DECREASING NEGATIVE ECOLOGICAL IMPACTS OF PV FARMS: IDENTIFICATION OF SUITABLE AREAS IN HUNGARY

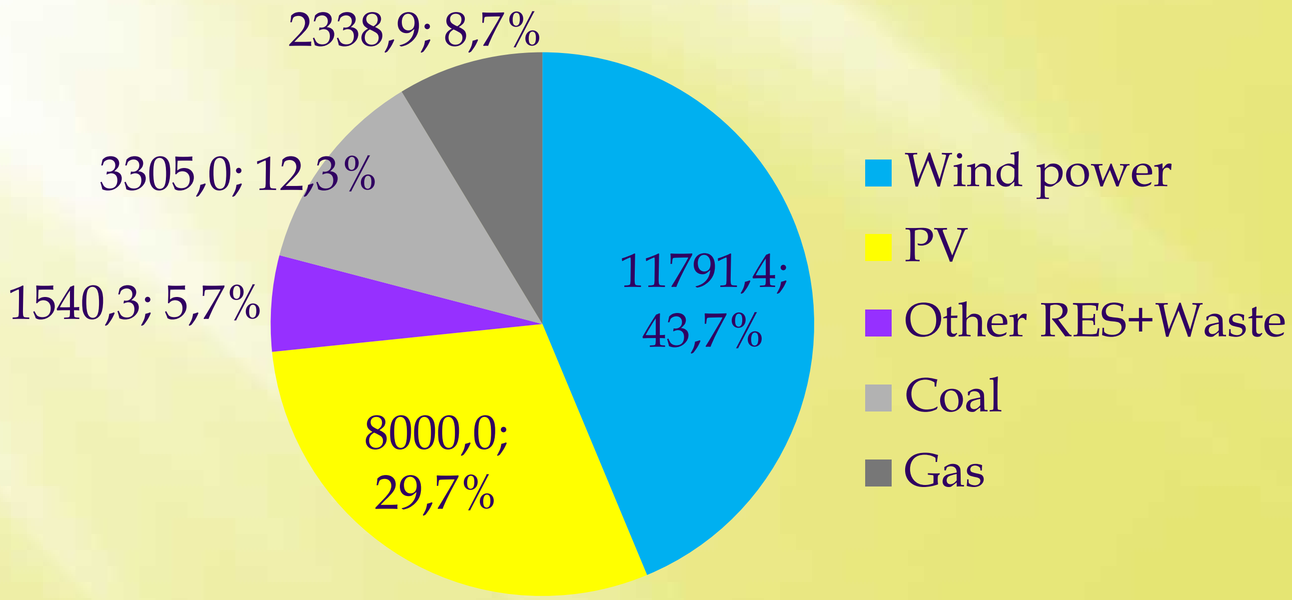
Lea Végh
Hokkaido University (PhD I.)

27.03.2015
Pécs
Perspectives of Renewable Energy in the Danube Region

Introduction

► Renewable Energy Directive
   ➢ aim: 20% energy share by 2020 in the EU[1]

New power capacity installations in EU, 2014[2] (MW)



[1]EC 2009
[2]EWEA 2015

Introduction

► Hungary share of PV is basically nonexistent

- 1576 MWh-0.005% gross electricity in 2013[3]

► Compared to other countries lags behind

- Germany 4.7% of electricity generation from PV in 2013[4]
- solar irradiation less favourable than in Hungary[5]

[3]MAVIR 2014
[4]IEA 2014
[5]Šúri et al. 2007

Introduction

► PV farms: non-residential, ground mounted utility scale installations

► Local ecological impacts[6,7]:

- ➢ habitat loss, disturbance, fragmentation

► Mitigation[8,9,10,11]:

- ➢ Location of the project
- ➢ Degraded areas suffer less, even positive impacts

