

Croatia

Country Profile

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1. Overview of Electricity Supply

The Republic of Croatia was involved in a violent struggle with Bosnia and Herzegovina and Serbia, upon achieving independence from the former Yugoslavia in 1991. As with the other participants in this war, the transportation and energy infrastructure was damaged and the economy was devastated. With the formal resolution of the conflict in 1996, international aid and government efforts focused on rebuilding infrastructure and stabilizing the fragile economy. Significant progress has been made and, aside from a return to conflict in 1999, the economy has grown steadily. This environment has facilitated the establishment of democratic and market oriented regimes.

The electricity sector is composed entirely of the state-owned monopoly Hrvatska Elektroprivreda (HEP), who is responsible for generation, transmission, and distribution systems. HEP generates 95 percent of the electricity in Croatia with hydroelectric and thermal generating stations. The installed capacity is about 4066 MW, which consists of about 50.8% hydropower, 0.4% wind power, and 0.1% landfill gas for renewables. In terms of growth areas, natural gas accounts for most of the plants under construction or planned. However, renewables have a strong presence, with hydro making up 19% of planned generation, and wind making up 16%. (UDI, June 2009).

Croatia began its transition to democracy and a market-oriented economy in January 2000 with the election of a coalition of democratic parties to Parliament. In June 2001, five pivotal energy laws were passed that were instrumental in establishing the basis for the restructuring of the energy sector. Subsequently, Croatia has become an active member of the "Athens Process," making the political decision to join the South East Europe Electricity Market as a prerequisite to eventual integration into the single European electricity market.

There has been little investment, foreign or domestic, in Croatia's power-generating facilities since the country became independent. Thus, due to the age of the country's existing thermal power plants, large levels of investment are needed to sustain the country's generating capacity. In addition, Croatia has been depleting its own oil and gas reserves and has become increasingly dependent on imported energy.

The privatization process has accelerated in recent years with the resolution of regional conflicts and the stabilization of the economy. To date, most small- to medium-sized enterprises have been privatized, and the private sector now accounts for about 50 percent of GDP. In July 2001 the government passed energy legislation that brings the Croatian electric sector in line with EU standards with an eye on accession, some of the renewable energy highlights are noted in the following section.

The table below displays summary information about Croatia.

Demographical Information	
Population, millions (2009)	4.49
Land area, thousand sq km (2009)	56.54
Macroeconomic Information (2008)	
GDP, billion US\$	73.4
Real GDP growth rate, percent	4.8
Foreign direct investment (net), million US\$ (2007)	4,650
Electricity disposition, billion kWh (2006)	
Generation	12.41
Consumption	15.57
Exports	3.31
Imports	8.37
Generation capacity, GW (2005)	
Nuclear	0.0
Thermal	1.80
Hydro	2.06
Other renewables	0.02
Total	3.88
<i>Sources: CIA World Factbook, U.S. Energy Information Administration, United Nations Conference on Trade and Development.</i>	

Croatia Country Summary Table

In addition to the minimum renewable energy systems share, the five bylaws included several other key points:

- Eligible producer (priority access to the grid, purchase obligation purchase obligation, feed feed-in tariffs for renewables)
- Fund for environment protection and energy efficiency (“polluters-pay” principle)
- Energy license not needed for projects up to 5 MW
- Cost-sharing possibility for grid connection

From Croatia’s Energy Law:

ENERGY POLICY AND ENERGY STRATEGY Article 5 (1) The basic act that outlines the energy policy and planning of the development of the energy sector is the Energy Strategy. (2) The Energy Strategy shall deal with: ensuring the secure and reliable supply of energy and its efficient generation and use, specifically the use of different renewable energy resources, care for the environment in performing all energy activities; promotion of competition in the energy sector on the principles of non-discrimination and transparency; protection of energy consumers; the connection of the Croatian energy system or its parts with the European energy systems or the systems of other countries by taking into account economic development trends and energy needs; drawing up National Energy Programs, capital investments, incentives for investments in renewable energy resources and energy efficiency programs and implementation of measures for environmental protection.

