# The significance of RES on $CO_2$ emissions

*Zagreb, November 2014*

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American Chamber of Commerce in Croatia  Američka gospodarska komora u Hrvatskoj

# Summary

According to the Kyoto Protocol, the permitted $CO_2$ emission in Croatia equals a total amount of 34.64 million t/y. It is believed that the reduction of $CO_2$ emissions can be achieved most effectively in the energy sector, especially in the production of electricity by using renewable energy sources (RES). The current price of emission allowances for $CO_2$ on the EU ETS market is 5-7 EUR/t, but it is expected that the price of emission allowances for $CO_2$ will exceed 15 EUR/t.

According to statistical information on the share of RES, the Republic of Croatia is an average EU member. However, information on consumption and domestic generation of electricity without $CO_2$ emissions (hydro power plants, wind power plants and the nuclear power plant Krško) for 2012 point to a lack of electricity of about 10,200 GWh. Import of the specified amount of electricity in the period of 8 years requires funds in the amount of more than EUR 4,000 million, and production in the existing domestic thermal plants (fuel import and purchasing allowances for $CO_2$ emissions) in the period of 8 years requires funds in the amount of approximately EUR 7,400 million. Hypothetical production in new coal thermal plants would require total funds of about 4,300 million EUR in the period of 8 years, and production in new gas thermal power plants would require total funds of about 6,000 million EUR in the period of 8 years.

Since these are enormous funds of the Republic of Croatia, a possibility was considered to produce the lack of electricity from renewable energy sources (RES) according to the preferences from the National Action Plan for RES (biomass, hydropower and geothermal energy), for which there are no costs for purchasing emission allowances for $CO_2$, or fuel costs in case of some forms of RES (hydropower, geothermal energy). It was found that due to the insufficient energy potential of the aforementioned types of RES, the production of electricity of about 10,200 GWh could not be realised completely and that the energy balance should include significantly larger proportions of wind and solar energy for the production of electricity, for which there are also no costs for purchasing emission allowances for $CO_2$ or fuel costs.

AmCham advocates measures which will allow increasing the capacities of wind and solar power plants through the promotion of investments of potential investors in these sources of energy. The key tasks for the realization of this approach are the following:

- Simplifying the administrative procedure;
- Abolishing the existing quotas for the construction of wind and solar power plants;
- Eliminating barriers to the connection of wind and solar power plants with higher power to the power network.

This analysis also shows that the climate and energy goals of the EU for 2030 in terms of a competitive, safe and low-carbon EU economy are unattainable for the Republic of Croatia without ensuring conditions for the widespread use of solar and wind energy.

## Contents

# Introduction

Today the scientific and professional community mostly accepts the opinion on $CO_2$ as the key factor of climate changes that can be influenced by human activity, thus affecting the process of global warming.

The Republic of Croatia signed the Kyoto Protocol in March 1999. This Protocol determined the reduction of greenhouse gas emissions in Croatia by 5 percent in the period of 2008-2012, compared to the emission from the reference year 1990. In response to this difficult task Croatia submitted a request to increase the quota of greenhouse gas emissions compared to the reference year 1990. In November 2006 a decision was adopted in Nairobi allowing Croatia to increase emissions from the reference year in the amount of 3.5 million tonnes of $CO_2$ equivalent emission. The adoption of this Decision created the preconditions for the ratification of the Kyoto Protocol, which was ratified by the Croatian Parliament on 27 April 2007. Croatia thereby became a full signatory to the Protocol with all the rights and obligations 90 days after the ratification. According to the Protocol, the permitted $CO_2$ emission in Croatia equals a total amount of 34.64 million t/y.

Given the achieved state of technological development, it is considered today that the most effective reduction of $CO_2$ emissions can be achieved in the energy sector. This particularly applies to the production of electricity, where renewable energy sources (RES) have played a significant role in reducing $CO_2$ emissions, with great potential for further reduction of $CO_2$ emissions. However, the production of electricity in thermal power plants **requires** purchasing emission allowances on the EU ETS market.

