Renewable Energy Potentials: Solar PV and Onshore Wind

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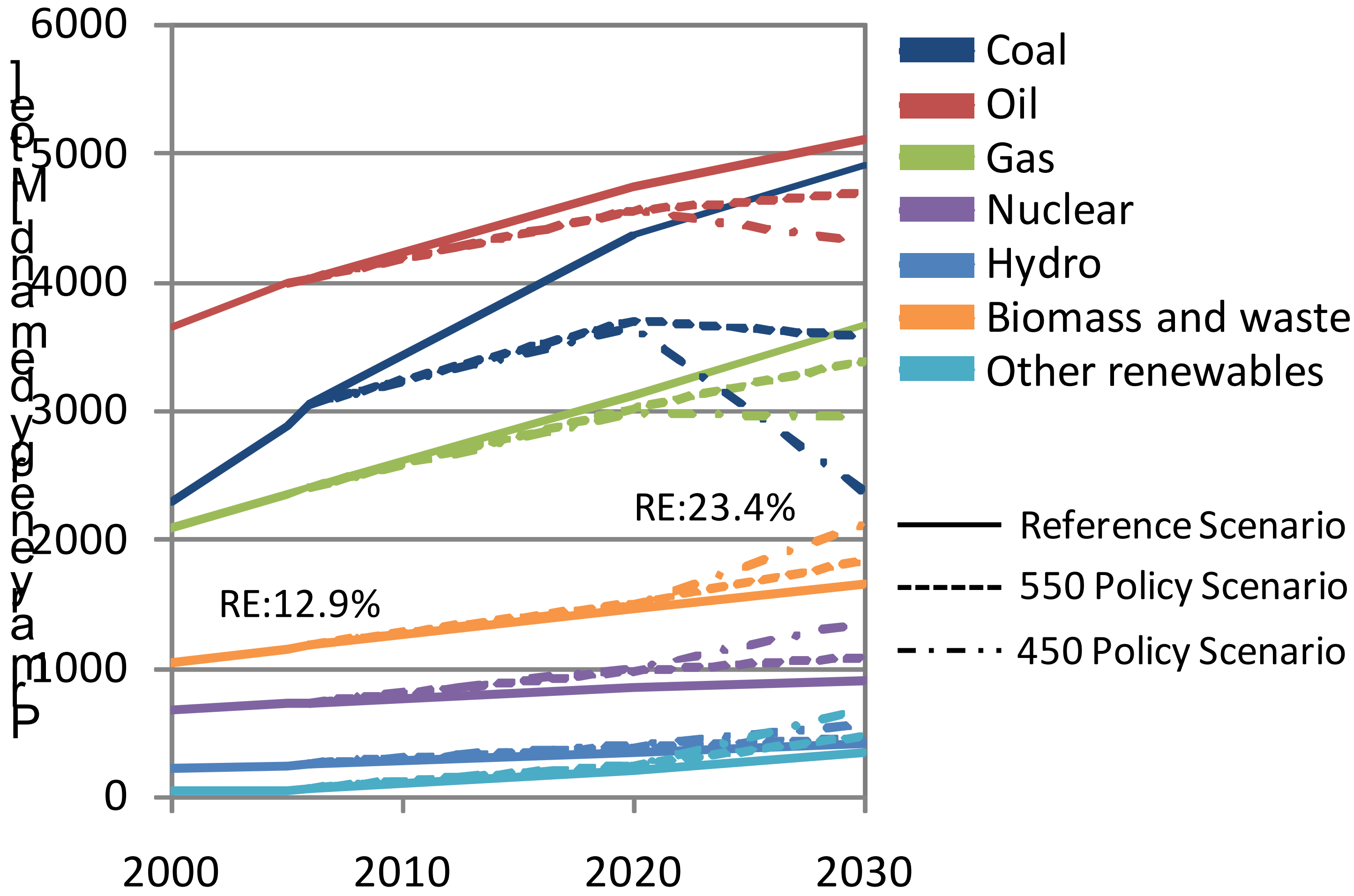
World primary energy demand scenarios