In line with the Energy Strategy and the Strategy Implementation Program, the Croatian Government shall initiate implementation of national energy programs that are to ensure meeting long-term development targets and provide directions for the development of energy sectors, investments in renewable energy resources and facilities for their exploitation, and energy efficiency programs.

Tariff systems should provide incentives for the promotion of energy efficiency and management of demand side, including the promotion of the use of renewable energy resources.

Energy co-generators that produce electricity and heat in a single plant and that use waste or renewable energy resources in an economically viable way and in compliance with environmental protection measures, can gain the status of eligible (preferential) producer.

The Croatian Government shall prescribe the minimum share of renewable energy resources, excluding large hydro plants (exceeding 5 MW), to be used by an energy undertaking carrying out electricity supply activities as a public service.

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3. Wind

Wind power in Croatia is rapidly growing. It’s first two wind farms went into operation in 2005, and 2006, bringing a capacity of about 18 MW. Two more farms, with about 26 MW in capacity is under construction and is set to go online in 2009, and over 400 MW of additional specific projects are planned. (Data as of June 2009, UDI). The 2007 feed-in tariff has been one of the incentives to feed the growth of the wind power market in Croatia. Alternatively, one of the main barriers to growth includes concerns about grid integration with the transmission infrastructure. This is actively being studied and improvements are being developed.

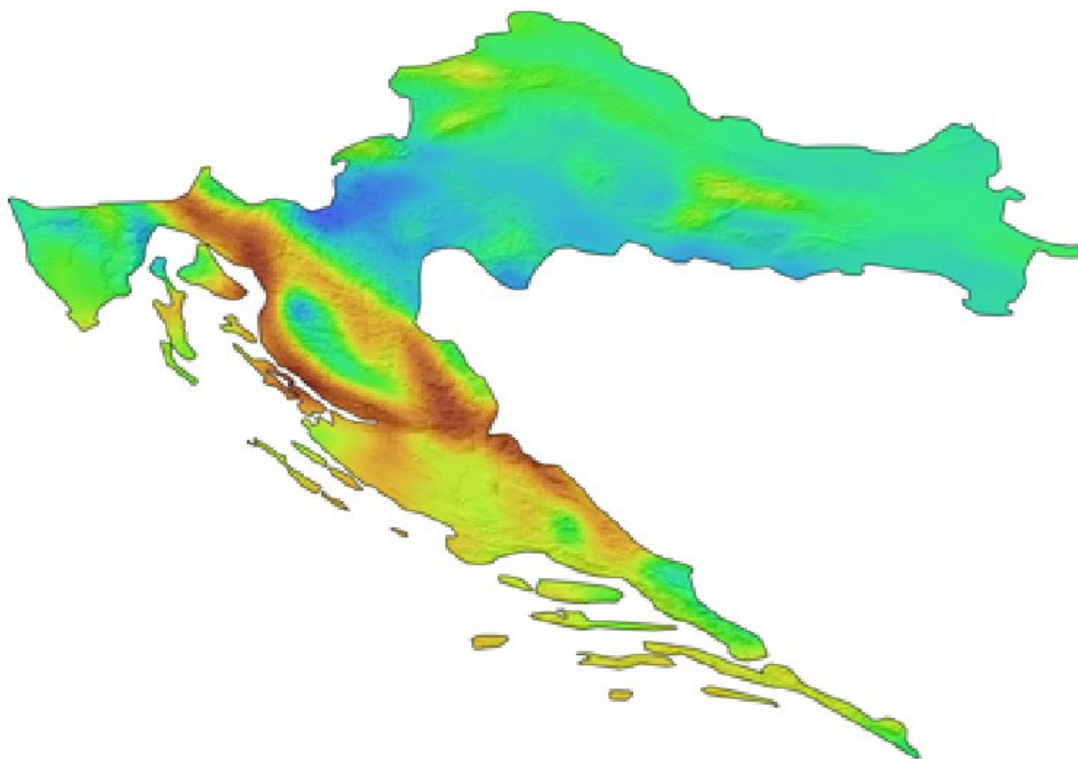
In 1997 Croatia launched the National Energy Programs (NEP), which included ENWIND or Wind Energy Utilization Program. The utilization program set a target of 400 MW wind energy by 2030. Although the policy is not clearly defined, the state owned utility company HEP decided to offer a feed-in tariff equal to 90 percent of the average electricity price for renewables, which was roughly 5.7 € Cents / kWh. However, this tariff applies only to projects with an installed capacity of less than 5 MW. The feed-in tariff of larger projects must be negotiated on a case to case basis.

