

Fakultet kemijskog inženjerstva i tehnologije
Zavod za termodinamiku, strojarstvo i energetiku



ENERGETIKA

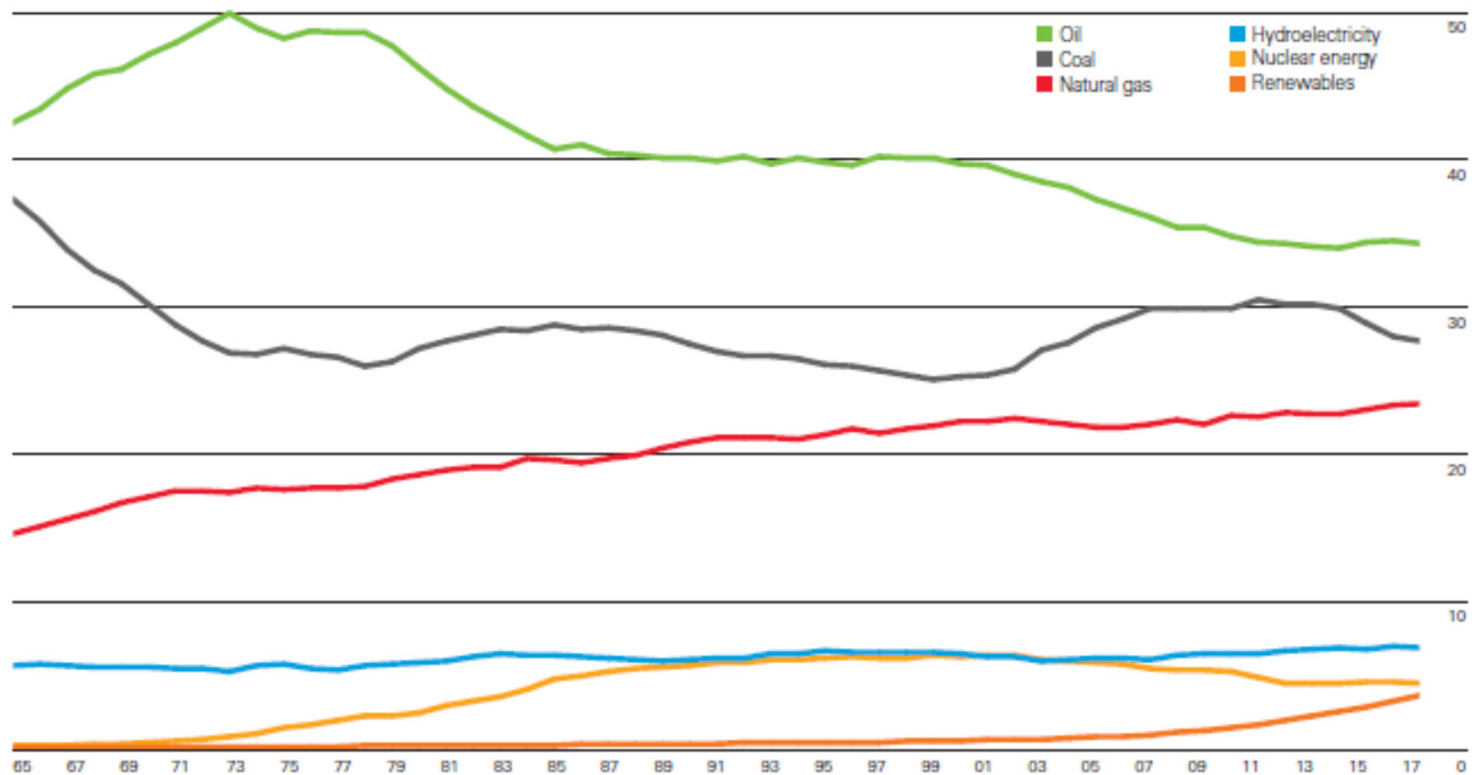
Studij: Kemijsko inženjerstvo (V semestar)

prof. dr. sc. Igor Sutlović

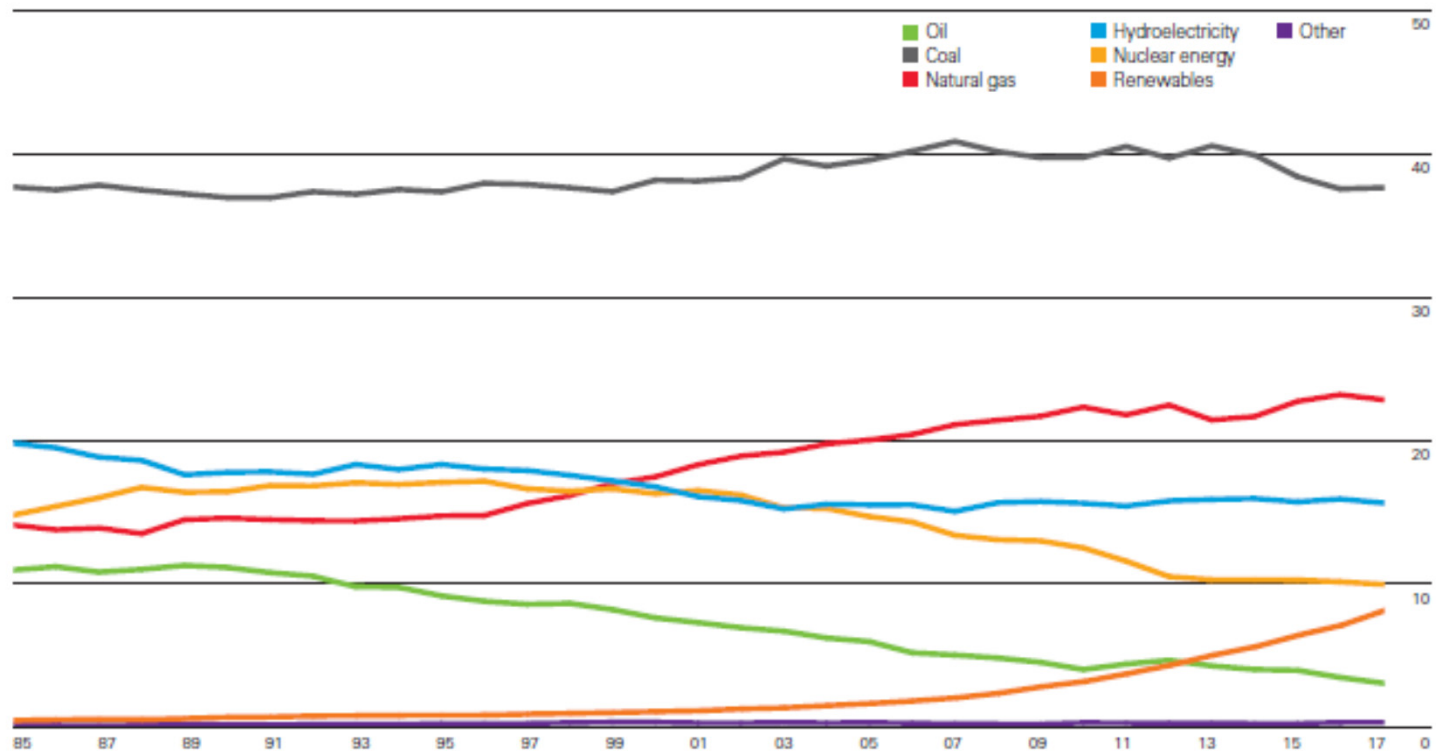


EU 20-20-20 ciljevi

- Smanjenje emisije stakleničkih plinova u EU za 20% u odnosu na one iz 1990.,
- 20% potrošnje energije u EU osigurati treba biti iz obnovljivih izvora,
- smanjiti 20% potrošnju primarne energije u odnosu na očekivanu razinu, kroz mjere energetske učinkovitosti.



Udio potrošnje primarne energije u Svijetu prema gorivu(%), BP Statistical Review of World Energy 2017.



Udjeli proizvedene el. e., Prema gorivu u Svijetu (%), BP Statistical Review of World Energy 2017.

 Nuclear energy

Consumption*

Exajoules (input-equivalent)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Growth rate per annum		Share 2021
												2021	2011-21	
Canada	0.89	0.89	0.97	1.00	0.94	0.93	0.92	0.91	0.92	0.88	0.83	-5.8%	-0.6%	3.3%
Mexico	0.10	0.08	0.11	0.09	0.11	0.10	0.10	0.12	0.10	0.10	0.11	6.6%	1.1%	0.4%
US	7.93	7.67	7.82	7.85	7.81	7.84	7.79	7.76	7.76	7.54	7.40	-1.6%	-0.7%	29.3%
Total North America	8.91	8.65	8.90	8.94	8.85	8.87	8.81	8.80	8.78	8.53	8.34	-1.9%	-0.7%	33.0%
Argentina	0.06	0.06	0.06	0.05	0.07	0.08	0.06	0.06	0.08	0.10	0.10	1.5%	4.8%	0.4%
Brazil	0.15	0.15	0.15	0.14	0.14	0.15	0.14	0.14	0.15	0.13	0.13	4.5%	-1.2%	0.5%
Chile	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Colombia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ecuador	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Peru	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trinidad & Tobago	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Venezuela	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Central America	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Caribbean	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other South America	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total S. & Cent. America	0.21	0.21	0.20	0.20	0.20	0.22	0.20	0.21	0.22	0.22	0.23	3.2%	0.9%	0.9%
Austria	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Belgium	0.46	0.38	0.40	0.32	0.24	0.40	0.39	0.26	0.40	0.31	0.46	46.7%	-0.1%	1.8%
Bulgaria	0.16	0.15	0.13	0.15	0.14	0.15	0.14	0.15	0.15	0.15	0.15	-1.0%	-0.4%	0.6%
Croatia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyprus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Czech Republic	0.27	0.29	0.29	0.28	0.25	0.22	0.26	0.27	0.28	0.27	0.28	2.2%	0.3%	1.1%
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Finland	0.22	0.22	0.22	0.22	0.22	0.22	0.21	0.21	0.22	0.21	0.22	1.2%	-0.4%	0.9%
France	4.22	4.03	3.99	4.08	4.07	3.73	3.66	3.77	3.63	3.21	3.43	7.1%	-2.0%	13.5%
Germany	1.03	0.94	0.92	0.91	0.85	0.78	0.70	0.69	0.68	0.58	0.62	7.1%	-4.9%	2.5%
Greece	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hungary	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.14	0.15	0.15	0.14	-0.5%	-0.3%	0.6%
Iceland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Italy	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Latvia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	0.04	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.04	0.03	-6.5%	-1.3%	0.1%
North Macedonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poland	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Romania	0.11	0.11	0.11	0.11	0.11	0.10	0.11	0.10	0.10	0.10	0.10	-1.7%	-0.9%	0.4%
Slovakia	0.15	0.15	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.14	2.1%	-0.3%	0.6%
Slovenia	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	0.05	0.06	0.05	-10.3%	-1.4%	0.2%
Spain	0.55	0.58	0.53	0.54	0.53	0.54	0.53	0.51	0.53	0.53	0.51	-3.2%	-0.7%	2.0%
Sweden	0.58	0.61	0.63	0.61	0.52	0.58	0.60	0.63	0.60	0.45	0.48	7.8%	-1.8%	1.9%
Switzerland	0.26	0.24	0.25	0.26	0.22	0.20	0.19	0.22	0.23	0.21	0.17	-19.5%	-4.2%	0.7%
Turkey	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ukraine	0.86	0.85	0.78	0.83	0.82	0.75	0.79	0.77	0.76	0.69	0.78	13.0%	-1.0%	3.1%
United Kingdom	0.66	0.67	0.66	0.60	0.65	0.66	0.65	0.59	0.51	0.46	0.41	-8.9%	-4.5%	1.6%
Other Europe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Europe	9.76	9.46	9.29	9.29	9.01	8.71	8.61	8.56	8.47	7.56	7.98	5.8%	-2.0%	31.5%
Azerbaijan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Belarus	-	-	-	-	-	-	-	-	-	1	0.05	1608.5%	-	0.2%
Kazakhstan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Russian Federation	1.65	1.68	1.62	1.69	1.82	1.82	1.87	1.87	1.90	1.96	2.01	2.9%	2.0%	7.9%
Turkmenistan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uzbekistan	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other CIS	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.02	-27.6%	-2.9%	0.1%
Total CIS	1.67	1.70	1.65	1.71	1.84	1.84	1.89	1.89	1.92	1.99	2.08	5.0%	2.2%	8.2%

Nuclear energy

Consumption*

Iran	†	0.01	0.04	0.04	0.03	0.06	0.06	0.06	0.06	0.06	0.03	-44.2%	41.1%	0.1%
Iraq	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Israel	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kuwait	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oman	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Qatar	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Saudi Arabia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
United Arab Emirates	-	-	-	-	-	-	-	-	-	0.01	0.10	548.8%	-	0.4%
Other Middle East	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Middle East	†	0.01	0.04	0.04	0.03	0.06	0.06	0.06	0.06	0.07	0.13	76.9%	62.0%	0.5%
Algeria	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Egypt	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Morocco	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Africa	0.12	0.12	0.13	0.13	0.11	0.14	0.13	0.11	0.12	0.13	0.09	-25.3%	-2.6%	0.4%
Eastern Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Middle Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Western Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Northern Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Southern Africa	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Africa	0.12	0.12	0.13	0.13	0.11	0.14	0.13	0.11	0.12	0.13	0.09	-25.3%	-2.6%	0.4%
Australia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bangladesh	-	-	-	-	-	-	-	-	-	-	-	-	-	-
China	0.83	0.93	1.05	1.25	1.59	1.97	2.28	2.70	3.18	3.32	3.68	11.2%	16.1%	14.6%
China Hong Kong SAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-
India	0.31	0.31	0.31	0.32	0.36	0.35	0.34	0.36	0.41	0.40	0.40	-1.6%	2.6%	1.6%
Indonesia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Japan	1.55	0.17	0.14	-	0.04	0.16	0.27	0.45	0.60	0.39	0.55	42.2%	-9.8%	2.2%
Malaysia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New Zealand	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pakistan	0.04	0.03	0.04	0.04	0.04	0.05	0.07	0.08	0.08	0.09	0.14	65.9%	14.3%	0.6%
Philippines	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Singapore	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Korea	1.47	1.42	1.31	1.46	1.53	1.50	1.36	1.22	1.33	1.45	1.43	-1.4%	-0.3%	5.6%
Sri Lanka	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Taiwan	0.40	0.38	0.39	0.40	0.34	0.29	0.21	0.25	0.29	0.29	0.25	-11.7%	-4.6%	1.0%
Thailand	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Vietnam	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Asia Pacific	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Asia Pacific	4.60	3.25	3.24	3.48	3.90	4.33	4.54	5.06	5.89	5.94	6.46	9.0%	3.4%	25.5%
Total World	25.28	23.40	23.45	23.78	23.96	24.17	24.25	24.68	25.46	24.44	25.31	3.8%	*	100.0%
of which: OECD	20.57	18.59	18.60	18.61	18.37	18.25	18.02	18.00	18.16	16.99	17.27	2.0%	-1.7%	68.2%
Non-OECD	4.71	4.82	4.84	5.17	5.59	5.93	6.23	6.68	7.30	7.46	8.04	8.1%	5.5%	31.8%
European Union	7.99	7.69	7.59	7.61	7.32	7.10	6.98	6.97	6.97	6.20	6.62	7.0%	-1.9%	26.1%

*Based on gross generation and not accounting for cross-border electricity supply. "Input-equivalent" energy is the amount of fuel that would be required by thermal power stations to generate the reported electricity output. Details on thermal efficiency assumptions are available in the appendices and definitions page and at bp.com/statisticalreview.

†Less than 0.005.

*Less than 0.05%.

Notes: Annual changes and share of total are calculated using exajoules figures. Growth rates are adjusted for leap years.

Obnovljivi izvori energije (OIE)



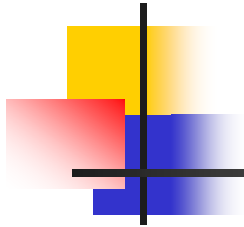
Obnovljivi izvori energije u hrvatskom se “Zakonu o energiji” definiraju kao:

„izvori energije koji su sačuvani u prirodi i obnavljaju se u cijelosti ili djelomično, posebno energija vodotoka, vjetra, neakumulirana sunčeva energija, biodizel, biomasa, bioplin, geotermalna energija itd.”

Iz “Uredbe o minimalnom udjelu električne energije proizvedene iz obnovljivih izvora energije i kogeneracije čija se proizvodnja potiče” (Vlada RH 2007.g):

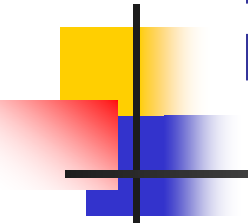
Do 31. prosinca 2010. godine minimalni udio električne energije proizvedene iz postrojenja koja koriste obnovljive izvore energije čija se proizvodnja potiče, iznositi će 5,8% u ukupnoj potrošnji električne energije.

Do 31. prosinca 2010. godine minimalni udio električne energije proizvedene iz kogeneracijskih postrojenja čija se proizvodnja potiče i isporučene u prijenosnu, odnosno distribucijsku mrežu iznositi će 2,0% u ukupnoj potrošnji električne energije.



- **Zakon o obnovljivim izvorima energije i visokoučinkovitoj kogeneraciji NN [100/15](#), [123/16](#), [131/17](#)**
- **Čl.4.**
- 11. obnovljivi izvori energije – obnovljivi nefosilni izvori energije (aerothermalna, energija iz biomase, energija iz biotekućine, energija mora, hidroenergija, energija vjetra, geothermalna i hidrothermalna energija, energija plina iz deponija otpada, plina iz postrojenja za obradu otpadnih voda i bioplina, sunčeva energija i biorazgradivi dio certificiranog otpada za proizvodnju energije na gospodarski primjeren način sukladno propisima iz upravnog područja zaštite okoliša)

- **Čl. 6.**
- (1) Za potrebe izvještavanja i statističkih obrada koji se rade prema ovome Zakonu te klasifikaciji postrojenja obnovljivi izvori energije dijele se na sljedeće:
 1. energiju sunca
 2. energiju vjetra
 3. hidroenergiju
 4. geothermalnu energiju
 5. energiju biomase te
 6. nescificirane i ostale obnovljive izvore energije.



PRAVILNIK O KORIŠTENJU OBNOVLJIVIH IZVORA ENERGIJE I KOGENERACIJE (NN 67/07)

Ciljevi

članak 2.

Korištenjem obnovljivih izvora energije i kogeneracije ostvaruju se interesi Republike Hrvatske u području energetike, utvrđeni Strategijom energetskega razvitka Republike Hrvatske, zakonima i drugim propisima kojima se uređuje obavljanje energetske djelatnosti, osobito u pogledu:

- dugoročnog smanjenja ovisnosti o uvozu energenata,
- učinkovitog korištenja energije i smanjenja utjecaja uporabe fosilnih goriva na okoliš,
- otvaranja novih radnih mjesta i razvoja poduzetništva u energetici,
- poticanja razvoja novih tehnologija i domaćeg gospodarstva u cjelini,
- diverzifikacije proizvodnje energije i sigurnosti opskrbe.

Renewable energy

Renewables consumption*

Exajoules (input-equivalent)	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Growth rate per annum		
												2021	2011-21	Share 2021
Canada	0.28	0.32	0.33	0.34	0.48	0.54	0.55	0.56	0.56	0.57	0.58	2.2%	7.3%	1.4%
Mexico	0.09	0.11	0.12	0.14	0.17	0.18	0.20	0.24	0.31	0.35	0.39	9.4%	15.4%	1.0%
US	3.25	3.50	3.99	4.30	4.53	5.13	5.60	5.88	6.20	6.65	7.48	12.8%	8.7%	18.7%
Total North America	3.63	3.94	4.44	4.78	5.18	5.85	6.34	6.68	7.07	7.57	8.44	11.8%	8.8%	21.2%
Argentina	0.05	0.06	0.07	0.07	0.08	0.08	0.09	0.10	0.14	0.16	0.20	26.1%	15.6%	0.5%
Brazil	0.93	0.96	1.12	1.30	1.55	1.61	1.75	1.96	2.16	2.19	2.39	9.5%	9.9%	6.0%
Chile	0.05	0.07	0.08	0.08	0.10	0.13	0.16	0.19	0.22	0.22	0.29	27.3%	18.4%	0.7%
Colombia	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07	14.9%	5.4%	0.2%
Ecuador	†	†	†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-6.4%	8.2%	•
Peru	0.02	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	4.5%	11.2%	0.1%
Trinidad & Tobago	†	†	†	†	†	†	†	†	†	†	†	-0.4%	1.0%	•
Venezuela	†	†	†	†	†	†	†	†	†	†	†	-0.3%	41.3%	•
Central America	0.07	0.08	0.09	0.10	0.12	0.13	0.13	0.15	0.17	0.16	0.17	7.3%	9.5%	0.4%
Other Caribbean	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.05	0.06	0.07	14.3%	10.0%	0.2%
Other South America	0.02	0.02	0.03	0.04	0.06	0.07	0.08	0.09	0.10	0.11	0.11	1.0%	17.6%	0.3%
Total S. & Cent. America	1.21	1.29	1.50	1.72	2.03	2.15	2.35	2.65	2.95	3.02	3.35	11.4%	10.8%	8.4%
Austria	0.10	0.10	0.11	0.12	0.14	0.14	0.15	0.15	0.16	0.15	0.15	-1.2%	4.8%	0.4%
Belgium	0.10	0.12	0.13	0.14	0.16	0.16	0.18	0.19	0.21	0.26	0.25	-1.9%	9.3%	0.6%
Bulgaria	0.01	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.05	0.06	6.7%	18.2%	0.1%
Croatia	†	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.04	15.1%	29.5%	0.1%
Cyprus	†	†	†	†	†	†	†	†	0.01	0.01	0.01	20.3%	12.5%	•
Czech Republic	0.07	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	-0.1%	4.0%	0.3%
Denmark	0.15	0.16	0.17	0.19	0.20	0.20	0.23	0.22	0.24	0.24	0.27	12.8%	6.0%	0.7%
Estonia	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.04	13.5%	10.6%	0.1%
Finland	0.14	0.14	0.15	0.16	0.17	0.17	0.20	0.22	0.23	0.22	0.25	12.8%	6.0%	0.6%
France	0.30	0.37	0.40	0.44	0.50	0.51	0.56	0.61	0.69	0.73	0.74	1.4%	9.4%	1.9%
Germany	1.24	1.40	1.45	1.58	1.83	1.82	2.08	2.16	2.31	2.44	2.28	-6.2%	6.3%	5.7%
Greece	0.05	0.06	0.08	0.08	0.09	0.10	0.10	0.11	0.12	0.14	0.16	9.8%	13.2%	0.4%
Hungary	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.06	0.07	0.08	20.3%	8.7%	0.2%
Iceland	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05	-2.9%	1.7%	0.1%
Ireland	0.05	0.05	0.05	0.06	0.07	0.07	0.09	0.10	0.11	0.13	0.11	-14.2%	7.9%	0.3%
Italy	0.44	0.58	0.66	0.68	0.70	0.72	0.74	0.72	0.73	0.74	0.76	3.7%	5.6%	1.9%
Latvia	†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.2%	16.0%	•
Lithuania	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	-7.6%	11.8%	0.1%
Luxembourg	†	†	†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	5.7%	15.1%	•
Netherlands	0.15	0.15	0.14	0.14	0.16	0.17	0.19	0.21	0.26	0.36	0.43	18.3%	11.1%	1.1%
North Macedonia	†	†	†	†	†	†	†	†	†	†	†	-7.6%	54.5%	•
Norway	0.02	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.08	0.11	0.13	16.3%	19.8%	0.3%
Poland	0.15	0.19	0.19	0.22	0.24	0.23	0.24	0.24	0.28	0.30	0.32	8.9%	8.1%	0.8%
Portugal	0.14	0.15	0.17	0.17	0.17	0.18	0.18	0.18	0.19	0.19	0.20	7.1%	3.5%	0.5%
Romania	0.02	0.04	0.06	0.07	0.10	0.10	0.11	0.09	0.10	0.11	0.10	-4.2%	15.6%	0.3%
Slovakia	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	15.1%	7.2%	0.1%
Slovenia	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.8%	7.8%	•
Spain	0.63	0.75	0.77	0.74	0.72	0.71	0.73	0.75	0.78	0.86	0.97	13.6%	4.4%	2.4%
Sweden	0.22	0.24	0.26	0.27	0.33	0.34	0.37	0.36	0.41	0.45	0.49	8.1%	8.5%	1.2%
Switzerland	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.05	0.05	0.06	0.06	4.6%	12.1%	0.1%
Turkey	0.06	0.08	0.11	0.12	0.17	0.24	0.29	0.38	0.43	0.50	0.61	22.0%	26.4%	1.5%
Ukraine	†	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.06	0.09	0.11	16.7%	44.4%	0.3%
United Kingdom	0.36	0.42	0.55	0.66	0.84	0.84	0.99	1.12	1.22	1.35	1.24	-8.1%	13.2%	3.1%
Other Europe	†	†	†	†	†	†	0.01	0.01	0.02	0.02	0.03	14.2%	41.6%	0.1%
Total Europe	4.55	5.30	5.83	6.24	7.00	7.12	7.91	8.33	9.10	9.91	10.14	2.6%	8.3%	25.4%

Renewable energy

Renewables consumption*

Azerbaijan	-	-	†	†	†	†	†	†	†	†	†	†	-0.3%	-	•
Belarus	†	†	†	†	†	†	†	†	†	†	†	†	15.1%	13.4%	•
Kazakhstan	†	†	†	†	†	†	†	†	0.01	0.01	0.02	0.03	30.5%	168.1%	0.1%
Russian Federation	0.01	†	†	0.01	0.01	0.01	0.01	0.02	0.02	0.04	0.06	0.06	53.9%	27.3%	0.2%
Turkmenistan	†	†	†	†	†	†	†	†	†	†	†	†	-0.4%	30.6%	•
Uzbekistan	-	-	-	-	-	†	†	†	†	†	†	†	625.5%	-	•
Other CIS	†	†	†	†	†	†	†	†	†	†	†	†	34.7%	51.2%	•
Total CIS	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	0.04	0.07	0.10	0.10	41.4%	29.4%	0.3%
Iran	†	†	†	†	†	†	†	†	0.01	0.01	0.02	0.02	2.2%	21.9%	•
Iraq	-	-	-	-	-	-	-	-	†	†	†	†	-0.4%	-	•
Israel	†	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.04	0.06	0.06	28.7%	32.8%	0.1%
Kuwait	-	-	†	†	†	†	†	†	†	†	†	†	-0.4%	-	•
Oman	-	-	†	†	†	†	†	†	†	†	†	†	15.2%	-	•
Qatar	†	†	†	†	†	†	†	†	†	†	†	†	0.5%	-	•
Saudi Arabia	†	†	†	†	†	†	†	†	†	†	†	†	300.2%	64.6%	•
United Arab Emirates	†	†	†	†	†	†	0.01	0.01	0.01	0.04	0.04	0.05	12.6%	72.7%	0.1%
Other Middle East	†	†	†	†	†	†	0.01	0.01	0.02	0.03	0.04	0.04	6.8%	68.5%	0.1%
Total Middle East	0.01	0.01	0.01	0.02	0.02	0.04	0.05	0.07	0.12	0.15	0.18	0.18	18.0%	37.3%	0.4%
Algeria	†	†	†	†	†	†	†	0.01	0.01	0.01	0.01	0.01	-2.7%	42.8%	•
Egypt	0.02	0.02	0.02	0.01	0.02	0.03	0.03	0.03	0.06	0.09	0.10	0.10	7.9%	19.0%	0.2%
Morocco	0.01	0.01	0.01	0.02	0.02	0.03	0.03	0.05	0.06	0.06	0.07	0.07	13.2%	25.2%	0.2%
South Africa	0.01	0.01	0.01	0.03	0.06	0.08	0.11	0.13	0.14	0.15	0.16	0.16	4.9%	35.6%	0.4%
Eastern Africa	0.03	0.04	0.04	0.06	0.08	0.08	0.08	0.09	0.10	0.10	0.11	0.11	7.6%	12.5%	0.3%
Middle Africa	†	†	†	†	†	†	†	†	†	†	†	†	-0.1%	3.4%	•
Western Africa	†	†	†	†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	23.5%	21.1%	•
Other Northern Africa	†	†	†	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	-4.8%	19.3%	•
Other Southern Africa	†	†	†	†	†	†	†	†	†	†	†	†	4.5%	6.3%	•
Total Africa	0.07	0.08	0.09	0.13	0.19	0.23	0.27	0.32	0.39	0.44	0.47	0.47	7.6%	20.5%	1.2%
Australia	0.12	0.15	0.18	0.20	0.23	0.25	0.26	0.32	0.40	0.48	0.59	0.59	22.4%	16.8%	1.5%
Bangladesh	†	†	†	†	†	†	†	†	†	†	†	†	15.1%	20.6%	•
China	1.16	1.49	1.99	2.45	2.90	3.78	5.06	6.37	7.38	8.52	11.32	11.32	33.1%	25.6%	28.4%
China Hong Kong SAR	†	†	†	†	†	†	†	†	†	†	†	†	13.7%	3.6%	•
India	0.49	0.56	0.63	0.71	0.78	0.88	1.05	1.31	1.48	1.58	1.79	1.79	13.2%	13.9%	4.5%
Indonesia	0.11	0.12	0.13	0.16	0.13	0.21	0.21	0.40	0.49	0.57	0.63	0.63	11.2%	19.5%	1.6%
Japan	0.34	0.38	0.45	0.56	0.72	0.75	0.91	1.01	1.09	1.20	1.32	1.32	9.9%	14.3%	3.3%
Malaysia	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.04	0.05	0.05	0.06	0.06	22.8%	13.0%	0.2%
New Zealand	0.09	0.09	0.09	0.10	0.11	0.11	0.11	0.10	0.11	0.11	0.11	0.11	3.2%	2.4%	0.3%
Pakistan	†	†	†	0.01	0.01	0.02	0.04	0.05	0.05	0.04	0.05	0.05	23.2%	70.3%	0.1%
Philippines	0.11	0.11	0.11	0.12	0.13	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-4.0%	3.3%	0.4%
Singapore	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	17.2%	5.9%	•
South Korea	0.10	0.11	0.13	0.18	0.21	0.22	0.28	0.32	0.35	0.34	0.44	0.44	29.6%	16.1%	1.1%
Sri Lanka	†	†	†	†	†	†	0.01	0.01	0.01	0.01	0.02	0.02	24.9%	27.2%	•
Taiwan	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.07	0.08	0.10	0.12	0.12	16.3%	11.7%	0.3%
Thailand	0.08	0.10	0.13	0.16	0.18	0.21	0.24	0.28	0.32	0.31	0.32	0.32	3.2%	15.3%	0.8%
Vietnam	†	†	†	†	†	†	†	0.01	0.06	0.11	0.27	0.27	134.4%	73.1%	0.7%
Other Asia Pacific	†	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.03	17.8%	18.0%	0.1%
Total Asia Pacific	2.67	3.19	3.94	4.73	5.50	6.68	8.41	10.46	12.06	13.64	17.22	17.22	26.7%	20.5%	43.1%
Total World	12.14	13.82	15.81	17.63	19.95	22.09	25.36	28.53	31.74	34.80	39.91	39.91	15.0%	12.6%	100.0%
of which: OECD	8.89	10.01	11.13	12.06	13.43	14.32	15.83	16.82	18.16	19.63	21.11	21.11	7.9%	9.0%	52.9%
Non-OECD	3.25	3.81	4.68	5.57	6.52	7.77	9.53	11.72	13.57	15.17	18.80	18.80	24.2%	19.2%	47.1%
European Union	4.05	4.71	5.05	5.33	5.86	5.90	6.45	6.63	7.19	7.72	7.92	7.92	2.9%	6.9%	19.8%

*Based on gross generation and not accounting for cross-border electricity supply. "Input-equivalent" energy is the amount of fuel that would be required by thermal power stations to generate the reported electricity output.

†Less than 0.005.

*Less than 0.05%.

Notes: Growth rates are adjusted for leap years.

Annual changes and share of total are calculated using exajoules figures and incorporate adjustments for assumed changes in thermal efficiency.