The current price of emission allowances for $CO_2$ is 5-7 EUR/t. It is believed that the withdrawal of about 900 million emission units on the EU ETS market will cause the price of emission allowances for $CO_2$ to exceed the amount of 15 EUR/t.

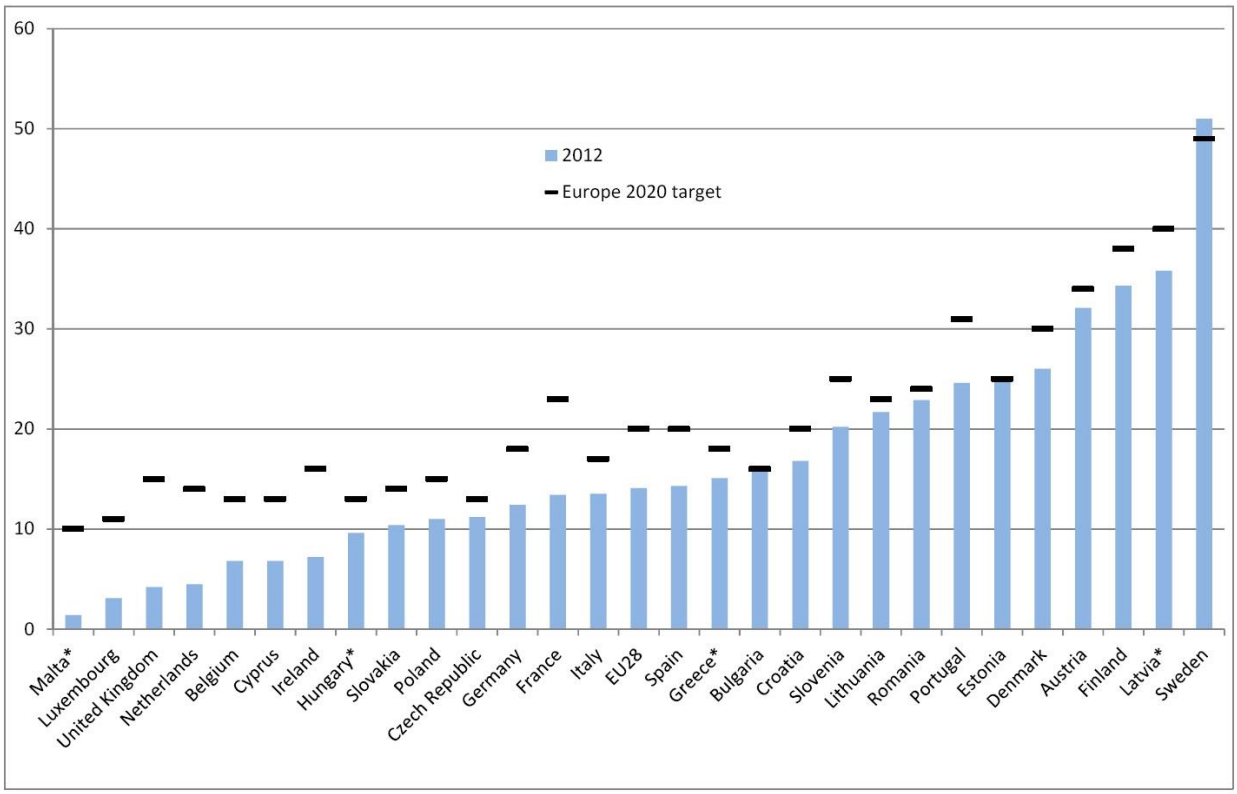
## Situation in the EU

With the aim to reduce $CO_2$ emissions, the European Union set a goal to achieve a 20 % share of renewable energy sources in gross energy consumption by 2020, wherein the following is taken into account:

- Individual national goals;
- Different starting points of each state;
- The potential of renewable sources; and
- Economic situation in the Member States.

