International Workshop on

Perspectives of Renewable Energy in the Danube Region

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COST-BENEFIT ANALYSIS OF DIFFERENT PHOTOVOLTAIC SYSTEMS IN CROATIA, HUNGARY, SERBIA AND SLOVENIA

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Wuppertal Institut für Klima, Umwelt, Energie GmbH

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Bilateral project

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

PROJECT: Photovoltaic Systems as Actuators of Regional Development; REG-PHOSYS

Goal : A development of the optimal PV-system for cross-border region regarding to characteristic climate conditions (insolation, temperature, humidity) and different solar cell technologies

ETFOS

Photovoltaic Systems as Actuators of Regional Development REG-PHOSYS

Hungary-Croatia
IPA Cross-border Co-operation Programme

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Project team leader : Dr.Viktor Varjú

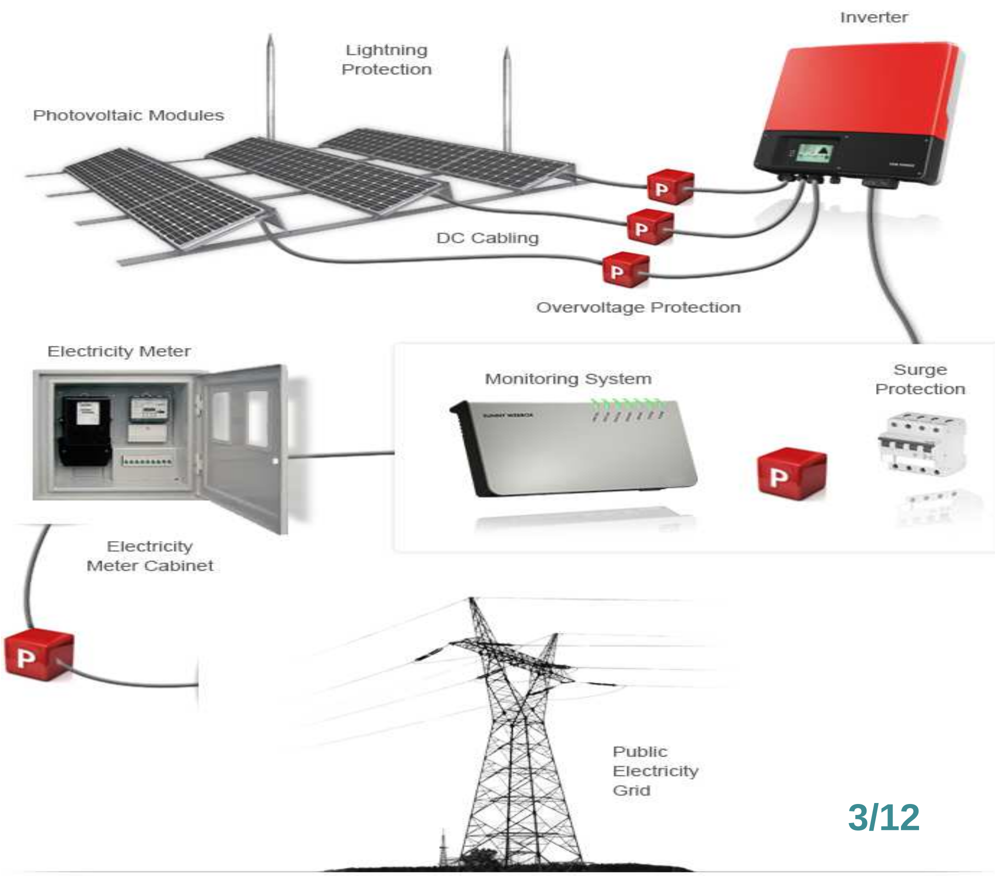
Cost-benefit model

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

1) Scale-system choosing:

a) solar home system users: It is small scale PV system. In this case, solar panels are installed on the roof structure of houses (mini home power plants), by which the complete photovoltaic system attains capacity of the order of 4 kW.

b) energy investors: This category involves big business enterprises which establish large-scale PV parks and feed electric energy produced by them into the central mains system which very well is corresponded to large-scale PV system of 300 kW.

