ASESSMENT OF ROOF & FAÇADE POTENTIALS FOR SOLAR USE IN EUROPE

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Abstract – This paper describes an approach to the assessment of roof & facade potentials for solar use in Europe. Instead of relying on estimation of roof and facade areas available for solar use, this work formulates a mathematical description of the correlation between solar usable areas and population's density in Europe. Detailed research into the areas available, performed in Northrhine-Westfalia, Germany, formed the database for formulating this interrelationship.
By adopting this method to Europe it was possible to give a detailed overview of the European roof and façade potentials for solar use.

1. INTRODUCTION

To get an impression of the chances and energetic potentials the use of solar energy offers, it is important to know the areas available for system installation. This is true for solarthermal and photovoltaic systems as well, as both technologies are strictly dependent on area.

The assessment of areas available for solar use was often was based on estimation.

More specific research into "solar areas" has been done by site-specific census of roof and façade areas in single cities or communities. Unfortunately these data are only valid for the specific single location.

2. APPROACH TO THE ASSESSMENT OF ROOF & FAÇADE POTENTIALS

The approach of this work was to find a more general use for the data obtained from the detailed research into available areas for specific locations and thus to develop a new method roof- and façade area assessment for solar use

2.1 Used data

Detailed analysis of roof and façade areas of residential and non-residential buildings in Northrine-Westfalia, Germany were collected by H. Unger and M. Mohr (H. Unger and M. Mohr, 1992).

Among others they analysed building structures, site densities and statistical data from building authorities and land registers to produce a detailed overview of the areas available for solar use in Northrine-Westfalia.

2.2 Correlation of population density and roof & façade areas available for solar use

Using the above mentioned data, this work tried to find a new perspective to this data in order to produce a more general approach to the area assessment.

Assuming that building and living structures in western European countries are primary dependent from local population's densities and that they are similar if population density is, it seemed feasible to find a significant correlation between roof & façade areas and population density that could be used for assessing "solar use" areas for the whole EU.

The following graphs give an overview of the underlying data and the fitting curve that was found for roof & façade areas on residential and non residential buildings.

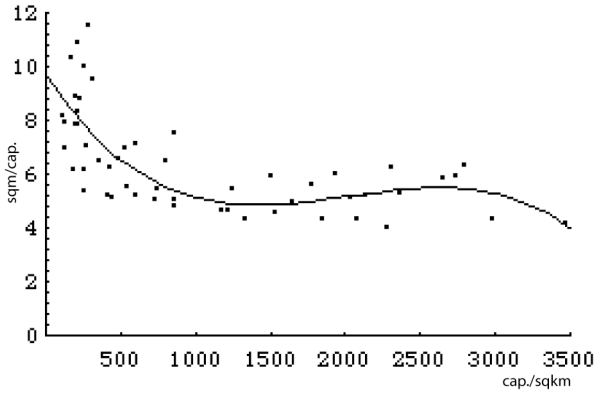

Figure 1: Roof area on non-residential buildings against density of population.

Note for calculation: Take the value at 1,500 cap./sqkm, if population density is above 1,500 cap/sqkm.

The available roof area on non-residential buildings varies from about 9 sqm/cap in low populated regions down to approx. 4 sqm/cap at 3500 inhabitants per sqkm. (Figure 1, above)

This fitting curve is described by:

$$\text{Fit} = 9.625 - 0.00816871\ x + 4.42832\ 10^{-6}\ x^2 - 7.29043\ 10^{-10}\ x^3,$$

where x = population density.

Eq. (1): Correlation of roof area of non-residential buildingsand population density.

Area available at façade of non-residential buildings is not as dependent from population density as the roof area. The range lies within approx. 5 sqm/cap (low populated)

to about 3 sqm/cap in densely populated regions. (Figure 2, below).

This fitting curve is described by:

$$Fit = 5.3159 - 0.00455371\ x + 2{,}85612\ 10^{-6}\ x^2 - 4.98563\ 10^{-10}\ x^3,$$

where x = population density.

Eq. (2): Correlation of facade area of non-residential buildings and population density.

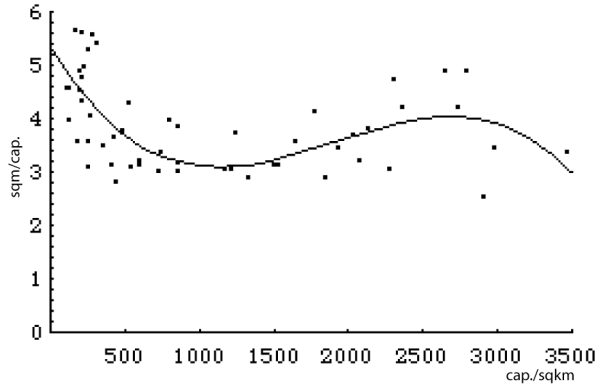

Figure 2: Facade area on non-residential buildings against density of population.

