PV POTENTIAL IN HUNGARY

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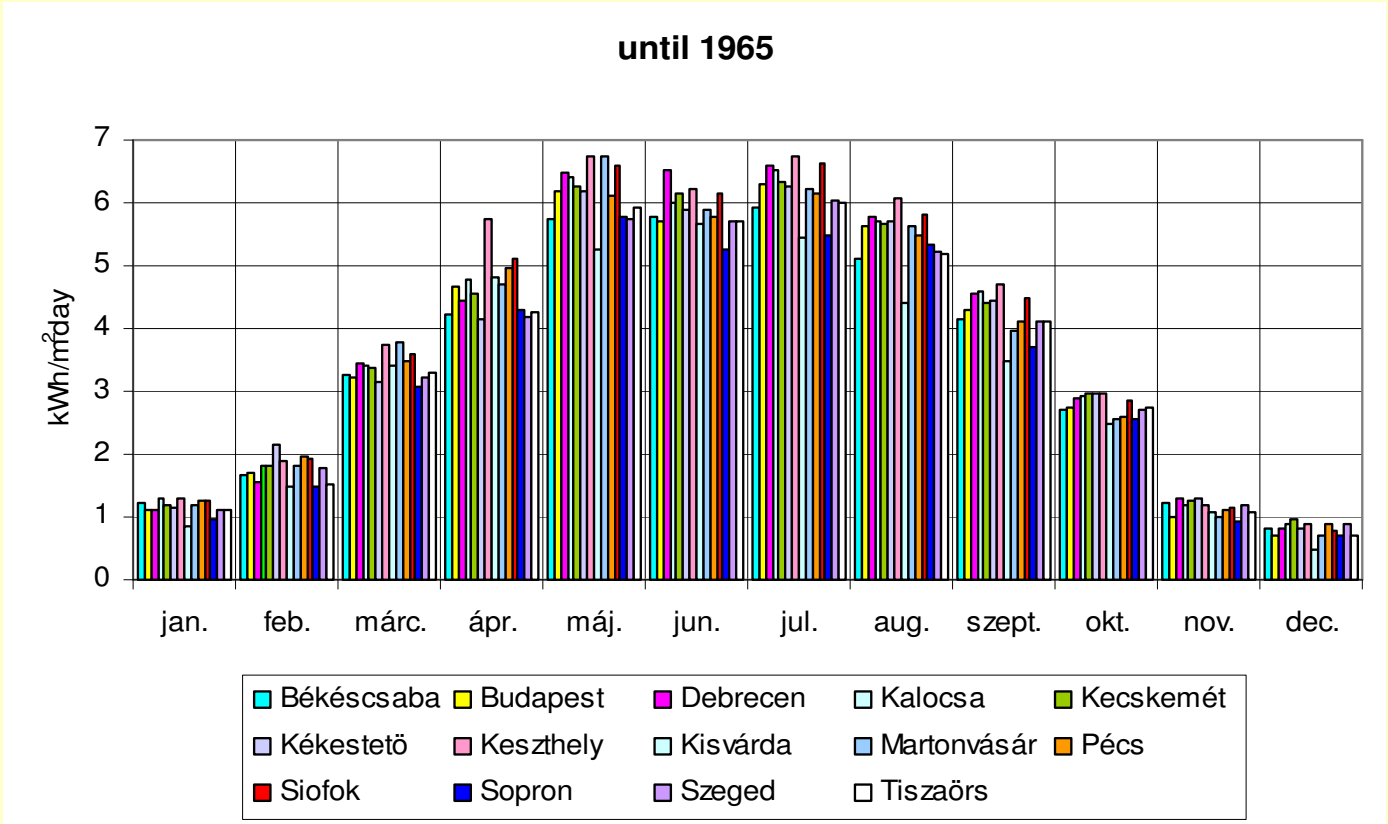
Solar radiation in Hungary