Renewables: Renewable energy generation*

Terawatt-hours												Growth rate per annum			Share 2021
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2021	2011-21		
Canada	21.0	23.1	23.7	24.7	39.8	46.3	45.9	47.5	47.3	49.3	50.0	1.6%	9.1%	1.4%	
Mexico	9.1	10.5	11.6	13.8	16.6	18.2	19.9	23.9	31.5	36.2	39.7	10.0%	15.9%	1.1%	
US	201.9	228.3	266.2	296.8	315.8	367.4	417.7	451.6	483.7	547.7	624.5	14.3%	12.0%	17.1%	
Total North America	231.9	261.9	301.5	335.3	372.2	432.0	483.6	523.0	562.5	633.2	714.1	13.1%	11.9%	19.5%	
Argentina	1.4	1.9	2.1	2.1	2.1	1.7	2.0	3.1	7.4	13.0	17.2	32.8%	28.1%	0.5%	
Brazil	35.3	40.8	47.6	59.3	71.6	84.9	96.1	106.3	117.6	126.5	144.0	14.1%	15.1%	3.9%	
Chile	4.7	6.4	7.4	6.9	9.0	11.7	15.0	17.9	20.7	22.0	28.5	30.3%	19.9%	0.8%	
Colombia	1.4	1.5	1.4	1.8	1.9	2.0	2.0	2.2	2.6	3.0	3.2	6.1%	8.5%	0.1%	
Ecuador	0.3	0.3	0.4	0.5	0.5	0.6	0.5	0.5	0.7	0.6	0.5	-12.0%	6.2%	•	
Peru	0.7	0.7	1.2	1.7	1.7	1.8	1.8	2.8	2.9	3.2	3.3	2.9%	17.0%	0.1%	
Trinidad & Tobago	†	†	†	†	†	†	†	†	†	†	†	-	1.6%	•	
Venezuela	†	†	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	41.7%	•	
Central America	6.7	7.8	8.6	9.8	11.6	13.1	12.9	15.2	16.7	16.0	17.1	7.4%	9.9%	0.5%	
Other Caribbean	1.3	1.7	2.3	2.3	2.5	2.6	3.0	3.2	4.4	5.2	5.9	15.1%	16.8%	0.2%	
Other South America	1.5	1.7	1.9	3.1	5.0	6.1	7.1	8.2	8.4	9.5	9.4	-0.2%	20.2%	0.3%	
Total S. & Cent. America	53.3	62.8	72.9	87.6	106.1	124.5	140.6	159.6	181.6	199.1	229.3	15.5%	15.7%	6.3%	
Austria	6.7	7.5	8.5	9.2	10.4	11.1	12.8	12.4	13.8	13.4	13.3	-1.0%	7.1%	0.4%	
Belgium	8.2	10.1	11.4	11.9	14.1	13.9	15.5	16.9	19.2	23.1	22.4	-2.9%	10.6%	0.6%	
Bulgaria	1.0	2.1	2.8	2.8	3.1	3.2	3.3	4.2	4.6	4.7	4.6	-0.6%	16.3%	0.1%	
Croatia	0.3	0.4	0.7	0.9	1.1	1.5	1.8	2.1	2.5	2.9	3.3	16.3%	29.3%	0.1%	
Cyprus	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.6	0.8	28.1%	15.7%	•	
Czech Republic	5.2	6.0	6.5	7.3	7.6	7.4	7.7	7.8	8.0	8.0	8.0	0.1%	4.4%	0.2%	
Denmark	14.2	14.8	16.0	18.0	18.9	18.4	21.8	20.7	23.1	23.4	26.0	11.4%	6.3%	0.7%	
Estonia	1.2	1.4	1.2	1.3	1.5	1.5	1.8	1.9	2.1	2.7	3.1	13.5%	10.4%	0.1%	
Finland	11.7	11.6	12.7	12.8	13.7	14.5	16.7	18.8	19.4	19.7	22.1	12.4%	6.6%	0.6%	
France	19.6	25.5	28.6	31.5	37.5	39.1	44.0	49.5	57.1	63.3	62.8	-0.6%	12.3%	1.7%	
Germany	106.8	121.7	129.0	141.4	168.3	167.7	194.7	204.4	220.6	231.8	217.6	-5.9%	7.4%	5.9%	
Greece	4.1	5.7	8.0	7.7	8.8	9.4	9.8	10.4	12.1	14.2	15.8	11.6%	14.4%	0.4%	
Hungary	2.5	2.4	2.6	2.8	3.0	3.0	3.3	3.5	4.5	5.3	6.7	26.4%	10.4%	0.2%	
Iceland	4.7	5.2	5.3	5.2	5.0	5.1	5.2	6.0	6.0	6.0	5.8	-2.6%	2.1%	0.2%	
Ireland	4.7	4.5	5.0	5.7	7.1	6.8	8.2	9.5	10.9	12.6	10.7	-14.2%	8.6%	0.3%	
Italy	37.1	50.3	59.2	62.1	63.4	65.6	67.7	65.6	69.4	68.8	71.4	4.1%	6.8%	2.0%	
Latvia	0.2	0.4	0.6	0.8	0.9	1.0	1.1	1.1	1.1	1.0	1.0	-7.6%	17.6%	•	
Lithuania	0.6	0.8	1.0	1.1	1.3	1.6	1.9	1.8	2.1	2.3	2.0	-10.1%	12.4%	0.1%	
Luxembourg	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.6	0.7	0.9	1.0	7.7%	17.9%	•	
Netherlands	12.3	12.4	12.1	11.6	13.6	14.6	17.4	18.8	22.7	33.0	40.1	22.1%	12.6%	1.1%	
North Macedonia	†	†	†	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	-7.5%	65.6%	•	
Norway	1.6	1.9	2.3	2.5	2.8	2.4	3.1	4.1	5.9	10.3	12.2	18.9%	22.3%	0.3%	
Poland	10.8	14.8	14.6	17.7	20.7	20.7	21.6	19.6	23.5	25.3	27.8	10.1%	9.9%	0.8%	
Portugal	12.6	13.8	15.7	16.0	15.7	16.5	16.7	17.0	18.6	18.0	19.2	6.8%	4.3%	0.5%	
Romania	1.6	2.9	5.2	6.5	9.6	8.9	9.8	8.5	9.1	9.2	9.0	-2.3%	18.9%	0.2%	
Slovakia	1.2	1.4	1.5	2.0	2.2	2.3	2.2	2.2	2.3	2.3	2.7	16.6%	8.3%	0.1%	
Slovenia	0.3	0.4	0.5	0.5	0.5	0.6	0.6	0.5	0.6	0.7	0.6	-6.7%	6.7%	•	
Spain	55.6	66.4	74.2	71.1	68.9	68.2	69.5	69.8	73.8	83.2	95.8	15.4%	5.6%	2.6%	
Sweden	17.6	19.4	21.3	22.0	27.1	27.1	29.9	28.9	33.5	39.7	42.1	6.2%	9.1%	1.2%	
Switzerland	1.6	1.9	2.2	2.6	2.8	3.2	3.7	3.9	4.2	4.7	5.1	8.1%	12.1%	0.1%	
Turkey	5.8	7.4	9.8	12.0	16.5	23.8	29.9	38.8	44.6	51.5	62.7	22.0%	27.0%	1.7%	
Ukraine	0.3	0.8	1.3	1.7	1.7	1.6	1.9	2.6	5.4	9.4	11.0	17.6%	45.8%	0.3%	
United Kingdom	29.5	35.9	48.5	58.6	77.1	77.6	93.0	104.6	113.7	127.8	116.9	-8.4%	14.7%	3.2%	
Other Europe	0.1	0.1	0.1	0.2	0.3	0.4	0.7	1.0	2.2	2.4	2.8	14.6%	43.6%	0.1%	
Total Europe	380.0	450.3	509.0	548.4	626.1	639.5	718.3	758.4	837.8	922.7	946.5	2.9%	9.6%	25.9%	
Azerbaijan	-	-	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2%	-	•	
Belarus	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.5	0.6	0.7	18.6%	22.2%	•	
Kazakhstan	†	†	†	†	0.2	0.4	0.4	0.5	1.1	2.3	3.0	31.0%	169.5%	0.1%	
Russian Federation	0.6	0.5	0.5	0.8	1.0	1.1	1.2	1.4	1.8	3.5	5.4	54.6%	25.4%	0.1%	
Turkmenistan	†	†	†	†	†	†	†	†	†	†	†	-	31.3%	•	
Uzbekistan	-	-	-	-	-	†	†	†	†	†	†	628.2%	-	•	
Other CIS	†	†	†	†	†	†	†	0.1	0.1	0.1	0.2	36.6%	51.5%	•	
Total CIS	0.7	0.6	0.7	1.0	1.4	1.8	2.1	2.5	3.8	6.8	9.6	41.6%	30.6%	0.3%	

Renewables: Renewable energy generation*

Iran	0.2	0.3	0.2	0.2	0.2	0.2	0.4	1.0	1.2	1.8	1.8	2.6%	22.7%	•
Iraq	-	-	†	0.1	0.1	0.1	0.1	0.4	0.4	0.4	0.4	-	-	•
Israel	0.3	0.5	0.5	0.9	1.3	1.8	1.8	2.0	3.3	4.4	5.7	30.3%	35.5%	0.2%
Kuwait	-	-	†	†	†	†	0.1	0.1	0.1	0.1	0.1	-	-	•
Oman	-	-	†	†	†	†	†	†	†	0.3	0.4	15.6%	-	•
Qatar	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	0.6%	•
Saudi Arabia	†	†	†	†	†	†	0.1	0.2	0.2	0.2	0.8	301.7%	65.5%	•
United Arab Emirates	†	†	0.1	0.3	0.3	0.3	0.7	1.3	3.8	4.6	5.2	13.0%	73.6%	0.1%
Other Middle East	†	†	†	0.1	0.3	1.1	1.3	2.2	3.0	3.9	4.1	7.2%	70.3%	0.1%
Total Middle East	0.7	0.9	1.1	1.8	2.3	3.7	4.7	7.2	12.1	15.7	18.5	18.6%	39.4%	0.5%
Algeria	†	†	†	0.1	0.1	0.3	0.5	0.6	0.6	0.7	0.7	-2.4%	43.6%	•
Egypt	1.7	1.8	1.6	1.2	1.9	2.6	2.7	3.5	6.5	9.7	10.5	8.3%	19.6%	0.3%
Morocco	0.7	0.7	1.2	1.9	2.5	3.4	3.5	4.8	6.3	6.1	6.9	13.6%	25.9%	0.2%
South Africa	0.5	0.5	0.8	2.5	5.8	7.9	11.3	13.1	13.9	15.7	16.5	5.4%	41.1%	0.5%
Eastern Africa	3.2	3.5	4.1	5.5	7.6	7.9	8.1	8.9	10.6	10.3	11.1	8.1%	13.4%	0.3%
Middle Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1%	4.4%	•
Western Africa	0.2	0.3	0.4	0.4	0.6	0.8	0.8	1.0	1.3	1.5	1.9	24.7%	22.7%	0.1%
Other Northern Africa	0.1	0.2	0.4	0.5	0.5	0.6	0.6	0.6	0.8	0.8	0.7	-4.4%	20.0%	•
Other Southern Africa	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.5	0.5	0.6	5.1%	7.6%	•
Total Africa	6.8	7.6	8.8	12.4	19.3	23.8	27.9	33.0	40.5	45.4	49.0	8.1%	21.7%	1.3%
Australia	11.1	13.2	16.4	18.3	21.7	24.1	25.7	32.2	41.2	49.9	61.3	23.3%	18.7%	1.7%
Bangladesh	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.5	15.5%	21.3%	•
China	104.3	136.8	183.8	229.5	279.1	369.5	502.0	636.4	742.0	863.2	1152.5	33.9%	27.2%	31.5%
China Hong Kong SAR	†	†	†	†	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.0%	6.1%	•
India	41.9	49.5	55.9	63.0	69.9	79.8	99.1	123.9	141.1	152.0	171.9	13.3%	15.2%	4.7%
Indonesia	9.6	9.7	9.6	10.3	10.5	11.3	13.4	26.7	26.9	28.6	31.5	10.5%	12.6%	0.9%
Japan	31.0	34.2	41.2	52.2	68.2	72.3	87.5	98.7	106.7	117.8	130.3	10.9%	15.4%	3.6%
Malaysia	1.5	1.5	1.2	0.9	1.0	1.1	1.1	2.0	2.6	2.8	3.1	12.3%	7.4%	0.1%
New Zealand	8.9	9.3	9.6	10.6	11.4	11.3	11.1	11.1	11.4	11.5	11.9	3.6%	2.9%	0.3%
Pakistan	†	0.1	0.3	0.6	1.1	2.2	3.8	4.9	4.8	4.6	5.7	24.0%	70.7%	0.2%
Philippines	10.1	10.5	9.9	10.7	12.3	13.9	13.6	13.9	14.0	14.4	13.5	-6.1%	2.9%	0.4%
Singapore	0.6	0.6	0.7	0.8	0.9	0.9	0.9	0.9	1.0	1.0	1.2	18.3%	6.6%	•
South Korea	7.6	8.6	10.2	14.7	17.3	18.9	24.1	27.2	30.5	31.1	40.2	29.8%	18.1%	1.1%
Sri Lanka	0.1	0.2	0.3	0.3	0.4	0.5	0.7	0.7	1.0	1.3	1.6	25.6%	28.1%	•
Taiwan	3.4	3.4	3.8	3.9	4.3	4.5	5.2	6.4	7.9	10.4	12.1	17.6%	13.6%	0.3%
Thailand	4.1	5.2	7.2	9.0	10.0	12.5	14.9	17.9	21.4	20.5	21.9	6.9%	18.3%	0.6%
Vietnam	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.7	6.1	12.1	28.3	135.5%	75.4%	0.8%
Other Asia Pacific	0.4	0.5	0.6	0.8	0.9	1.0	1.2	1.5	2.0	2.2	2.6	18.8%	19.4%	0.1%
Total Asia Pacific	235.0	283.6	351.1	426.0	509.7	624.4	805.1	1005.5	1160.9	1323.7	1690.1	28.0%	21.8%	46.2%
Total World	908.3	1067.8	1245.1	1412.5	1637.2	1849.6	2182.3	2489.2	2799.2	3146.6	3657.2	16.5%	14.9%	100.0%
of which: OECD	673.4	779.5	896.9	976.5	1112.8	1197.6	1351.0	1453.5	1592.3	1766.1	1910.1	8.4%	11.0%	52.2%
Non-OECD	234.9	288.3	358.2	436.0	524.3	652.0	831.3	1035.7	1206.9	1380.5	1747.2	26.9%	22.2%	47.8%
European Union	336.4	397.2	439.5	465.5	519.8	525.5	580.9	597.5	655.9	710.6	730.2	3.0%	8.1%	20.0%

*Renewable energy is based on gross generation from renewable sources including wind, geothermal, solar, biomass and waste, and not accounting for cross-border electricity supply.

†Less than 0.05.

•Less than 0.05%.

Notes: Growth rates are adjusted for leap years.

Annual changes and share of total are calculated using terawatt-hours.

Renewable energy: Generation by source*

Terawatt-hours	2020			2021 Growth rate	2021			2021 Total	2021 Growth rate			Total
	Wind	Solar	Other renewables†		Wind	Solar	Other renewables†		Wind	Solar	Other renewables†	
Canada	35.6	4.3	9.4	49.3	35.1	5.2	9.7	50.0	-1.2%	20.9%	3.6%	1.6%
Mexico	19.7	9.5	7.0	36.2	20.9	11.9	6.9	39.7	6.4%	26.3%	-1.6%	10.0%
US	341.4	132.0	74.3	547.7	383.6	165.4	75.5	624.5	12.7%	25.6%	1.9%	14.3%
Total North America	396.7	145.8	90.7	633.2	439.6	182.4	92.1	714.1	11.1%	25.5%	1.8%	13.1%
Argentina	9.4	1.3	2.3	13.0	12.9	2.2	2.1	17.2	37.9%	63.8%	-6.8%	32.8%
Brazil	57.1	10.7	58.7	126.5	72.3	16.8	55.0	144.0	27.1%	56.3%	-6.2%	14.1%
Chile	5.6	7.6	8.7	22.0	9.5	10.6	8.5	28.5	69.7%	39.5%	-3.0%	30.3%
Colombia	†	0.2	2.8	3.0	0.1	0.3	2.8	3.2	493.0%	66.8%	0.3%	6.1%
Ecuador	0.1	†	0.5	0.6	0.1	†	0.4	0.5	-19.4%	-2.1%	-11.6%	-12.0%
Peru	1.8	0.8	0.5	3.2	1.8	0.9	0.6	3.3	-0.4%	3.4%	13.7%	2.9%
Trinidad & Tobago	-	†	-	†	-	†	-	†	-	-	-	-
Venezuela	0.1	†	†	0.1	0.1	†	†	0.1	-	-	-	-
Central America	3.7	2.6	9.7	16.0	4.1	3.0	10.0	17.1	9.8%	17.3%	3.8%	7.4%
Other Caribbean	2.1	1.8	1.2	5.2	2.3	2.4	1.3	5.9	7.8%	31.6%	3.3%	15.1%
Other South America	5.5	0.8	3.1	9.5	5.1	1.0	3.3	9.4	-7.5%	26.1%	6.0%	-0.2%
Total S. & Cent. America	85.5	26.0	87.6	199.1	108.2	37.2	84.0	229.3	27.0%	43.5%	-3.9%	15.5%
Austria	6.8	2.0	4.6	13.4	6.8	2.1	4.4	13.3	-0.3%	4.3%	-4.3%	-1.0%
Belgium	12.8	5.1	5.3	23.1	11.9	5.6	4.9	22.4	-6.7%	10.1%	-6.5%	-2.9%
Bulgaria	1.5	1.5	1.7	4.7	1.4	1.5	1.7	4.6	-2.7%	0.9%	-	-0.6%
Croatia	1.7	0.1	1.1	2.9	2.1	0.1	1.2	3.3	20.5%	2.2%	10.9%	16.3%
Cyprus	0.2	0.3	0.1	0.6	0.2	0.5	†	0.8	2.8%	60.8%	-30.8%	28.1%
Czech Republic	0.7	2.2	5.1	8.0	0.6	2.2	5.3	8.0	-13.7%	-3.4%	3.5%	0.1%
Denmark	16.3	1.2	5.9	23.4	16.0	1.3	8.7	26.0	-1.6%	8.5%	47.8%	11.4%
Estonia	0.8	0.1	1.8	2.7	0.7	0.3	2.1	3.1	-11.8%	99.2%	19.4%	13.5%
Finland	8.0	0.2	11.5	19.7	8.2	0.3	13.6	22.1	2.7%	39.7%	18.7%	12.4%
France	39.7	12.9	10.7	63.3	37.0	14.6	11.2	62.8	-6.7%	13.3%	5.2%	-0.6%
Germany	132.1	48.6	51.1	231.8	117.7	49.0	50.9	217.6	-10.7%	1.0%	-0.1%	-5.9%
Greece	9.3	4.4	0.5	14.2	10.5	5.2	0.2	15.8	12.8%	16.5%	-60.8%	11.6%
Hungary	0.7	2.5	2.2	5.3	0.7	3.8	2.2	6.7	-0.3%	54.7%	2.4%	26.4%
Iceland	†	-	6.0	6.0	†	-	5.8	5.8	-8.4%	-	-2.6%	-2.6%
Ireland	11.5	0.1	0.9	12.6	9.7	0.1	1.0	10.7	-15.7%	•	3.6%	-14.2%
Italy	18.6	24.6	25.7	68.8	20.6	25.1	25.8	71.4	11.1%	2.4%	0.7%	4.1%
Latvia	0.2	†	0.9	1.0	0.1	†	0.8	1.0	-21.1%	•	-4.8%	-7.6%
Lithuania	1.6	0.1	0.6	2.3	1.4	0.1	0.6	2.0	-12.0%	-3.7%	-6.5%	-10.1%
Luxembourg	0.4	0.2	0.4	0.9	0.3	0.2	0.4	1.0	-3.2%	37.6%	5.1%	7.7%
Netherlands	15.3	8.8	8.8	33.0	17.9	11.4	10.8	40.1	17.0%	30.8%	22.4%	22.1%
North Macedonia	0.1	†	0.1	0.2	0.1	†	0.1	0.2	-11.3%	7.8%	-5.8%	-7.5%
Norway	9.9	0.1	0.3	10.3	11.8	0.2	0.3	12.2	19.1%	40.7%	-	18.9%
Poland	15.8	2.0	7.5	25.3	16.2	3.9	7.6	27.8	2.8%	102.2%	1.3%	10.1%
Portugal	12.3	1.7	4.0	18.0	13.2	2.2	3.7	19.2	7.8%	30.9%	-6.4%	6.8%
Romania	6.9	1.7	0.5	9.2	6.6	1.7	0.7	9.0	-5.1%	-1.6%	30.0%	-2.3%
Slovakia	†	0.7	1.7	2.3	†	0.7	2.0	2.7	•	1.6%	22.6%	16.6%
Slovenia	†	0.4	0.3	0.7	†	0.3	0.3	0.6	-11.2%	-17.7%	7.9%	-6.7%
Spain	56.4	20.7	6.1	83.2	62.4	26.8	6.6	95.8	10.8%	30.1%	8.1%	15.4%
Sweden	27.5	1.0	11.2	39.7	27.3	1.4	13.3	42.1	-0.5%	40.4%	19.6%	6.2%
Switzerland	0.1	2.6	2.0	4.7	0.1	3.0	1.9	5.1	-	16.0%	-1.8%	8.1%
Turkey	24.8	11.0	15.8	51.5	31.1	12.8	18.7	62.7	25.8%	17.5%	19.1%	22.0%
Ukraine	3.3	5.4	0.8	9.4	3.9	6.3	0.8	11.0	19.9%	18.1%	3.3%	17.6%
United Kingdom	75.4	13.2	39.3	127.8	64.5	12.4	40.0	116.9	-14.2%	-5.6%	2.0%	-8.4%
Other Europe	1.8	0.4	0.3	2.4	2.0	0.4	0.3	2.8	12.5%	16.2%	26.9%	14.6%
Total Europe	512.7	175.7	234.4	922.7	503.0	195.6	247.9	946.5	-1.6%	11.6%	6.1%	2.9%
Azerbaijan	0.1	†	0.1	0.2	0.1	0.1	0.1	0.2	-4.6%	17.8%	-3.4%	0.2%
Belarus	0.2	0.2	0.3	0.6	0.2	0.3	0.3	0.7	-	68.1%	-	18.6%
Kazakhstan	1.0	1.2	†	2.3	1.7	1.3	†	3.0	63.1%	4.7%	-29.8%	31.0%
Russian Federation	1.1	1.9	0.5	3.5	2.6	2.3	0.5	5.4	127.8%	24.5%	1.3%	54.6%
Turkmenistan	-	†	-	†	-	†	-	†	-	-	-	-
Uzbekistan	-	†	-	†	†	†	-	†	-	624.6%	-	628.2%
Other CIS	0.1	0.1	†	0.1	0.1	0.1	†	0.2	35.4%	54.2%	-3.8%	36.6%
Total CIS	2.5	3.4	0.9	6.8	4.6	4.1	0.9	9.6	84.7%	21.1%	*	41.6%

Renewable energy: Generation by source*

Iran	1.1	0.6	†	1.8	1.1	0.7	†	1.8	0.7%	6.1%	-	2.6%
Iraq	-	0.4	-	0.4	-	0.4	-	0.4	-	-	-	-
Israel	-	4.2	0.2	4.4	-	5.4	0.2	5.7	-	30.7%	22.3%	30.3%
Kuwait	†	0.1	-	0.1	†	0.1	-	0.1	-	-	-	-
Oman	0.1	0.2	-	0.3	0.1	0.3	-	0.4	-	23.3%	-	15.6%
Qatar	-	†	0.1	0.1	-	†	0.1	0.1	-	-	-	-
Saudi Arabia	-	0.2	-	0.2	-	0.8	-	0.8	-	301.7%	-	301.7%
United Arab Emirates	-	4.6	†	4.6	-	5.1	†	5.2	-	13.0%	-	13.0%
Other Middle East	1.4	2.4	†	3.9	1.7	2.4	†	4.1	19.9%	0.1%	-	7.2%
Total Middle East	2.6	12.7	0.4	15.7	2.9	15.2	0.4	18.5	10.8%	20.4%	12.2%	18.6%
Algeria	†	0.7	-	0.7	†	0.7	-	0.7	36.7%	-2.8%	-	-2.4%
Egypt	6.8	2.8	-	9.7	7.6	2.8	-	10.5	11.7%	-	-	8.3%
Morocco	4.6	1.5	-	6.1	5.1	1.8	-	6.9	11.5%	20.1%	-	13.6%
South Africa	7.0	8.3	0.4	15.7	8.2	7.9	0.4	16.5	17.5%	-4.5%	-	5.4%
Eastern Africa	2.0	1.2	7.1	10.3	2.6	1.4	7.1	11.1	33.5%	16.1%	-0.3%	8.1%
Middle Africa	†	0.1	0.1	0.1	†	0.1	0.1	0.1	-	0.2%	-	0.1%
Western Africa	0.4	0.8	0.2	1.5	0.4	1.2	0.2	1.9	-0.1%	44.4%	0.2%	24.7%
Other Northern Africa	0.5	0.3	-	0.8	0.4	0.3	-	0.7	-7.7%	0.6%	-	-4.4%
Other Southern Africa	-	0.4	0.2	0.5	-	0.4	0.2	0.6	-	7.8%	-	5.1%
Total Africa	21.3	16.1	8.1	45.4	24.4	16.5	8.0	49.0	14.9%	3.1%	-0.2%	8.1%
Australia	22.6	23.8	3.4	49.9	26.8	31.2	3.3	61.3	18.9%	31.2%	-1.7%	23.3%
Bangladesh	†	0.4	†	0.4	†	0.5	†	0.5	-	15.9%	-	15.5%
China	466.5	261.1	135.6	863.2	655.6	327.0	169.9	1152.5	40.9%	25.6%	25.6%	33.9%
China Hong Kong SAR	†	†	0.1	0.1	†	†	0.1	0.1	2.8%	2.8%	1.9%	2.0%
India	60.4	58.7	32.9	152.0	68.1	68.3	35.5	171.9	13.0%	16.7%	8.0%	13.3%
Indonesia	0.5	0.2	27.9	28.6	0.4	0.2	30.9	31.5	-7.7%	13.0%	10.8%	10.5%
Japan	7.8	75.1	34.8	117.8	8.2	86.3	35.8	130.3	5.8%	15.1%	3.0%	10.9%
Malaysia	-	1.2	1.6	2.8	-	1.5	1.6	3.1	-	28.6%	0.6%	12.3%
New Zealand	2.3	0.2	9.0	11.5	2.6	0.2	9.0	11.9	14.9%	28.2%	0.2%	3.6%
Pakistan	2.7	1.2	0.6	4.6	3.4	1.5	0.7	5.7	26.0%	26.3%	11.0%	24.0%
Philippines	1.0	1.4	12.0	14.4	1.2	1.5	10.8	13.5	21.6%	6.7%	-9.9%	-6.1%
Singapore	-	0.3	0.7	1.0	-	0.4	0.8	1.2	-	34.8%	11.2%	18.3%
South Korea	3.1	19.3	8.6	31.1	3.2	21.8	15.2	40.2	0.8%	13.4%	77.2%	29.8%
Sri Lanka	0.5	0.7	0.1	1.3	0.7	0.8	0.1	1.6	41.1%	17.1%	9.2%	25.6%
Taiwan	2.3	6.1	2.0	10.4	2.2	7.9	2.0	12.1	-2.6%	30.7%	0.7%	17.6%
Thailand	3.7	5.2	11.7	20.5	3.7	5.2	13.0	21.9	-	1.9%	11.3%	6.9%
Vietnam	1.1	10.9	0.1	12.1	2.4	25.8	0.2	28.3	123.3%	137.9%	25.6%	135.5%
Other Asia Pacific	0.5	1.1	0.6	2.2	0.5	1.5	0.6	2.6	-1.2%	34.9%	6.1%	18.8%
Total Asia Pacific	575.1	466.7	281.9	1323.7	779.2	581.5	329.4	1690.1	35.9%	24.9%	17.2%	28.0%
Total World	1596.4	846.2	703.9	3146.6	1861.9	1032.5	762.8	3657.2	17.0%	22.3%	8.7%	16.5%
of which: OECD	935.4	442.5	388.2	1766.1	976.7	523.3	410.1	1910.1	4.7%	18.6%	5.9%	8.4%
Non-OECD	661.1	403.8	315.7	1380.5	885.2	509.2	352.7	1747.2	34.3%	26.5%	12.0%	26.9%
European Union	397.3	143.3	170.0	710.6	389.5	160.6	180.1	730.2	-1.7%	12.4%	6.2%	3.0%

*Based on gross generation and not accounting for cross-border electricity supply.

†Includes electricity generated from: geothermal, biomass and other sources of renewable energy (not already itemized).

†Less than 0.05.

*Less than 0.05%.

A more extensive time series of renewables by source is available at bp.com/statisticalreview.

Note: Growth rates are adjusted for leap years.

Renewable energy: Solar capacity

Installed photovoltaic (PV) power*												Growth rate per annum		
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2011-21	Share 2021	
Canada	0.6	0.8	1.2	1.8	2.5	2.7	2.9	3.1	3.3	3.3	3.6	8.9%	19.2%	0.4%
Mexico	†	0.1	0.1	0.2	0.3	0.6	1.1	2.5	4.4	5.1	7.0	36.8%	66.7%	0.8%
US	5.2	8.1	11.8	16.0	21.7	33.0	41.4	49.8	59.1	73.8	93.7	27.3%	33.6%	11.1%
Total North America	5.8	9.0	13.1	18.0	24.5	36.3	45.4	55.4	66.8	82.3	104.4	27.2%	33.4%	12.4%
Argentina	†	†	†	†	†	†	†	0.2	0.4	0.8	1.1	40.6%	96.4%	0.1%
Brazil	†	†	†	†	†	0.1	1.2	2.4	4.6	7.9	13.1	66.1%	115.3%	1.5%
Chile	-	†	†	0.2	0.6	1.1	1.8	2.1	2.7	3.2	4.4	36.4%	na	0.5%
Honduras	†	†	†	†	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.3%	60.7%	0.1%
Other S. & Cent. America	0.2	0.3	0.4	0.6	0.9	1.1	1.8	2.2	2.8	3.2	3.8	20.3%	36.0%	0.5%
Total S. & Cent. America	0.2	0.4	0.5	0.8	1.9	2.8	5.3	7.5	11.0	15.5	22.8	47.2%	61.6%	2.7%
Austria	0.2	0.3	0.6	0.8	0.9	1.1	1.3	1.5	1.7	2.0	2.7	32.1%	31.5%	0.3%
Belgium	2.0	2.6	2.9	3.0	3.1	3.3	3.6	4.0	4.6	5.6	6.6	18.4%	12.8%	0.8%
Bulgaria	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	8.4%	22.7%	0.1%
Czech Republic	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	0.1%	1.0%	0.3%
Denmark	†	0.4	0.6	0.6	0.8	0.9	0.9	1.0	1.1	1.3	1.5	18.4%	56.9%	0.2%
France	3.0	4.4	5.3	6.0	7.1	7.7	8.6	9.7	10.8	12.0	14.7	22.7%	17.2%	1.7%
Germany	25.9	34.1	36.7	37.9	39.2	40.7	42.3	45.2	48.9	53.7	58.5	9.1%	8.5%	6.9%
Greece	0.6	1.5	2.6	2.6	2.6	2.6	2.6	2.7	2.8	3.3	3.5	7.7%	19.2%	0.4%
Hungary	†	†	†	0.1	0.2	0.2	0.3	0.7	1.4	2.1	2.1	0.3%	87.3%	0.3%
Italy	13.1	16.8	18.2	18.6	18.9	19.3	19.7	20.1	20.9	21.7	22.7	5.1%	5.6%	2.7%
Netherlands	0.1	0.3	0.7	1.0	1.5	2.1	2.9	4.6	7.2	10.9	14.2	30.5%	57.8%	1.7%
Poland	†	†	†	†	0.1	0.2	0.3	0.6	1.5	4.0	6.3	58.6%	137.2%	0.7%
Portugal	0.2	0.2	0.3	0.4	0.4	0.5	0.6	0.7	0.9	1.1	1.8	64.2%	26.5%	0.2%
Romania	†	†	0.8	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4%	106.3%	0.2%
Slovakia	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.3%	0.8%	0.1%
Spain	4.3	4.6	4.7	4.7	4.7	4.7	4.7	4.8	8.8	10.3	13.6	33.1%	12.3%	1.6%
Sweden	†	†	†	0.1	0.1	0.2	0.2	0.4	0.7	1.1	1.6	42.9%	62.9%	0.2%
Switzerland	0.2	0.4	0.8	1.1	1.4	1.7	1.9	2.2	2.5	3.0	3.4	16.3%	31.5%	0.4%
Turkey	†	†	†	†	0.2	0.8	3.4	5.1	6.0	6.7	7.8	17.5%	102.6%	0.9%
Ukraine	0.2	0.4	0.7	0.8	0.8	1.0	1.2	2.0	5.9	7.3	8.1	10.3%	45.6%	1.0%
United Kingdom	1.0	1.8	2.9	5.5	9.6	11.9	12.8	13.1	13.3	13.5	13.7	2.0%	29.9%	1.6%
Other Europe	0.1	0.3	0.5	0.6	0.7	0.8	1.0	1.1	1.6	2.3	3.0	28.7%	35.9%	0.4%
Total Europe	53.6	71.7	81.9	88.8	97.5	104.6	113.3	124.2	146.0	167.0	191.1	14.7%	13.6%	22.7%
Russian Federation	†	†	†	†	0.1	0.1	0.2	0.5	1.3	1.4	1.7	16.7%	206.1%	0.2%
Other CIS	†	†	†	0.1	0.2	0.2	0.3	0.7	1.3	1.9	3.3	69.7%	109.5%	0.4%
Total CIS	†	†	†	0.1	0.2	0.3	0.5	1.2	2.6	3.3	4.9	47.1%	118.1%	0.6%
Israel	0.2	0.3	0.4	0.6	0.8	0.9	1.0	1.3	1.8	2.2	2.3	4.0%	28.4%	0.3%
Jordan	†	†	†	†	†	0.3	0.4	0.7	1.2	1.4	1.5	5.3%	185.0%	0.2%
United Arab Emirates	†	†	†	†	†	†	0.3	0.5	1.8	2.2	2.6	18.4%	70.2%	0.3%
Other Middle East	†	†	0.1	0.1	0.2	0.3	0.5	0.8	0.9	1.1	1.5	33.8%	73.8%	0.2%
Total Middle East	0.2	0.3	0.5	0.7	1.0	1.5	2.1	3.3	5.7	7.0	8.0	13.7%	44.0%	0.9%
Algeria	-	-	-	†	†	0.2	0.4	0.4	0.4	0.4	0.4	0.3%	na	0.1%
Egypt	†	†	†	†	†	†	0.2	0.7	1.6	1.7	1.7	0.3%	60.1%	0.2%
Morocco	†	†	†	†	†	†	†	0.2	0.2	0.2	0.2	21.1%	32.4%	0.0%
South Africa	†	†	0.3	1.1	1.3	2.0	3.1	4.4	4.4	5.5	5.7	4.5%	99.7%	0.7%
Other Africa	0.2	0.3	0.4	0.5	0.6	0.7	1.0	1.4	1.8	1.9	2.3	17.1%	25.6%	0.3%
Total Africa	0.3	0.3	0.7	1.6	1.9	3.0	4.7	7.2	8.4	9.7	10.3	6.5%	44.1%	1.2%
Australia	2.5	3.8	4.6	5.3	5.9	6.7	7.4	8.6	13.0	17.3	19.1	10.3%	22.7%	2.3%
China	3.1	6.7	17.7	28.4	43.5	77.8	130.8	175.0	204.6	253.4	306.4	21.2%	58.3%	36.3%
India	0.6	1.0	1.4	3.4	5.4	9.7	17.9	27.1	34.9	39.0	49.3	26.7%	56.4%	5.9%
Japan	4.9	6.6	13.6	23.3	34.2	42.0	49.5	56.2	63.2	69.8	74.2	6.6%	31.2%	8.8%
Malaysia	†	†	0.1	0.2	0.3	0.3	0.4	0.5	0.9	1.5	1.8	20.8%	124.7%	0.2%
Pakistan	†	†	0.1	0.2	0.3	0.6	0.7	0.7	0.8	0.9	1.1	26.3%	50.1%	0.1%
Philippines	†	†	†	†	0.2	0.8	0.9	0.9	1.0	1.1	1.4	29.8%	91.9%	0.2%
South Korea	0.7	1.0	1.6	2.5	3.6	4.5	5.8	8.1	12.0	14.6	18.2	24.9%	37.9%	2.2%
Taiwan	0.1	0.2	0.4	0.6	0.9	1.2	1.8	2.7	4.1	5.8	7.7	32.7%	50.4%	0.9%
Thailand	0.1	0.4	0.8	1.3	1.4	2.4	2.7	3.0	3.0	3.0	3.0	2.3%	44.1%	0.4%
Vietnam	†	†	†	†	†	†	†	0.1	5.0	16.7	16.7	0.3%	127.3%	2.0%
Other Asia Pacific	0.1	0.2	0.3	0.3	0.5	0.7	1.0	1.2	1.8	2.3	2.8	20.8%	37.3%	0.3%
Total Asia Pacific	12.1	20.0	40.6	65.6	96.2	146.8	218.8	294.2	344.1	425.3	501.6	18.3%	45.1%	59.5%
Total World	72.2	101.7	137.2	175.6	223.2	295.2	390.2	483.0	584.7	710.3	843.1	19.0%	27.9%	100.0%

*End of year.

