Intelligent Energy Europe

TRANS-SOLAR

CROATIAN NATIONAL REPORT

Energy Institute Hrvoje Požar

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A. Introduction

1. Overview of the country

The Republic of Croatia is a southern Central European country at the crossroads between the Pannonian Plain and the Mediterranean Sea. The capital is Zagreb. Croatia borders with Slovenia and Hungary to the north, Serbia to the northeast, Bosnia and Herzegovina to the east, and Montenegro to the far southeast. Its southern and western flanks border the Adriatic Sea, and it also shares a sea border with Italy in the Gulf of Trieste.

Figure 1: Geographical position of Croatia (Source: CIA Factbook)

1.1. Basic Facts about the Republic of Croatia

Area: 56 594 km²

Territorial sea and inland sea area: 31 067 km²

Length of sea coastline with islands: 5 835 km

Land border length: 2 028 km

The highest mountain: Dinara (1 831 m)

Number of islands (47 inhabited): 1 185

Islands over 100 m²: Krk, Cres, Brač, Hvar, Pag, Korčula, Dugi otok, Mljet

Climate: continental climate conditions in the northern and eastern parts and Mediterranean ones along the Adriatic coast

Terrain: plains, lakes and rolling hills in the continental north and northeast, densely wooded mountains in part of the Dinaric Alps and rocky coastlines on the Adriatic Sea

Population (2001 Census): 4 437 460

Population density per km²: 78.5

Capital: Zagreb (779 145 inhabitants)

Religions: Roman Catholic, Orthodox, Islam, Jewish, Protestant and others

Language: Croatian

Script: Latin

Currency: Kuna (HRK); 7,3 HRK = EUR 1 (constant)

Political system: Parliamentary democracy

Universities: Zagreb, Split, Rijeka, Osijek, Zadar, Dubrovnik, Pula

National parks: Plitvička jezera, Krka, Paklenica, Mljet, Risnjak, Brijuni, Kornati, Sjeverni Velebit

Source: DZS

1.2. Meteorology: temperatures, global daily radiation

1.2.1. Climate

This region called Dalmatia has a Mediterranean type of climate with mild winters and warm, sometimes even hot and sunny summers. The coast is backed by the high mountains of the Dinaric Alps - rising up to 1800 m (Velebit, Biokovo). Winter rainfall in this part of Croatia is heavy.
Average temperature in January:
the interior -1 to 3° C; mountains -5 to 0° C; coast 5 to 10°C
Average temperature in August:
the interior 22 to 26° C; mountains 15 to 20°C; coast 26 to 30°C
In southern Dalmatia, where the sirocco winds (known here as the jugo) bring a moderating influence from Africa: summers are sunny, warm, and dry, and winters are rainy. In the north the winters are drier and colder as a result of the cold northeast wind known as the bora (bura). In the summer the mistral wind has a cooling effect on the coast and the islands.
Summers on this part of the Croatianian coast are not completely rainless, and the bright and sunny weather is sometimes disturbed by thunderstorms so having a light waterproof overcoat is essential.
Sunshine averages in Croatia are from about four hours a day in winter and from ten to twelve hours a day in summer.
Moving towards the continental part of Croatia, inland climatic conditions swiftly become more typically Eastern European with cold winters and warm summers. Summers in continental Croatia tent to get the wettest season too.
Much of inland Croatia is mountainous and hilly. Winters in Continental Croatia are full of snow that stays for long periods in the higher Croatian regions.
Slavonia and Eastern Croatia is mostly fertile flat land in the valleys of the river Danube (Dunav), river Drava, and River Sava where winters are very cold with snow and ice.

1.2.2. Solar radiation

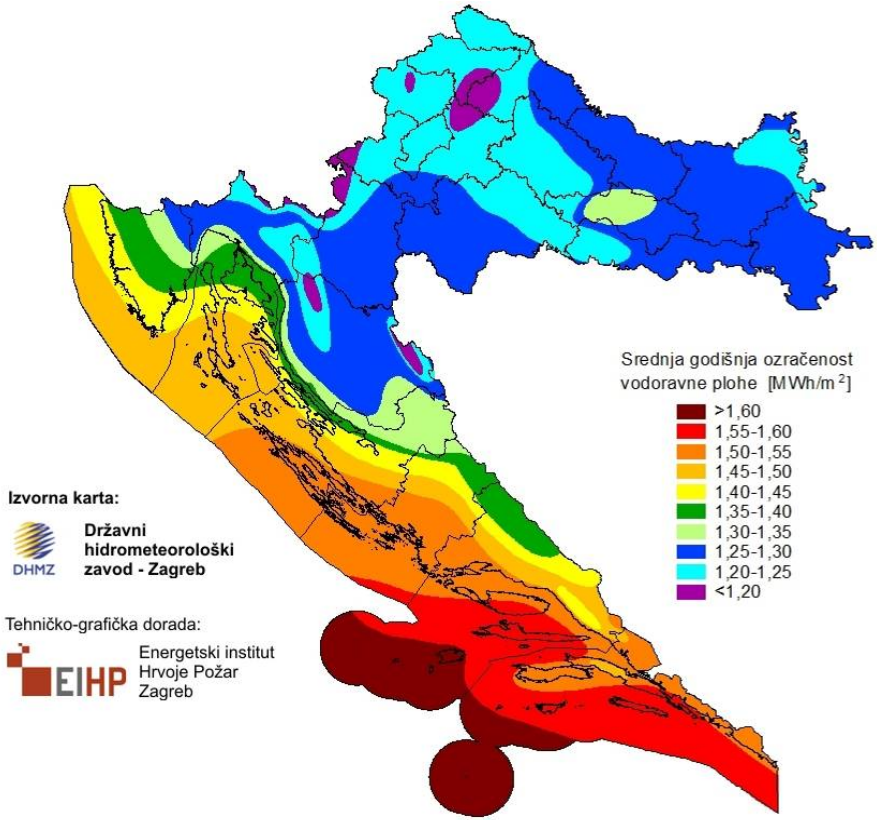


Figure 2: Annual sum of global irradiation on a horizontal plane (Source EIHP)

Research in solar energy in Croatia has experienced rather strong support during the 1970s and 80s. However, starting from late 1980s there are wide gaps in solar radiation measurements on meteorological stations of Croatian State Meteorological Service (Croatian: Državni hidrometeorološki zavod - DHMZ). During 2003 meteorological network of the State meteorological service was upgraded with six instruments, with diffuse solar radiation measured in Zagreb and Split. Energy Institute Hrvoje Požar initiated several solar radiation measurements projects. In cooperation with the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture of the University of Split (FESB) and State Meteorological Service, measurement of solar radiation components with a multipyranometer array has started in Zagreb and Split. In the framework of European Union technical assistance CARDS 2003, a project 'Solar and Wind Energy Resource Assessment in Croatia' will initiate complex solar radiation measurements on several locations in County of Zadar, Šibenik-Knin, Split-Dalmatia and Dubrovnik-Neretva.

In order to provide reliable solar radiation data for the design of solar energy conversion systems, the Energy Institute Hrvoje Požar and the Ministry of Economy, Labour and Entrepreneurship with the cooperation of the State Meteorological Service initiated development of the Solar Radiation Atlas of Republic of Croatia based on existing solar radiation data and knowledge. The Atlas, based on sunshine duration measurement and cloud cover observations, covers 43 locations. An algorithmic chain closely follows proposed mathematical models in the European Solar Radiation Atlas, with some modification for the measurement situation in Croatia.

The starting point of solar energy calculations is the monthly mean daily global irradiation on a horizontal plane. This data is calculated from sunshine duration measured on 37 locations from 1961 till 1980. A linear correlation between sunshine duration and irradiation, with correlation coefficients calculated from pyranometer measurements from 11 locations, 6 of them in the area of the Republic of Croatia.

The map of horizontal plane global irradiation, made by the State meteorological service are based on irradiation measurements (6 locations), sunshine duration measurements (37 locations) and cloud cover observations (94 locations).

The maps are updated and modified for GIS (geographic information system) applications. One annual and twelve monthly maps are made. Monthly maps have the gradient of 200 Wh/m². In some particular areas the gradient is even smaller, at 100 Wh/m².
Solar radiation entering the upper border of the Earth's atmosphere depends only on geographical latitude. However, on the ground influence of terrain takes place. This is manifested in the deformation of the radiation isolines. Closely following the variations with latitude, global irradiation is generally decreasing from northwest towards southeast of the country. Major influence of latitude is modified on the ground due to a complex terrain orography. Area around Križevci, Brinje and Lička Plješivica have global annual irradiation between 1,15 and 1,20 MWh/m². Irradiation values are increasing with a small gradient over Psunj area towards Učka Mountain, and trough Velebit towards Bosnia border (Drvar). Going west from that region, the isolines are very dense and oriented almost parallel to the coastline because of the orientation of mountain ranges on the coast and islands.
Irradiation is the greatest on open-sea islands of the South Adriatic (1,65 MWh/m²) and gradually decreases through the coastal mountains range where most of the continental Croatia has annual irradiation between 1,2 and 1,3 MWh/m².

