University of Zagreb
Faculty of Mechanical Engineering and Naval Architecture
DEPARTMENT OF ENERGY, POWER ENGINEERING AND ENVIRONMENT

"Kako planirati, financirati i voditi projekte s integracijom mjera energetske učinkovitosti u urbanoj obnovi„

„Pametni gradovi i integracija solarnih fotonaponskih sustava"

Doc. dr. sc. Goran Krajačić

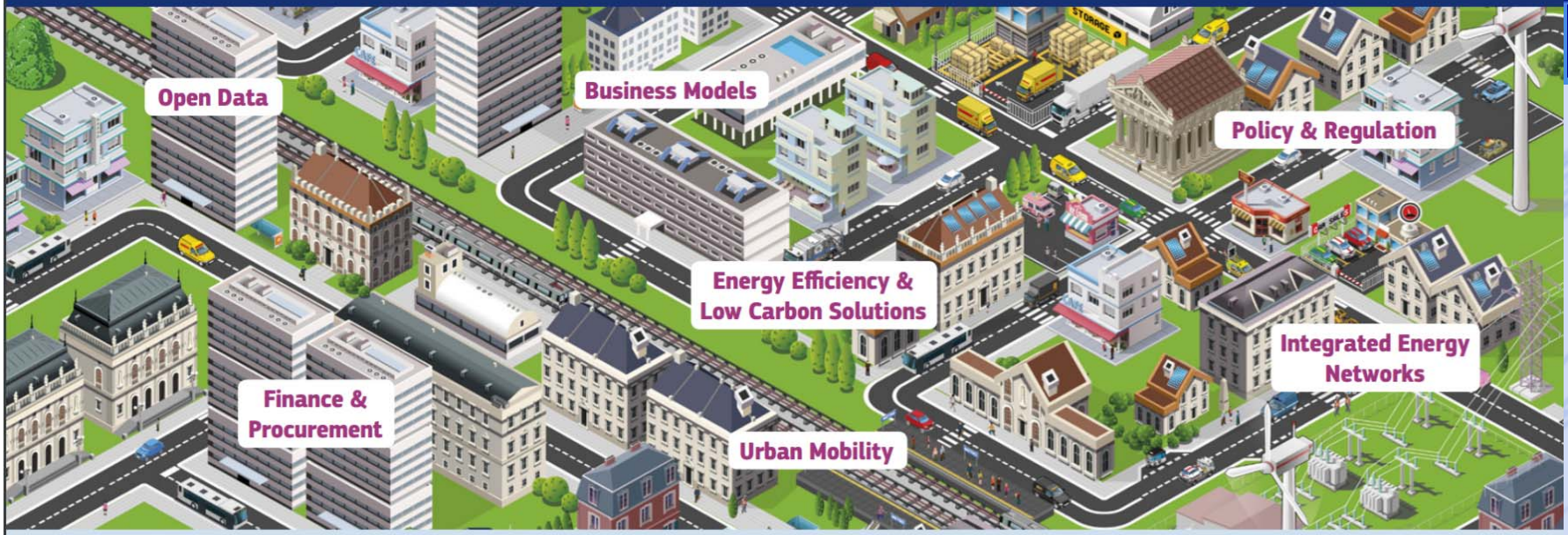
15.2.2017. Zagreb

Beyond Energy Action Strategies BEAST
Co-funded by the Intelligent Energy Europe Programme of the European Union

European Innovation Partnership

Smart Cities & Communities

Invitation for Commitments



❶ Smart Cities and Community a European Innovation Partnership

How to make our cities smarter?

The Partnership integrates the **ICT**, **energy** and **transport** sectors. It aims to apply innovative solutions to tackle issues such as **congestion**; **air pollution**; **high energy costs** and to achieve **better mobility**; **cleaner urban environment**; **energy efficiency**.


congestion


air pollution


high energy costs

better mobility

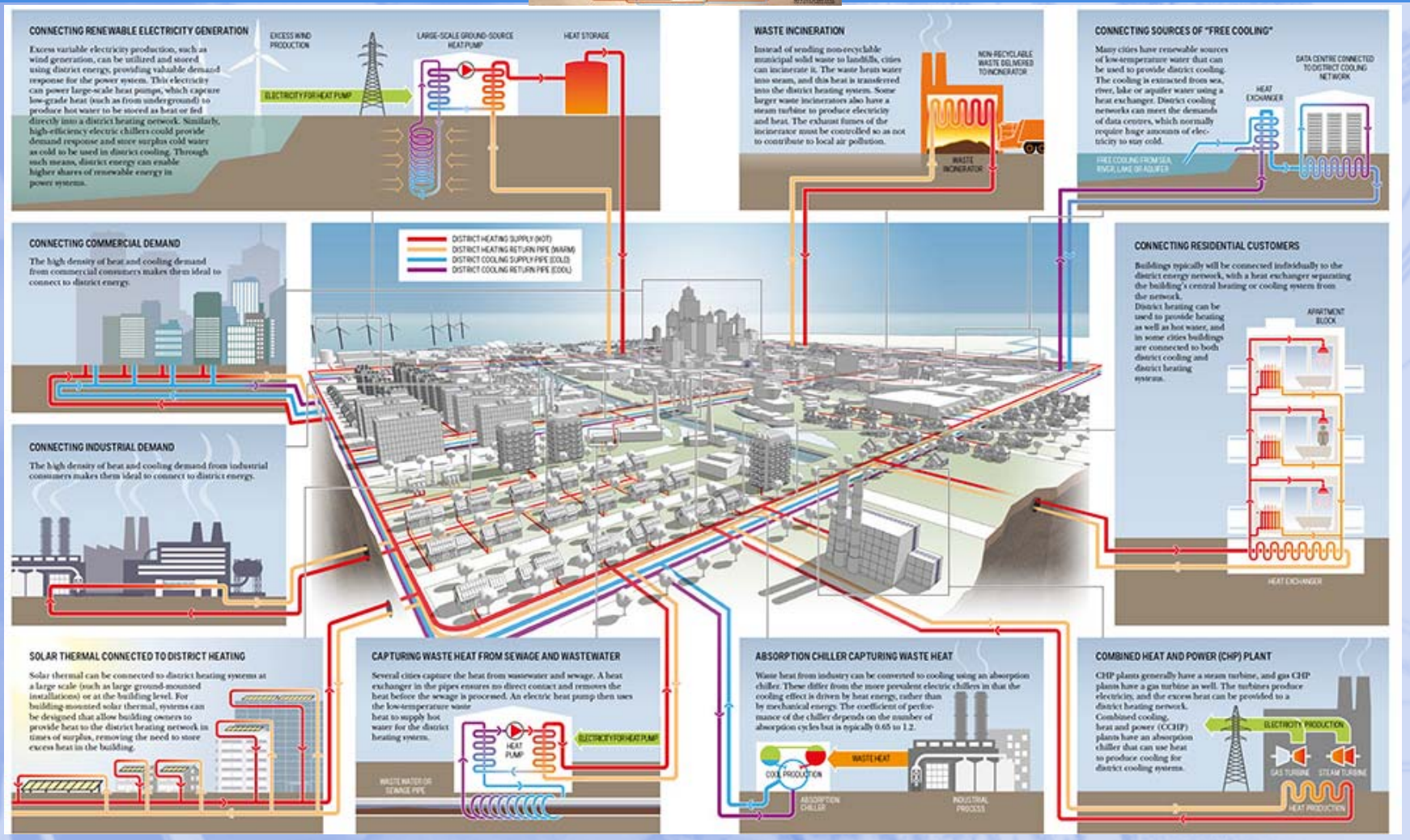

cleaner urban environment

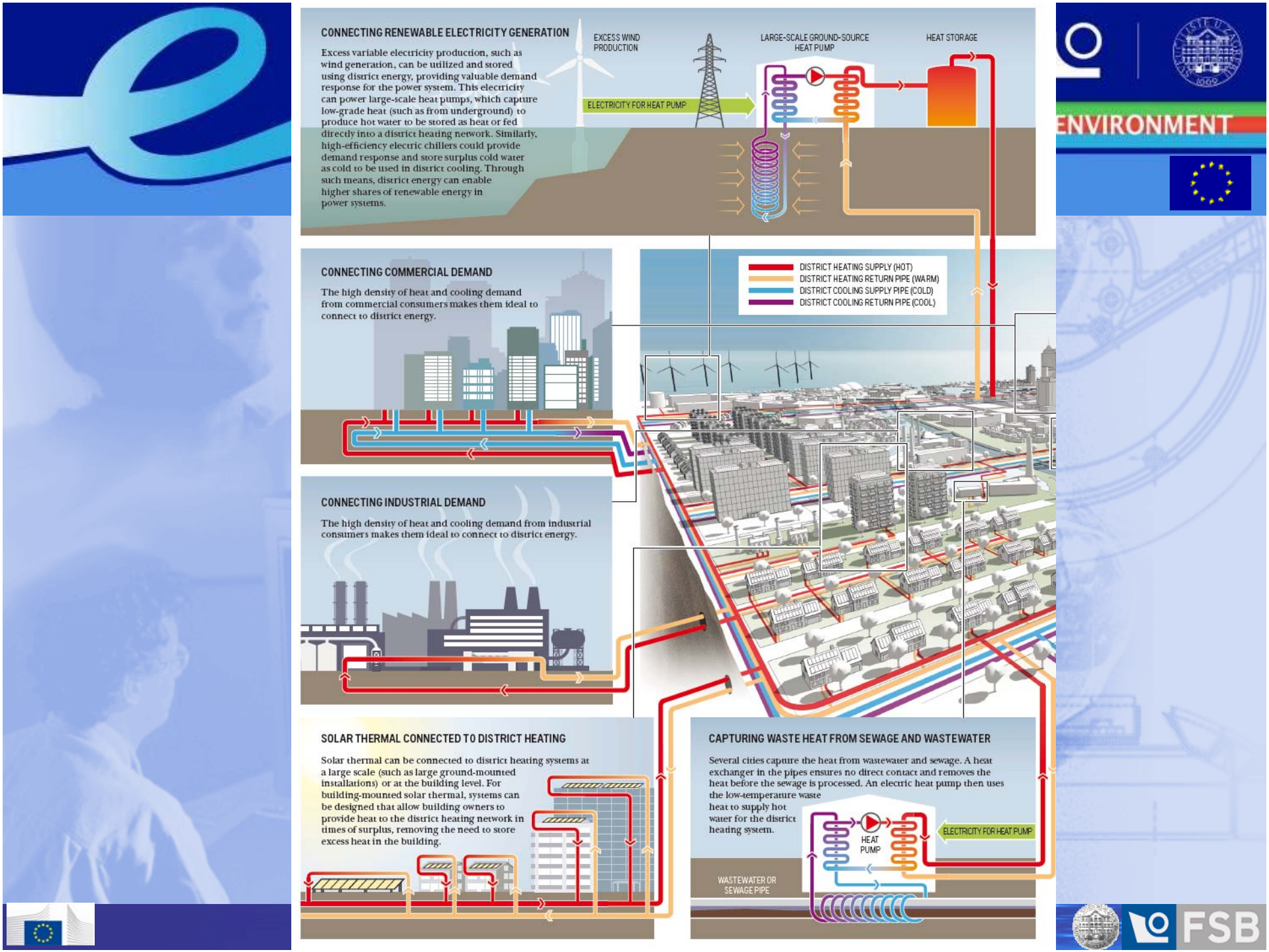

energy efficiency

Beyond Energy Action Strategies BEAST

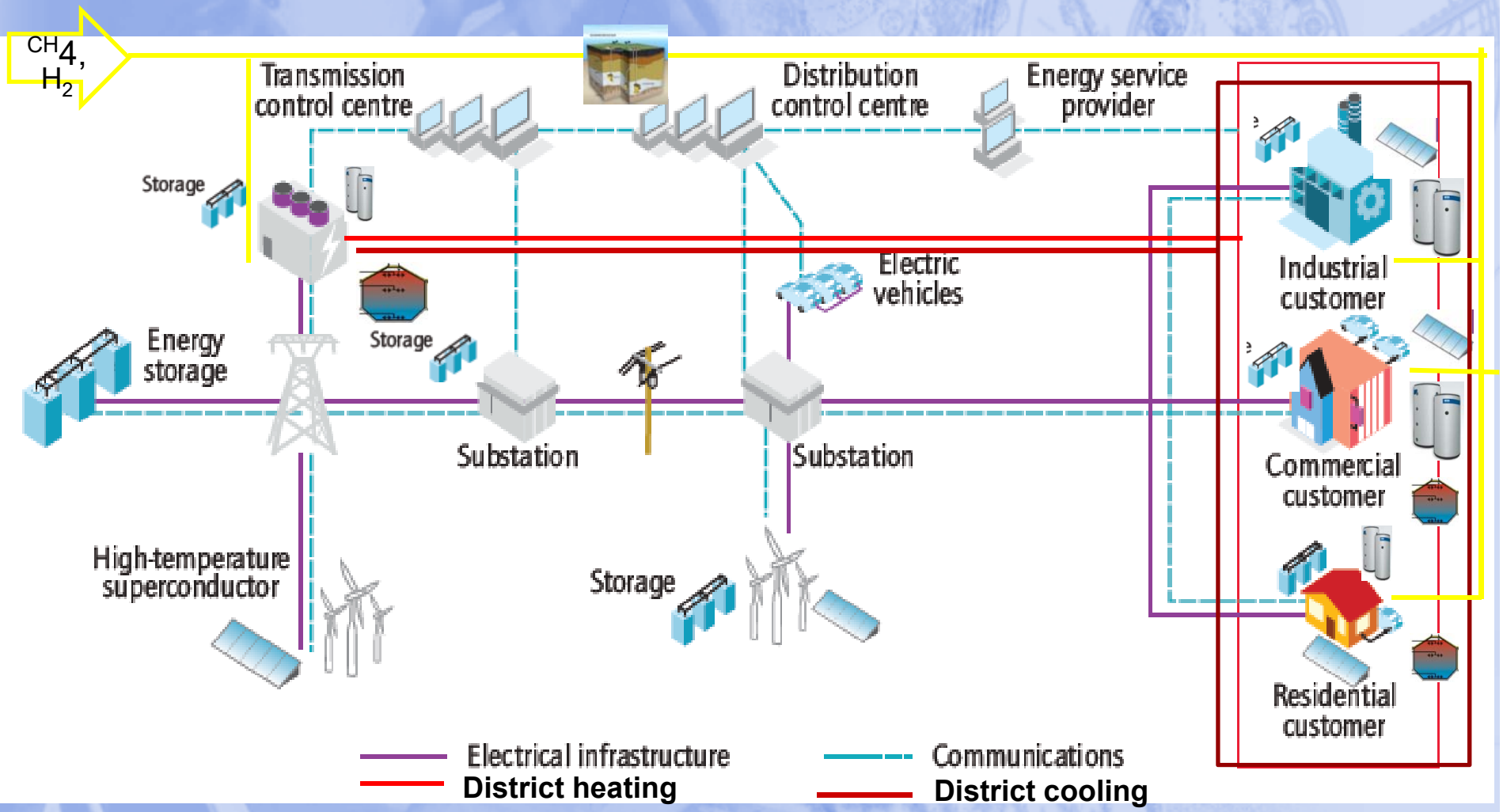
Co-funded by the Intelligent Energy Europe Programme of the European Union