These goals are also followed by other European countries that are not EU members.

The following diagram (source Eurostat Newsrelease, 37/2014 – 10.3.2014) shows the achieved share of RES in total energy consumption in the EU in 2012.




The biggest growth since data monitoring started until 2012 was achieved in Sweden, Denmark and Austria, and the largest share of renewable energy sources in energy consumption two years ago was connected with Sweden with a share of 51 %, Latvia with 35,8 %, Finland with 34,3 % and Austria with 32,1 %.

## Situation in Croatia

The previous data shows that the Republic of Croatia is an **average EU member**, which may lead to the conclusion (at first sight) that Croatia has a reasonable energy policy with regard to using RES and that there are no reasons for concern.
The following table shows the **energy balance of production and consumption of electricity in the Republic of Croatia** in GWh (information is taken from the leaflet of the Ministry of the Economy in Croatia for 2012). The table includes the information on total electricity consumption (gross consumption which includes losses) and the information on electricity production without $CO_2$ emissions (domestic production of electricity in hydro and wind power plants and production of electricity in the nuclear power plant Krško). Information in the table has been rounded for convenience.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Deficit | 10,200 |

The table shows that a **deficit of about 10,200 GWh** appears in the balance sheet. The stated deficit can be met by **importing** electricity or its **production in existing domestic thermal power plants**, or a combination of both.

### Electricity imports

The **import of electricity** in the stated amount of about 10,200 GWh requires annual assets (with the assumed price of 35 EUR/MWh) of EUR 360 million. The total cost of electricity imports would amount to approximately **EUR 2,900 million** in the period of 8 years. With the more realistic assumption of the unit price of electricity of 50 EUR/MWh (Quarterly Report on European Electricity Markets, Market Observatory for Energy DG Energy Volume 6, issue 2, Second quarter 2013, http://ec.europa.eu/energy/observatory/electricity/doc/20130814_q2_quarterly_report_on_european_electricity_markets.pdf), electricity imports would require annual assets of around **EUR 510 million**, amounting to **EUR 4,080 million** in the period of 8 years.

### Production of electricity in existing thermal power plants

For the **production** of the stated electricity deficit in domestic thermal power plants, **emission allowances for $CO_2$ emissions** of about **8 million tonnes** per year would have to be purchased. As noted in the introduction, a minimum unit price of $CO_2$ emission of 15 EUR/t can be expected. This would equal about **EUR 120 million** at an annual level. If we added **fuel costs** (mostly imported) in the annual amount of approximately **EUR 800 million** to this cost, we would arrive at the total amount of approximately **EUR 920 million** which would have to be secured each year for the production of electricity in the existing domestic power plants. The cost of electricity production in existing domestic power plants in the period of 8 years would amount to **EUR 7,400 million**.

## Production of electricity in new thermal power plants

The construction of **new coal and gas thermal power plants** is planned in Croatia. Figures for both cases are provided below for illustration purposes.

In the hypothetical case of compensating for the said electricity deficit from **future coal thermal power plants** (condensation thermal power plants), the corresponding annual **cost of $CO_2$ emissions** (at 15 EUR/t) would amount to around **EUR 140 million**, and **fuel cost to around EUR 420 million**, which would amount to the annual figure of about **EUR 560 million** (this analysis leaves out the investment cost and other costs associated with the new plants). In this case, the cost of fuel and $CO_2$ emissions would equal approximately **EUR 4,480 million** in the period of 8 years.

In the other hypothetical case, if the said electricity deficit was produced in the future **gas thermal power plants** (combined process with steam and gas turbines), the corresponding annual **cost of $CO_2$ emissions** (at 15 EUR/t) would equal approximately **EUR 50 million** and **fuel cost EUR 700 million**. This would annually amount to a total of **EUR 750 million** (the investment cost and other costs associated with the new plants are left out here as well), which would cumulatively amount to **EUR 6,000 million** in the period of 8 years.