1.3. Relief

A considerable part of Croatia lies at an altitude of over 500 m, but there are no mountains higher than 2000 m. Lowlands prevail in eastern and northwestern Croatia, while the highest mountains in the mountainous part are found in the area which separates the continental mainland from the Coast (Risnjak 1528 m, Velika Kapela 1533 m, Plješivica 1657m) or close to the sea (Učka 1396m, Velebit 1758m). The highest mountains in Dalmatia are Biokovo (1762m) close to the sea and Dinara (1831m) in the hinterland.

1.4. Population: evolution for the last 10 years, actual situation and forecast

The population of Croatia at the end of 2001 was **4,437,460 people,** estimated population in 2008 is 4,453,500. The density of population per km² is 78.5.

The tendency is for a further decrease of the population.

1.5. Additional available statistic

1.5.1. Available statistic concerning energy

Table 1: GDP in Croatia for the period 2000 – 2006 (Source: DZS)

	2000	2001	2002	2003	2004	2005	2006
GDP (million HRK)	152.519	165.639	181.231	198.422	212.827	231.349	250.590
Real GDP growth rate (%)	2,9	4,4	5,6	5,3	4,3	4,3	4,8
Year-on-year consumer price growth (%)	4,6	3,8	1,7	1,8	2,1	3,3	3,2
Average exchange rate (HRK:USD)	8,3	8,3	7,8	6,7	6,0	6,0	5,8
Average net monthly wage (HRK)*	3.324	3.541	3.719	3.939	4.172	4.375	4.603

Table 2: Primary energy production in Croatia for the period 2002 – 2007 (Source: EIHP)

	2002.	2003.	2004.	2005.	2006.	2007.	2007./06.	2002.-07.
	PJ						%	
Ogrjevno drvo Fuel wood	12,39	15,96	15,86	14,77	17,18	15,11	-12,0	4,1
Sirova nafta Crude oil	47,00	44,61	42,44	40,11	38,90	37,27	-4,2	-4,5
Prirodni plin Natural gas	74,53	76,83	77,08	79,76	94,27	100,12	6,2	6,1
Vodne snage Hydro power	52,01	46,48	69,00	62,40	58,18	42,21	-27,4	-4,1
Obnovljivi izvori Renewables			0,02	0,20	0,24	0,71	200,7	
UKUPNO TOTAL	185,94	183,87	204,40	197,23	208,76	195,44	-6,4	1,0

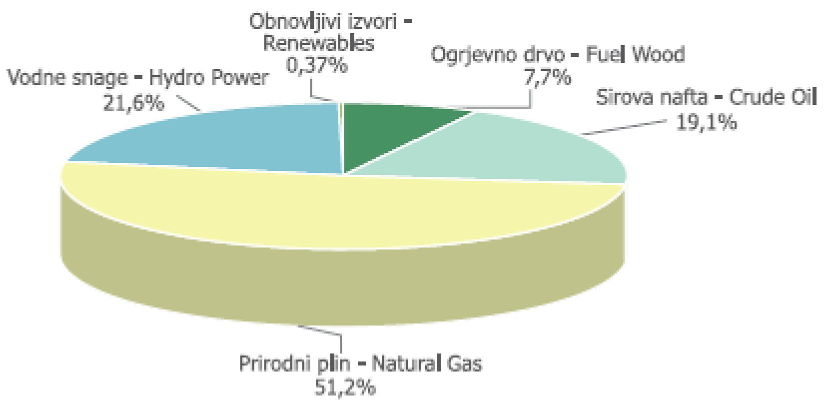


Figure 3: Shares in primary energy production in 2007 (Source: EIHP)

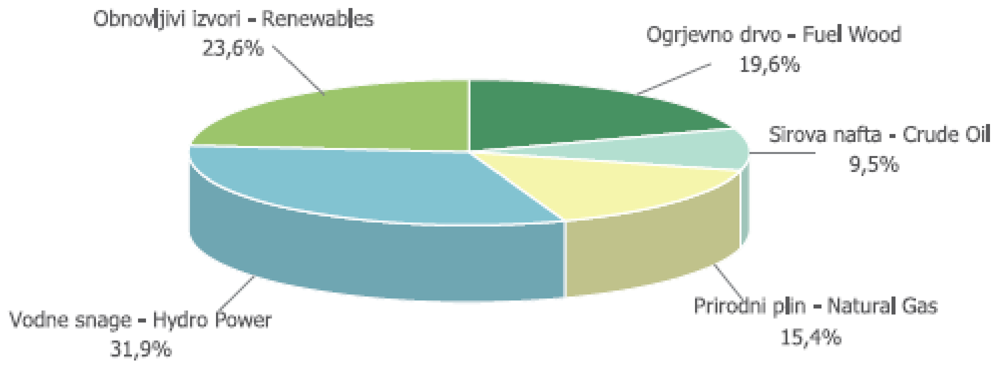


Figure 4: Shares in primary energy production in 2030 (Source: EIHP)

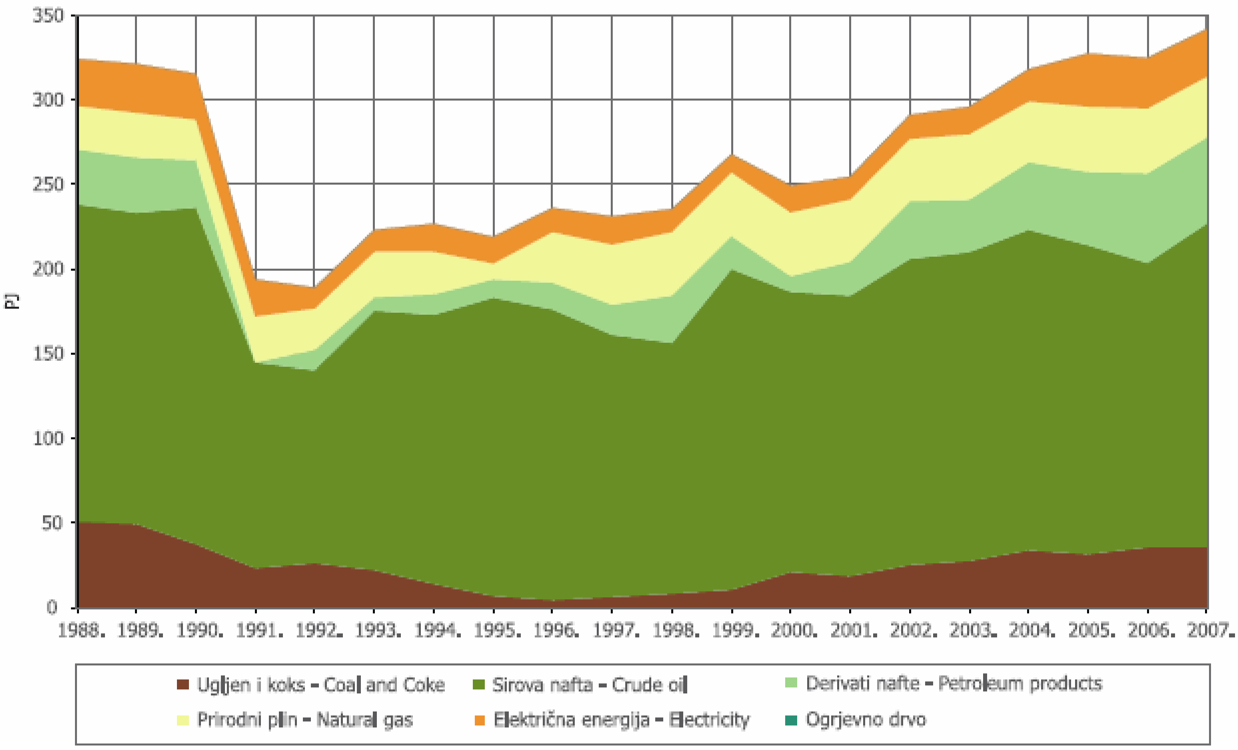


Figure 5: Energy import in Croatia for the period 1988 - 2007 (Source: EIHP)

Croatia is dependent on energy as it imports more than 70% of its primary energy sources. The significant domestic energy source is oil, gas and hydroelectricity.

