug	0,647	0,611	0,525	0,412	0,281	0,165	0,042	0,0003
15-Sep	0,532	0,472	0,391	0,290	0,171	0,050	0,001	-
15-Oct	0,362	0,320	0,237	0,163	0,052	0,001	-	-
15-Nov	0,194	0,149	0,072	0,004	-	-	-	-
15-Dec	0,142	0,104	0,045	0,0008	-	-	-	-

Winter and summer time calculation had been taken into consideration.

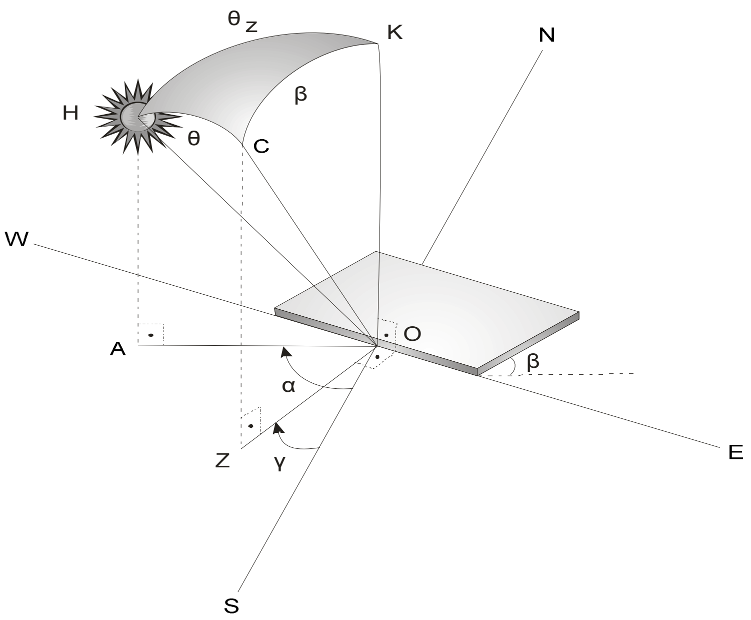
Values of total irradiation of inclined board had been calculated on the basis of the formula of Liu and Jordan [12], and they are later shown in table 12. In the expression (2) it has been assumed that the diffuse radiation of sky is isotropic, as well as that the reflected radiation is also isotropic.

$$H_\beta = H_{b\beta} + H_{d\beta} + H_{r\beta} = \left[\left(1 - \frac{H_d}{H}\right)\cdot R_b + \frac{H_d}{H}\cdot\frac{1+\cos\beta}{2} + \rho\cdot\frac{1-\cos\beta}{2}\right]\cdot H \qquad (2)$$

Where it is:

- H_β – total hour irradiation on inclined board;
- $H_{b\beta}$ – total hour direct irradiation on inclined board;
- $H_{d\beta}$ – total hour diffuse irradiation on inclined board;
- $H_{r\beta}$ – total hour reflected irradiation on inclined board;
- H – total hour irradiation on horizontal board (values given in table 1);
- H_d / H – share of diffuse radiation in total radiation for horizontal surface (given in table 1.);
- ρ – reflection factor (albedo) it is adopted that it is ρ=0,27;
- $\beta=34^o$ – angle of slope of recipient surface;
- $R_b=\cos\theta/\sin(h)$ – slope coefficient of direct radiation;
- θ – angle of entrance of sun rays is the angle between normal on the surface and sun rays;
- h – height of the Sun.

For easier understanding of this expression, on picture 1 are shown angles which are necessary for defining sun position and orientation of recipient surface.



Picture 3. Different angles which define entrance of sun rays onto the inclined surface

Procedure and expressions which are necessary for acquiring the value R_{b}, i.e. θ and α, for each hour during day and during year are shown and explained in the literature [13]. In further text only formulas and table values which are necessary for the calculation and which are calculated in Excel are given.

Table 4. Data on position of Gradiška and solar panel

Geographic latitude for Gradiška	$\varphi=45{,}14^{o}$
Geographic longitude for Gradiška	$L=17{,}25^{o}$
Standard meridian for B&H	$Lst=15^{o}$
Slope of the panel	$\beta=34^{o}$
Azimuth of panel	$\gamma=0^{o}$

The angle of declination for any day a year can be calculated with the expression (3) and the values are given in table 5:

$$\delta=23{,}5\cdot\sin\left[360\cdot\left(\frac{284\cdot n}{365}\right)\right] \qquad (3)$$

Where *n* is ordinal number of days a year starting from 1. January.

Important data is also the solar time which is given by following expression and table 6.

$$\text{Solar time} = \text{Local time} + ET \pm 4(L_{st} - L_{loc}) \qquad (4)$$

Where it is:

- L_{st} – standard meridian for local time zone;
- L_{loc} – geographic longitude;
- ET – equitation of time.

$$ET=229{,}2 \cdot (0{,}000075+0{,}001868 \cdot \cos B-0{,}032077 \cdot \sin B-0{,}01465 \cdot \cos 2B-0{,}04089 \cdot \sin 2B) \qquad (5)$$

Where it is $B = (n-1)\frac{360}{365}$.

Values of time equation and „B“ are given in table 5

Table 5. Values of parameters necessary for determination of sun time

Days	Day in year - n	Declination of Sun - δ [º]	B [º]	Equitation of time - ET [`]
15.Jan	15	-21,269	13,808	-8,641
15.Feb	46	-13,289	44,384	-14,261
15.Mar	74	-2,819	72	-9,635
15.Apr	105	9,415	102,575	-0,229
15.May	135	18,792	132,164	3,938
15.Jun	166	23,314	162,740	-0,029
15.Jul	196	21,517	192,329	-5,793
15.Aug	227	13,784	222,904	-4,884
15.Sep	258	2,217	253,479	4,649
15.Oct	288	-9,599	283,068	14,419
15.Nov	319	-19,148	313,644	15,153
15.Dec	349	-23,335	343,233	4,927

Table 6. Values of sun time in decimal record.

Days/hours	0,5	1,5	2,5	3,5	4,5	5,5	6,5	7,5
15.Jan	0,553	1,553	2,553	3,553	4,553	5,553	6,553	7,553
15.Feb	0,460	1,460	2,460	3,460	4,460	5,460	6,460	7,460
15.Mar	0,537	1,537	2,537	3,537	4,537	5,537	6,537	7,537
15.Apr	0,693	1,693	2,693	3,693	4,693	5,693	6,693	7,693
15.May	0,763	1,763	2,763	3,763	4,763	5,763	6,763	7,763
15.Jun	0,697	1,697	2,697	3,697	4,697	5,697	6,697	7,697
15.Jul	0,601	1,601	2,601	3,601	4,601	5,601	6,601	7,601
15.Aug	0,616	1,616	2,616	3,616	4,616	5,616	6,616	7,616
15.Sep	0,775	1,775	2,775	3,775	4,775	5,775	6,775	7,775
15.Oct	0,938	1,938	2,938	3,938	4,938	5,938	6,938	7,938
15.Nov	0,950	1,950	2,950	3,950	4,950	5,950	6,950	7,950
15.Dec	0,779	1,779	2,779	3,779	4,779	5,779	6,779	7,779
Days/hours	8,5	9,5	10,5	11,5	12,5	13,5	14,5	15,5
15.Jan	8,553	9,553	10,553	11,553	12,553	13,553	14,553	15,553
15.Feb	8,460	9,460	10,460	11,460	12,460	13,460	14,460	15,460
15.Mar	8,537	9,537	10,537	11,537	12,537	13,537	14,537	15,537
15.Apr	8,693	9,693	10,693	11,693	12,693	13,693	14,693	15,693
15.May	8,763	9,763	10,763	11,763	12,763	13,763	14,763	15,763
15.Jun	8,697	9,697	10,697	11,697	12,697	13,697	14,697	15,697

15.Jul	8,601	9,601	10,601	11,601	12,601	13,601	14,601	15,601
15.Aug	8,616	9,616	10,616	11,616	12,616	13,616	14,616	15,616
15.Sep	8,775	9,775	10,775	11,775	12,775	13,775	14,775	15,775
15.Oct	8,938	9,938	10,938	11,938	12,938	13,938	14,938	15,938
15.Nov	8,950	9,950	10,950	11,950	12,950	13,950	14,950	15,950
15.Dec	8,779	9,779	10,779	11,779	12,779	13,779	14,779	15,779
Days/hours	16,5	17,5	18,5	19,5	20,5	21,5	22,5	23,5
15.Jan	16,553	17,553	18,553	19,553	20,553	21,553	22,553	23,553
15.Feb	16,460	17,460	18,460	19,460	20,460	21,460	22,460	23,460
15.Mar	16,537	17,537	18,537	19,537	20,537	21,537	22,537	23,537
15.Apr	16,693	17,693	18,693	19,693	20,693	21,693	22,693	23,693
15.May	16,763	17,763	18,763	19,763	20,763	21,763	22,763	23,763
15.Jun	16,697	17,697	18,697	19,697	20,697	21,697	22,697	23,697
15.Jul	16,601	17,601	18,601	19,601	20,601	21,601	22,601	23,601
15.Aug	16,616	17,616	18,616	19,616	20,616	21,616	22,616	23,616
15.Sep	16,775	17,775	18,775	19,775	20,775	21,775	22,775	23,775
15.Oct	16,938	17,938	18,938	19,938	20,938	21,938	22,938	23,938
15.Nov	16,950	17,950	18,950	19,950	20,950	21,950	22,950	23,950
15.Dec	16,779	17,779	18,779	19,779	20,779	21,779	22,779	23,779

Summer and winter time calculation had not been taken into consideration.

Solar hour angle (ω) is time expressed with angle, and it is calculated starting from the sunny noon. Values are given in the table 7.

$$\omega = 15 \cdot (\text{Solar time} - 12) \qquad (6)$$

Table 7. Values of sun angle ω [°].

days\hours	0:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30
15.Jan	-172,41	-157,41	-142,41	-127,41	-112,41	-97,41	-82,41	-67,41
15.Feb	-173,82	-158,82	-143,82	-128,82	-113,82	-98,82	-83,82	-68,82
15.Mar	-172,66	-157,66	-142,66	-127,66	-112,66	-97,66	-82,66	-67,66
15.Apr	-170,31	-155,31	-140,31	-125,31	-110,31	-95,31	-80,31	-65,31
15.May	-169,27	-154,27	-139,27	-124,27	-109,27	-94,27	-79,27	-64,27
15.Jun	-170,26	-155,26	-140,26	-125,26	-110,26	-95,26	-80,26	-65,26
15.Jul	-171,70	-156,70	-141,70	-126,70	-111,70	-96,70	-81,70	-66,70
15.Aug	-171,47	-156,47	-141,47	-126,47	-111,47	-96,47	-81,47	-66,47
15.Sep	-169,09	-154,09	-139,09	-124,09	-109,09	-94,09	-79,09	-64,09
15.Oct	-166,65	-151,65	-136,65	-121,65	-106,65	-91,65	-76,65	-61,65
15.Nov	-166,46	-151,46	-136,46	-121,46	-106,46	-91,46	-76,46	-61,46
15.Dec	-169,02	-154,02	-139,02	-124,02	-109,02	-94,02	-79,02	-64,02
day\hours	8:30	9:30	10:30	11:30	12:30	13:30	14:30	15:30
15.Jan	-52,41	-37,41	-22,41	-7,41	7,59	22,59	37,59	52,59
15.Feb	-53,82	-38,82	-23,82	-8,82	6,18	21,18	36,18	51,18
15.Mar	-52,66	-37,66	-22,66	-7,66	7,34	22,34	37,34	52,34
15.Apr	-50,31	-35,31	-20,31	-5,31	9,69	24,69	39,69	54,69
15.May	-49,27	-34,27	-19,27	-4,27	10,73	25,73	40,73	55,73
15.Jun	-50,26	-35,26	-20,26	-5,26	9,74	24,74	39,74	54,74
15.Jul	-51,70	-36,70	-21,70	-6,70	8,30	23,30	38,30	53,30
15.Aug	-51,47	-36,47	-21,47	-6,47	8,53	23,53	38,53	53,53
15.Sep	-49,09	-34,09	-19,09	-4,09	10,91	25,91	40,91	55,91
15.Oct	-46,65	-31,65	-16,65	-1,65	13,35	28,35	43,35	58,35
15.Nov	-46,46	-31,46	-16,46	-1,46	13,54	28,54	43,54	58,54

15.Dec	-49,02	-34,02	-19,02	-4,02	10,98	25,98	40,98	55,98
days\hours	16:30	17:30	18:30	19:30	20:30	21:30	22:30	23:30
15.Jan	67,59	82,59	97,59	112,59	127,59	142,59	157,59	172,59
15.Feb	66,18	81,18	96,18	111,18	126,18	141,18	156,18	171,18
15.Mar	67,34	82,34	97,34	112,34	127,34	142,34	157,34	172,34
15.Apr	69,69	84,69	99,69	114,69	129,69	144,69	159,69	174,69
15.May	70,73	85,73	100,73	115,73	130,73	145,73	160,73	175,73
15.Jun	69,74	84,74	99,74	114,74	129,74	144,74	159,74	174,74
15.Jul	68,30	83,30	98,30	113,30	128,30	143,30	158,30	173,30
15.Aug	68,53	83,53	98,53	113,53	128,53	143,53	158,53	173,53
15.Sep	70,91	85,91	100,91	115,91	130,91	145,91	160,91	175,91
15.Oct	73,35	88,35	103,35	118,35	133,35	148,35	163,35	178,35
15.Nov	73,54	88,54	103,54	118,54	133,54	148,54	163,54	178,54
15.Dec	70,98	85,98	100,98	115,98	130,98	145,98	160,98	175,98

Summer and winter time calculation is not taken into consideration.