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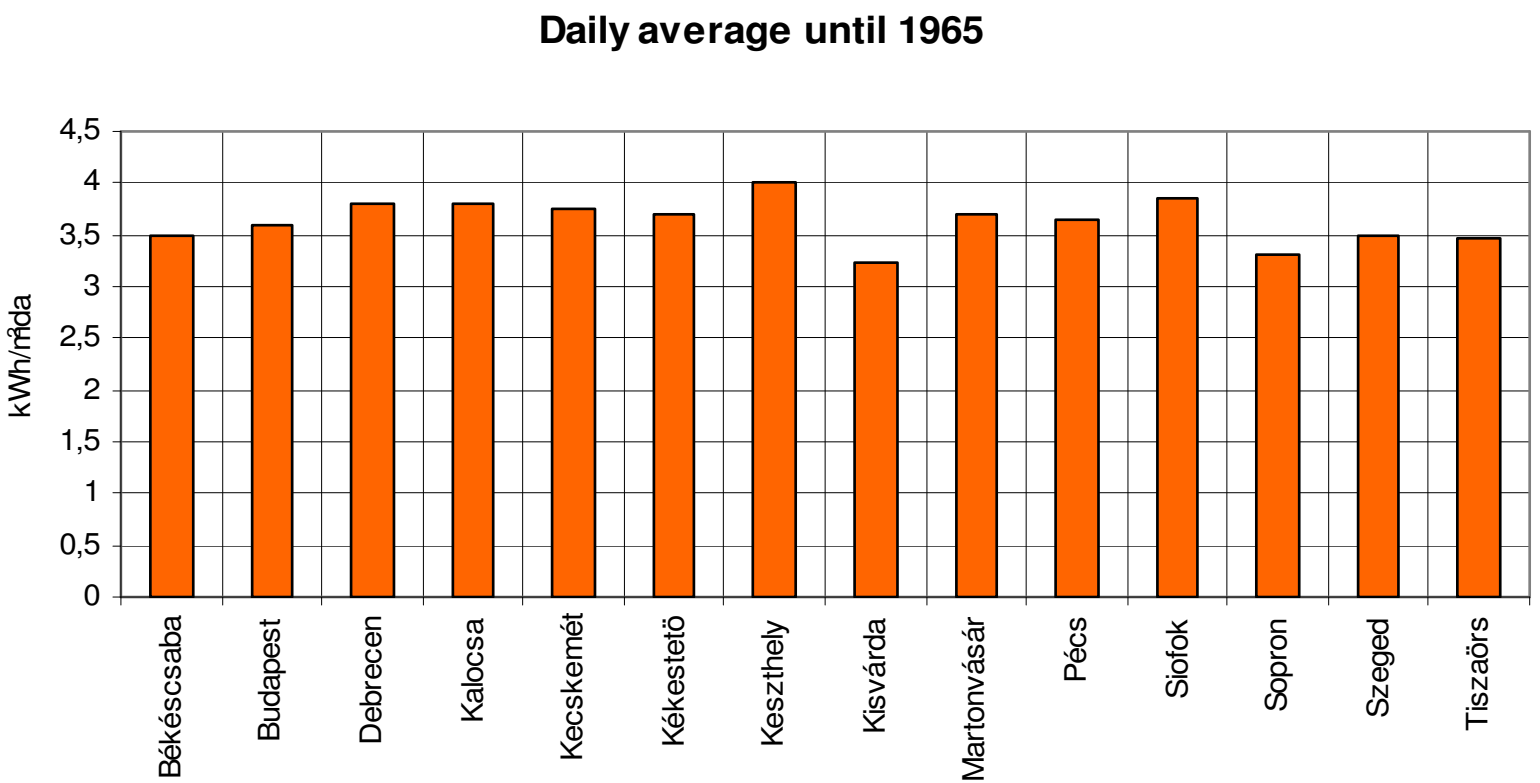