1.5.2. CO_2 emissions

According to the preliminary results for the year 2006, CO_2 emissions from the energy sector amounted to around 20 million tons, which is 1.7 per cent less than in the previous year and 2,2 percent less than in 1990.
The main source of CO_2 emissions is fuel combustion. In 2006 stationary energy sources emitted 67 per cent of CO_2; namely, 33% of CO_2 was emitted from energy production and transformation plants, 17% from manufacturing industries and construction and 17% from non-industrial combustion furnaces. Road transport contributed to total energy emissions with 27 per cent, while other mobile sources contributed 5%. In addition to the energy sector, production processes without fuel combustion (mainly cement industry) and extraction and distribution of fossil fuels (CO_2 extraction from natural gas in CPS Molve) are also significant sources of CO_2 emissions (10 to 14% of total national CO_2 emissions).

Figure 6: Trends in CO_2 emissions from fuel combustion (Source: EIHP)

Table 3: CO_2 emissions from energy subsectors in the period from 2002 to 2007 (Source: EIHP)

	2002.	2003.	2004.	2005.	2006.	2007.*	2007./06.	2002.-07.
	tona				metric tons		%	
Postrojenja za proizvodnju i transformaciju energije Energy production and transformation plants	23 290	35 701	25 655	32 761	30 442	38 246	25,6	10,4
Neindustrijska ložišta Non-industrial combustion furnaces	6 604	6 038	5 525	5 232	4 402	3 388	-23,0	-12,5
Industrija i građevinarstvo Manufacturing industries and construction	29 278	14 805	12 496	9 334	10 639	8 424	-20,8	-22,1
Cestovni promet Road transport	5 367	6 606	7 313	7 818	8 328	7 355	-11,7	6,5
Ostali mobilni izvori Other mobile sources	2 784	3 030	2 810	2 902	3 083	3 320	7,7	3,6
Ukupno Total	67 323	66 179	53 799	58 047	56 895	60 733	6,7	-2,0

* -preliminarni rezultati

* - preliminary results

B. State of the Market

2. Overview of the market situation

Solar energy research in Croatia dates back to 1976 in the framework of project *Solar Energy and its Conversion* at the *Ruđer Bošković Institute* in Zagreb. In 1978 *Society for Solar Energy* was established in Rijeka and the scientific journal *Sunčeva energija* saw its first publication. The journal existed until 1990. During the 1970s research groups in the field of solar energy were established within the Ruđer Bošković Institute in Zagreb, the Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture in Split, Faculty of Mechanical Engineering and Naval Architecture in Zagreb and Technical Faculty in Rijeka. In the 1980s more that 15 factories of various capacities producing solar thermal collectors existed. Solar collector factories operated until the latter years of the last century in Zagreb (Rade Končar factory), Split (Termofriz factory), Varaždin (VIKO factory) and Pula (Tehnomont shipyard). Production ceased in Končar factory in 1997 leaving only Tehnomont Pula shipyard operational today, its survival mostly due to integration with wider production/shipbuilding. The capacity of this factory is circa 20,000 square meters of solar collector per annum, augmented by the production of solar hot water tanks. Today, the collectors are produced in low volumes.
The majority of solar collectors in Croatia were installed in 1980s during the period of increased social sensitivity toward solar energy, mostly all of domestic origin. Until 2001 installed surfaced were humble with cumulative surfaces rapidly declining as the collector systems installed in 1980s reached their functional lifetime. But starting in 2002 due to increased public interest, increasing energy prices (small in today's terms) and availability of cheaper systems have resulted in a rapid increase. Another sharp increase is also visible in 2007, evidently due to the same factors.

2.1. Problems encountered

The most significant problem solar energy sector encountered was the Croatian War for Independence form Yugoslavia from 1991-1995. The war caused a decrease in all level of economic activities. However other reasons were also significant:
- Lack of any stimulation measures, subsidy or fiscal intervention in solar sector from the government
- Unorganized market for solar systems: installers not being trained for solar systems installation, systems poorly designed and maintained etc.
- Energy prices being not reflecting real cost of energy, electricity and gas subsidization from the government

2.2. Reasons of success or failure

Three major factors of success can be identified: availability, information and money. In recent few years, several major European companies entered Croatian solar thermal market and increased sales in the high end market segment. The available supply of good quality systems being installed by installer's trained in various "Solar Training Academies" created demand for their products and services. Information dissemination from several sources caused people to pay more interest to alternatives to fossil fuel production of hot water, and finally, increase of the price of energy strongly reduced pay back periods for solar water systems.

2.3. Demonstration projects of high visibility

High visibility project were installed before 1990. Several can be identified:
- Flat plate systems in tourist facilities in Poreč and Rabac (Valamar, Hoteli Rabac)
- Flat plate and concentration system in Orlando hotel in Srebreno near Dubrovnik

- Flat plate systems in hotels Kompas, Park, Lero and Excelsior in Dubrovnik
- Combined flat plate solar systems and ground heat pumps in Punta Verudela in Pula, ACI marine in Ičići and Nautica facility in Dubrovnik
- Flat plate system in Omorika hotel in Crikvenica.

2.4. Description of the present situation

The majority of systems installed before 1990 have fulfilled their operational life span and are considered defunct. We can estimate that around 70.000 m² of solar collectors are in operation. This has happened without any support from the government. A strong increase in collector installation can be noticed in recent years. There are some announcements that a subsidy scheme is being drafted by the Ministry of Economy with the cooperation of the Environmental Protection and Energy Efficiency Fund, but no details have been disclosed.

2.5. Imports / exports figures

Only one company in Croatia produces solar collectors. There are several companies producing solar tanks. No data exists regarding the origin of imported collectors, but major players are German and Austrian companies.

2.6. Installers organization

Installers are not organized in any association. However there are two solar associations active in the dissemination and promotion field: Croatian Society for Solar Energy was established in 1988 in Rijeka and Croatian Professional Society for Solar Energy established in 2004 in Zagreb.

2.7. Types of solar systems

Most common systems installed have flat plate collectors with selective absorber, close loop systems with pump, heat exchanger, integrated in heat storage and antifreeze protection.
A sharp increase in vacuum tube collectors is noticeable, used mainly in systems requiring higher temperatures and availability throughout the year.

2.7.1. Flat-plate collectors

Flat-plate collectors are the most common solar collectors for use in solar water-heating systems in homes and in solar space heating. A flat-plate collector consists basically of an insulated weatherproofed metal box with a glass or plastic cover (the glazing) and a dark-coloured absorber plate. Sunlight passes through the glazing and strikes the absorber plate, which heats up, changing solar energy into heat energy. The heat is transferred to a liquid passing through pipes attached to the absorber plate. Absorber plates are commonly painted with "selective coatings," which absorb and retain heat better than ordinary black paint. In an air-based collector the circulating fluid is air, whereas in a liquid-based collector it is usually water.
Flat-plate collectors heat the circulating fluid to a temperature considerably less than that of the boiling point of water and are best suited to applications where the demand temperature is 30-70°C and/or for applications that require heat during the winter months.
Flat collectors can be mounted in a variety of ways, depending on the type of building, thee application, and the size of collector. Options include mounting on a roof, in the roof itself, or free-standing.

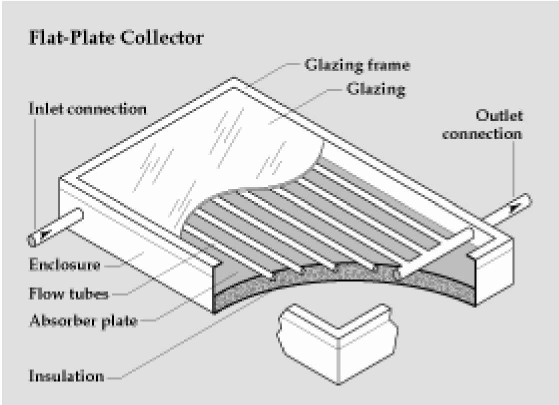


Figure 7: Flat-Plate Collector (Source: US Department of Energy, Solar Energy Technologies Program)

2.7.2. Evacuated-tube collectors

Evacuated-tube (vacuum) collectors are highly efficient collectors that have multiple evacuated glass tubes connected parallel above a metal reflector which heat up solar absorbers and solar working fluid (water or an antifreeze mix -- typically propylene glycol). The vacuum within the evacuated tubes reduces conduction heat losses, allowing them to reach considerably higher temperatures than most flat-plate collectors. The evacuated tubes draw their energy from the available light rather than outside temperature. For these reasons they can perform well in colder conditions. The advantage is largely lost in warmer climates. The high temperatures that can occur may require special system design to avoid or mitigate overheating conditions though some have built in temperature limitation.