Expression for acquiring cos(θ) is given with (7), and values of cos(θ) are given with table 8.

$$\cos\theta=\sin(\varphi\text{-}\beta)\cdot\sin\delta+\cos(\varphi\text{-}\beta)\cdot\cos\delta\cdot\cos\omega \qquad (7)$$

Table 8. Values of cos(θ).

days\hours	0:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30
15.Jan	-0,98	-0,91	-0,79	-0,63	-0,42	-0,19	0,05	0,28
15.Feb	-0,99	-0,93	-0,82	-0,64	-0,43	-0,19	0,06	0,30
15.Mar	-0,98	-0,92	-0,79	-0,61	-0,39	-0,14	0,12	0,36
15.Apr	-0,92	-0,85	-0,71	-0,53	-0,30	-0,06	0,19	0,44
15.May	-0,85	-0,77	-0,64	-0,46	-0,24	-0,01	0,24	0,47
15.Jun	-0,81	-0,74	-0,62	-0,44	-0,24	-0,01	0,23	0,45
15.Jul	-0,83	-0,77	-0,65	-0,47	-0,27	-0,04	0,20	0,43
15.Aug	-0,90	-0,83	-0,70	-0,52	-0,30	-0,06	0,19	0,43
15.Sep	-0,96	-0,87	-0,73	-0,54	-0,31	-0,06	0,19	0,44
15.Oct	-0,97	-0,88	-0,74	-0,54	-0,31	-0,06	0,19	0,43
15.Nov	-0,96	-0,88	-0,74	-0,55	-0,33	-0,09	0,15	0,38
15.Dec	-0,96	-0,89	-0,76	-0,58	-0,37	-0,14	0,10	0,32
days\hours	8:30	9:30	10:30	11:30	12:30	13:30	14:30	15:30
15.Jan	0,49	0,66	0,78	0,84	0,84	0,77	0,65	0,49
15.Feb	0,52	0,70	0,83	0,90	0,90	0,85	0,73	0,55
15.Mar	0,58	0,77	0,89	0,96	0,96	0,90	0,77	0,59
15.Apr	0,65	0,82	0,94	1,00	0,99	0,91	0,78	0,59
15.May	0,67	0,83	0,94	0,99	0,97	0,90	0,77	0,59
15.Jun	0,65	0,81	0,92	0,97	0,96	0,89	0,77	0,60
15.Jul	0,64	0,80	0,92	0,98	0,97	0,91	0,79	0,62
15.Aug	0,64	0,81	0,93	0,99	0,99	0,92	0,79	0,61
15.Sep	0,65	0,82	0,93	0,99	0,97	0,89	0,75	0,56
15.Oct	0,63	0,79	0,89	0,93	0,91	0,82	0,67	0,48
15.Nov	0,58	0,73	0,83	0,86	0,84	0,75	0,61	0,42
15.Dec	0,51	0,67	0,78	0,82	0,81	0,73	0,60	0,43
days\hours	16:30	17:30	18:30	19:30	20:30	21:30	22:30	23:30
15.Jan	0,28	0,05	-0,19	-0,42	-0,63	-0,80	-0,92	-0,98
15.Feb	0,34	0,10	-0,15	-0,39	-0,61	-0,79	-0,92	-0,99
15.Mar	0,37	0,12	-0,13	-0,38	-0,60	-0,79	-0,91	-0,98

15.Apr	0,37	0,12	-0,13	-0,37	-0,59	-0,76	-0,88	-0,93
15.May	0,37	0,13	-0,11	-0,34	-0,54	-0,71	-0,81	-0,86
15.Jun	0,39	0,16	-0,08	-0,30	-0,50	-0,66	-0,77	-0,82
15.Jul	0,41	0,18	-0,06	-0,29	-0,49	-0,66	-0,78	-0,84
15.Aug	0,39	0,15	-0,10	-0,33	-0,55	-0,72	-0,84	-0,90
15.Sep	0,33	0,08	-0,18	-0,42	-0,63	-0,80	-0,92	-0,97
15.Oct	0,24	0,00	-0,26	-0,49	-0,70	-0,86	-0,96	-1,00
15.Nov	0,20	-0,04	-0,28	-0,51	-0,70	-0,85	-0,95	-0,99
15.Dec	0,22	-0,01	-0,25	-0,47	-0,67	-0,82	-0,93	-0,98

Summer and winter time calculation had not been taken into consideration.

Table 9. Values of angle θ [°].

days\hours	0:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30
15.Jan	167,53	156,10	142,62	128,72	114,75	100,84	87,10	73,67
15.Feb	173,59	159,19	144,60	130,01	115,47	101,00	86,65	72,50
15.Mar	168,94	156,34	142,06	127,46	112,77	98,05	83,35	68,72
15.Apr	157,30	147,98	135,50	121,86	107,72	93,32	78,78	64,15
15.May	148,25	140,76	129,91	117,43	104,14	90,39	76,39	62,25
15.Jun	144,25	137,89	128,05	116,34	103,62	90,35	76,76	63,03
15.Jul	146,34	140,13	130,20	118,33	105,46	92,04	78,31	64,41
15.Aug	153,68	145,86	134,38	121,36	107,62	93,52	79,20	64,76
15.Sep	162,79	150,97	137,18	122,82	108,25	93,58	78,87	64,16
15.Oct	166,77	152,08	137,36	122,67	108,02	93,44	78,98	64,71
15.Nov	164,69	151,36	137,33	123,17	109,03	94,99	81,16	67,70
15.Dec	163,93	152,42	139,17	125,49	111,72	98,03	84,54	71,45
days\hours	8:30	9:30	10:30	11:30	12:30	13:30	14:30	15:30
15.Jan	60,81	48,99	39,18	33,22	33,26	39,28	49,12	60,96
15.Feb	58,71	45,60	33,99	25,95	25,19	32,23	43,42	56,35
15.Mar	54,20	39,98	26,51	15,90	15,75	26,25	39,68	53,90
15.Apr	49,47	34,76	20,05	5,50	9,69	24,35	39,07	53,77
15.May	48,06	33,91	20,10	8,69	12,88	25,98	40,00	54,18
15.Jun	49,27	35,69	22,81	13,16	15,31	26,52	39,71	53,37
15.Jul	50,46	36,61	23,22	12,20	13,07	24,61	38,08	51,95
15.Aug	50,24	35,68	21,12	6,85	8,74	23,12	37,68	52,23
15.Sep	49,49	34,97	20,93	9,80	14,03	27,21	41,55	56,15
15.Oct	50,81	37,69	26,53	20,80	24,63	35,00	47,84	61,62
15.Nov	54,89	43,34	34,36	30,32	33,10	41,33	52,52	65,14
15.Dec	59,05	47,92	39,18	34,70	36,11	42,83	52,87	64,69
days\hours	16:30	17:30	18:30	19:30	20:30	21:30	22:30	23:30
15.Jan	73,83	87,26	101,00	114,92	128,89	142,78	156,26	167,63
15.Feb	70,05	84,15	98,47	112,92	127,46	142,04	156,63	171,12
15.Mar	68,41	83,04	97,74	112,46	127,15	141,75	156,04	168,73
15.Apr	68,44	83,04	97,55	111,89	125,92	139,31	151,18	158,78
15.May	68,36	82,45	96,36	109,94	122,95	134,86	144,55	149,77
15.Jun	67,14	80,85	94,36	107,50	119,97	131,25	140,25	145,16
15.Jul	65,90	79,79	93,49	106,87	119,66	131,38	141,01	146,69

15.Aug	66,75	81,17	95,47	109,53	123,20	136,08	147,22	154,26
15.Sep	70,85	85,56	100,26	114,90	129,39	143,56	156,79	166,04
15.Oct	75,82	90,25	104,81	119,45	134,14	148,85	163,56	177,77
15.Nov	78,51	92,28	106,28	120,41	134,57	148,65	162,22	171,87
15.Dec	77,46	90,77	104,37	118,11	131,86	145,41	158,16	167,22

Summer and winter time calculation had not been taken into consideration.

Values of sin(h) are given in table 10 and they are calculated by following expression:

$$\sin h = \sin\varphi \cdot \sin\delta + \cos\varphi \cdot \cos\delta \cdot \cos\omega \tag{8}$$

Table 10. Values of sin(h).

Days/hours	0:30	1:30	2:30	3:30	4:30	5:30	6:30	7:30
15.Jan	-0,909	-0,864	-0,778	-0,656	-0,508	-0,342	-0,170	-0,005
15.Feb	-0,845	-0,803	-0,717	-0,593	-0,440	-0,268	-0,089	0,085
15.Mar	-0,734	-0,686	-0,595	-0,465	-0,306	-0,129	0,055	0,233
15.Apr	-0,570	-0,516	-0,420	-0,286	-0,126	0,052	0,233	0,407
15.May	-0,428	-0,373	-0,278	-0,148	0,008	0,179	0,353	0,518
15.Jun	-0,358	-0,308	-0,218	-0,093	0,056	0,221	0,390	0,552
15.Jul	-0,389	-0,343	-0,255	-0,132	0,017	0,183	0,355	0,520
15.Jul	-0,509	-0,459	-0,367	-0,238	-0,082	0,092	0,270	0,442
15.Sep	-0,665	-0,607	-0,505	-0,368	-0,203	-0,023	0,161	0,335
15.Oct	-0,795	-0,730	-0,624	-0,483	-0,317	-0,138	0,042	0,212
15.Nov	-0,880	-0,818	-0,716	-0,580	-0,421	-0,249	-0,077	0,086
15.Dec	-0,917	-0,863	-0,770	-0,643	-0,492	-0,326	-0,157	0,003
Days/hours	8:30	9:30	10:30	11:30	12:30	13:30	14:30	15:30
15.Jan	0,144	0,265	0,351	0,395	0,394	0,350	0,264	0,142
15.Feb	0,242	0,372	0,465	0,515	0,520	0,477	0,391	0,267
15.Mar	0,392	0,523	0,615	0,663	0,664	0,617	0,525	0,396
15.Apr	0,560	0,684	0,769	0,809	0,802	0,748	0,651	0,518
15.May	0,664	0,780	0,859	0,894	0,884	0,830	0,734	0,604
15.Jun	0,695	0,809	0,888	0,926	0,919	0,869	0,779	0,654
15.Jul	0,667	0,786	0,870	0,912	0,909	0,863	0,775	0,652
15.Aug	0,596	0,720	0,806	0,850	0,846	0,797	0,705	0,576
15.Sep	0,489	0,611	0,694	0,730	0,720	0,661	0,560	0,422
15.Oct	0,359	0,474	0,548	0,577	0,558	0,494	0,388	0,247
15.Nov	0,227	0,336	0,407	0,434	0,415	0,353	0,251	0,115
15.Dec	0,144	0,256	0,332	0,365	0,355	0,301	0,208	0,082
Days/hours	16:30	17:30	18:30	19:30	20:30	21:30	22:30	23:30
15.Jan	-0,007	-0,172	-0,344	-0,510	-0,658	-0,779	-0,865	-0,909
15.Feb	0,114	-0,058	-0,237	-0,411	-0,568	-0,698	-0,791	-0,841
15.Mar	0,237	0,059	-0,125	-0,303	-0,462	-0,593	-0,685	-0,733
15.Apr	0,357	0,180	-0,001	-0,175	-0,328	-0,452	-0,537	-0,577
15.May	0,449	0,278	0,104	-0,062	-0,207	-0,324	-0,402	-0,438
15.Jun	0,505	0,340	0,171	0,009	-0,134	-0,248	-0,327	-0,365

15.Jul	0,503	0,337	0,165	0,000	-0,147	-0,266	-0,350	-0,392
15.Aug	0,420	0,246	0,067	-0,105	-0,258	-0,382	-0,469	-0,512
15.Sep	0,258	0,078	-0,106	-0,281	-0,434	-0,556	-0,639	-0,676
15.Oct	0,081	-0,098	-0,279	-0,449	-0,596	-0,710	-0,785	-0,813
15.Nov	-0,044	-0,216	-0,388	-0,551	-0,692	-0,801	-0,872	-0,899
15.Dec	-0,070	-0,235	-0,404	-0,565	-0,706	-0,818	-0,893	-0,927

Summer and winter time calculation had not been taken into consideration.