Various studies indicate the Croatian islands and the Adriatic coast are good locations for wind energy development. The highest measured wind speeds were 7.3 m/s at 25 m above ground level (~ 8 m/s at 50m).

One of the most interesting opportunities for wind energy development in Croatia is the 55 inhabited islands. Autonomous wind energy systems could provide these islands with power and more importantly with clean water by using RO (Reverse Osmosis) desalination systems. The cost of clean water by RO would be about 1.3 - 2.0 € / m³, compared to the current € 5.0 / m³ at some islands.

Croatia Wind Resource Map (Source: 3Tier)

Croatia Wind Map at 80m



5km Wind Map at 80m



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4. Biomass

Historically, biomass has been used in the rural population in large amounts for heating and cooking in all Croatian regions. Heating wood and commercial and non-commercial cutting of

woodlands amounted to 15 per cent of primary energy consumption in 1970 whereas, due to urbanization and growth of living standards, the corresponding value in 1990 was 5.3 percent. In 1998, Croatia biomass contributed 5.1 per cent of the total energy supply.

The use of biogas in Croatia is growing, and in fact the largest anaerobic digestion biogas plant in Europe is under construction in Croatia (10 MW). The Vukovar plant is expected to be online at the end of 2010. There is also a 3 MW landfill gas plant operating in Prudinek. Croatia is also one of six target countries in the BiG>East project, which promotes biogas as a renewable energy source in Eastern Europe. The project has performed studies assessing existing biogas installations, technical potential, policies and barriers for Croatia.

Croatia hopes to increase its biofuel share in transport fuels to 5.75% by 2012, and 20% by 2020.

Almost 44 percent of Croatia is covered by woods and forests. Developed agriculture and woody biomass have a great potential as a source of renewable energy.

According to one estimate, Croatia's total technical energy potential biomass for energy amounted to approximately 33.8 PJ/a in 1995. The major source for such energy is the wooden mass from forests (fuel wood, residues and wood waste from the wood processing industry). However, agricultural residues also have a significant potential in both Eastern Croatia and the coastal zone.

Agricultural crops:

- Practically and economically collectible quantities in fresh and dried form for possible energy utilization (burning or pyrolysis gasification), or anaerobic digestion for production of biogas/electricity/heat and organic fertilizers.
- Public and private garden waste.
- Tree pruning and related woody waste.
- Livestock solid and liquid wastes. Choice of processes as above.
- Agro-industry (abattoirs, food and drink industry etc.): Solid and liquid wastes.
- MSW: Municipal solid waste, preferably separated at source. Organic fraction typically 40 percent. Options for incineration combined with desulphurization or biogas-producing anaerobic digestion.
- Sewage sludge: Incinerated in dried form or digested anaerobically. The anaerobic digestion process also mitigates pollution and protects the environment.

Appropriate infrastructure for collection/transportation combined with fiscal or monetary incentives and green taxes would be needed to achieve effective utilization of the fore-mentioned solid and liquid wastes.

