

Overview and Perspectives of Renewable Energy Sources in the Danube Region in Croatia

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2. RES in Croatia

Legal framework for RES in Croatia

Legal Framework for RES in Croatia

RES regulation legislation passed by the Government of Republic of Croatia, starting from July 2007, updated and changed 2012, 2013:

1. Ordinance on Fees for Incentivizing Electricity Production from Renewable Energy Sources and Cogeneration (Official Gazette 33/2007, 128/2013) – who is paying and how
2. Tariff System for the Production of Electricity from Renewable Energy Sources and Cogeneration (Official Gazette 33/2007, 63/2012) – who is being incentivized and how
3. Rules on Acquiring the Status of Electricity Eligible Producer (Official Gazette 67/2007, 35/2011, 132/2013) - legal rules
4. Rules on Usage of Renewable Energy Sources and Cogeneration (Official Gazette 67/2007, 88/2012) - technical rules
5. Ordinance on a Minimal Share of Incentivized Electricity Production from Renewable Energy Sources and Cogeneration (Official Gazette 33/2007, 8/2011) - by Dec 31, 2020 13,6% from RES and 4% from cogeneration



2. RES in Croatia

Incentive tariffs for solar (PV) power plant in Croatia 2014

Solar power plants with installed capacity ≤ 5 MW

Roof-top solar power plants with installed capacity ≤ 5 MW			The incentive price correction for roof-top solar power plants with installed capacity ≤ 300 kW		
Group	Type of the plant	The incentive price C (kn/kWh)	Corrective coefficient for thermal system usage k1	The incentive price correction Ck=(C x k1)	
1.a.1.	solar power plants with installed capacity up to and including 10 kW	1,91	1,2	2,29	0,30 €/kWh
1.a.2.	solar power plants with installed capacity exceeding 10 kW up to and including 30 kW	1,70	1,1	1,87	0,24 €/kWh
1.a.3.	solar power plants with installed capacity exceeding 30 kW and up to and including 300 kW	1,54	1,03	1,59	0,21 €/kWh
Ground-mounted solar power plants with installed capacity ≤ 5 MW					
Group	Type of the plant	The incentive price C (kn/kWh)			
1.a.4.	ground-mounted solar power plants	RC			0,05 €/kWh

Limited by quotas: 12 MW in 2014!?



C - The incentive price (Article 5, paragraph 1 of Tariff System for the production of electricity from renewable energy sources and cogeneration, ("Official Gazette", 133/2013, 151/2013)) corrected for every year according to Article 17, paragraph 8, except for the power plants with an incentive price of RC (Article 5, paragraph 10).

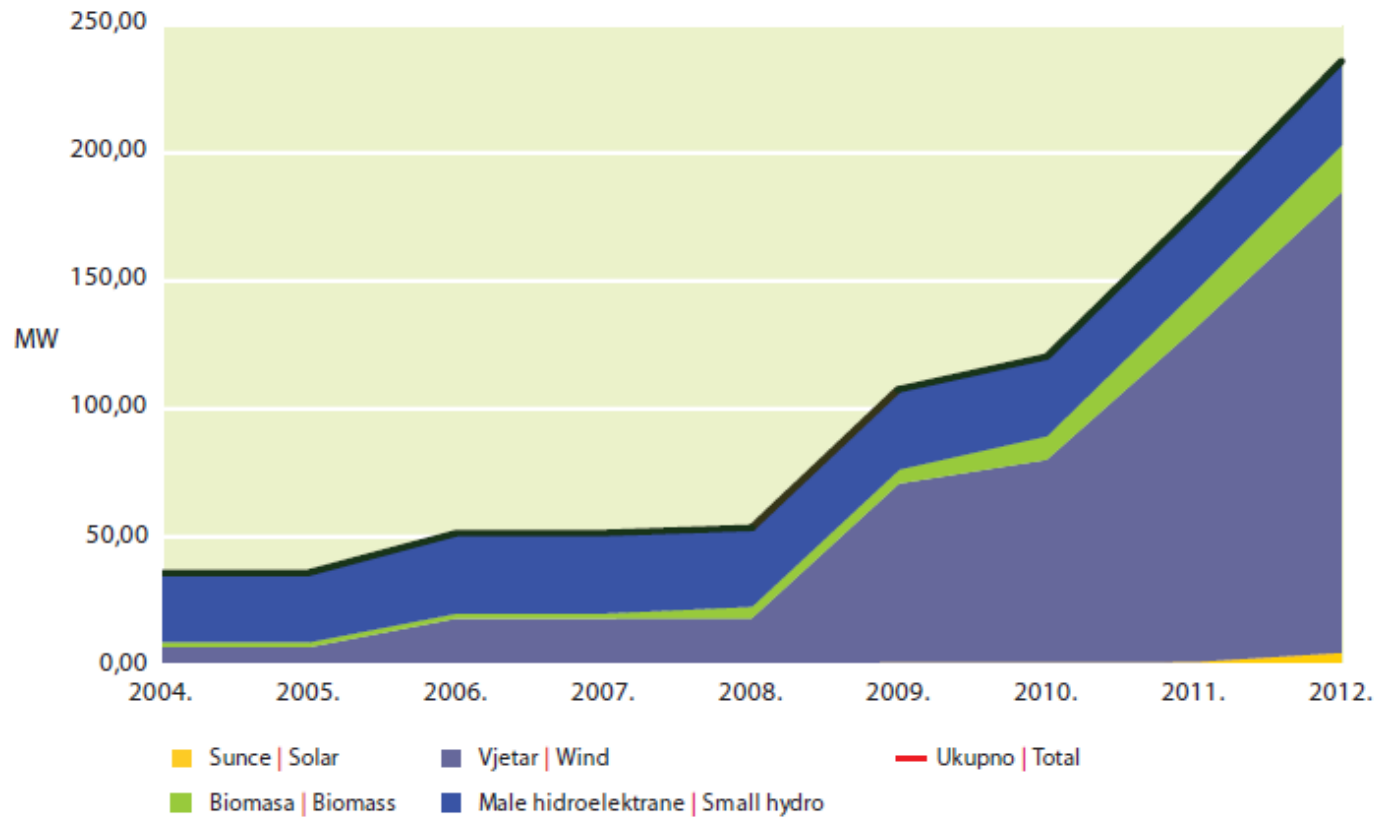
2. RES in Croatia

Incentive tariffs for other RES power plant in Croatia 2014

Group	Type of the plant	Incentive price C (kn/kWh)	
The plant with installed capacity ≤ 5 MW			
1.b.1	hydro power plants with installed capacity up to and including 300 kW	1,07	0,14 €/kWh
1.b.2	hydro power plants with installed capacity exceeding 300 kW up to and including 2 MW	0,93	0,12 €/kWh
1.b.3	hydro power plants with installed capacity exceeding 2 MW	0,88	0,11 €/kWh
1.c.	wind power plants	RC	0,05 €/kWh
1.d.1.	solid biomass plants including biodegradable ind. and municipal waste with electricity up to and including 300 kW	1,30	0,17 €/kWh
1.d.2.	solid biomass plants including biodegradable ind. and municipal waste with electricity exceeding 300 kW up to and including 2 MW	1,25	0,16 €/kWh
1.d.3.	solid biomass plants including biodegradable ind. and municipal waste with electricity exceeding 2 MW	1,20	0,15 €/kWh
1.e.	geothermal power plants	1,20	0,15 €/kWh
1.f.1.	biogas power plants from agricultural plants and organic remains and waste from agriculture and food processing industry, landfill gas power plants and power plants using gas from water treatment plants with electricity up to and including 300 kW	1,34	0,18 €/kWh
1.f.2.	biogas power plants from agricultural plants and organic remains and waste from agriculture and food processing industry, landfill gas power plants and power plants using gas from water treatment plants with electricity exceeding 300 kW up to and including 2 MW	1,26	0,16 €/kWh
1.f.3.	biogas power plants from agricultural plants and organic remains and waste from agriculture and food processing industry, landfill gas power plants and power plants using gas from water treatment plants with electricity exceeding 2 MW	1,18	0,15 €/kWh
1.g.	liquid biofuel power plants	RC	0,05 €/kWh