†Less than 0.05.

Note: Growth rates are adjusted for leap years.

Source: IRENA (2022), Renewable Energy Statistics 2022, The International Renewable Energy Agency, Abu Dhabi.

Renewable energy: Wind capacity

Installed wind turbine capacity* Gigawatts												Growth rate per annum			Share 2021
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2021	2011-21		
Canada	5.3	6.2	7.8	9.7	11.2	12.0	12.3	12.8	13.4	13.6	14.3	5.3%	10.5%	1.7%	
Mexico	0.6	1.8	2.1	2.6	3.3	4.1	4.2	4.9	6.1	6.5	7.7	18.6%	29.0%	0.9%	
US	45.7	59.1	60.0	64.2	72.6	81.3	87.6	94.5	104.1	118.7	132.7	12.1%	11.3%	16.1%	
Total North America	51.5	67.1	69.9	76.5	87.1	97.3	104.0	112.2	123.5	139.9	154.7	11.7%	11.6%	18.8%	
Argentina	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.8	1.6	2.6	3.3	25.8%	49.4%	0.4%	
Brazil	1.4	1.9	2.2	4.9	7.6	10.1	12.3	14.8	15.4	17.2	21.2	23.4%	31.0%	2.6%	
Chile	0.2	0.2	0.3	0.7	0.9	1.0	1.3	1.5	1.6	2.1	3.1	46.4%	32.8%	0.4%	
Costa Rica	0.1	0.1	0.1	0.2	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.3%	11.9%	0.0%	
Uruguay	†	0.1	0.1	0.5	0.9	1.2	1.5	1.5	1.5	1.5	1.5	0.3%	42.6%	0.2%	
Other S. & Cent. America	0.4	0.6	0.8	1.0	1.4	1.6	1.6	1.8	2.0	2.1	2.3	6.6%	20.5%	0.3%	
Total S. & Cent. America	2.2	3.1	3.7	7.5	11.2	14.5	17.3	20.8	22.6	26.0	31.8	22.5%	30.6%	3.8%	
Austria	1.1	1.3	1.7	2.1	2.5	2.7	2.9	3.1	3.2	3.2	3.5	9.5%	12.3%	0.4%	
Belgium	1.1	1.4	1.8	1.9	2.2	2.4	2.8	3.3	3.9	4.7	4.8	2.4%	16.2%	0.6%	
Bulgaria	0.5	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6%	2.7%	0.1%	
Denmark	4.0	4.2	4.8	4.9	5.1	5.2	5.5	6.1	6.1	6.3	7.0	12.4%	5.9%	0.9%	
Finland	0.2	0.3	0.4	0.6	1.0	1.6	2.0	2.0	2.3	2.6	3.3	26.3%	32.3%	0.4%	
France	6.8	7.6	8.2	9.2	10.3	11.6	13.5	14.9	16.5	17.5	18.7	7.1%	10.7%	2.3%	
Germany	28.7	31.0	33.5	38.6	44.6	49.4	55.6	58.7	60.7	62.2	63.8	2.8%	8.3%	7.7%	
Greece	1.6	1.8	1.8	2.0	2.1	2.4	2.6	2.9	3.6	4.1	4.5	8.5%	10.5%	0.5%	
Ireland	1.6	1.7	1.9	2.3	2.5	2.8	3.3	3.7	4.1	4.3	4.3	0.9%	10.6%	0.5%	
Italy	6.9	8.1	8.5	8.7	9.1	9.4	9.7	10.2	10.7	10.9	11.3	4.0%	5.0%	1.4%	
Netherlands	2.3	2.4	2.7	2.9	3.4	4.3	4.2	4.4	4.5	6.6	7.8	18.2%	12.9%	0.9%	
Norway	0.5	0.7	0.8	0.9	0.9	0.9	1.2	1.7	2.9	4.0	4.7	15.7%	24.7%	0.6%	
Poland	1.8	2.6	3.4	3.8	4.9	5.7	5.8	5.8	6.3	6.3	7.0	10.8%	14.5%	0.8%	
Portugal	4.3	4.4	4.6	4.9	4.9	5.1	5.1	5.2	5.2	5.1	5.2	2.7%	2.1%	0.6%	
Romania	1.0	1.8	2.8	3.2	3.1	3.0	3.0	3.0	3.0	3.0	3.0	0.3%	11.8%	0.4%	
Spain	21.5	22.8	23.0	22.9	22.9	23.0	23.1	23.4	25.6	26.8	27.5	2.8%	2.5%	3.3%	
Sweden	2.8	3.6	4.2	5.1	5.8	6.4	6.8	7.3	8.7	10.0	12.1	21.4%	15.9%	1.5%	
Turkey	1.7	2.3	2.8	3.6	4.5	5.8	6.5	7.0	7.6	8.8	10.6	20.4%	19.9%	1.3%	
Ukraine	0.1	0.2	0.4	0.5	0.5	0.5	0.6	0.6	1.3	1.4	1.8	26.0%	28.3%	0.2%	
United Kingdom	6.6	9.0	11.3	13.1	14.3	16.1	19.6	21.8	24.1	24.5	27.1	11.1%	15.2%	3.3%	
Other Europe	1.3	1.6	1.7	1.9	2.2	2.4	2.5	2.8	3.0	3.2	3.6	12.6%	11.8%	0.5%	
Total Europe	96.4	109.4	120.9	133.8	147.5	161.4	176.9	188.6	203.5	216.3	232.1	7.7%	9.2%	28.2%	
Russian Federation	†	†	†	†	†	†	†	0.1	0.1	0.9	2.0	107.4%	69.5%	0.2%	
Other CIS	†	†	†	0.1	0.1	0.2	0.2	0.3	0.5	0.7	1.4	103.6%	79.0%	0.2%	
Total CIS	†	†	†	0.1	0.1	0.2	0.2	0.3	0.6	1.6	3.3	105.8%	72.7%	0.4%	
Iran	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.3	0.3	1.0%	12.2%	0.0%	
Jordan	†	†	†	†	0.1	0.2	0.2	0.3	0.4	0.5	0.6	20.3%	84.0%	0.1%	
Other Middle East	†	†	†	†	†	†	†	†	0.1	0.1	0.1	0.3%	29.6%	0.0%	
Total Middle East	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.8	0.9	1.0	11.7%	25.4%	0.1%	
Egypt	0.6	0.6	0.6	0.6	0.8	0.8	0.8	1.1	1.1	1.4	1.6	19.2%	11.4%	0.2%	
Morocco	0.3	0.3	0.5	0.8	0.8	0.9	1.0	1.2	1.2	1.4	1.4	2.4%	18.9%	0.2%	
South Africa	†	†	0.3	0.6	1.1	1.5	2.1	2.1	2.1	2.5	3.0	17.8%	76.3%	0.4%	
Tunisia	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3%	16.4%	0.0%	
Other Africa	0.1	0.1	0.2	0.2	0.4	0.5	0.5	0.8	0.8	0.9	1.1	13.1%	24.2%	0.1%	
Total Africa	1.0	1.1	1.7	2.4	3.3	3.8	4.6	5.5	5.5	6.5	7.3	13.4%	22.1%	0.9%	
Australia	2.1	2.6	3.2	3.8	4.2	4.3	4.8	5.4	6.3	8.6	9.0	4.3%	15.5%	1.1%	
China	46.4	61.6	76.7	96.8	131.0	148.5	164.4	184.7	209.6	282.1	329.0	16.9%	21.6%	39.9%	
India	16.2	17.3	18.4	22.5	25.1	28.7	32.8	35.3	37.5	38.6	40.1	4.2%	9.5%	4.9%	
Japan	2.4	2.6	2.6	2.8	2.8	3.2	3.5	3.5	4.0	4.4	4.5	2.6%	6.3%	0.5%	
New Zealand	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.9	17.3%	3.9%	0.1%	
Pakistan	†	0.1	0.1	0.2	0.3	0.6	0.8	1.2	1.2	1.2	1.3	8.3%	71.7%	0.2%	
Philippines	†	†	†	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3%	29.7%	0.1%	
South Korea	0.4	0.5	0.6	0.6	0.8	1.1	1.2	1.4	1.5	1.6	1.7	4.7%	14.9%	0.2%	
Taiwan	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.9	1.0	10.6%	7.1%	0.1%	
Thailand	†	0.1	0.2	0.2	0.2	0.5	0.6	1.1	1.5	1.5	1.5	0.3%	70.4%	0.2%	
Other Asia Pacific	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.7	0.9	1.1	4.7	344.1%	42.9%	0.6%	
Total Asia Pacific	68.8	86.0	103.4	128.8	166.7	189.2	210.5	235.2	264.4	341.3	394.2	15.8%	19.1%	47.8%	
Total World	220.1	266.9	299.8	349.3	416.2	466.9	514.2	563.5	621.3	731.8	824.9	13.0%	14.1%	100.0%	

Source: IRENA (2022), Renewable Energy Statistics 2022, The International Renewable Energy Agency, Abu Dhabi.

*End of year.
†Less than 0.05.

Notes: Capacity figures in this table include both onshore and offshore wind and are on an AC basis.
Growth rates are adjusted for leap years.

The European Power Sector in 2018

Up-to-date analysis on the electricity transition

ANALYSIS

Power production 2018, by fuel by country, TWh

Table 2

TWh	Lignite	Hard Coal	Other fossil	Gas	Nuclear	Hydro	Solar	Wind	Bio mass	Consumption	Imports	Production
EU28	300	324	131	614	829	344	127	382	198	3276	26	3249
Austria	0	2	4	9	0	37	2	6	5	72	9	64
Belgium	0	0	5	23	29	0	4	7	5	91	17	74
Bulgaria	19	1	0	2	16	5	1	1	0	38	-8	46
Cyprus	0	0	5	0	0	0	0	0	0	5	0	5
Czech	37	4	3	4	30	2	2	1	5	73	-14	87
Denmark	0	6	1	1	0	0	1	15	8	36	5	32
Estonia	0	0	10	0	0	0	0	1	1	10	-2	12
Finland	3	6	1	5	23	14	0	6	10	88	20	68
France	0	7	7	29	413	64	10	29	8	505	-63	568
Germany	146	83	26	84	76	17	46	112	52	595	-47	642
Greece	17	0	6	14	0	7	4	6	0	61	6	55
Hungary	5	0	0	7	16	0	0	1	2	46	14	32
Ireland	2	4	0	16	0	0	0	8	1	31	0	31
Italy	0	27	18	130	0	47	24	18	26	332	44	289
Latvia	0	0	0	3	0	2	0	0	1	8	1	7
Lithuania	0	0	1	0	0	0	0	1	1	13	10	3
Netherlands	0	34	6	55	2	0	3	9	5	121	6	114
Poland	49	80	5	11	0	2	0	13	8	175	6	169
Portugal	0	12	2	15	0	13	1	13	3	56	-3	59
Romania	16	0	1	10	11	18	2	6	0	62	-3	65
Slovakia	1	1	1	2	15	4	1	0	2	30	4	27
Slovenia	4	0	0	0	6	5	0	0	0	15	-1	16
Spain	0	38	19	57	57	33	13	52	6	284	10	274
Sweden	0	0	3	1	69	62	0	16	11	147	-17	164
United Kingdom	0	17	7	132	65	5	13	58	36	352	19	333
Luxembourg	0	0	0	0	0	0	0	0	0	7	6	1
Malta	0	0	1	0	0	0	0	0	0	2	2	1
Croatia	0	2	0	2	0	8	0	1	1	19	5	14

Own calculations

Electricity generation by fuel*

Terawatt-hours	2016								2017							
	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew-ables	Other†	Total	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew-ables	Other†	Total
US	26.0	1482.1	1346.2	848.1	263.8	367.4	14.4	4347.9	22.7	1368.7	1314.0	847.3	296.5	418.9	13.6	4281.8
Canada	4.3	68.4	65.8	96.4	387.1	42.3	0.4	664.6	4.3	73.4	76.1	96.7	396.9	45.6	0.5	693.4
Mexico	33.5	192.0	34.4	10.6	30.7	18.0	1.1	320.3	40.8	181.1	31.0	10.9	31.7	19.6	-	315.0
Total North America	63.8	1742.5	1446.4	955.0	681.6	427.7	15.8	5332.9	67.7	1623.2	1421.1	954.9	725.1	484.1	14.1	5290.2
Argentina	20.7	74.4	1.9	8.4	38.3	3.0	0.4	147.2	11.1	82.8	1.7	6.3	41.6	3.0	0.5	147.0
Brazil	14.9	56.5	26.1	15.9	380.9	84.6	-	578.9	17.2	65.4	25.2	15.8	369.5	97.9	-	590.9
Other S. & C. America	106.1	108.3	51.9	-	272.1	38.9	0.1	577.4	90.8	94.7	42.4	-	308.4	43.2	0.4	577.9
Total S. & C. America	141.7	239.2	80.0	24.3	691.3	126.4	0.6	1303.5	119.2	242.8	69.4	22.0	717.4	144.1	0.9	1315.8
Germany	5.8	81.3	261.7	84.6	20.5	169.1	26.0	649.1	5.7	86.0	242.2	75.9	19.7	198.1	26.6	654.2
Italy	12.1	126.1	38.4	-	42.4	65.6	5.0	289.8	9.0	144.6	32.8	-	36.3	68.4	4.5	295.4
Netherlands	1.3	52.6	36.7	4.0	0.1	14.6	5.9	115.2	1.1	56.4	31.4	5.3	0.1	17.5	4.8	116.6
Poland	2.3	7.8	132.9	-	2.1	20.7	0.8	166.6	1.9	9.8	134.1	-	2.6	21.2	0.8	170.3
Spain	16.8	52.8	37.4	58.6	36.4	68.2	4.4	274.6	17.7	63.1	45.1	58.1	18.5	69.5	3.5	275.4
Turkey	1.9	89.2	92.3	-	67.2	23.8	-	274.4	2.0	108.2	97.6	-	58.4	29.4	-	295.5
United Kingdom	1.8	143.4	30.7	71.7	5.4	77.8	8.5	339.4	2.2	133.3	22.6	70.3	5.9	92.9	8.6	335.9
Other Europe	21.5	150.4	230.8	643.8	471.5	197.6	33.0	1748.6	22.1	173.2	235.6	641.0	434.7	218.2	33.2	1758.0
Total Europe	63.6	703.7	861.0	862.7	645.7	637.4	83.7	3857.8	61.6	774.6	841.3	850.7	576.2	715.1	81.9	3901.3
Kazakhstan	2.1	20.0	60.6	-	11.6	0.4	-	94.6	2.0	25.1	64.3	-	11.2	0.4	-	103.0
Russian Federation	25.2	529.4	149.3	196.6	184.8	1.1	4.7	1091.0	15.8	529.9	153.3	203.1	183.3	1.2	4.7	1091.2
Ukraine	1.6	9.8	61.2	81.0	7.7	1.6	1.7	164.6	1.3	7.3	50.6	85.6	8.7	1.7	1.9	157.1
Other CIS	3.3	127.5	3.8	2.4	44.8	0.4	0.3	182.4	3.8	129.8	3.8	2.6	47.5	0.5	0.3	188.2
Total CIS	32.1	686.7	274.8	279.9	248.9	3.4	6.6	1532.6	22.9	692.0	272.1	291.3	250.6	3.8	6.8	1539.5
Iran	39.7	223.5	0.5	6.6	15.4	0.5	-	286.1	34.3	245.5	0.5	7.1	16.4	0.6	-	304.4
Saudi Arabia	156.6	213.7	-	-	-	0.1	-	370.4	154.3	221.1	-	-	-	0.1	-	375.6
United Arab Emirates	1.6	127.7	-	-	-	0.3	-	129.6	1.6	133.7	-	-	-	0.5	-	135.8
Other Middle East	130.6	215.8	24.4	-	4.7	3.4	†	379.0	126.1	238.5	22.3	-	3.6	4.7	†	395.2
Total Middle East	328.5	780.7	24.9	6.6	20.2	4.3	†	1165.1	316.3	838.8	22.7	7.1	20.0	6.0	†	1210.9
Egypt	34.8	137.5	-	-	13.3	2.6	-	188.2	27.2	149.9	-	-	13.4	2.7	-	193.2
South Africa	†	1.7	223.2	15.9	0.7	7.9	3.3	252.7	†	1.9	223.8	15.8	0.9	8.7	4.1	255.1
Other Africa	51.0	160.8	26.5	-	105.9	12.3	0.5	357.1	54.2	173.3	27.1	-	114.2	13.1	0.4	382.4
Total Africa	85.9	300.0	249.7	15.9	119.9	22.9	3.8	798.0	81.5	325.1	250.9	15.8	128.5	24.5	4.5	830.7
Australia	6.0	48.9	162.3	-	17.8	24.1	0.2	259.4	6.3	54.9	159.1	-	13.7	25.2	0.2	259.4
China	10.4	188.3	4163.6	213.3	1153.3	360.9	43.5	6133.2	14.9	196.2	4360.9	248.3	1155.8	47.4	0.3	6495.1
India	10.0	74.0	1090.4	37.9	128.4	80.7	0.1	1421.5	10.3	75.5	1141.4	37.4	135.6	96.4	0.3	1497.0
Indonesia	23.3	59.3	135.4	-	19.4	11.3	†	248.6	23.5	53.2	152.3	-	18.4	13.0	†	260.4
Japan	82.0	397.2	330.9	17.7	80.0	83.1	11.5	1002.3	54.8	401.5	342.5	29.1	79.2	98.9	14.1	1020.0
Malaysia	1.5	63.7	70.9	-	21.8	1.4	-	159.3	1.6	61.9	72.5	-	24.8	1.6	-	162.3
South Korea	17.7	123.1	235.6	162.0	2.8	13.9	5.8	561.0	12.4	120.8	264.4	148.4	3.0	16.0	6.7	571.7
Taiwan	10.9	85.6	120.0	31.7	6.6	4.4	4.9	264.1	12.1	93.8	126.4	22.4	5.4	5.2	4.9	270.3
Thailand	0.5	126.1	37.1	-	3.5	12.5	-	179.7	0.3	121.0	35.7	-	4.7	14.8	-	176.6
Vietnam	0.7	45.0	64.5	-	63.9	0.3	-	174.6	0.8	44.4	74.3	-	70.2	0.4	-	190.1
Other Asia Pacific	79.8	185.8	103.5	5.8	131.0	29.8	0.9	536.7	76.9	195.6	116.6	8.1	131.4	30.7	0.7	559.9
Total Asia Pacific	242.8	1397.0	6514.2	468.3	1628.5	622.4	66.9	10940.3	213.9	1418.7	6846.0	493.7	1642.2	773.9	74.4	11462.9
Total World	958.4	5849.7	9451.0	2612.8	4036.1	1844.6	177.5	24930.2	883.0	5915.3	9723.4	2635.6	4059.9	2151.5	182.6	25551.3
of which: OECD	226.6	3056.4	3007.2	1970.4	1406.8	1193.7	114.2	10975.2	196.1	3016.2	2992.0	1956.1	1391.1	1347.7	114.2	11013.2
Non-OECD	731.8	2793.3	6443.8	642.4	2629.2	651.0	63.3	13954.9	686.9	2899.1	6731.5	679.5	2668.8	803.9	68.4	14538.1
EU	59.3	607.2	719.4	839.9	350.0	602.5	76.2	3254.6	57.2	658.5	693.8	830.5	299.7	673.3	73.6	3286.6

9,9%

30,3%

23,2%

15%

25,2%

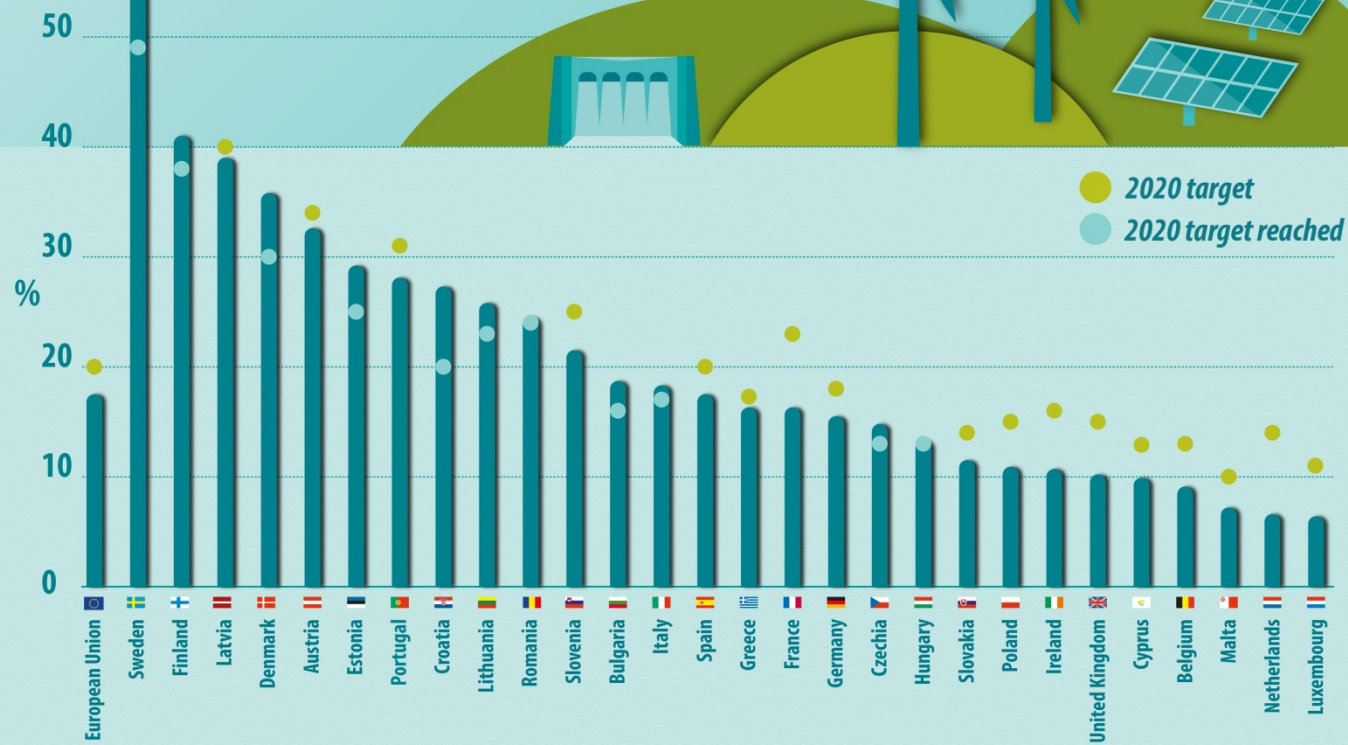
27,7%

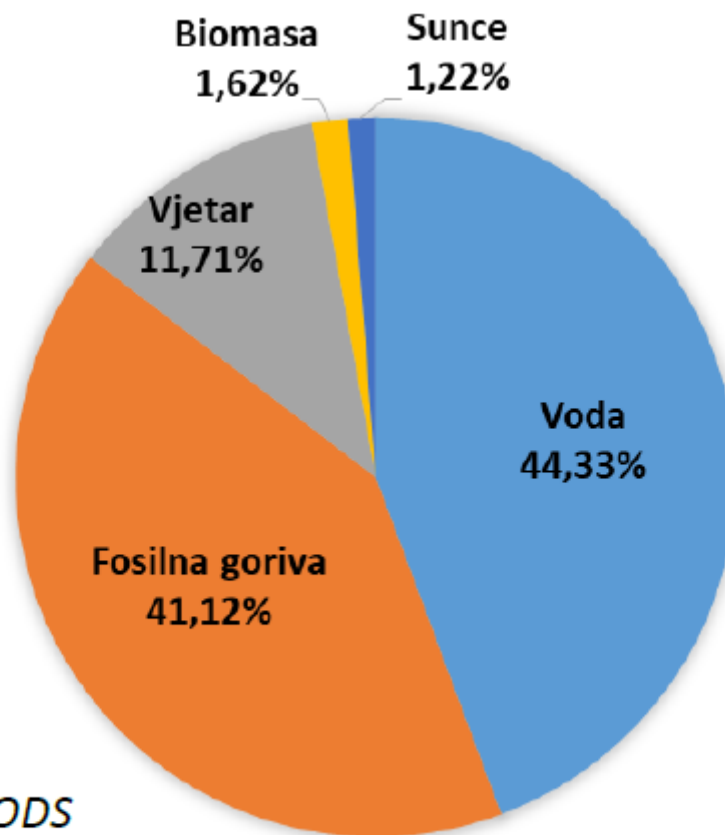
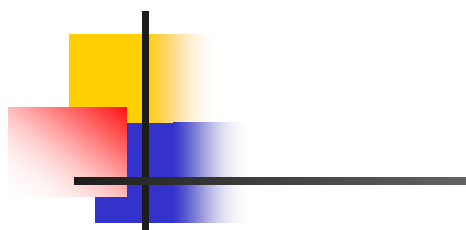
7,3%

Electricity generated in China (7,3% of total) 2,4 times bigger than in Germany (30,3% of total)

Share of energy from renewable sources in the EU Member States

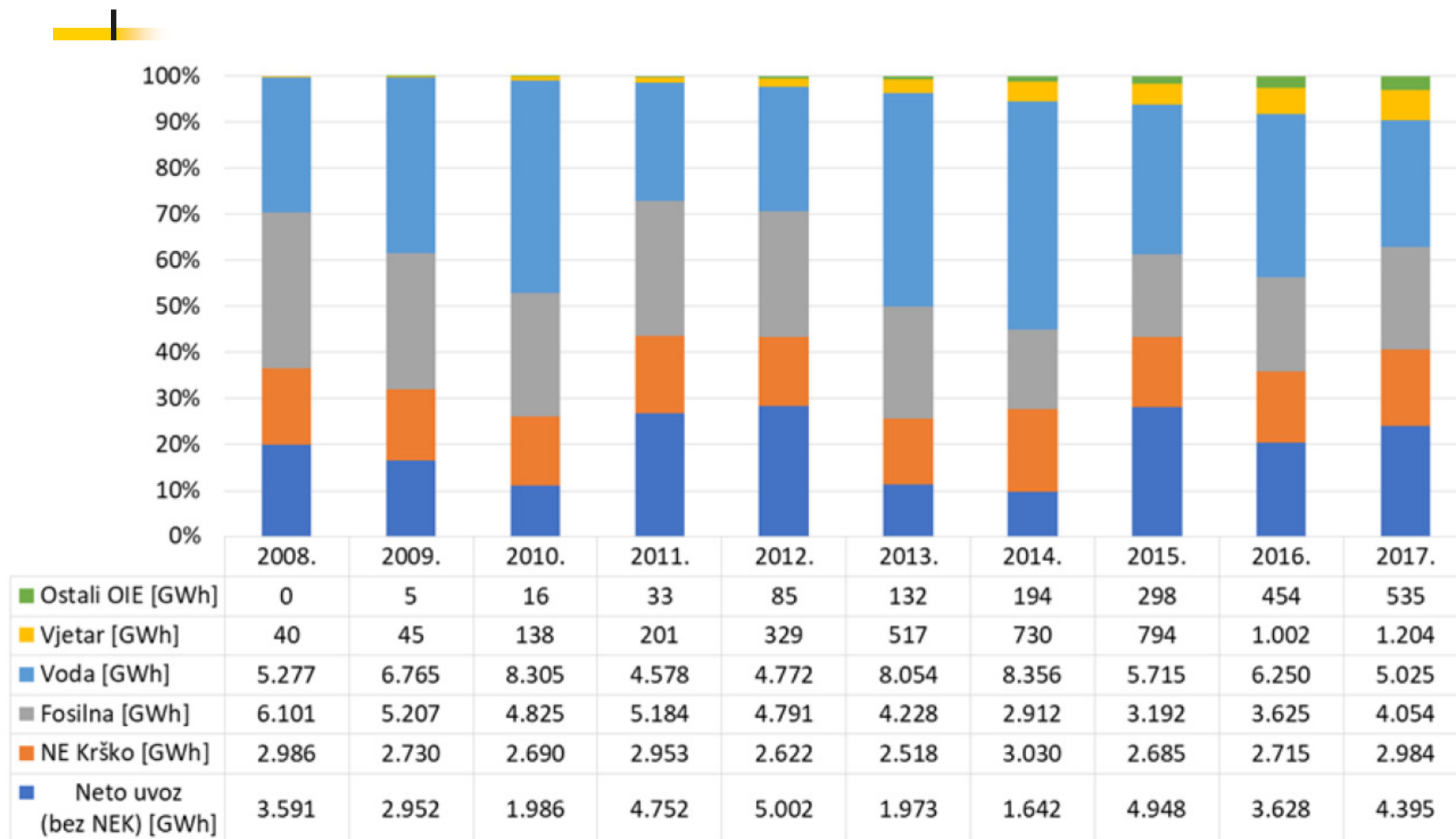
(2017, in % of gross final energy consumption)





Izvor: HOPS i HEP ODS

Udio pojedinih primarnih izvora energije u snazi elektrana na teritoriju Republike Hrvatske na kraju 2017. godine



Slika 4.5.4. Udio pojedinih izvora nabave električne energije za potrebe hrvatskog elektroenergetskog sustava od 2008. do 2017. godine



Koji su glavni oblici OIE?