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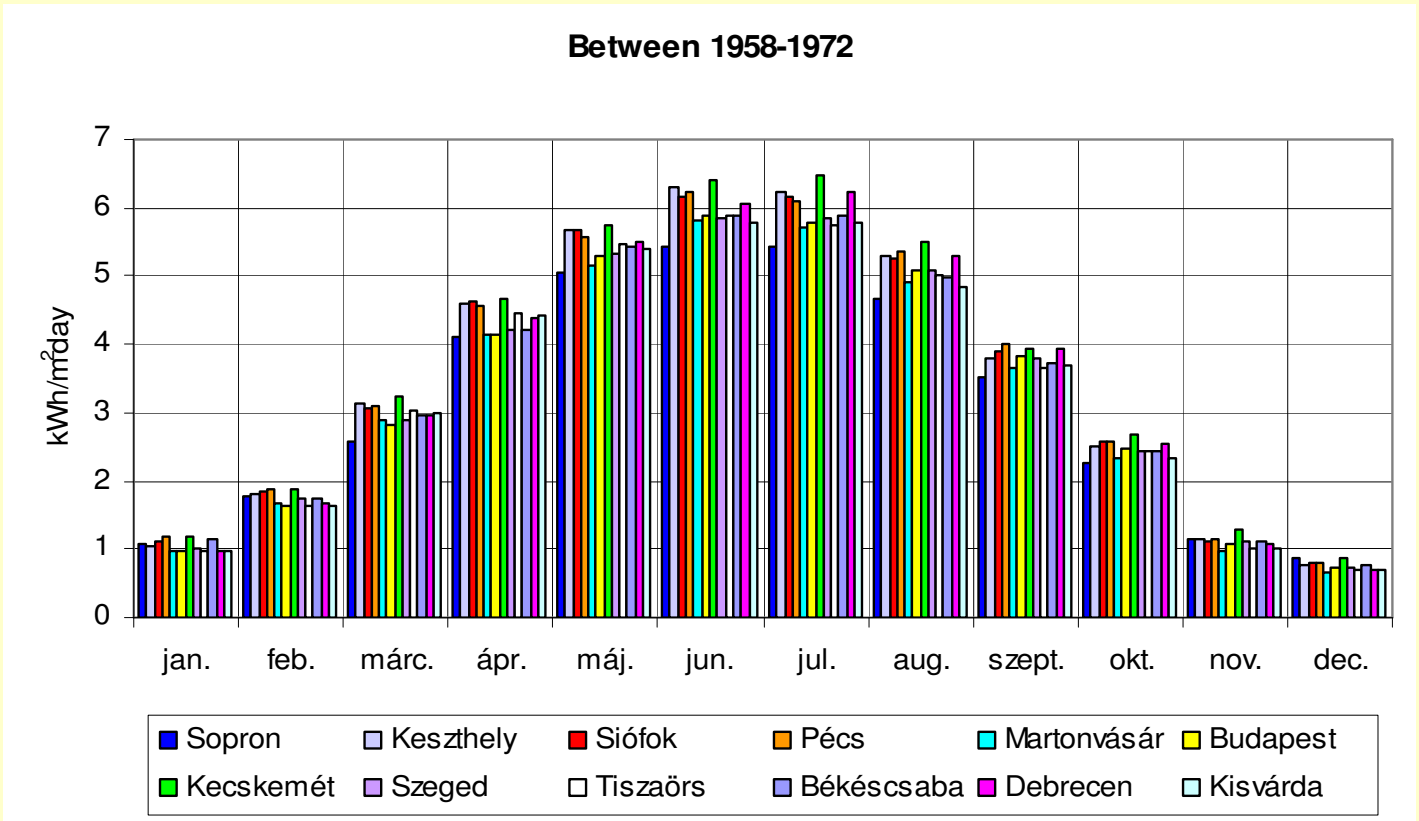