2. RES in Croatia

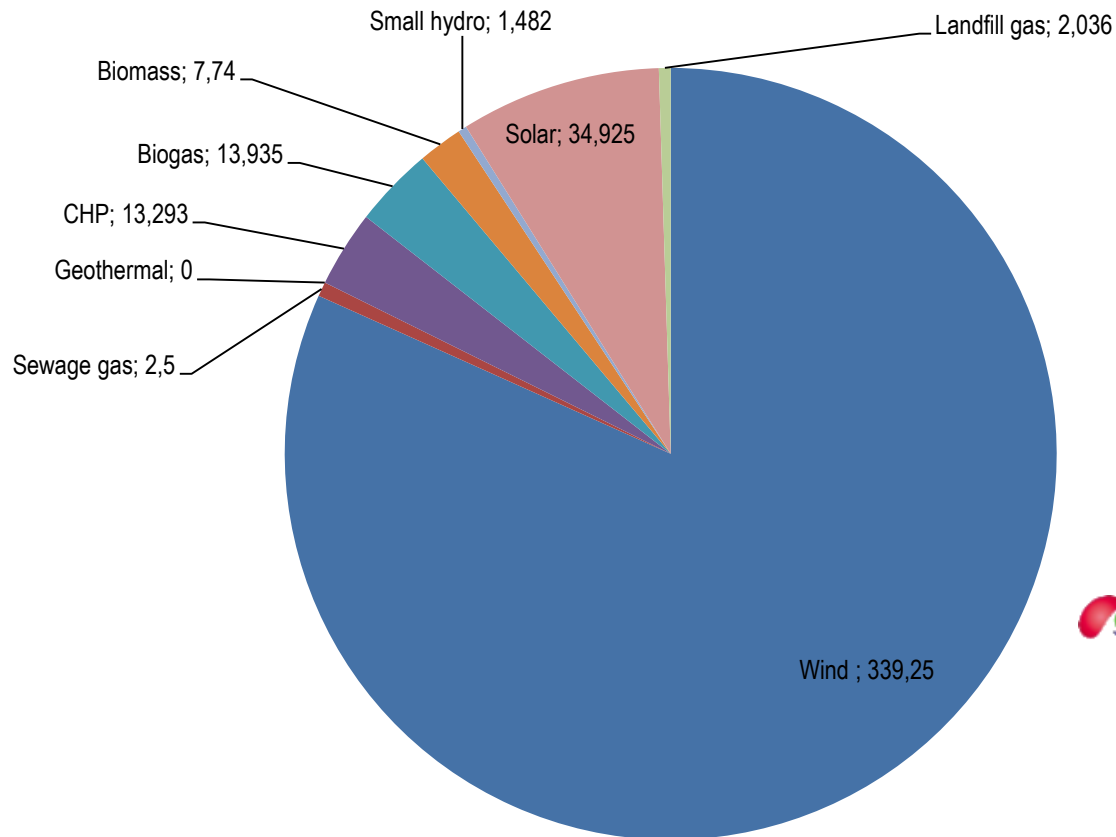
RES power plant capacity in Croatia 2004-2012



Slika | Figure 8.2.2. Instalirani kapaciteti za proizvodnju električne energije iz obnovljivih izvora u Hrvatskoj | Installed capacities for RES-E generation in Croatia – Izvor | Source: EIHP

2. RES in Croatia

Installed capacity (RES) in Croatia - End of February 2015.



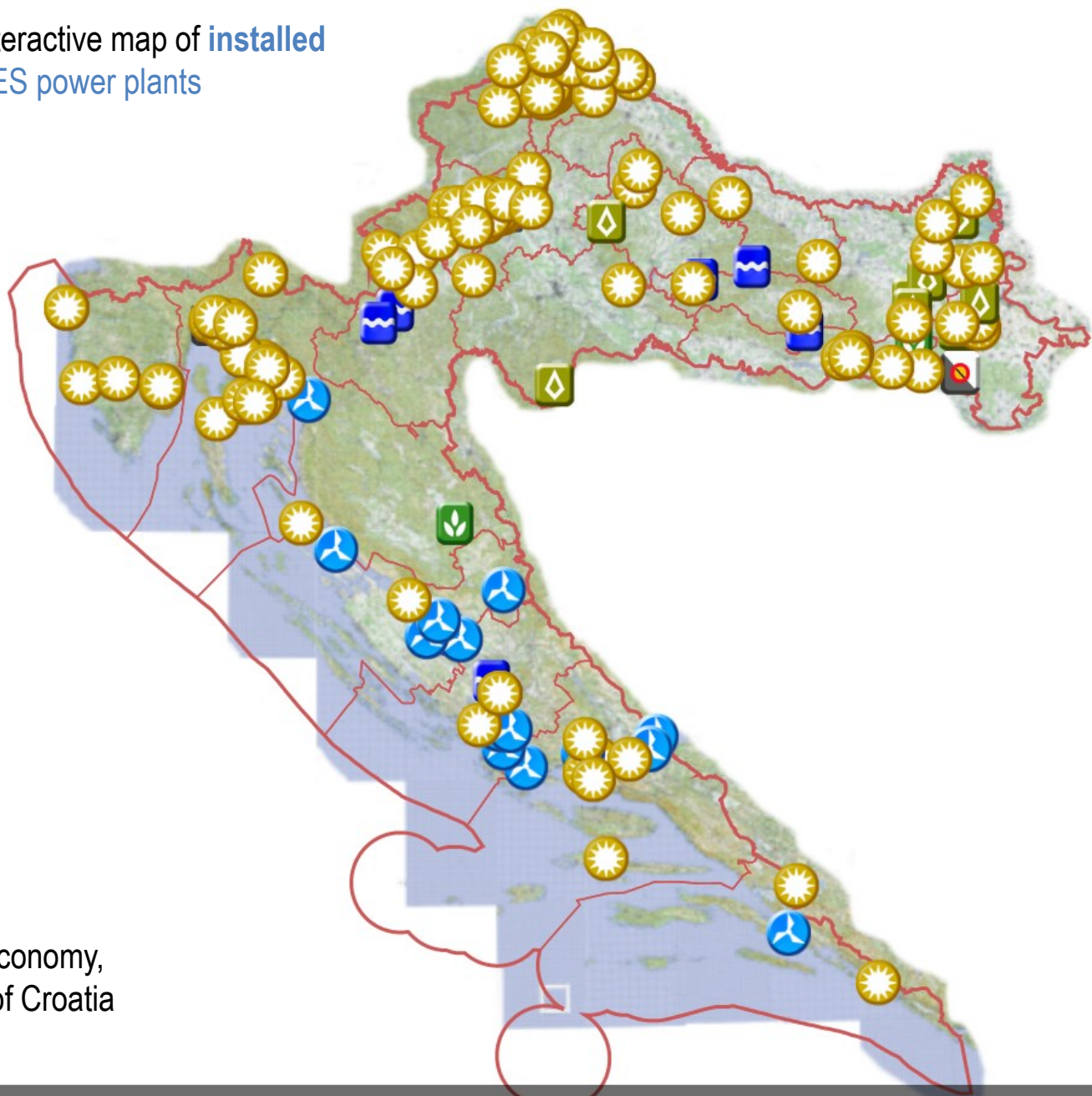
Additional planned projects in the Register of RES and CHP: over 3100 MW!!!
Large hydro power plants: 2108 MW, small hydro power plants 31,4 MW – not in incentive scheme