- Sunčeva energija,
- energija vjetra,
- hidroenergija,
- biomasa, otpad i biogoriva,
- geotermalna energija,
- energija plime i oseke, morskih struja i valova,
- vodik i gorive ćelije.

Fotonaponske ćelije

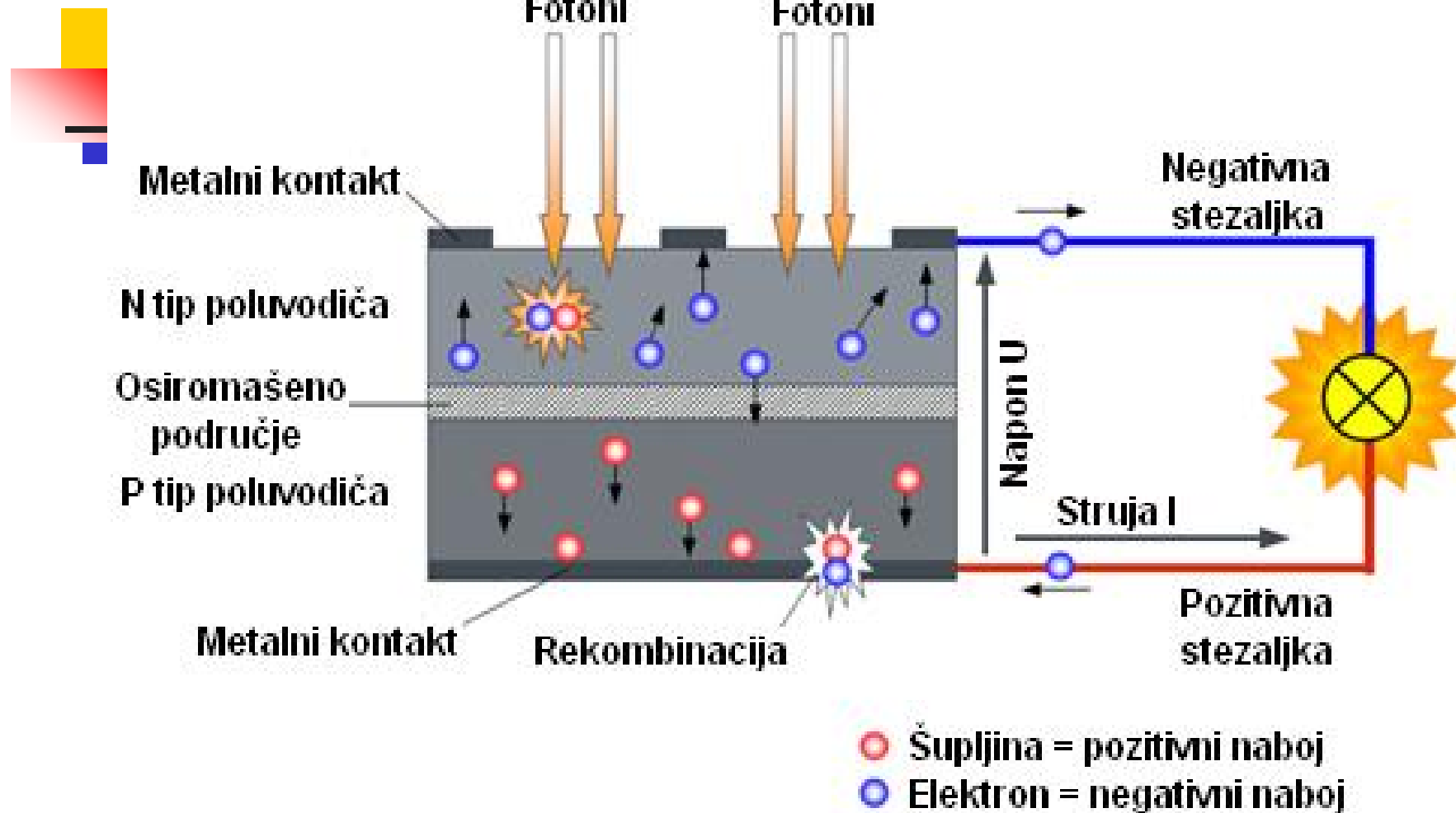
Tipovi FN ćelija od kristalnih poluvodiča su:

vrsta ćelije	iskorištenje η
monokristalna-Si ćelija	0,17
polikristalna-Si ćelija	0,15
amorfna-Si ćelija	0,09
CdS/Cu ₂ S	0,10
CdS/CdTe	0,12
GaAlAs/GaAs	0,24
GaAs	0,27



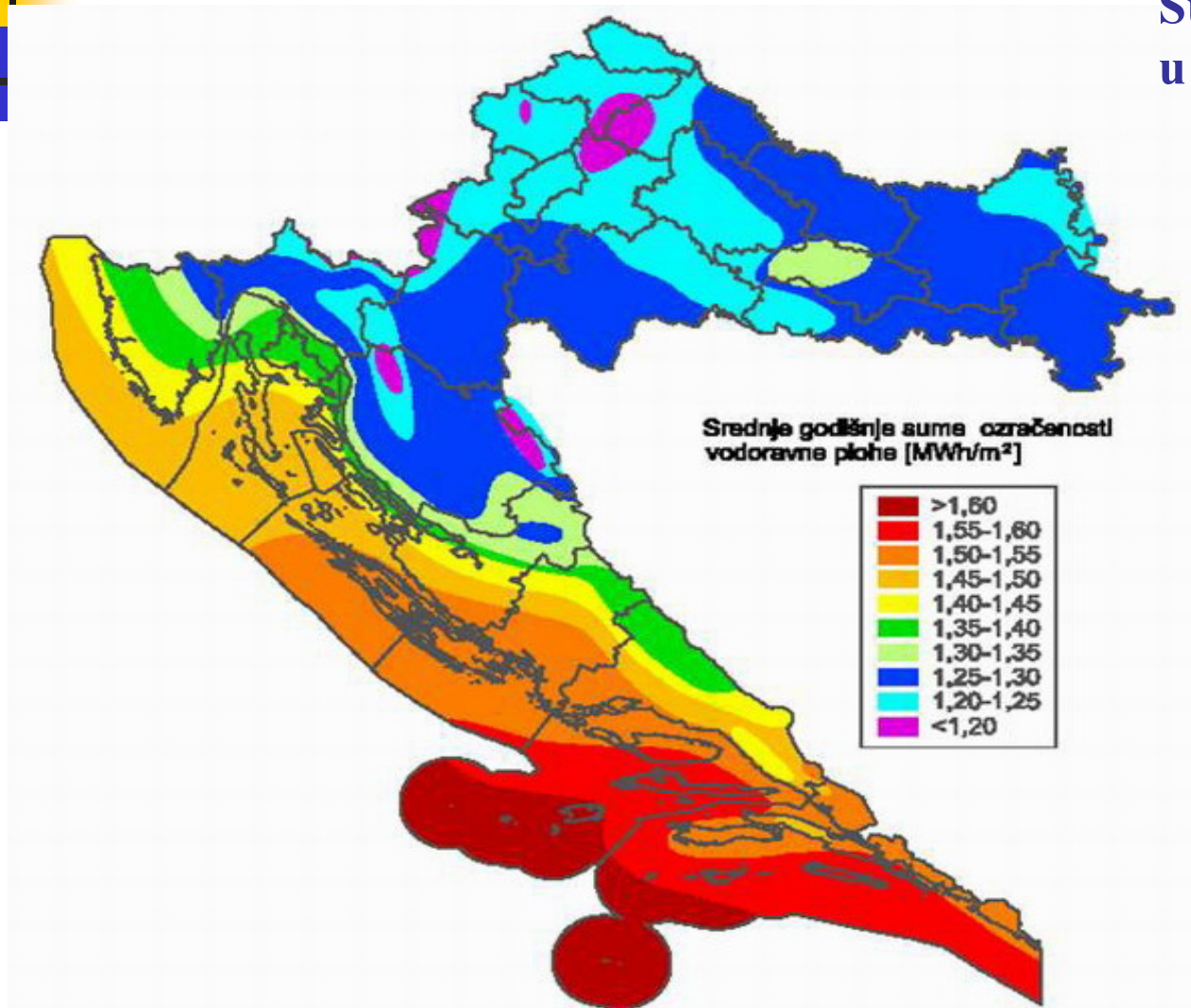
Fotonaponska solarna ćelija - uređaj u kojem se odvija direktna pretvorba energije sunčevog zračenja u električnu energiju

Princip rada fotonaponskih ćelija zasniva se na fotoelektričnom efektu



Solarna ćelija – solarni modul – solarni generator

Potencijal Sunčeva zračenja u Hrvatskoj





Iskorištavanja energije Sunca:

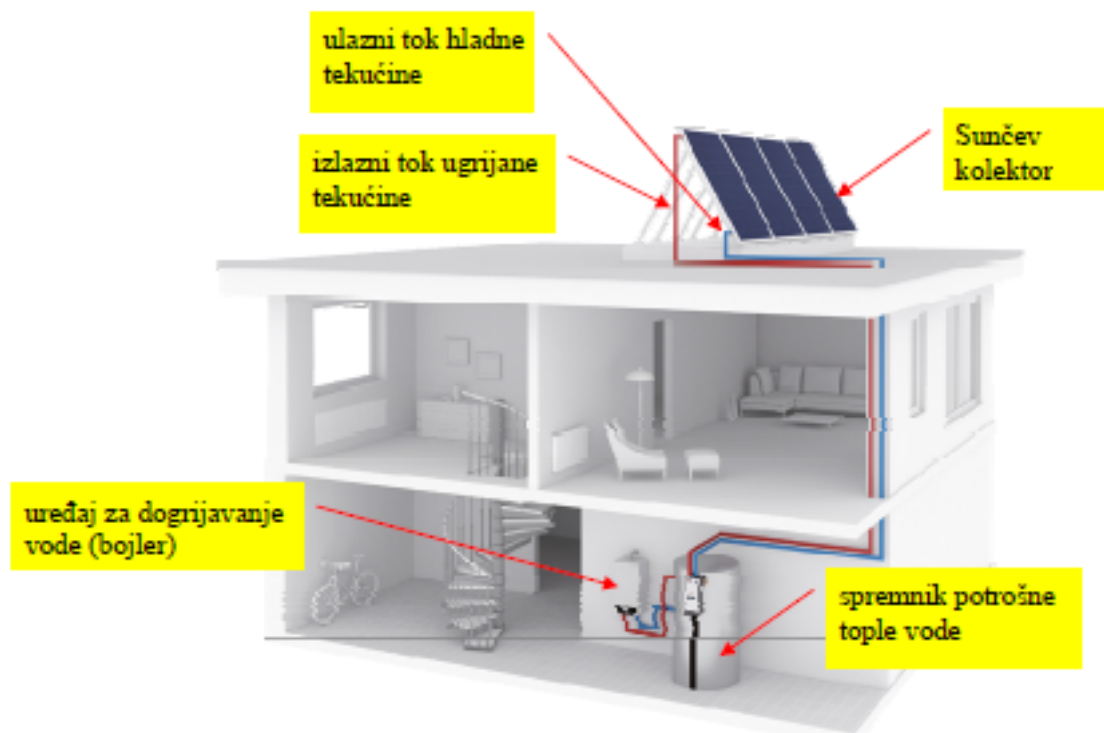
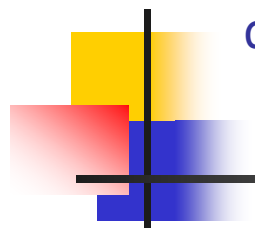
pasivno - podrazumijeva korištenje toplinskog dijela spektra za zagrijavanje prostora ili nekog drugog medija (npr. vode)

aktivno - sustavi koji se sastoje od sunčevog kolektora koji služi za skupljanje (apsorpciju) dozračene energije i odgovarajućeg sustava cijevi koje ugrijani medij odvođe do potrošača toplinske energije (potrošna topla voda i/ili grijanje). U ovakvim sustavima nužno je ugraditi i pumpu potrebnu za recirkulaciju radnog medija

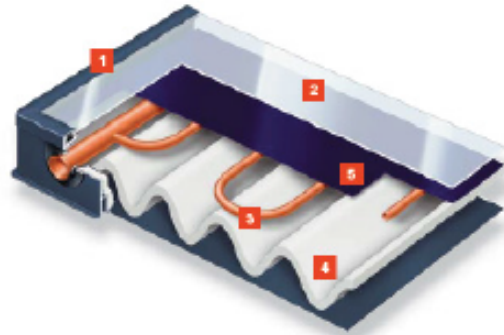
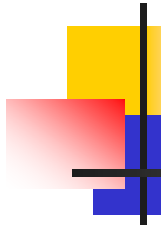
fotonaponske ćelije - direktna pretvorba Sunčeve energije u električnu energiju

fokusiranje Sunčeve energije - upotreba u velikim energetske postrojenjima

Aktivno iskorištavanje sunčeve energije za proizvodnju tople vode uz dogrijavanje

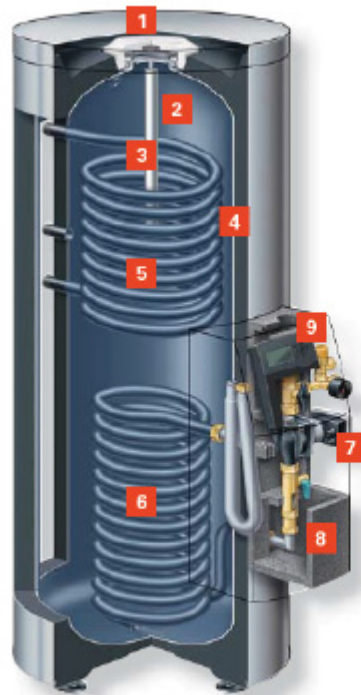


Slika 5. Tehničko rješenje za iskorištavanje Sunčevog zračenja uz pomoć kolektora (izvor: www.viessmann.hr)



1. Okvir i držač Sunčevog kolektora
2. Stakleni pokrov kolektora
3. Cijevna zavojnica koja apsorbira toplinu
4. Toplinska izolacija
5. Visokoapsorbirajući pokrovni lim koji apsorbira Sunčevo (toplinsko) zračenje

Slika 6. Presjek Sunčevog kolektora tipa Vitosol 200-FM (izvor: www.viessmann.hr)



1. Otvor za čišćenje i kontrolu
2. Spremnik
3. Anoda za antikorozijsku zaštitu
4. Toplinska izolacija
5. Izmjenjivač topline-cijevna zavojnica za dogrijavanje vode spojena uređaj za zagrijavanje vode (bojler)
6. Izmjenjivač topline-cijevna zavojnica za zagrijavanje vode spojena na Sunčev kolektor
7. Pumpa
8. , 9. Regulacijska oprema

Slika 7. Spremnik tople vode tipa Vitocell 100-B (izvor: www.viessmann.hr)



FN ćelije najčešće možemo vidjeti kao bazno napajanje izoliranih sustava (off-grid) kao što su, telekomunikacijski i radijski sistemi, svjetionici, cestovna signalizacija ili pak naplata parkirališta.

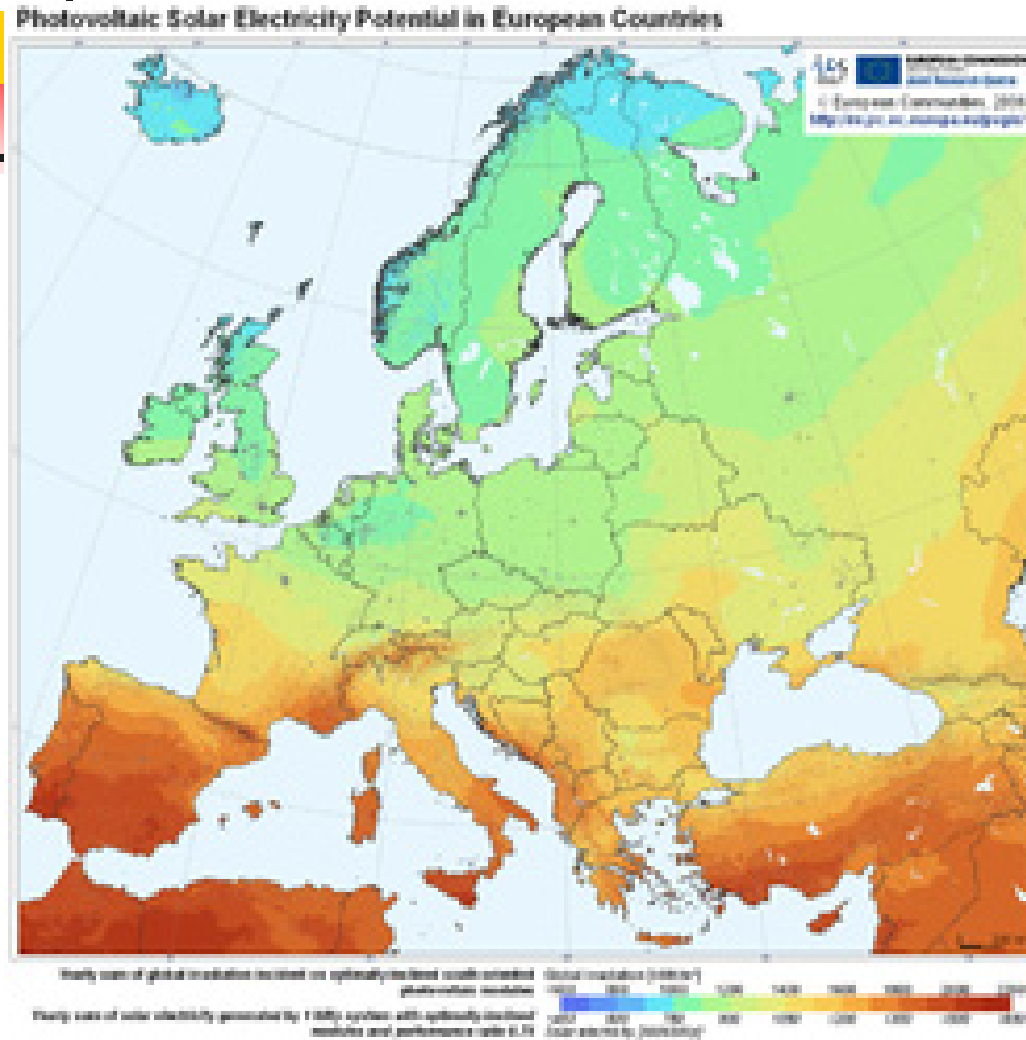
Koriste se i u dekorativne svrhe kao npr. u Zadru (instalaciji Pozdrav Suncu).



"...Kada bismo samo 3 posto teritorija Hrvatske prekrili Sunčevim pretvornicima u toplinsku i električnu energiju, dobili bismo oko osam puta više od današnje ukupne energetske potrošnje u Hrvatskoj."

Dr.sc. Natko Urli s Instituta "Ruđer Bošković"

Potencijal Sunčeva zračenja u Europi



Prva europska zemlja po iskorištenosti sunčeve energije u Europi je Njemačka.

SOLARNI PARK WALDPOLENZ

Snaga 35 MW

smanjenje
emisije od 25.000
tona CO₂
godišnje

20 do 40%
jeftinija energija

550,000 solarnih ploča

40 MW električne energije za oko 40,000 kuća

2000 m dužine

600 m širine

SOLARNI PARK GÖTTELBORN

8,4 MW

Smanjenje emisije od
6500 tona CO₂ godišnje

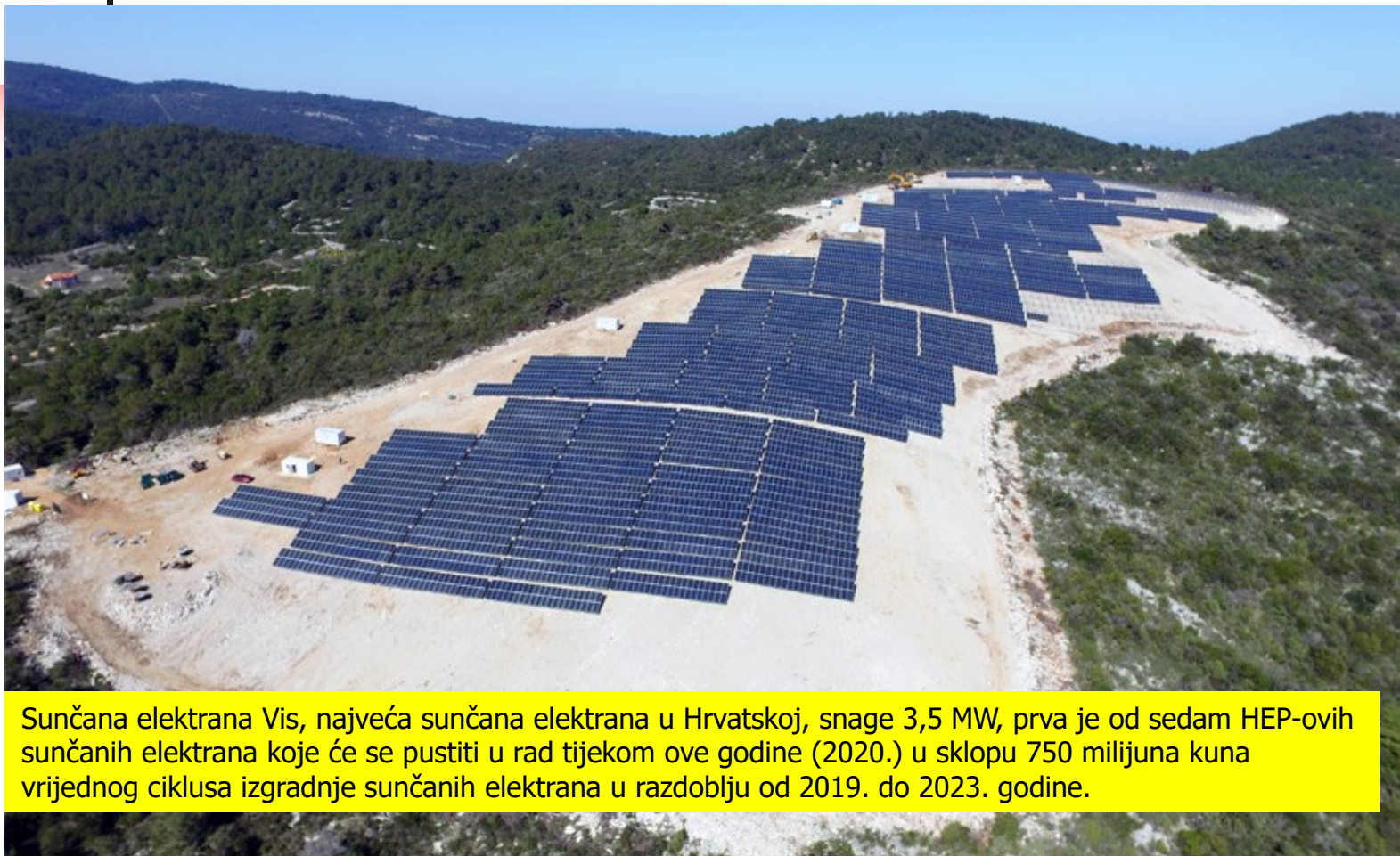
SOLARNI PARK MUEHLHAUSEN

6,3 MW

redukcija emisije 6200 tona CO₂ godišnje

57,600 solarnih ploča





Sunčana elektrana Vis, najveća sunčana elektrana u Hrvatskoj, snage 3,5 MW, prva je od sedam HEP-ovih sunčanih elektrana koje će se pustiti u rad tijekom ove godine (2020.) u sklopu 750 milijuna kuna vrijednog ciklusa izgradnje sunčanih elektrana u razdoblju od 2019. do 2023. godine.

HEP-ove investicije u sunčeve elektrane s planiranim ulaskom u pogon do kraja 2020.

SE	Vis	Cres	Marići	Kaštelir 2	Vrlika Jug	Obrovac	Stankovci
lokacija	Žena Glava, Otok Vis	Orlec, Cres	Žminj, Istra	Kaštelir Labinci, Istra	Radna zona Kosore, Vrlika	Bivša tv. Glinice, Obrovac	Poslovna zona Stankovci,
Snaga, MW	3,5	6,5	1	2	2,1	7,35	2,5
Proizvodnja GWh	5	8,5	1,2	2,9	2,9	11,3	4,6
Investicija mil. kn	31,3	41	9	15	11	52	26,3
kn/kW	8942*	6307	9000	5172	5238	7074	10520
Radni sati**	1428	1307	1200	1450	1380	1537	1840
Površina, ha	5,5	17	-	-	-	-	-
En. gustoća kW/m ²	0,064	0,0382	-	-	-	-	-

* ugrađen baterijski spremnik snage 1MW, kapaciteta 1MWh

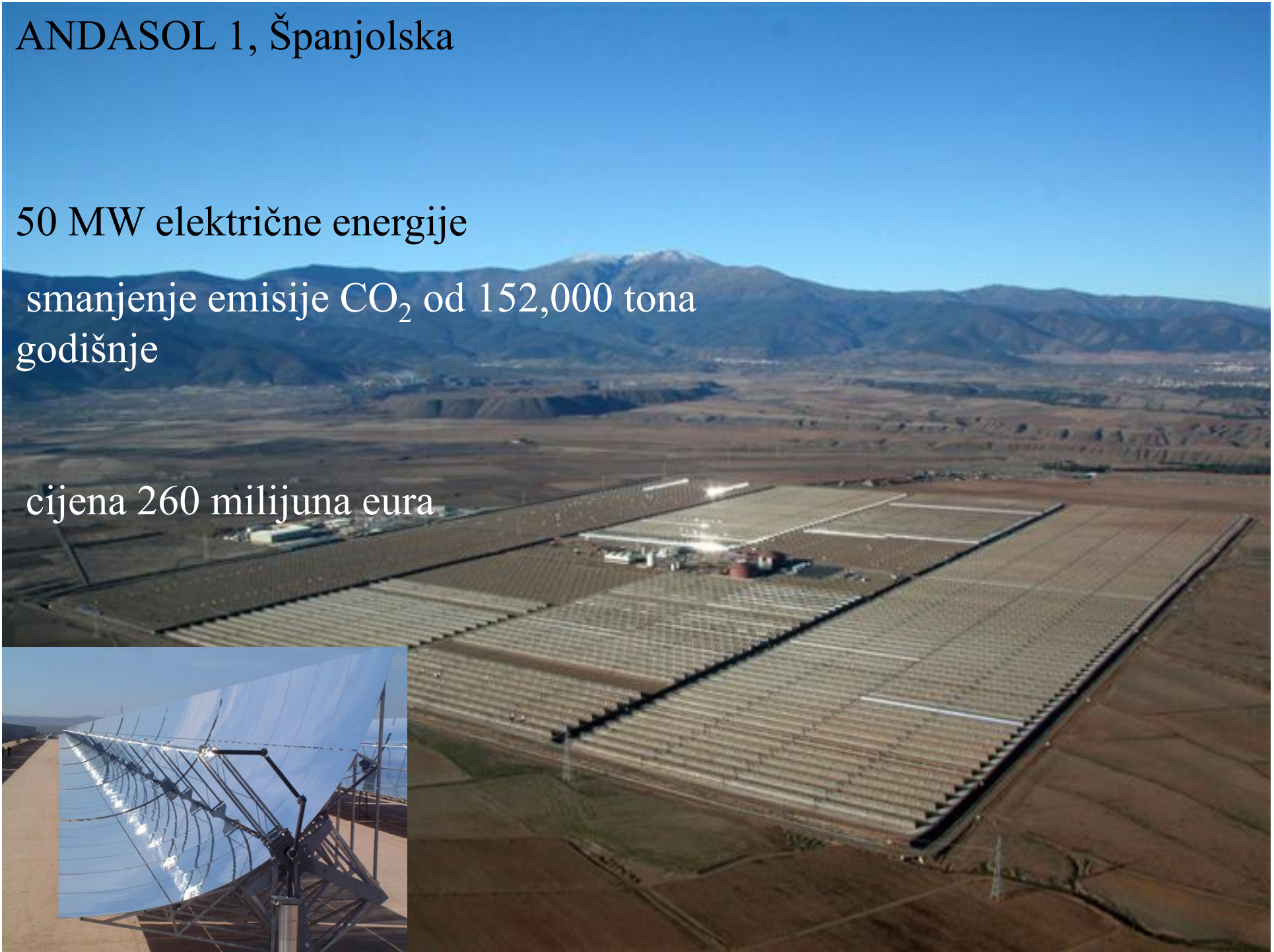
** proizvodnja/snaga

ANDASOL 1, Španjolska

50 MW električne energije

smanjenje emisije CO₂ od 152,000 tona
godišnje

cijena 260 milijuna eura



**Spain,
Olmedilla
(Castila La Mancha)**

60 MW



**Solarni park
Merida/Don
Alvaro**

30 MW



**Spain,
Crevillent
(Alicante)**

6,2 MW

7500 tons CO2
emission reduction
annually

SERPA, Portugal

11 MW

52, 000 solarnih panela

75 milijuna dolara

površina 60 hektara

redukcija emisije od
30,000 tona CO₂

godišnje



Parabolični koncentrirajući solarni kolektori
Concentrating Solar Power (CSP) Godišnja proizvodnja el.
energije 134 milijuna kWh

- Nevada Solar One- pustinja Mojave, Nevada, SAD,
pored Las Vegasa, u pogonu od srpnja 2007g.