A claimed advantage this design has over the flat-plate type is that the constant profile of the round tube means that the collector is always perpendicular to the sun's rays and therefore the energy absorbed is approximately constant over the course of a day. The question what to do with the "lost" sun shining through the gaps between evacuated tubes (gaps which can be as wide as the tubes' absorptive surface themselves) can be addressed either by adding specially curved metal reflectors under the evacuated tubes or by reverting to the use of flat plate collectors which are designed not to offer any gaps in the collector's light interception profile.

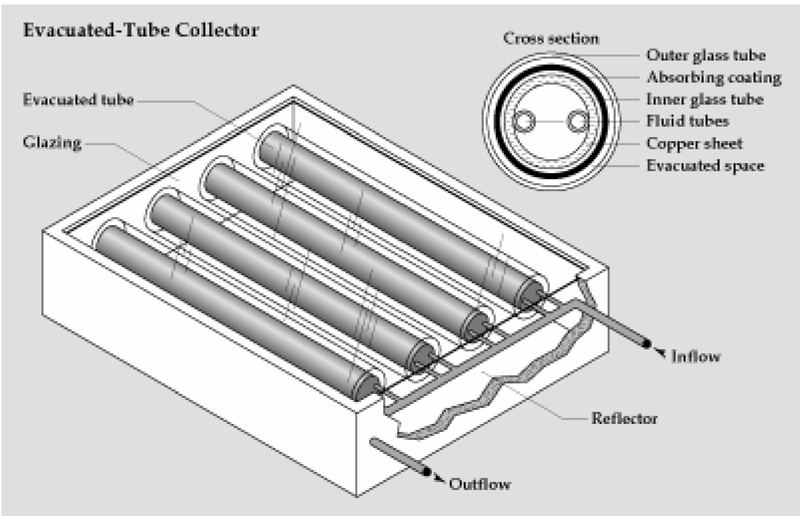


Figure 8: Evacuated-Tube Collector (Source: US Department of Energy, Solar Energy Technologies Program)

3. Solar collector production and sales

Table 4: Solar collector production and sales in Croatia for the period 1998 - 2007

Year	Flat Plate Collectors Production and sales in m²				Vacuum Collectors Production and sales in m²				Unglazed Collectors in m²
	A	B	C	D = A-B+C	A	B	C	D = A-B+C	
	Total national production	Exports	Imports	Total home market sales	Total national production	Exports	Imports	Total home market sales	Total home market sales
1998	936		950	1886			100		
1999	926		1150	2076			100		
2000	670		1400	2070			110		
2001	724		1710	2434			150		
2002	600		3656	4256			162		
2003	700		4018	4718			302		
2004	800		5282	6082			575		
2005	1000		4202	5202			772		
2006	1000		5487	6487			1121		
2007	1000		8183	9183			1698		
Total	**8356**		**36038**	**44394**			**5090**		

Statistical data for the market of solar thermal systems is not available and a direct survey of the manufacturers and importers was necessary. Estimated quantity for previous period (before 1998) is 15.000 m² solar collectors in operation. The total number of collectors is estimated to be around 65.000 m².

Out of the 14 companies participating in the questionnaire, only two offer both flat and vacuum tube collectors. Other firms offer only flat collectors and only one company has production of flat collectors. No sales of unglazed collectors were reported.

3.1. Estimated solar park in working order in 2007

Flat plate collectors in m²: 60.000
Vacuum collectors in m²: 5000
Unglazed collectors in m²: 0

Total in m² 65.000 m²

3.2. Estimated annual solar thermal energy production in 2007

If we take an average of 600 kWh/m²*year for the different type of collectors then in total the estimated annual solar thermal energy production in 2007 would be 65.000 m² x 600 kWh/m² * year = 39.000 MWh

3.3. CO_2 emissions avoided in 2007 (on the basis of oil)

CO_2 emissions avoided in 2007 are 65.000 m² x 210 kg/ m²*year = 13.650 t.

4. Product types and solar thermal applications

4.1. Product types

4.1.1. Flat plate collector

The major type of solar collectors used is the flat plate collectors with selective absorber. Close loop systems with pump, heat exchanger, integrated in heat storage and antifreeze protection are most common.

- Absorber: Cu
- Absorption coefficient: 95%
- Reflecting ability: 5%
- Heat carrying liquid: Propylene glycol
- Annual production: 620 kWh/m²

Used for:
- Domestic hot water production
- Pool water heating
- Combined systems (domestic hot water and space heating with additional source)

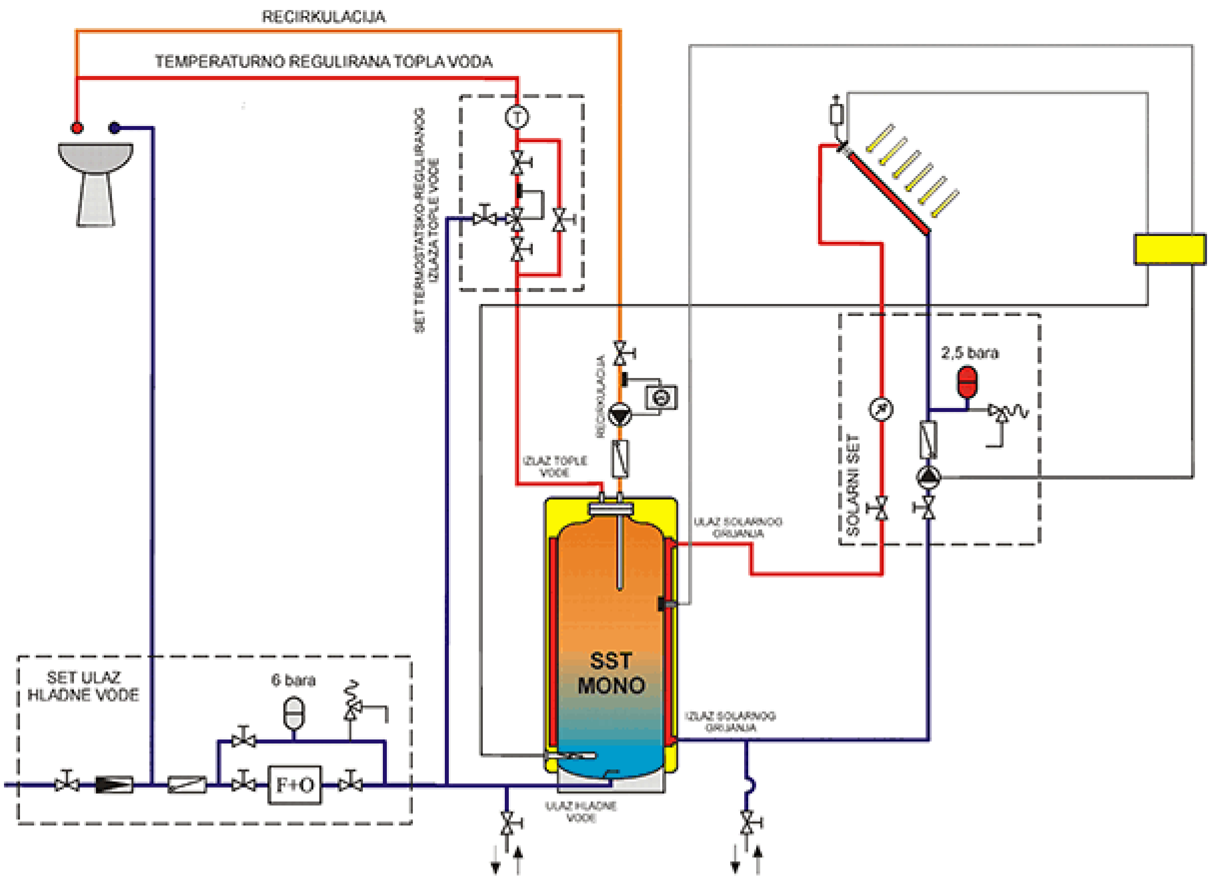


Figure 9 Flat plate collector system for domestic hot water production (Source: Horvatić)

4.1.2. Evacuated-tube collectors

Because of their high price, evacuated-tube (vacuum) collectors are not used much as flat plate collectors.