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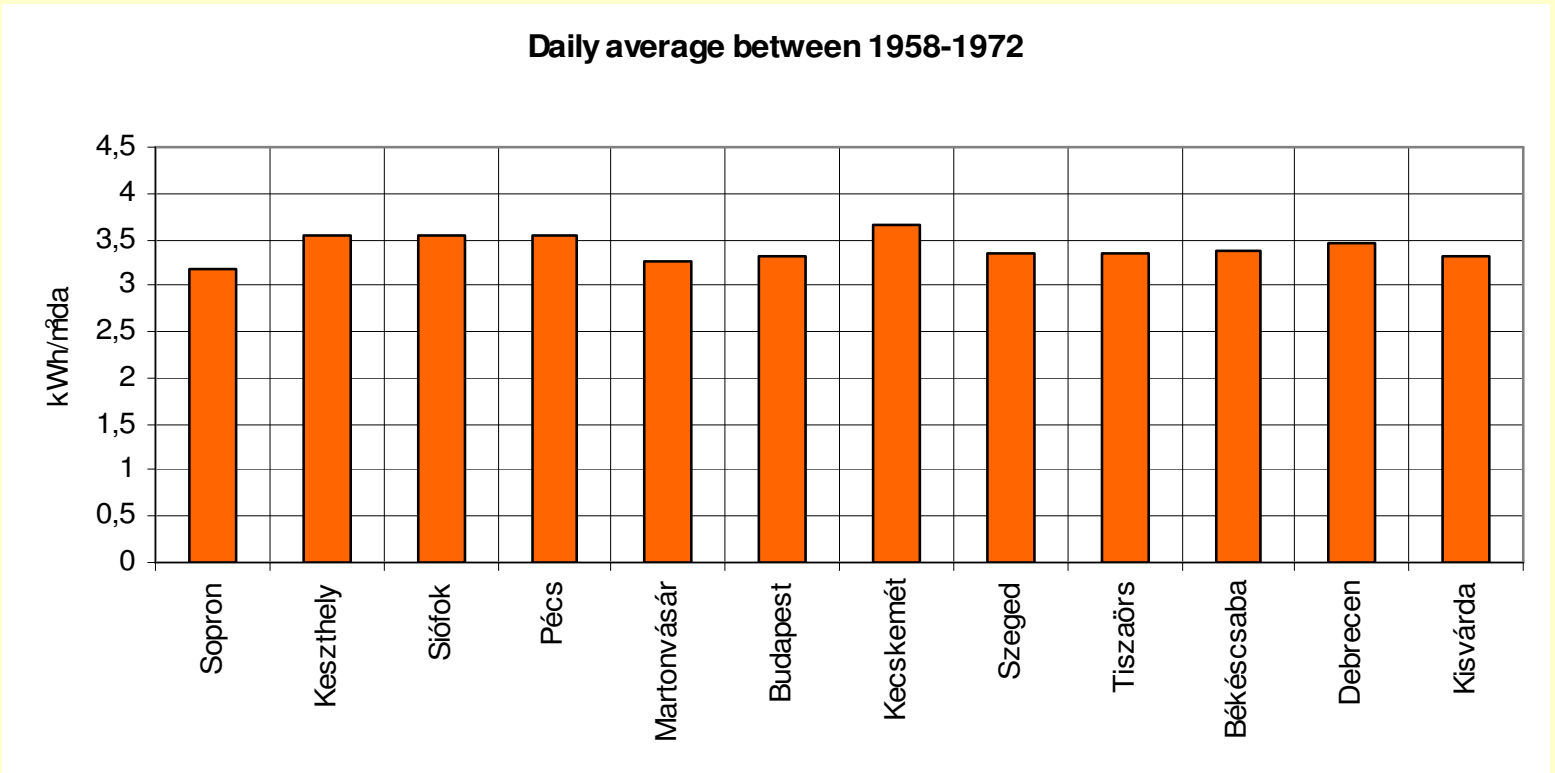