Croatia Biomass Resource Data

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006–2007, km ²)	(avg. 2006–2007, %)
Arable Land	8660	15
Permanent Crops	780	1
Permanent Meadows and Pastures	2710	5
Forest Area	21368	38
Other Land	20527	36
Inland Water	620	1
Primary crop production	(avg. 2006–2007, tonne)	(tonne / 100 km ²)
Total primary crops (rank among COO)	5,596,117 (16)	9,889 (19)
Top 10 primary crops		
Maize	1,679,558	2,968
Sugar beet	1,571,172	2,776
Wheat	877,301	1,550
Potatoes	244,931	433
Barley	182,131	322
Grapes	179,713	318
Soybeans	132,426	234
Apples	76,224	135
Sunflower seed	67,959	120
Oats	60,815	107
Animal units, number	(avg. 2006–2007, number)	(number / 100 km ²)
Cattle	482,950	853
Poultry	7,903,000	13,965
Pigs	1,488,744	2,631
Equivalent animal units	1,157,478	2,045
Annual roundwood production	(2006–2007, m ³)	(m ³ / 100 km ²)
Total	4,331,000	7,653
Fuel	838,000	1,481
Industrial	3,493,000	6,172
Wood-based panels	168,000	297
	(2006–2007, tonne)	(tonne / 100 km ²)
Paper and paperboard	554,500	981
Recovered paper	0.0	0.0

Source: Food and Agriculture Organization of the United Nations

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5. Solar

Solar energy for heating purposes has been used in Croatia since 1975 in all kinds of facilities and for various purposes, and the first photovoltaic applications occurred in the late 1980's. However, the use of solar energy in energy balance remains negligible.

The SUNEN national energy program was established with the aim of stimulating increased solar energy usage. The solar energy application for electric energy generation will depend on the global technology development.

The country is reported as having an aggregate installed capacity of 6 MWth in the year 2000. By far the major part of this is comprised by flat plate collectors used for heat production, for houses, commercial buildings and other installations. During the last war in Croatia (1991-95) most of the solar production activities ceased or were severely curtailed.

Currently, while Croatia still does not have any large-scale electrical production from solar, but one of Europe's largest solar thermal power plants is planned in Croatia. The 60 MW plant is planned to come online in Promina during 2011. Also, about 6 MW of PV are planned for 2014. The Croatian government is encouraging solar power plants, and many more projects are being discussed.

Croatia Solar Direct Normal Insolation (Source: NASA)



Croatia Solar Global Horizontal Irradiance (Source: NASA)



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6. Geothermal

Although Croatia does not currently have any operating geothermal power plants, it has two aquifers being used to produce large-scale heat energy. Over the past several years, several projects have been under study to produce geothermal electricity. In addition, Croatia has been working on developing a geothermal strategy, and an overall energy strategy that includes geothermal power.

Croatia has a centuries-long tradition of using geothermal water from natural springs for medical purposes. In the early 70s, along with research for oil and gas, the existence of geothermal water began being observed. The calculations of temperature gradient based on the data obtained from exploration of the wells showed that the average gradient in the northern part of the country, part of the Pannonian sedimentary basin, is considerably higher than the world average, while in the southern Dinarides area its value is below that figure (0.049°C/m and 0.018°C/m respectively, compared to 0.03°C/m in the world, Jelić et al., 1995).

The geothermal potential of the reservoirs in the northern part of Croatia could be a significant renewable energy resource, substantially contributing to the overall energy efficiency and the environmentally acceptable energy policy. The geothermal energy content of the medium temperature reservoirs (between 100 and 200°C) can be converted into electric energy, while that of the low temperature reservoirs (below 100°C) is perfectly suitable for heating and cooling of buildings, heating greenhouses, in various industrial processes, for medical purposes, etc.

The UNDP FINAL REP ON GEOTHERMAL RESOURCES (part II) has highly useful information on Geothermal Energy for a number of countries including Croatia. The Croatian section is reproduced herewith in its main part.

The most prospective fields are located in the following areas:

- In *Zagreb* (the capital of Croatia) a reservoir containing low-mineralized (2 g/l) thermal water with temperature 55-82°C was discovered at a depth of 500-1000 m during exploration drilling.
- In *Lunjkovec-Kutnjak* a geothermal reservoir formed by high-porous (7.5 percent) carbonate breccia was found. The thermal water contains 5 g/l of dissolved salts and 3 m³/m³ of dissolved gases (mainly CO₂). The projected average discharge of wells is 80 kg/s per each well, the wellhead pressure is 3-5 bars, and the wellhead temperature is 125-140 °C.
- In *Velika Ciglena* a dolomite jointing reservoir located at a depth of 3 km contains geothermal brine (24 g/l) with a gaseous factor of 30 m³/m³ (CO₂ and 59 ppm H₂S). The expected discharge of operating wells is 100 kg/s with wellhead pressure 20-25 bars and wellhead temperature of 165-170°C.



