POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Observations on the new wind energy resource potential estimates

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Treatment of the Data Spreadsheet

Data sheet „ Combined “

	Class 3 MW	Class 4 MW	Class 5 MW	Class 6 MW	Class 7 MW
Aruba	386	0	0	0	0
Afghanistan	220,041	75,967	33,164	33,077	15,847
Angola	0	0	0	0	0
Anguilla	291	33	0	0	0
Albania	0	0	0	0	0
Andorra	1984	0	0	0	0
Netherlands Antilles	1545	1245	0	0	0
United Arab Emirates	2,701	894	305	140	25
Argentina	628045	594638	619701	473205	168574
Armenia	6,905	2,255	1,035	845	425

Wind Class	3	4	5	6	7
Power Density [W/ m^2]	350-450	450-550	550-650	650-800	>800
Average Annual Wind Speed [m/s]	6.7	7.25	7.75	8.4	10.35
CF	0.23	0.27	0.30	0.34	0.47
Full load hours ~	2040	2350	2630	3000	4100

Source: NREL web site, Hoogwijk (2004)

Data processing:

1. Wind classes converted into average annual wind speed (see table)
2. Wind speed data transformed into CF using linear relationship by Monique Hoogwijk for k=2
3. Areas converted into installed capacity using the 5MW/km² assumption
4. Installed capacities multiplied by capacity factor and 8760 h/ a➔ potential electricity production by CF
5. Data compiled into ten discrete wind energy grades and aggregated to 11 world regions

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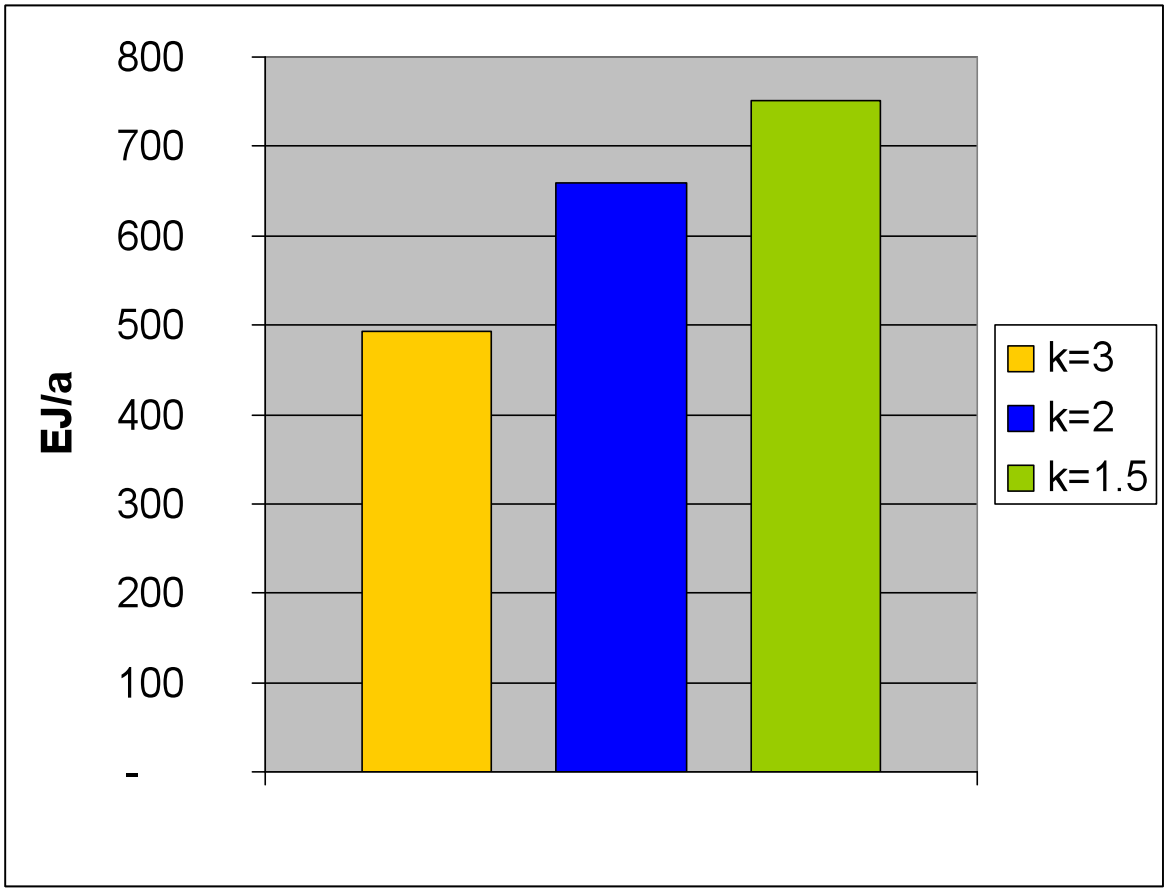
Sensitivity Analysis