DISTRICT ENERGY IN CITIES




CONNECTING RENEWABLE ELECTRICITY GENERATION
Excess variable electricity production, such as wind generation, can be utilized and stored using district energy, providing valuable demand response for the power system. This electricity can power large-scale heat pumps, which capture low-grade heat (such as from underground) to produce hot water to be stored as heat or fed directly into a district heating network. Similarly, high-efficiency electric chillers could provide demand response and store surplus cold water as cold to be used in district cooling. Through such means, district energy can enable higher shares of renewable energy in power systems.
EXCESS WIND PRODUCTION
ELECTRICITY FOR HEAT PUMP
LARGE-SCALE GROUND-SOURCE HEAT PUMP
HEAT STORAGE
CONNECTING COMMERCIAL DEMAND
The high density of heat and cooling demand from commercial consumers makes them ideal to connect to district energy.
DISTRICT HEATING SUPPLY (HOT)
DISTRICT HEATING RETURN PIPE (WARM)
DISTRICT COOLING SUPPLY PIPE (COLD)
DISTRICT COOLING RETURN PIPE (COOL)
CONNECTING INDUSTRIAL DEMAND
The high density of heat and cooling demand from industrial consumers makes them ideal to connect to district energy.
SOLAR THERMAL CONNECTED TO DISTRICT HEATING
Solar thermal can be connected to district heating systems at a large scale (such as large ground-mounted installations) or at the building level. For building-mounted solar thermal, systems can be designed that allow building owners to provide heat to the district heating network in times of surplus, removing the need to store excess heat in the building.
CAPTURING WASTE HEAT FROM SEWAGE AND WASTEWATER
Several cities capture the heat from wastewater and sewage. A heat exchanger in the pipes ensures no direct contact and removes the heat before the sewage is processed. An electric heat pump then uses the low-temperature waste heat to supply hot water for the district heating system.
HEAT PUMP
ELECTRICITY FOR HEAT PUMP
WASTEWATER OR SEWAGE PIPE

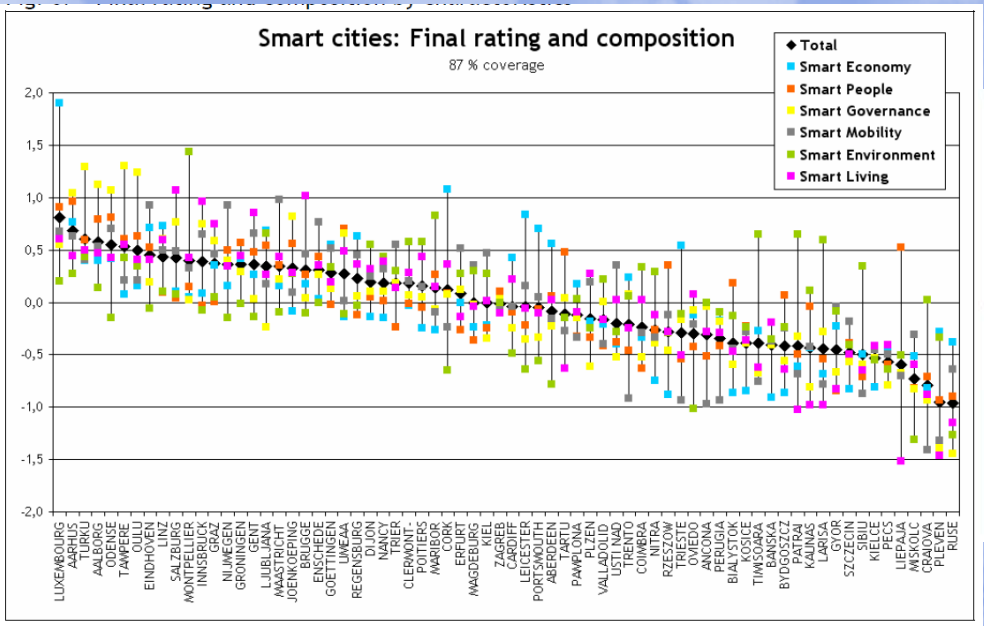
Energetski sustavi suvremenih gradova

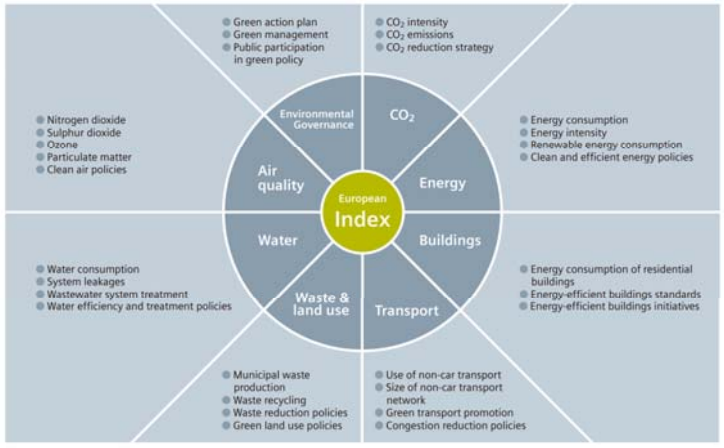


Urbana energetika i pametni gradovi?

Co-funded by the Intelligent Energy Europe Programme of the European Union

Pametni i zeleni gradovi





The European Green City Index evaluates 16 quantitative and 14 qualitative indicators. The methodology for Europe was adapted for the other regional Indexes

Source: the Economist Intelligence Unit, sponsored by Siemens

Julije Domac shared Regionalna energetska agencija Sjeverozapadne Hrvatske's photo — with Velimir Šegon.
8 hrs ·

We don't do it again - before next time! 🙂

Krasna je ovo priča - prijava je odrađena zajednički i u suradnji se kolegama iz HEP-a, HT-a, IBM-a, ZG Holdinga, Razvojne agencije Grada Zagreba, FSB-a, FER-a. REGEA tim je u ime Grada Zagreba bio zadužen za operativnu koordinaciju prijave hrvatskih partnera! Bravo Velimire - još jedan od tvojih epskih uspjeha!

I kao što su rekli naši kolege iz Danske - Thank you for the fight! We don't do it again - before next time. Now it's beer time...

Regionalna energetska agencija Sjeverozapadne Hrvatske
11 hrs · Like Page

Danas smo prijavili projekt vrijedan preko 15 milijuna eura za Grad Zagreb na natječaj programa Obzor2020 (Horizon2020) - Smart Cities and Communities. Osnovni cilj projekta je razvoj pametnih gradova s naglaskom na energetiku, te ostvarenje mjerljivih rezultata u vidu energetskih ušteda i smanjenja emisija CO2. U projektu sudjeluju tri tzv. 'Lighthouse' grada: Zagreb, Albertslund (Danska) te Savona (Italija) i tri tzv. 'Follower' grada, koji nakon provedbe repliciraju iskustvo tri vodeća grada: Nicosia (Cipar), Emden (Njemačka) i Constanta (Rumunjska). U iščekivanju rezultata spremamo nove projekte. #regea #smartcities #pametnigradovi #energetskaučinkovitost

Sun City - Nizozemska

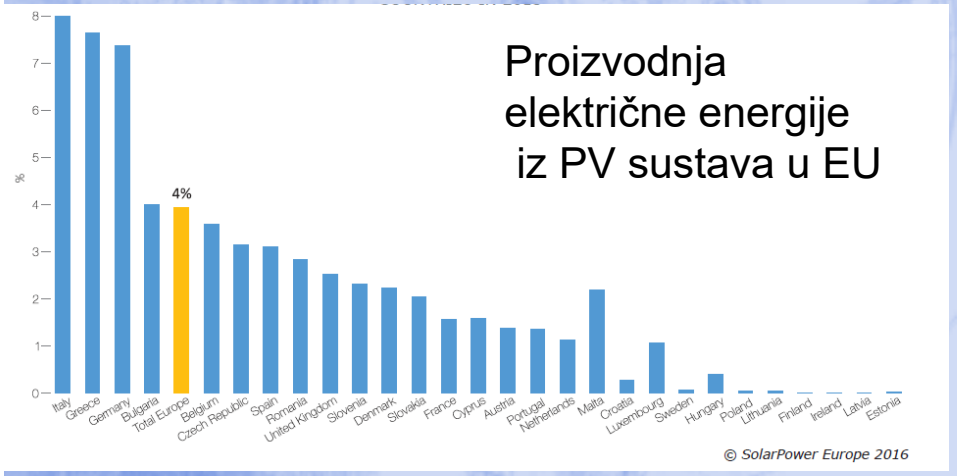
SUN-City Project – Heerhugowaart (NL)

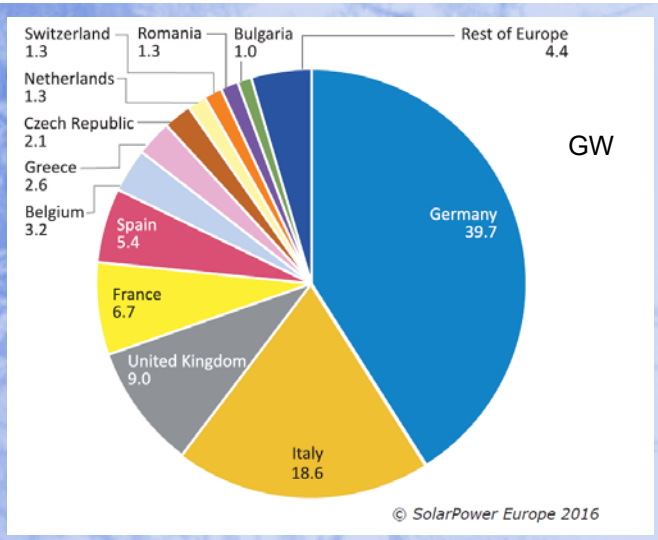
Integracija solarnih fotonaponskih sustava

Tržište fotonaponskih sustava 2015. EU

	2015	2014		%
United Kingdom	3700	2467.3	↗	50.0
Germany	1460	1898.2	↘	-23.1
France	879	927.0	↔	-5.2
Netherlands	400	302.0	↗	32.5
Italy	300	385.0	↘	-22.1
Switzerland	280	320.0	↘	-12.5
Turkey	209	40.2	↗	419.9
Denmark	180	46.7	↗	285.4
Austria	150	159.3	↔	-5.8
Romania	102	72.0	↗	41.7
Belgium	75	90.1	↘	-16.7
Hungary	60	42.1	↗	42.7
Sweden	60	35.1	↗	70.7
Poland	50	26.8	↗	86.6
Spain	49	22.0	↗	122.7
Portugal	28	119.0	↘	-76.5
Malta	20	26.0	↘	-23.1
Croatia	11	12.8	↘	-14.1
Greece	10	17.1	↘	-41.3
Other EU28 markets	40	30.0	↗	33.3
Other European markets	50	20.0	↗	150.0