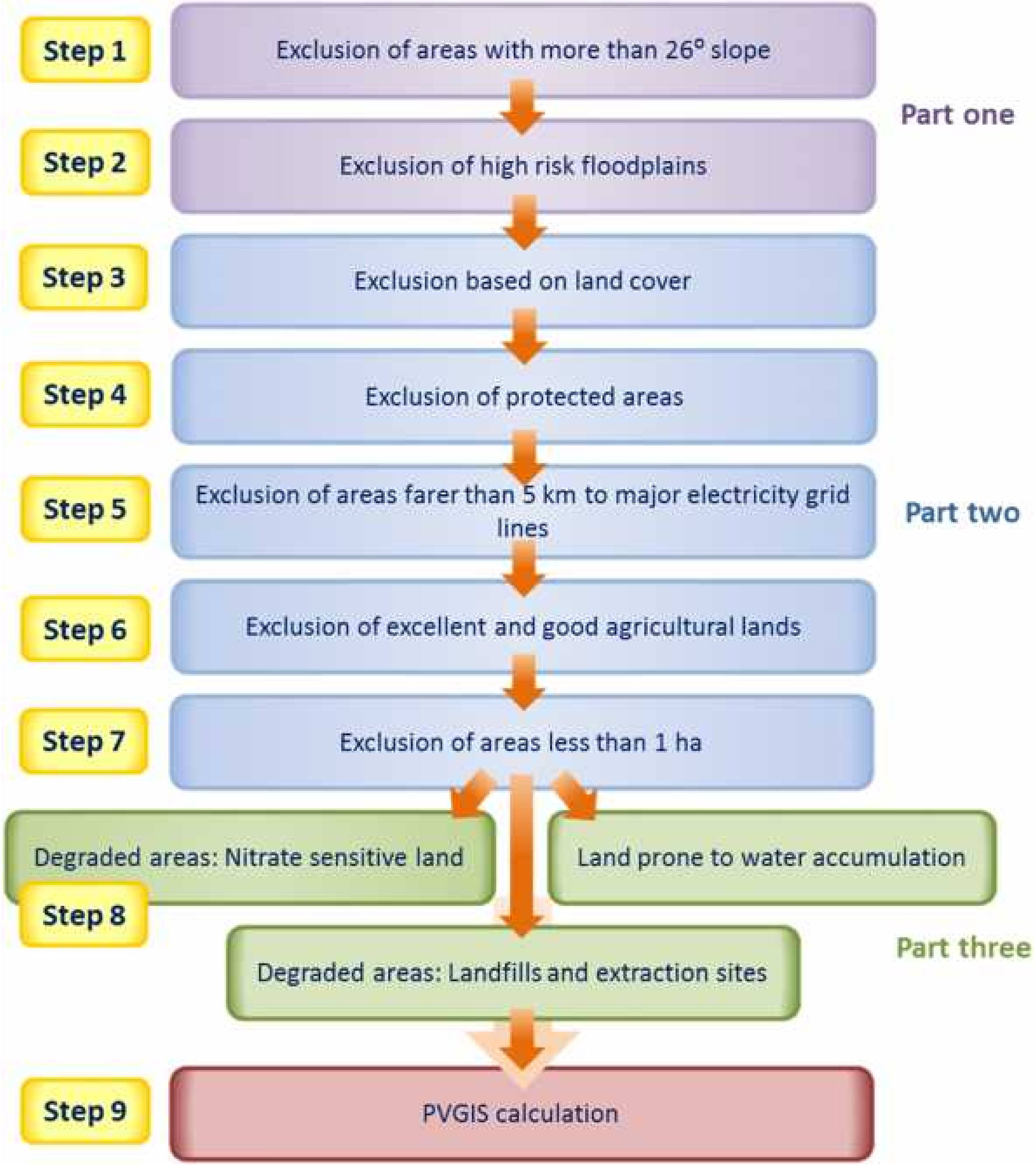
[6-7]Arvizu et al. 2011; Hernandez et al. 2014

[8-11]Peschel 2010; Wade 2011; Kelly and Delfino 2012; Gekas et al. 2002

Aims

- ► Draw attention to mitigation of ecological impacts
- ► Identifying degraded areas in Hungary, which would be suitable for PV farm installations
- ► Providing a basic electricity potential calculation based on this areas
- ► Using:
  - ➢ GIS analysis
  - ➢ Globally available datasets

Methods



Step 1
Exclusion of areas with more than 26° slope
Step 2
Exclusion of high risk floodplains
Part one
Step 3
Exclusion based on land cover
Step 4
Exclusion of protected areas
Step 5
Exclusion of areas farer than 5 km to major electricity grid lines
Part two
Step 6
Exclusion of excellent and good agricultural lands
Step 7
Exclusion of areas less than 1 ha
Degraded areas: Nitrate sensitive land
Land prone to water accumulation
Step 8
Degraded areas: Landfills and extraction sites
Part three
Step 9
PVGIS calculation

Methods

► Electricity potential calculation[5]