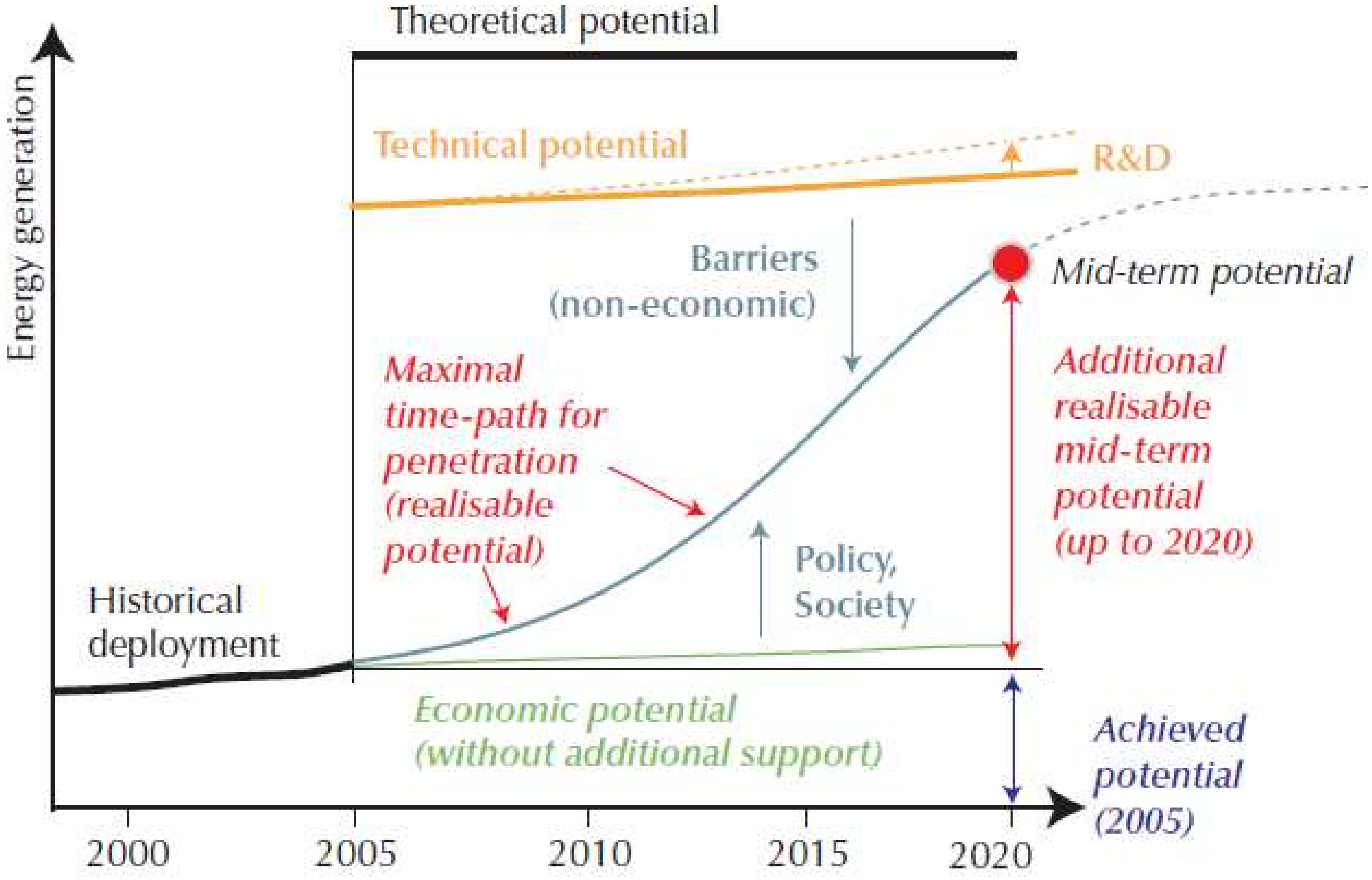
Source: IEA, WEO2008

Purpose of this study

To Evaluate Renewable Energy potentials (Solar PV and Onshore Wind)

- ✓ How much renewables we can use?
- ✓ How much the regional difference of those potentials is?
- ✓ Are that potentials economically efficient?