## Promoting the production of electricity from RES

According to cost projection for RES in accordance with the goals of the **National Action Plan for Renewable Energy Sources** (NAP – Ministry of the Economy, https://vlada.gov.hr/UserDocsImages//Sjednice/Arhiva//NAPOIE_17102013_finalR1.pdf) in the period from 2013 to 2020 (period of 8 years), **total costs for incentive price payment should cumulatively** be around **EUR 1,800 million** (according to the Energy Development Strategy of the Republic of Croatia, these costs should be around EUR 2,800 million in the same period of 8 years).

# The availability of RES resources in the Republic of Croatia

Previous analyses show that **the existing model of electric power supply necessarily generates the need for huge financial resources for electricity imports, i.e. for importing energy sources and purchasing emission allowances for $CO_2$, regardless of whether we are talking about existing thermal power plants or thermal power plants that are planned for construction**. It is therefore necessary, regardless of the current acceptable statistical indicators on the development state of RES in respect to the EU requirements, to change the paradigm of energy development of the Republic of Croatia and rely more on the production of electric power from sources that are neutral in respect to $CO_2$ emissions and that rely on **domestic resources**, thus reducing the import dependence of the Republic of Croatia. Such sources are:

- Biomass;
- Hydropower;
- Geothermal energy;
- Wind energy;
- Solar energy.

For each of the stated forms of renewable energy there is no **cost of purchasing allowances for $CO_2$ emissions**, and for hydropower, geothermal energy, wind and solar energy **there are no fuel costs either**.

## Biomass

The total energy potential of **biomass** (Nikola Karadža, EIHP, Potencijal obnovljivih izvora energije u RH (The potential of of renewable energy sources in the Republic of Croatia), 10.05.2011, Zadar, http://repam.net/uploads/repam/document_translations/doc/000/000/004/EIHP_Zadar_20110510.pdf?2011) in the Republic of Croatia is around 50 PJ (this includes all biomass of plant and animal origin and biomass from waste that can be processed by thermochemical or biochemical conversion), which can be theoretically used, if fuel wood is excluded, to produce about **2,900 GWh** of electricity (or about 28 % of the total energy deficit). In addition to biomass being a neutral source of energy in respect to $CO_2$ emissions and having a domestic origin, it should be emphasised that energy transformations of some forms of biomass also solve serious environmental problems (for example anaerobic digestion in which animal waste is turned into biogas).
The following table shows the theoretical **contribution of biomass** to the production of electricity.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Potential contribution of biomass for electricity production | 2,900 |
| Deficit | 7,300 |

The table shows that the inclusion of the total (theoretical) available biomass potential in the energy balance of production and consumption of electricity still leaves a **deficit of about 7,300 MWh**.

## Hydropower

It is estimated that the Republic of Croatia has an **unused hydropower potential** of about **6,000 GWh** (Mr.sc. Hubert Bašić, Zdenko Mahmutović, Željko Pavlin, Mogućnosti korištenja vodnog potencijala u strategiji energetskog razvitka Republike Hrvatske (Possibilities of using water resources in the energy development strategy of the Republic of Croatia), https://www.google.hr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=0CCMQFjAB&url=https%3A%2F%2Fbib.irb.hr%2Fdatoteka%2F61621.StudijaMogunosti99HE2.doc&ei=l9ozVPraMILaap_BgrAM&usg=AFQjCNGEK8_-gnxwBIUyiEVhL-shVgT1lw&sig2=oS04VFxkRLLc1WMeFx1c8g&bvm=bv.76943099,d.ZWU), which equals around 59 % of the total energy deficit. This potential contribution of unused hydropower is shown in the following table.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Potential contribution of biomass for electricity production | 2,900 |
| Potential contribution of new hydro power plants | 6,000 |
| Deficit | 1,300 |

Even with the assumption of complete utilization of the remaining hydropower potential, the balance sheet includes a **deficit** of the production of electricity of around **1,300 GWh**.