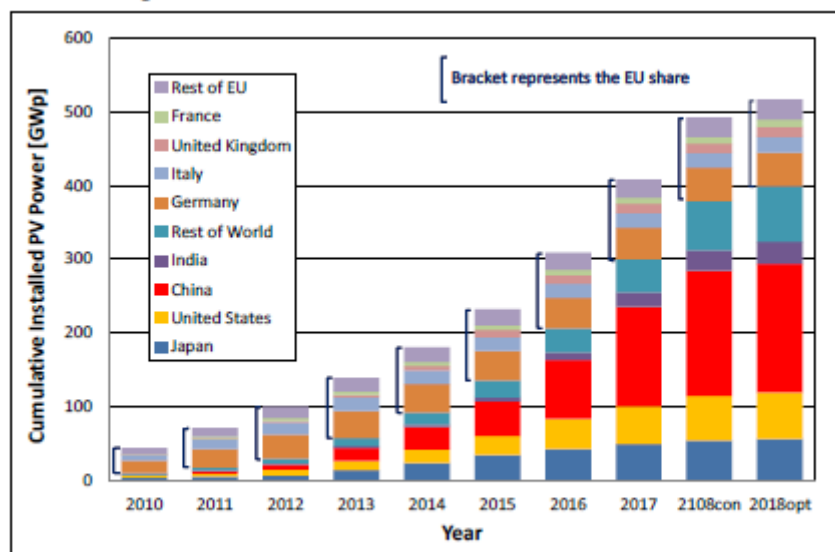


Snaga 64MW, površina
1,6km², od čega 1,2km²
otpada na polje kolektora

Smanjenje emisije CO₂
jednako emisiji 20000
automobila godišnje



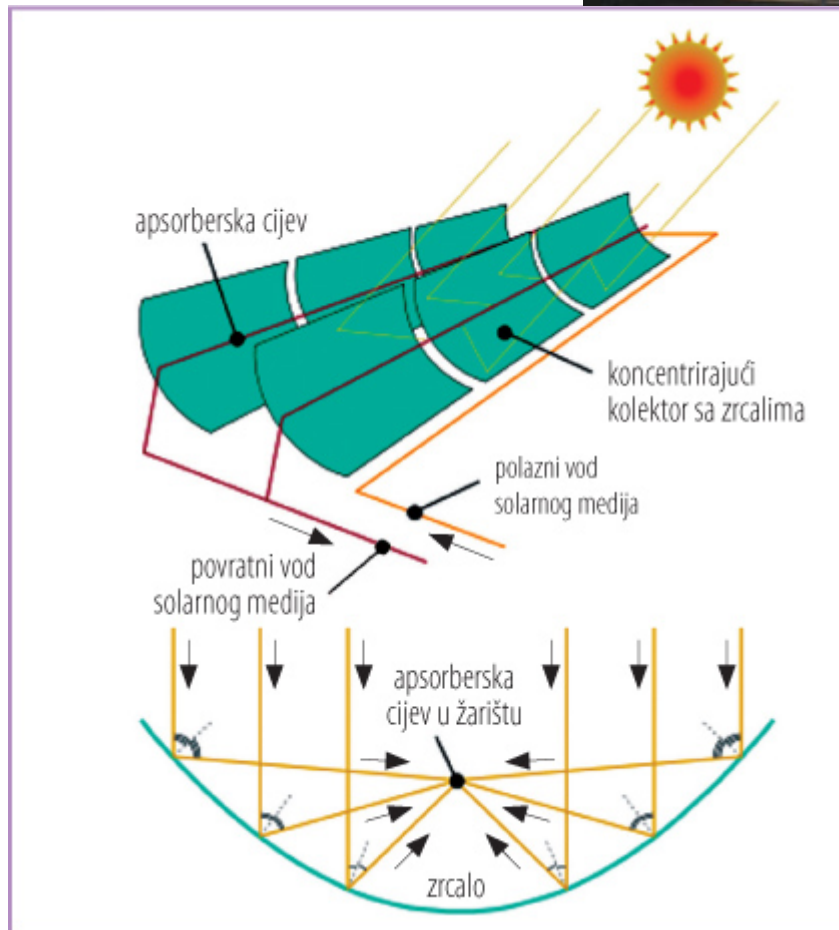
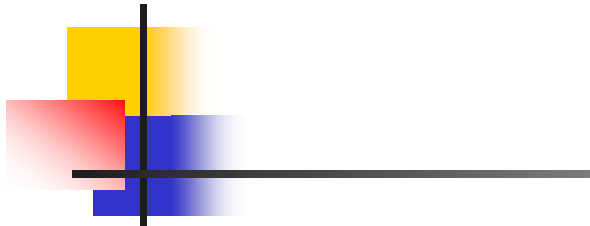
Figure 4: Cumulative PV installations from 2010 to 2018 estimates



Source: [IEA 2018b, Sol 2018, Sys 2018] and own analysis

JRC SCIENCE FOR POLICY REPORT PV Status Report 2018

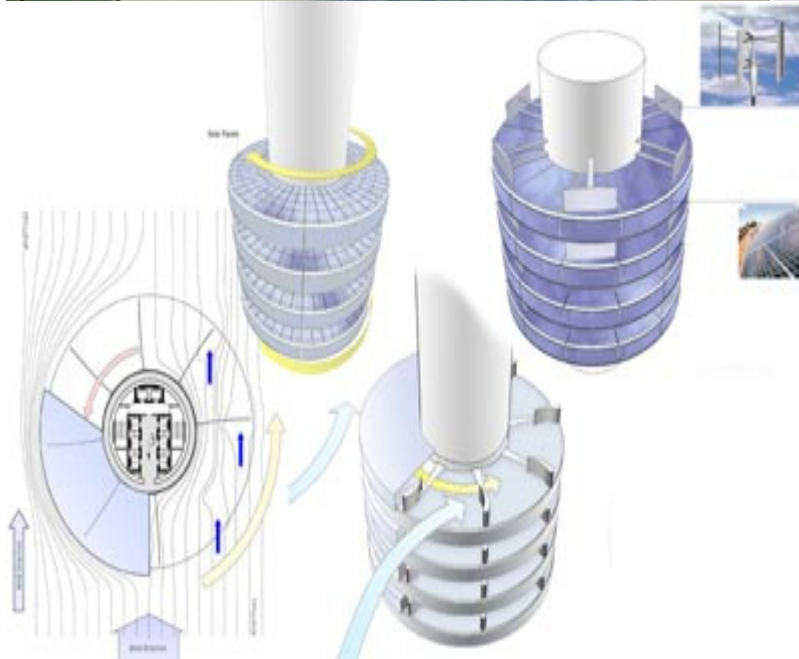
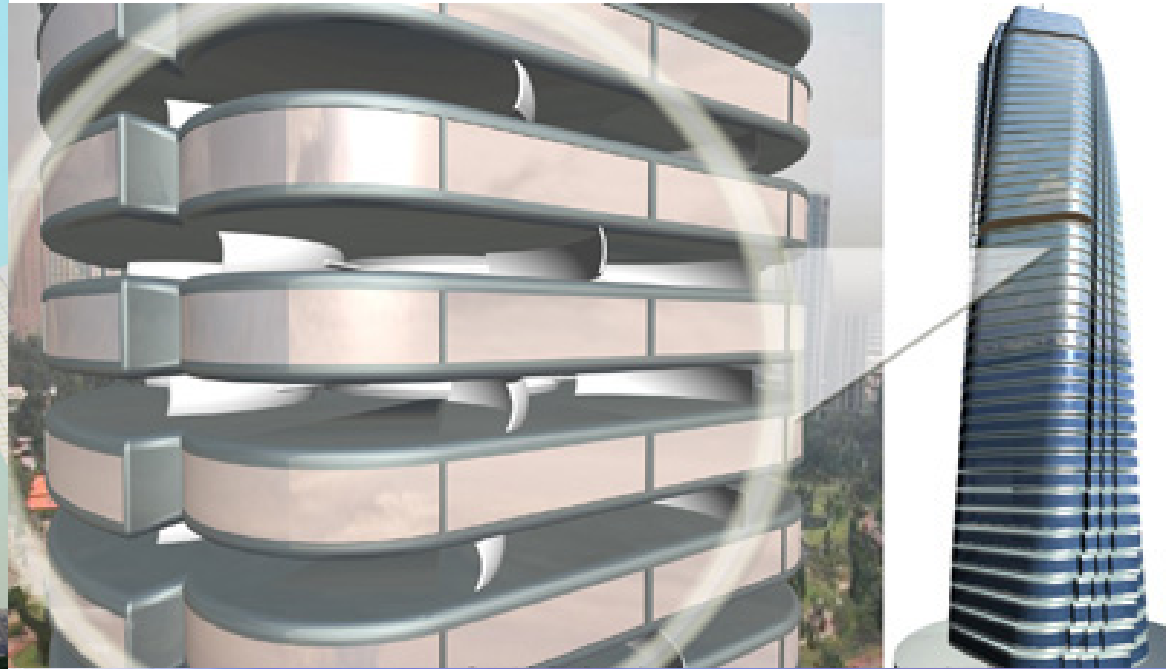


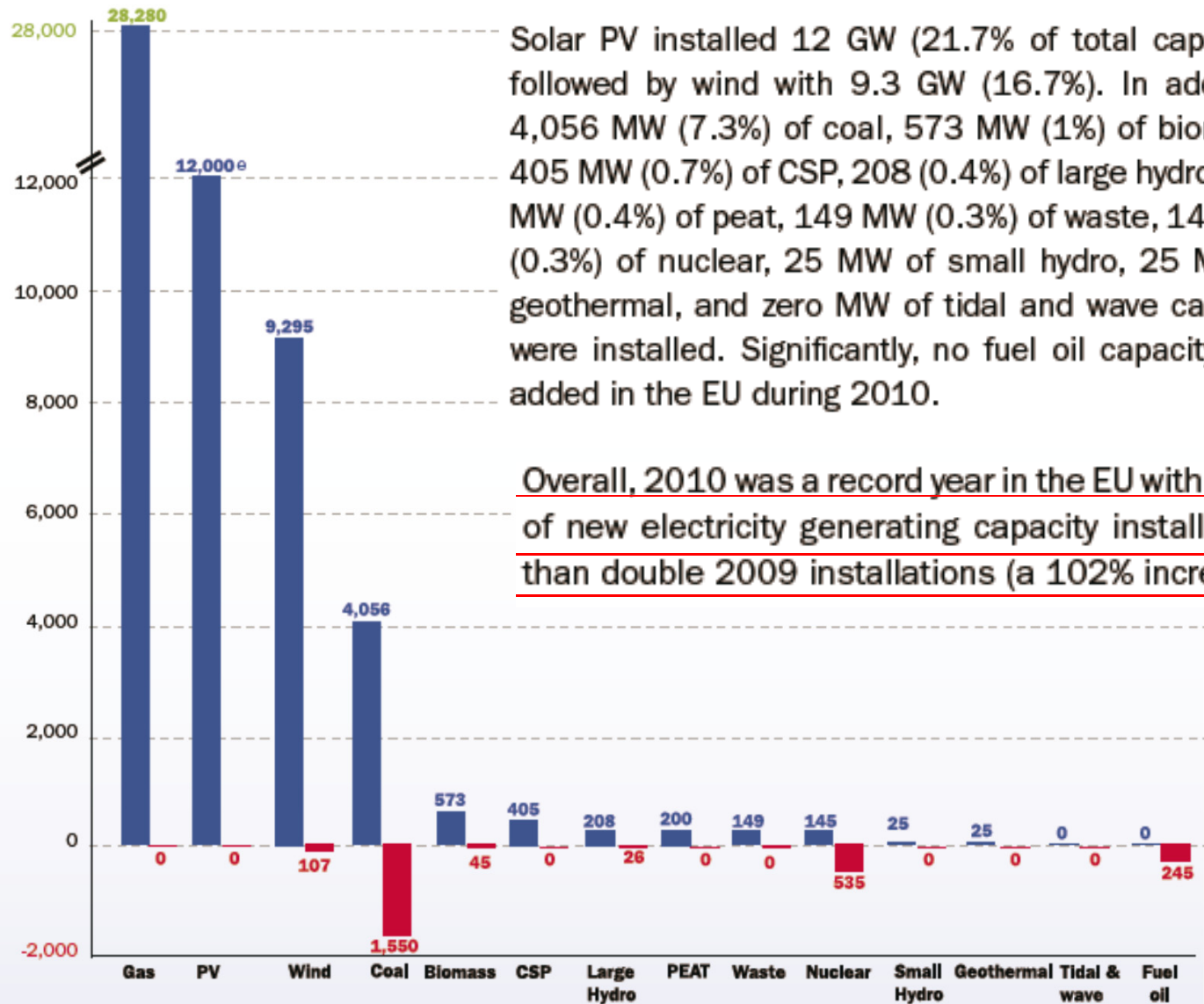
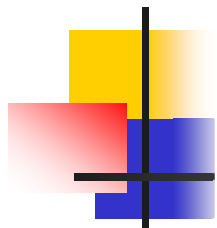


Više od 182 000 zrcala, 18200 cijevi na koje se fokusira zračenje, temperatura koja se postiže u njima 390°C



DUBAI «Dynamic Tower»





Solar PV installed 12 GW (21.7% of total capacity), followed by wind with 9.3 GW (16.7%). In addition, 4,056 MW (7.3%) of coal, 573 MW (1%) of biomass, 405 MW (0.7%) of CSP, 208 (0.4%) of large hydro, 200 MW (0.4%) of peat, 149 MW (0.3%) of waste, 145 MW (0.3%) of nuclear, 25 MW of small hydro, 25 MW of geothermal, and zero MW of tidal and wave capacity were installed. Significantly, no fuel oil capacity was added in the EU during 2010.

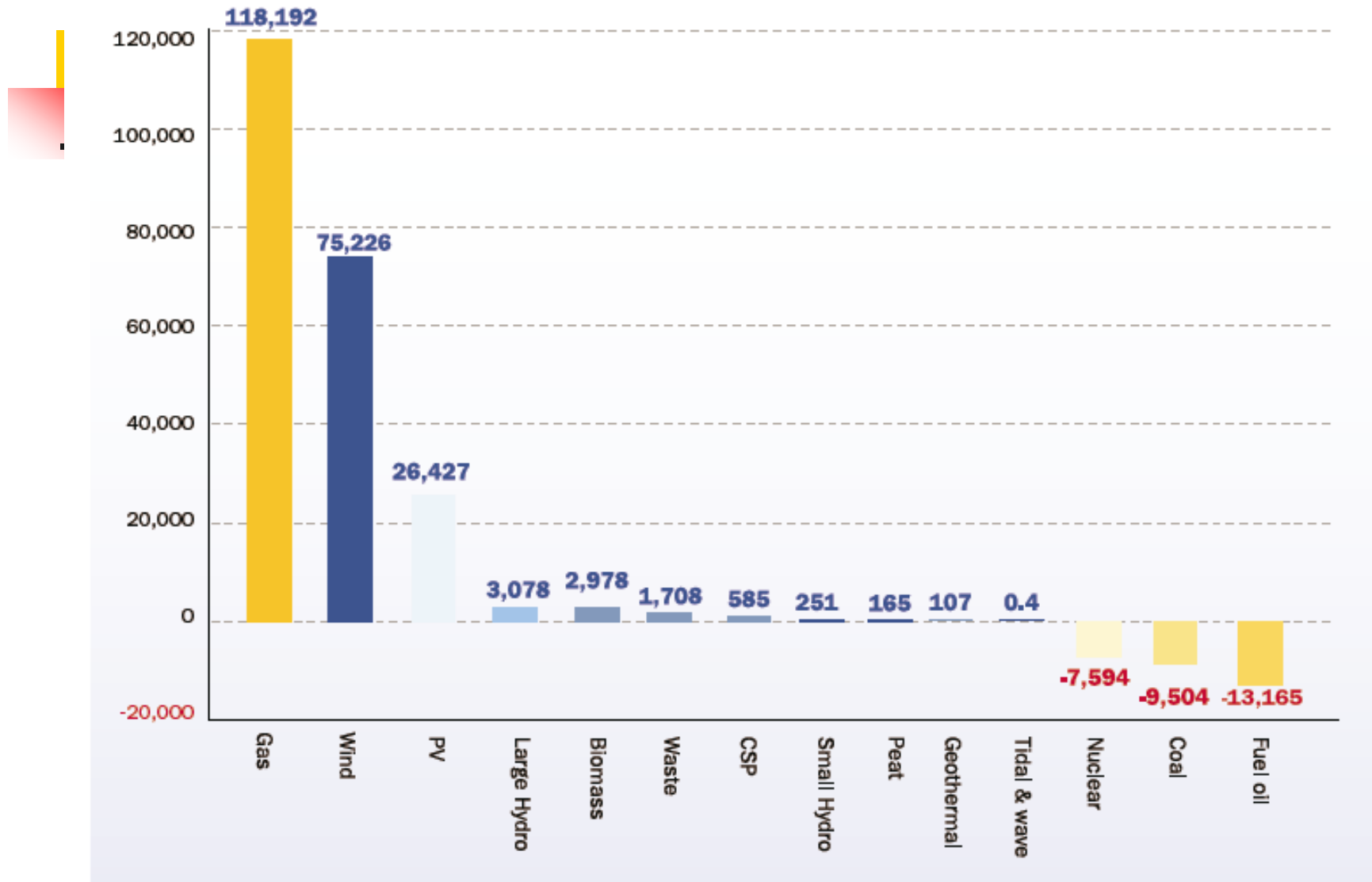
Overall, 2010 was a record year in the EU with 55.4 GW of new electricity generating capacity installed, more than double 2009 installations (a 102% increase).

⁽⁴⁾ According to Platts PIE (January 2011) almost 30 GW of gas projects have been cancelled or suspended in recent years

⁽⁵⁾ In 2008 the net addition was only 16 MW

NET ELECTRICITY GENERATING INSTALLATIONS IN EU 2000 – 2010 IN MW

FIGURE 2.2



Executive summary

2010 annual installations

- 9,295 MW of wind power capacity (worth some €12.7 billion) was installed in the EU during 2010, down 10% compared to the previous year;
- Wind power accounted for 16.8% of total 2010 power capacity installations;
- More renewable power capacity was installed during 2010 than any other year, an increase of 31% compared to 2009;
- Renewable power installations accounted for 41% of new installations during 2010, 22,645 MW of total of 55,363 MW of new power capacity;
- More power capacity was installed in 2010 than ever before, an increase of 102%, due to increasing renewable power installations and gas power installations;

Trends & cumulative installations

- Wind power installations accounted for 16.8% of new capacity installations in 2010, the first year since 2007 that wind power did not install more than any other generating technology;
- For only the second time since 1998² the EU power sector installed more coal than it decommissioned¹, highlighting the urgency of moving to a 30% greenhouse gas reduction target for 2020 and introducing an Emissions Performance Standard;
- The EU power sector continues its move away from fuel oil and nuclear, each technology continuing to decommission more than it installs;
- The EU's total installed power capacity increased by 52,855 MW (net) to 876,023 MW, with wind power increasing its share of installed capacity to 84,278 MW (9.6%).

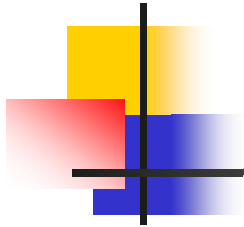
Data for wind power installations

- Annual installations of wind power have increased steadily over the last 15 years from 814 MW in 1995 to 9,295 MW in 2010, an annual average market growth of 17.6%;
- A total of 84,278 MW is now installed in the European Union, an increase in installed cumulative capacity of 12.2%.
- Germany remains the EU country with the largest installed capacity, followed by Spain, Italy, France and the UK;
- Increasing installations in emerging EU markets – offshore in Northern Europe, and onshore in South East Europe (Romania, Poland and Bulgaria) – offset the fall in installations in the mature onshore markets of Germany, UK, and Spain;
- The wind capacity installed by the end of 2010 would in a normal year produce 181 TWh of electricity, representing 5.3%³ of electricity consumption;

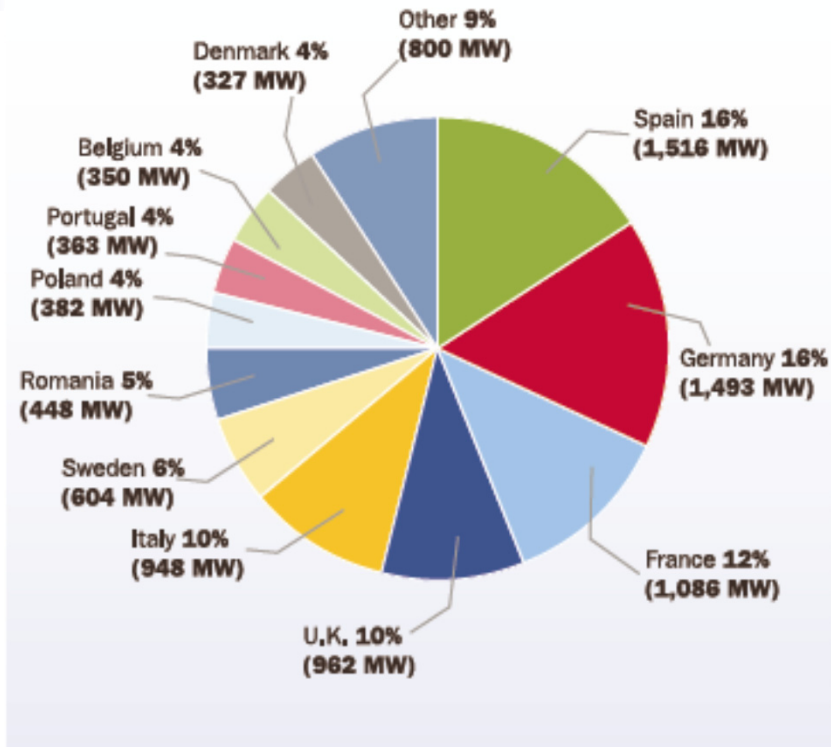
⁽¹⁾ According to Platts PIE (January 2011) almost 23 GW of coal projects have been cancelled or suspended in recent years

⁽²⁾ In 2008 the net addition was only 16 MW.

⁽³⁾ According to the latest figures from Eurostat, gross electricity consumption in the EU-27 was 3,390.7 TWh in 2008.



**EU MEMBER STATE MARKET SHARES FOR NEW CAPACITY
INSTALLED DURING 2010. TOTAL 9,295 MW** FIGURE 1.1



The European Power Sector in 2018

Up-to-date analysis on the electricity transition

ANALYSIS

- 1** **CO₂ emissions in the power sector fell by 5% in 2018.** Half of this was structural, from new wind, solar and biomass displacing hard coal. The other half was weather-related, as increased hydro generation reversed the temporary rise in gas in 2017. Overall EU ETS emissions, we estimate, fell by 3%, from 1754 Mt in 2017 to 1700 Mt in 2018.
- 2** **It's a tale of two types of coal: Europe's transition from hard coal to renewables is accelerating ...** Hard coal generation fell by 9% in 2018, and is now 40% lower than in 2012. In 2018, Germany and Spain announced that coal phase-out plans were imminent. That would now put three quarters of Europe's 2018 hard coal generation under national coal phase-outs. The remaining quarter is almost all in Poland.
- 3** **...however, the transition from lignite – the dirtier, brown coal – to renewables proving much harder.** Lignite generation fell by only 3% in 2018. Half of Europe's lignite generation in 2018 was in Germany; the Coal Commission announcement for a 2038 phase-out includes lignite. The other half is in countries where this is not yet the case: Poland, Czech Republic, Bulgaria, Greece, Romania and Slovenia.
- 4** **Wind is strong, but get ready for solar!** Renewables rose to 32.3% of EU electricity production in 2018. While this year's rise was mainly due to wind growth picking up and hydro returning back to normal, solar will be the next big thing: solar additions increased by more than 60% to almost 10 GW in 2018 and could triple to 30 GW by 2022. Module prices fell by 29% in 2018. Solar outperformed during the 2018 summer heatwave, when coal, nuclear, wind and hydro all stumbled. Bold national plans for solar in 2030 were drafted in Italy, France and Spain in 2018. The EU's 2030 RES target, agreed in 2018, will result in even more.
- 5** **For the first time, the fuel and carbon costs alone for coal and gas plants were on a par with the full cost of wind and solar.** Coal and gas generation costs rose in 2018: coal price rose 15%, gas rose 30%, and the CO₂ price rose 170%. Consequently, electricity prices rose to 45–60 €/MWh in Europe. This is the level at which the latest wind and solar auctions cleared in Germany.

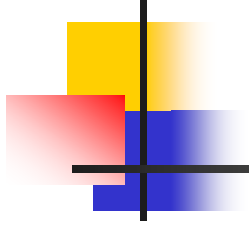


Photo: Siemens

VJETROELEKTRANE A ŠTO KADA VJETAR NE PUŠE?

Proizvodnja električne energije iz vjetra smanjuje zagađenje okoliša, no zahtijeva i znatna ulaganja. Piše: Marijan Kalea, energetski stručnjak

Iskustva iz razvijenih zemalja pokazuju kako svaki instalirani megavat vjetroelektrana zahtijeva oko 0,85 megavata rezerve u konvencionalnoj proizvodnji

Pojava vjetra čudljiva je, ne ovisi o dobu dana ili o sezoni u godini, poput Sunčeva zračenja ili - donekle - vodotoka. Premda, dakako, u određenu je predjelu vjetar donekle vjerojatniji u stanovito vrijeme, primjerice u ljetno predvečerje. Ali i na takvim mjestima i u to vrijeme može posve izostati.

Vjetroelektranama proizvodi se električna energija samo kada ima vjetra, točnije, kada je njegova brzina iznad neke minimalne i ispod neke maksimalne vrijednosti. U drugim se razdobljima vjetroelektrana mora obustaviti. U Njemačkoj se potkraj 2010. godine vrtilo 26.981 MW vjetroelektrana, a godišnje trajanje iskorištenja instalirane snage vjetroelektrana bilo je 1442 sata. Dakle, kada bi vjetroelektrane radile punom snagom, tijekom 16,5% ukupnog godišnjeg trajanja - godina traje 8760 sati - u njemačkim bi se vjetroelektranama proizvela sva godišnja proizvodnja. Ili, još slikovitiije: kada bi svaki šesti dan vjetroelektrane radile punom snagom, pet dana posve bi mirovale. Dakako, u stvarnim prilikama ima razdoblja u kojima one rade punom snagom, pa razdoblja kada rade smanjenom snagom i razdoblja kada doista uopće ne rade.

Skupa rezervna snaga

Statistika pogona hrvatskih vjetroelektrana u 2011. godini (tada ih je prosječno bilo u pogonu oko 100 MW) kaže da se u prosjeku svaka četiri dana zbije jedan sat kada je njihov ukupni angažman bio nula ili blizu nule! U tim razdobljima mora se potražnja pokriti konvencionalnim elektranama (točnije: termoelektranama, akumulacijskim hidroelektranama ili elektranama na biomasu i biopljin). Njemačko je iskustvo da se na 1 megavat u vjetroelektranama mora instalirati još 0,85-0,95 megavata u elektranama na stalne izvore energije, dakako računa li se s jednakom sigurnošću opskrbe kupaca.

Dakle, treba li iduće godine - radi pokrivena stalno rastuće potražnje za električnom energijom - sustavu dodati novih 100 MW elektrana i namjeravamo li to učiniti vjetroelektranama, morat ćemo izgraditi 100 MW u vjetroelektranama i dograditi još 85-95 MW u elektranama na stalne izvore energije. Da bi istodobno te dograđene elektrane bile donekle podiskorištene, jer neće biti angažirane onda kada vjetra ima te će proizvodnja u njima biti skuplja negoli bi bila da nema vjetroelektrana; stalni troškovi podijelit će se na manje pro-

izvedenih kilovatsati. Ne dogradi li se sustav tim rezervnim elektranama, sigurnost opskrbe kupaca iz vlastitoga sustava bitno će se smanjiti.

Ako je tome tako, a tako jest, zašto uopće gradimo vjetroelektrane? Pa, ostvaruje se ušteda goriva za konvencionalne elektrane i - s tim u vezi - smanjenje opterećenja okoliša stakleničkim plinovima. Točno govoreći, ta ušteda ne odgovara baš potpuno cjelokupnoj proizvodnji u vjetroelektranama. Naime, neke konvencionalne elektrane koje trebaju biti neprestano spremne da preuzmu iznenađena zlostaju proizvodnju vjetroelektrana ne smiju prije toga raditi blizu punog opterećenja - jer u tom slučaju ne mogu preuzeti dodatno opterećenje. Ili, moraju biti spremne za rasterećenje ako je naglo porastao angažman vjetroelektrana. Radit će, dakle, u području nižeg stupnja djelovanja od optimalnog te će se u njima za takav rad utrošiti više goriva po jedinici proizvedene električne energije nego što bi se utrošilo da rade u optimalnom području.

Sve bolje prognoze

Snaga vjetroelektrane mijenja se s trećom potencijom brzine vjetra u većem dijelu radnog područja. Dakle, smanji li se brzina vjetra na polovinu, ali tako da to bude još uvijek iznad minimalne brzine - snaga vjetroelektrane padne na osminu. Često se upozorava da će stalno povećanje točnosti predviđanja pojave vjetra s vremenom ublažiti probleme u sustavu. To je točno, sve manje će biti potreban regulacijski angažman konvencionalnih elektrana. Ali, i uz pretpostavku potpuno točne prognoze vjetra za određeni sat u ovom ili sljedećem danu, svejedno ostaje potreba jednake rezerve u sustavu. Jer, ako se točno predvidi da će snaga svih vjetroelektrana biti u nekom trenutku 1% i tako se ostvari, trebat će imati 99% rezerve kako bi se to nadoknadio.

Još jedan zanimljiv pogled prema Njemačkoj: koliki je udio vjetroelektrana i snazi svih elektrana na obnovljive izvore energije a koliki je njihov udio u proizvodnji električne energije iz obnovljivih izvora? Dakle (2010.) udio vjetroelektrana u ukupnoj snazi bio je 52%, a njihov udio u ukupnoj proizvodnji bio je samo 38%. Istodobno elektrane na biomasu i njemačke hidroelektrane imale su zajednički udio i snazi od 20%, a proizvele su čak 50% ukupne proizvodnje iz svih obnovljivih izvora energije.

134

megavata snažne su vjetroelektrane trenutano instalirane u Hrvatskoj

1446

sati je godišnje trajanje iskorištenja snage njemačkih vjetroelektrana

1

dan u tjednu u prosjeku vjetroelektrane rade punom snagom, ostatak miruju

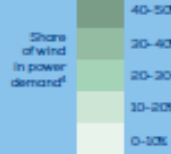
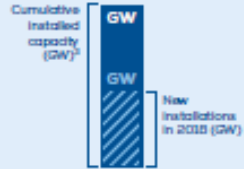
0,85

megavata stalnih izvora energije potrebno je kao rezerva za instalaciju 1 megavata u energiji vjetra

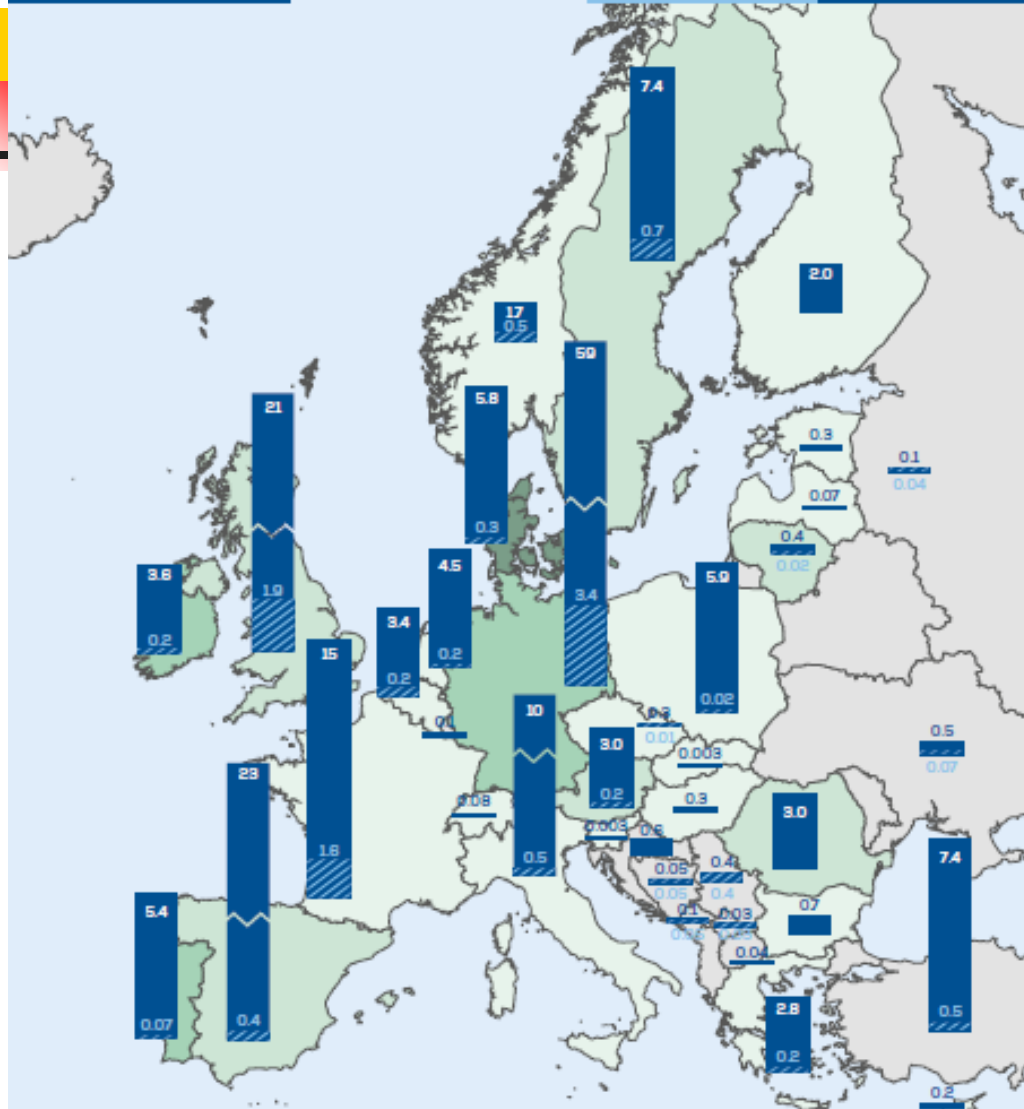
Problem je što su rezervne elektrane u pravilu vrlo slabo iskorištene i zato vrlo skupe

11.7 GW
TOTAL EUROPE

10.1 GW
OF NEW WIND POWER
IN THE EU



WIND ENERGY COVERED
14%
OF EU ELECTRICITY DEMAND IN 2018



3. Cumulative capacity in each country reflects decommissioning in 2018: Austria (29 MW), Denmark (12.7 MW), Finland (3 MW), France (12.6), Germany (249 MW), Greece (15.4 MW), the Netherlands (72 MW), Portugal (13.7 MW), Sweden (13.3 MW).

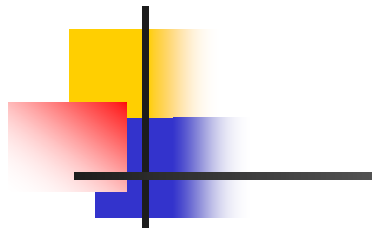
4. Grey colored countries did not provide data for electricity generation and consumption to ENTSO-E transparency platform.