Plant types RERCPPP
Tools
Borders

Plant types RERCPPP

- Select all
- Solar power plant
- Hydro power plant
- Wind power plant
- Biomass power plant
- Geothermal power plant
- Biogas powerplant
- Liquid biofuel power plants
- Landfill gas power plant and gas from the plant wastewater treatment
- Cogenerations
- Other
- Planned
- Working

Interactive map of installed RES power plants

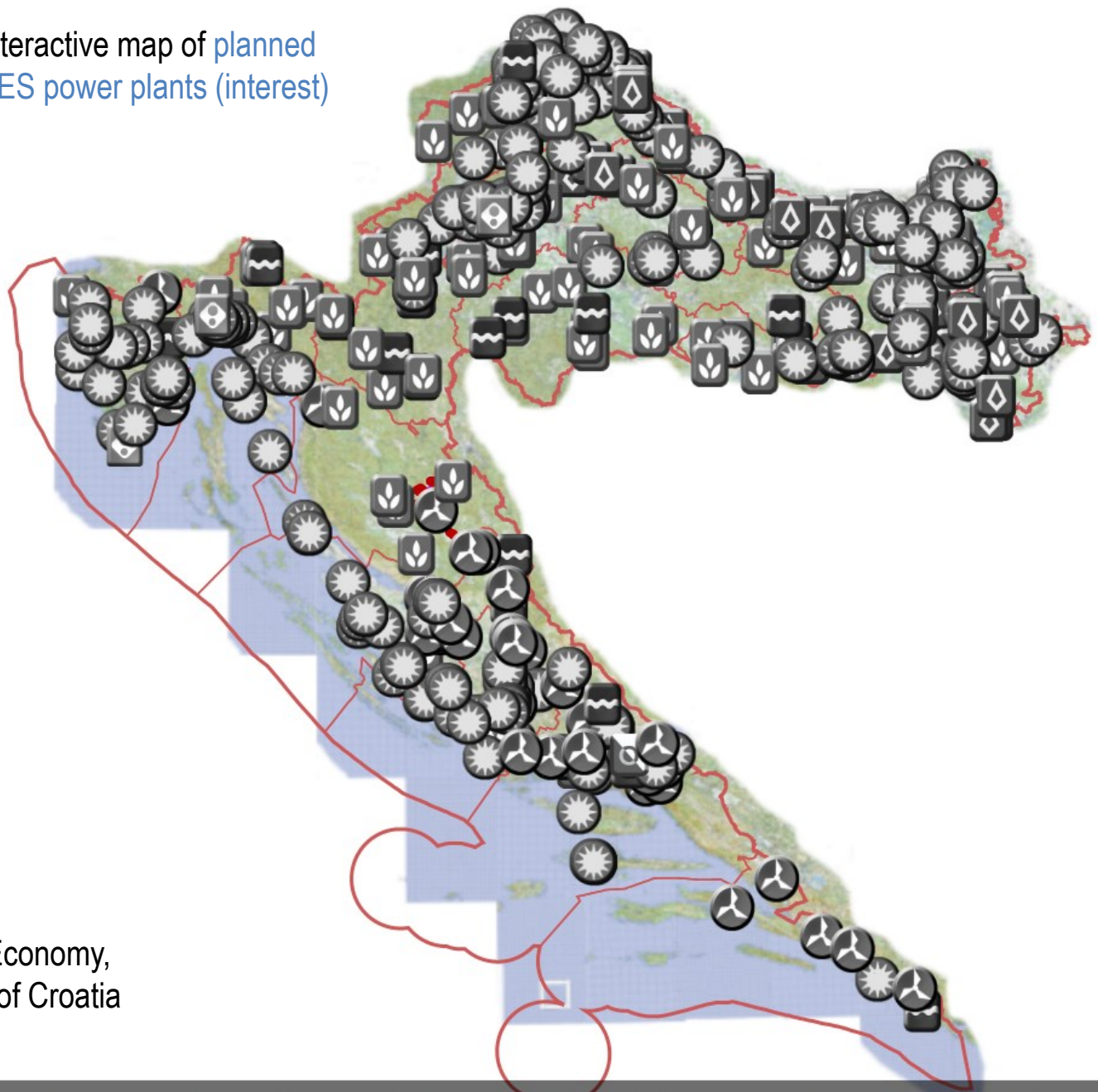


Source: MINGO - Ministry of Economy, Labour and Entrepreneurship of Croatia

Plant types RERCPPP ✕

- Select all
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- Biomass power plant
- Geothermal power plant
- Biogas powerplant
- Liquid biofuel power plants
- Landfill gas power plant and gas from the plant wastewater treatment
- Cogenerations
- Other
- Planned Working

Interactive map of planned RES power plants (interest)