Total global wind energy output according to Weibull shape parameter k



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Comparison to other sources: Case of Germany

Assumption: 5MW/km² installed capacity

1. Result IMAGE&NREL over wind class 3 to 7 using Monique Hoogwijks function to estimate CF's from wind speed, k=2: 780 PJ
2. Result IMAGE&NREL over wind class 3 to 7 using equally distributed capacity factors (CF 25-45%, from "combined" sheet): 880 PJ
3. Result IMAGE re-scaled over capacity factors CF 25-50%: 1740 PJ
4. Result IMAGE re-scaled over capacity factors 10-50%: 4340 PJ

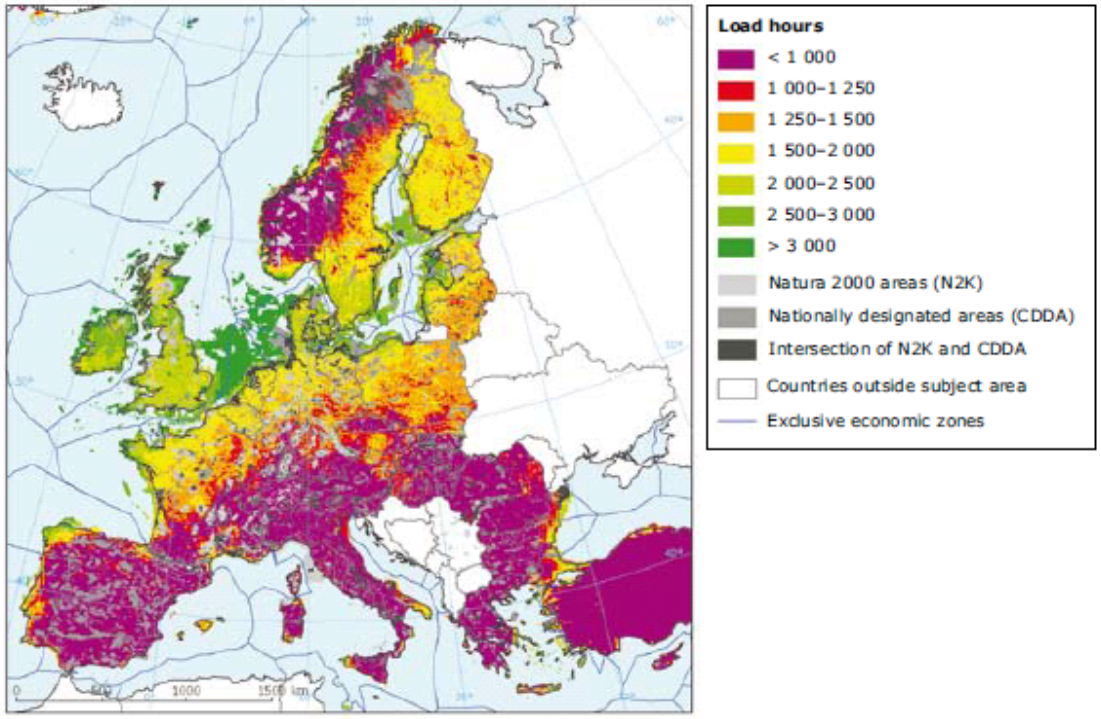
BMU (2008), optimistic scenario in 2020: ~265 PJ with CF = 23.3%

Total electricity production 2008: ~2300PJ

Reference: "Weiterentwicklung der Ausbaustrategie Erneuerbare Energien Leitstudie 2008", BMU, 2008

