

“Estimation of Maximum PV Penetration in the Domestic Sector in Greece”

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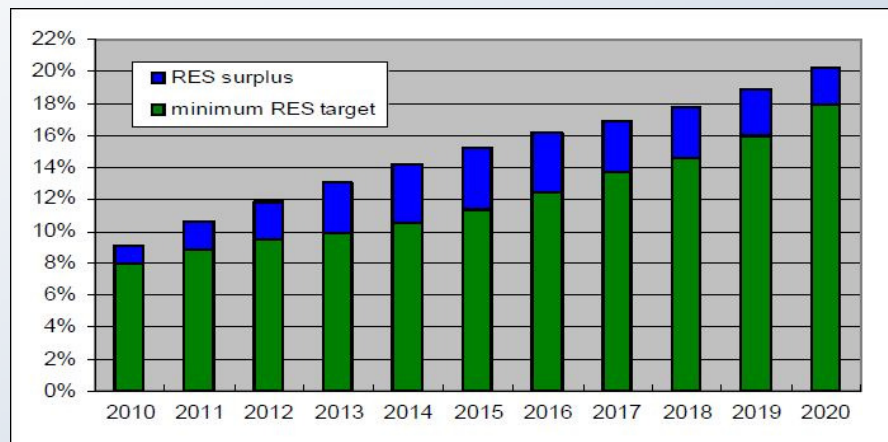
Renewable Energy Sources (RES) Utilization in the residential sector in Greece

- Prevailing RES in the residential sector is Solar Energy and Biomass , used mainly for heat production.
- Biomass use accounts 600ktoe.
- Solar Energy utilization, comes from the use of Domestic Solar Thermal Systems. Roughly a quarter of all Greek Households have one.
- More than 4.07m² of solar thermal collectors are currently installed (conserved about 1,613 GWh_{el}).

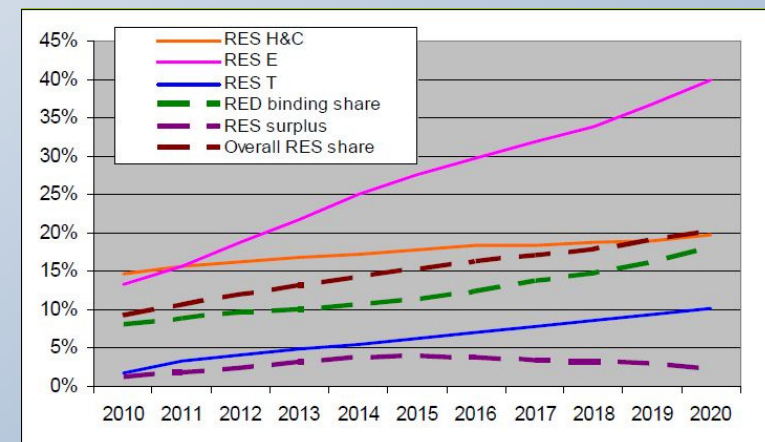
National Goals for RES contribution in Greece's Energy Balance

Law L3851/2010 specified that RES should cover 20% of final energy consumption, 2% above the mandatory level of 18% set by Directive 2009/28/EC. It further sets:

- RES electricity share to 40%
- RES heating and cooling share to 20% and
- RES transport share to 10%



**RES in gross final energy consumption
projection up to 2010***



**Share projection of RES in the final
consumption of the
three main sectors***

Composition of national electricity mix for the electricity production fed in to the System in 2009*

Fuel used	%
Lignite/carbon	51,42
Natural Gas	15,70
Petroleum	11,16
Nuclear	-
RES	14,28
Others	7,35