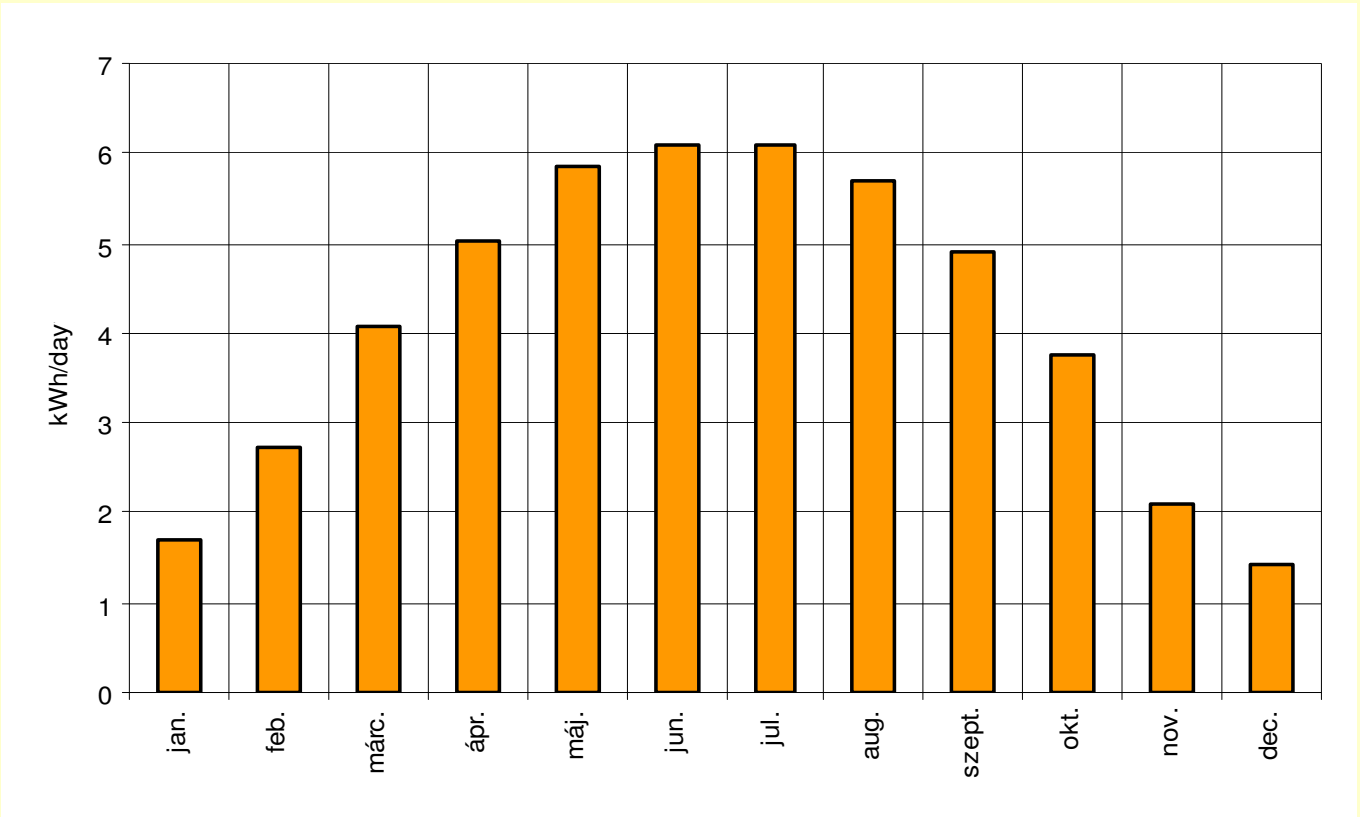
Solar radiation in Hungary

- 1168-1460/1150-1332 kWh/m^2
- Yearly total in Hungary $1.16*10^{14}$ kWh/year. 1250 kWh/m^2 average
- 2900 fold of the Hungarian yearly demand of electrical energy.
- Yearly home electrical energy demand = 1,5 m^2 solar radiation.