Definition of the Potential



Source: Based on IEA calculations & Resch et al., 2008.

Today's Presentation

Review of Last Year

- ✓ The used GIS data in this study
- ✓ Calculation method of the technical potentials of the solar PV and the onshore wind power
- ✓ Calculation results of the technical potentials

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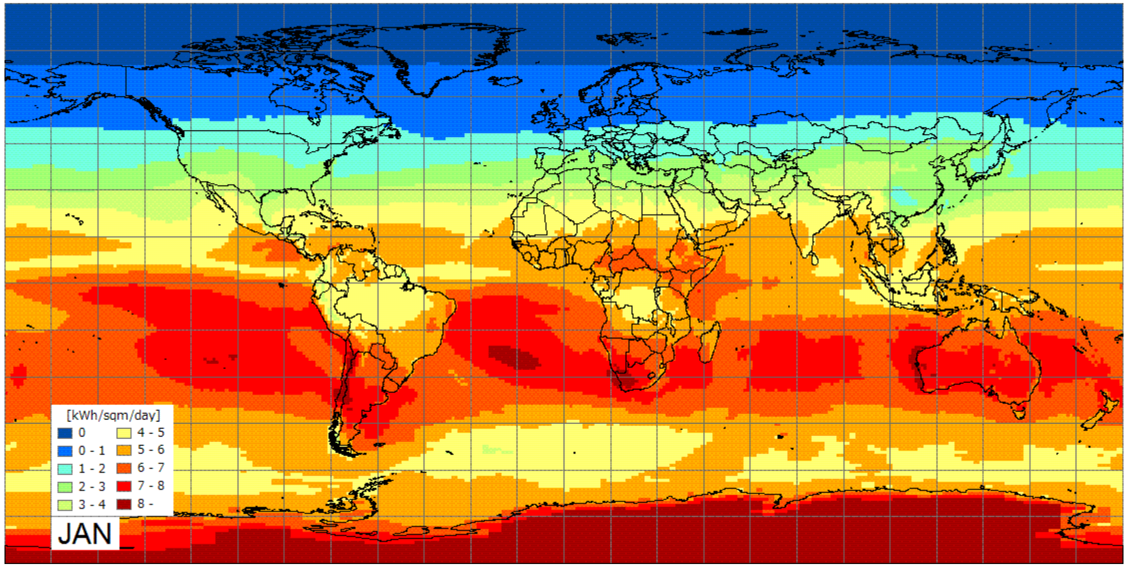
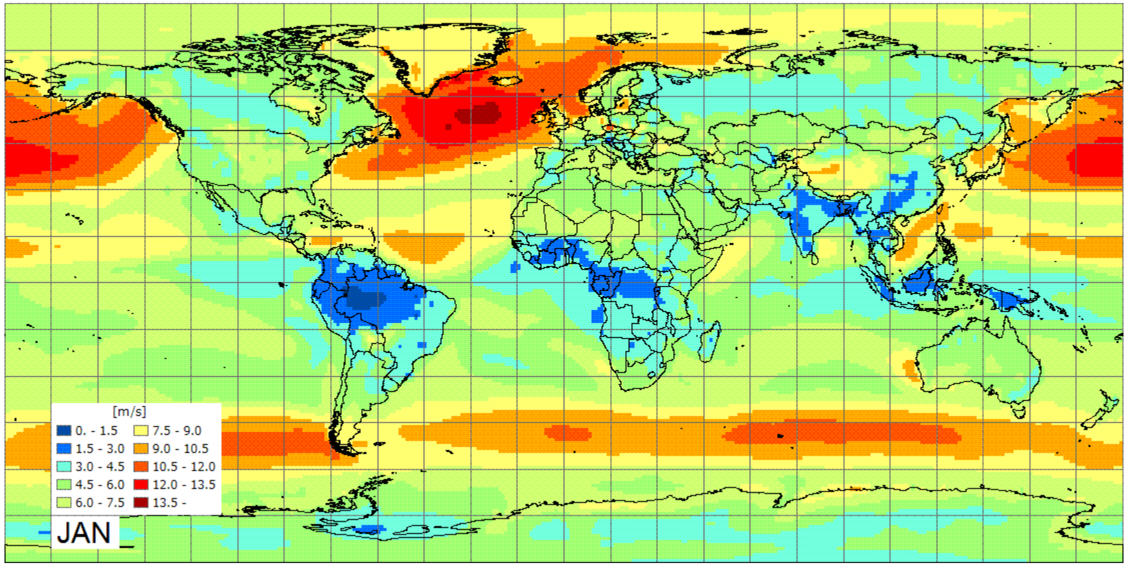
- ✓ Calculation method of the power generating cost of the solar PV and the onshore wind power
- ✓ Calculation results of the power generating cost