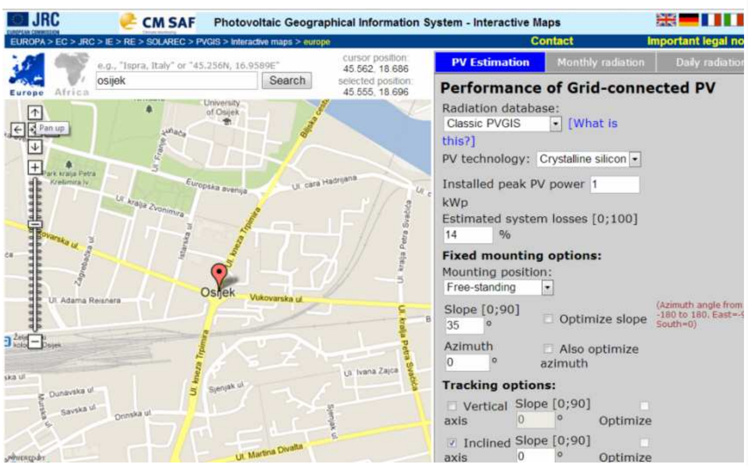


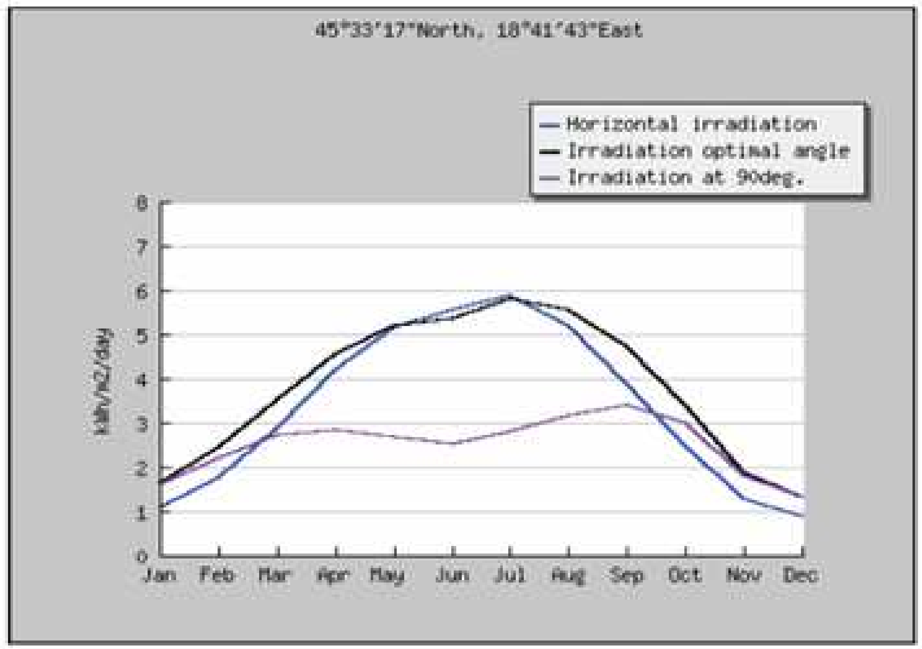
Cost-benefit model

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

2) Determing of the average solar radiation :

1st option: ***Use analytic data from available data bases;*** **PVGIS- Photovoltaic Geographical Information System (PVGIS) with 1-2 km resolution, public and available on: http://re.jrc.ec.europa.eu/pvgis/.**





Average daily radiation by months for OS

Installed PV-system

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

2nd option (our) **:** ***Use analytic data from available measurements,*** **Installed PV-system-10kW, location Osijek**

3) Solar cell technology: The following photovoltaic modules were installed at the roof of Faculty of Electrical Engineering building in Osijek:

1) ***monocrystalline technology***; BISOL, BMO250, 250W,
2) **polycrystalline technology** BISOL, BMU250, 250W,
3) ***CIS technology***; SOLAR FRONTIER, SF-150, 150W,
4) **amorphous technology**; MASDAR MPV100-S, 100W,
5) ***high-efficiency monocrystalline technology ;*** PANASONIC, VBHN2450SE10, 245W.