Values of slope coefficient (R_b=cosθ/sin(h)) are given in the following table. Thereby, values for time when sun is not shining on panel because of its slope i.e. when it is Rb<0 are not given.

Table 11. Values of coefficient of Rb.

days\hours	6:30	7:30	8:30	9:30	10:30	11:30
15.Jan	-	8,8888	3,3902	2,4762	2,2113	2,1196
15.Feb	-	3,5312	2,1429	1,8809	1,7828	1,7445
15.Mar	2,0977	1,5583	1,4903	1,4655	1,4543	1,4497
15.Apr	0,8347	1,0721	1,1596	1,2013	1,2222	1,2306
15.May	0,6670	0,8982	1,0064	1,0637	1,0936	1,1054
15.Jun	0,5868	0,8222	0,9393	1,0034	1,0377	1,0520
15.Jul	0,5713	0,8313	0,9548	1,0211	1,0566	1,0720
15.Aug	0,6927	0,9640	1,0739	1,1286	1,1567	1,1687
15.Sep	1,2003	1,2995	1,3283	1,3408	1,3468	1,3490
15.Oct	4,5058	2,0142	1,7589	1,6699	1,6321	1,6201
15.Nov	-	4,4200	2,5390	2,1651	2,0306	1,9906
15.Dec	-	4,4444	3,5719	2,6173	2,3381	2,2506
days\hours	12:30	13:30	14:30	15:30	16:30	17:30
15.Jan	2,1200	2,2132	2,4814	3,4132	-	-
15.Feb	1,7417	1,7729	1,8569	2,0725	2,9858	-
15.Mar	1,4497	1,4542	1,4652	1,4895	1,5558	2,0514
15.Apr	1,2293	1,2176	1,1919	1,1407	1,0282	0,6718
15.May	1,1022	1,0832	1,0432	0,9684	0,8218	0,4724
15.Jun	1,0496	1,0299	0,9880	0,9116	0,7695	0,4679
15.Jul	1,0712	1,0539	1,0158	0,9451	0,8124	0,5269
15.Aug	1,1678	1,1540	1,1230	1,0631	0,9409	0,6234
15.Sep	1,3484	1,3446	1,3362	1,3184	1,2721	0,9961
15.Oct	1,6277	1,6587	1,7321	1,9268	3,0227	-
15.Nov	2,0170	2,1278	2,4288	3,6465	-	-
15.Dec	2,2754	2,4327	2,8994	5,2405	-	-

Summer and winter time calculation had not been taken into consideration.

Now from the expression (2) the data on irradiation of each square meter of inclined surface $H_β$ during each hour in a day can be calculate.

Table 12. Intensities of total hour irradiation of Sun on inclined surface H_β in kWh/m².

days\hours	05÷06	06÷07	07÷08	08÷09	09÷10	10÷11	11÷12	12÷13
15-Jan	-	-	0,0549	0,1400	0,2128	0,2889	0,2990	0,3138
15-Feb	-	0,0008	0,0909	0,1678	0,2623	0,3365	0,4007	0,4035
15-Mar	0,0003	0,0584	0,1700	0,3026	0,4419	0,4818	0,4910	0,4852
15-Apr	-	0,0152	0,1174	0,2490	0,3723	0,4548	0,5725	0,5605
15-May	0,0071	0,0464	0,1680	0,3247	0,4198	0,5204	0,5830	0,6080
15-Jun	0,0139	0,0582	0,1818	0,3090	0,4162	0,5300	0,6201	0,6600
15-Jul	0,0065	0,0401	0,1610	0,3179	0,4863	0,5903	0,6998	0,7378
15-Aug	0,0003	0,0199	0,1356	0,2966	0,4288	0,5509	0,6349	0,6685
15-Sep	-	0,0039	0,1101	0,2453	0,4109	0,5235	0,6080	0,6263
15-Oct	-	-	0,0793	0,1861	0,2902	0,4380	0,4416	0,4712
15-Nov	-	0,0010	0,1172	0,1889	0,2625	0,3103	0,3203	0,3074
15-Dec	-	-	0,0333	0,1138	0,1754	0,2299	0,2464	0,2389
days\hours	13÷14	14÷15	15÷16	16÷17	17÷18	18÷19	19÷20	20÷21
15-Jan	0,2720	0,2129	0,1277	0,0070	-	-	-	-
15-Feb	0,3359	0,3010	0,2037	0,1061	0,0027	-	-	-
15-Mar	0,4912	0,3981	0,2652	0,1555	0,0520	-	-	-
15-Apr	0,5843	0,5414	0,4406	0,3291	0,2092	0,0813	0,0061	-
15-May	0,6252	0,5542	0,5072	0,4160	0,2469	0,1102	0,0246	0,0007
15-Jun	0,6688	0,5770	0,4969	0,3997	0,2681	0,1399	0,0427	0,0058
15-Jul	0,7459	0,6772	0,5958	0,4445	0,2886	0,1527	0,0354	0,0038
15-Aug	0,7054	0,6614	0,5585	0,4232	0,2685	0,1259	0,0165	0,0001
15-Sep	0,6384	0,5652	0,4665	0,3428	0,1978	0,0499	0,0005	-
15-Oct	0,4693	0,4192	0,3192	0,2353	0,1040	0,0006	-	-
15-Nov	0,2773	0,2304	0,1466	0,0026	-	-	-	-
15-Dec	0,1989	0,1604	0,1010	0,0005	-	-	-	-

Summer and winter time calculation had been taken into consideration.

In these data, the influence of the above mean sea level and anisotropy of sky had been neglected, so such obtained data on daily irradiation differ for 2% to 3% of those given in the table 1.

1.5. Values of produced, submitted and spent electricity

Now we can approach to calculation of producing electricity from solar plant. On the basis of the expressed some statements [8], [14] it is adopted that aside direct sun radiation, PV modules generate electricity also from difuse and reflected radiation. For simplification of calculation, some factors had been neglected and others assumptions had been adopted:

- The influence of temperature on module had been neglected;
- It has been adopted that output electricity is proportionally changed with the change of intensity of total sun radiation.

From the data on total sun radiation which is radiated for each hour during day (table 12.) it can be found how much electricity can be received from photovoltaic plant for each hour during day with the following expression:

$$D_i = H_{\beta i} \cdot A_M \cdot N_M \cdot \eta_M \cdot \eta_g \cdot \eta_{inv} \quad (9)$$

Where it is:

- D_i – quantity of electricity which is received from PV plant within an hour;
- $H_{\beta i}$ – quantity of energy of sun light which is radiated on one square meter of module within one hour;
- A_M = 1,634 [m^2] – surface of one module type SLA240M;
- N_M = 24 – number of modules;
- η_M = 0,147 – coefficient of utilization of PV module;
- η_g = 0,8 – share of utilization of power of PV module for 25 years of working life (stops, repairs and similar taken into consideration);
- η_{inv} = 0,95 – coefficient of utilization of inverter.

Now on the basis of the above stated expression and adopted assumptions which simplify the calculation, the table review of quantity of produced electricity by panel for each hour during day can be given.

Table 13. Quantity of electricity produced by panel during each hour in kWh.

days\hours	05÷06	06÷07	07÷08	08÷09	09÷10	10÷11	11÷12	12÷13
15-Jan	-	-	0,2405	0,6132	0,9322	1,2659	1,3099	1,3747
15-Feb	-	0,0034	0,3982	0,7350	1,1493	1,4743	1,7555	1,7678
15-Mar	0,0014	0,2559	0,7450	1,3256	1,9362	2,1108	2,1512	2,1258
15-Apr	-	0,0665	0,5144	1,0910	1,6312	1,9925	2,5081	2,4558
15-May	0,0311	0,2031	0,7359	1,4224	1,8391	2,2798	2,5542	2,6640
15-Jun	0,0610	0,2549	0,7966	1,3537	1,8234	2,3220	2,7168	2,8914
15-Jul	0,0285	0,1757	0,7052	1,3927	2,1305	2,5863	3,0662	3,2323
15-Aug	0,0011	0,0872	0,5939	1,2993	1,8786	2,4137	2,7817	2,9290
15-Sep	-	0,0170	0,4825	1,0747	1,8002	2,2937	2,6640	2,7441
15-Oct	-	-	0,3473	0,8153	1,2714	1,9190	1,9346	2,0646
15-Nov	-	0,0043	0,5136	0,8276	1,1503	1,3595	1,4031	1,3469
15-Dec	-	-	0,1461	0,4986	0,7685	1,0074	1,0795	1,0466
days\hours	13÷14	14÷15	15÷16	16÷17	17÷18	18÷19	19÷20	20÷21
15-Jan	1,1918	0,9328	0,5593	0,0306	-	-	-	-
15-Feb	1,4715	1,3189	0,8924	0,4650	0,0118	-	-	-
15-Mar	2,1520	1,7441	1,1620	0,6814	0,2276	-	-	-
15-Apr	2,5598	2,3721	1,9305	1,4417	0,9167	0,3562	0,0267	-
15-May	2,7390	2,4281	2,2221	1,8226	1,0816	0,4828	0,1077	0,0030
15-Jun	2,9302	2,5278	2,1771	1,7513	1,1745	0,6127	0,1871	0,0253
15-Jul	3,2677	2,9669	2,6104	1,9475	1,2643	0,6691	0,1550	0,0165
15-Aug	3,0905	2,8978	2,4471	1,8543	1,1763	0,5515	0,0724	0,0005
15-Sep	2,7968	2,4762	2,0438	1,5017	0,8667	0,2187	0,0022	-
15-Oct	2,0560	1,8367	1,3986	1,0310	0,4555	0,0028	-	-
15-Nov	1,2150	1,0095	0,6423	0,0115	-	-	-	-
15-Dec	0,8715	0,7026	0,4427	0,0022	-	-	-	-

Summer and winter time calculation had been taken into consideration.

Using this data and data on daily consumption of electricity in household (table 1), by difference of these two tables quantities of electricity which household spends for proper needs, submits to network and takes from network can be calculated. These data are given in the following tables.

Table 14. Quantity of electricity which household produces for proper needs during each hour in kWh.