© SolarPower Europe 2016

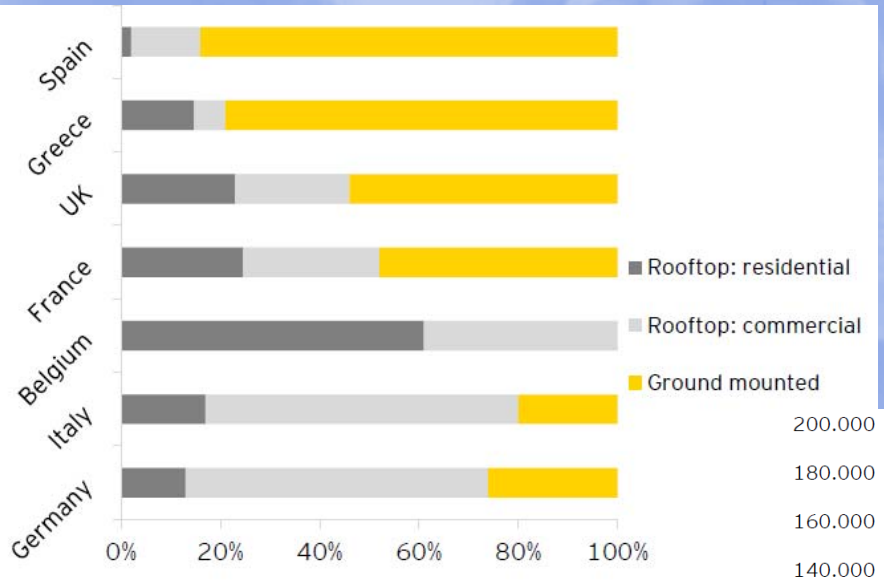


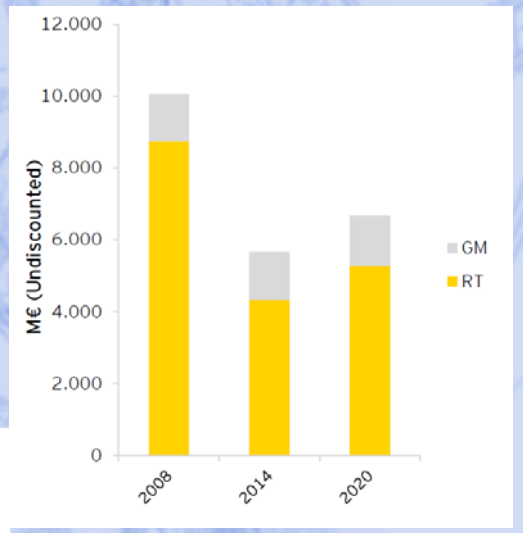


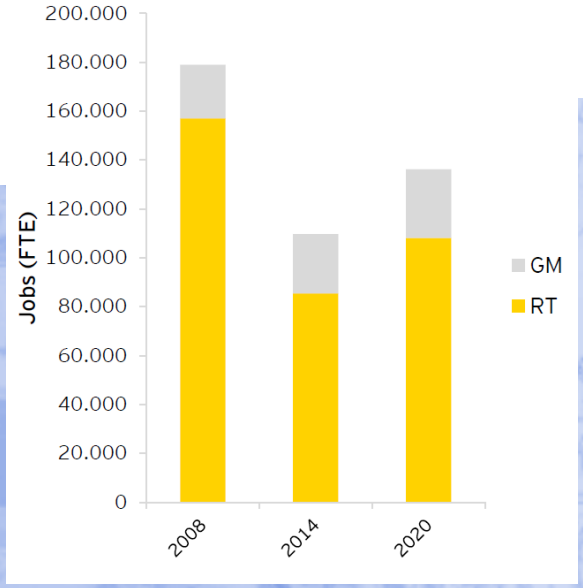
PV indikatori po zemljama EU

Zemlja	Instalirano 2015 [MW]	Kumulativno 2015 [MW]	kW/osobi	kW/GDP
Njemačka	1460	39640	0,4866	1068,46
Italija	300	18920	0,3104	700,74
Belgija	75	3200	0,2842	87,43
Grčka	10	2600	0,2414	160,49
Češka	n/a	2070	0,1965	131,01
Švicarska	280	1360	0,1645	18,63
Bugarska	n/a	1040	0,1447	165,08
Velika Britanija	3700	9080	0,1395	229,29
Danska	180	791	0,1394	16,55
Španjolska	49	5400	0,1163	232,76
Slovenija	1,4	240	0,1162	12,83
Austrija	170	940	0,1092	23,86
Slovačka	2	591	0,1089	40,76
Francuska	850	6550	0,0985	199,70
Nizozemska	400	1288	0,0757	32,20
Rumunjska	102	1301	0,0656	160,62
Portugal	28	460	0,0446	26,59
Hrvatska	10	44	0,0104	4,23

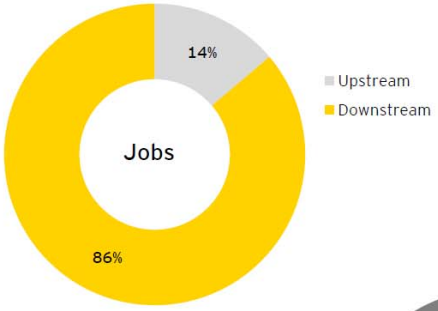
Instalacije, poslovi i tržište fotonaponskih sustava EU-28 (2014.)

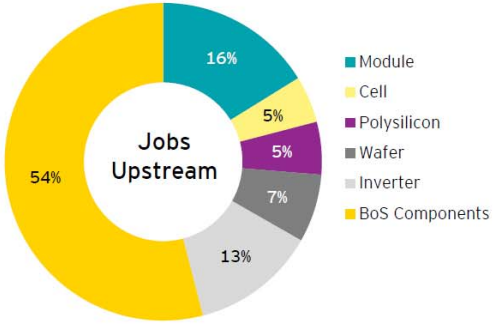


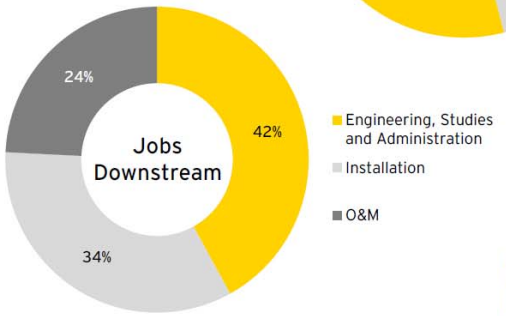


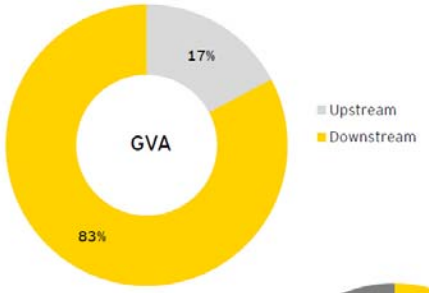


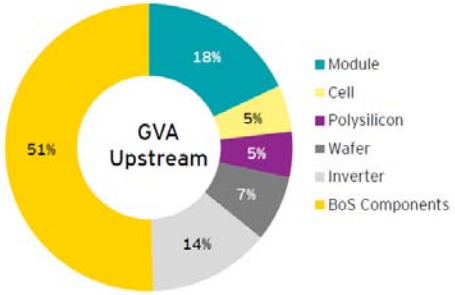
Poslovi i dodana vrijednost u proizvodnji i instalaciji PV sustava EU 28

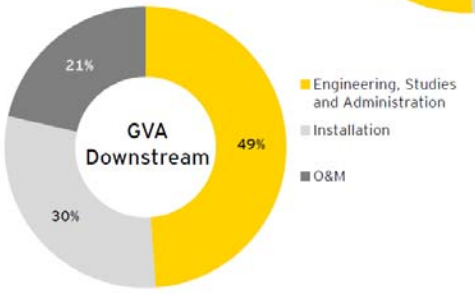












Giga-tvornice za PV?

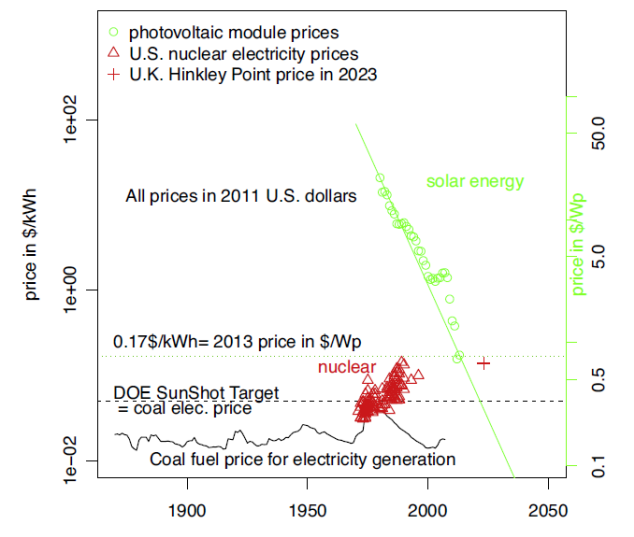
NOVEMBER 4 TSLA: 190.56 3.14

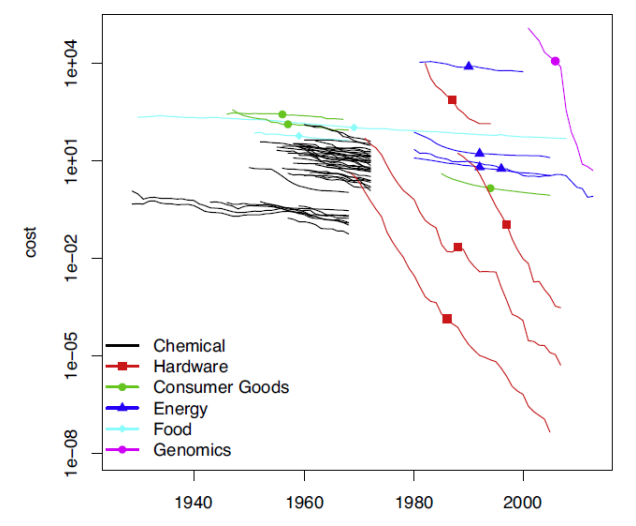
SolarCity's solar Gigafactory will produce up to 10 GW/year under Tesla, says Elon Musk

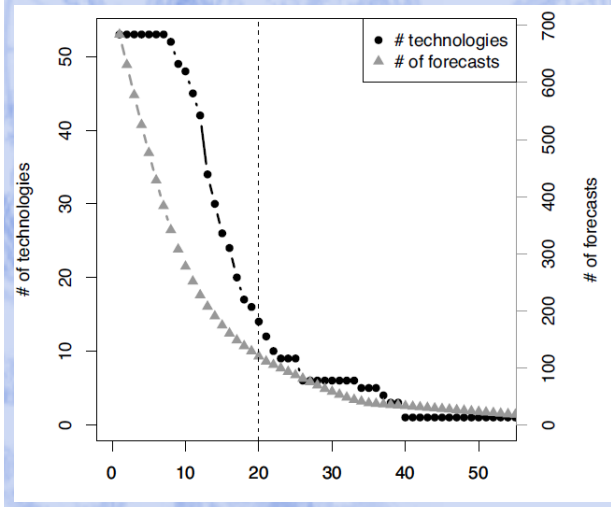
Fred Lambert - 3 weeks ago @FredericLambert

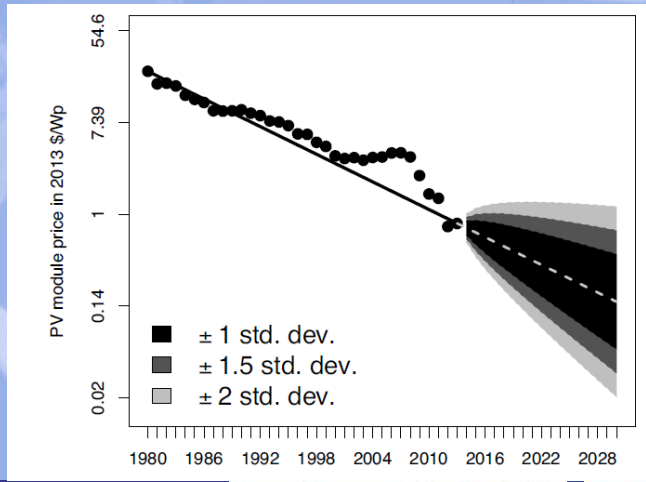
TESLA SOLARCITY PANASONIC

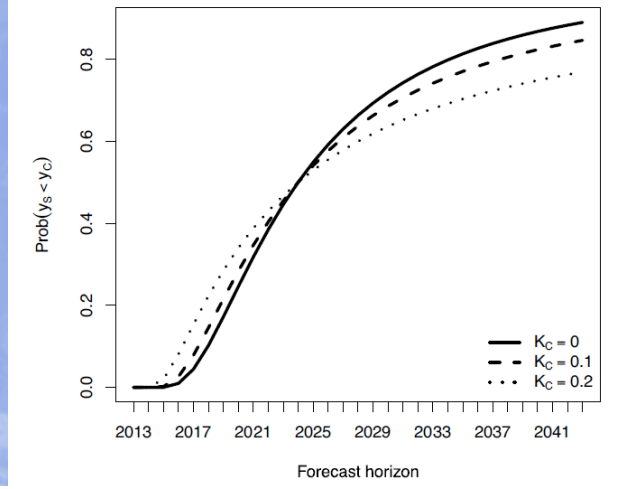
Može li se predvidjeti tehnološki napredak?