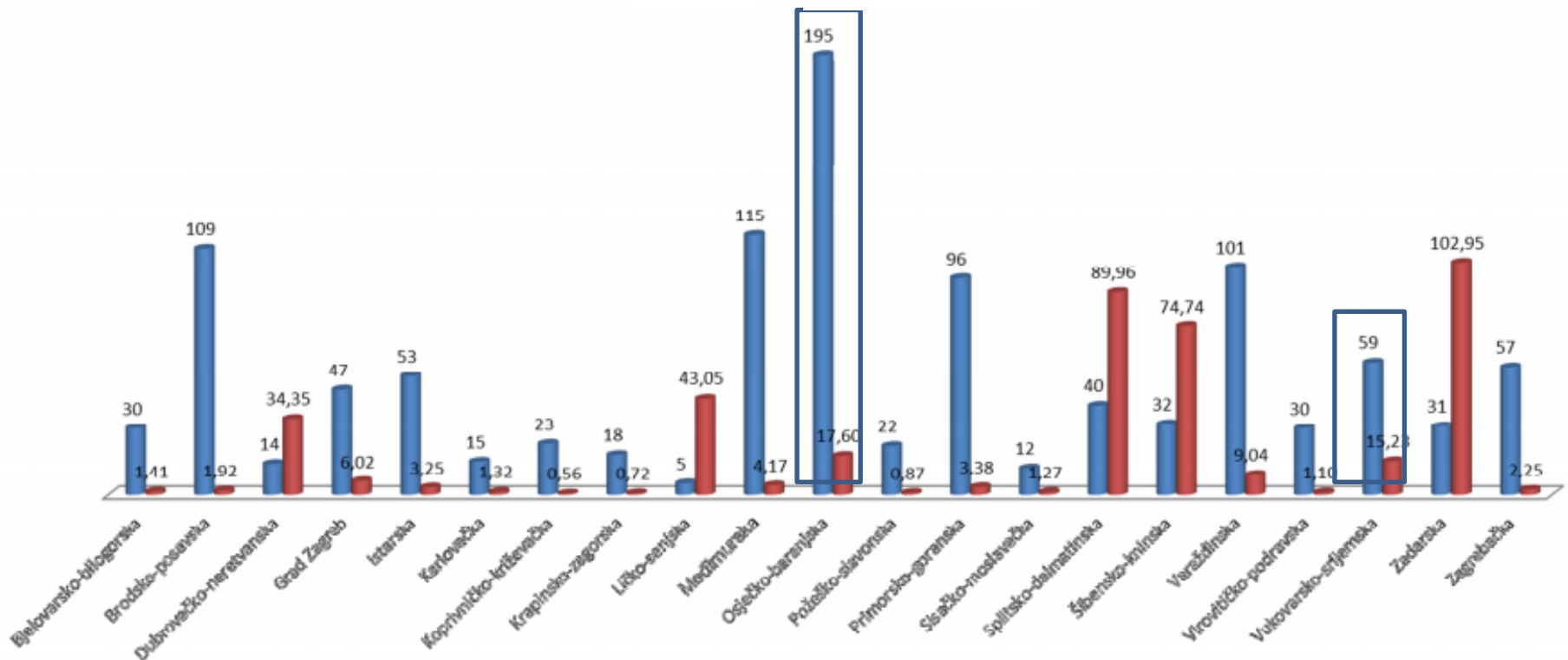
Source: MINGO - Ministry of Economy, Labour and Entrepreneurship of Croatia

3. RES in the Danube region in Croatia

Number of RES plants and installed capacity

Installed capacity (on grid) and number of plants per Counties

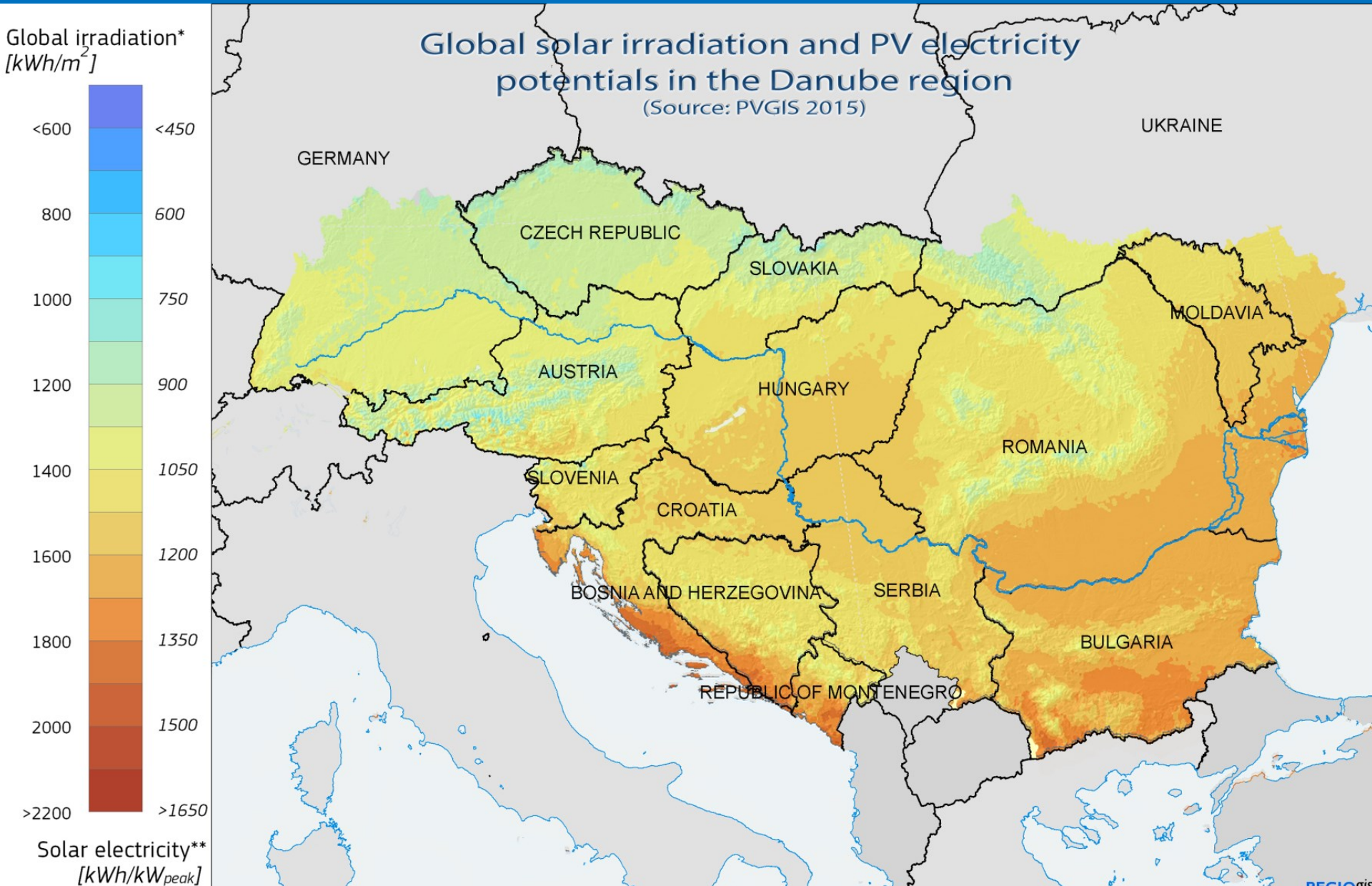
■ No. of plants ■ Installed capacity (MW)



Source: Ministry of Economy, Labour and Entrepreneurship of Croatia
<http://oie-aplikacije.mingo.hr/pregledi/>