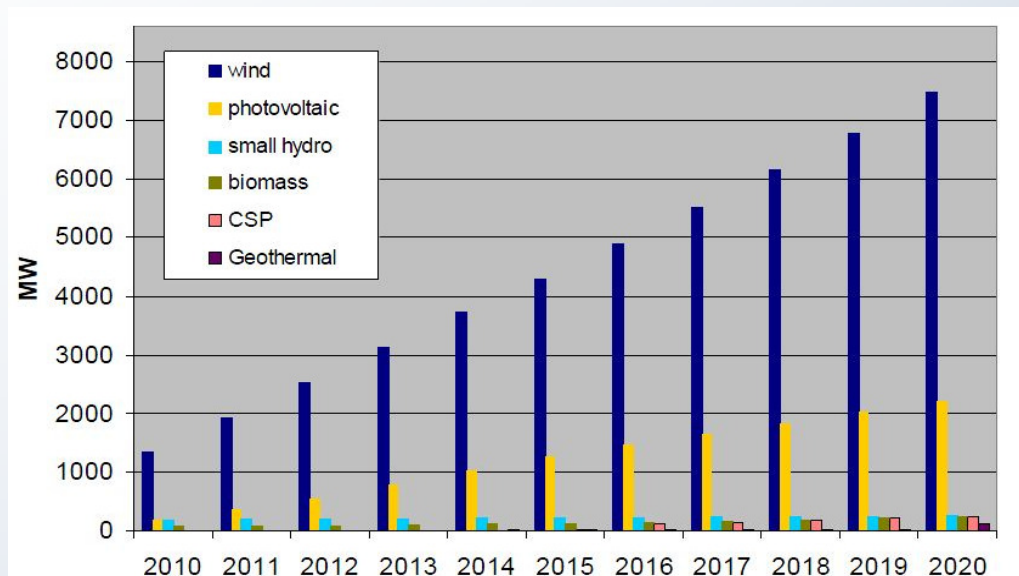
RES capacity comes mainly >85% from large Hydro plants.

RES Electricity utilization in Greece

- Recently, due to private funding, RES capacity has increased and an additional 1,086 MW were installed excluding cogeneration.

RES installed Capacity as of 6/2009 excluding Hydro		
	Installed Capacity [MW] (Operational)	Installed Capacity [MW] (Awaiting)
PV	178	110
Biomass	41	43
Wind	842	2,900

RES Electricity utilization in Greece - Perspectives



According to the latest National Renewable Energy Action Plan, the electricity mix will change considerable with strong emphasis on natural gas, wind and **PV installations**.

Installed Capacity of RES technologies up to 2020*

PV policies and Legislation in Greece

Greek RES policy framework, regarding deployment of solar electricity can be divided in three distinct periods:

- First Period: up to 1999
- Second Period: 2006 to 2009
- Third Period: 2009 to today



PV policies and Legislation in Greece – First Period

- All RES installations were controlled by the Greek government through the Public Power Corporation and/or local authorities.
- Installations were limited in isolated areas not usually connected in the main interconnected electricity grid of Greece.
- In 1999, Law 2273 was implemented.
- The impact of this law in the total installed capacity of PV was small, as it didn't surpassed 1.4 MW.

PV policies and Legislation in Greece – 2006 to 2009 Period

- In 2006, Law 3468 was passed in an effort to stimulate the PV market.
- Feed in tariff system - guaranteed period of 10 years for PV generated electricity, possibility of another 10 year extension.
- Simplified the administrative procedures necessary to obtain a permit for RES installation.
- Incentives for domestic producers (households). (Installation cost , tax deductible up to 750 €).
- **More** than 7.500 applications were submitted to the Regulatory Authority of Energy .
- Total installed capacity of more than 3.750 MWp.

PV policies and Legislation in Greece – 2009 - 2010 Period

- In 2009, Law 3734 and in 2010, Law 3851 were introduced.
- Simplified even more the permits necessary for the installation of PV systems. The concept of solar roofs is introduced for households.
- It concerns households that want to install PV up to a maximum of 10kWp in their roof.
- The initiative is restricted to areas of the interconnected electricity grid of Greece (continental Greece and islands connected with it).

“Solar Roof” Programme

- PV systems up to a maximum of 10kWp in building roofs is allowed.
- For multi story buildings only **one** system can be installed regardless of the number of households dwelling there.
- **All** the produced electricity is sold to the Public Power Corporation at a rate of **0.55€/kWh**.
- In order to qualify for this program an electricity connection in the owner's name is necessary.
- Part of the building's water thermal load must be covered from RES (DSHWS, GHP, etc).

Maximum PV Potential Estimation

In order to estimate the maximum technical potential for the installation of <10kWp PV systems, a number of physical limitations, such as:

- the total number,
- the available area
- and type of buildings

for all the regions of Greece is considered.