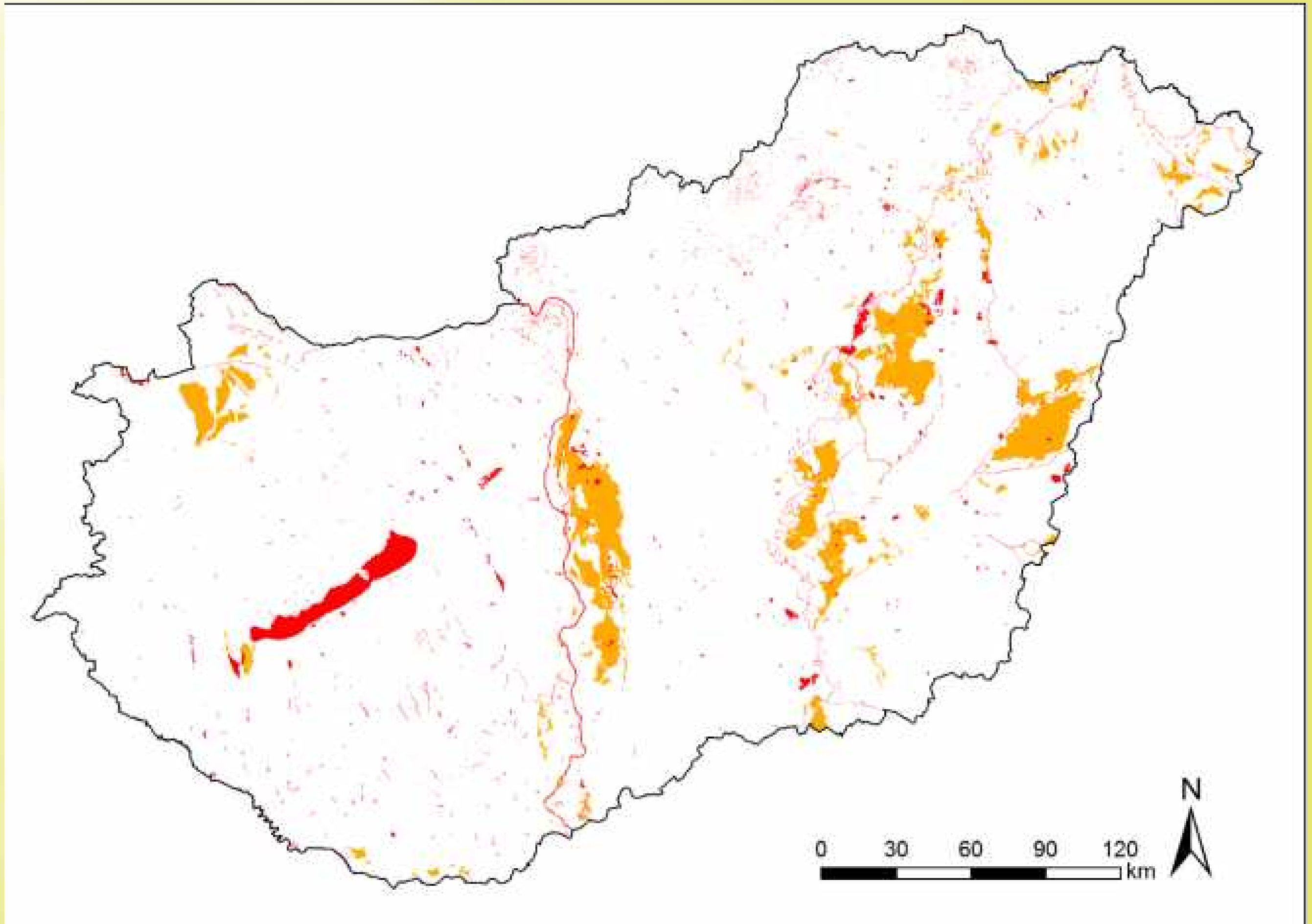
$$E = P_k PR G$$

- E = electricity generation (kWh)
- P_k = unit peak power (assumed to be 1 kW_p)
- PR = performance ratio (assumed the value of 0.75)
- G = mean of the yearly total