Days/hours	05÷06	06÷07	07÷08	08÷09	09÷10	10÷11	11÷12	12÷13
15-Jan	-	-	0,240	0,168	0,042	0,042	0,868	0,294
15-Feb	-	0,003	0,398	0,168	0,042	0,042	0,868	0,294
15-Mar	0,001	0,256	0,745	0,168	0,042	0,042	0,868	0,294
15-Apr	-	0,067	0,514	0,168	0,042	0,042	0,868	0,294
15-May	0,031	0,203	0,736	0,168	0,042	0,042	0,868	0,294
15-Jun	0,042	0,255	0,797	0,168	0,042	0,042	0,868	0,294
15-Jul	0,028	0,176	0,705	0,168	0,042	0,042	0,868	0,294
15-Aug	0,001	0,087	0,594	0,168	0,042	0,042	0,868	0,294
15-Sep	-	0,017	0,483	0,168	0,042	0,042	0,868	0,294
15-Oct	-	-	0,347	0,168	0,042	0,042	0,868	0,294
15-Nov	-	0,004	0,514	0,168	0,042	0,042	0,868	0,294
15-Dec	-	-	0,146	0,168	0,042	0,042	0,868	0,294
Days/hours	13÷14	14÷15	15÷16	16÷17	17÷18	18÷19	19÷20	20÷21
15-Jan	0,168	0,042	0,559	0,031	-	-	-	-
15-Feb	0,168	0,042	0,892	0,465	0,012	-	-	-
15-Mar	0,168	0,042	1,162	0,681	0,228	-	-	-
15-Apr	0,168	0,042	1,4	1,302	0,588	0,356	0,027	-
15-May	0,168	0,042	1,4	1,302	0,588	0,483	0,108	0,003
15-Jun	0,168	0,042	1,4	1,302	0,588	0,613	0,187	0,025
15-Jul	0,168	0,042	1,4	1,302	0,588	0,669	0,155	0,017
15-Aug	0,168	0,042	1,4	1,302	0,588	0,552	0,072	0,000
15-Sep	0,168	0,042	1,4	1,302	0,588	0,219	0,002	-
15-Oct	0,168	0,042	1,399	1,031	0,455	0,003	-	-
15-Nov	0,168	0,042	0,642	0,012	-	-	-	-
15-Dec	0,168	0,042	0,443	0,002	-	-	-	-

Summer and winter time calculation had been taken into consideration.

Table 15. Quantity of electricity which household submits to network during each hour in kWh.

Days/hours	05÷06	06÷07	07÷08	08÷09	09÷10	10÷11	11÷12	12÷13
15-Jan	-	-	-	0,445	0,890	1,224	0,442	1,081
15-Feb	-	-	-	0,567	1,107	1,432	0,887	1,474
15-Mar	-	-	-	1,158	1,894	2,069	1,283	1,832
15-Apr	-	-	-	0,923	1,589	1,950	1,640	2,162
15-May	-	-	-	1,254	1,797	2,238	1,686	2,370
15-Jun	0,019	-	-	1,186	1,781	2,280	1,849	2,597
15-Jul	-	-	-	1,225	2,089	2,544	2,198	2,938
15-Aug	-	-	-	1,131	1,837	2,372	1,914	2,635
15-Sep	-	-	-	0,907	1,758	2,252	1,796	2,450
15-Oct	-	-	-	0,647	1,229	1,877	1,067	1,771
15-Nov	-	-	-	0,660	1,108	1,317	0,535	1,053
15-Dec	-	-	-	0,331	0,726	0,965	0,212	0,753
Days/hours	13÷14	14÷15	15÷16	16÷17	17÷18	18÷19	19÷20	20÷21
15-Jan	1,024	0,891	-	-	-	-	-	-
15-Feb	1,303	1,277	-	-	-	-	-	-

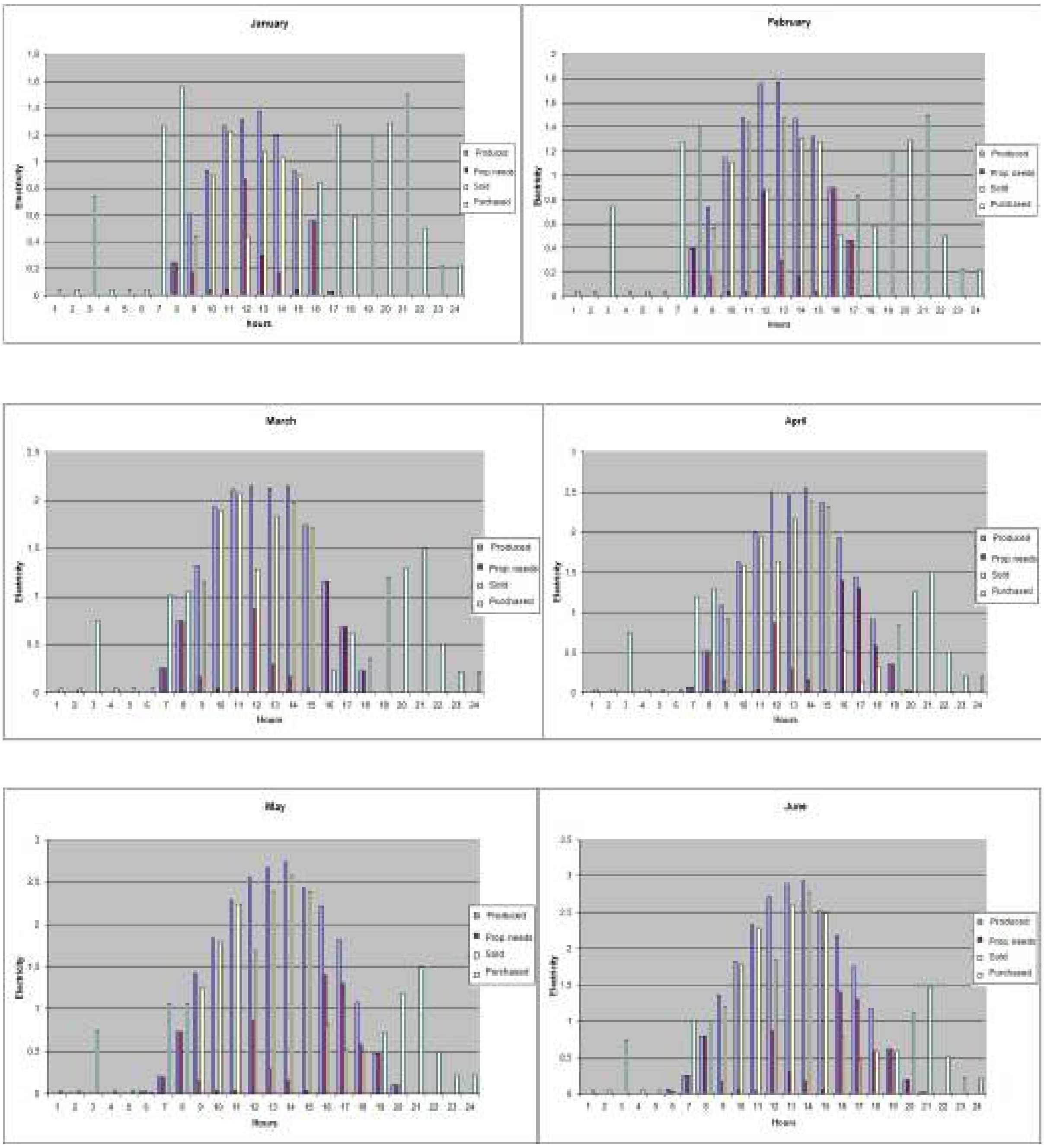
15-Mar	1,984	1,702	-	-	-	-	-	-
15-Apr	2,392	2,330	0,531	0,140	0,329	-	-	-
15-May	2,571	2,386	0,822	0,521	0,494	-	-	-
15-Jun	2,762	2,486	0,777	0,449	0,587	-	-	-
15-Jul	3,100	2,925	1,210	0,646	0,676	-	-	-
15-Aug	2,922	2,856	1,047	0,552	0,588	-	-	-
15-Sep	2,629	2,434	0,644	0,200	0,279	-	-	-
15-Oct	1,888	1,795	-	-	-	-	-	-
15-Nov	1,047	0,968	-	-	-	-	-	-
15-Dec	0,704	0,661	-	-	-	-	-	-

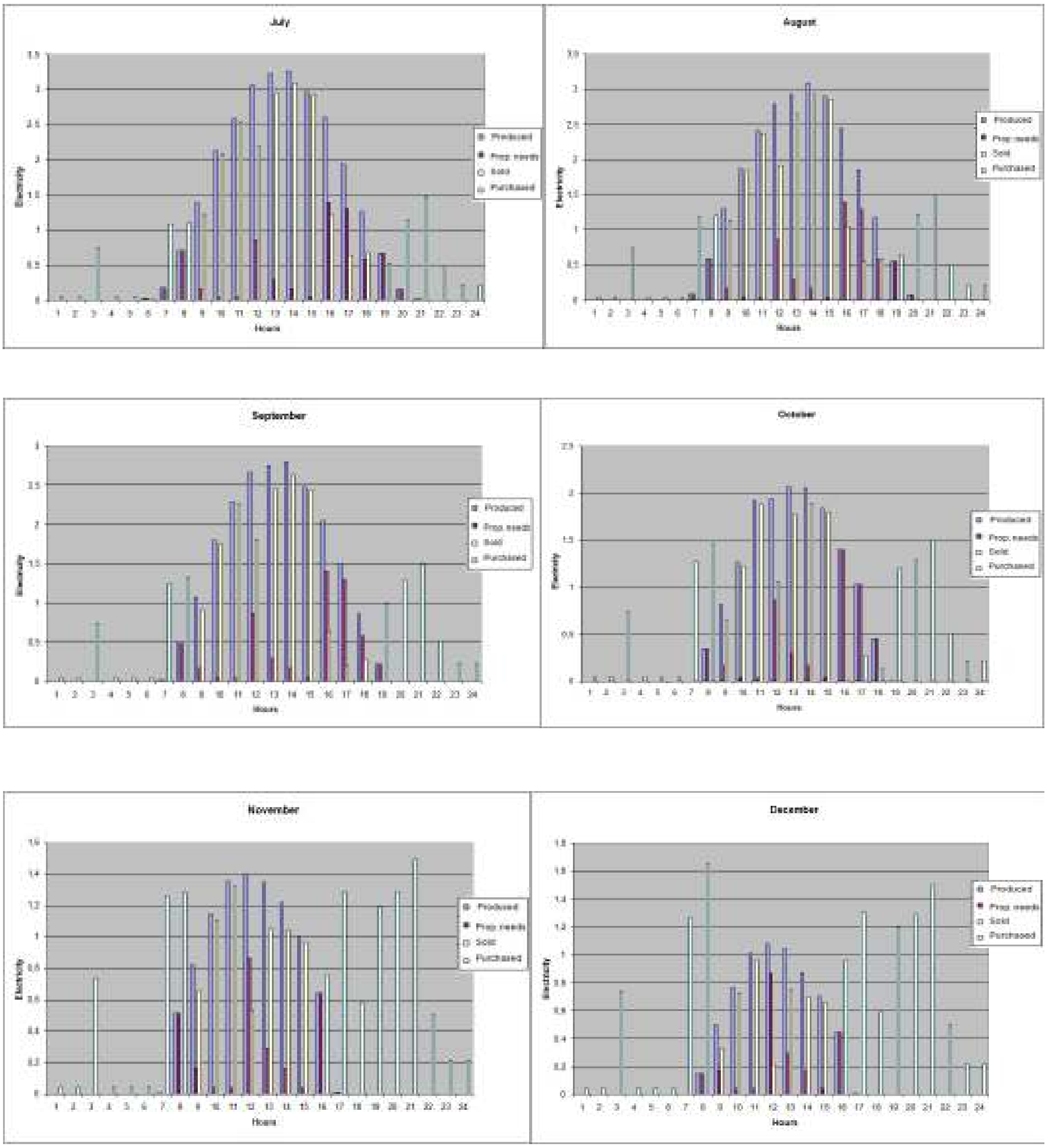
Table 16. Quantity of electricity which household takes from network during each hour in kWh.