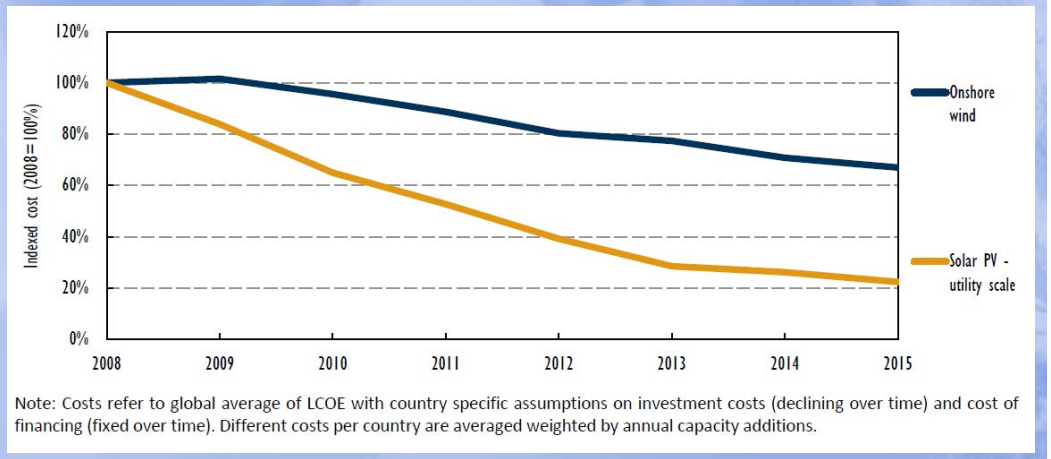




Research Policy 45 (2016) 647–665

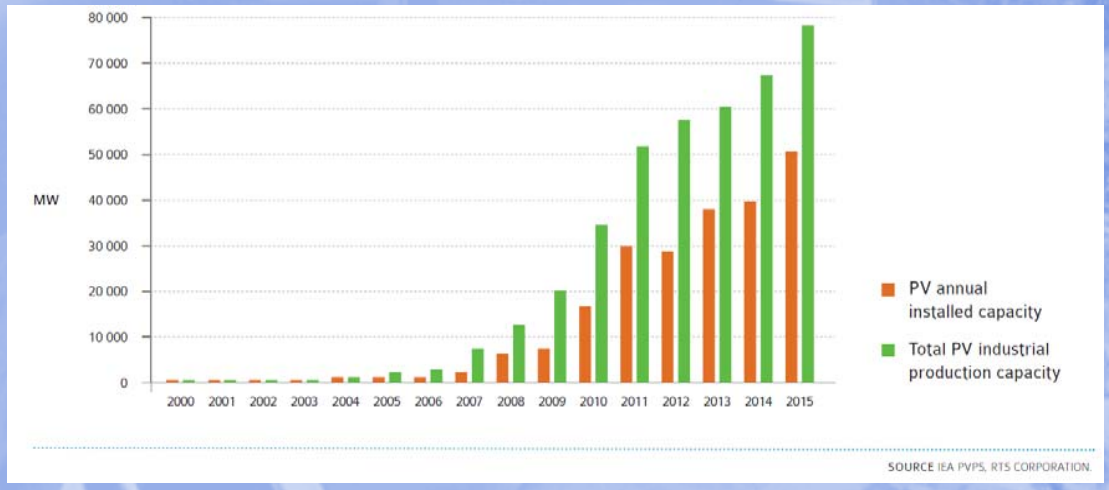
J. Doyne Farmer,
Francois Lafond

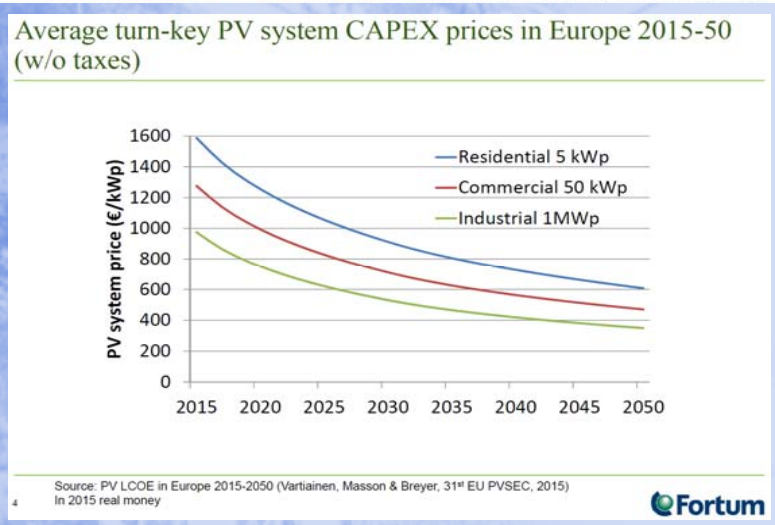
Cijene fotonaponskih sustava



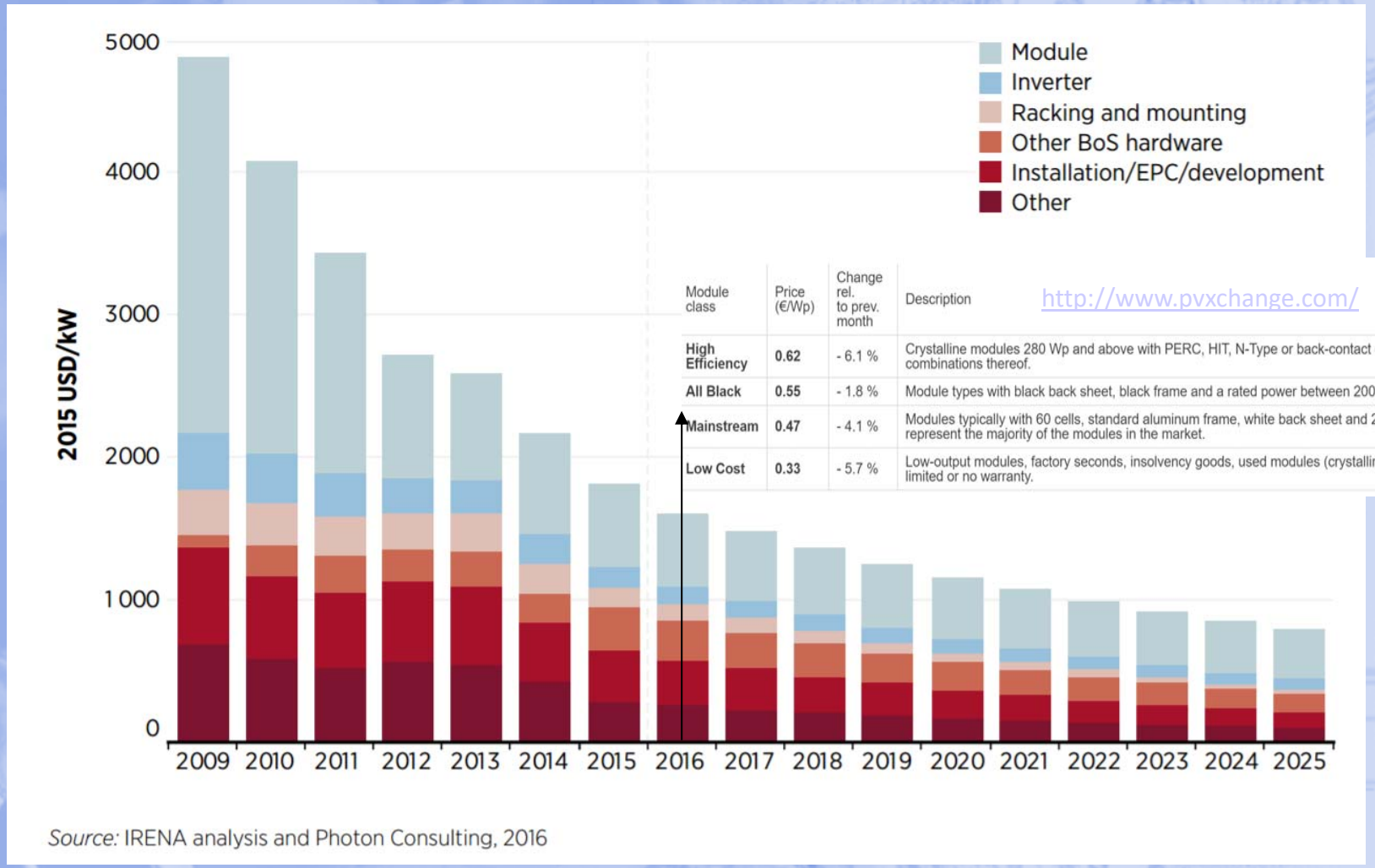
Note: Costs refer to global average of LCOE with country specific assumptions on investment costs (declining over time) and cost of financing (fixed over time). Different costs per country are averaged weighted by annual capacity additions.

Izvor: IEA PVPS, Trends 2016 in Photovoltaic Applications, report IEA PVPS T1-30: 2016





PV sustavi pad troškova u periodu 2009.-2025.

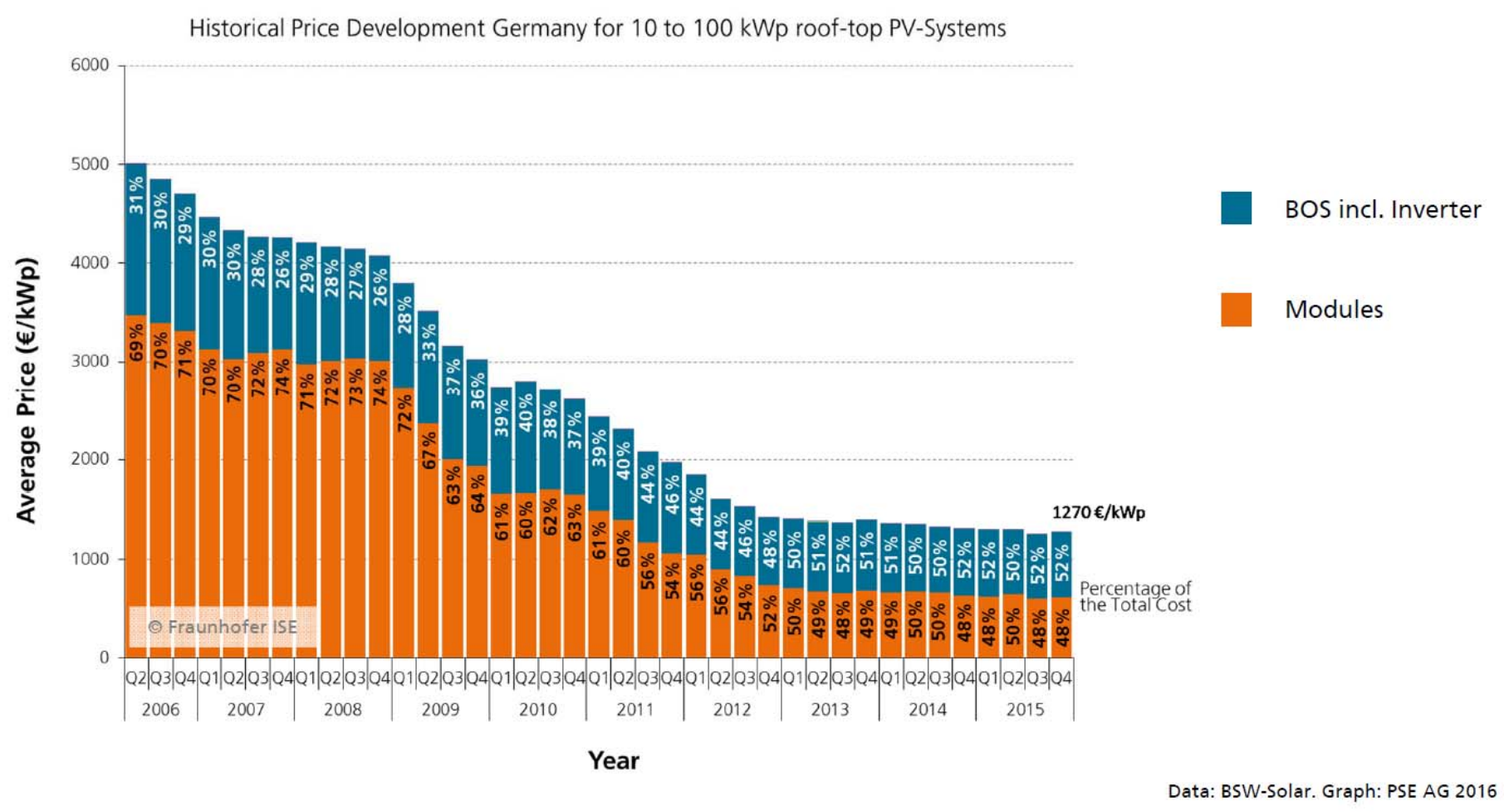


Module class	Price (€/Wp)	Change rel. to prev. month	Description
High Efficiency	0.62	- 6.1 %	Crystalline modules 280 Wp and above with PERC, HIT, N-Type or back-contact cells, or combinations thereof.
All Black	0.55	- 1.8 %	Module types with black back sheet, black frame and a rated power between 200 Wp and 280 Wp.
Mainstream	0.47	- 4.1 %	Modules typically with 60 cells, standard aluminum frame, white back sheet and 250 - 275 Wp, represent the majority of the modules in the market.
Low Cost	0.33	- 5.7 %	Low-output modules, factory seconds, insolvency goods, used modules (crystalline), products with limited or no warranty.