Comparison to other sources: Europe

Map 5.2 Natura 2000 and CDDA areas in Europe, and full load-hour potential

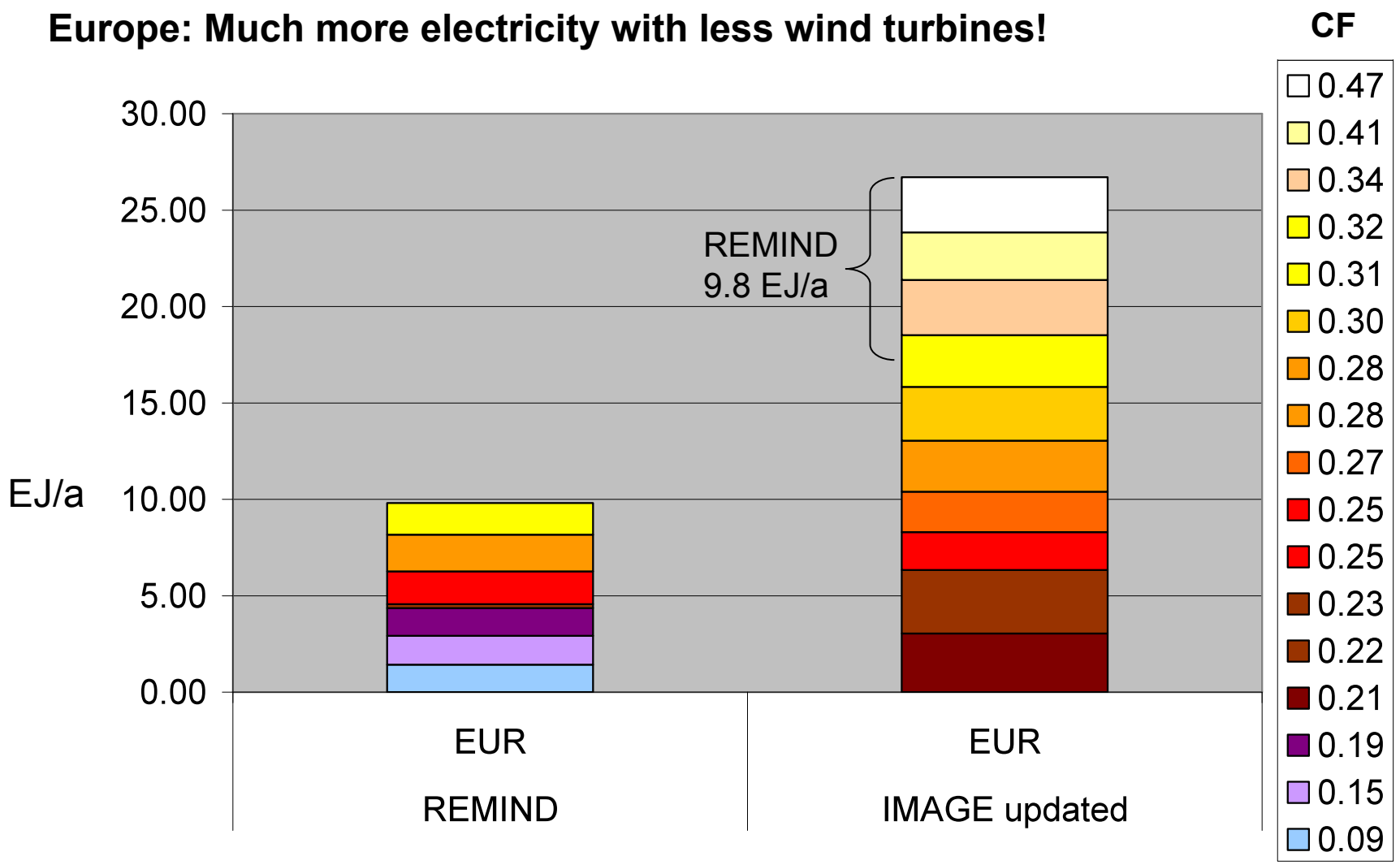


Source: EEA, 2008.