Source: WindEurope

Wind energy in Europe in 2018

Trends and statistics





Ukupan broj vjetrogeneratc

Proizvo•a•: Vestas Danska

Tip: V52

Težina: 83 tona

Visina: 49 m

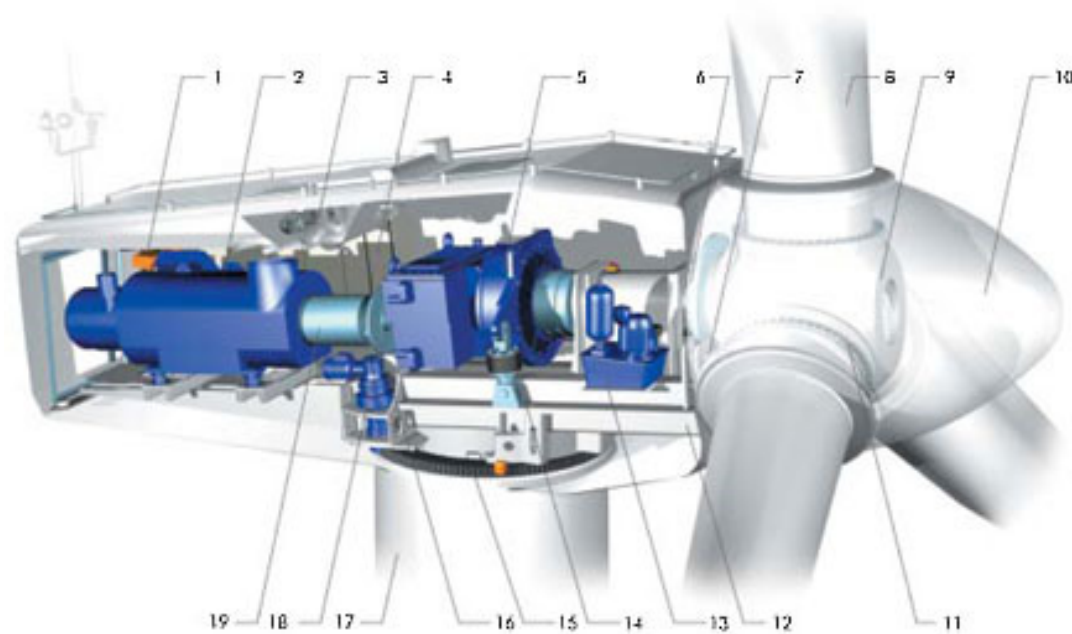
Nazivna snaga: 850 kW

Površina zahvata: 2 124 •etvornih metara

Regulator snage: Pitch regulacija rada vjetroturbine/
Optispeed™

Hidrauli•na ko•nica

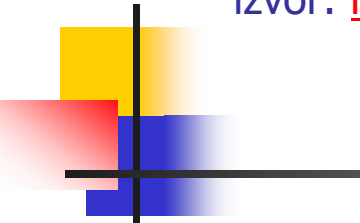
- 1. Servisna dizalica (service crane)
- 2. OptiSpeed™ - generator
- 3. Rashladni sustav (cooling system)
- 4. VMP-top kontroler sa konverterom
- 5. Prijenosnik (gearbox)
- 6. Glavna osovina (main shaft)
- 7. Sistem za blokiranje rotora (Rotor lock system)
- 8. Krak, lopatica
- 9. BladeHub (glava nosa•a rotora)
- 10. Spinner
- 11. Ležaj krila (blade bearing)
- 12. Temeljna plo•a stroja (machine foundation)
- 13. Hidrauli•na jedinica (hydraulic unit)
- 14. Zakretna ruka (gear torque arm)
- 15. Zakretni prsten (yaw ring)
- 16. Ko•nica (brake)
- 17. Toranj (tower)
- 18. Oprema za zakretanje (yaw gear)
- 19. Kompozitna spojnica diska; generator-prijenosnik (Composite disk coupling)



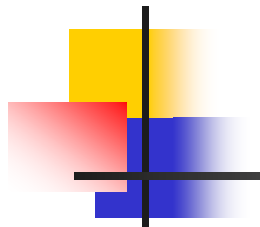
Mjerenje brzine vjetra

Bf-Beaufort, kn-knot (čvor)=1,852km/h, 1mph=1,609km/h,

izvor: <http://prognoza.hr/prognoze.php?id=pomorci> (www.meteo.hr)

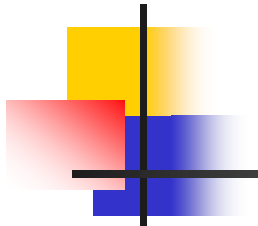


		Brzina				Visina valova	
		km/h	m/s	kt	mph	m	ft
0 Bf	tišina	< 1	0-0.2	< 1	< 1	-	-
1 Bf	lahor	1-5	0.3-1.5	1-3	1-3	0.1(0.1)	0.25(0.25)
2 Bf	povjetarac	6-11	1.6-3.3	4-6	4-7	0.2(0.3)	0.5(1)
3 Bf	slabi	12-19	3.4-5.4	7-10	8-12	0.6(1)	2(3)
4 Bf	umjereni	20-28	5.5-7.9	11-16	13-18	1(1.5)	3.5(5)
5 Bf	umjereno jaki	29-38	8.0-10.7	17-21	19-24	2(2.5)	6(8.5)
6 Bf	jaki	39-49	10.8-13.8	22-27	25-31	3(4)	9.5(13)
7 Bf	žestoki	50-61	13.9-17.1	28-33	32-38	4(5.5)	13.5(19)
8 Bf	olujni	62-74	17.2-20.7	34-40	39-46	5.5(7.5)	18(25)
9 Bf	jaki olujni	75-88	20.8-24.4	41-47	47-54	7(10)	23(32)
10 Bf	orkanski	89-102	24.5-28.4	48-55	55-63	9(12.5)	29(41)
11 Bf	jaki orkanski	103-117	28.5-32.6	56-63	64-72	11.5(16)	37(52)
12 Bf	orkan	>=118	>=32.7	>=64	>=73	14(-)	45(-)

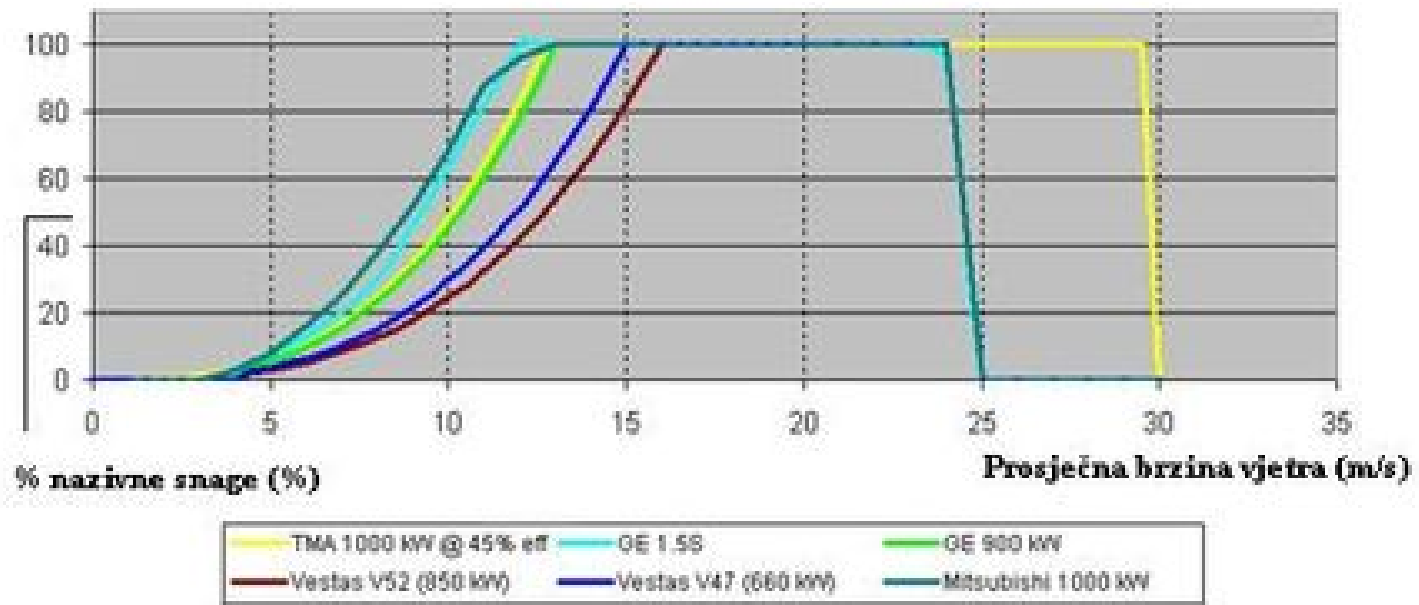


Stanje mora

Stanje more	Opis	Visina valova (m)	Izgled mora
0	mirno (<i>glatko, zrcalno, bonaca</i>)	0	more poput zrcala
1	mirno (<i>naborano</i>)	0-0.1	mali valići ili bore s pojavama
2	malo valovito (<i>valićasto</i>)	0.1-0.5	kratki ili mali valovi; uobličeni; bregovi izgledaju staklasto
3	umjereno valovito	0.5-1.25	veći valovi; mjestimice bjeline na valnim bregovima; more stvara isprekidano šuštanje
4	valovito	1.25-2.5	valovi s mnogo bjelina; mogućnost prskanja; šum mora slični muklom žamoru
5	jače valovito	2.5-4	valovi se propinju; neprekidne bjeline; pjena s vrhova prigodice se otpuhava kao morski div; valovi stvaraju neprekidno žamor
6	uzburkano	4-6	visoki valovi imaju velike bjeline s kojih se pjena otpuhuje u gustim prugama; more se počinje valjati, a njegov je šum poput mukle huke
7	teško	6-9	veliki valovi se propinju; imaju duge pjenušave bregove koji se neprekidno ruše i stvaraju hućanje; velike količine pjene otpuhnete s bregova daju morskoj površini bjelkast izgled i mogu utjecati na vidljivost; valovi se valjaju teško i udarno
8	vrlo teško	9-14	valovi visoki da manji i srednji brodovi u blizini povremeno nestaju iz vida; vjetar otkida vrhove svih valova; more je potpuno prekriveno gustim prugama pjene; zrak je toliko ispunjen pjenom i morskim dimom da ozbiljno ograničava vidljivost; valjanje valova stvara tutnjavu
9	izuzetno teško	>14	valovi se međusobno križaju iz raznih i nepredvidivih smjerova tvoreći složenu interferenciju koju je teško opisati; valovi se mogu prigodice djelomice rušiti



Krivulje snage raznih vjetroagregata

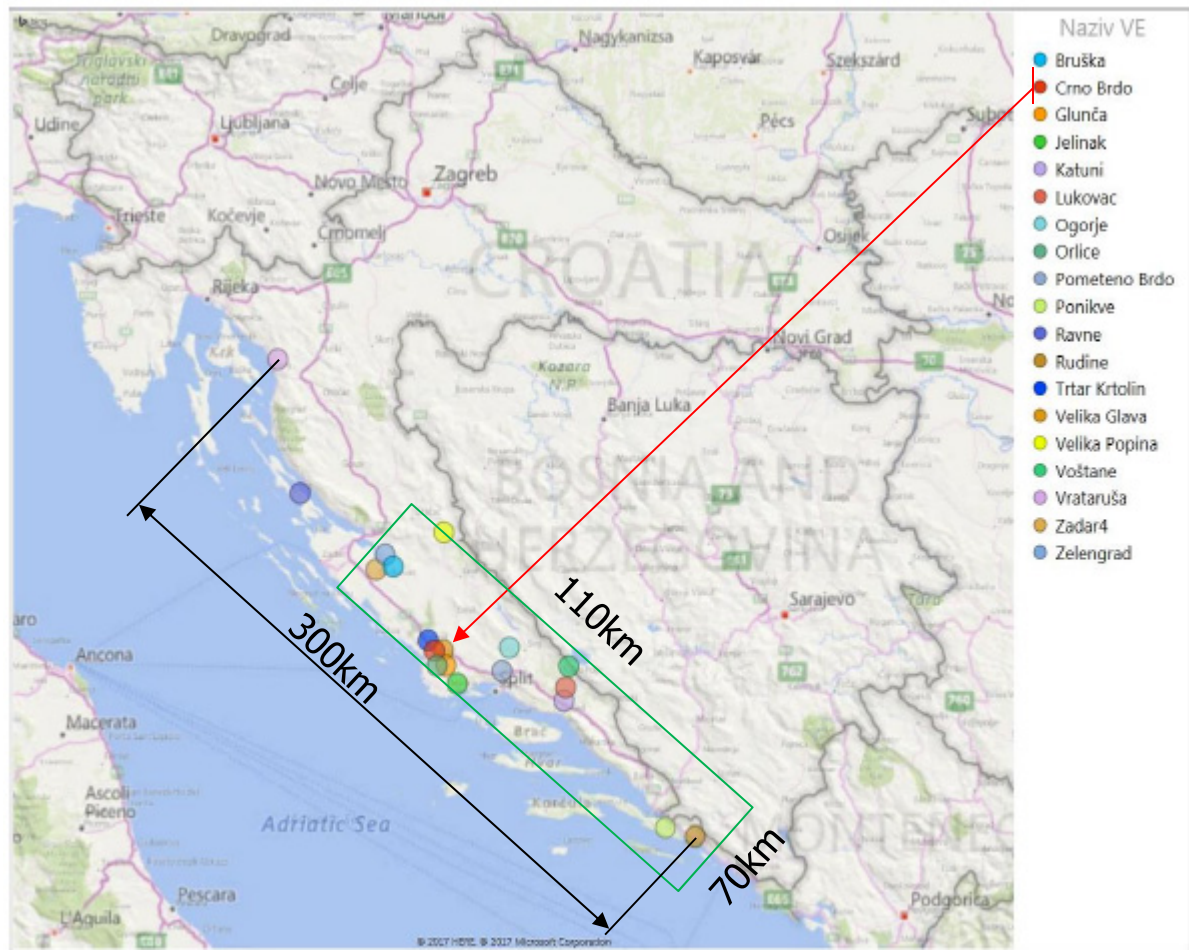


Tablica 1 Osnovni parametri vjetroelektrana u redovnom pogonu

Table 1 Basic parameters overview of wind power plants in normal operation

Br No	Naziv VE WPP name	Lokacija (županija/općina) Location (county/municip.)	Ukupna instalirana snaga (MW) Total installed capacity (MW)	Ukupno odobrena snaga priključenja (MW) Total approved connected capacity (MW)	Napon priključenja (kV) Connection voltage (kV)	U redovnom pogonu od In normal operation since
1	Ravne	Zadarska/Pag	5,95	5,95	10	2005
2	Trtar Krtolin	Šib-Knin/Šibenik	11,2	11,2	30	2007
3	Orlice	Šib-Knin/Šibenik	9,6	9,6	30	2009
4	Vrataruša	Prim-Goran/Senj	42	42	110	2010
5	Velika Popina	Zadarska/Gračac	53,4	54,2	110	2011 / 2017
6	Pometeno Brdo	Split-Dalm/Split	20	20	110	2010 / 2011 / 2012 / 2015
7	Crno Brdo	Šib-Knin/Šibenik	10,5	10	10	2011
8	Bruška	Zadarska/Benkovac, Obrovac	36,8	36	110	2011
9	Ponikve	Dub-Neret/Ston	36,8	34	110	2012
10	Jelinak	Šib-Knin/Marina, Seget	30	30	110	2013
11	Voštane	Split-Dalm/Trilj	42	40	110	2013
12	Zadar4	Zadarska/Benkovac	9,2	9,2	10	2013
13	Velika Glava	Šib-Knin/Drniš, Šibenik, Unešić	43,7	43	110	2014
14	Zelengrad	Zadarska/Obrovac	42	42	110	2014
15	Ogorje	Split-Dalm/Muč	45	44	110	2015
16	Rudine	Dub-Neret/Dubrovačko primorje	34,2	34,2	110	2015
17	Glunča	Šib-Knin/Šibenik	20,7	23	110	2016
18	Katuni	Split-Dalm/Šestanovac	34,2	39,9	110	2016
19	Lukovac	Split-Dalm/Cista Provo	48,75	48	110	2018
UKUPNO TOTAL			576	576,25		

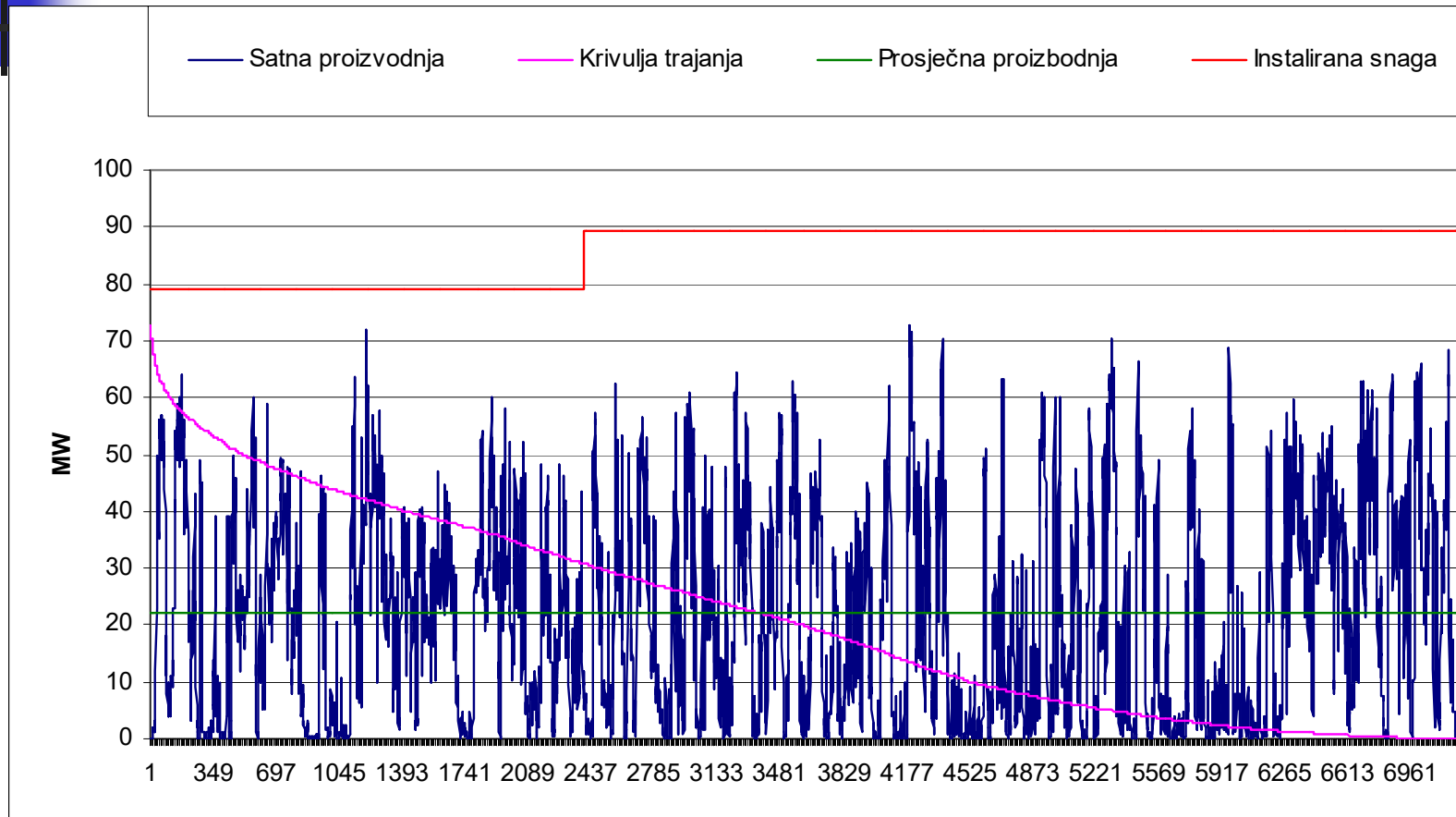
VJETROELEKTRANE U POGONU			
VJETROELEKTRANA	ODOBRENA SNAGA (MW)	SKLOPLJEN UOKM	PRIKLJUČAK NA MREŽ (kV)
VE Ravne	5,95	prosinac 2006.	10
VE Trtar-Krtolin	11,2	prosinac 2007.	30
VE Orlice	9,6	lipanj 2009.	30
VE Vrataruša	42	srpanj 2009.	110
VE Crno Brdo	10	ožujak 2011.	10
VE ZD2	18	studen 2011.	110
VE ZD 3	18	studen 2011.	110
VE Pometeno brdo	20	studen 2011	110
VE Ponikve	34	listopad 2012.	110
VE Jelinak	30	prosinac 2012.	110
VE ST 1-2 Kamensko	20	lipanj 2013.	110
VE ST 1-1 Voštane	20	lipanj 2013.	110
VE ZD 4 faza I.	9,2	srpanj 2013.	10
VE Velika Glava, Bubrig i Crni Vrh	43	prosinac 2013.	110
VE Zelengrad - Obrovac	42	ožujak 2014.	110
VE Ogorje	44	srpanj 2015.	110
VE Rudine	35	srpanj 2015.	110
VE Katuni	39	studen 2016.	110
VE Glunča	22	listopad 2016.	110
VE ZD 6P + ZD6	54	lipanj 2017.	110
VE Lukovac	48	srpanj 2017.	110
VE Kom-Orjak-Greda	10	studen 2018.	35
VE Krš Pađene	142	srpanj 2019.	220
VE Jasenice	10	kolovoz 2019.	35
VE Korlat	58	ožujak 2020.	110
UKUPNO	794,95		



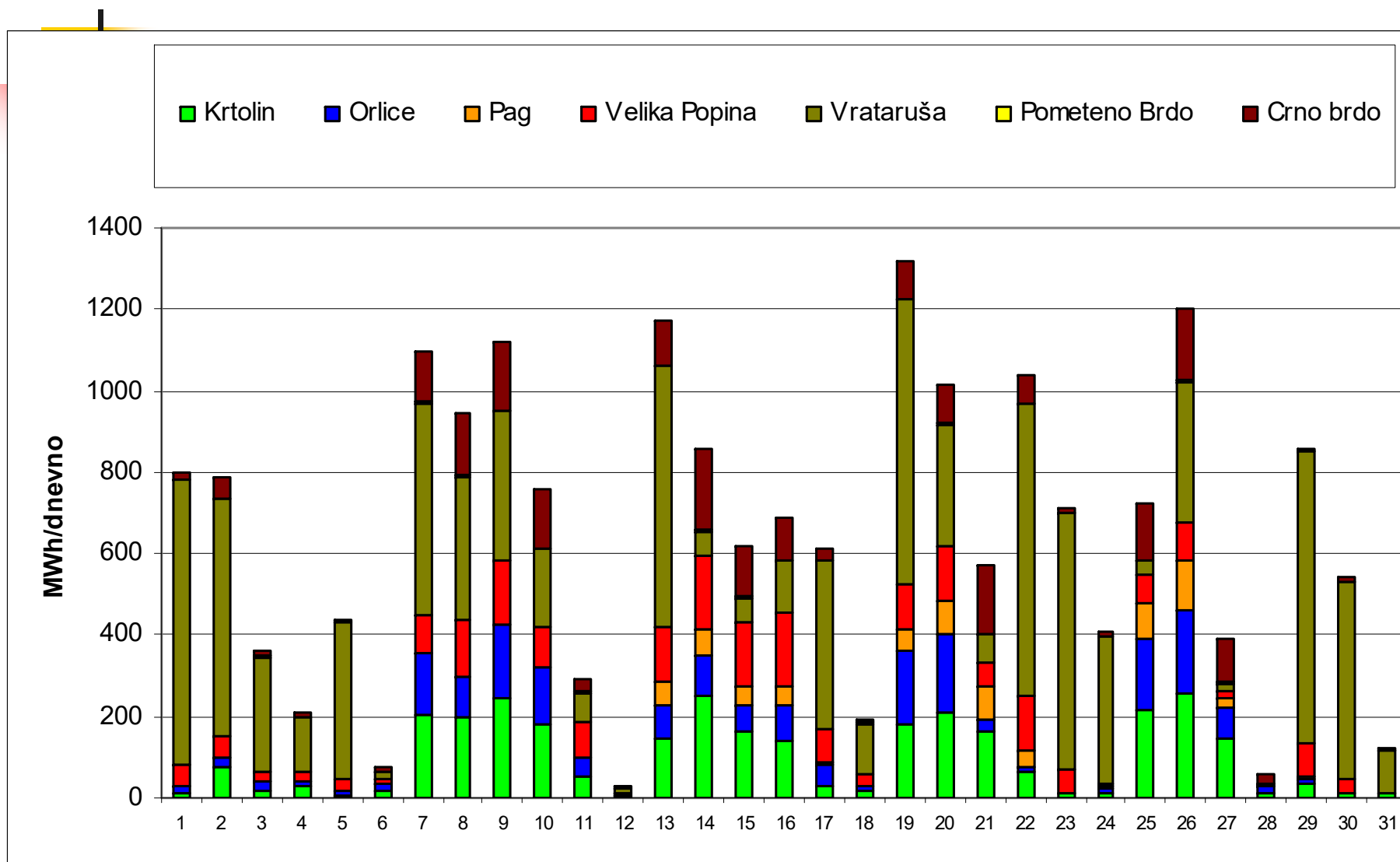
WPP in Croatia

Satna proizvodnja od 1.01.- 31.10.2011. godine

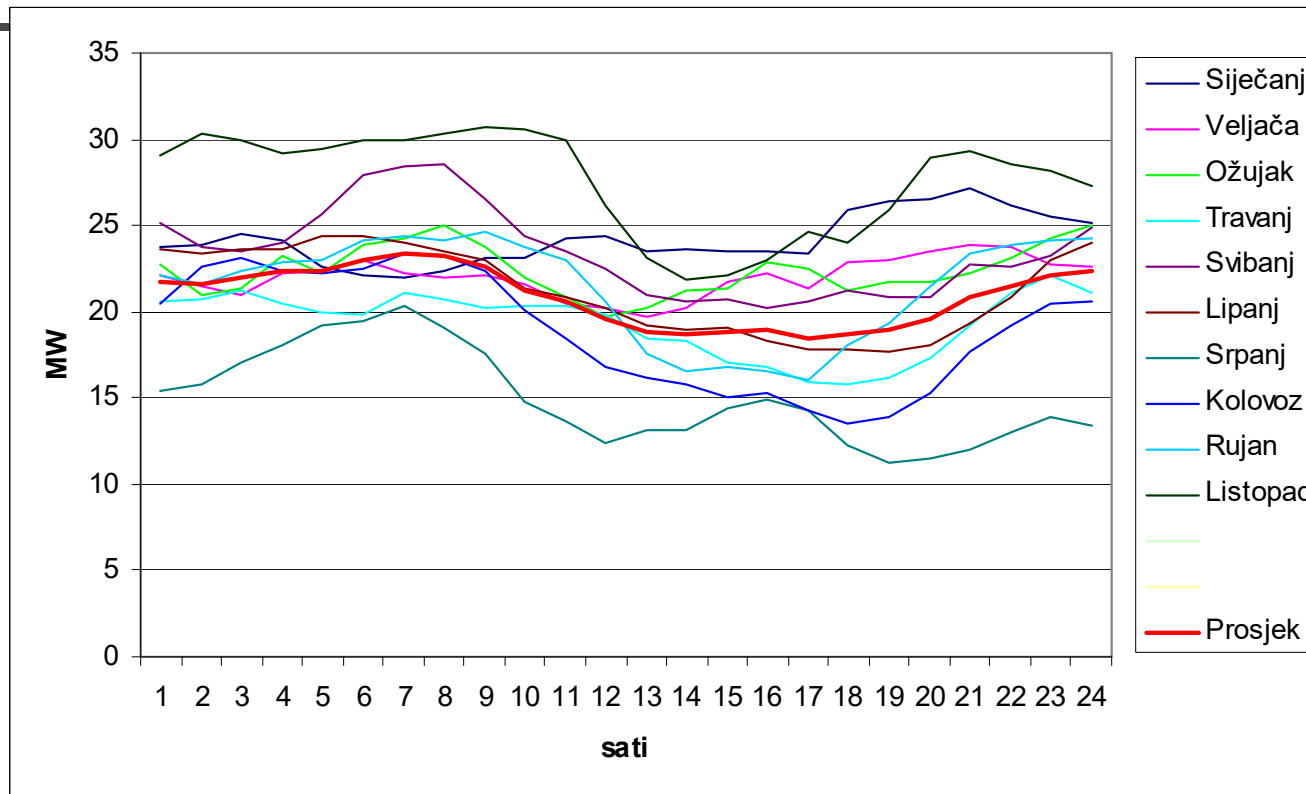
Prosječna satna proizvodnja 21,3 MW, maksimalna satna proizvodnja 72,71 MW.



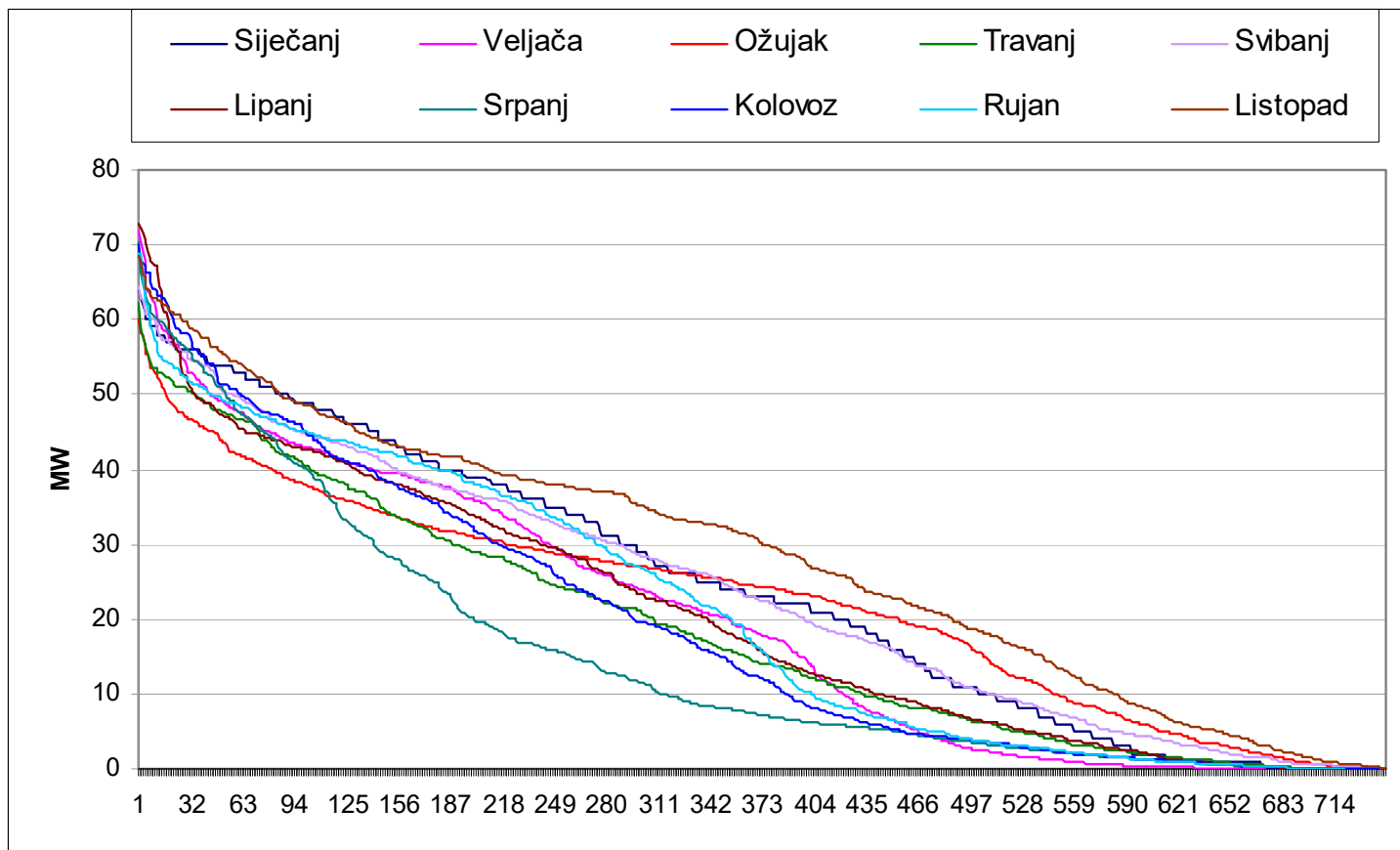
Dnevna proizvodnja u listopadu 2010.