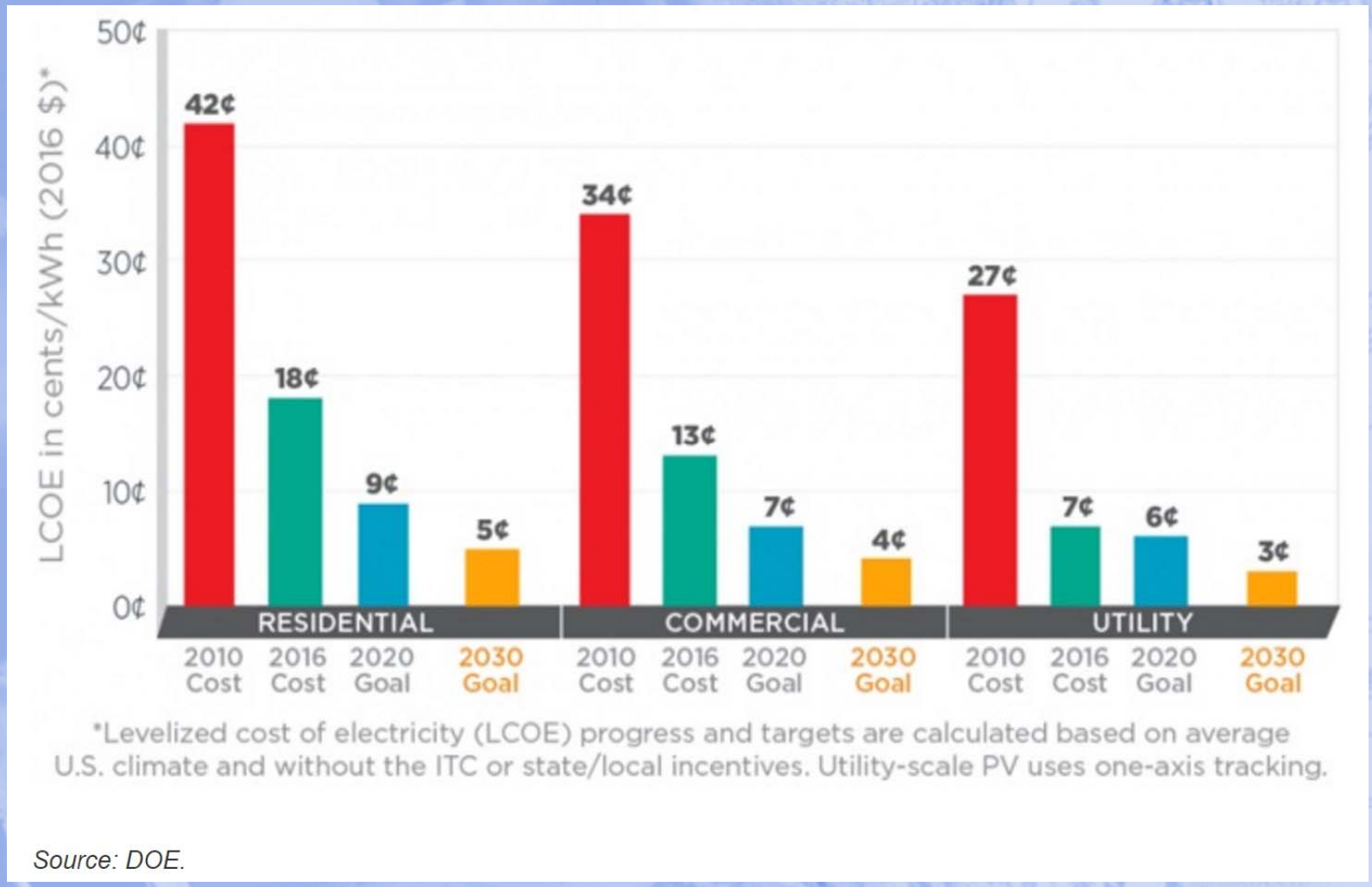
http://www.pvxchange.com/

Source: IRENA analysis and Photon Consulting, 2016

Krovni fotonaponski sustavi u Njemačkoj



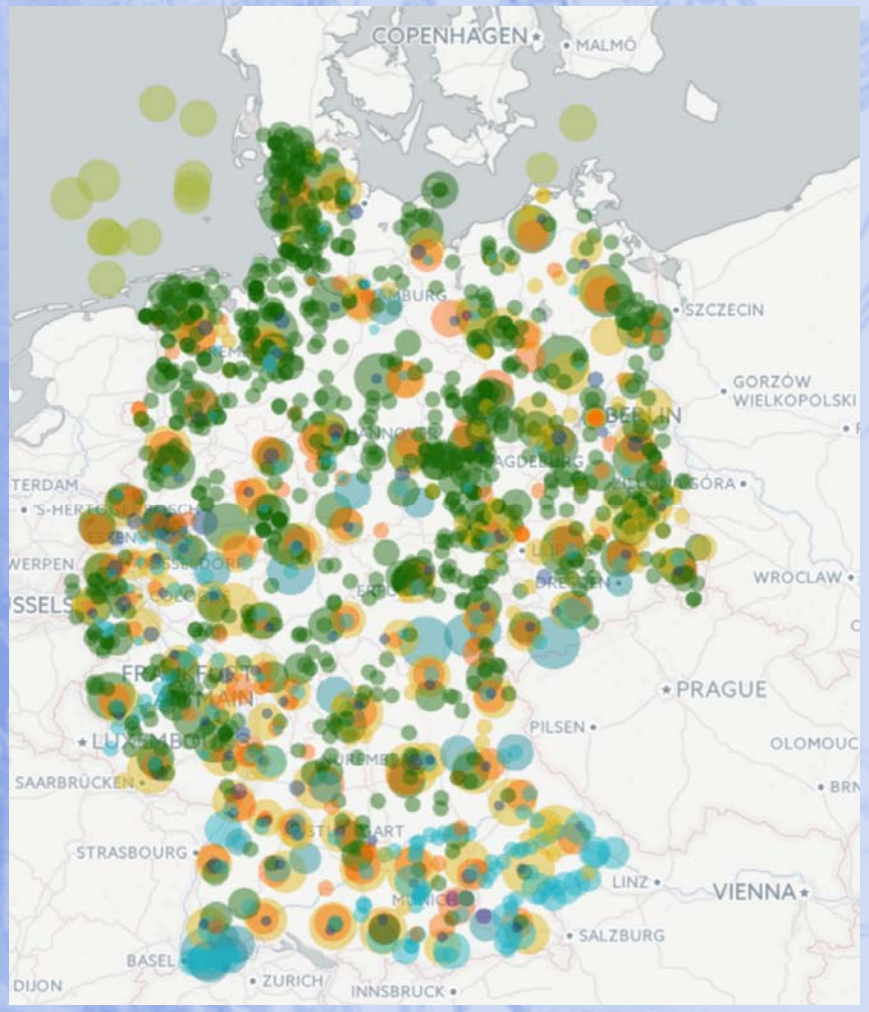
Budući trošak PV sustava?



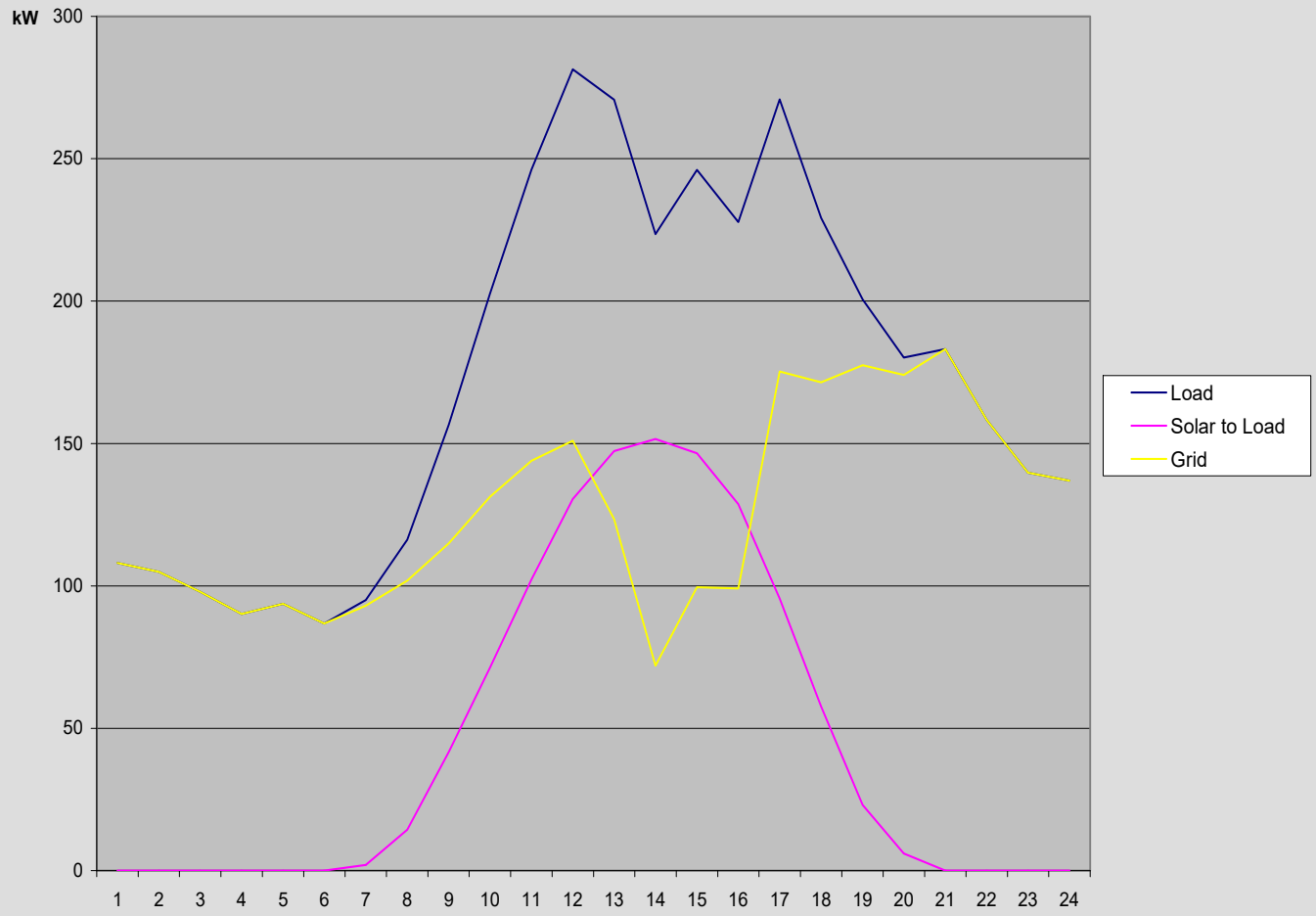
Source: DOE.

Power system Germany

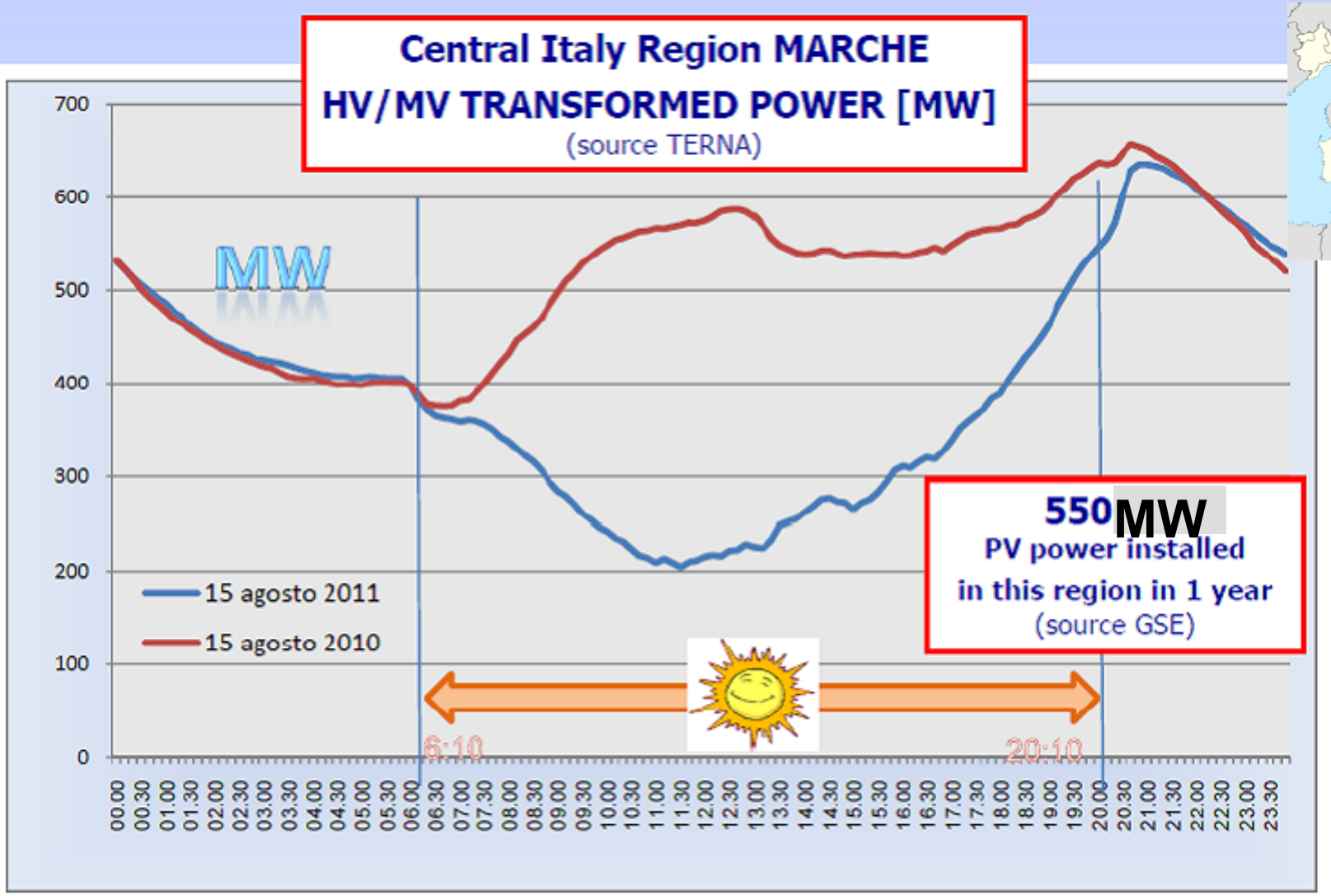
Germany registered a record in wind and solar PV penetration, when the output of these sources exceeded 90% of the country's electricity demand at one point on 8 May 2016 (Agora Energiewende, 2016).