Days/hours	00÷01	01÷02	02÷03	03÷04	04÷05	05÷06	06÷07	07÷08
15-Jan	0,042	0,042	0,742	0,042	0,042	0,042	1,267	1,559
15-Feb	0,042	0,042	0,742	0,042	0,042	0,042	1,264	1,401
15-Mar	0,042	0,042	0,742	0,042	0,042	0,041	1,011	1,054
15-Apr	0,042	0,042	0,742	0,042	0,042	0,042	1,200	1,285
15-May	0,042	0,042	0,742	0,042	0,042	0,011	1,064	1,063
15-Jun	0,042	0,042	0,742	0,042	0,042	-	1,012	1,002
15-Jul	0,042	0,042	0,742	0,042	0,042	0,014	1,091	1,094
15-Aug	0,042	0,042	0,742	0,042	0,042	0,041	1,180	1,205
15-Sep	0,042	0,042	0,742	0,042	0,042	0,042	1,250	1,316
15-Oct	0,042	0,042	0,742	0,042	0,042	0,042	1,267	1,452
15-Nov	0,042	0,042	0,742	0,042	0,042	0,042	1,263	1,285
15-Dec	0,042	0,042	0,742	0,042	0,042	0,042	1,267	1,653
Days/hours	08÷09	09÷10	10÷11	11÷12	12÷13	13÷14	14÷15	15÷16
15-Jan	-	-	-	-	-	-	-	0,841
15-Feb	-	-	-	-	-	-	-	0,508
15-Mar	-	-	-	-	-	-	-	0,238
15-Apr	-	-	-	-	-	-	-	-
15-May	-	-	-	-	-	-	-	-
15-Jun	-	-	-	-	-	-	-	-
15-Jul	-	-	-	-	-	-	-	-
15-Aug	-	-	-	-	-	-	-	-
15-Sep	-	-	-	-	-	-	-	-
15-Oct	-	-	-	-	-	-	-	0,001
15-Nov	-	-	-	-	-	-	-	0,758
15-Dec	-	-	-	-	-	-	-	0,957
Days/hours	16÷17	17÷18	18÷19	19÷20	20÷21	21÷22	22÷23	23÷00
15-Jan	1,271	0,588	1,197	1,288	1,498	0,504	0,217	0,217
15-Feb	0,837	0,576	1,197	1,288	1,498	0,504	0,217	0,217
15-Mar	0,621	0,360	1,197	1,288	1,498	0,504	0,217	0,217
15-Apr	-	-	0,841	1,261	1,498	0,504	0,217	0,217
15-May	-	-	0,714	1,180	1,495	0,504	0,217	0,217
15-Jun	-	-	0,584	1,101	1,473	0,504	0,217	0,217
15-Jul	-	-	0,528	1,133	1,481	0,504	0,217	0,217
15-Aug	-	-	0,645	1,216	1,498	0,504	0,217	0,217
15-Sep	-	-	0,978	1,286	1,498	0,504	0,217	0,217
15-Oct	0,271	0,133	1,194	1,288	1,498	0,504	0,217	0,217
15-Nov	1,290	0,588	1,197	1,288	1,498	0,504	0,217	0,217

15-Dec	1,300	0,588	1,197	1,288	1,498	0,504	0,217	0,217

All these values would be clearer if they would be presented in charts which had been done on the following picture.





Picture 4. Charts of production and consumption of electricity in household for individual months

In the following part a table review of total monthly and annual quantities of energy that is produced and consumed in household are given.

Table 17. Total monthly and annual quantities of electricity that is produced or consumed in household in kWh.

	Totally produced		Consumed for proper purposes		Sold to network		Purchased from network	
	Average daily	Total monthly	Average daily	Total monthly	Average daily	Total monthly	Average daily	Total monthly
January	8,45	261,98	2,45	76,08	6,00	185,89	11,40	353,36
February	11,44	320,40	3,39	95,05	8,05	225,35	10,46	292,83

March	16,62	515,19	4,70	145,62	11,92	369,57	9,16	283,83
April	19,86	595,90	5,88	176,33	13,99	419,56	7,98	239,26
May	22,62	701,12	6,48	200,81	16,14	500,31	7,38	228,63
June	23,61	708,18	6,83	204,98	16,77	503,20	7,02	210,61
July	26,21	812,66	6,66	206,58	19,55	606,08	7,19	222,86
August	24,07	746,32	6,22	192,84	17,85	553,48	7,63	236,60
September	20,98	629,47	5,63	169,04	15,35	460,44	8,22	246,55
October	15,13	469,11	4,86	150,64	10,27	318,48	8,99	278,81
November	9,48	284,51	2,80	83,87	6,69	200,64	11,06	331,72
December	6,57	203,54	2,21	68,66	4,35	134,88	11,64	360,78
Total per year	-	6248,38	-	1770,51	-	4477,87	-	3285,84

From the data in the above table it can be seen how much is the production and consumption of electricity, on monthly and annual level. For further work the values on annual level are more important therefore in further chapters it can be calculated the cost-effectiveness of such plant, which is the most important data if we want to proceed with further installation of such plant.

1.6. Redemption of electricity and tariff stands in the Republic of Srpska

By Resolution on methodology of determining the level of redemption prices of electricity from renewable sources of installed power up to 5 MW, it is defined the methodology of determining the level of redemption prices and conditions of overtaking the electricity from renewable sources of installed power up to 5 MW in electric power system on the territory of the Republic of Srpska, which overtakes authorized electro-distribution of the public enterprise "Elektroprivreda Republike Srpske" from producer of electricity from renewable sources of installed power up to 5 MW. In accordance with that Resolution, determination of the level of redemption price of electricity from renewable sources of installed power up to 5 MW is performed by application of corrective coefficients on the amount of the current tariff stand for active energy, higher season and bigger daily, for category of consumption on 10 (20) kV voltage from Tariff system for selling the electricity on the territory of the Republic of Srpska ("Official gazette of the Republic of Srpska", No 23/94).

In accordance with the previous stand, relative amount of coefficients of correction for electric power plant on sun energy have been determined and it is 1,10.

On the basis of the Law on electricity consolidated text („Official gazette of the Republic of Srpska", No 8/08), Statute of Regulatory Commission for energetics of the Republic of Srpska („Official gazette of the Republic of Srpska", No 41/04 and 67/07), Rule-book on work of Regulatory Commission for electricity of the Republic of Srpska („Official gazette of the Republic of Srpska", No 96/04), as well as Rule-book on qualified producer and in Rule-book on qualified manufacturer and incentive of electricity production from renewable sources and combined production of thermal and electric energy, Regulatory Commission for energetics of the Republic of Srpska (REERS) has still in April of 2008 determined the Draft of Resolution on height of premiums and guaranteed redemption prices of electric energy produced in qualified electric plants and efficient cogeneration plants. By this Resolution are determined incentive prices for electricity produced in electric plants which use renewable sources and in efficient cogeneration plants, in accordance with the stipulations of the Rule-book on qualified manufacturer and incentive of production of electricity from renewable sources and combined production of thermal and electric energy.

Government of the Republic of Srpska, before all due to the lack of interest of "Elektroprivreda Republike Srpske" for taking over such energy, and somewhat higher production prices, still has not given the agreement on such Resolution.

Guaranteed redemption prices, and contained amount of premium, for electricity produced in qualified electric plant, whose source of energy is Sun, in the period of effectiveness of contract on mandatory redemption, are stated in the table 19.

Table 18. Overview of guaranteed redemption prices without VAT, KM/kWh [2], [5]

Type of electric plant according to type of source			**Guaranteed redemption price**	**Premium contained in redemption price**
Sun energy	Thermal generators		0,3913	0,3395
	Photovoltaic generators	- up to 42 kW	0,9496	0,8978
		- over 42 kW	0,8677	0,8159

Guaranteed redemption prices determined by this resolution are applied for calculation at mandatory redemption of electricity from manufacturer who exercises the right on incentive. Manufacturer of electric power in qualified electric plant in which he produces electric energy for proper purposes, has the right on premium for electric energy spent in proper engines in the amount of 20% of premium determined by this resolution for mandatory redemption. If manufacturer of electric energy in qualified electric plant or in efficient cogeneration plant sells all or part of the produced electricity on the concurrent market, without using the right of mandatory redemption, for all that electric energy, he has the right on premium in height of 10% of premium determined by this resolution for mandatory redemption. The right on guaranteed redemption price, i.e. premium, has the manufacturer of electric energy after acquiring certificate on eligibility of electric plant for current year.

On the basis of the article 23. indent 4. of Law on electric energy („Official gazette of the Republic of Srpska" No: 8/08, 34/09 and 92/09), article 10. stand 1. item 4. Statute of Regulatory Commission for energetics of the Republic of Srpska („Official gazette of the Republic of Srpska" no. 41/04, 67/07, 113/07 and 109/09) article 37. stand 1. item 3. of Rule-book on work of Regulatory Commission for electric energy of the Republic of Srpska („Official gazette of the Republic of Srpska" No 96/04), article 49, 73. and 74. of Rule-book on tariff methodology and tariff procedure („Official gazette of the Republic of Srpska" No 61/05) and article 72. stand 1. of the Rule-book on public debates and dispute solving and complaints („Official gazette of the Republic of Srpska" No 71/05), in tariff procedure for approving the price on the threshold of the electric plant, for determining tariff stands for users of distributive systems and tariff stands for non-qualified buyers of electric energy in the Republic of Srpska, Regulatory Commission for energetic of the Republic of Srpska [2], [5], on 1. (first) regular session held on 30.12.2009, in Trebinje, has reached Decision on tariff stands for non-qualified buyers of electric energy in the Republic of Srpska (hereinafter: Regulatory Commission) determines the prices of the electric energy, expressed through tariff stands, which serve for calculation and charge of electric energy from non-qualified buyers, table 4.

Table 19. Tariff stands for non-qualified buyers of electricity [2], [5]

DESCRIPTION			**Accounting power**		**Active electric energy**	
Categories of consumption and groups of buyers		Unit of measure	KM/kW/month		KM/kWh	
		Season	HS (winter)	LS (summer)	HS (winter)	LS (summer)
Name of category	Name of group	Time of day				
0,4 kV - households	1 TG	ST	2,0352	1,5655	0,1172	0,0902
	2 TG	VT	2,0352	1,5655	0,1410	0,1083
		MT	-	-	0,0705	0,0541

Tariff stands stated in the above table do not contain added value taxes. Tariff stands in higher season (HS) are applied in the period from 1. October till 31. March. Tariff stands in lower season (LS) are applied in the period from 1. April till 30. September.

Higer daily tariff stands (HT) are applied in time from 06:00 till 22:00 hours for winter time calculation, i.e. from 07:00 till 23:00 hours for summer time calculation. Lower daily tariff stands (LT) are applied in time from 22:00 till 06:00 hours for winter time calculation, i.e. from 23:00 till 07:00 hours for summer time calculation and in days of weekend uninterruptedly from Friday at 22:00 (23:00) till Monday in 06:00 (07:00) hours.

This Resolution enters into force on the day of its reach, and it is applied for the calculation of the spent electricity from 01.01.2010.

Therefore, to all household energy is calculated per middle tariff except those who have calibrated two-tariff counter and integrated meter and which have submitted the request for their energy to be calculated in two-tariff way.

1.7. Economic financial aspect of using Sun energy

On the basis of data on consumption and production of electricity in household (table 17.) and values of incentives which are given in table 18, easily can be calculated the money values which household pays for consumption of electricity and amount which is acquired while solar plant working. On the basis of these data it can be seen how much this plant is cost effective. In the following text are calculated and shown incomes of this plant for two values of redemption price. The first one is valid redemption price which is formed by application of corrective coefficients on the amount of the valid tariff stand for active energy, and the other one is according to the Draft of Resolution on height of premium and guaranteed redemption prices of electricity which was determined by Regulatory Commission for energetics of the Republic of Srpska, but which still has not acquired the approval of the Government of the Republic of Srpska.