irradiation on horizontal or optimally inclined plane (kWh/m^2)

[5]Šúri et al. 2007

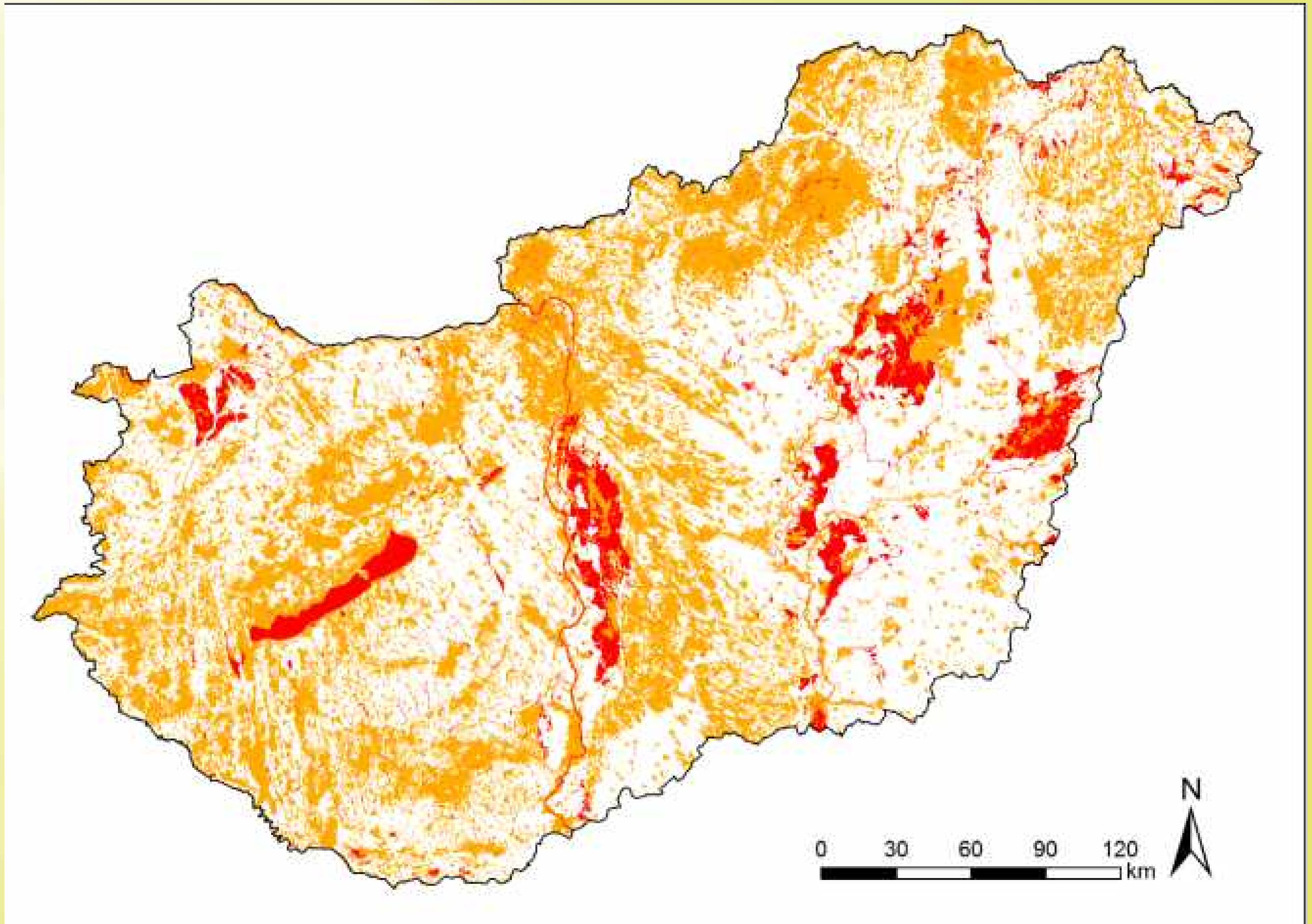
Results- Part one

- Step 1 Exclusion of areas of 26° < slope
- Step 2 Exclusion of high risk floodplains