GIS Data (Insolation, Wind Speed)



Monthly Averaged Insolation Incident on a horizontal surface (Jul 1983 - Jun 2005)

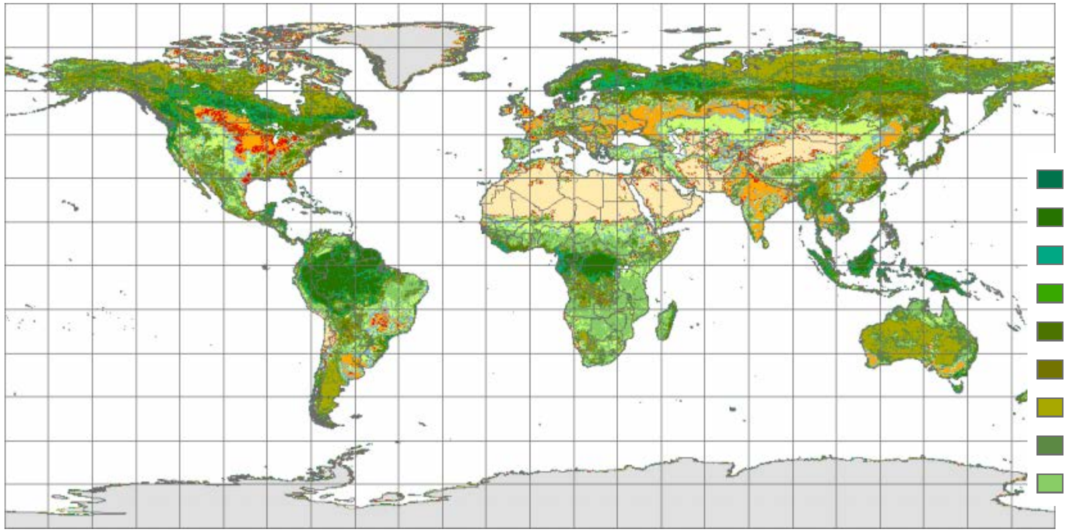
Monthly Averaged Wind Speed at 50m abobe (Jul 1983 – Jun 1993)



Source: NASA LaRC Atmospheric Science Data Center

Resolution: 1 deg × 1deg

GIS Data (Land Cover, Wilderness Areas)