- Absorber: Copper with selective coating
- Absorber isolation: vacuum
- Absorption coefficient: 96%
- Reflecting ability: 4%
- Heat carrying liquid: mix glycol and water
- Annual production: 720 kWh/m²

Used for:
- Domestic hot water production
- Space heating
- Pool water heating
- Combined systems (domestic hot water and space heating with additional source)

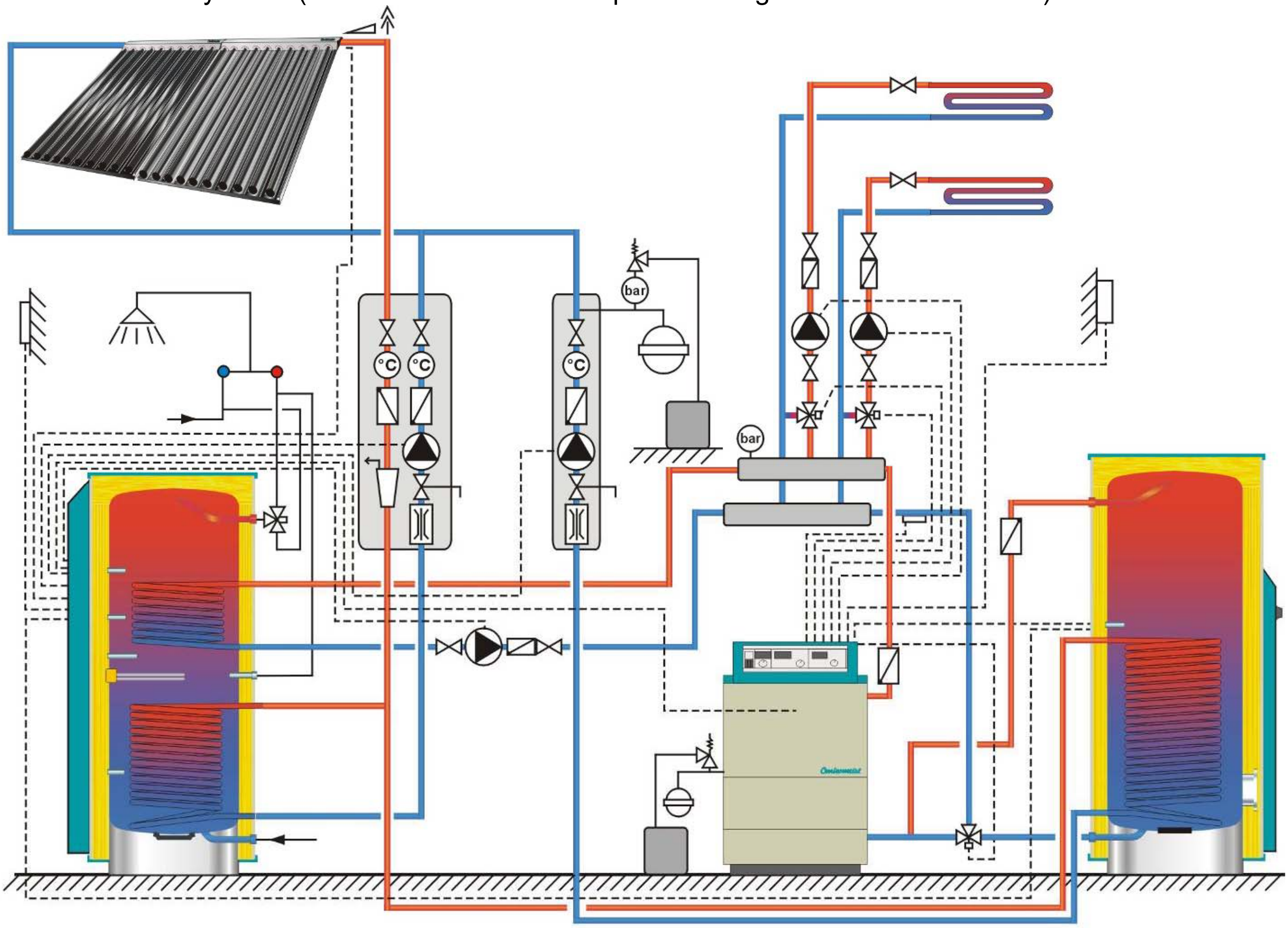


Figure 10 Combined system with vacuum solar collectors (Source: EIHP)

4.2. Applications

No data exists regarding installation and usage figures by segment. However the following tendencies can be mentioned:

- Domestic hot water production.
  This is the largest segment of the solar thermal applications in Croatia
- Large solar systems
  Almost all installations with larger collectors are in the tourist industry, and almost all are installed in coastal region of Croatia. No statistical survey of installations has been made
- Space heating
  Combined space and hot water systems are very rare in Croatia, though one could expect the biggest potential from this segment.
- District heating.
  There are no district heating applications so far in the country.

5. Market share of major manufacturers

Tehnomont Pula is the only producer of solar collectors in Croatia. It produces 2 m² flat plate selective absorber solar collectors. The flat plate market share in 2007 can be estimated at around 10 %.

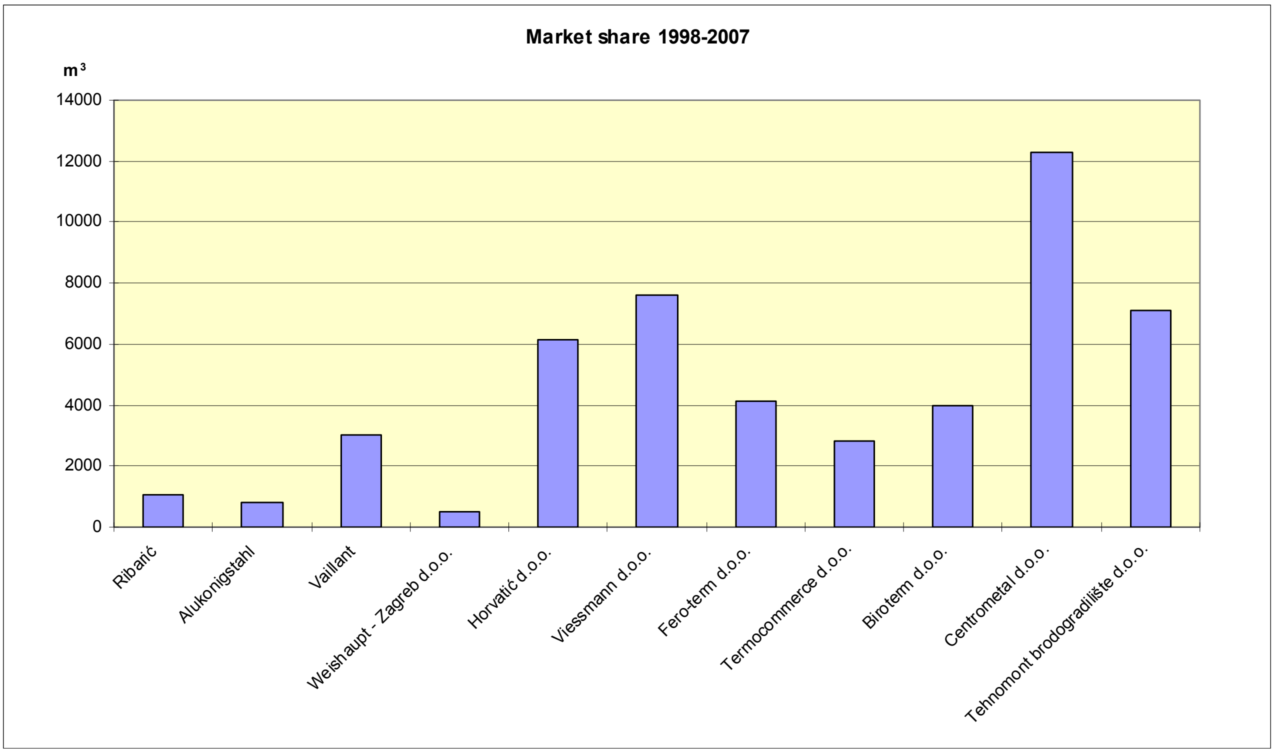


Figure 11 Market share of producers of solar collectors 1998 – 2007 [Source: EIHP]

6. Employment

There are no statistical data on the employment in the solar thermal market but we can estimate this number to be 200 people in production and sales.

C. State of Production

7. Product technology and production methods

7.1. Product technology description

The only collector which is produced in Croatia has the following characteristics:

- Flat plate collectors with selective absorber; size 2,0 m²
- Absorber material: copper
- Surface treatment.
- Insulation: mineral wadding
- Transparent cover: prismatic solar glass
- Casing: eluxated aluminum profile
- Cover: Selective cover

7.2. Product technology description

One company is producing solar collectors but the absorber is imported and the rest is produced and assembled in Croatia.

8. Breakdown of solar systems costs

The usual solar system uses flat plate collectors. The price for one single plate with a size of 2m² is between 330 and 430 Euro. For vacuum collectors prices are around 630 Euros.
Most solar tanks are also imported but two firms producing them in Croatia. Price for solar tanks (300 liters) is around 650 Euros. They also produce automatic regulation systems.
The rest of the equipment (pumps, pipes...) are imported and therefore prices are very similar between all firms.