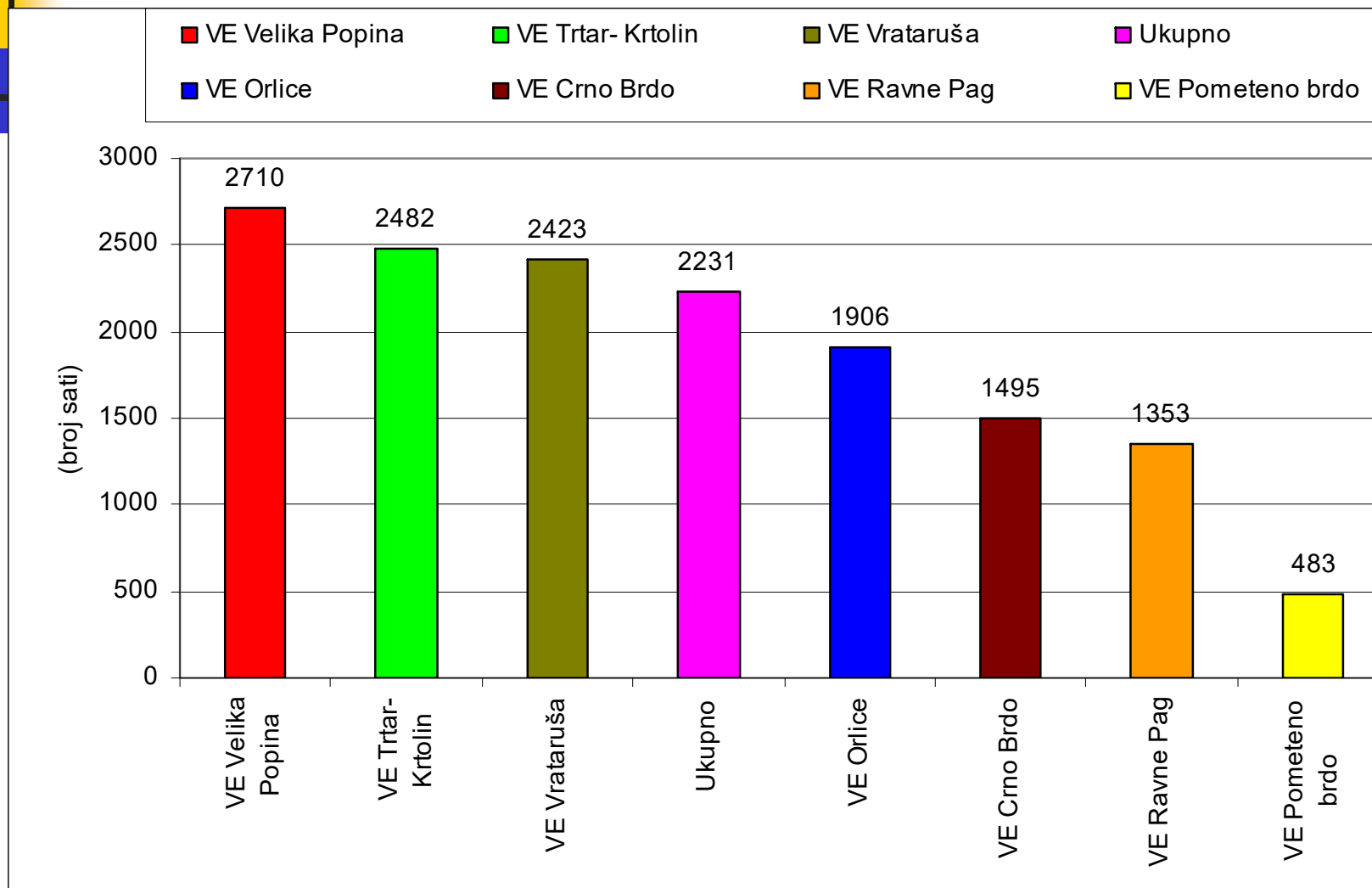
Prosječna satna proizvodnja u pojedinom mjesecu
- *vidi se utjecaj temperature zraka na dijagram proizvodnje*

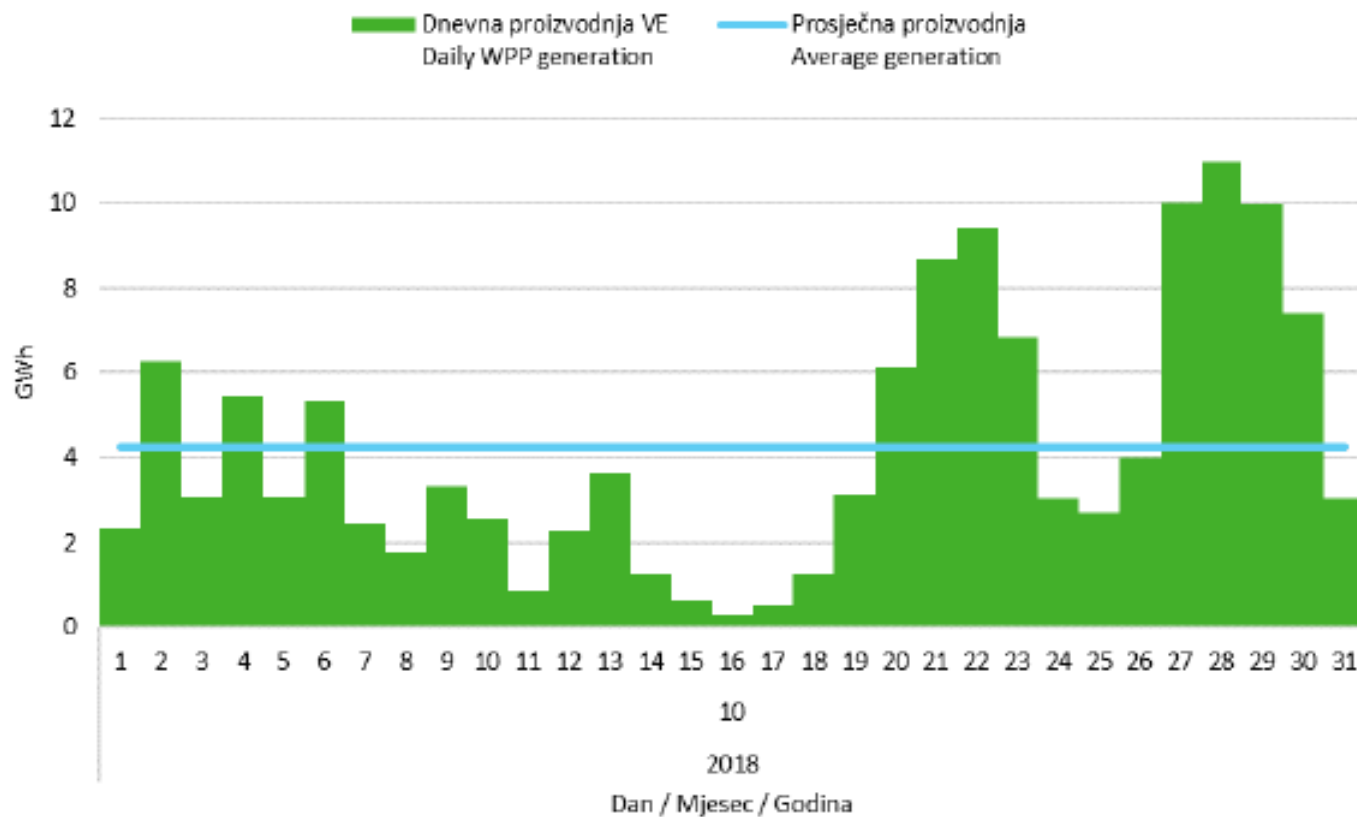
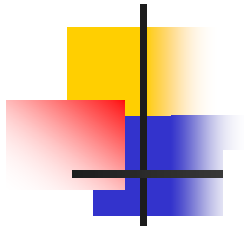


Mjesečne krivulje trajanja proizvodnje VE 10/2010.



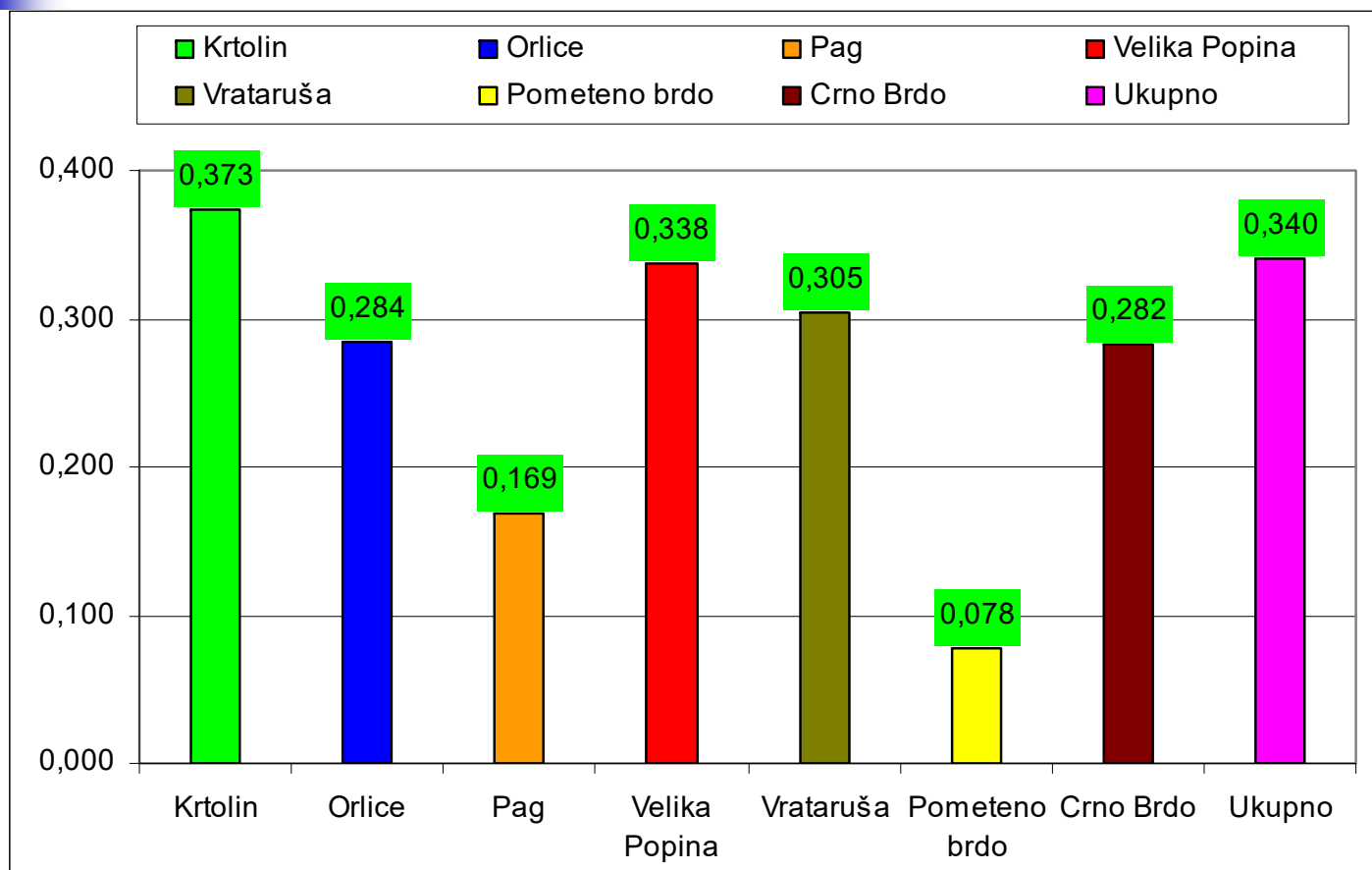
Broj sati rada na godišnjem nivou

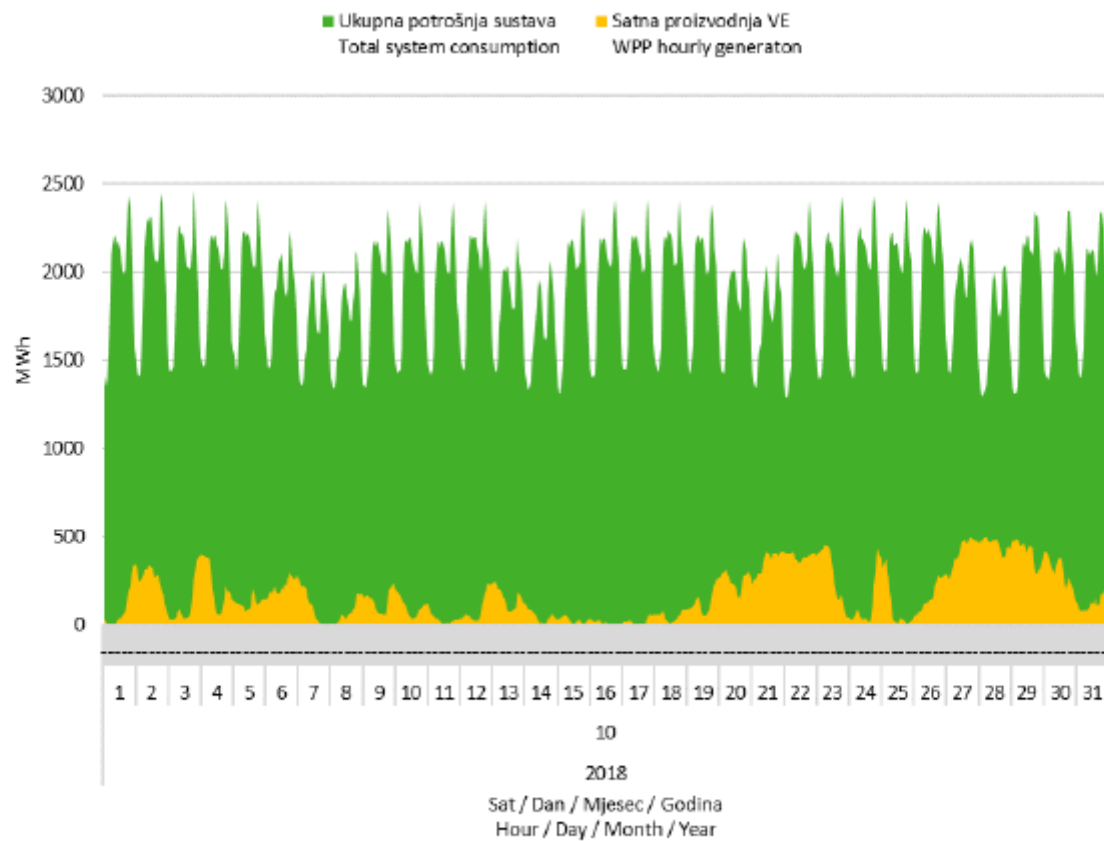




Slika 5 Dnevna proizvodnja svih vjetroelektrana u listopadu 2018. godine

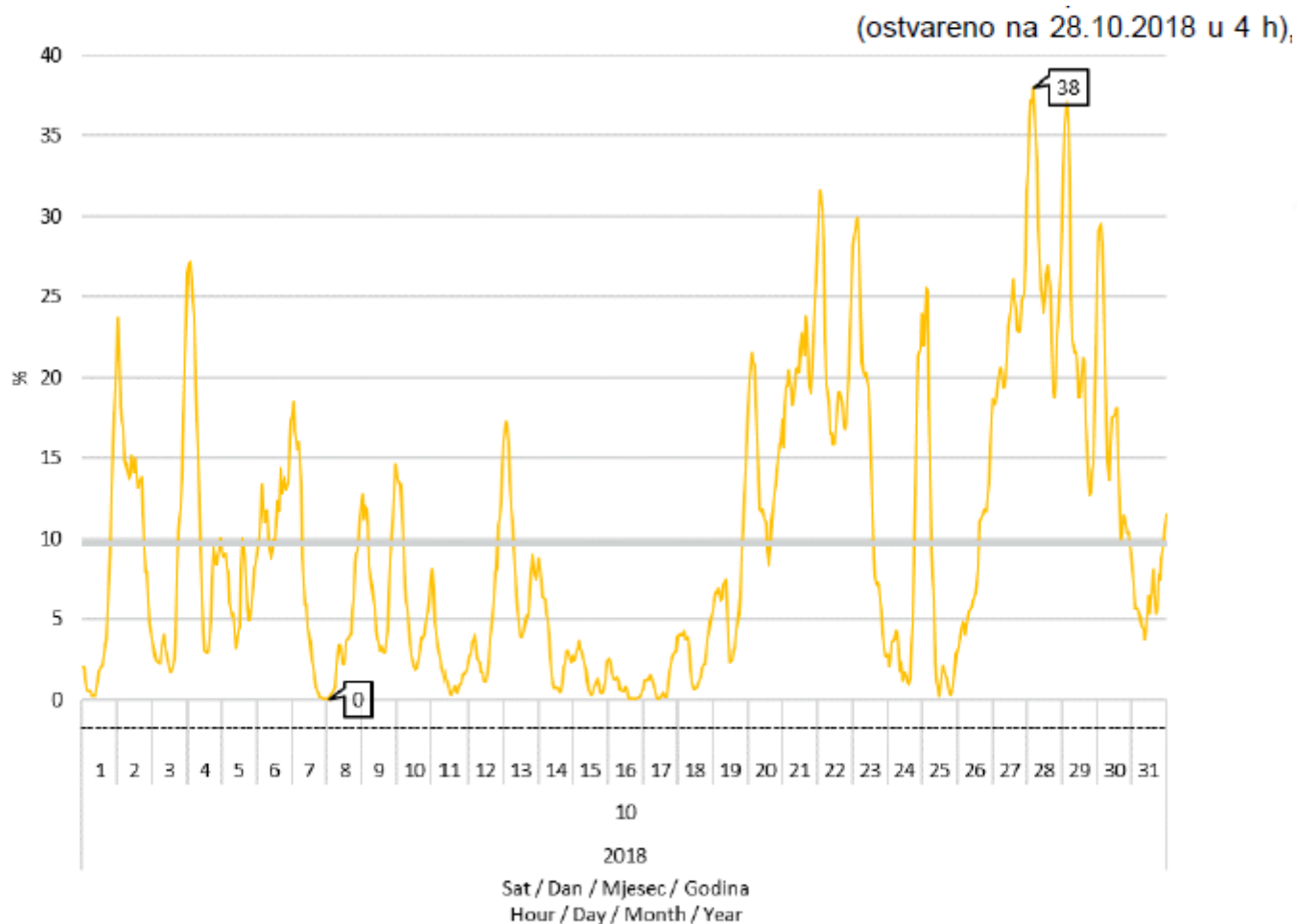
Faktor iskorištenja: stvarno angažirana snaga/instalirana snaga





Slika 7 Usporedba satnog dijagrama opterećenja sustava i proizvodnje vjetroelektrana u listopadu 2018. godine

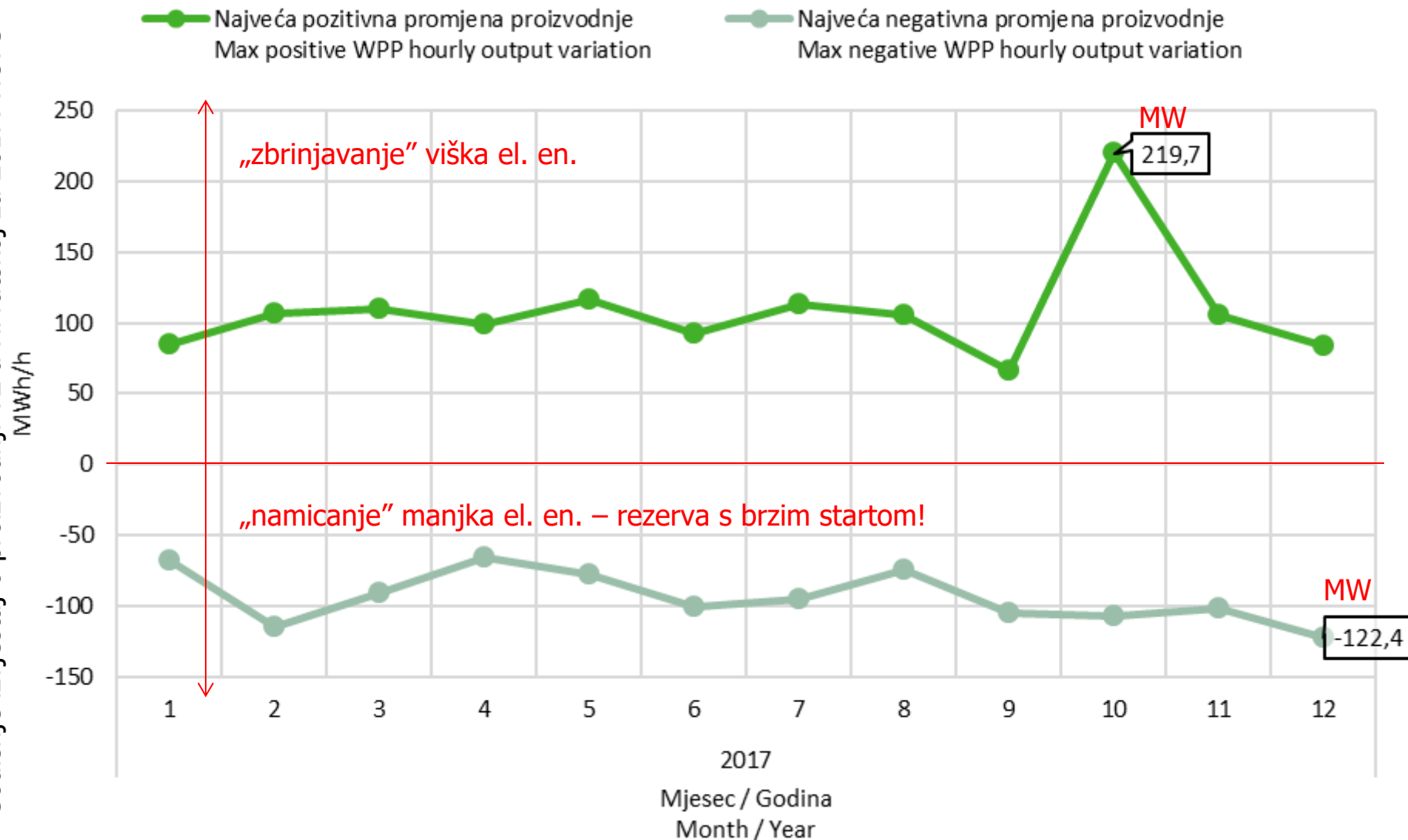
Mjesečni izvještaj o proizvodnji VE u Hrvatskoj , listopad 2018.-HOPS



Slika 8 Udio proizvodnje vjetroelektrana u pokrivanju satnog opterećenja elektroenergetskog sustava u listopadu 2018. godine

Na razini 2017. najveća pokrivenost potrošnje 35,2% 6.11.2017. u 3h, godišnje 15%

Godišnje izvještaj o proizvodnji VE u Hrvatskoj za 2017.-HOPS



Drugim riječima, prikazana je razlika ostvarene prosječne proizvodnje VE u dva uzastopna sata. Najveća pozitivna satna promjena proizvodnje VE iznosila je 219,7 MW, dok je najveća negativna satna promjena proizvodnje VE iznosila -122,4 MW. Prosječna pozitivna satna promjena proizvodnje u promatranom razdoblju iznosila je 108,62 MW, a prosječna negativna -93,65 MW.

Is a 100% renewable European power system feasible by 2050?

William Zappa*, Martin Junginger, Machteld van den Broek

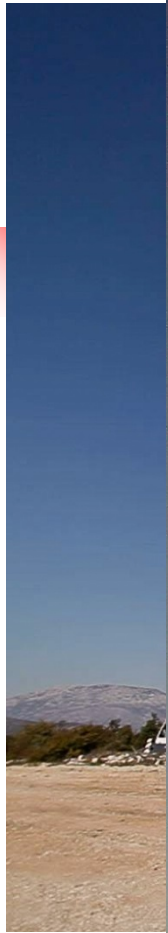
Copernicus Institute of Sustainable Development, Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, The Netherlands

Applied Energy 233–234 (2019) 1027–1050

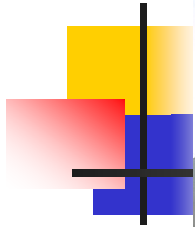
ABSTRACT

In this study, we model seven scenarios for the European power system in 2050 based on 100% renewable energy sources, assuming different levels of future demand and technology availability, and compare them with a scenario which includes low-carbon non-renewable technologies. We find that a 100% renewable European power system could operate with the same level of system adequacy as today when relying on European resources alone, even in the most challenging weather year observed in the period from 1979 to 2015. However, based on our scenario results, realising such a system by 2050 would require: (i) a 90% increase in generation capacity to at least 1.9 TW (compared with 1 TW installed today), (ii) reliable cross-border transmission capacity at least 140 GW higher than current levels (60 GW), (iii) the well-managed integration of heat pumps and electric vehicles into the power system to reduce demand peaks and biogas requirements, (iv) the implementation of energy efficiency measures to avoid even larger increases in required biomass demand, generation and transmission capacity, (v) wind deployment levels of 7.5 GW y^{-1} (currently 10.6 GW y^{-1}) to be maintained, while solar photovoltaic deployment to increase to at least 15 GW y^{-1} (currently 10.5 GW y^{-1}), (vi) large-scale mobilisation of Europe's biomass resources, with power sector biomass consumption reaching at least 8.5 EJ in the most challenging year (compared with 1.9 EJ today), and (vii) increasing solid biomass and biogas capacity deployment to at least 4 GW y^{-1} and 6 GW y^{-1} respectively. We find that even when wind and solar photovoltaic capacity is installed in optimum locations, the total cost of a 100% renewable power system ($\sim 530 \text{ €bn y}^{-1}$) would be approximately 30% higher than a power system which includes other low-carbon technologies such as nuclear, or carbon capture and storage ($\sim 410 \text{ €bn y}^{-1}$). Furthermore, a 100% renewable system may not deliver the level of emission reductions necessary to achieve Europe's climate goals by 2050, as negative emissions from biomass with carbon capture and storage may still be required to offset an increase in indirect emissions, or to realise more ambitious decarbonisation pathways.









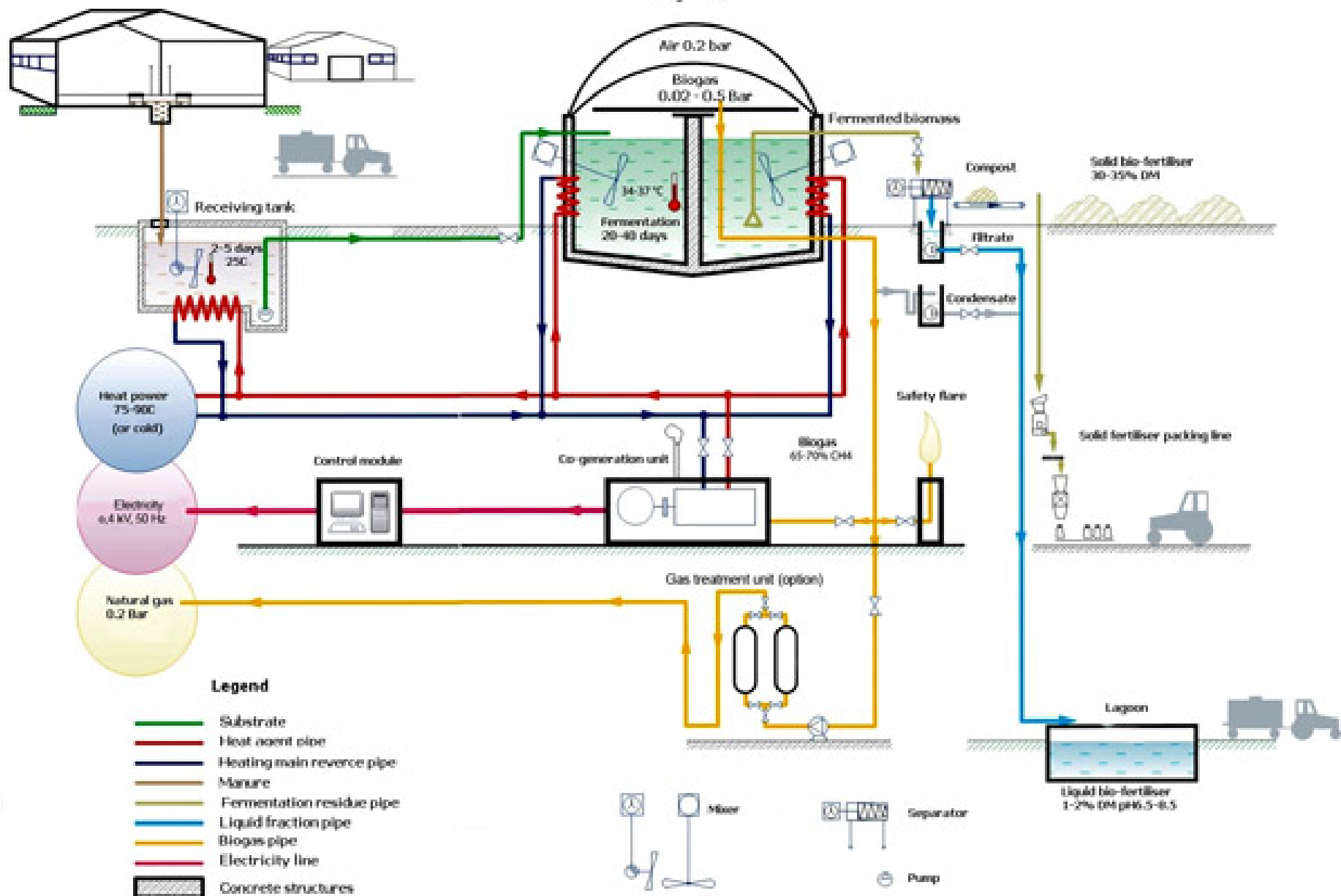


Pod pojmom biomase se podrazumijevaju dvije kategorije:

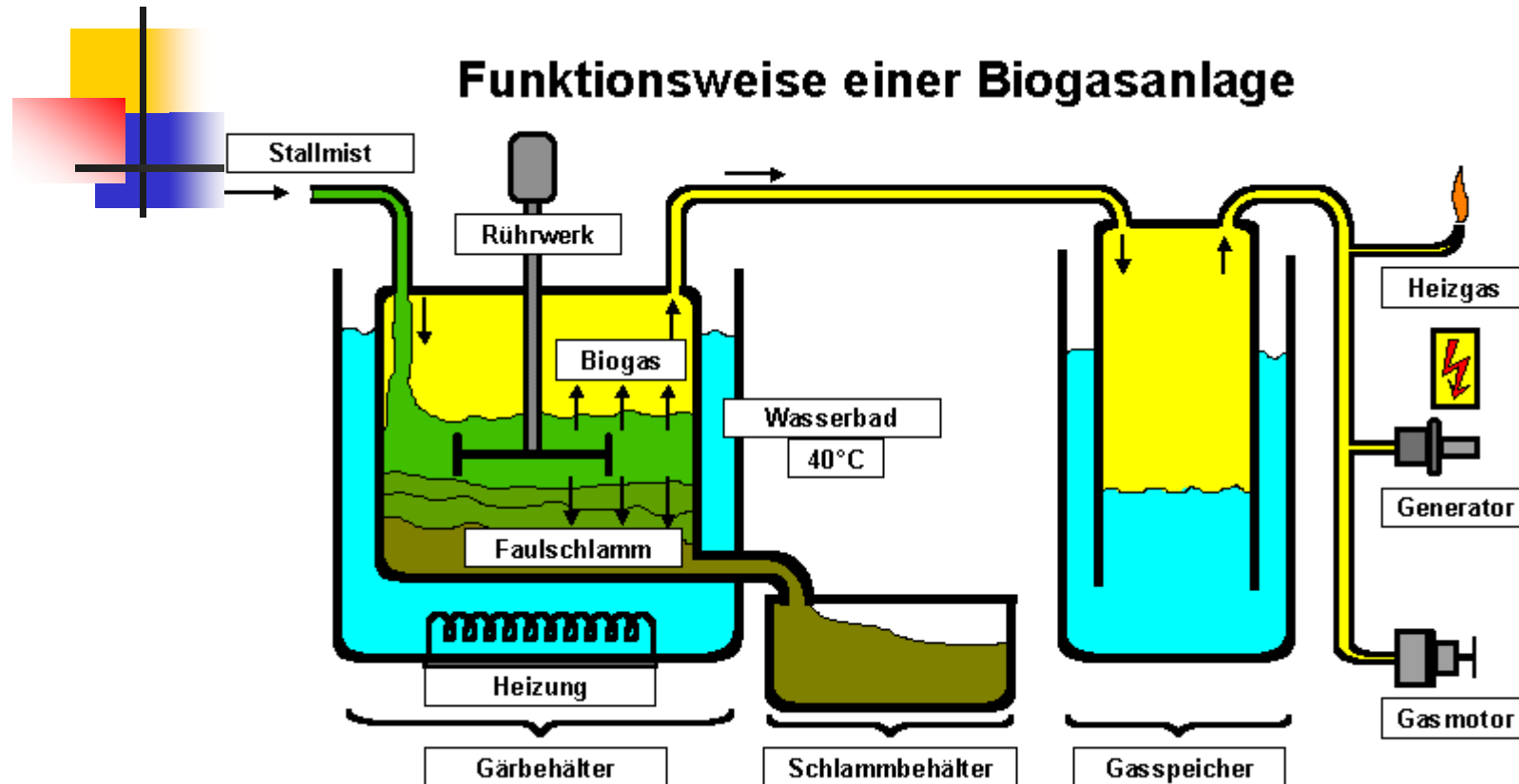
- Biomasa koja je nastala kao proizvod probavnog sustava domaćih životinja-stajski gnoj i
- biomasa koja se dobiva izravno preradom ili drva ili se drvo pak koristi isključivo za tu namjenu



Farm izvor ZORG™



izvor: www.seilnacht.com/referate/biogas01.htm



U fermentatoru se u kontroliranim uvjetima iz izmeta životinja-stajskog gnoja proizvodi bioplin koji sadrži metan. Taj metan se može do potrebne čistoće izdvojiti iz bioplina te ga je moguće utiskivati u plinovod zajedno sa prirodnim plinom (tzv. zeleni plin). Moguće ga je izravno koristiti kao energent u kogeneracijskom postrojenju za proizvodnju električne i toplinske energije.