1.7.1. Money values for saved electricity in solar plant (energy produced for proper purposes)

Middle summer tariff for electricity is 0,0902KM/kWh, middle winter tariff is 0,1172KM/kWh, and middle annual tariff would be 0,1037KM/kWh. On the basis of middle annual tariff and quantity of electricity which is produced in panel for proper purposes, it can be calculated how much money household saves on the annual level:

$$P_V = D_{Vuk} \cdot 0{,}1037$$
$$P_V = 1770{,}51 \cdot 0{,}1037 = 183{,}61 \left[KM \right] \quad (10)$$

where:

- D_{Vuk} – annual quantity of produced electricity for proper needs (table 17);
- P_V – money values of saved household electricity;

If the Government of the Republic of Srpska had adopted Proposal on incentives, than total money value which household could save, by calculating values of energy which is spent for proper purposes and incentives for used energy for proper purpose would be bigger. The height of premium which is contained in the redemption price is 0.8978KM/kWh, and incentive for electricity which is produced from renewable sources for proper purposes is 20% of this premium. Such possible saving is given in the following expression:

$$P_{Vp} = D_{Vuk} \cdot 0{,}1037 + D_{Vuk} \cdot 0{,}8978 \cdot 20\%$$
$$P_{Vp} = 1770{,}51 \cdot 0{,}1037 + 1770{,}51 \cdot 0{,}8978 \cdot 0{,}2 = 501{,}52 \ \left[KM \right] \quad (11)$$

Where:

- P_{Vp} – money values of saved electricity of household which would be if the proposed incentives were used which Government did not adopt.

1.7.2. Money values for sold electricity to network

Redemption price for electricity produced in photovoltaic plants is accounted on the basis of the valid tariff and correction factor for solar electric plants which is 1,1 which means that redemption price is 110% of valid tariff stand. In that way redemption price of electricity from solar plant is 0,2178KM/kWh. When everything is calculated, total height of the incomes for the produced electricity which household submits to network during year amounts to:

$$P_M = D_{Muk} \cdot 0{,}1037 \cdot 110\%$$
$$P_M = 4477{,}87 \cdot 0{,}1037 \cdot 2{,}1 = 975{,}14 \ \left[KM \right] \quad (12)$$

where:

- D_{Muk} – annual quantity of electricity which household sells to network (table 17);
- P_M – money values which household earns by selling electricity to network.

Upon proposal which Government had not adopted, guaranteed redemption price of electricity produced from photovoltaic plants of power to 42kW, would be 0,9496KM/kWh. In that case annual incentive which household would get for sold energy to network would be:

$$P_{Mp} = D_{Muk} \cdot 0,9496$$
$$P_{Mp} = 4477,87 \cdot 0,9496 = 4252,19 \; [KM] \tag{13}$$

Where:

- P_{Mp} – money value which household earns by selling electricity to network if proposed incentives would be applied.

1.7.3. Money values for electricity purchased from network

During its work, household will use the electricity from network in the moments when there is no sufficient inflow of light. Amount which household would pay to electro-distribution for purchased electricity on annual level, is given with the following expression:

$$P_K = D_{Kuk} \cdot 0,1037 + D_{OS} \cdot 12$$
$$P_K = 3285,84 \cdot 0,1037 + 5,9412 \cdot 12 = 340,74 + 71,29 = 412,03 \; [KM] \tag{14}$$

Where it is:

- D_{Kuk} – annual quantity of electricity which household purchases from network;
- D_{OS} – middle monthly fee for accounting power;
- P_K – money value which household annually pays for purchase of electricity from electro-distribution;

It also should be mentioned that during calculation of all previous money values VAT is not taken into consideration. When we take VAT into consideration than amount which household would pay for electricity purchased from network is:

$P_K = 482,08 \; [KM]$.

1.8. Costs of equipment, materials and works

While elaborating costs for implementation of this solar plant, data from available catalogues of companies Solaris and MSA and some other works [7], [9], and [15] are used. Prices in catalogues are given in Croatian kuna, so they were calculated in KM upon the exchange rate of 0,26517 HRK for 1 KM. Also it has been taken into the consideration the 10% discount for advance payment while purchasing the module. Upon the reflection on other similar projects, it is adopted that the price of the construction and other materials will be around 3,25% of total costs, and that contingences are around 10% of total costs. Review of all costs is shown in the following table.

Table 20. Costs while implementing solar plant with included VAT

No	Name	Unit price	Quantity	Amount [KM]	Amount [%]
1	Module SLA240M	1451,97	24	34847,28	65,04
2	Inverter Sunny mini central 6000A	5325,63	1	5325,63	9,94
3	Set of frames for four modules	462,27	6	2773,60	5,18
4	House connecting measuring cabinet with automatic galvanic switch	3531,28	1	3531,28	6,59
5	Other material and mounting work	3468,17	1	1741,24	3,25
6	Contingencies	10671,28	1	5357,67	10
Total investments KM				53576,71	100

In total price which is shown in the previous table, it has been calculated and other auxiliary equipment and small inventory which is not specified in text.

Important data is also specific cost i.e. price of 1 kW installed power of photovoltaic plant which in this case is 8929,45 KM/kW.

1.9. Conclusion

As conclusion, in the following tables data from items 2.7.1, 2.7.2, 2.7.3. and table 17. and 20 have been extracted , and which are related to financial and energy part of solar plant.

Table 21. Extracted data which characterize solar plant in energy sense

Name	Amount	Unit of measure
1. Totally produced electricity in solar plant	6248,38	kWh/year
a. Spent for proper purposes	1770,51	kWh/year
b. Sold to network	4477,87	kWh/year
c. Spent from network	3285,84	kWh/year

Table 22. Extracted data which characterize solar plant in financial sense

Name	Money amount		Unit of measure
	upon current tariff	upon proposal of REERS	
1. Total income and savings of household *	1158,74	4753,71	KM/year
a. Savings because of the consumption for proper purposes *	183,6	501,52	KM/year
b. Electricity sold to network*	975,14	4252,19	KM/year
c. Spent from network *	412,03	-	KM/year
2. Price of costing of solar plant	53576,71	-	KM

* VAT not included

2. POSSIBILITY OF INSTALLMENT OF SOLAR COLLECTOR ON RESIDENTIAL FACILITY OF ONE AVERAGE GRADIŠKA's HOUSEHOLD

In this point it will be considered the possibility of installing solar collector for heating sanitary water, for the purposes of one average four-member household on the territory of Gradiška. Data on concrete measurings and structure of consumption of hot sanitary water during day and year, which could be used for this work, are not available. But there are some recommendations which can completely serve for defining the size of collectors and boiler. On the basis of data on number of members of household, surface of facility or some other input data, and all depending on the type of facility for which the calculation is used, those recommendations can be chosen [22], [24].

Degree of utilization of one solar system for water heating is in function of degree of utility of its components (collector, pipeline and boiler) and it is important to have the notion on how much energy of sun radiation can be turned into heat.

Degree of utility depends on more variable sizes which vary during day, such as: intensity of sun radiation, air temperature, wind speed, temperature of absorbers, temperature of input water into collector, temperature of input water into boiler, water consumption, isolation of collectors and boiler.

Collector manufacturers skillfully avoid question on its usefulness so they mostly don't give or just give the information on degree of absorption and emission of radiation. Therefore, in order to get the degree on utility we will rely on the example from the surroundings [22], where it is given the shift of degree of utilization of plain solar collector during year, so as input data will be used values on radiated sun radiation (table 1).

2.1. Model of using solar collector system

Upon recommendations, for average four-member household which has middle water consumption, it is necessary the surface of collector of around 3,5m² and boiler volume of around 210 l. It has been chosen set of closed system with compulsive circulation type VS200/BL1. Among other things, this set contains laminar selective collectors type ST-2000 (gross surface 2,1m² and net surface 1,8m²) two items and boiler type V-200/BL1 (200 l with one-way conductor of heat) from the catalogue of company Gidas d.o.o. from Banja Luka.

Aside laminar collectors in use are also vacuum collectors. Laminar collector is chosen because even though it is less efficient than vacuum collector, it also has lower price than vacuum.

Collectors would be placed on roof, turned towards south and leaned under the angle of 34°, which is the optimum angle for collecting sun energy during whole year (table 1.).

It is a closed system of circulation where water or some other working means which is heated in collector, goes into boiler and there over pipe switcher delivers heat to sanitary water. On the other hand, sanitary water would come in boiler and heated over there, and than it would go into electric boiler where it would be if necessary additionally heated and used for sanitary purposes.

2.2. Calculation of collected energy

2.2.1. Degree of usefulness of solar collector system

As it has been said, utilization of solar collector is complexly dependable on more variables. Therefore it has been adopted the utilization of laminar collector which had been tested during one year on Belgrade area, and which is given in the following table.

Table 23. Adopted degree of utilization of collectors during year (page 72 [22])

Month	Degree of utilization of collector η_k
January	0,401
February	0,405
March	0,44
April	0,47
May	0,465
June	0,455
July	0,435
August	0,4
September	0,41
October	0,425
November	0,43
December	0,415

Since that degree of utilization of boiler also depends on more occasional variables, according to experiential data, it is adopted that its utilization is η_B=0,9 and also it has been adopted that losses in pipeline are 2 %, i.e. it is η_{cev}=0,98.

2.2.2. Collected energy during year

How much is the radiated sun energy per square meter of surface, and for the angle of surface of 34°, it is given in table 12. In this table are data on radiated energy for each hour, and in following table will be shown data on radiated energy for whole month and one average day a month .

Table 24. Daily and monthly radiation of solar collector

Month	Number of days per month	Daily kWh/m²	Monthly kWh/m²
January	31	1,992	61,75
February	28	2,767	77,48
March	31	3,833	118,82
April	30	4,672	140,16
May	31	5,309	164,58

June	30	5,517	165,51
July	31	6,158	190,9
August	31	5,680	176,08
September	30	4,939	148,17
October	31	3,517	109,03
November	30	2,186	65,58
December	31	1,624	50,34
Total per year			1468,4

Quantity of energy, which would be gained from collector for heating sanitary water, can be calculated with the following expression:

$$G_K = H_i \cdot n_{k\,ST2000} \cdot A_{kol\,ST2000} \cdot \eta_{kol\,i} \cdot \eta_{cev} \cdot \eta_B \left[kWh\right] \quad (15)$$

Where it is:

- G_K – quantity of energy gained from solar system;
- H_i – radiated quantity of sun energy during certain month;
- $A_{kol\,ST2000}$ – net surface of one collector type ST-2000 ($A_{kol\,ST2000}$ =1,8 m^2);
- $n_{k\,ST2000}$ – number of collectors type ST2000 ($n_{k\,ST2000}$ = 2);
- $\eta_{kol\,i}$ – degree of utilization of collector during certain month;
- η_B – degree of utilization of boiler (η_B=0,9);
- η_{cev} – degree of utilization of pipeline network (η_{cev}=0,98).

In the following table, on the basis of expression (15), are given calculated values for each month.

Table 25. Daily and monthly production of thermal energy Gk

Month	Daily kWh	Monthly kWh
January	2,54	78,63
February	3,56	99,63
March	5,36	166,01
April	6,97	209,17
May	7,84	243,00
June	7,97	239,11
July	8,51	263,67
August	7,21	223,64
September	6,43	192,89
October	4,75	147,13
November	2,98	89,54
December	2,14	66,34
Total per year		2018,74

From table 25 it can be seen that average four-member household for heating sanitary water could get 2018,74kWh of energy using solar collectors, and remaining energy which would be necessary for further heating of the water to the necessary temperature, would be provided by consuming electricity in electric boiler.

2.3. Money values of saved electricity

Household heats its sanitary water with 2018,74kWh of energy acquired from Sun, and the rest is heated up with electric heater in electric boiler. This means that those 2018,74kWh of energy is saved because this quantity of energy is not necessary to be spent on electricity but just to convert it from sun radiation which is „free“.

So it can be calculated how much money household saves on annual level using solar heating of sanitary water. Middle annual tariff for electricity is 0,1037KM/kWh, and VAT is 17% so in the following expression is given annual savings:

$$\begin{aligned} P_{Vk} &= G_{Kg} \cdot (0{,}1037 \cdot PDV) \\ P_{Vk} &= 2018{,}74 \cdot (0{,}1037 \cdot 1{,}17) = 244{,}93 [KM] \end{aligned} \tag{16}$$

Where it is:

- G_{Kg} – annual quantity of energy obtained from solar collector;
- P_{Vk} – money value of saved electricity of household.