Maximum PV Potential Estimation

- Necessary area for PV installation ranges (depending on the type of arrays used and the type of the roof) from 12-15 m² in a terrace, to 7-10 m² in a sloped roof per installed kW.
- That means an area of 70 m² to 150 m² per system and per building (in all cases an area available in almost all dwellings in Greece).
- In Attica 72% of all buildings have a terrace, while for the rest of the country the percentage drops to 35%.



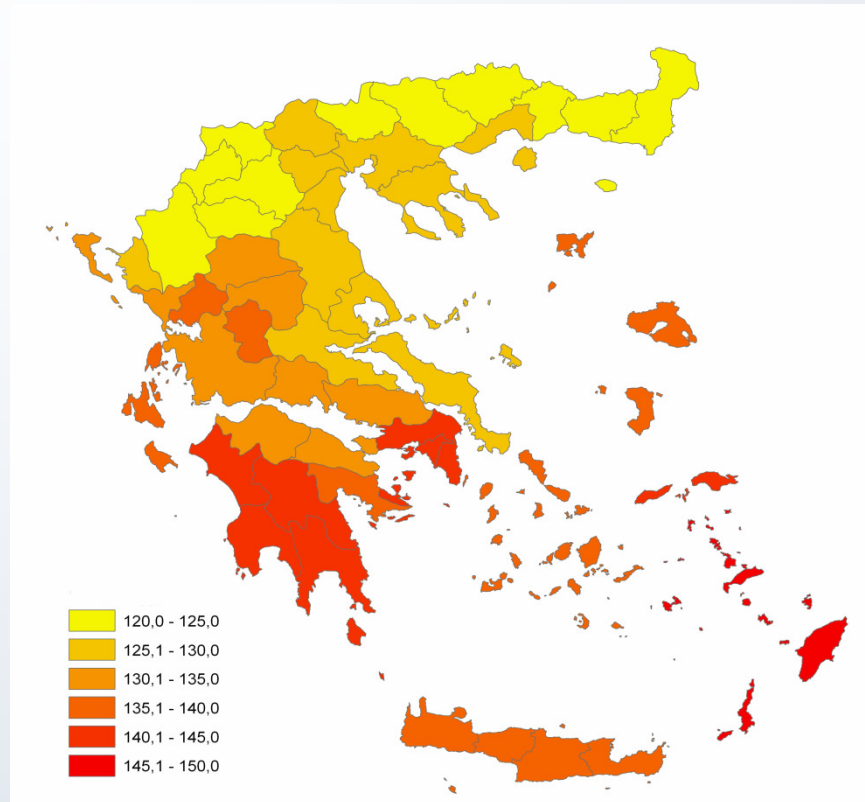
Maximum PV Potential Estimation

Number of buildings (housing), total built area and technical potential				
Region	Total number Of Buildings	Number of Buildings used for housing	Number of buildings with a Terrace	Maximum Installed Capacity [MW]
Thrace	159,191	131,588	46,056	1,316
Macedonia	830,938	589,004	206,151	5,890
Thessaly	349,655	250,485	87,670	2,505
Epirus	171,112	127,929	44,775	1,279
Ionian Islands	128,876	95,290	33,352	953
Attica	754,728	663,207	470,877	6,632
Central Greece	410,476	308,249	107,887	3,082
Peloponnesus	555,272	431,704	151,096	4,317
Aegean Islands	343,454	253,691	88,792	2,537
Crete	287,268	214,803	75,181	2,148
Total	3,990,970	3,065,950	1,311,837	30,660