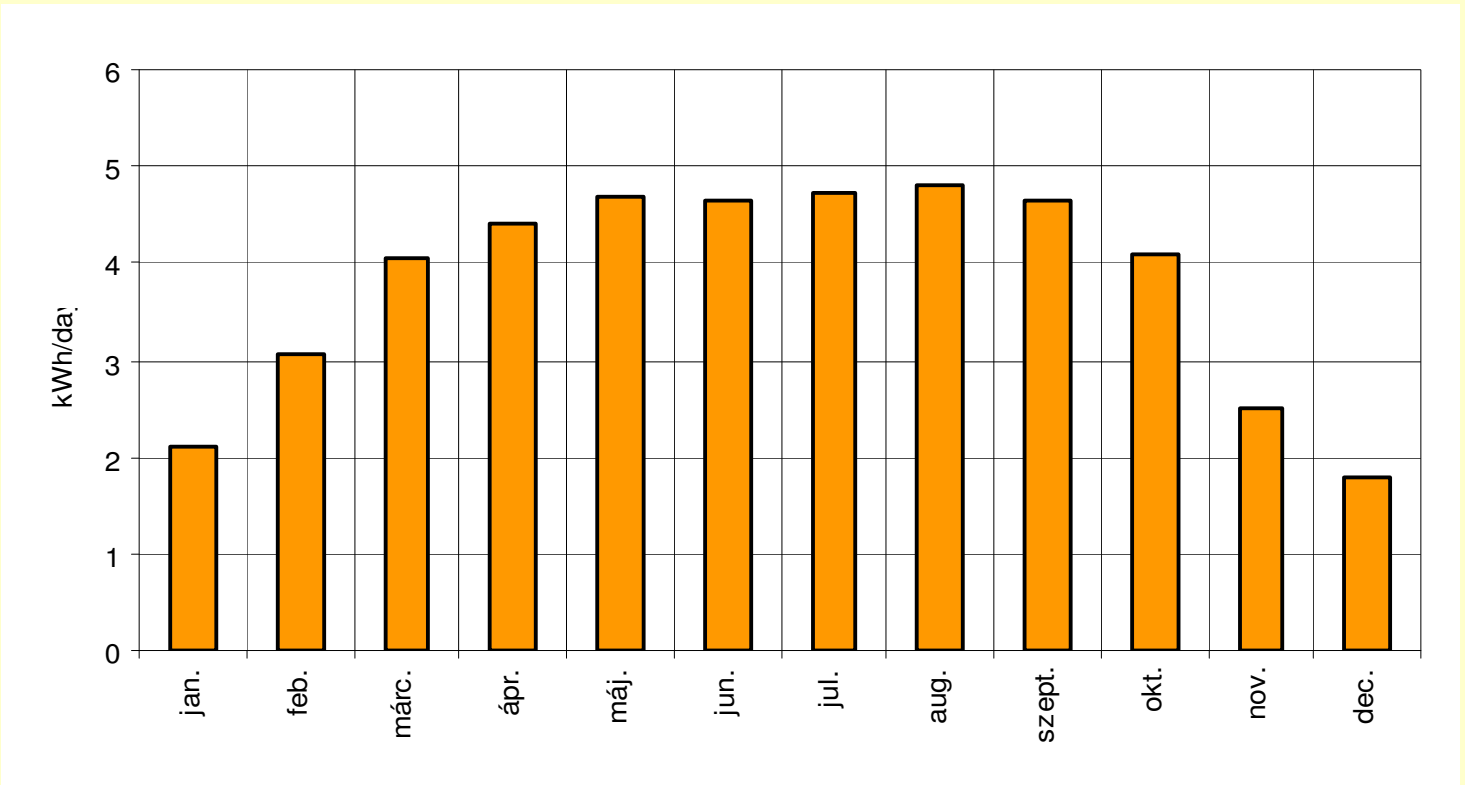
Tilt angle multipliers

Tilt angle	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
30º	1,75	1,57	1,35	1,16	1,05	1,00	1,03	1,12	1,28	1,51	1,71	1,83	1,21
60º	2,14	1,77	1,34	1,02	0,84	0,77	0,80	0,95	1,22	1,65	2,06	2,32	1,11

Daily energy production of PV 1 kW_p at 30° (1500 kWh/y)



Daily energy production of PV 1 kW_p at 60° (1390 kWh/y)



Applications in 2004

- Off grid systems (80 kWp)
- Grid connected systems (55 kWp)
- Quasiautonomous power supplies (3 kWp)
- Consumer products (n.a.)

Possibilities of PV installations

- For buildings and for other objects
- For free land areas
- Data input: Hungarian Statistical Yearbook

Possibilities of PV installations

- Apartments with big panel technology in 2001: 508.000
- Apartments with block technology in 2001: 280.000
- Other dwellings in 2001: 3.200.000

Apartments

- Calculating with 40/ staircases, 4/levels, 50 m^2 /apartment.

  Flat roof areas = 200 m^2 /staircases

  Staircases: (508.000 + 280.000)/40= 19.700
- Total flat roof areas : 19.700*4*50 = 3.940.000 m^2

Other dwellings

- Supposing 50% family house and 50% buildings with common roofs with 4 levels, 4 apartment/level

Family houses

- Calculating with 100 m^2 / house, tent roof tilt angle 45°. One of the roofs area: 35 m^2
- Total areas of one roof of the family houses: 1.600.000*35 : 56.000.000 m^2

Buildings with 4 levels

- Calculating with 4 apartments/level, 50 m^2 /apartment. Building area: 200 m^2 / 16 apartments. One of the tent roof areas: 70 m^2 .
- Total areas of one roof of the buildings with 4 levels: 70*1.600.000/16=7.000.000 m^2

Agricultural buildings

- Agricultural buildings in 2000 : 27.000.000 m^2
- Supposing 50% flat roof, 50% saddle roof with tilt angle 45^o on 1:5 ratio rectangular ground plan (one roof/ground plan ratio: 0,75) .
- Flat roof area total: 13.500.000 m^2
- One side of saddle roofs total: 10.125.000 m^2

Educational and community buildings

- Educational buildings in 2003: 14.000
- Community buildings in 2003: 16.600
- Supposing: 400 m^2 ground plan area, flat roof 30 %, saddle roof 70 % with tilt angle 45° on 1:2 ratio rectangular ground plan (one roof/ground plan ratio: 0,7) .