February 2015

Solar energy potentials of Danube



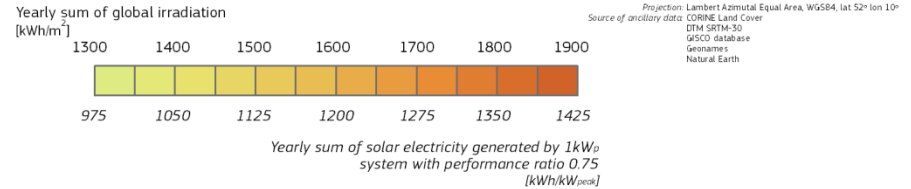
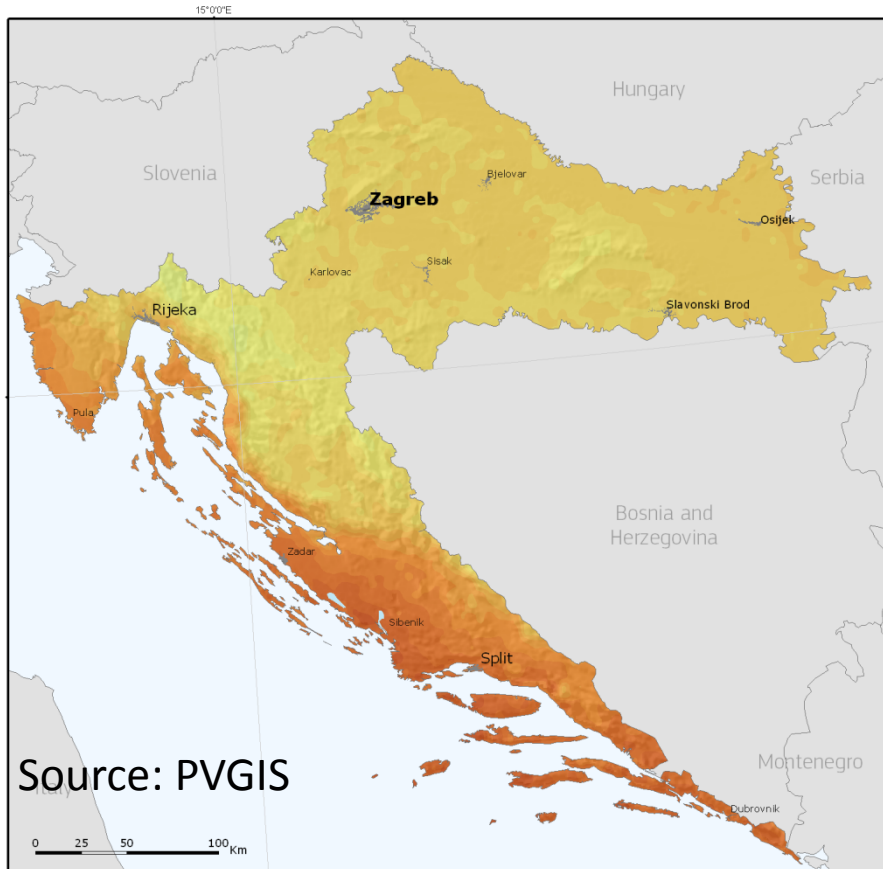
3. RES in the Danube region in Croatia

Solar energy potentials



Global irradiation and solar electricity potential
 Optimally-inclined photovoltaic modules

CROATIA / HRVATSKA



Authors: Thomas Huld, Irene Pinedo-Pascua
 European Commission - Joint Research Centre
 Institute for Energy and Transport, Renewable Energy Unit
 PVGIS <http://re.jrc.ec.europa.eu/pvgis/>

- Short and easy access to the grid for small scale PV (up to 30 kW)
- Limited by quotas: 12 MW in 2014!?
- PV LCOE from 2014 cheaper the market price of electricity even in the northern Croatia. Moving from feed-in tariff for kWh of PV (with solar collectors) towards subsidies for RES equipment (PV, solar collectors heat pumps...) in households (e.g. 45% in Osijek-Baranya County, 40% on national level).

3. RES in the Danube region in Croatia

Biogas energy potentials in Osijek Baranya County

Raw material	Availability of manure	Theoretical energy potential (MWh/year)	Theoretical energy potential (TJ/year)
Biogas production in monodigestion			
Cattle manure	344 764	189 620	683
Pig manure	251 901	41 967	151
Poultry manure	16 972	16 758	60
Raw material	Area required for growing maize silage (ha)	Theoretical energy potential (MWh/year)	Theoretical energy potential (TJ/year)
Biogas production in digestion with maize silage (silage mass portion ~30%)			
Cattle manure + silage	4 395	342 814	1 234
Pig manure + silage	3 211	153 897	553
Poultry manure + silage	216	24 279	87

http://repam.net/uploads/repam/document_translations/doc/000/000/070/REPAM_studija_14_osjecko-baranjska.pdf?2012, accessed: 19th December 2014

3. RES in the Danube region in Croatia

Biogas energy potentials in Vukovar Srijem County

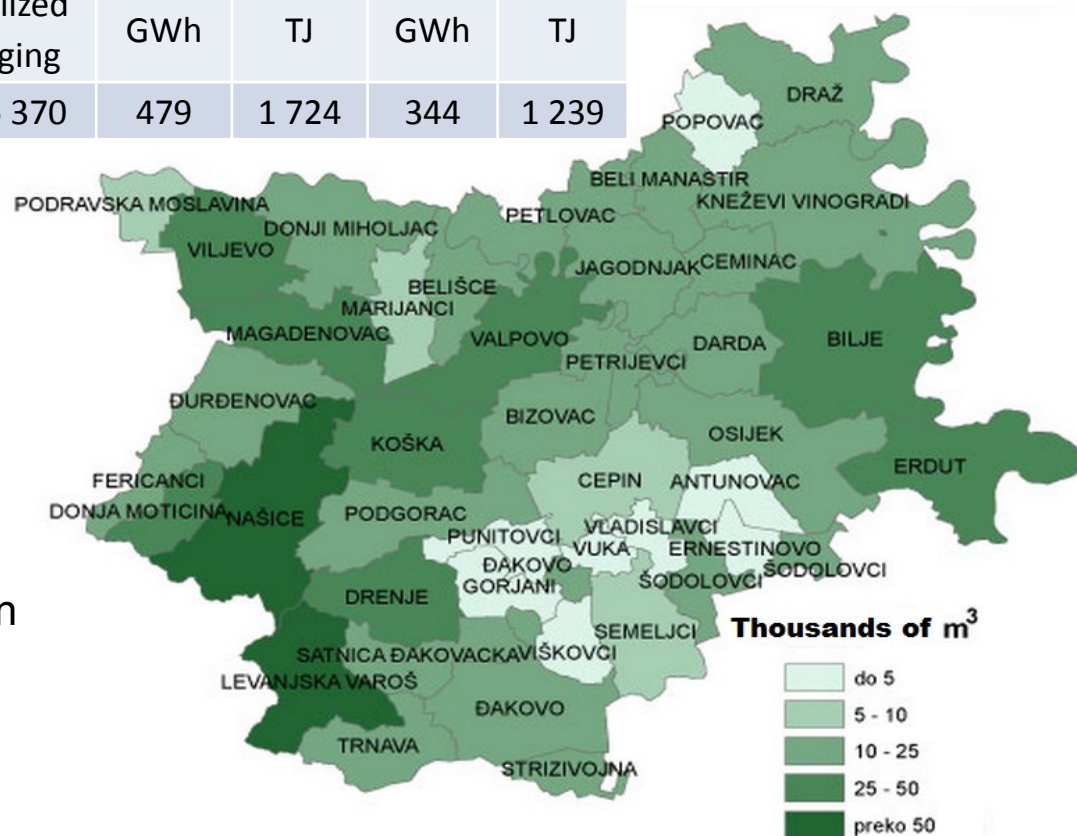
Raw material	Availability of manure	Theoretical energy potential (MWh/year)	Theoretical energy potential (TJ/year)
Biogas production in monodigestion			
Cattle manure	252 050	138 628	499
Pig manure	100 319	16 713	60
Poultry manure	9 535	9 440	34
Raw material	Area required for growing maize silage (ha)	Theoretical energy potential (MWh/year)	Theoretical energy potential (TJ/year)
Biogas production in digestion with maize silage (silage mass portion ~30%)			
Cattle manure + silage	3 213	250 624	902
Pig manure + silage	1 279	61 289	221
Poultry manure + silage	122	13 676	49

http://repam.net/uploads/repam/document_translations/doc/000/000/066/REPAM_studija_16_vukovarsko-srijemska.pdf?2012, accessed: 19th December 2014