Installed PV-system

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

Laboratory for Renewable Energy Sources- Faculty of Electrical Engineering Osijek

1) ***monocrystalline technology***; BISOL, BMO250, 250W,
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Cost-benefit model

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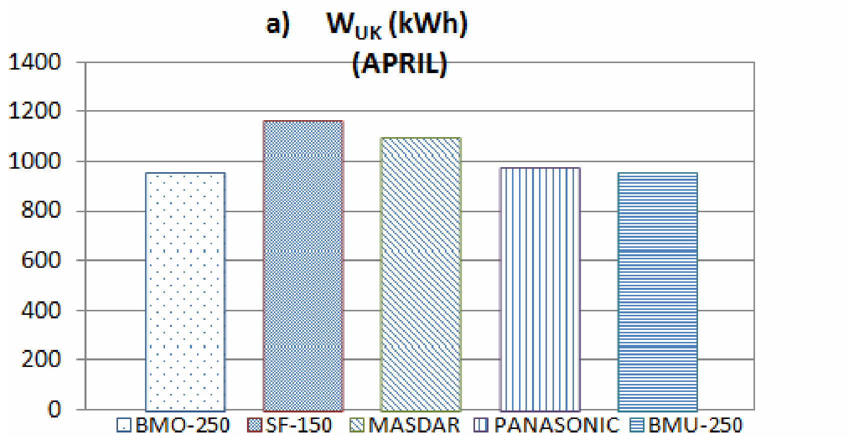

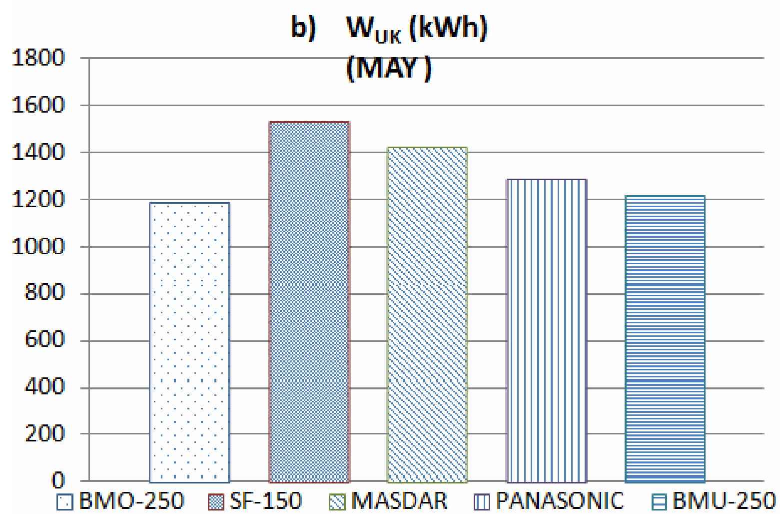

Technology	Total power
1.BMO250	952.4 kWh
2.BMU250	948.2 kWh
3.SF150	1162 kWh
4.MASDAR	1090 kWh
5. PANAS	973.9 kWh

Database; project: REG-PHOSYS

available on:

http://regphosys.eu./en/filebrowser/down-load/1812

CIS technology- by PV-emulation

Cost-benefit model

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4) Dataset of the Model

Denomination of data	**Applied Source:**
Technical data, parameters	
Average annual energy production	Measurement results by the University of Osijek, ETFOS
PV panel capacity	Technical specifications
PV panel unit price	Price offers
Inverter unit price	Based on the Photon GmbH dataset[9]
Panel life-cycle, capacity reduction	Based on the study by Jordan and Kurtz [10]
Inverter lifetime	Based on technical parameters 12.5 years
System installation costs	Practical experience
Cost charged for central network connection	Price fixed in Croatia (223 EUR/kW) and Slovenia (130 EUR/kW) while no such cost exists in Hungary and Serbia.
Internal system, cost of system construction	Experience-based determination (by business undertakings executing construction) of 20% of the cost incurred for the complete system
Annual maintenance costs	Experience-based determination (by business undertakings executing construction) of 15% of annual revenue
Price-type data	
Retail price of electricity	Electricity price trends, regulations
Electricity transmission rates	National legal regulations, directives
Other data	
Annual inflation rate	Long-term forecasts of Eurostat, OECD and national banks (HR: 0.5%; HU: 0.4%; SLO: 0.5%; SRB: 1.6%)
Real interest rate	Long-term forecasts of Eurostat, OECD and national banks (HR: 5%; HU: 5%; SLO: 2.5%; SRB: 6.5%)
Whole investigation period	According to long-term vision 25 years

Evaluation methodology

Several economic calculations:

1) *Inflation-adjusted or deflated profit* economic calculations, (it eliminates the drawback implied by the above indicator, more specifically, it is suitable for long-term investigations and its calculation allows for the comparison of not only specific years but also a period of several years)
2) *Net present values* (NPV), (It indicates the value of a given investment in year "t". It is defined as sum of the present values (PVs) of incoming and outgoing cash flows over a period of time.)
3) Levelized cost of electricity (LCOE) (it indicates the ratio of total expenses and income/savings in a longer time period)