Note for calculation: Take the value at 1,250 cap./sqkm, if population density is above 1,250 cap/sqkm.

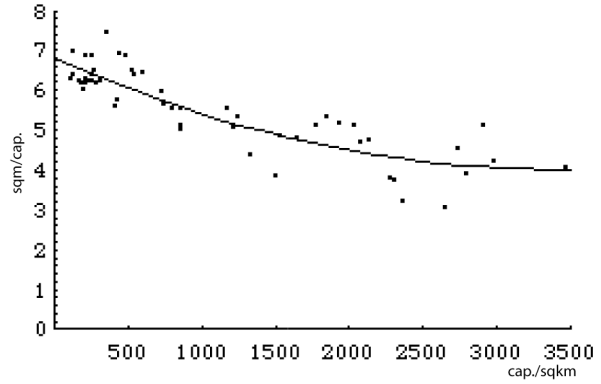

Figure 3: Roof area on residential buildings against density of population.

Note for calculation: Take the value at 3,500 cap./sqkm, if population density is above 3,500 cap/sqkm.

The roof area available on residential buildings ranges from about 7 sqm/cap to about 4.5 sqm/cap in densely populated regions (Figure 3, above).

This fitting curve is described by:

$$Fit = 6.81584 - 0.0016288\ x + 2.36943\ 10^{-7}\ x^2,$$

where x = population density.

Eq. (3): Correlation of roof area of residential buildings and population density.

The 'solar use" facade area on residential buildings is about 6 sqm/cap in low populated regions and slightly decreases to approx.5 sqm/cap in densely populated regions (Figure 4, below).

This fitting curve is described by:

$$Fit = 6.17306 - 0.000718385\ x + 1.06068\ 10^{-7}\ x^2,$$

where x = population density.

Eq. (3): Correlation of roof area of residential buildings and population density.

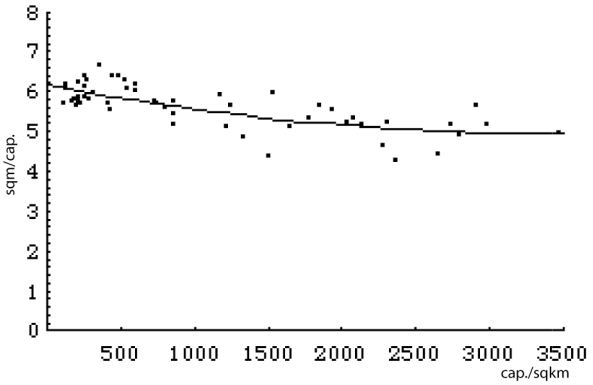

Figure 4: Facade area on residential buildings against density of population.

Note for calculation: Take the value at 3,500 cap./sqkm, if population density is above 3,500 cap/sqkm.

3. THE EUROPEAN ROOF & FAÇADE AREA POTENTIAL

Applying the so found formulation to the area of the European Union results in a total "solar use" area of about 7,000 square kilometers, thereof approx. 4,600 sqkm on top of the roofs and about 2,400 sqkm on buildings facades.

Roof areas were multiplied by a factor of 0.9 and façade areas by 0.66 to consider losses due to non usable fractions of the areas and shadowing.

The results for the different EU15 member countries are presented in the table below:

	Net area	
	Roof **km²**	Facade **km²**
Austria	103	55
Belgium	118	65
Germany	985	531
Denmark	65	35
Spain	528	244
France	750	398
Finland	72	37
Greece	130	70
Italy	739	392
Ireland	49	26
Luxembourg (grand-duche)	5	3
Netherlands	175	96
Portugal	137	71
Sweden	21	11
United Kingdom	692	378
EU15	**4571**	**2411**

Table 1: Roof & façade area potential for all types of buildings in the EU 15.

Related to the are per inhabitant (sqm/cap.) the values are as follows:

	Net area	
	Roof **sqm/cap**	Facade **sqm/cap**
Austria	12,9	6,9
Belgium	11,8	6,4
Germany	15,7	8,5
Denmark	12,7	6,8
Spain	13,5	6,3
France	13,2	7,0
Finland	14,4	7,4
Greece	12,8	6,9
Italy	13,0	6,9
Ireland	14,0	7,3
Luxembourg (grand-duche)	12,6	6,7
Netherlands	11,6	6,4
Portugal	13,9	7,2
Sweden	14,7	7,6
United Kingdom	12,0	6,5
EU15	**13,4**	**7,1**

Table 1: Roof & façade area potential for all types of buildings in the EU 15, as area per inhabitant.

4. REFERENCES

Book:
D. Gernhard, M.Mohr, M. Skiba, H. Unger (1992) Theoretisches und technisches Potential von Solarthermie, Photovoltaik, Biomasse und Wind in Nordrhein-Westfalen (The theoretical and technical potentials of Solarthermic, Photovoltaic, Biomass and Wind in Northrhine-Westfalia), pp. 16-28 and 133-140, Ruhr-Universität Bochum, RUB-E-I-35