3. RES in the Danube region in Croatia

Biomass energy potentials in Osijek-Baranya County

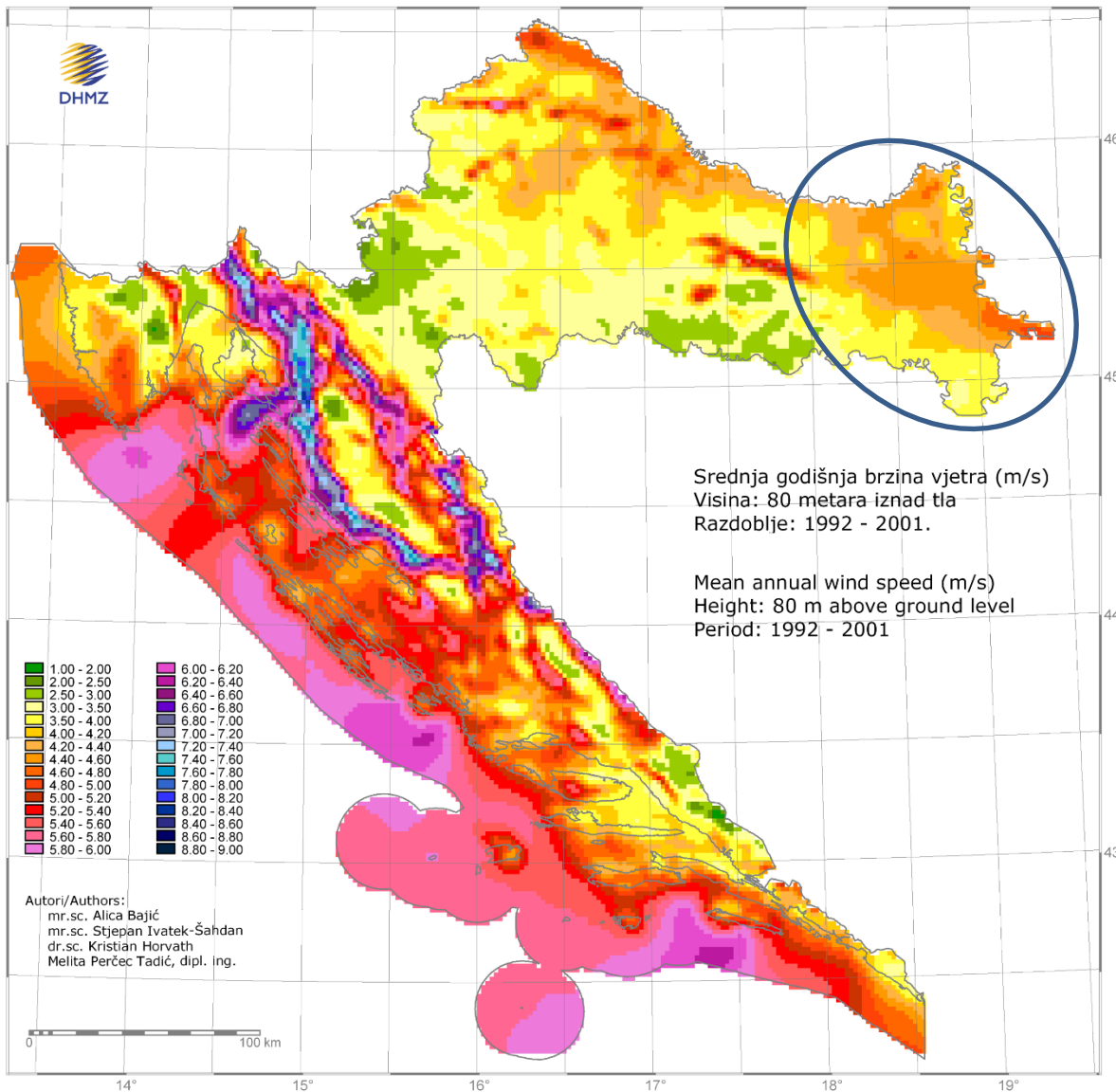
Total timber stock (m ³)	Total annual growth (m ³)	Annual allowable cut of the stacked wood (including conifers) (m ³)		Theoretical energy potential of annual cut of stacked wood (including conifers)			
				Planned logging		Realized logging	
				GWh	TJ	GWh	TJ
22 291 528	758 689	Planned logging	Realized logging	479	1 724	344	1 239
		274 143	186 370				



Total wood stock of economic forests in Osijek – Baranya County

3. RES in the Danube region in Croatia

Average annual wind speed [m/s] at 80 m height



Wind speeds mostly not sufficient for commercial wind turbines!!!

- 3.00-3.50
- 3.50-4.00
- 4.00-4.20
- 4.20-4.40
- 4.40-4.60
- 4.60-4.80
- 4.80-5.00
- 5.00-5.20