Table 5: Solar system Costs for typically sized systems

Solar Systems Costs for Typically Sized Systems		
	6m²	**15m²**
Total costs (excl. VAT)	710 Euro / m²	620 Euro / m²
VAT (%)	140 Euro / m²	130 Euro / m²
Total cost (incl. VAT)	**850 Euro / m²**	**750 Euro / m²**

9. Typical solar domestic hot water systems

9.1. Single family house, Zagreb

- System type: heat exchanger closed loop
- Collector type: flat plate selective
- Collector area (m²). 4 m²
- Collector area per person (m²/person): 0,7 m² /person
- Hot water storage (liters): 300 l
- Price per m² system costs: 600 EUR
- Amortization based on the present energy price: more than 10 years
- Eventual subsidies. None so far.

Figure 12 Solar roof in Špansko, Zagreb with flat plate collectors and photovoltaic modules (Source EIHP)

9.2. Small cooperative, Zagreb

- System type: heat exchanger closed loop
- Collector type: flat plate selective
- Collector area (m²). 40 m²
- Collector area per person (m²/person): 0.5
- Collector area per dwelling (m²/dwelling): 1.5 m²/dwelling
- Hot water storage (liters): 6 m^3
- Price per m² system costs: 450 EUR
- Amortization based on the present energy price: around 8 years
- Eventual subsidies: None so far

9.3. Nursing home "Kuća Sv. Franje"

- System type: n.a.
- Collector type: flat plate selective
- Collector area: 60 m²
- Collector area per person: n.a.
- Hot water storage (liters): n.a.
- Price per m² system costs: n.a.
- Amortization based on the present energy price: n.a.
- Eventual subsidies: None so far

Figure 13 Flate plate collectors on roof of nursing home "Kuća Sv. Franje", Odra, Zagreb

9.4. General hospital, Zadar

- System type: heat exchanger closed loop
- Collector type: flat plate selective
- Collector area (m²): 42x14,3=600,6 m²
- Collector area per person (m²/person): n.a.
- Hot water demand at 60°C: 360,36 MWh/y
- Hot water storage (liters): 30000
- Price per m² system costs: 360 Euro/ m²
- Amortization based on the present energy price; 7,5 yrs
- Eventual subsidies. Possible subsidies from the Fund for Environmental Protection and Energy Efficiency (30%)

9.5. Typical consumer motivation

- Single family house: pay-back period is reduced with rising energy prices; fashionable for people with enough income; wide spread in southernmost regions.

- Dwelling: motivation of the investor in newly built dwellings.

- Hospital: mostly demonstration projects financed through different programs and the state. Opportunities for financing under the structural and rural development funds.

- Hotels: rapid growth due to high demand of hot water, rapid development of tourist sector and favorable conditions especially at seaside resorts. Possible to shut down gas boilers during summer periods.

10. Typical solar combined systems

The used systems are explained in point 4.1.

10.1. Typical consumer motivation

The typical customer motivation for combined system purchase is basically the same as the typical customer motivation for solar domestic hot water production systems, to decrease primer energy source and decrease expenses

11. Conventional water heating and energy prices

11.1. Electricity prices for households

The Croatian Power Utility is the only company selling electricity in Croatia. The prices for 2008 are:

Table 6: Electrical energy prices in Croatia for 2008

Type	Time	Price Euro/kWh with VAT
Two tariff counter	Day	0,125
	Night	0,053
Singe tariff counter		0,120

11.2. Prices for heat energy

However, heat energy is supplied by different suppliers in Croatia. The prices vary in wide range due to complicated local conditions.
Heat energy prices with VAT.

Table 7: Heat energy prices in Croatia for 2008

No	Heat supplier	Prices of heat energy	
		households Euro/kWh	Commercial area, Euro/kWh
1.	HEP -Zagreb	0,016	0,027
2.	HEP- Zagreb county	0,019 – 0,024	0,027
3.	HEP - Osijek	0,015	0,0014 -0,027
3.	HEP - Sisak	0,018	0,031
4.	ENERGO RIJEKA	0,054	0,069

11.3. Prices for natural gas

Natural gas is provided by several suppliers. The prices range between 0,24 and 0,30 Euro/m^3.
The price of bottled gas is 0,97 Euro /kg.

Table 8: Conventional energy prices in Croatia for 2008 (Source HEP, EIHP, INA, ProPlin, Hrvatske šume):

Conventional Energy Prices	
Date: 2008	**Housing** VAT incl.
Electricity - normal	0,08 Euro/ kWh
Electricity - discounted rate	- Euro/ kWh
Electricity – peak rate Electricity - low rate	0,15 Euro/ kWh 0,05 Euro/ kWh
Fuel - Oil	0,05 Euro/ kWh
Bottled gas Natural gas	0,08 Euro/ kWh 0,03 Euro/ kWh
District heating (basic fee) District heating (heating fee)	1,52 Euro/ month kW 0,02 Euro/ kWh
Wood*	0,0075 Euro/ kWh

* *price at forest road*
Note: The price for dwellings and single family houses is the same.

12. Standards and codes of practice

12.1. Is there an obligation for collectors to be tested or certified?

There is no obligation for certification and there is no laboratory in Croatia for testing solar collectors that is authorized to give the needed certificates. Therefore no quality certificate can be granted for collectors made in Croatia.
Technical committee TO- 180 "Solar Energy" has been establish in order to bring international norms into Croatian nomenclature. However, the progress is slow due to lack of interest of relevant stakeholders. The following norms are in the process of being adopted as Croatian norms (HRN)

ISO

1. ISO 9022-9:1994 Optics and optical instruments -- Environmental test methods -- Part 9: Solar radiation
2. ISO 9022-17:1994 Optics and optical instruments -- Environmental test methods -- Part 17: Combined contamination, solar radiation
3. ISO 9050:2003 Glass in building -- Determination of light transmittance, solar direct transmittance, total solar energy transmittance, ultraviolet transmittance and related glazing factors
4. ISO 9059:1990 Solar energy -- Calibration of field pyrheliometers by comparison to a reference pyrheliometer
5. ISO 9060:1990 Solar energy -- Specification and classification of instruments for measuring hemispherical solar and direct solar radiation
6. ISO 9459-1:1993 Solar heating -- Domestic water heating systems -- Part 1: Performance rating procedure using indoor test methods
7. ISO 9459-2:1995 Solar heating -- Domestic water heating systems -- Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems
8. ISO 9459-3:1997 Solar heating -- Domestic water heating systems -- Part 3: Performance test for solar plus supplementary systems
9. ISO 9488:1999 Solar energy -- Vocabulary
10. ISO 9553:1997 Solar energy -- Methods of testing preformed rubber seals and sealing compounds used in collectors
11. ISO 9806-1:1994 Test methods for solar collectors -- Part 1: Thermal performance of glazed liquid heating collectors including pressure drop
12. ISO 9806-2:1995 Test methods for solar collectors -- Part 2: Qualification test procedures
13. ISO 9806-3:1995 Test methods for solar collectors -- Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop
14. ISO 9808:1990 Solar water heaters -- Elastomeric materials for absorbers, connecting pipes and fittings -- Method of assessment
15. ISO 9845-1:1992 Solar energy -- Reference solar spectral irradiance at the ground at different receiving conditions -- Part 1: Direct normal and hemispherical solar irradiance for air mass 1,5
16. ISO 9846:1993 Solar energy -- Calibration of a pyranometer using a pyrheliometer
17. ISO 9847:1992 Solar energy -- Calibration of field pyranometers by comparison to a reference pyranometer
18. ISO/TR 9901:1990 Solar energy -- Field pyranometers -- Recommended practice for use
19. ISO/TR 10217:1989 Solar energy -- Water heating systems -- Guide to material selection with regard to internal corrosion
20. ISO/TR 12596:1995 Solar heating -- Swimming-pool heating systems -- Dimensions, design and installation guidelines

EN

1. EN 12975-1:2000 Thermal solar systems and components - Solar collectors - Part 1: General requirements
2. EN 12975-2:2001 Thermal solar systems and components - Solar collectors - Part 2: Test methods
3. EN 12976-1:2000 Thermal solar systems and components - Factory made systems - Part 1: General requirements
4. EN 12976-2:2000 Thermal solar systems and components - Factory made systems - Part 2: Test methods
5. ENV 12977-1:2001 Thermal solar systems and components - Custom built systems - Part 1: General requirements
6. ENV 12977-2:2001 Thermal solar systems and components - Custom built systems - Part 2: Test methods
7. ENV 12977-3:2001 Thermal solar systems and components - Custom built systems - Part 3: Performance characterization of stores for solar heating systems

At the Faculty of Mechanical Engineering and Naval Architecture, a laboratory was constructed for testing water collectors, which is equipped with instruments and is using methods, required by the European norms EN12975, EN12976, EN12977.

13. Level of R & D

13.1. Type of R & D activities.

Several projects regarding solar thermal energy have been approved. However the funding range from 4-10.000 EUR per project annually, and cannot be considered adequate for any research other than literature surveys.