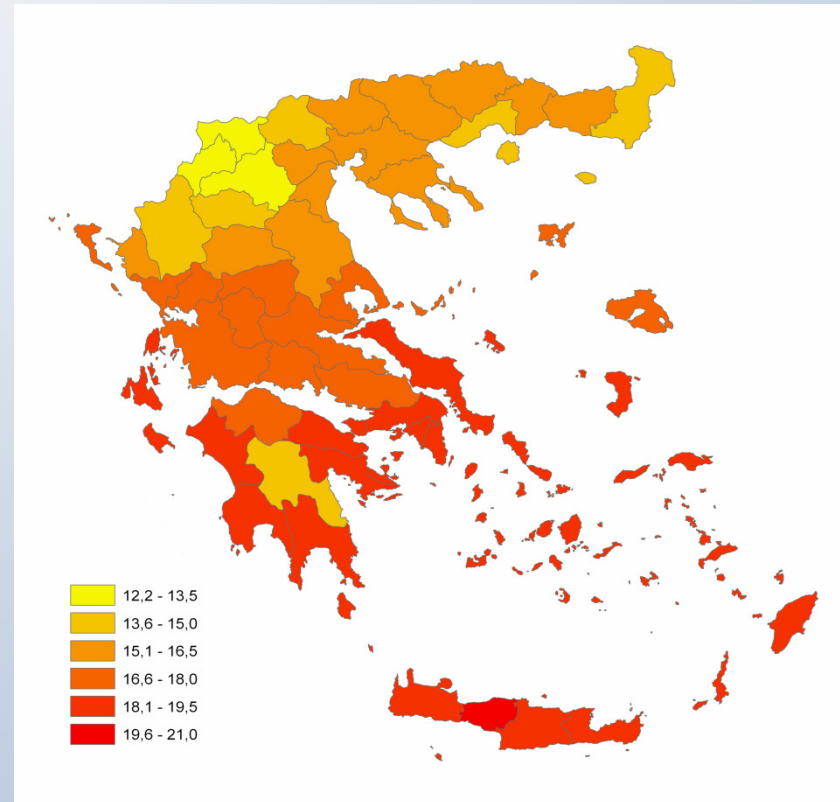
Potential Electricity Production Estimation

- The electricity that can be generated is estimated taking into account the different meteorological conditions throughout the country.
- Due to different climatic conditions, the calculations are performed for each of the country's regions.
- For the calculations, meteorological data of each region's capital, considered representative for the entire region since the capital usually includes the highest percentage of population and buildings, are used.
- The RETSCREEN 4 software is used for the estimations.

Potential Electricity Production Estimation



Average annual solar radiation on a 45°
inclined surface [kWh/m²]



Average annual air temperature [°C]

Potential Electricity Production Estimation

- The on-grid model was used.
- No load is specified and the array size is defined up to 10 kWp.
- The available energy is what is produced by the array minus inverter losses.
- All produced energy from the system is considered to be absorbed by the grid.



Potential Electricity Production Estimation

Monthly Electricity exported to the grid by a typical 10kwp PV system [MWh]								
Month	Macedonia	Thrace	Ionian Islands	Epirus	Peloponnesus	Thessaly	Attica	Central Greece
1	0.891	0.969	1.025	0.934	0.960	0.900	0.714	0.866
2	0.938	0.985	1.090	0.992	0.948	0.928	0.859	0.881
3	1.167	1.192	1.444	1.301	1.233	1.166	1.177	1.130
4	1.184	1.155	1.480	1.311	1.256	1.247	1.301	1.250
5	1.293	1.232	1.587	1.454	1.376	1.321	1.448	1.331
6	1.385	1.287	1.606	1.531	1.472	1.422	1.386	1.438
7	1.440	1.365	1.690	1.581	1.515	1.465	1.456	1.474
8	1.436	1.357	1.676	1.547	1.486	1.465	1.455	1.469
9	1.291	1.239	1.521	1.358	1.334	1.321	1.314	1.323
10	1.004	1.081	1.293	1.186	1.151	1.020	1.138	1.071
11	0.798	0.866	0.986	0.849	0.837	0.788	0.933	0.796
12	0.722	0.796	0.850	0.751	0.763	0.722	0.738	0.694
Annual	13.550	13.524	16.247	14.795	14.330	13.767	13.920	13.724

Potential Electricity Production Estimation

- Total energy production is calculated by multiplying the number of buildings that are used as dwellings with the energy produced by a single 10 kWp system for every region in Greece.
- Total electricity fed to the grid could reach 36.3 TWh, indicatively total electricity consumption in Greece in 2008 was 67 TWh.

Conclusions

- It is evident that PV penetration in the domestic sector can reach very high levels.
- The simplification of the administrative process for the installation of PV systems for domestic users and the implementation of an attractive feed in tariff scheme have, and will continue to have, a positive impact on new installations.
- In case of the maximum potential, the theoretic installable capacity will be able to cover at least half of today's electricity needs.
- In order though, to reach even a small percentage of the theoretical PV potential another obstacle has to be removed, that of the power transmission grid saturation.