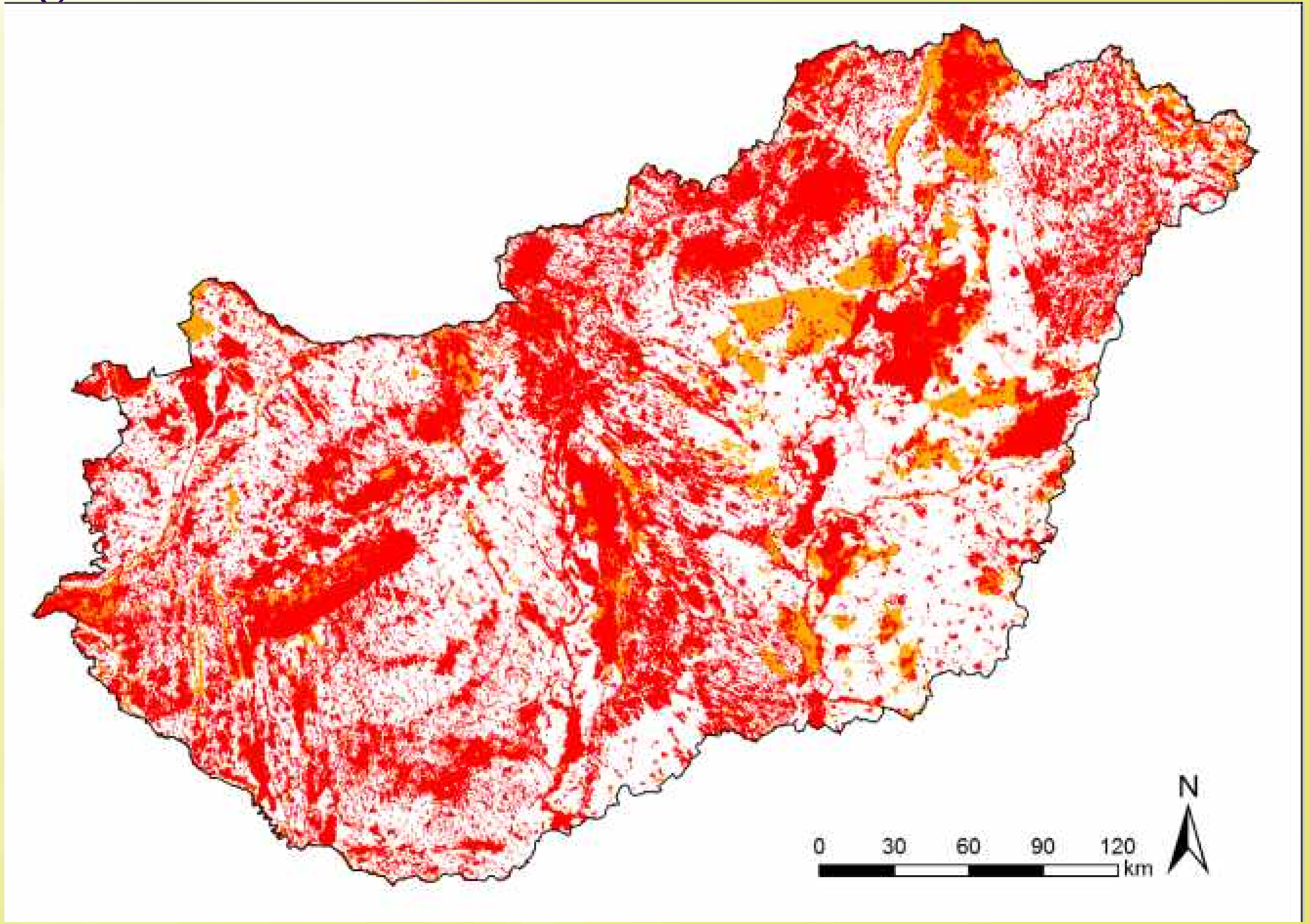
Results- Part two

- Step 3 Exclusion of areas based on land cover



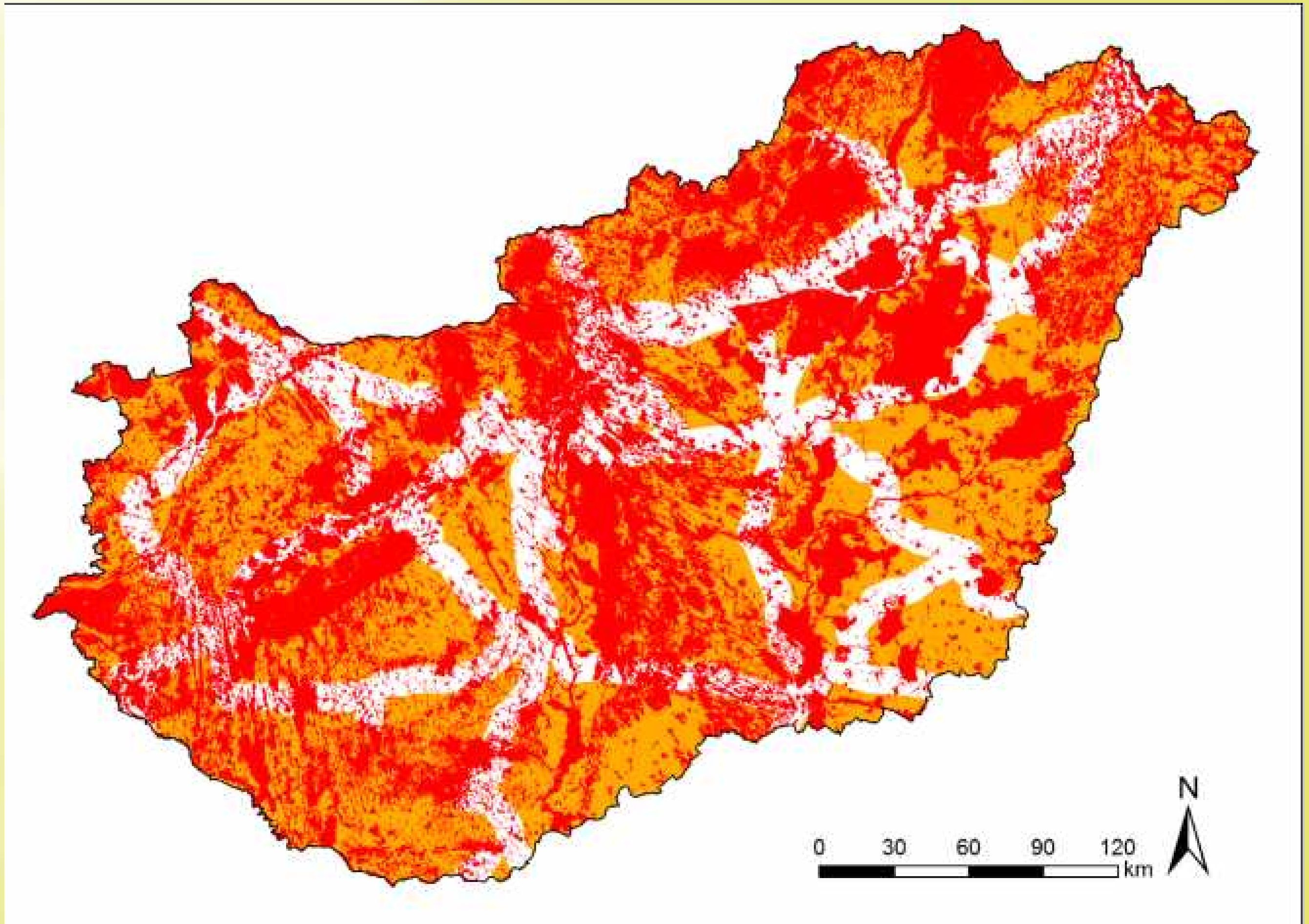
Results- Part two

- Step 4 Exclusion of protected areas
  - National parks, Natura 2000 areas and other nationally designated areas