Termoelektrana se opet nameće Turopolju



Uvid u studiju počinje 20. prosinca, a traje do 18. siječnja 2013, svakim radnim danom od 8 do 15 sati. Studija će biti javno prezentirana 15. siječnja, naravno, u 14 sati u gradskoj vijećnici. Prigovori i primjedbe mogu se dostaviti do 25. siječnja

Nedavno je u Jutarnjem listu objavljen skromni poziv na javnu raspravu o Studiji utjecaja na okoliš termoelektrane koja bi se trebala izgraditi na ledini između Velike Gorice i Novoga Čiča, tik uz cestu za Vukovinu. Uvid u studiju počinje 20. prosinca, a traje do 18. siječnja 2013, svakim radnim danom od 8 do 15 sati. Studija će biti javno prezentirana 15. siječnja, naravno u 14 sati u gradskoj vijećnici. Prigovori i primjedbe mogu se dostaviti do 25. siječnja. Previše je uočljivo da je javna rasprava organizirana u blagdansko vrijeme kad je, od zakonom propisanih 30 dana, barem polovica neradna. I dnevni uvid je pomno izabran, do 15 sati, a većina Velikogoričana radi do 17. I javna prezentacija je usred dana kako bi joj što manje građana moglo prisustvovati. Sve navodi na pomisao da nam nepoznati ali moćni čimbenici opet pokušavaju poturiti termoelektanu.

Zbrda - zdola studija

Prvi put, u proljeće ove godine, projekt izgradnje termoelektrane na bio masu, najavljen je na sva zvana. Građanima je predstavljeno da je to fantastičan projekt koji će povećati zaposlenost, riješiti problem grijanja velikogoričkih zgrada koje se griju na skupi mazut, iako je toplinska energija tek sekundarni proizvod, a glavni je električna energija. Poslije izgradnje termoelektrane, koja bi zapošljavala jedva 12 ljudi, sve bi bilo jeftinije i ljepše. Samo što se zavirilo u Studiju o utjecaju na okoliš, postalo je uočljivo da je riječ o zbrda – zdola sklepanoj alibi studiji. Svemoćni HEP i građevinski lobi koji želi investiciju od 85 milijuna eura, mislili su da će projekt proći bez ozbiljne rasprave i truda, pa su građanima poturili jednu improvizaciju. Mislili smo „lako ćemo“,

kad im se dogodila Akcija za Turopolje, istinska građanska inicijativa iz Novoga Čiča. Akcija je digla cijelo Turopolje na noge, angažirala stručnjake koji su dokazali da je riječ o megalomanskom projektu. Zgrada termoelektrane bila bi svega kilometar od Velike Gorice, Novog Čiča i Vukovine. Radila bi na šumsku bio masu snage 22,5 MW električne energije i 35 MW toplinskog učinka. U Europi se takva mamutska postrojenja smatraju neisplativima. Njezina veličina je monstruoza, betonski „bunker“ visok četrdesetak metara s dimnjakom od 75 metara. Takva grdosija bi trebala gutati 29 šlepera drvene sječke dnevno (!?) za koju Studija ne kaže gdje će se nabaviti? Studija je još neodređena glede odlagališta pepela koji će ostati u ogromnim količinama iza spalionice sječke. Odlagalište naprosto nije određeno. Studija je potpuno šlampava po pitanju zaštite zraka i podzemnih voda. Sve bi se riješilo velikim pročistačima.

Sporna europska praksa

Europska praksa je različita. Ima primjera da male bio elektrane dobro posluju, a velike su neisplative. U obližnjoj Austriji izgrađeno je čak stotinjak bio elektrana, ali zatvaraju se jedna po jedna. Prvi problem je nedostatak bio mase. Kada je država prestala sufinancirati projekte, bio masa je, zbog manjka na domaćem tržištu, uvažana (i iz Hrvatske) po znatno većim, čak dvostrukim cijenama

od planiranog. Time je priča o jeftinoj električnoj energiji bila završena. Struja od bio mase postala je znatno skuplja od hidroenergije.

Zanemaren smrad

Veliki problem sa bio elektranama u naseljenim područjima je nesnosan smrad koji nastaje kao produkt paljenja drvene sječke i svakojakog drvenog otpada opterećenog ljepilima, otapalima, lakovima i lazurama za drvo. Većina gradova je vrlo brzo zatvorila bio elektrane zbog čudovišnog smrada i zbog emisije fine prašine koji pročistači i filtri izbacuju uokrug 5 kilometara od termoelektrane. Jedan Velikogoričanin koji je upoznat s praksom u Europi kaže da možemo zaboraviti igru na čistom zraku ili sušenje rublja na otvorenom, jer najfinija prašina pepela prodire u sve i stvara sivu milimetarsku patinu.

Bioelektrana kontra turizma

Nedavno je javnosti prezentiran urbanistički plan uređenja jezera Čiče. Kupališta, restorani, zabavni

Glasnik Turopolja

22.12.2012

Tko će ubiti šumu?

Otpadne vode bi se ispuštale u Želin i Lomnicu te prirodnim vodotokovima završavale u Odri – posljednjoj turopoljskoj rijeci koja je još koliko-toliko – toliko nezagađena. Potencijalno zagađenje Odre je, po mom mišljenju najgori dio plana izgradnje termoelektrane. Silne otpadne vode i pepeo uništile bi Odru koja dvaput godišnje plavi Turopoljski lug, prirodnu hrastovu godinu koja se očuvala doslovce tisućama godina. Tko uništi Odru u kojoj je još više od sto vrsta riba uništiti će i zaštićeni Turopoljski lug zaštićeno Odransko polje i sva naselja uz Odru. Tamo gdje se ubije šuma nastaje pustoš i pustinja. Drastično se mijenja klima i vegetacija, uvjeti za život čovjeka postaju vrlo teški i nemogući. Zato je izgradnja bioelektrane jednaka biocidu, uništenju života u prelijepom Turopolju.

Odgovornost političara

One političare koji javno ili tajno podrže ili omoguće tako, po život svih građana, katastrofalan projekt, treba proglasiti zločincima i zauvijek izgnati iz društvenog života Turopolja. Tu kompromisa ne smije biti. Gubitak izbora nije za takve ljude nikakva kazna. Naši životi i životi naše djece i budućih generacija ne smiju biti onemogućeni zbog neodgovornih, korumpiranih ulizica i beskičmenjaka koji naloge Europske unije slušaju zbog privatnih interesa i nešto Judinih škuda. Već podatak da je javna rasprava organizirana u vrijeme božićnih i novogodišnjih praznika inicira sumnju da se zločinački projekt pokušava potihom progurati. Uz pobuđenu svijest da su ugroženi naši životi i opstanak i angažiranost Akcije za Turopolje, takvo što se neće dogoditi. Javna rasprava simbolično počinje na dan „smaka svijeta“ koji bi se i dogodio da se termoelektrana izgradi usred ravna Turopolja.

Aleksandar Božić

BARIŠIĆ: NISAM LUD DA SAM KONTRA GRAĐANA

O bioelektrani bilo je govora na aktualnom satu sjednice Gradskog vijeća od 20. prosinca. Vesna Škare Ožbolt osvrnula se na bioelektranu i na priču da gradonačelnik Barišić podržava projekt. Tražila je jasan odgovor - da ili ne? Što se tiče bioelektrane gradonačelnik kaže: „Naravno da nisam za, nisam lud da idem kontra svojih sugrađana. Predlažem da pogledamo dokumente i uhvatimo nit. Pogledajmo tko je investitor, tko je donio prostorni plan, tko je donio studiju utjecaja na okoliš“. Barišić je aludirao da je bioelektrana projekt HNS-a kojeg je u javnost plasirao saborski zastupnik Goran Beus Richembergh još 2005. godine, a realizacija je krenula 2009. za vrijeme Tonina Picule.

Iz drvene biomase dobivaju se tri osnovna proizvoda koji se koriste u energetske svrhe. peleti, briketi i sječka



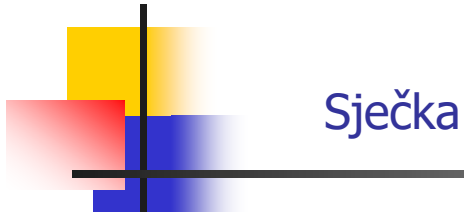
Osnovne karakteristike peleta:

gustoća	≈650 kg/m ³
promjer:	≈6mm
dužina	do 30 mm
sadržaj vode	do 10%
udio drvene prašine	1 % (javlja se kod transporta)
d. topl. vrijednost	≈5 kWh/kg (18000kJ/kg)
ostatak pepela nakon gorenja:	0,5%



Osnovne karakteristike briketa:

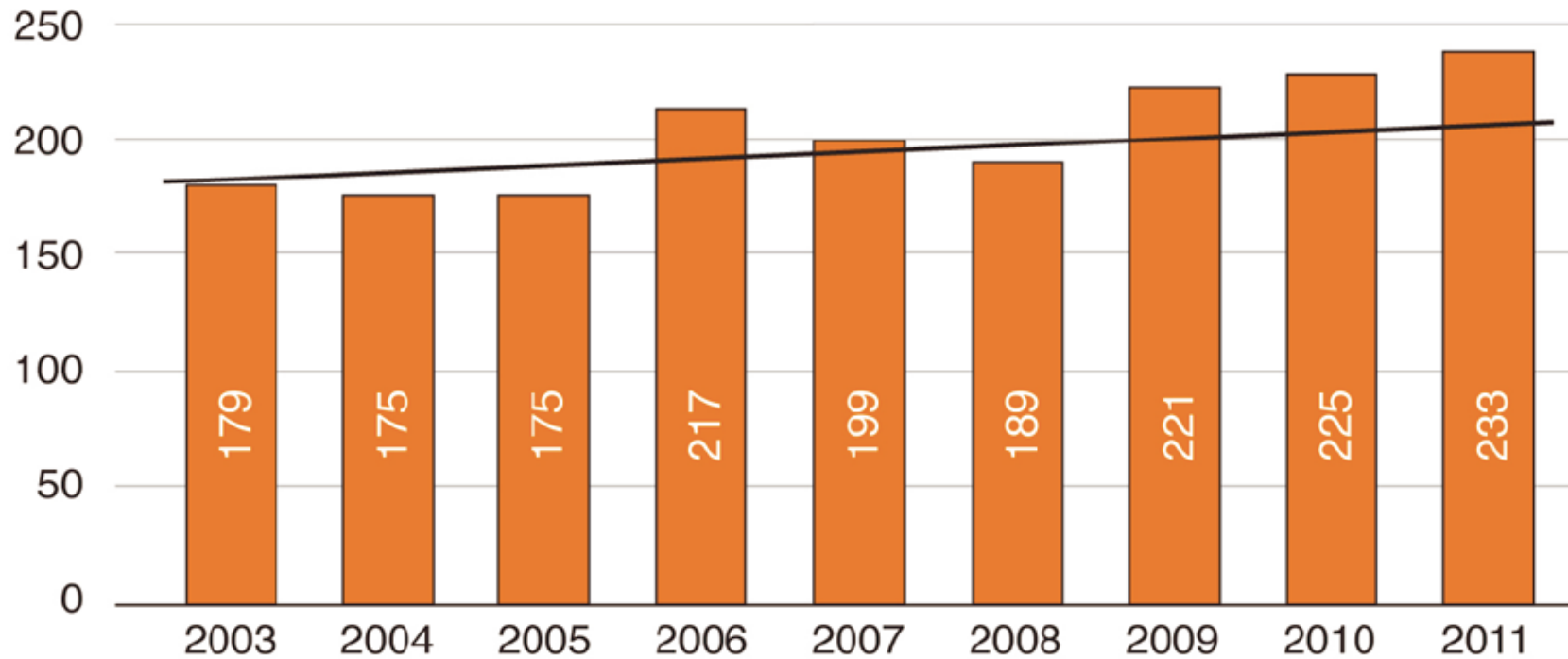
svojstva	drveni briket	ogrijevno drvo	smeđi ugljen
oblik i mjere	ø 90 mm	-	-
sadržaj vlage	oko 10%	10 - 20%	12 - 60%
sadržaj pepela	0,35%	< 0,5%	2 - 10%
sadržaj sumpora	ø	ø	2%
gornja topl. vrijednost	17.600 kJ/kg	-	-
donja topl.vrijednost	16.500 kJ/kg	14.700 - 16.700 kJ/kg	8.400 - 20.100 kJ/kg



Sječka



Prosječna godišnja
cijena EUR/t





Lindner
Sommerauer



Biomasse - Heizanlagen

Miscanthus

(Elefantengras)



Lindner
Sommerauer

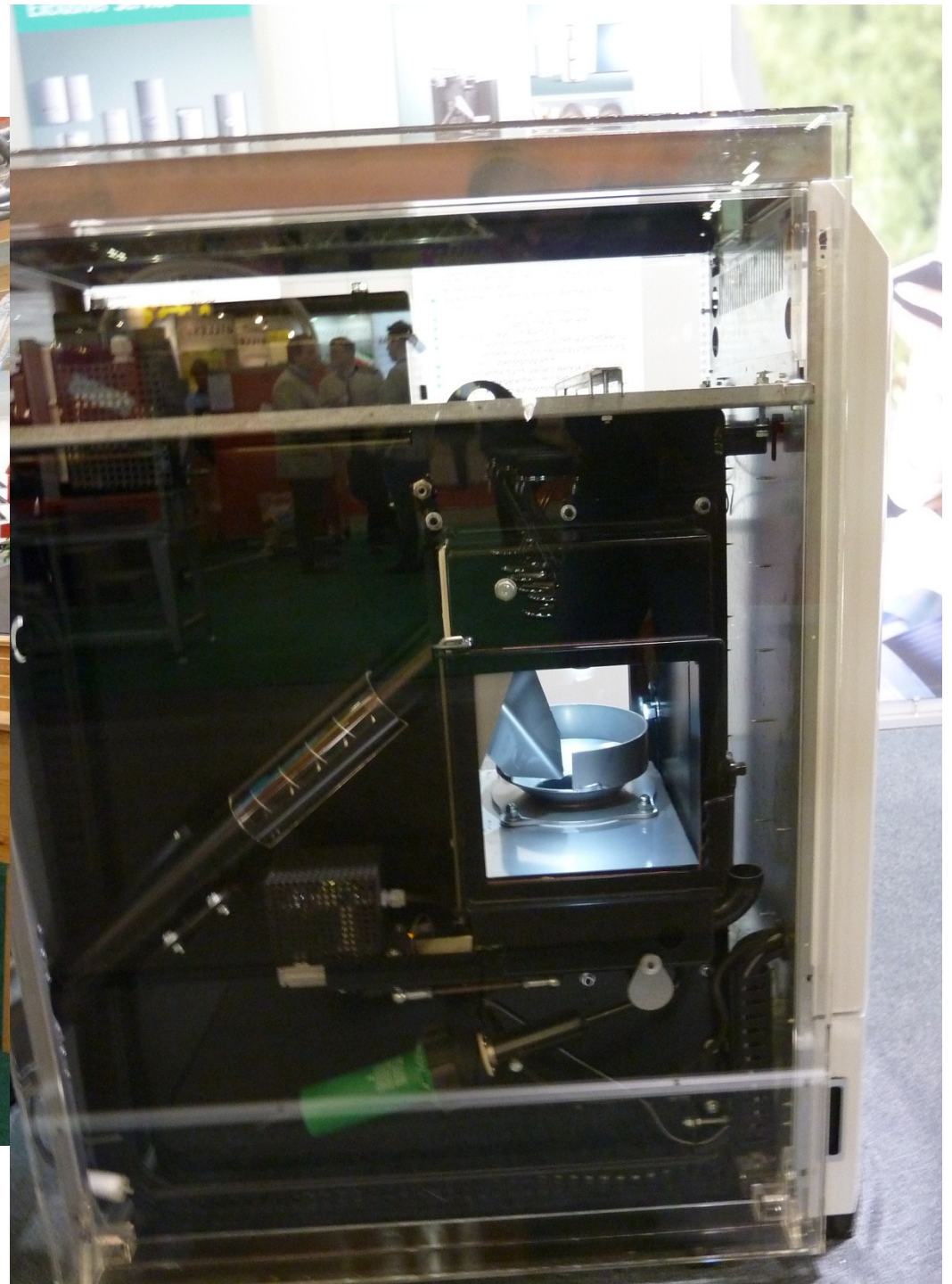


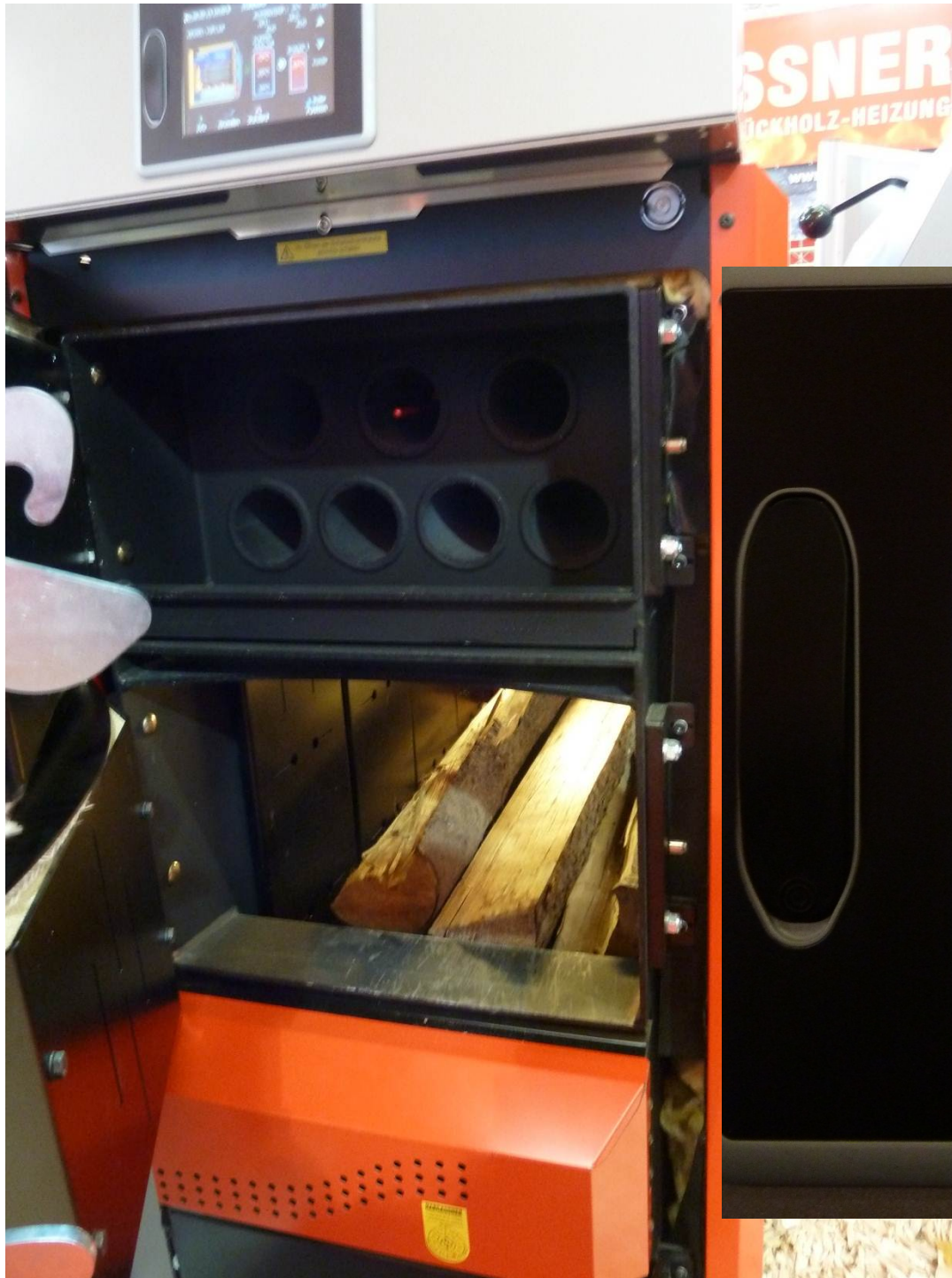
Biomasse - Heizanlagen

Holzpellets

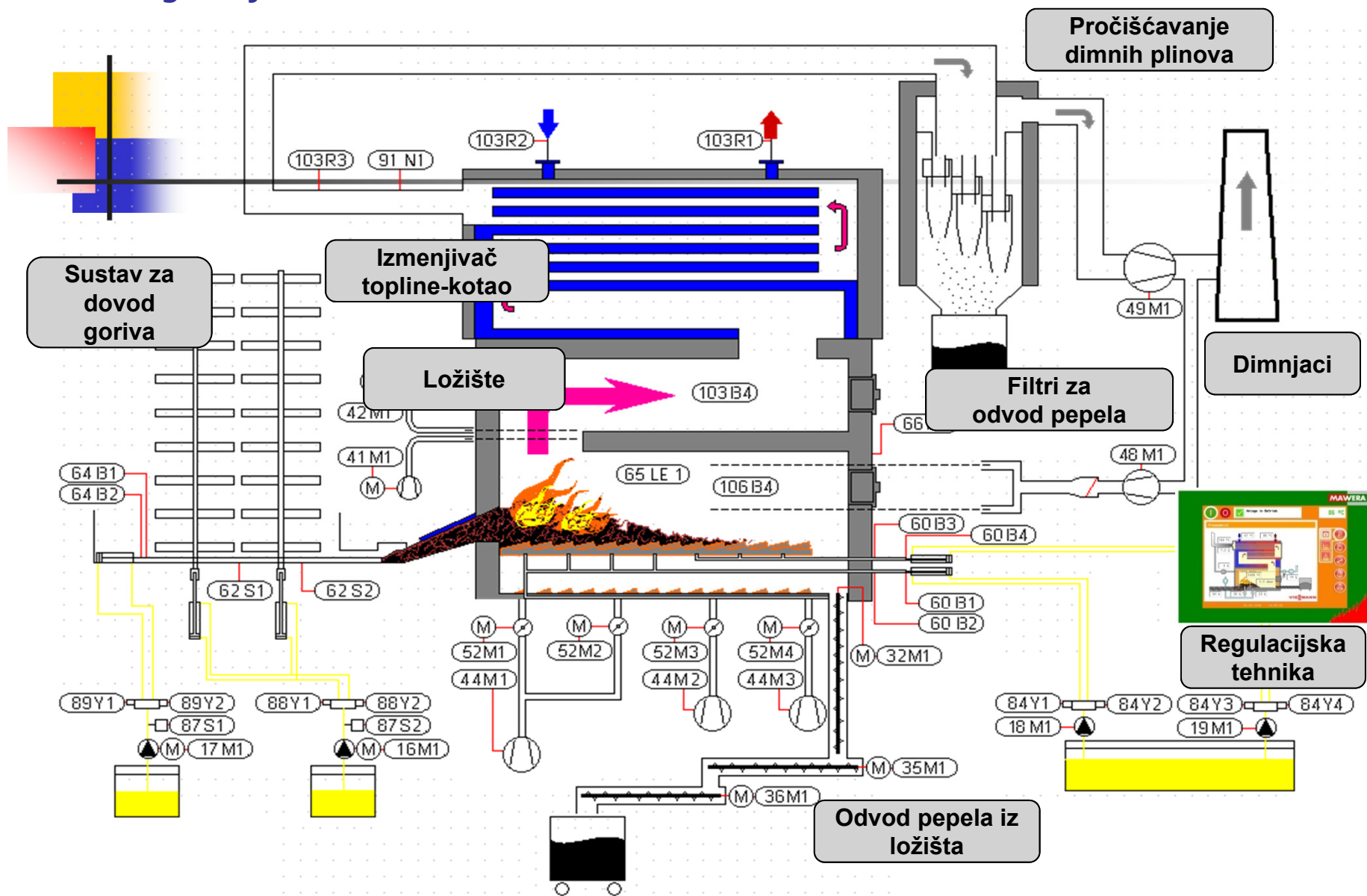








Izgaranje biomase





Neka druga razmišljanja.

*Stupanj djelovanja nekih postrojenja
i uređaja za transformaciju primarnog oblika energije*

Postrojenje	Stupanj djelovanja
Starije parne termoelektrane	33% i manje
Novije parne termoelektrane	oko 40%
Plinsko-turbinske elektrane	oko 40%
Plinsko-parna termoelektrana	oko 60%
Kogeneracijska elektrana	do 85%
Velika hidroelektrana	do 95%
Sunčani kolektor, jednostavni	oko 45%
Fotonaponska ćelija – amorfna	do 6%
Fotonaponska ćelija – multikristalna	11-14%
Fotonaponska ćelija – monokristalna	12-16%
Geotermalne elektrane, električno korištenje	oko 15%


Izvor: www.strom.de



Ukupna emisija klimatski štetnih plinova¹ iz elektrana (CO₂-ekvivalent, gram/kWh)

Tip elektrana	Izravna emisija	Neizravna emisija	Ukupna emisija
Velike hidroelektrane	3,5-40	10-20	13,5-55
Male hidroelektrane	3,5-35	15-20	18,5-55
Vjetroelektrana 600 kW	0	40	40
Vjetroelektrana 1,5 MW	0	50	50
Elektrana na biomasu 700 kW	13	50	63
Elektrana na biomasu 11,5 MW	18	45	63
Velika fotonaponska elektrana	0	180	180
Mala fotonaponska elektrana	0	220	220
Konv.termoelektrane na plin	340	80	420
Konv.termoelektrane na kam.ugljen	820	100	920

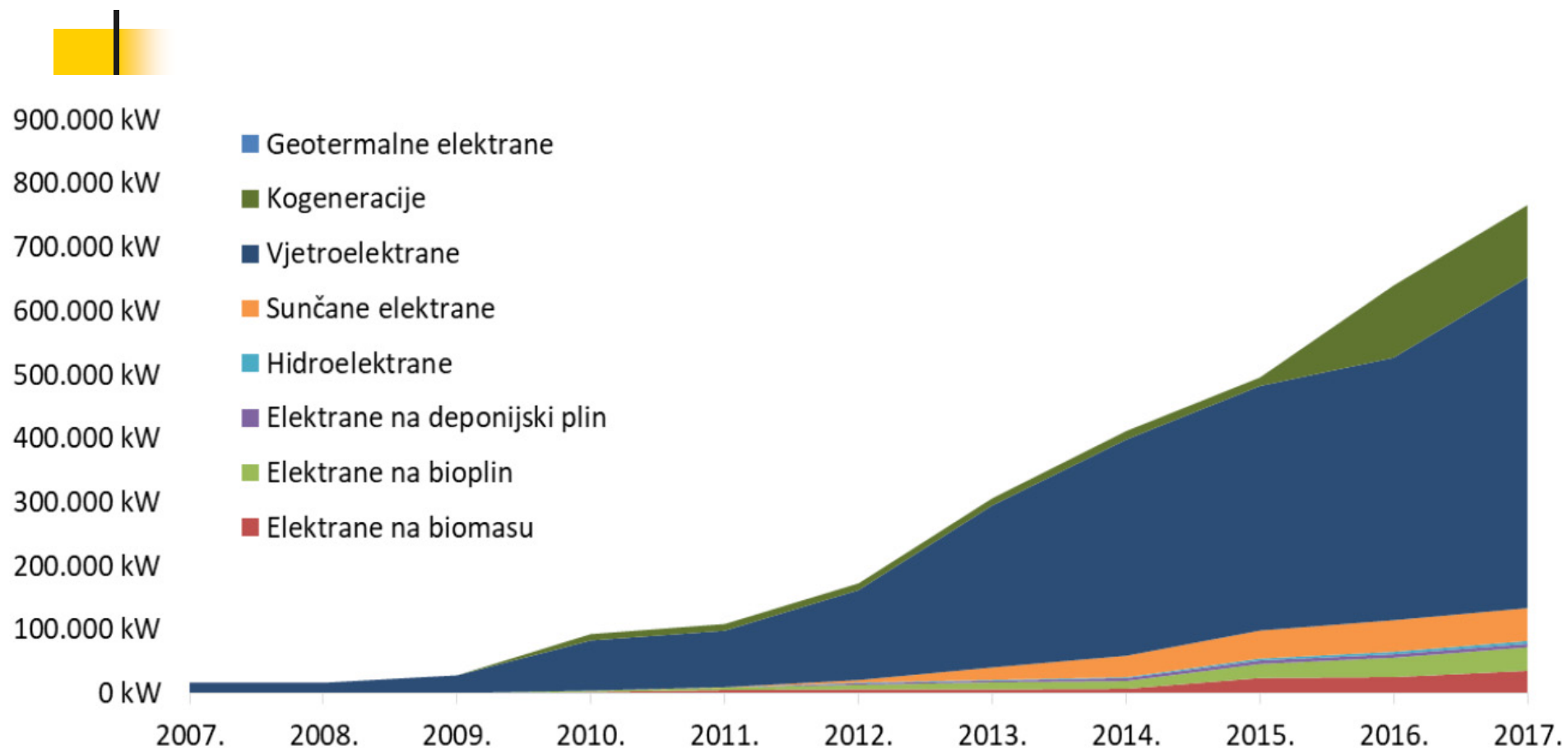
Izvor: VEÖ-Journal 3/2004



Troškovi nekih izvora električne energije

Tip izvora	Veličina (MW)	Investicijski troškovi (€/kW)	Troškovi pogona (€/kWh)
Hidroelektrane (mali pad)	5	900-1000	0,02-0,03
Kombi-elektrane	40	550-850	0,04-0,06
Kogeneracija	5	800-850	0,05-0,06
Vjetroelektrane (na kopnu)	15	900-1300	0,04-0,09
Vjetroelektrane (na moru)	100	1500-2000	0,05-0,12
Gorivne stanice	5	1100-1600	0,08-0,10
Fotonaponski sustavi	5	6000-10000	0,75-1,00

Izvor: Utjecaj vjetroelektrane na naponske i strujne prilike u elektroenergetskoj mreži, Energetski institut «Hrvoje Požar», Zagreb, veljača 2003



Izvor: HROTE

Slika 4.6.1. Instalirana snaga postrojenja u sustavu poticaja u razdoblju od 2007. do 2017. godine prema vrsti postrojenja

Prosječna ponderirana cijena električne energije koja je u 2017. godini isplaćena povlaštenim proizvođačima u sustavu poticaja (0,84 kn/kWh) je preko dva puta veća od godišnjeg prosjeka cijena električne energije na tržištu dan unaprijed na mađarskoj i slovenskoj burzi električne energije (0,38 kn/kWh).

Odlukom o naknadi za obnovljive izvore energije i visokoučinkovitu kogeneraciju, koju je **Vlada Republike Hrvatske** donijela 31. kolovoza 2017. godine, od 1. rujna 2017. godine povećale su se visine naknada za obnovljive izvore energije i visokoučinkovitu kogeneraciju s 0,035 kn/kWh na 0,105 kn/kWh, odnosno s 0,005 kn/kWh na 0,007 kn/kWh za kupce koji su obveznici ishođenja dozvole za emisije stakleničkih plinova. Time se osjetno povećala krajnja cijena električne energije koju plaćaju krajnji kupci. Istovremeno, zbog načina financiranja sustava poticanja, smanjio se udio opskrbljivača električnom energijom u prikupljenim sredstvima za sustav poticaja, s 58% na 52%.

S početkom rada EKO bilančne grupe trebala je prestati obveza opskrbljivača električnom energijom u pogledu preuzimanja električne energije koju HROTE otkupljuje od

Tablica 4.6.3. Proizvodnja i isplaćeni poticaji povlaštenim proizvođačima u 2017. godini prema vrsti postrojenja

Vrsta postrojenja/primarni izvor energije	Broj postrojenja	Instalirana snaga [MW]	Proizvodnja električne energije [MWh]	Udio u proizvodnji [%]	Isplaćeni poticaji (bez PDV-a) [mil. kn]	Udio u isplatama [%]
Sunčane elektrane	1.223	51,49	73.996	3,25%	142,88	7,47%
Hidroelektrane	12	4,48	15.867	0,70%	15,30	0,80%
Vjetroelektrane	21	519,00	1.178.211	51,74%	874,21	45,70%
Elektrane na biomasu	17	35,95	186.011	8,17%	234,48	12,26%
Geotermalne elektrane	0	0,00	0	0,00%	0,00	0,00%
Elektrane na bioplin	32	36,73	278.661	12,24%	356,52	18,64%
Elektrane na deponijski plin i plin iz postrojenja za pročišćavanje otpadnih voda	2	5,50	78	0,00%	0,03	0,00%
Kogeneracije	6	113,29	544.497	23,91%	289,36	15,13%
Ukupno	1.313	766,45	2.277.321	-	1.912,78	-

Izvor: HROTE