Geothermal resources of Croatia with temperatures above 65°C.

The total potential thermal capacity of high and medium temperature geothermal fields is estimated as 839 MWt with a waste discharge temperature of 50 °C, or 1170 MWt at 25 °C. The potential capacity of binary GeoPP constitutes about 48 MWe.

Status and prospects of using geothermal resources in Croatia:

State of using: at the present time the thermal water is used for heating rooms, swimming pools and in balneology**. The total installed thermal capacity in 2000 was 36.7 MWt (113.9 MWt including balneology), however the load factor is small (0.11 – 0.15). The use of geothermal energy in 1999 constituted 131.4 TJ/yr (554.75 TJ/yr including balneology).

Used technologies: spouting (free flow) maintenance, direct usage of geothermal water with discharge to surface water reservoirs (*Bizovac, Ivanic*); re-injection is used at some fields (*Zagreb*).

Strategy of development: development of thermal facility of 7 MWt in the region *Blato (Zagreb)* is planned in the near term [...]. It is supposed to increase the usage of geothermal

energy up to 1700 – 1900 TJ/yr by 2005 [...]. The construction of a binary GeoPP is planned in the field *Velika Ciglena* based on an existing well. The first 4.4 MWe stage could come online in 2005, followed by an expansion up to 13.1 MWe by 2015. The technical possibility of creation and the profitability of this power plant were demonstrated in a pre-feasibility study completed in 1995 by "Virkir Orkint Consulting".

Incentives: the using of local energy resources substituting for imported fuel, and the reduction of harmful emissions from the power projects (including the greenhouse gases). It is especially important in Croatia for developing the tourism business.

Identified barriers:

Technological barriers – the absence of modern equipment produced in Croatia (reliable downhaul pumps, heat pumps, equipment of binary GeoPP) and of experience of applying the modern technologies;

Price barriers – the created geothermal projects should compete with traditional fuel projects. The existence of gas pipelines near the most prospective of the geothermal fields is a deterrent. However, Croatia's gas resources are diminishing. Geothermal energy produced for heat is currently sold at 50% of the price of natural gas.

Financial barriers – the shortage of budget funds and the absence of investors.

Government policies: in 1997 the Croatian government approved the Program of Geothermal Energy Utilization (GEON) as a part of National Program of the Croatian Energy Sector Development and Organization (PROHES). The Program foresees, in particular, the development in the near term of legislative measures promoting the development of geothermal power engineering.

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7. Hydroelectric

Croatia's mountainous territory and numerous rivers give it ample hydroelectric-generating potential. The country has numerous hydropower plants (HPPs), located predominantly along the Adriatic coastline and near the Slovenian-Croatian border. The country's four major hydroelectric plants are in those two main areas of the country. The Varazdin hydro plants is located near the Slovenian-Hungarian border, and the three hydro plants along the Adriatic coastline are Senj, Obrova and Zakućac. All of these are owned and operated by the national electricity company, Hrvatska Elektroprivreda (HEP).

Hydroelectric power plants make 51 percent of the totally installed capacity of power plants on the territory of Croatia. The total installed capacity of hydroelectric power plants in Croatia is 2066 MW. There are an additional 42 MW under construction and 508 MW planned (UDI, June 2009). The majority of hydro plants were constructed during the '60s and the '70s of the last century, while the last hydro plants were constructed in the late '80s.

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8. Relevant Links

Please see webpage for relevant links.

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9. References

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10. Country Contacts

Contacts made in the preparation of this assessment are gratefully thanked for their contribution to this report. Please see webpage for contacts listing.

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