Educational and community buildings

- Total flat roofs area of the educational buildings: 0,3*14.000*400 = 1.680.000 m^2
- Total one side of the saddle roofs area of the educational buildings: 0,7*14.000*400*0,7= 2.744.000 m^2
- Total flat roofs area of community buildings: 0,3*16.600*400 = 1.992.000 m^2
- Total one side of the saddle roofs area of the community buildings: 0,7*16.600*400*0,7= 3.253.600 m^2

Agricultural free lands

- Field and grazing ground in 2002: 10 610 km^2
- Agricultural land area to be not subsidized: 10.000 km^2

Railways

- Rails in 2002: 7.898 km
- Supposing from 1 m up to 4 m high with a tilt angle 30^{o} solar modules could be installed one side of the railway area.
- Solar modules could be installed on one side of the railway area: 7,898.000*3*2 = 47.388.000 m^2

Motorways

- Motorways in 2002: 581 km
- Supposing from 2 m up to 4 m high with a tilt angle 60^{o} solar modules could be installed (sound barrier).
- Solar modules could be installed on one side of the motorway sound barrier: 581.000*2*0,865 = 1.005.130 m^2

Installation on flat area

- No problem with the southern orientation.
- Calculate with shading

Installation on flat area

- Just no shading if

$$d = b \times \frac{\sin(180^o - \beta - \delta)}{\sin \delta}$$

where **β** tilt angle, ***b*** width of solar field, ***d*** array distance, ***δ*** solar radiation angle

Installation on flat area

- At a tilt angle 30° in Budapest (latitude: 47,5°) in December 21 ***d/b*** = 2,32 .
- Inclined solar area = 0,431* flat area

Losses of orientation

- Just southern orientation only few cases in buildings, motorways and railways.
- The energy loss only 7 % if the deviation from south not more than +/- 45^{o}.

Losses of orientation

- Calculating with 10% orientation loss one side of the Hungarian motorways and 50 % of railways (radiant pattern) are potential for installation.

Shading losses

- The most difficult task
- Supposing 50% of the total areas with others.

POTENTIAL

- Solar modules could be installed principle on one side of the saddle roofs and on 0,431*flat roofs.
- Solar modules could be installed really only 50% of the principle areas and 25% of the railway. (shading & others)
- Because of orientation loss the effective solar areas are with 10% lower

POTENTIAL

- Calculating with 10% average module efficiency
  1 m^2 solar module nominal power = 100 Wp
- Calculating with 80% matching and other conversion losses 1 kWp solar arrays produce yearly average in Hungary at different tilt angles as follows:
  at 30^o 1200 kWh/year, at 45^o 1150 kWh/year and at 60^o 1100 kWh/year.

POTENTIAL

	Horizontal area (km^2)	30° tilted area (km^2)	45° tilted area (km^2)	60° tilted area (km^2)	Principal solar module area (km^2)	Really solar module area decr. with orientation losses (km^2)	Tilt angle of installation (°)	Solar module power to be installed (MWp)	Yearly average energy production (10^9kWh)
Apartment houses w. panel&block techn.	3,94				1,698	0,764	30	76,416	0,0916996
Other dwelling houses			63		63	28,350	45	2835	3,26025
Agricultural buildings with flat roofs	13,5				13,5	6,075	30	607,5	0,729
Agricultural buildings with saddle roofs			10,125		10,125	4,556	45	455,625	0,5239688
Educational buildings with flat roofs	1,68				0,724	0,326	30	32,5836	0,0391003
Educational buildings with saddle roofs			2,744		2,744	1,235	45	123,48	0,142002
Community buildings with flat roofs	1,992				0,859	0,386	30	38,63484	0,0463618
Community buildings with saddle roofs			3,2536		3,254	1,464	45	146,412	0,1683738
Field&grazing ground	10610				4573	2057,810	30	205780,95	246,93714
Agricultural land area not subsidized	10000				4310	1939,500	30	193950	232,74
Along the rails		47,388			47,388	10,662	30	1066,23	1,279476
Sound barriers				1,00513	1,005	0,452	60	45,23085	0,0497539
TOTAL	20631,112	47,388	79,1226	1,00513	9027,207	4051,581		405158,06	486,00713

POTENTIAL

- Yearly average electrical energy production of the solar equipment to be installed potentially in Hungary =486 billion kWh.
- Yearly demand of the electrical energy in Hungary today < 40 billion kWh.
- PV potential more than 12 fold.

Not taking account

- Building facades!

Thanks for your attention

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