## Geothermal energy

The potential contribution of **geothermal energy** for the production of electricity is estimated at around **400 GWh** (Nikola Karadža, EIHP, Potencijal obnovljivih izvora energije u RH (The potential of of renewable energy sources in the Republic of Croatia), 10.05.2011, Zadar, http://repam.net/uploads/repam/document_translations/doc/000/000/004/EIHP_Zadar_20110510.pdf?2011), which amounts to approximately 4 % of the total energy deficit. The potential contribution of unused geothermal energy is shown in the following table.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Potential contribution of biomass for electricity production | 2,900 |
| Potential contribution of new hydro power plants | 6,000 |
| Potential of geothermal energy | 400 |
| Deficit | 900 |

The addition of the available potential of geothermal energy **still leaves a negative balance sheet**, i.e. there is still a deficit of around **900 GWh** of electricity.

## Wind and solar energy

In the practical sense, **wind and solar energy** are an **"unlimited resource"** which can be used not just to compensate for the current deficits in the production of electricity, but also to compensate for the possible future increase in electricity consumption. However, for the acceptance and use of large amounts of electricity produced in wind or solar power plants, it is necessary to promptly do the following:

- Accept available global and European solutions;
- Become involved in their further development; and
- Eliminate barriers that prevent greater use of wind and solar energy for the production of electricity.

## Proposal

The previous table shows that even with the use of all **available biomass, hydropower and geothermal energy resources** in the conditions of total consumption of 18,200 GWh there is still a **deficit** of electricity of about **900 GWh**. It is therefore necessary to include the additional production of electricity from **wind and solar energy** in the balance sheet, which is shown in the following table.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Potential contribution of biomass for electricity production | 2,900 |
| Potential contribution of new hydro power plants | 6,000 |
| Potential of geothermal energy | 400 |
| Potential of new solar and wind power plants | 900 |
| Deficit | 0 |

The compensation of the mentioned 900 GWh of electricity can be realized by installing additional capacities in wind and solar power plants of around 500 MW. With the aim of prompt elimination of the **need to import electricity, i.e. to import fuel for thermal power plants and purchase allowances for $CO_2$ emissions**, solar power plants are favoured due to the short period of time necessary for their implementation. For example, the **installation of systems of 10 kW on 50,000 roofs** (which provides the required 500 MW) **could be realized in only several months** under the assumption of removing the barriers that prevent the realization of such an idea at this moment.

It should be noted, however, that the **realization of the remaining hydro, biomass and geothermal energy potential** will last for years, resulting in continued huge deficits of electricity produced without $CO_2$ emissions and based on domestic resources. Therefore, it is necessary to make a **shift toward greater use of wind and solar energy**. One hypothetical transitional scenario that can be implemented within a **short time** is shown in the following table.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Short-term contribution of biomass for electricity production | 0 |
| Short-term contribution of new hydro power plants | 0 |
| Short-term contribution of geothermal energy | 0 |
| Short-term contribution of new solar and wind power plants | 3,400 |
| Deficit | 6,800 |

This scenario takes into account the reality of a relatively long duration of the execution of projects related to energy utilization of hydro, biomass and geothermal energy potential and the focus of electricity production is transferred

from RES to solar and wind energy. The required electricity production of about 3,400 GWh can be realized in new solar and wind power plants in less than 2 years. The electricity deficit of about 6,800 GWh can still be realized through import or production in existing thermal power plants. In this scenario, the need for electricity imports, i.e. for fuel imports and purchasing emission allowances for $CO_2$ is reduced by an annual amount of approximately **EUR 170 million to EUR 310 million** or **EUR 1,360 million to EUR 2,480 million** in the period of 8 years.