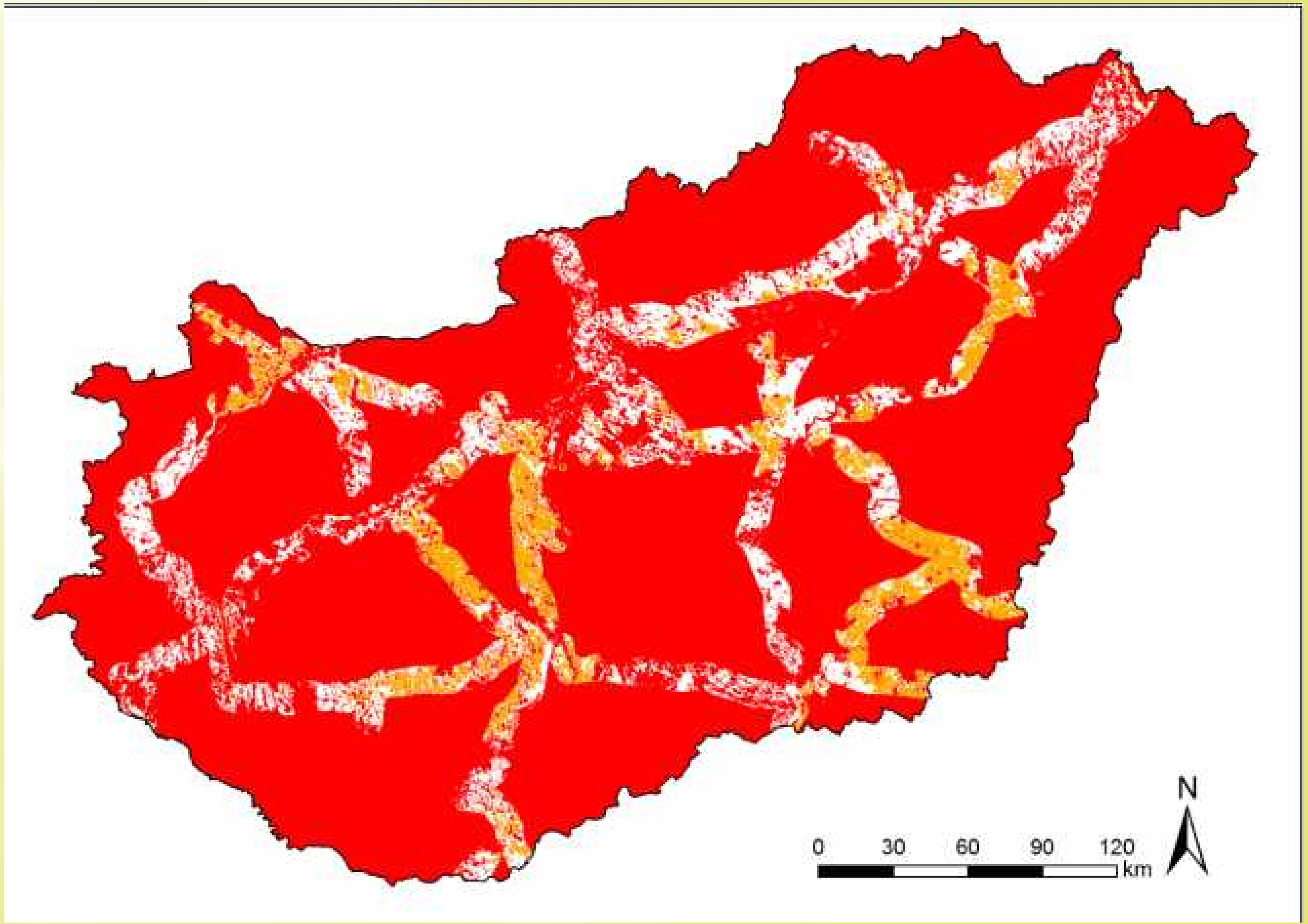
Results- Part two

- Step 5 Exclusion of areas farer than 5 km to major electricity grid lines



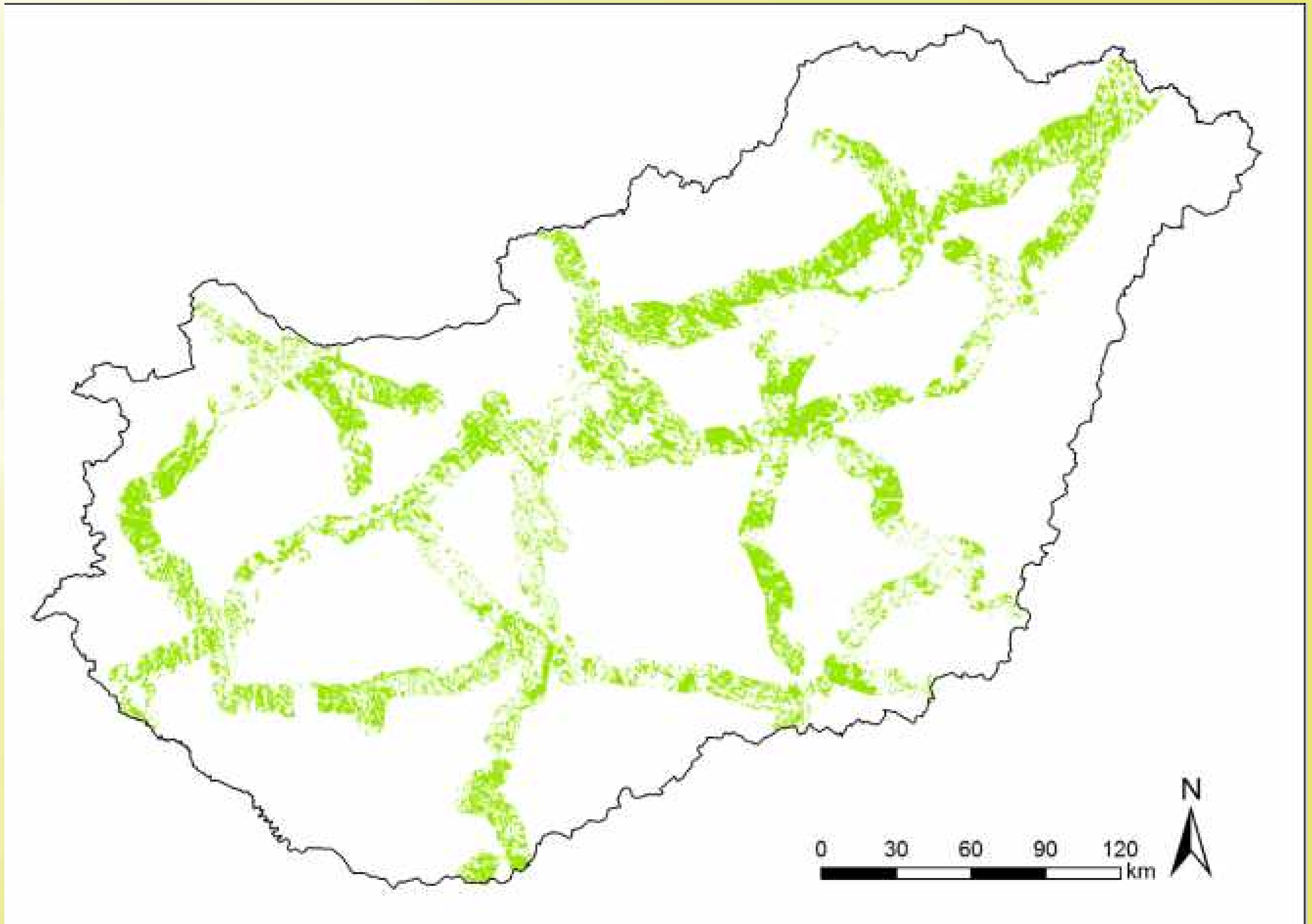
Results- Part two

- Step 6 Exclusion of excellent and good agricultural lands