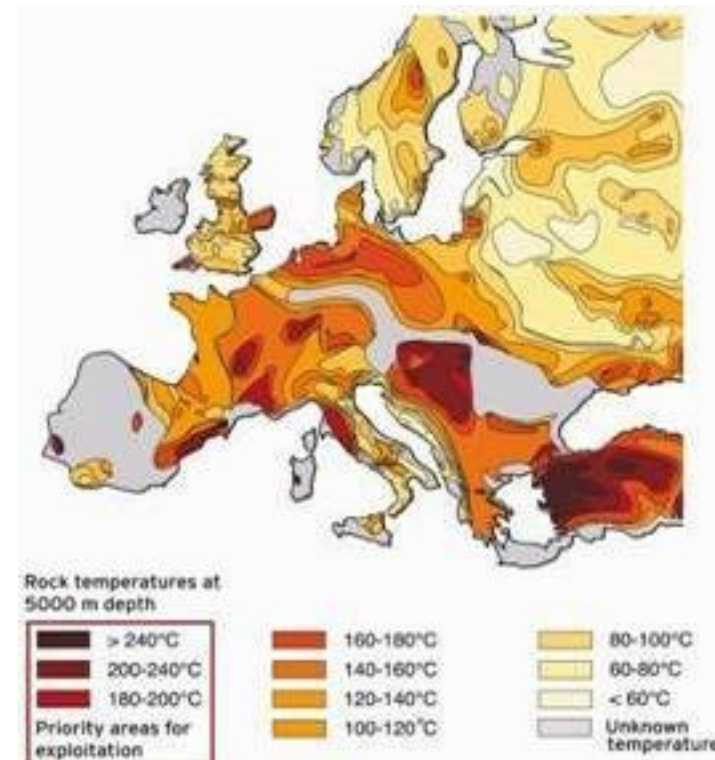
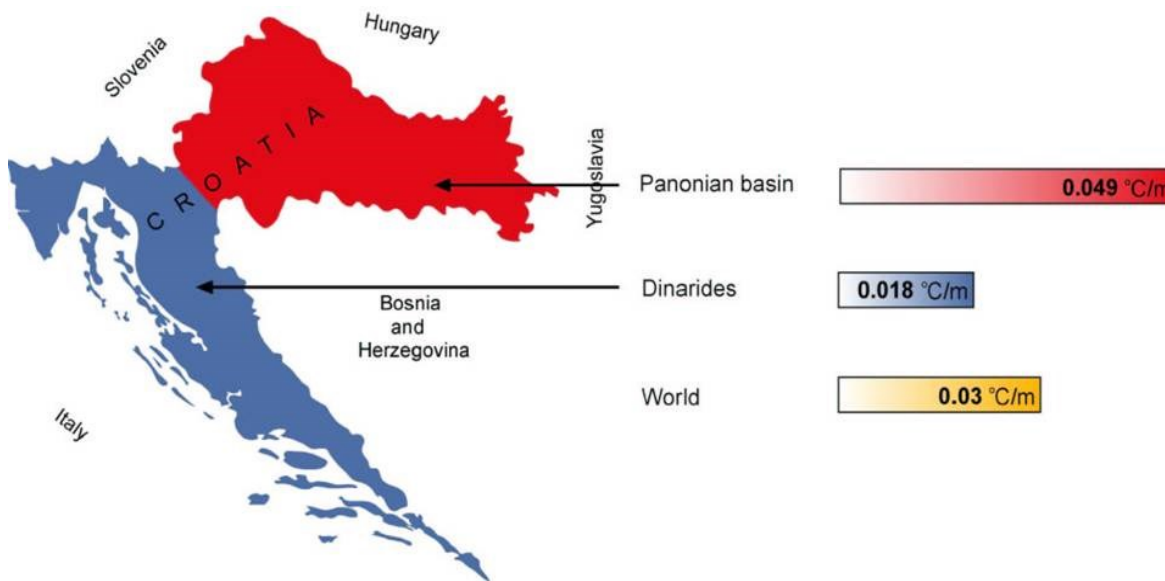
Only few locations in hills and along Danube perspective for small wind farms.

Source: Croatian wind atlas
 DHMZ - Meteorological and Hydrological Service of Croatia

3. RES in the Danube region in Croatia Geothermal energy potentials

Geothermal potentials

- In Danube region of Croatia (Pannonian basin) the value of geothermal gradients ranges from 40 to 50° C/km! One of the hottest region in Europe (hot rocks).
- Huge potentials, but limited (geo)thermal water reservoirs and temperatures!
- Problems with permission for extracting mineral goods.



3. RES in the Danube region in Croatia

Geothermal energy potentials

Geothermal potentials

Thermal water is already found in several deep research wells like:

- Slavonka-1 – 75° C (1 667 m), water is used for [spa therapy and heating](#);
- Mandarinci-1 – 96°C (1 970 – 2 630 m);
- Bokšić-3 and Obradovci-2 – 41°C (300 – 850 m);
- Ernestinovo-1 – 74 °C (1 600 – 2100 m)
- Babina Greda – 110° C (1571-1585 m) and 121° C (1767-2266 m), geothermal power plant is planned to be built on this location;
- Domaljevac – 70 – 80°C (1212 m), water is used for heating of [greenhouses](#);
- Sikirevci – water of technological quality (655 – 665 m);
- Otok – 130 °C (2635 m) – water flow and quality still not tested;
- Ranisavlje – 130 ° C (3000 and 3063 – 3078 m) – water flow and quality still not tested;
- Lešić – 70 ° C (1063 – 1275 m) – water flow and quality still not tested.

4. Conclusions

on RES potentials in Danube region of Croatia

- Croatia (and it's Danube Region), has significant interest in the increasing of use of RES and in RES related industry, research and education.
- **Biomass and biogas:** most perspective in mix of rural and forest areas and it is expected to grow even more with payback period (with current feed-in tariff) less the 4 years
- **Region (the north) is leader (!?) in solar energy projects in Croatia** (dominantly small PV systems up to 30 kW) located mostly in urban area
- Geothermal energy is still in research phase in Croatia, but several locations have good potential for energy exploitation and it is currently used for spa and heat. **Potentials for future enhanced geothermal systems (EGS) in hydrofracturing of hot rocks.**
- Small hydropower plants potentials is in the focus of mountain regions and not **flat regions dominated by large rivers of Danube, Drava and Sava** – there is interest some in cascade hydro-system on Drava upstream of Osijek and usage of **agricultural water supply canal systems**. Large-hydro potentials is allready higly exploited.
- Due to wind speeds, wind highly developed on the coast, need for **development and implementation of cost and energy efficient small speed wind turbines.**

2. RES in Croatia

Croatian wind power plant industry - Končar

KONČAR

Wind turbine K80

OPERATION DATA

Rated power	2500 kW
Hub height	80 m
Power regulation	variable speed - pitch control
Cut - in wind speed	2,5 m/s
Rated wind speed	12,5 m/s
Cut - out wind speed	25 m/s
Survival wind speed	59,5 m/s

Generator synchronous direct drive variable speed
2500 kW, 690 V

Tower tubular conical steel

Braking system 3 independent control pitch systems
with emergency supply and rotor brake

Rotor

Orientation upwind
Number of blades 3
Blade material fiberglass (reinforced epoxy) with
integral lighting protection

Diameter 91 m

Swept area 6526 m²

Speed 5-16 rpm

Direction of rotation clockwise

Pitch control 3 blade pitch systems with
emergency supply

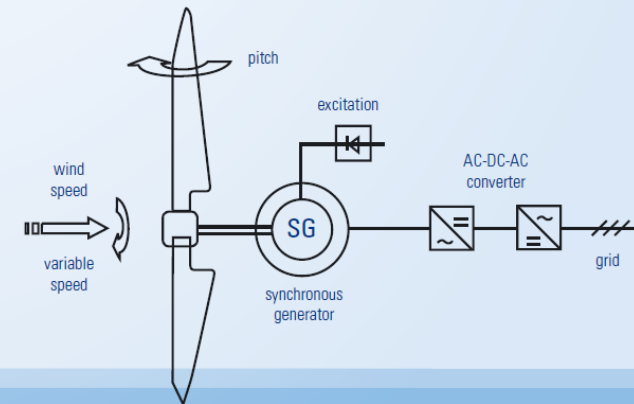
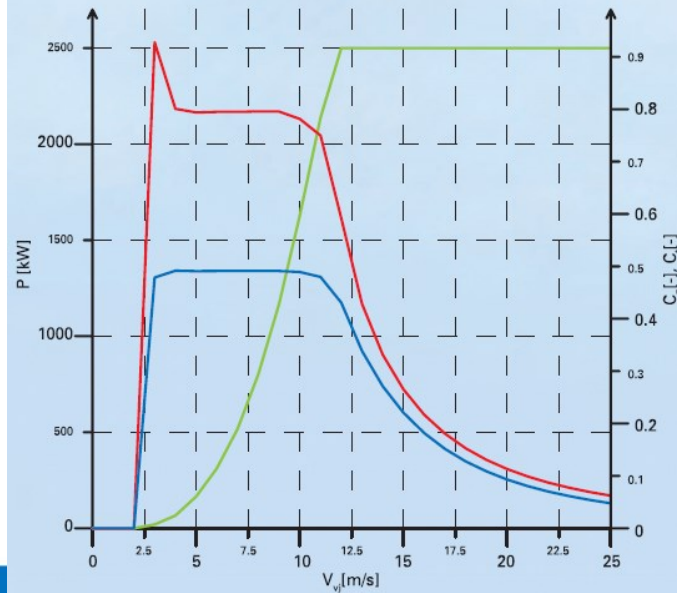
Grid connection AC-DC-AC converter