2.4. Equipment costs

While elaborating costs for installment of this solar system for heating sanitary water, data from available catalogue of company GIDAS d.o.o. and upon query in company Termoklima (both from Banja Luka) are used. Prices in catalogues are given in euros and without VAT, so they were recalculated in KM per exchange rate of 1,95583EUR for 1KM and VAT is added. Thereby it should be mentioned that upon query of company GIDAS d.o.o. an information was received that there is 15% discount while purchasing whole system, and which consists from:

- Solar collector;
- Boiler with one heat conductor;
- Hydraulic set (circulator, expansion container, ventilator, valves etc.);
- Base for expansion container and connecting pipe;
- Differential thermostat;
- Base for collector;
- Antifreeze liquid for solar system (package of 10 liters);
- Equipment for hydraulic installation.

A set of closed system with compulsive circulation VS200/BL1 of company Gidas d.o.o. and copper pipes with PVC isolation of Termoklima d.o.o. had been chosen. A discount of 15% on set of solar system is taken into consideration.

Upon review of other similar projects, it has been adopted that contingencies are around 10% of total costs. Review of all costs is shown in the following table.

Table 26. Costs while installing solar system with calculated VAT and discount

No.	Name	Unit price	Quantity	Amount [KM]	Amount [%]
1	Closed system with compulsive circulation VS200/BL1	4320,00	1	4320,00	86,9
2	Copper pipes with PVC insulation [KM/m]	10	20 m	200,00	4,0
3	Contingencies	-	-	452,00	9,1
Total investment KM				4972,00	100,0

In the total price which is shown in the previous table, it has been included other auxiliary equipment and small inventory which is not specified in text.

2.5. Conclusion

As conclusion, in following tables have been extracted data from tables 24, 25 and 26, and which are related to financial and energy part of this solar plant.

Table 27. Extracted data which characterize solar plant in energy sense

Name	Amount	Unit measure
1. Totally produced thermal energy	2018,73	kWh/year
2. Total savings of household	244,93	KM/year
3. Price of solar plant	4972,00	KM

3. POSSIBILITY OF INSTALLMENT OF SOLAR COLLECTOR ON THE BUILDING OF THE ADMINISTRATIVE SERVICE OF MUNICIPALITY GRADIŠKA

In this point it will be considered possibility of installment of solar collector for heating sanitary water, for the purposes of two upper floors of the Administrative service of municipality, because there are placed all services and great majority of officials. Concrete measurings on structure and consumption of hot sanitary water during day and night in this facility are also not available, so the recommendations will be used which can completely serve for defining the size of collector and boiler on the basis of data on number of residents [22], [24]. Here also we will rely on the example from the surroundings for acquiring the degree of utilization [22], where it has been given the change of degree of utilization of flat solar collector during year, so as input data will be used values on radiated sun radiation (table 1).

3.1. Model of use of solar collector system

On the basis of the enquiry, we have come up with the data that Administrative service has cca 160 people employed and that the surface of the two upper floors which are in property of Municipality is in total of 1.932,23m^2. If we suppose that the height of one floor is over 3m, we come to the data that their volume is around 6762,81m^3.

Upon recommendations from [22] (page 110), consumption of warm water for such space would be around 338 liters per day (i.e. 50 l of hot water per 1000m^3 administrative space).

Upon recommendations from [24] (page 7), consumption of hot water for such number of the administrative personnel would be around 800 liters of hot water daily (i.e. 5 l of hot water per one official daily).

It is adopted the consumption of 550 liters of hot water daily. So we get from [22] (page 144) that the necessary size of boiler is 480 liters and surface of collector of 7 m². A set of closed system with compulsory circulation type VS500/BL1 had been chosen. Among other things this set contains laminar collectors type ST-2000 (gross surface of 2,1m² and net surface 1,8m²) three items and boiler type V-500/BL1 (500 l with one-way conductor of heat) from the catalogue of the company Gidas d.o.o. from Banja Luka. Than it has been added one more laminar collector type ST-2000.

Roofs are not oriented towards south but towards southeast-east which makes it difficult to put solar collectors oriented towards south (picture 5). But due to „stepwise“ position this three roofs of Building in relation to one another, by right positioning of construction of the frame of collectors it is possible to place collectors which will be directed towards south, which will be taken into consideration during calculation. Otherwise, dimensions of this facility are cca 31x18 m. Collectors would be placed on roof, oriented towards south and leaned onto the angle of 34°, which is the optimal angle for receiving sun energy during whole year (table 1).

This is a closed system of circulation where working agent, when heated in collectors, parallely goes into boilers and there over pipe switcher submits heat to sanitary water. On the other hand, sanitary water would come parallely into boilers and got heated there, and than would be going to the electric boilers where it would be additionally heated and used for sanitary purposes.

Picture 5. Position of the building of the Administrative service of municipality [26].

3.2. Calculation of the collected energy

3.2.1. Degree of usefulness of solar collector system

As it has been said, utilization of solar collector is complexly dependable on more variables. This is reason why it has been adopted the use of laminar collector which is the same as in the previous item.

Table 28. Adopted degree of utility of collector during year (page 72 [22])

Month	Degree of utility of collector η_k
January	0,401
February	0,405
March	0,44
April	0,47
May	0,465
June	0,455
July	0,435
August	0,4
September	0,41
October	0,425
November	0,43
December	0,415

Since degree of utility of boiler also depends on more occasional variables, according to experimental data it has been adopted, as in the pervious item, that its utilization is η_B=0,9 and also it has been adopted that the cubic meters in pipeline are 2 %, i.e. that is η_{cev}=0,98.

3.2.2. Collected energy during year

How much is the radiated sun energy per square meter of surface, and for angle of surface of 34°, it has been given in tables 12. and 24. In those tables are given data on radiated energy for each hour, month and one average day in month.

Table 29. Daily and monthly irradiation of solar collector placed on Municipality

Month	Number of days per month	Daily kWh/m²	Monthly kWh/m²
January	31	1,992	61,75
February	28	2,767	77,48
March	31	3,833	118,82
April	30	4,672	140,16
May	31	5,309	164,58
June	30	5,517	165,51
July	31	6,158	190,9
August	31	5,680	176,08
September	30	4,939	148,17
October	31	3,517	109,03
November	30	2,186	65,58
December	31	1,624	50,34
Total per year			1468,4

Quantities of energy which would be obtained from collector system (calculated together for both houses) for heating sanitary water can be calculated with the following expression:

$$G_K = H_i \cdot n_{k\ ST2000} \cdot A_{kol\ ST2000} \cdot \eta_{kol\ i} \cdot \eta_{cev} \cdot \eta_B \left[kWh\right] \qquad (21)$$

Where it is:

- G_K – quantity of energy gained from solar system;
- H_i – radiated quantity of sun energy during certain month;
- $A_{kol\ ST2000}$ – net surface of one collector type ST-2000 ($A_{kol\ ST2000}$ =1,8 m^2);
- $n_{k\ ST2000}$ – number of collector type ST2000 ($n_{k\ ST2000}$ = 4);
- $\eta_{kol\ i}$ – degree of utilization of collector during certain month;
- η_B – degree of utilization of boiler (η_B=0,9);
- η_{cev} – degree of utilization of pipe network (η_{cev}=0,98).

In the following table, on the basis of the expression (21), are given calculated values for each month.

Table 30. Daily and monthly production of thermal energy Gk

Month	Daily kWh	Monthly kWh
January	5,07	157,25
February	7,12	199,26
March	10,71	332,01
April	13,94	418,33
May	15,68	485,99
June	15,94	478,23
July	17,01	527,34
August	14,43	447,27
September	12,86	385,78
October	9,49	294,26
November	5,97	179,08
December	4,28	132,68
Total per year		4037,48

From table 30 it can be seen that building of the Administrative service of Municipality, for heating sanitary water could get in total 4.037,48kWh of energy using solar collectors, and the rest of energy which would be necessary to heat up the water on the necessary temperature, would be provided by consuming electricity in electric boiler.

3.3. Money values of saved electricity

Building of Municipality heats its sanitary water with 4037,48kWh of energy acquired from Sun, and the rest is heated with electric heater in electric boiler. Which means those 4037,48kWh of energy is saved because that quantity of energy is not necessary to consume from electricity just to convert it from radiation which is „free-of-charge“.

In that way it can be calculated how much money Municipality saves annually by using solar heating of sanitary water. Middle annual tariff for electricity is 0,1037 KM/kWh and VAT is 17%, so in the following expression is given annual savings:

$$P_{Vk} = G_{Kg} \cdot (0{,}1037 \cdot PDV)$$
$$P_{Vk} = 4037{,}48 \cdot (0{,}1037 \cdot 1{,}17) = 489{,}86 [KM] \qquad (22)$$

Where it is:

- G_{Kg} – annual quantity of energy obtained from solar collector;
- P_{Vk} – money values of saved electricity of household.

3.4. Equipment costs

While elaborating costs for implementation of this solar system for heating sanitary water, data were used from the available catalogue of company GIDAS d.o.o. and upon enquiry in company Termoklima, both from Banja Luka. Prices in the catalogues are given in the euros without VAT, so they were recalculated in KM per exchange rate of 1,95583EUR for 1 KM and VAT had been added to them. Thereby it should be mentioned that there is a 15% discount while purchasing entire system, and which consists of:

- Solar collector;
- Boiler with one heat conductor;
- Hydraulic set (circulator, expansion container, ventilator, valves etc.);
- Base for expansion container and connecting pipe;
- Differential thermostat;
- Base for collector;
- Antifreeze liquid for solar system (package of 10 liters);
- Equipment for hydraulic installation.

A set of closed system with compulsive circulation VS500/BL1 (one set) and one additional collector type ST 2000 of company Gidas d.o.o. and copper pipes with PVC isolation of Termoklima d.o.o. had been chosen. A discount of 15% on set of solar system is taken into consideration.

Upon review on other similar projects, it has been adopted that contingencies are around 10% of total costs. Review of all costs is shown in the following table.

Table 31. Costs while installing solar system with calculated VAT and discount

No.	Name	Unit price	Quantity	Amount [KM]	Amount [%]
1	Closed system with compulsive circulation VS500/BL1	6245,63	1	6245,63	74,6
2	Solar collector ST2000	861,67	1	861,67	10,3
3	Copper pipes with PVC isolation [KM/m]	10	50 m	500,00	6,0
4	Contingencies	-	-	760,73	9,1
Total investment KM				8368,03	100,0

In the total price which is shown in the previous table, it has been included other auxiliary equipment and small inventory which is not specified in text.

3.5. Conclusion

As conclusion, in the following tables data were extracted from tables 29, 30 and 31, and which are related to financial and energy part of the solar plant.

Table 32. Extracted data which characterize solar plant in the energy sense

Name	Amount	Unit of measure
1. Totally produced thermal energy	4037,48	kWh/year
2. Total savings of municipality	489,86	KM/year
3. Price of costing of solar plant	8368,03	KM

4. USE OF SOLAR ENERGY IN GRADIŠKA DURING 2005

In this item it will be considered how much was distributed use of solar energy in Gradiška in baseline year 2005 and how much solar energy had been used on that occasion.

There is no concrete data on presence of use of solar energy so far or they are not available, but in the filed work it had been gathered information that two solar collectors are found in Gradiška. One is on the private residential facility in the Street V. S. Karadžića (near park at bus station), and other collector is on the private residential facility in the Street M. G. Nikolajeviča (near Pensioner center). Both solar collectors are used only for heating sanitary water and both systems are about twenty years old. In these facilities it has not been measured the structure of the consumption of hot sanitary water during day and year, so for the calculation of the quantity of produced hot sanitary water during day and year will be used recommendations which can sufficiently serve for defining [22], [24]. Here also, for acquiring the degree of use we will rely on the example from surroundings [22], where it has been given the change of degree of utilization of flat solar collector during year, so as input data will be used values on radiated sun radiation (table 1).

It should also be mentioned that these two facilities are not the only ones on the territory of municipality Gradiška which own solar system for heating sanitary water, but they are only available for acquiring technical information about them. Because in conversation with the employees of „Termoelektro-ns“ from Gradiška, which among other things also sells solar collectors as ordered, they told that there are some households in the rural part of municipality which have this way of heating of hot water. But some precise information on number and type of collector, year of installation of those systems and place where are these households are not familiar.