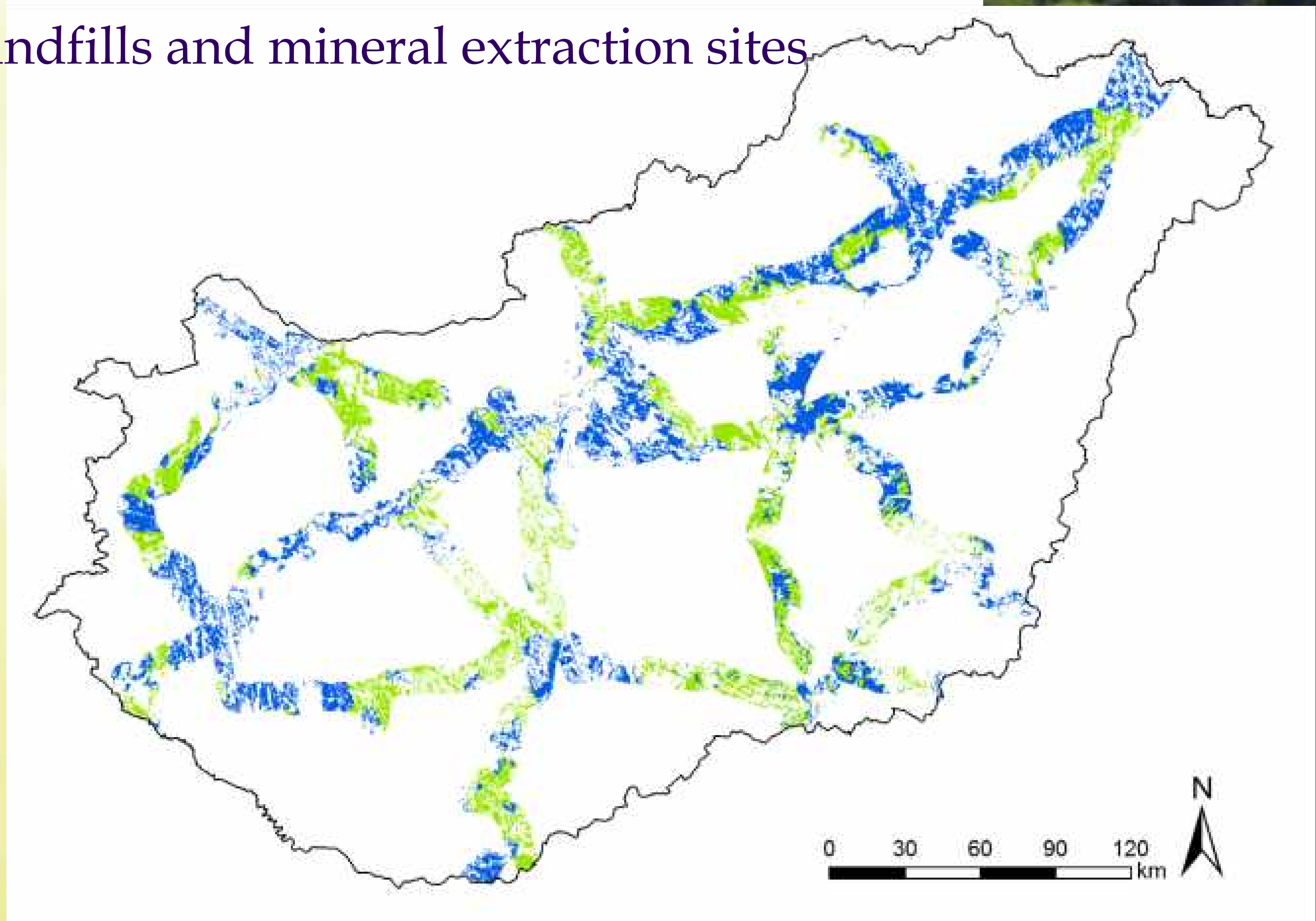
Results- Part two

- Step 7 Exclusion of areas less than 1 ha



Results-Part th

- Step 8 Higlighting ecologically degraded
  - Nitrate sensitive land
  - Land prone to water inundation
  - Landfills and mineral extraction sites