The following table shows the target scenario which can realistically be achieved by 2020, and which has significantly eliminated electricity import costs, i.e. costs for the import of fuel for thermal power plants and purchasing emission allowances for $CO_2$. However, this cost cannot be completely eliminated from this scenario without mass construction of energy storage systems (reversible hydro power plants, charging electric cars, battery systems for wind and solar power plants, etc.) because it presupposes the need for import or production of electricity in domestic thermal power plants for the purpose of balancing the power system. However, due to occasional excess production of electricity in solar and wind power plants, that cost can for the most part be compensated by potential electricity exports.

| | |
|---|---|
| Total electricity consumption in 2012 | 18,200 |
| Existing domestic production of electricity (hydro and wind power plants) | 5,200 |
| Existing production of the nuclear power plant Krško (50 % of total production) | 2,800 |
| Real potential of biomass for electricity production | 1,500 |
| Real potential of new hydro power plants | 3,000 |
| Real potential of geothermal energy | 200 |
| Potential of new solar and wind power plants | 5,500 |
| Deficit | 0 |

This scenario implies a 50 % use of the remaining **hydro potential in new hydro power plants of around 3,000 GWh**, **biomass potential of around 1,500 GWh, geothermal energy potential of around 200 GWh** and the use of **wind and solar potential for the production of electricity of around 5,500 GWh.**

The realization of this or a similar scenario requires the **elimination of legal, technical and other barriers** that prevent the connection of additional capacities to the power network. Among other things, that entails the following:

- Elimination of quotas and other legal obstacles for intensified construction of wind and solar power plants;
- Increasing the amount of resources for electricity produced from production plants using renewable energy sources and cogeneration;
- Implementation of a system for advanced network management, including solutions for prediction of wind and solar energy;
- Construction of systems for energy storage (reversible hydro power plants, battery systems, filling stations for electric cars...);
- Construction of new (cogeneration) power plants, i.e. reconstruction of the existing thermal power plants (peak loads, regulation and balancing of the power network...);
- Eliminating bureaucratic obstacles and considering all RES projects as strategic investments;
- Solving the problem of securing raw material (wood biomass) and setting up

a system for the consolidation of biomass resources for supplying biomass of agricultural origin.

The preceding analysis clearly shows that the final design of the energy development of the Republic of Croatia, in addition to biomass, remaining hydro potential and geothermal energy potential, requires the inclusion of **solar and wind energy potential** in the energy balance to the greatest extent possible. This approach would follow the development that is present today in the most developed states in the EU and **secure long-term production of electricity from domestic resources**. In addition to eliminating the existing legal, technical and other barriers, it is necessary to raise significantly the planned cumulative cost for the promotion of RES for about EUR 1,800 million in the period from 2013 to 2020, thus **encouraging more strongly investments in RES**. This would gradually **reduce the existing need for electricity imports or for the import of fuel for thermal power plants and purchasing emission allowances for $CO_2$**. However, the **import of permanent goods** (import components for RES, hardware equipment, software solutions…) **should not be restricted** in any way.

In addition to the above mentioned, attention has to be paid to **climate and energy goals for 2030** in regard to a competitive, safe and low-carbon EU economy. The main elements of the political framework for 2030 established by the Commission (http://europa.eu/rapid/press-release_IP-14-54_hr.htm) include the following:

- Mandatory goal of reducing greenhouse gas emissions by 40 %;
- Mandatory target of renewable energy in the EU, transition to a competitive, safe and sustainable energy system, of at least 27 %;
- Competitive, affordable and safe energy – diversification of supply and reliance on domestic sources of energy;
- New management system – new management conditions are proposed based on national plans for competitive, safe and sustainable energy.

It should be emphasized that this analysis also shows that the mentioned **climate and energy goals for 2030** for the Republic of Croatia are unattainable without ensuring the conditions for complete utilization of the available **hydro, biomass and geothermal energy** potentials, and without the **widespread use of solar and wind energy**.

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