Control microprocessor control system

Yaw system active with damping



K80 wind power curve (air density 1.225 kg/m³)

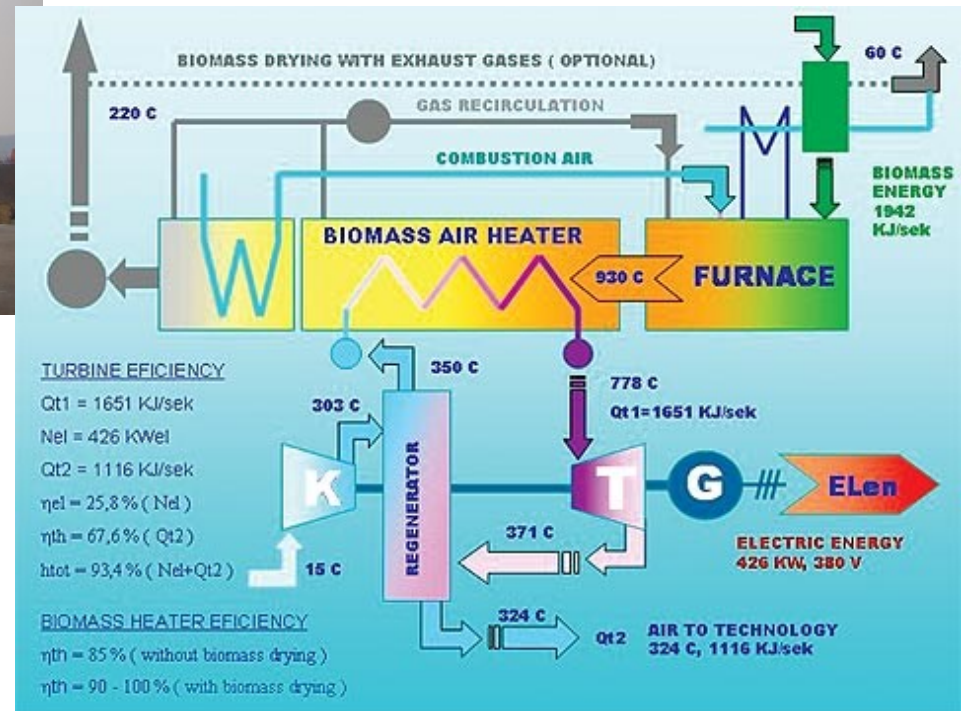


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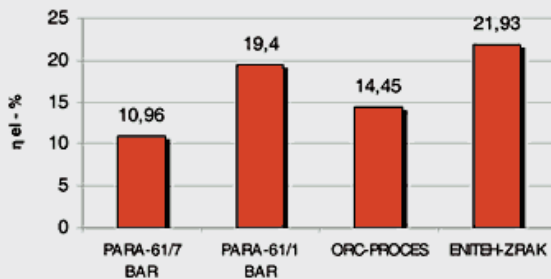
Croatian biomass power plant industry – Đuro Đaković



ENITEH 500
Indirect gas turbine process
400 kWe small CHP power plant



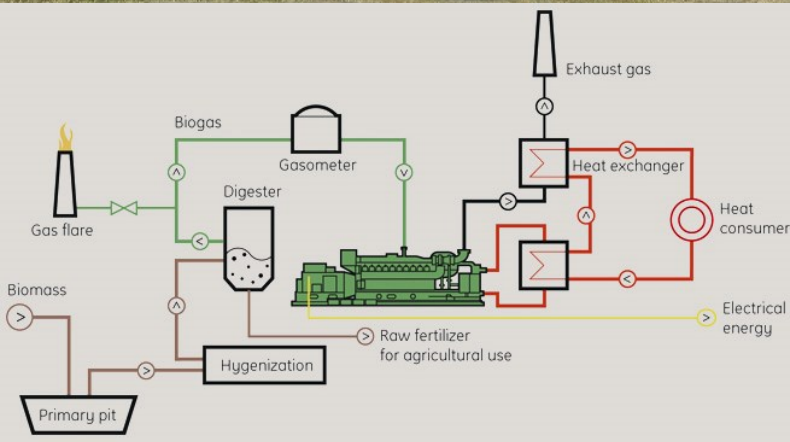
ELEKTRIČNA ISKORISTIVOST ENERGIJE BIOMASE
ELECTRIC EFFICIENCY OF BIOMASS ENERGY



TIPOVI KOGENERACIJSKIH SUSTAVA
TYPE OF COGENERATION PLANT

2. RES in Croatia

Example: eligible producer from biogas – PZ Osatina



2x1MWe (2x1,3 MWt) CHP farm Ivankovo
2x1MWe (2x1,3 MWt) CHP farm Tomašanci



2. RES in Croatia

Example: small HPP Jaruga (river Krka), 1895!



- Jaruga is second oldest HPP in the world and oldest in Europe, in operation from 28 August 1895, 3 days after HPP on Niagara
- Net head 26 m, turbine original on photo, 2 generators 42 Hz, 550 kW, transformer, 11,5 km of 3 kV lines on wooden towers to Šibenik (urban network with 6 TS 3000/100 V) – Hungarian company Ganz.
- After HPP Krka (later Jaruga I) in 1903 HPP Jaruga II (6 MW). Still in operation, last renewal of Jaruga II in 2008.: 2x2,8 MW, 35 GWh/yr.



2. RES in Croatia

Example: PV power plant ETFOS 1 (Laboratory for RES)

- Laboratory for Renewable Energy Sources at Josip Juraj Strossmayer University of Osijek Faculty of Electrical Engineering Osijek founded within IPA Hungary-Croatia cross-border project REGPHOSYS: Photovoltaic Systems as Actuators of Regional Development
- PV Power Plant ETFOS (rooftop of main amphitheatre)
 - 5 kW (20x250W) monocrystalline Si
 - 5 kW (40x250W) polycrystalline Si
 - 12 kW KACO inverter
- Indoor and outdoor test field for 5 PV technologies: high-efficient mono Si, CIS, thin film Si, mono SI, poly Si
- More data on: www.etfos.unios.hr/reslab