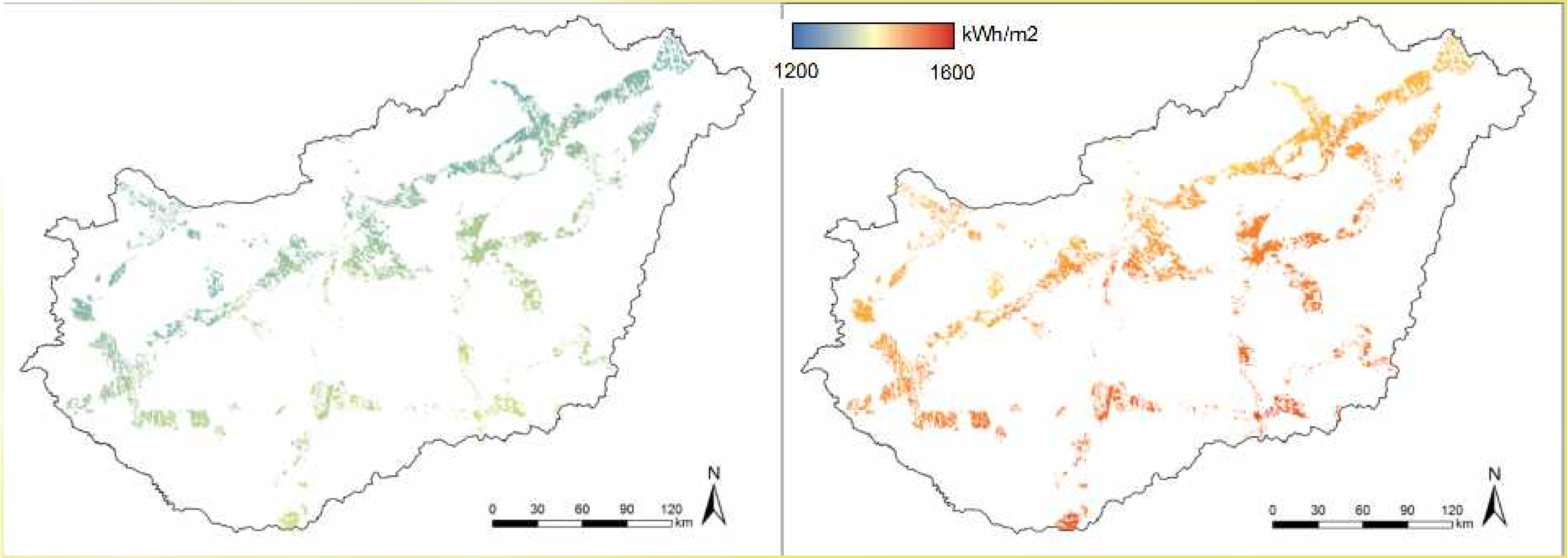
Results-Part three

		km^2		additional area if nitrate sensitive good quality agricultural land is considered	
Hungarian land area (without water bodies)		91152	Excluded area		
after	Step 1	91011	-141		
	Step 2	86616	-4395		
	Step 3	54202	-32414		
	Step 4	47605	-6597		
	Step 5	16766	-30839		
	Step 6	11930	-4836		1695
	Step 7	11923	-7		1694
	Step 8	6741	-5182		98
		674094	hectare		9845
		7265	Dump and mineral extraction sites		54

Discussion

- Step 9 PVGIS estimation[5]

Global yearly irradiation



Horizontal surface

Optimally inclined surface

[4]Šúri et al. 2007

Discussion

technology (m2/kWp)[12]	TWh			
	Horizontal surface		Optimally inclined	
	Step 8 973.5 kWh/kWp	Dump, Min. 960.75 kWh/kWp	Step 8 1119.75 kWh/kWp	Dump, Min. 1105.5 kWh/kWp
hybrid monocrystalline (5)	1309.16	13.98	1507.88	16.03
monocrystalline (6.7)	976.99	10.43	1125.28	11.96
polycrystalline (7.2)	909.14	9.71	1047.14	11.13
thin film (10)	654.58	6.99	753.94	8.01

- ►Hungary's net electricity demand was 36,269 GWh in 2013[3]
- ►if 1% of the identified areas (67 km^2) used ⟹ 18-41% of consumption covered
- ►50% of dump and mineral construction sites used ⟹ 9.7-22%

[12]Manap 2015
[3]MAVIR 2014

Conclusion

- ►Hungary has a great potential for PV
- ►sufficient degraded areas for installations
- ►major ecological impacts can be avoided
- ►Limitations
  - ➢ overall country analysis, no field trips
  - ➢ difficulty of identification of degraded areas

Thank you for your attention!

References

1. EC. DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. European Commission. 2009 [cited 2015 Feb 17];L 140/16. Available from: http://www.nezeh.eu/assets/media/fckuploads/file/Legislation/RED_23April2009.pdf
2. EWEA. Wind in power - 2014 European statistics. The European Wind Energy Association; 2015 [cited 2015 Feb 17]. Available from: http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf
3. MAVIR. Statistical data of the Hungarian power system, 2013. Hungarian Energy and Public Utility Regulatory Authority; 2014 [cited 2015 Feb 19]. Available from: http://www.mavir.hu/documents/10258/193045374/MEKHMAVIR_Stat_20141110_preview.pdf/09f1d77c-d399-4ccc-8bcc-0b12d4f60915
4. IEA. Renewables Information 2014 With 2013 Data. International Energy Agency; Paris: OECD Publishing; 2014 [cited 2015 Feb 18]. Available from: http://public.eblib.com/choice/PublicFullRecord.aspx?p=1798453
5. Šúri M, Huld TA, Dunlop ED, Ossenbrink HA. Potential of solar electricity generation in the European Union member states and candidate countries. *Sol Energy*. 2007 Oct;81(10):1295–305.
6. Arvizu D, Balaya P, Cabeza LF, Hollands KGT, Jäger-Waldau A, Kondo M, et al. Direct Solar Energy. In *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation,* editors Edenhofer O, Pichs-Madruga R, Sokona Y, Seyboth K, Matschoss P, Kadner S, et al., Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press; 2011 [cited 2014 Jul 9]. Available from: http://srren.ipcc-wg3.de/report/IPCC_SRREN_Ch03.pdf
7. Hernandez RR, Easter SB, Murphy-Mariscal ML, Maestre FT, Tavassoli M, Allen EB, et al. Environmental impacts of utility-scale solar energy. *Renew Sustain Energy Rev*. 2014 Jan;29:766–79.
8. Peschel T. Solar parks-Opportunities for Biodiversity; A report on biodiversity in and around ground-mounded photovoltaic plants. Berlin: German Renewable Energies Agency; 2010 Dec [cited 2014 Jun 4]. Report No.: Issue 45. Available from: www.renewables-in-germany.com
9. Wade A. Solar Parks and their Influence on Biodiversity. 2011.
10. Kelly K, Delfino K. Smart From the Start: Responsible Renewable Energy Development in the Southern San Joaquin Valley. Defenders of Wildlife; 2012 [cited 2014 Jun 4]. Available from: www.defenders.org
11. Gekas V, Frantzeskaki N, Tsoutsos T. Environmental Impact Assessment of Solar Energy Systems Results from Life Cycle Analysis. Skiathos; 2002. p. 1569–76.
12. Manap. Napelem típusok [Types of PV]. MANAP Iparági Egyesület. 2015 [cited 2015 Feb 18]. Available from: http://www.manap.hu/napelem-tipusok.html

Photos: Peschel 2010; www.idokep.hu; www.imgeye.com