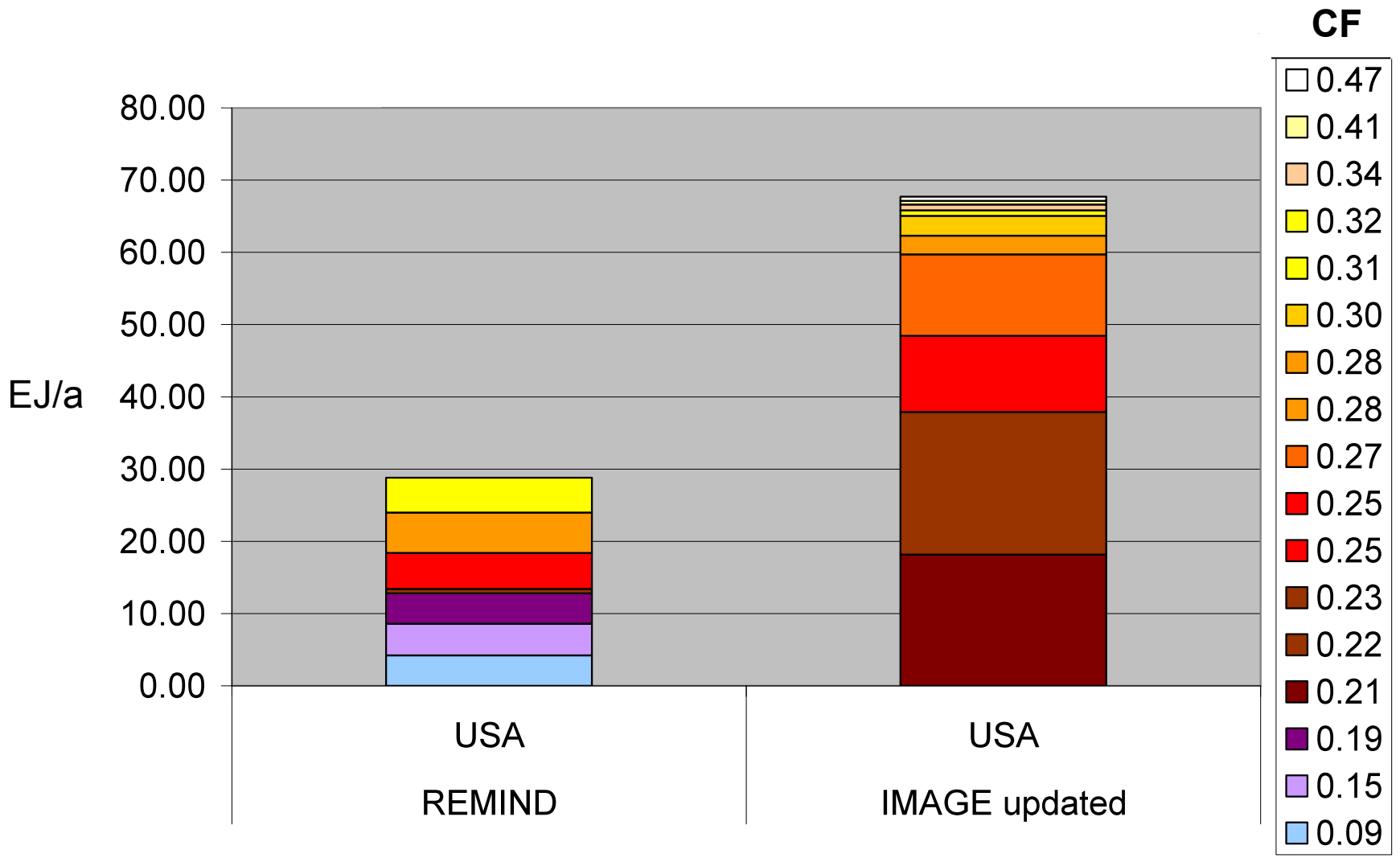
EEA:
only very few onshore areas with 2500-3000 or even more than 3000 full load hours are available (3000 flh = 34% CF)

IMAGE re-scaled:
More than 1/2 of the proposed wind locations in Europe have a CF>30% using the “Hoogwijk-function”