4.1. Model of use of solar collector system

In the conversation with both owners of facilities we have come to information on size of solar collectors and boilers:

- Each facility has three collectors of surface 1,2m² which is in total 3,6m² of collectors on each facility. Collectors are oriented towards south and leaned under the angle of 45°. Maybe it would be good to add that in time when collectors were installed, recommendations that were effective said that incidence of collectors should be the same as the angle of geographic latitude on which that system is;
- Both households have boiler size of 200 l;
- Both households have similar following equipment which ensures the work of such plants;
- Household in the Street V. S. Karadžića (Hypothetically called – „Household 1“) for a few years (before 2005) does not have the correct system of regulation, and working medium in collector is prone to freezing during colder period. So during colder days water is released from the collectors and this system is not in function. It has been adopted that system in Household 1 is not in function during December, January and February. Household in the Street M.G. Nikolajeviča (hypothetically called – „Household 2“) because of the working medium which contains antifreeze, is in function during whole year.

4.2. Calculation of collected energy

4.2.1. Degree of usefulness of solar collector system

As it has been already said, utility of solar collector is complexly dependable on more variables. That is why it has been adopted use of laminar collector which is the same as in previous items.

Table 33. Adopted degrees of utility of collector during year (page 72 [22])

Month	Degree of utility of collector η_k
January	0,401
February	0,405
March	0,44
April	0,47
May	0,465
June	0,455
July	0,435
August	0,4
September	0,41
October	0,425
November	0,43
December	0,415

Since degree of utility of boiler also depends on more occasional variables, according to experimental data it has been adopted, as in the pervious item, that its utilization is η_B=0,85 and also it has been adopted that the cubic meters in pipeline are 3 %, i.e. that η_{cev}=0,97. Such low degrees of utilization, unlike previous items where it is η_B=0,85 and η_{cev}=0,97, are adopted because of the old age of these systems.

4.2.2. Collected energy during year

How much is the radiated sun energy per square meter of surface, and for the angle of the surface of 45°, it has been given in the following table for both households. It has been taken into consideration that collector in the Household 1 is not in function during December, January and February, while collector system in Household 2 is in function during whole year.

Table 34. Irradiation of solar collector on Households 1 and 2 in kWh/m²

Month	Average monthly irradiation of Collectors in Household	Average monthly irradiation of Collectors in Household
January	0	63,37
February	0	75,61
March	118,71	118,71
April	132,09	132,09
May	151,69	151,69
June	151,68	151,68
July	174,46	174,46
August	163,73	163,73
September	143,44	143,44
October	110,83	110,83
November	68,70	68,70
December	0	48,94
Total per year	1215,34	1403,26

Quantities of energy which is obtained from collector systems for heating sanitary water can be calculated with following expression:

$$G_K = H_i \cdot n_{kol} \cdot A_{kol} \cdot \eta_{kol\,i} \cdot \eta_{cev} \cdot \eta_B \, [\text{kWh}] \quad (28)$$

Where it is:

- G_K – quantity of energy gained from solar system;
- H_i – radiated quantity of sun energy during certain month;
- A_{kol} – net surface of one collector type (A_{kol} =1,2 m²);
- n_{kol} – number of collector on one facility (n_{kol} = 3);
- $\eta_{kol\,i}$ – degree of utilization of collector during certain month;
- η_B – degree of utilization of boiler (η_B=0,85);
- η_{cev} – degree of utilization of pipe network (η_{cev}=0,97).

In the following table, on the basis of the expression (28), are given calculated values for each month. It should be one more time mentioned that both households have three collectors of same surface placed on roof.

Table 35. Daily and monthly production of thermal energy

Month	Household 1 kWh	Household 2 kWh
January	0	75,43
February	0	90,89
March	155,04	155,04
April	184,27	184,27
May	209,36	209,36
June	204,85	204,85
July	225,26	225,26
August	194,39	194,39
September	174,57	174,57
October	139,82	139,82
November	87,68	87,68
December	0	60,29
Total per year	1575,23	1801,84

From table 60, it can be seen that Household 1 for heating sanitary water uses 1575,23kWh/year of solar energy, and Household 2 1801,84kWh/year. The rest of energy which is necessary for water to be heated up to the necessary temperature, it is provided by consuming electricity in electric boiler. This means that gathered data on territory of Gradiška, it is annually used in total around 3377,07kWh of solar energy.

4.3. Conclusion

As conclusion, in the following tables data were extracted from tables 35, and which are related to utilization of solar energy for baseline year 2005.

Table 36. Utilization of sun energy (conversion into thermal) for year 2005 in Gradiška

Name		Quantity	Unit of measure
1. Total production of thermal energy in Household 1		1575,23	kWh/year
2. Total production of thermal energy in Household 2		1801,84	kWh/year
	Total in both households	3377,07	kWh/year

CONCLUSION

In this item, only the most important data which were gathered in previous items will be shown in table.

Extracted data on energy and financial characteristics of solar plant, in general for the purposes of one average four-member household in Gradiška:

Table 37. Extracted data which characterize solar plant for production of electricity, for the purposes of one average four-member household in Gradiška

Name	Quantity		Unit of measure
1. Total production of electricity in solar plant	6248,38		kWh/year
2. Price of solar plant for production of electricity	53576,71		KM
Name	Money amount		Unit of measure
	Per current tariff	Per proposal of REERS	
3. Total earnings and savings of household	1158,74	4753,71	KM/year

Table 38. Extracted data which characterize solar system for production of hot consumable (sanitary) water for the purposes of one average four-member household in Gradiška

Name	Quantity	Unit of measure
1. Total production of thermal energy	2018,73	kWh/year
2. Price of solar plant	4972,00	KM
3. Total savings of household	244,93	KM/year

Extracted data on energy and financial characteristics of solar plants for heating sanitary water if installed on certain facilities[12]:

Table 39. Extracted data on total produced thermal energy, if solar systems are installed on certain facilities

Name of facility	Quantity	Unit of measure
1. Residential units in property of Grammar school	5618,84	kWh/year
2. Houses for abandoned children and children without parental care	10379,71	kWh/year
3. Building of the Administrative service of Municipality	4037,48	kWh/year
4. Grammar school Gradiška	12543,46	kWh/year
5. Technical school in Gradiška	11096,14	kWh/year
6. Professional and technical high school in Gradiška	12413,68	kWh/year
Total of all facilities	56089,31	kWh/year

Table 40. Extracted data on totally saved money, if solar systems are installed on certain facilities

Name of the facility	Quantity	Unit of measure
1. Residential units in property of Grammar school	681,73	KM/year
2. Houses for abandoned children and children without parental care	1259,36	KM/year
3. Building of the Administrative service of Municipality	489,86	KM/year

[12] Detailed overview of Work on installment of solar systems on certain facilities on the area of municipality Gradiška, is in the data base of the Municipal service for monitoring the implementation of SEAP.

4. Grammar school Gradiška	1521,88	KM/year
5. Technical school in Gradiška	1346,28	KM/year
6. Professional and technical high school in Gradiška	1506,14	KM/year
Total of all facilities	6805,25	KM/year

Table 41. Extracted data on price of plant for heating sanitary water, if they are installed on certain facilities

Name of facility	Quantity	Unit of measure
1. Residential units in property of Grammar school	11203,85	KM
2. Houses for abandoned children and children without parental care	19920,52	KM
3. Building of the Administrative service of Municipality	8368,03	KM
4. Grammar school Gradiška	52092,63	KM
5. Technical school in Gradiška	47492,53	KM
6. Professional and technical high school in Gradiška	47539,60	KM
Total of all facilities	186617,16	KM

Extracted data on used solar energy in Gradiška for 2005

Table 42. Extracted data on total utilization of sun energy (conversion into thermal) for 2005 in Gradiška

Name of the facility	Quantity	Unit of measure
1. Household 1 (St. V. S. Karadžića)	1575,23	kWh/year
2. Household 2 (St. M. G. Nikolajeviča)	1801,84	kWh/year
Total in both households	3377,07	kWh/year

LITERATURE

[1] Government of the Republic of Srpska (2008): Third project of renewal of EES, Study of energy sector in B&H, *Module 12-Management of consumption, savings of energy and renewable energy sources*. Energy Institute "Hrvoje Požar"-Hrvatska, Soluziona-Španija, Faculty of Economics-BL/BiH, Mine Institute Tuzla-BiH, BiH.

[2] Milovanović, Z. N. (2009): "Nekonvencionalni izvori energije-održiv razvoj i korišćenje" U: *Zbornik radova sa 22. Međunarodnog kongresa o procesnoj industriji*. Union of Mechanical and Electrical Engineers and Technicians (SMEITS), Section for process techniques, Beograd, pp. 8.

[3] Anonymus (2010): *"Studija ekonomske opravdanosti izgradnje MHE Do na rijeci Bregavi"*. Planning, Prnjavor.

[4] Milovanović, Z. et. al. (2010): "Analiza samoodrživosti modela primjene vertikalne vjetroelektrane u ruralnom domaćinstvu". *Science-research project co-financed by Ministry of Scinece and technology of RS*. Banja Luka, University in Banja Luka, RJ Faculty for Mechanical Engineering.

[5] Regulatory Commission for energetics of the Republic of Srpska-RERS [online]. Available on: http://www.reers.ba, content up to date 2012.

[6] Pilot project solar roof Špansko/Zagreb-EIHP [online]. Available on: http://www.eihp.hr/hrvatski/solarnikrov.htm, content up to date 2012.

[7] Technical conditions for connecting micro sun electric plants on low-voltage network [online]. Available on: http://www.ho-cired.hr/referati/SO4-03.pdf, content up to date 2012.

[8] Bilić, Z. (2006): *"Napajanje udaljenog stambenog objekta pomoću energije vjetra i sunčevog zračenja"*. Thesis. Department: Faculty of Electric Engineering

[9] Solaris [online]. Available on: http://solaris-novigrad.hr, content up to date 2012.

[10] Solar project [online]. Available on: http://www.solarprojekt.hr, content up to date 2012.

[11] Homer energy [online]. Available on: http://www.homerenergy.com, content up to date 2012.

[12] Nodilo, K. (2010): *"Usporedba mjerenja i procjena za fotonaponske primjene"* Thesis. Zagreb:Faculty of Electric Engineering and Computer science.

[13] Axaopoulos, P. (n.d.): *3. "Osnovni principi solarne geometrije"*.

[14] Bošnjaković, M. (2010): *"Energija sunca 1, 2. i 3. Dio"*. University of Slavonski Brod.

[15] Pehar, T. (2009): *"Smjernice za izradu projektne dokumentacije fotonaponskog sustava spojenog na elektroenergetsku mrežu"*. Thesis. Zagreb: Faculty of Electric Engineering and Computer science

[16] Perić, M. (2002): *"Računalna simulacija rada fotonaponskog sustava"*. Master thesis. Zagreb: Faculty of Electric Engineering and Computer science.

[17] Radosavljević, M. J. et. al. (2004): *"Solarna energetika i održivi razvoj"*. Građevinska knjiga, Beograd.

[18] Pavlović, M. T., Čabrić, D. B.(2007): *"Fizika i tehnika solarne energetike"*. Građevinska knjiga, Beograd.

[19] Miličić, D. (2000): *"Energetska postrojenja sa nekonvencionalnim izorima energije"*, Excerpt from lectures within subject „Basics of thermoenergetics". Mašinski fakultet, Banja Luka.

[20] Matić, Z. (2007): *"Sunčeva energija"*. Graditeljska škola, Čakovec.

[21] Šljivac, D., Šimić, Z. (2008): *"Obnovljivi izvori energije sa osvrtom na gospodarenje"*. Croatian chamber of architects and civil engineeres, Osijek.

[22] Lambić, M (1992): *"Priručnik za solarno grejanje"*. Naučna knjiga, Beograd.

[23] Solar free energy [online]. Available on: http://solarna.besplatnaenergija.com, content up to date.
[24] Gidas d.o.o. (2011): *Megasun–No1 Under the sun*, Technical instruction, Banja Luka.
[25] Termo klima [online]. Available on: http://www.termoklimadoo.com, content up to date 2012.
[26] Google Earth [online]. Available on: http://www.google-earth.com, content up to date 2012.