13.2. Specific programs.

There are no specific programs earmarked for solar or renewable energy.

13.3. Role of government (national, regional).

Some counties have started to co-finance solar collectors on family houses.

13.4. Role of institutes and universities.

Focal point for R&D in Solar energy is Faculty for Mechanical Engineering and Naval Architecture in Zagreb, Thermodynamics Laboratory. Research in solar thermal is also undertaken in the Technical Faculty in Rijeka.

13.5. Level of financing by industry and public funds (EU incl.).

In October 2008, the Fund for Environmental Protection and Energy Efficiency issued two contract award procedures for financing use of LPG and Sun energy in households and public sector on unbridged islands of Croatia. Fund will give resources for preliminary project (90% of price, but no more than 1,800.00 HRK), construction work (50% of price, but no more than 5,000.00 HRK) and for loan interest (no more than 20.000 HRK) for financing project documentation and setting up the system.

D. State of Marketing

14. Distribution and marketing methods

Distribution is done by about 14 companies, mostly in the business of heating and distribution/ installation of imported solar collectors, but there are no established marketing principles in the sector.
The distribution is mostly done by the installers on specialist journals and fairs. The only manufacturer has the distribution network which covers the whole country.
In Croatia there is no practice of use of solar collectors as standard facilities in housing projects or of guaranteed solar results contracts. The usual guarantee for the solar collectors is 1-5 years.

15. Incentives and financing methods

15.1. What kind of financial incentives have been used in the past and are used presently

The Fund for Environmental Protection and Energy Efficiency grants funds of up to 30% for private and commercial projects and up to 100% for state and local organizations. The Fund for Environmental Protection and Energy Efficiency operates at the state level.

15.2. Public support for investments

There are no fiscal/tax incentives especially for solar thermal systems.

15.3. Third party financing

There are three administrative divisions in Croatia that finance or plan to finance installation of solar thermal systems.
Sisak-Moslavina County financed the use of solar thermal systems up to 20% of investment (but no more than 10,000.00 HRK) for private persons.
There are ongoing plans for financing solar thermal systems in Karlovac county, as well in the city Ivanić-grad.

E. Future Prospects

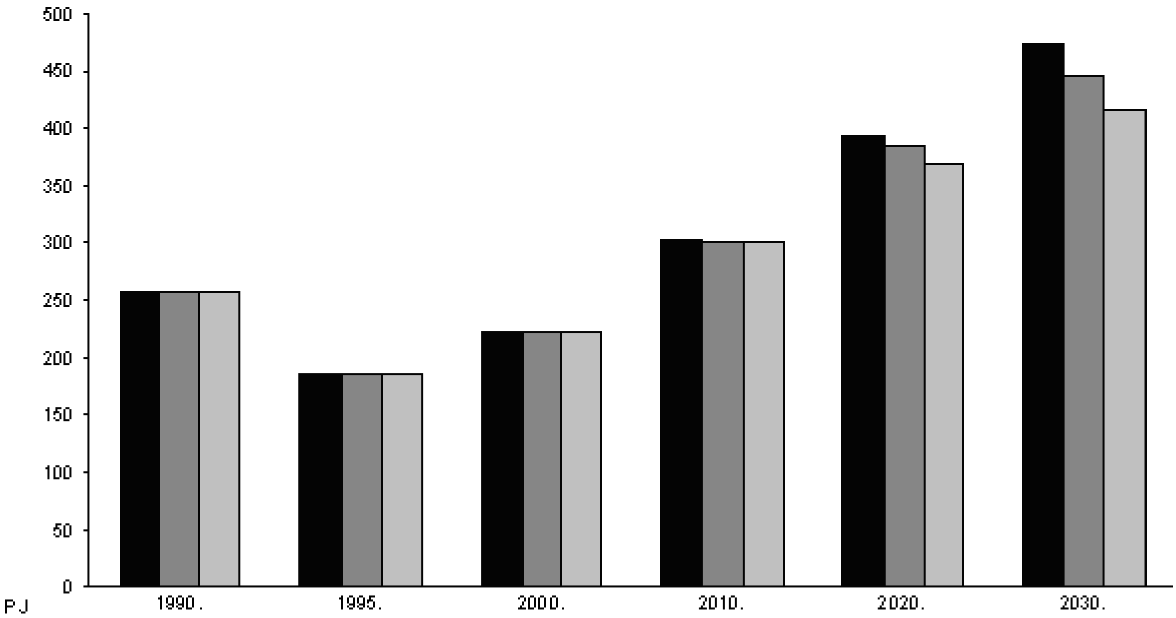
16. National energy policy

The National Strategy for Energy Sector and Energy Efficiency Development till 2030, adopted in 2002, sets long-term universal objectives reflecting the needs of the country.

<u>Goals</u>
- increasing energy efficiency
- secure energy supply
- allocation of energy sources
- using renewable energy sources
- realistic energy prices and development of energy market
- environment protection

The strategy has three different scenarios:
S1 - classic technology without active measures from government
S2 - new technology with active measures from the government
S3 - ecological scenario

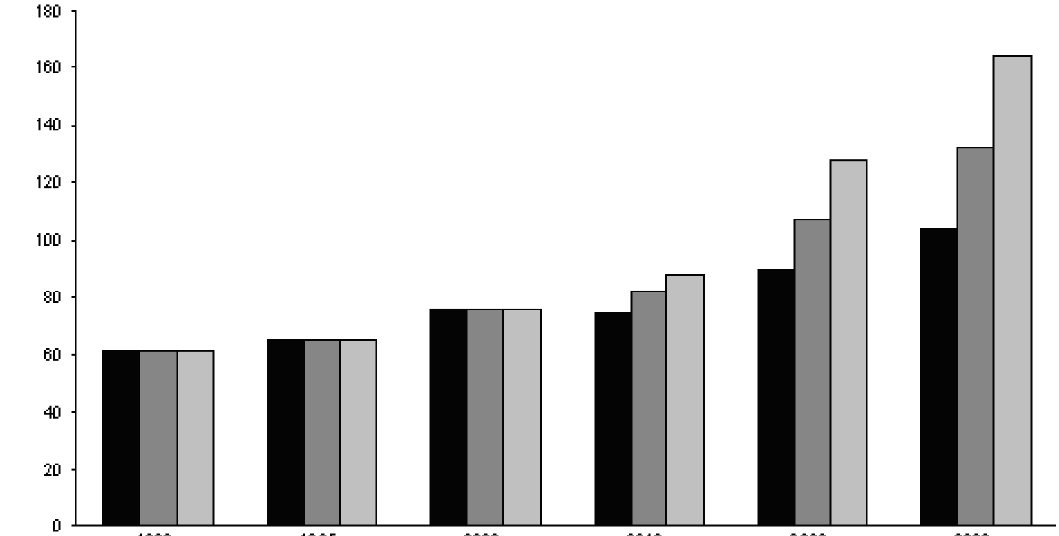
16.1. Energy consumption



PJ	1990.	1995.	2000.	2010.	2020.	2030.
S1	257.74	185.96	221.52	303.10	394.40	474.45
S2	257.74	185.96	221.52	302.12	384.82	446.40
S3	257.74	185.96	221.52	301.05	369.50	415.16

Figure 14: Enery consumption projections (Source: National Strategy for Energy Sector and Energy Efficiency Development till 2030)

16.2. Renewable energy sources utilization



	1990.	1995.	2000.	2010.	2020.	2030.
S1	61.23	65.27	75.79	74.47	89.80	103.90
S2	61.23	65.27	75.80	82.36	107.34	132.70
S3	61.23	65.27	75.79	87.69	127.69	164.39

Figure 15: Renewable energy sources utilization projections (Source: National Strategy for Energy Sector and Energy Efficiency Development till 2030)

16.3. Imported and domestic energy projections

(black= imported energy; grey= domestic energy)