Comparison with Standard REMIND-R

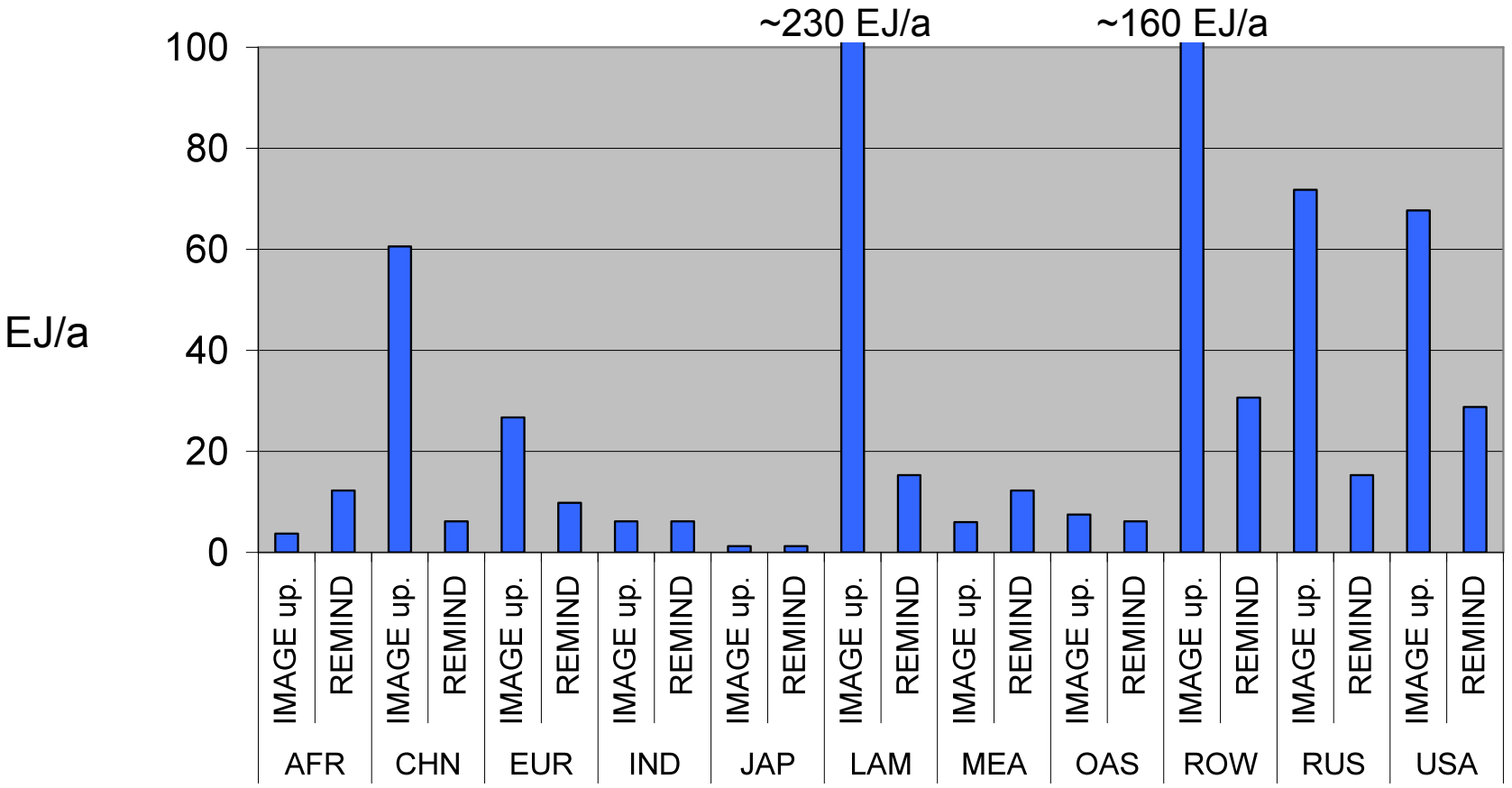


Comparison with Standard REMIND-R: USA



Comparison with Standard REMIND-R

	REMIND	IMAGE re-scaled
Global wind energy potential (EJ/a):	144	637



Open Questions

1. Data coverage
   a. Data coverage for Africa? (no data for South Africa, Namibia, etc.)
   b. Is zero potential for India realistic?
2. Methodology for assessing wind energy potentials
   a. Is the methodology of re-scaling sound?
   b. What areas should be excluded? (nature conservation, high altitude, …)
   c. Is the concept of using a standard turbine and fixed shape parameter of Weibull distribution biasing the results?
3. Validation of results
   a. How can we validate potentials against real world wind generation data? E.g. do we need to correct the CF calculated from power curve and wind speed distribution?
   b. How can we improve the assessment based on validation?

What bottom-up information should be provided?

1. Important parameters for assessing potentials per grid cell
   a. Reduction of CF due to maintenance and un-planned outages
   b. World wide wind frequency distribution
   c. Turbine design parameters (turbine size, hubheight, rotor diameter)
   d. Capacity per area (a function of turbine size?)

2. „Discounting“ capacity in grid cells based on
   a. Population data (as a proxy for demand)
   b. Proximity to existing grid
   c. Grid costs (low, medium, high)
   d. Barriers for grid extensions (mountains, sea, national borders, …)

5. Information per grade (= wind class 2-7) needed by ReMIND
   a. Capacity
   b. Average capacity factor
   c. Specific investment costs of typical turbine (a function of turbine size)