Integracija PV jedan objekt

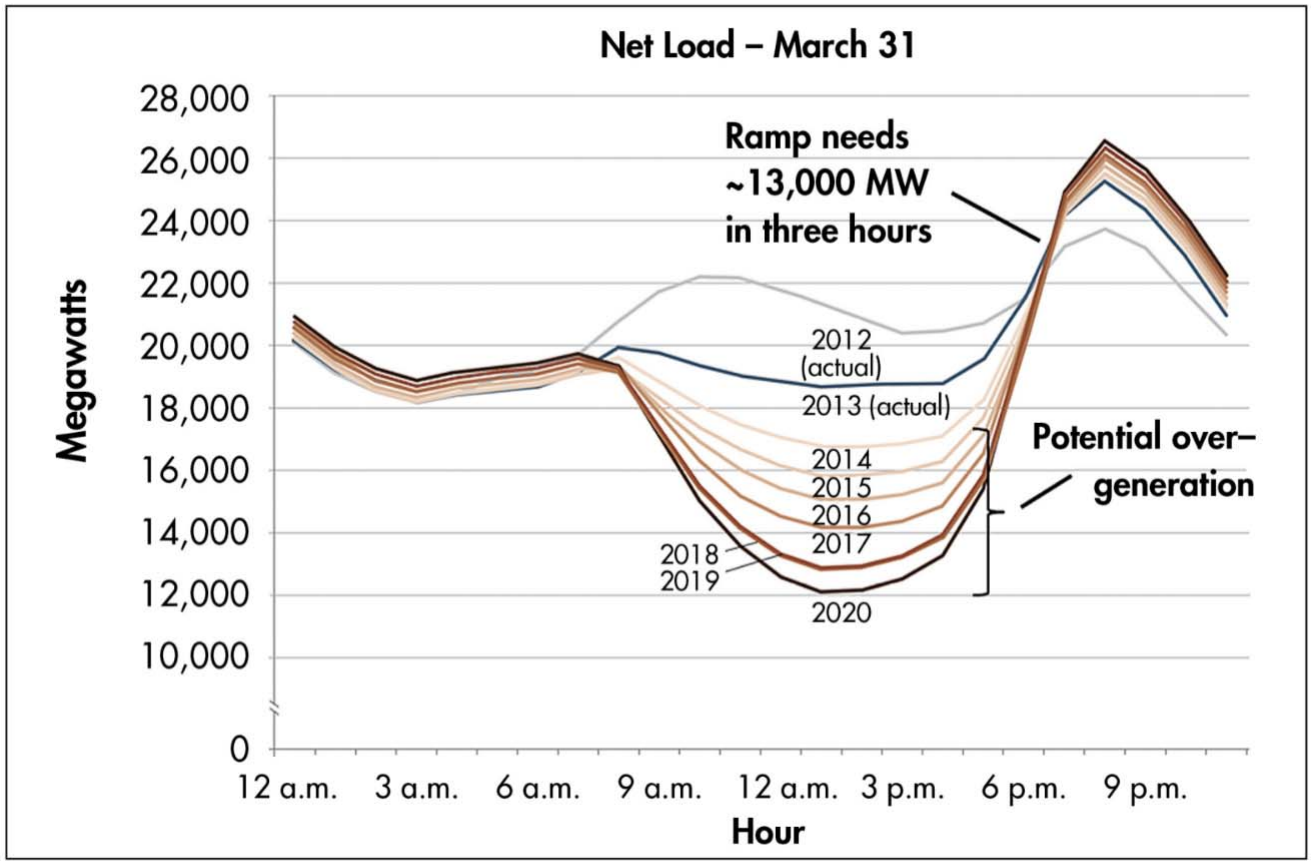


Integracija PV regija



California ostatno – neto opterećenje 2016.

Figure 1: Net load on the CAISO system



Source: CAISO

Mapiranje potencijala krovova?

Solarnim mapiranjem prema ugljično neutralnom kvartu?

Javno predstavljanje rezultata projekta Solarno mapiranje Trnskog održano je u sklopu Europskog tjedna održive energije, 20.06.2012. u 18 h u dvorani Dječjeg vrtića Trnsko, Trnsko 19, Zagreb.

Solarno mapiranje četvrti Trnsko u Zagrebu

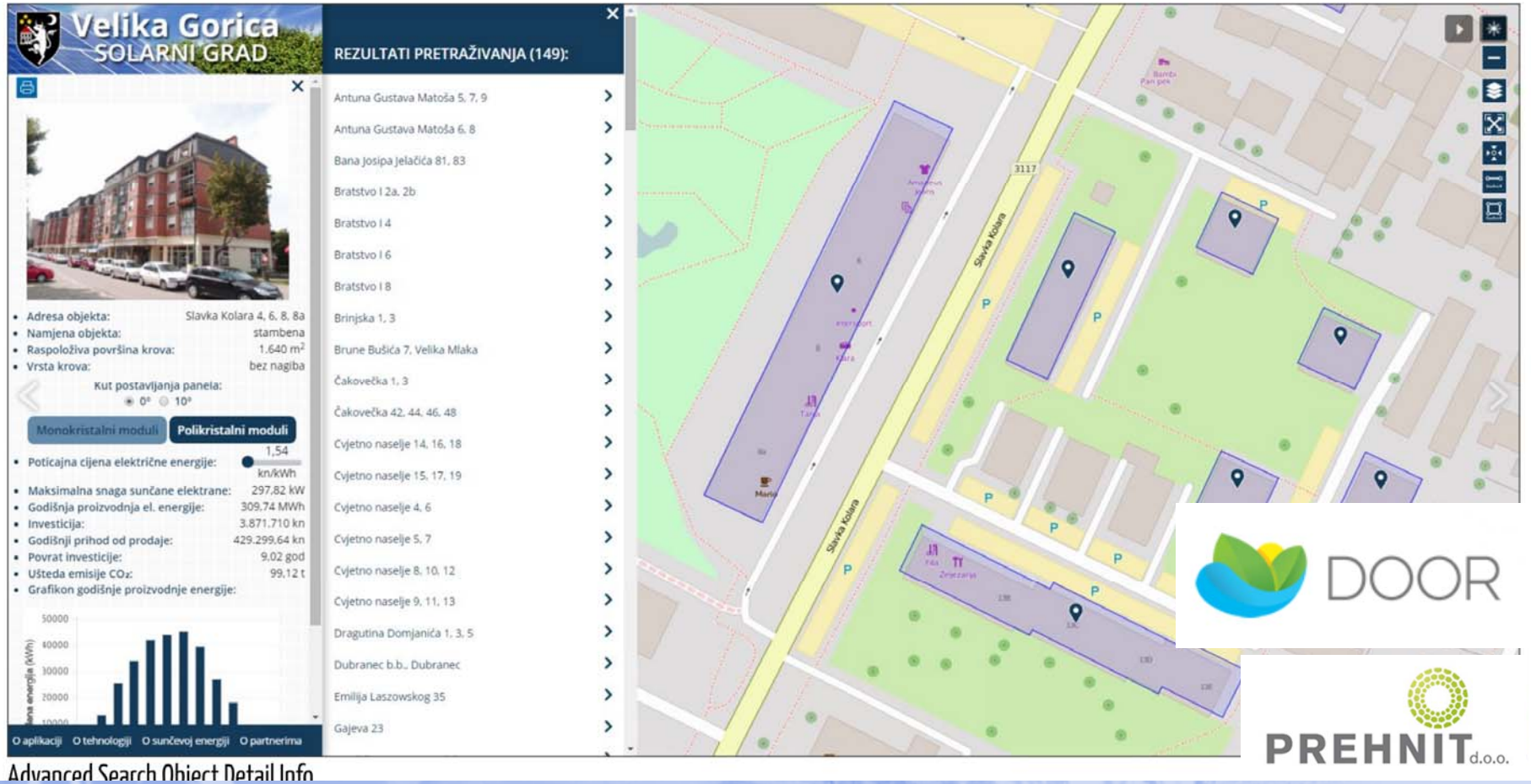
Solarno mapiranje Trnskog projekt je udruge DOOR (Društvo za oblikovanje održivog razvoja) u suradnji s udrugama Platforma 9,81 i Živim u Trnskom.

Trnsko je jedno od prvih novozagrebačkih naselja, najvedim dijelom izgrađeno 1960tih godina, na temelju tada prevladavajudeg principa ortogonalne matrice stambenih volumena unutar parkovno oblikovanog javnog prostora. Zgrade vedinom imaju ravne krovove male zasjenjenosti što ih čini idealnim za iskorištavanje energije sunca, koja se može pretvoriti u električnu ili toplinsku energiju. Ovim projektom obuhvadeni su samo potencijali za dobivanje električne energije pomodu fotonaponskih panela (FN) radi jednostavnosti izračuna. Postavljenjem fotonaponskih (FN) panela na krov neiskorištena krovna površina dobiva nove namjene: proizvodnja energije, dodatna zaštita od pregrijavanja i mogudnost ostvarivanja dodatnog prihoda.

Solarna mapa Trnskog - solmaptrnsko.net je interaktivna web mapa svih javnih i stambenih zgrada u naselju s prikazanim podacima o veličini FN postrojenja na pojedinoj zgradi, predviđenoj proizvodnji električne energije, veličini investicije, prihodu od povlaštenih otkupnih cijena i jednostavnim periodima otplate investicije. Solarne elektrane na krovovima mogu predstavljati prihodovnu aktivnost zgrade za daljnje ulaganje u energetsku učinkovitost (npr. postavljanje toplinske izolacije fasada, krova i novih prozora, modernizacija grijanja, individualno mjerenje topline, itd.), kvalitetnije održavanje zgrade ili ulaganja u projekte u zajednici.

Aplikacija solarnog mapiranja

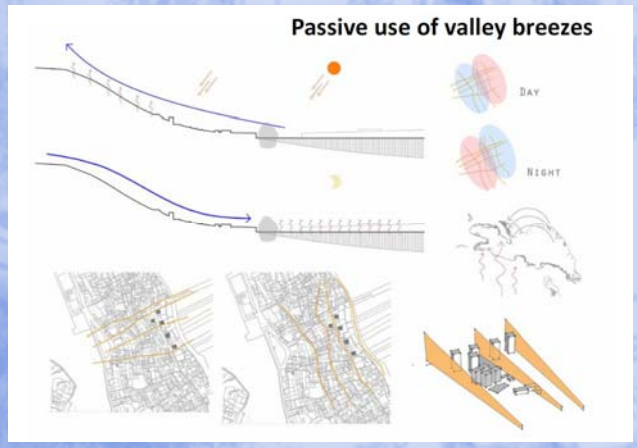
- http://prehnit.hr/hr/index.php/software-



Integracija PV u vanjske ovojnice

The Gruž lagoon

'FP7 EU City-zen Project, The Roadshow'. Coordinator: Dr Craig L. Martin



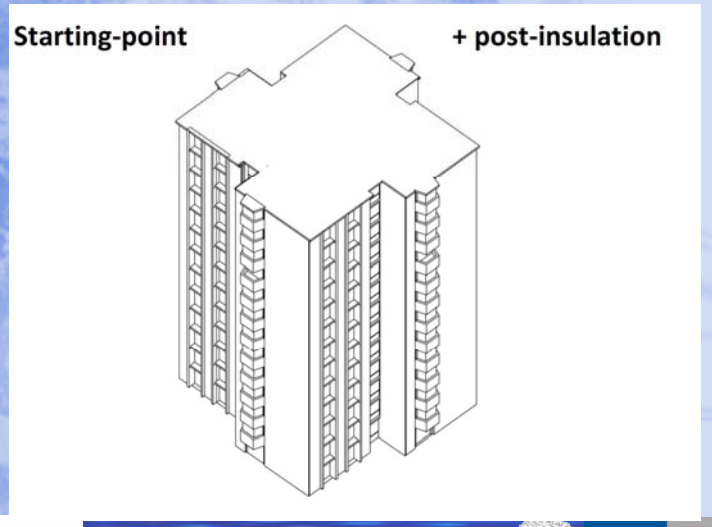


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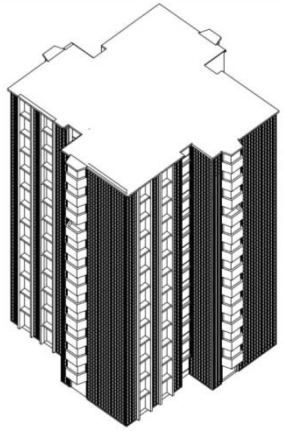
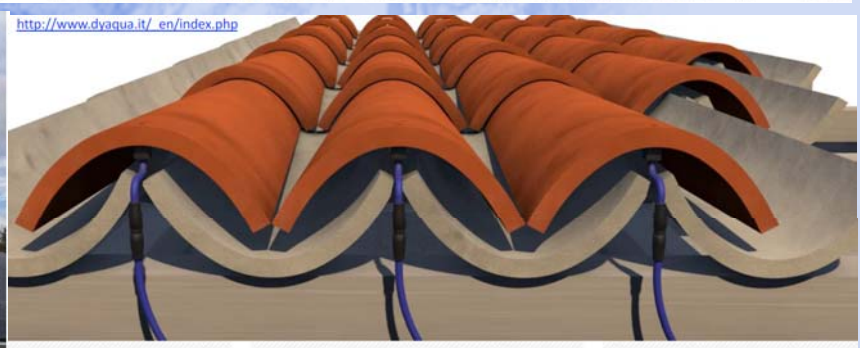
Image after post-insulation (and plaster finish)