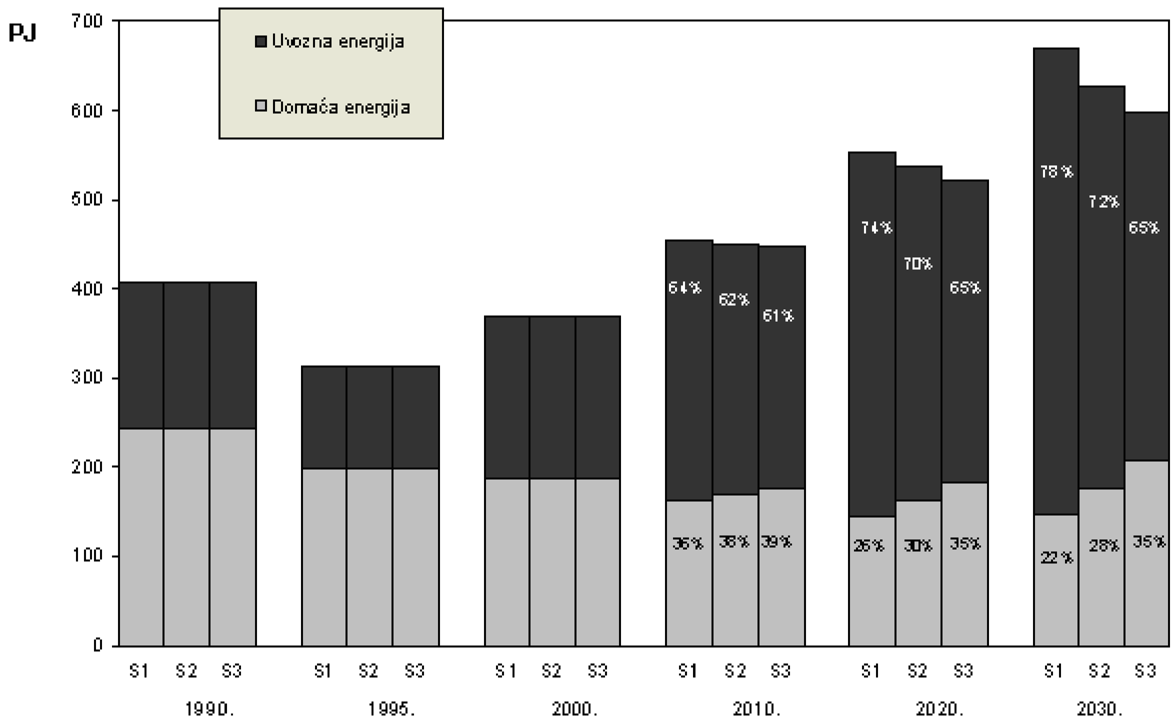


Figure 16: Imported and domestic energy projections (Source: National Strategy for Energy Sector and Energy Efficiency Development till 2030)

16.4. CO_2 emissions

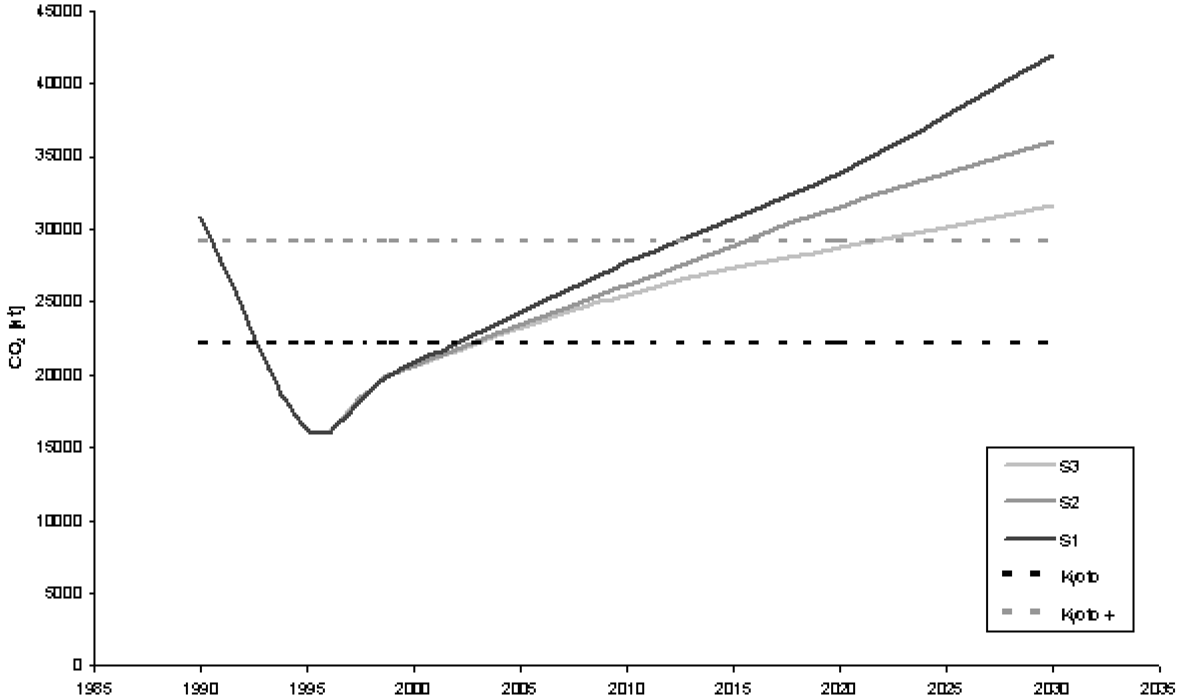


Figure 17: CO_2 emissions projections (Source: National Strategy for Energy Sector and Energy Efficiency Development till 2030)

17. Local bodies, prescribers, certification

17.1. Solar energy laboratories

- Solar laboratory, University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture, Ruđera Boškovića bb, 21000 Split
- Laboratory for Renewable Energy Sources, Department of Thermodynamics, Heat and Process Engineering Faculty Mechanical Engineering and Naval Architecture, University of Zagreb, Ivana Lučića 5, Croatia,Phone/Fax: +(385) 1 6168-146 http://www.fsb.hr/termolab/

17.2. Solar energy certification

In Croatia there are no institutes which offer certifications.

17.3. Solar energy associations

- Croatia professional association for Sun Energy, J. Kavanjina 14, 10000 Zagreb, Phone: +385 1 38 79 122, Fax: +385 1 38 88 918, www.hsuse.hr

18. Objectives for the solar industry / market

In 2008 draft document of Update/Upgrade of Energy Strategy of Croatia is issued whose very ambitious goals are:

- Promoting solar energy as a modern way for hot water production and residential heating (raising awareness);
- Primary orientation to solar heating systems due to advanced technology, low input costs and relatively quick investment return period (by 2010);
- Achieving the set indicators – 300,000 residents with at least 1.5 m² solar collectors installed to satisfy their own heating requirements (by 2020);
- Accomplishing 50% of newly constructed buildings with some form of solar energy source satisfying their own energy balance;
- Reaching fourth place in Europe with regard to MW of solar thermal systems per capita (by 2030).

19. Strategy to overcome the barriers to market development

Barriers

- High investment cost , slow payback period
- Risk of implementation of new technologies – especially in public buildings
- Lack of environmental consciousness
- Lack of financing
- RES are still not common part in daily life

On the national level there is no strategy to overcome these barriers. Some counties and municipality are starting to co-finance solar collectors for family houses. The rest of it is only on level for each producer in way of small marketing, promotion and education.

20. Concluding remarks

The market in Croatia is becoming every year bigger as we can see on previous tables and with help from the state, especially with co-financing from Fond for Environmental Protection and EE, the situation will become much better.

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Annex A: Solar Thermal Directory

List of firms producers, suppliers and installers of solar thermal systems in Croatia

No	Name	Address	Telephone /Fax	E-mail	website	Services	Origin of solar collectors:
1	Ribarić d.o.o.	Orljakovo 36/E, 47282, Kamanje		solar@ribaric.net			
2	Alukonigstahl d.o.o.	Oreškovićeva 3d, 10010, Zagreb		b.andjelic@alukoenigstahl.hr			
3	Vaillant GmbH Predstavništvo u RH	Planinska 11, 10000, Zagreb		boris.toplicanec@vaillant.hr			
4	Weishaupt - Zagreb d.o.o.	Drvinje 61, 10000, Zagreb		weishaupt-zg@zg.t-com.hr			
5	Horvatić d.o.o.	Samoborska 26, 10432, Bregana		suzana.horvatic@horvatic.hr			
6	Viessmann d.o.o.	Dr. Luje Naletilića 29, 10020, Zagreb		info@viessmann.hr			
7	Fero-term d.o.o.	Buzin Bani 73b, 10010, Zagreb		grijanje@fero-term.com			
8	Termocommerce d.o.o.	Floriana Andrašeca 14, 10000, Zagreb		info@termocommerce.hr			
9	Biroterm d.o.o.	Put Mulina 20, 21220, Trogir		biroterm@biroterm.hr			
10	Centrometal d.o.o.	Glavna 12, 40306, Macinec		komercijala@centrometal.hr			
11	Tehnomont brodogradilište d.o.o.	Fižela 6, 52100, Pula		info@tehnomont.hr			
12	Čepo	Novomarofska 13, 10000, Zagreb		cepo@zg.t-com.hr			
13	Sunce i partneri	Šibenska 4, 10000, Zagreb		zvonimir.radovecki@sunceipartneri.hr			
14	Bramac	Prilaz Ivana Visina 7, 10000, Zagreb		tomislav.ivancic@bramac.hr			