- **Technical and economical evaluation of a 4 kW solar home system users**

- **Technical and economical evaluation of a 300 kW PV system for energy investors**

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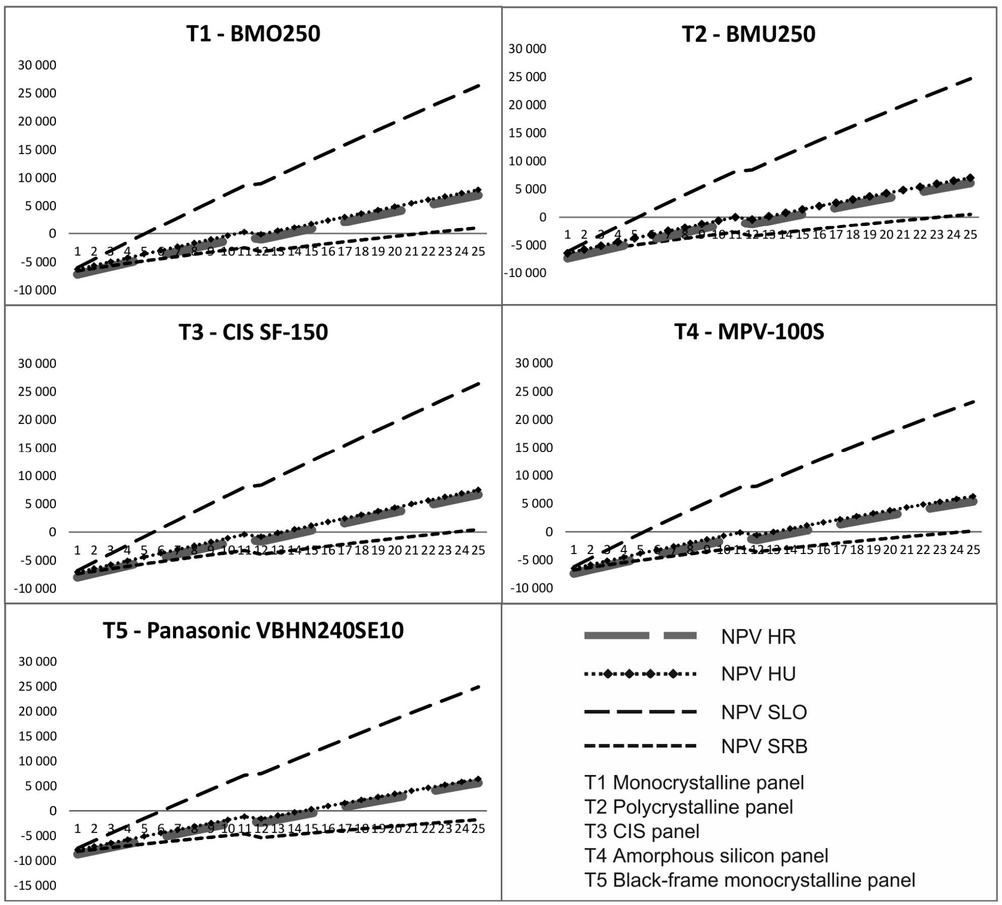
Technical and economical evaluation of a 4kW solar home system users

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

The net-present value regarding five technologies for Croatia, Hungary, Slovenia and Serbia:



The specific investment cost and profit for five different PV modules (EUR/kW)

PV system economic characteristcs	Mono Si Bisol BMO250	Poly Si Bisol BMU250	CIS Solar Frontier SF-150	Amorph Si Masdar MPV-100S	High-eff mono Si Panasonic
Specific investments -SLO	1897	1930	2092	1933	2260
Specific investments-SRB	**1767**	1800	1961	1803	2129
Specific investments-HU	**1767**	1800	1951	1803	2112
Specific investments-HR	1990	2023	2174	2026	**2345**
Specific profit in 25 years-SLO	8732	8353	**8953**	7973	8732
Specific profit in 25 years-SRB	2283	2189	2338	2095	**1949**
Specific profit in 25 years-HU	2933	2823	3003	2704	2936
Specific profit in 25 years-HR	2956	2848	3051	2734	2991