Image with PV façade cladding

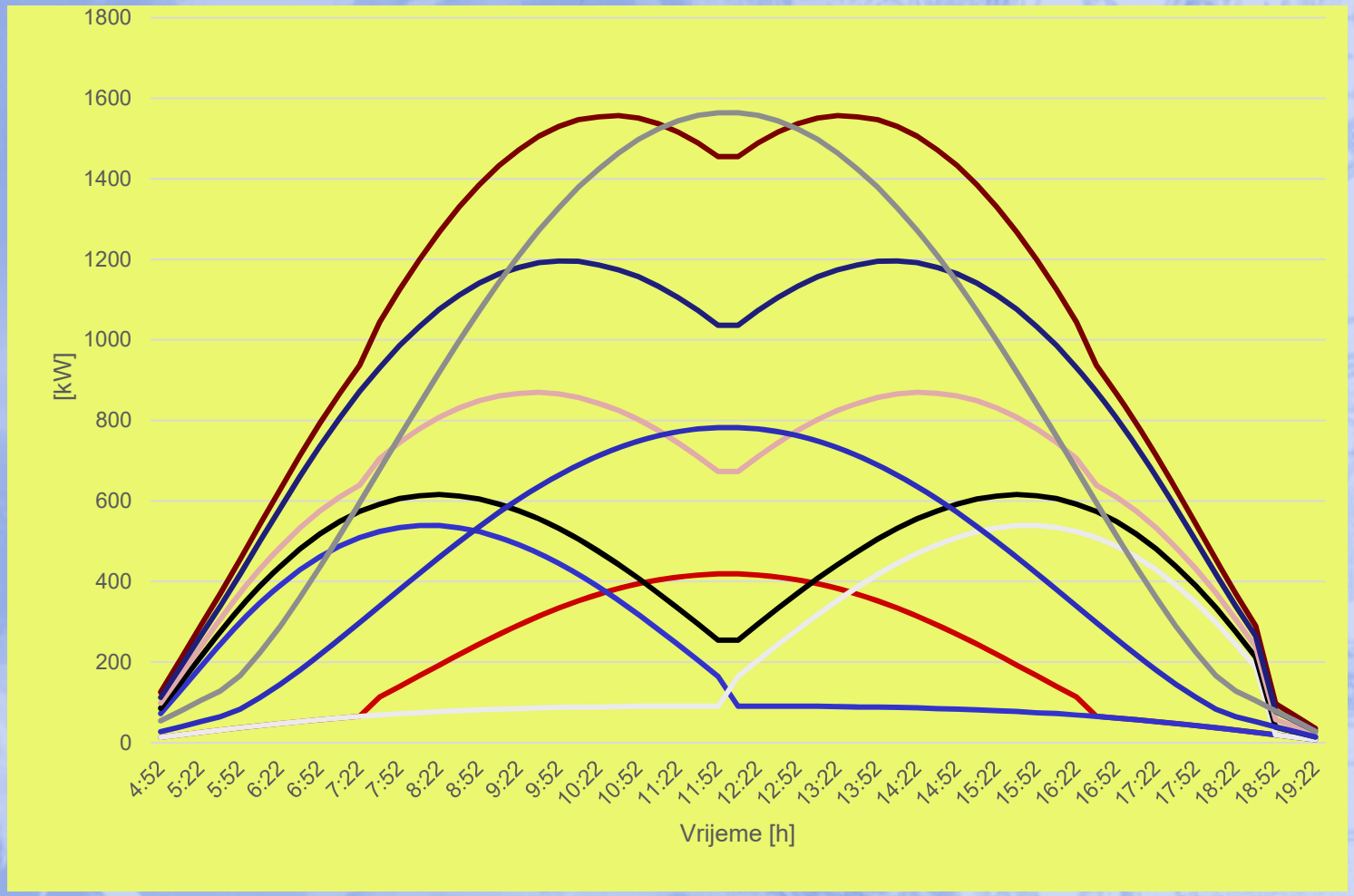


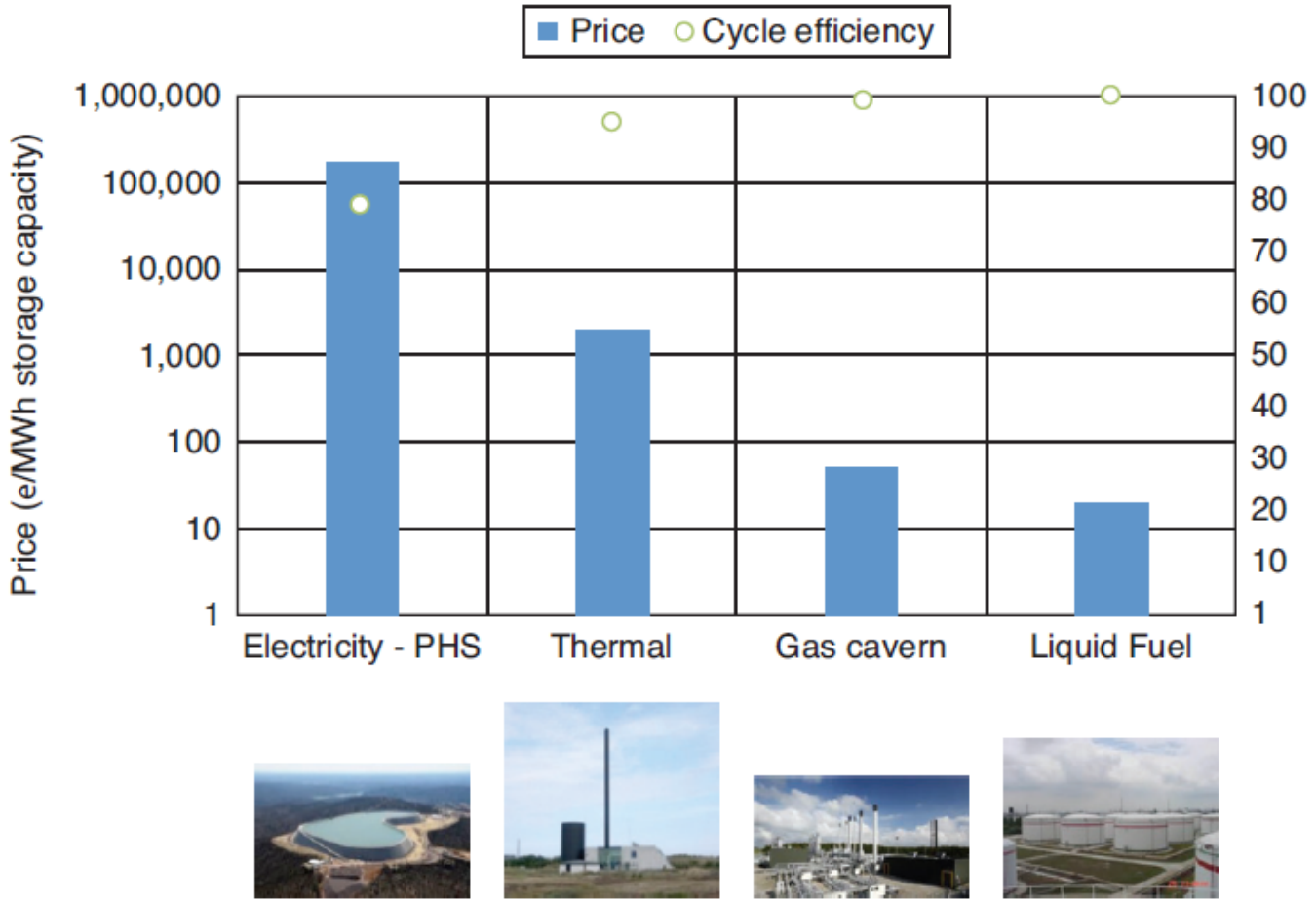
PV-covered parking lots

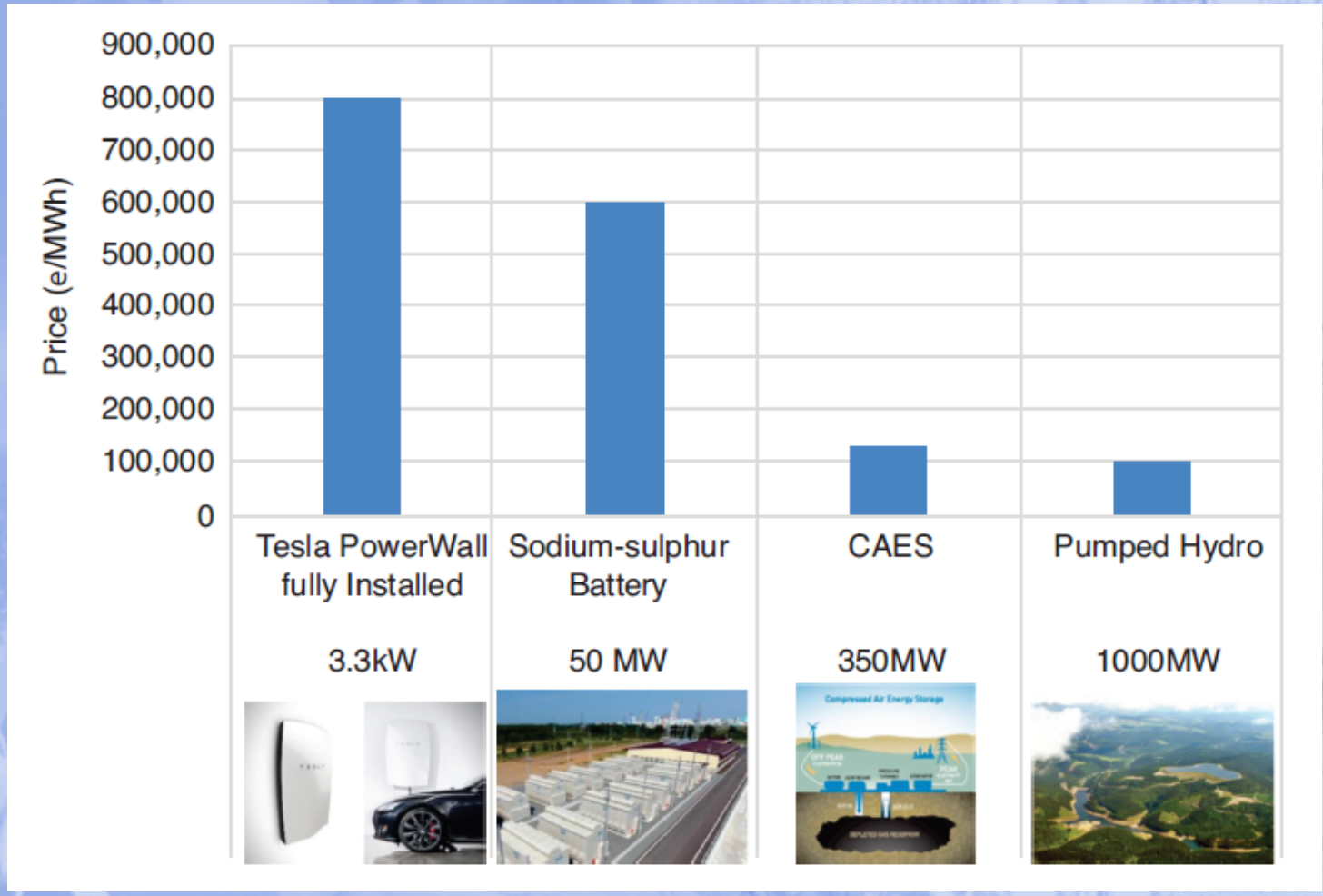
http://www.dyaqua.it/_en/index.php



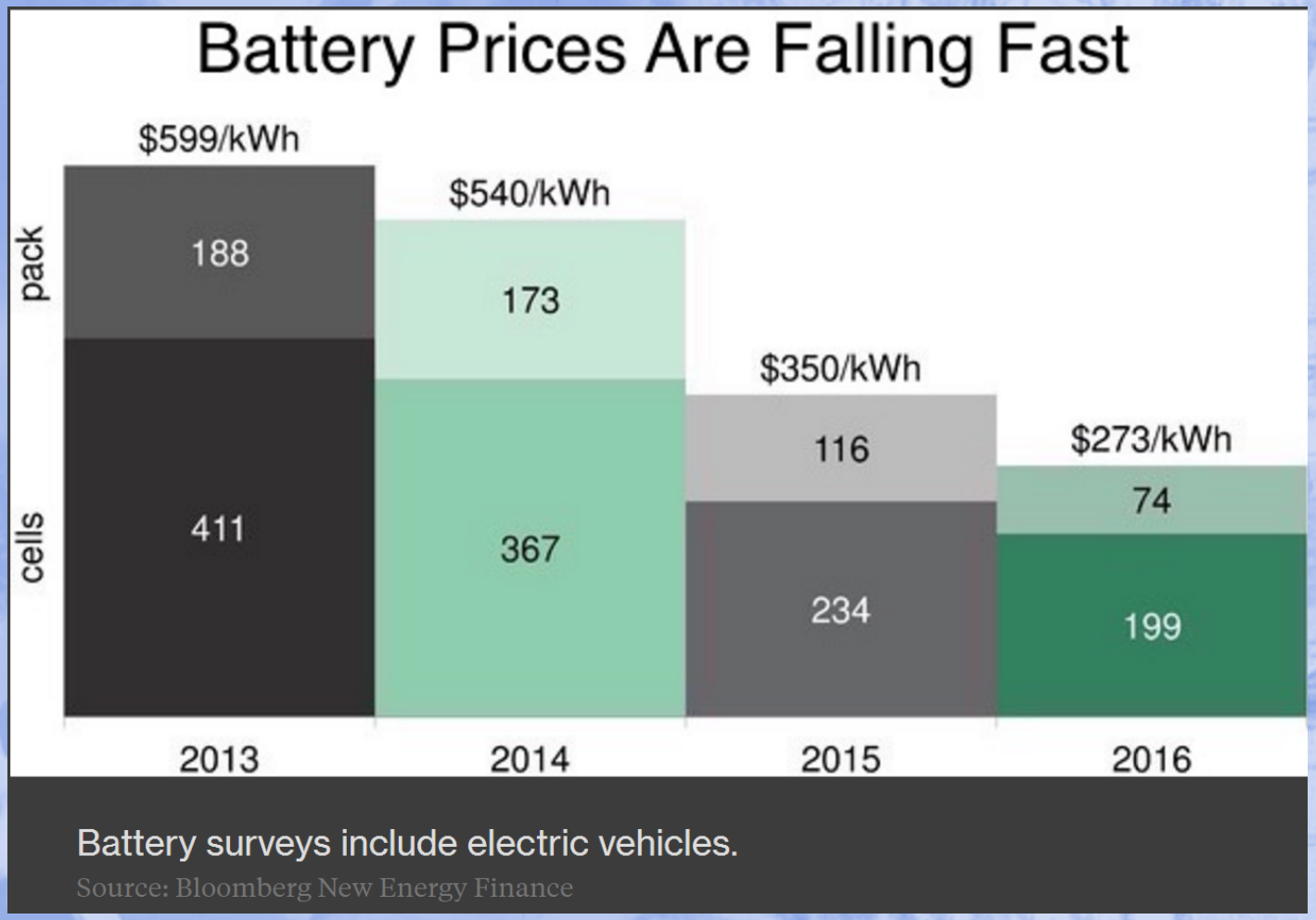
PV bočne fasade i krov



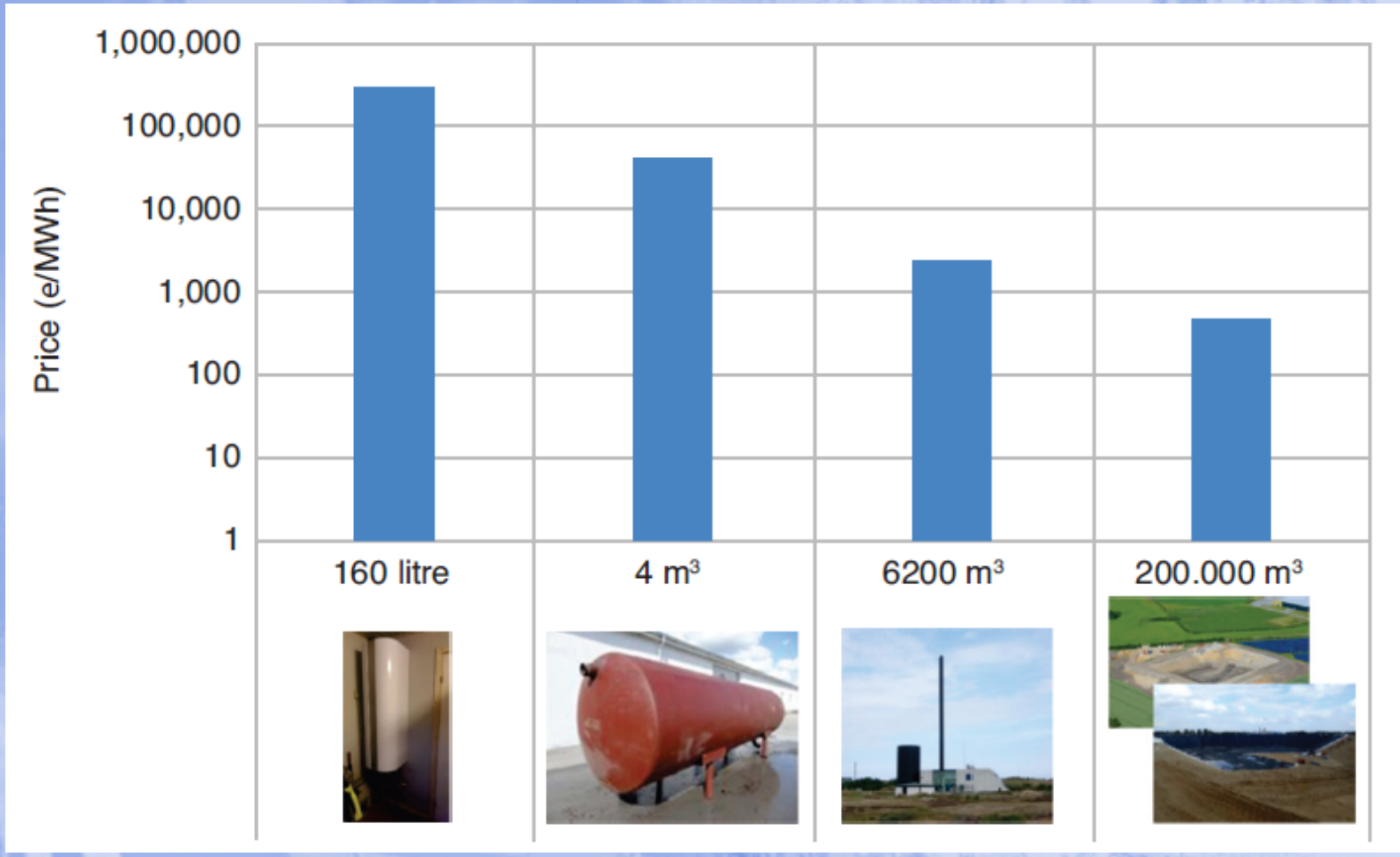

Price
Cycle efficiency
Price (e/MWh storage capacity)
1,000,000
100,000
10,000
1,000
100
10
1
100
90
80
70
60
50
40
30
20
10
1
Electricity - PHS
Thermal
Gas cavern
Liquid Fuel


900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Price (e/MWh)
Tesla PowerWall fully Installed
3.3kW
Sodium-sulphur Battery
50 MW
CAES
350MW
Pumped Hydro
1000MW

Skladištenje energije?



Investicijski trošak za toplinske spremnike



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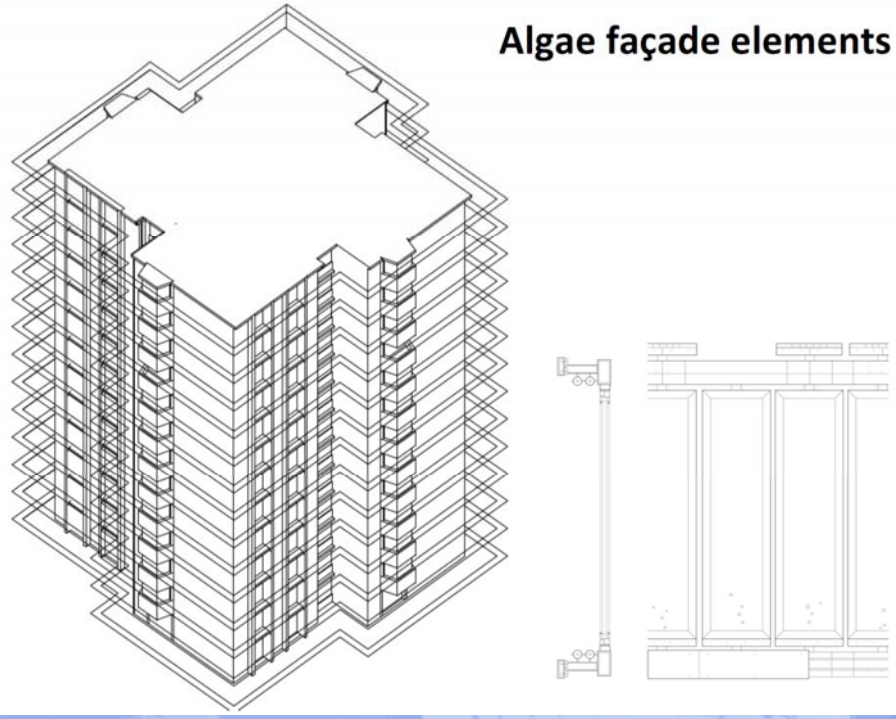
Algae façade elements



Algae façade

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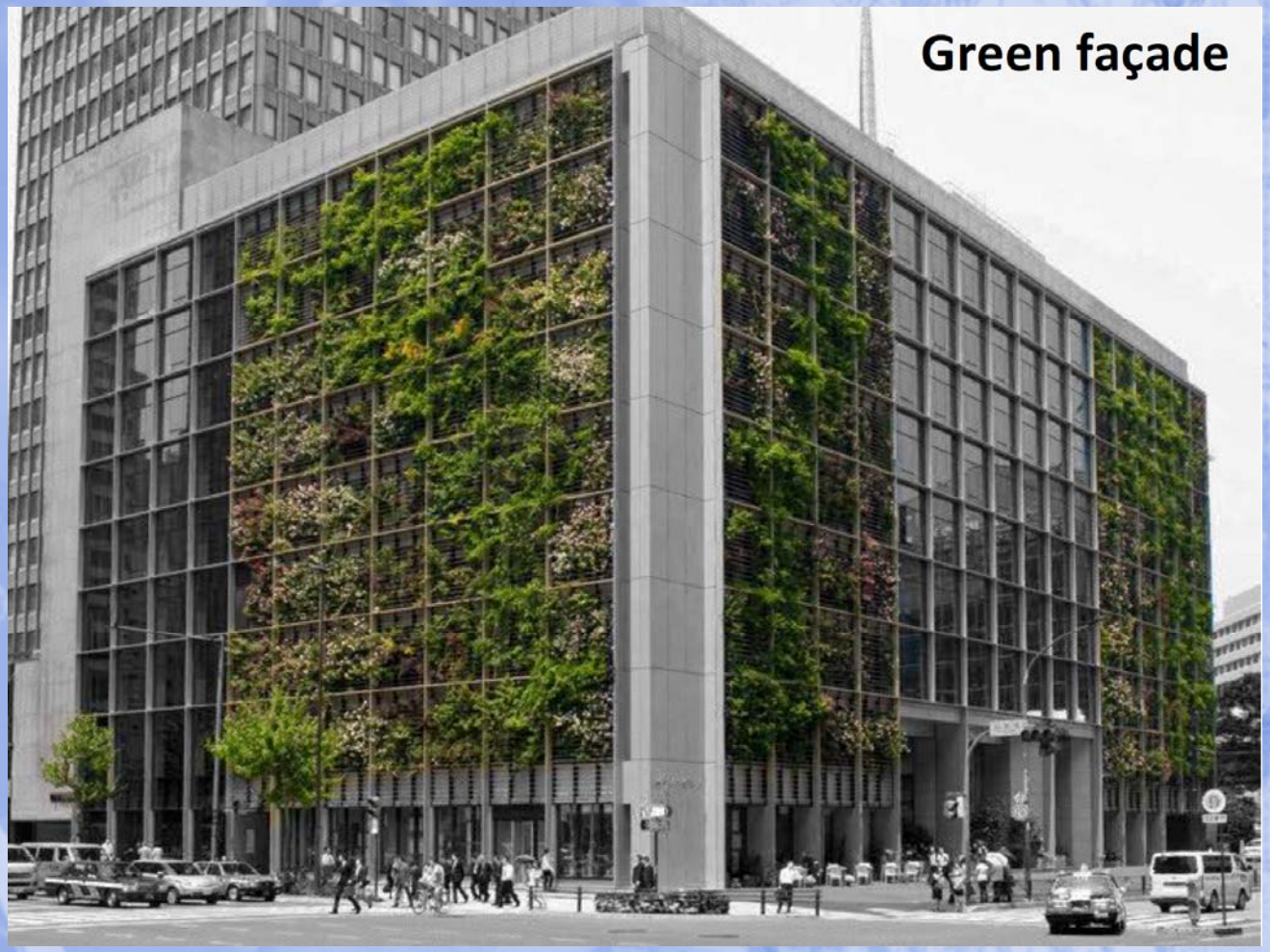

Hvala na pažnji!

goran.krajacic@fsb.hr