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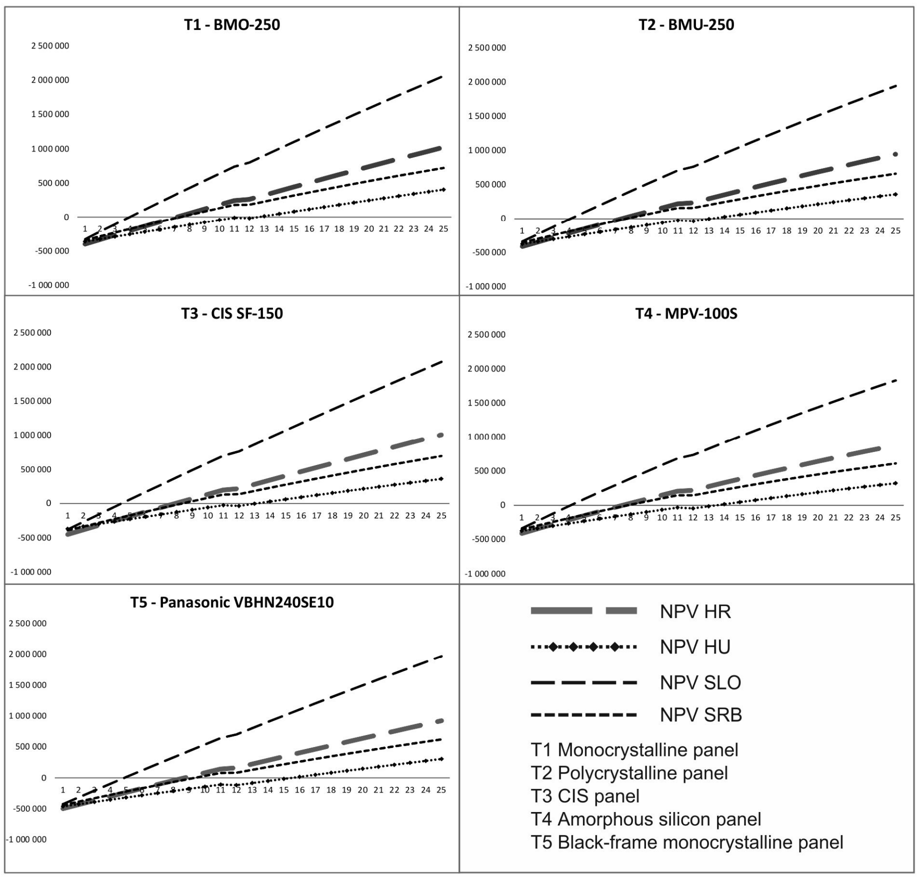
Technical and economical evaluation of a 300 kW PV system for energy investors

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

***The net-present value regarding five technologies for Croatia, Hungary, Slovenia and Serbia*:**



The specific investment cost and profit for five different PV modules (EUR/kW)

PV system economic characteristcs	Mono Si Bisol BMO250	Poly Si Bisol BMU250	CIS Solar Frontier SF-150	Amorph Si Masdar MPV-100S	High-eff mono Si Panasonic
Specific investments -SLO	1460	1494	1636	1496	1790
Specific investments-SRB	1318	1352	1494	1354	1648
Specific investments -HU	1330	1364	1506	1366	1660
Specific investments -HR	1553	1587	1729	1589	1883
Specific profit in 25 years –SLO	8486	8118	8701	7749	8486
Specific profit in 25 years -SRB	3871	3711	3964	3551	3871
Specific profit in 25 years-HU	2059	1981	2108	1897	2061
Specific profit in 25 years-HR	4109	3955	4201	3798	4103

Conclusions

Cost-benefit analysis of different photovoltaic systems in Croatia, Hungary, Serbia and Slovenia

- The photovoltaic system with technically the best ***high efficiency mono-crystalline modules*** is indeed the one with the highest and therefore least favourable specific investments, regardless of the system size.

- The system with the multilayer ***Copper-Indium-Selenium (CIS)*** modules**,** which has moderate specific investments and medium efficiency with regard to the tested technologies, displays the highest expected electricity production as a result of the use of different materials and better usage of the sun radiation spectrum. Thus, based on the techno-economic cost-benefit analysis, this technology would be the one to recommend among the five tested technologies.

- The cost-benefit analysis also resulted in a lower expected investment cost ***for larger systems*** (up to 300 kW), but due to the respective lower incentives compared to the small systems (up to 10 kW) it still results in lower expected specific deflated profit.