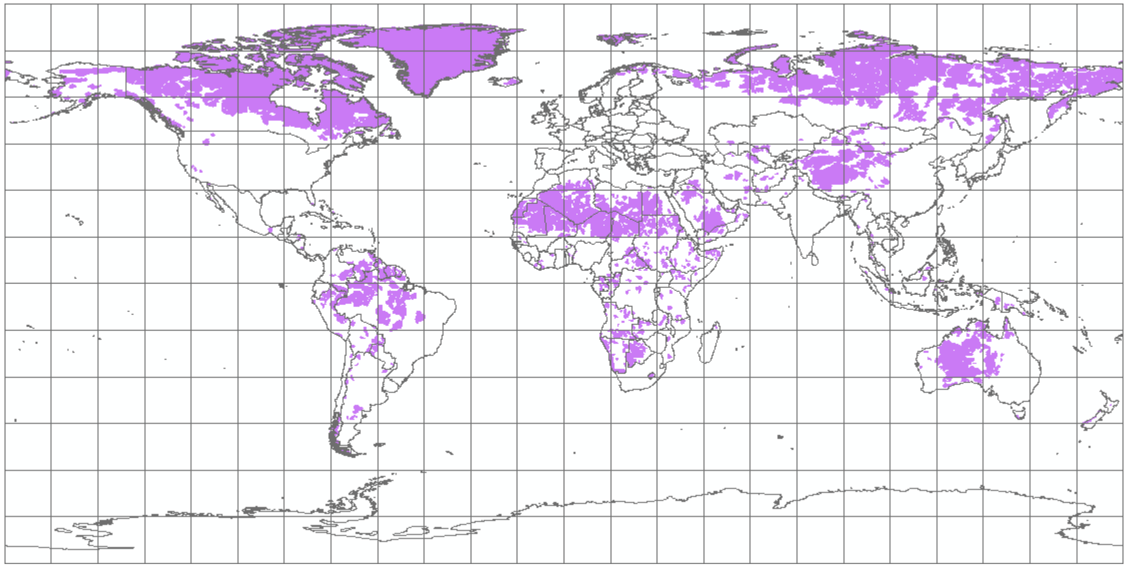


Land Cover Data

- 1 Evergreen Needleleaf Forest
- 2 Evergreen Broadleaf Forest
- 3 Deciduous Needleleaf Forest
- 4 Deciduous Broadleaf Forest
- 5 Mixed Forest
- 6 Closed Shrublands
- 7 Open Shrublands
- 8 Woody Savannas
- 9 Savannas
- 10 Grasslands
- 11 Permanent Wetlands
- 12 Croplands
- 13 Urban and Built-Up
- 14 Croplands/National Vegetation Mosaic
- 15 Snow and Ice
- 16 Barren or Sparsely Vegetated
- 17 Water Bodies

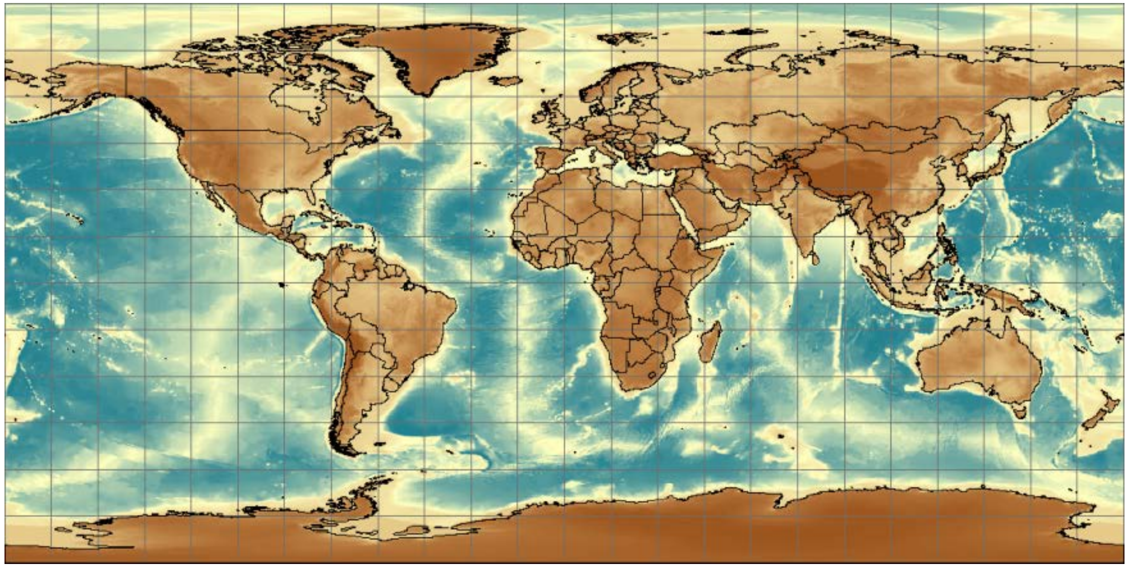
Source: NASA Land Processes Distributed Active Archive Center
Resolution: 30 sec × 30 sec

World Wilderness Areas



Sources: Sierra Club and World Bank, as integrated by UNEP/GRID

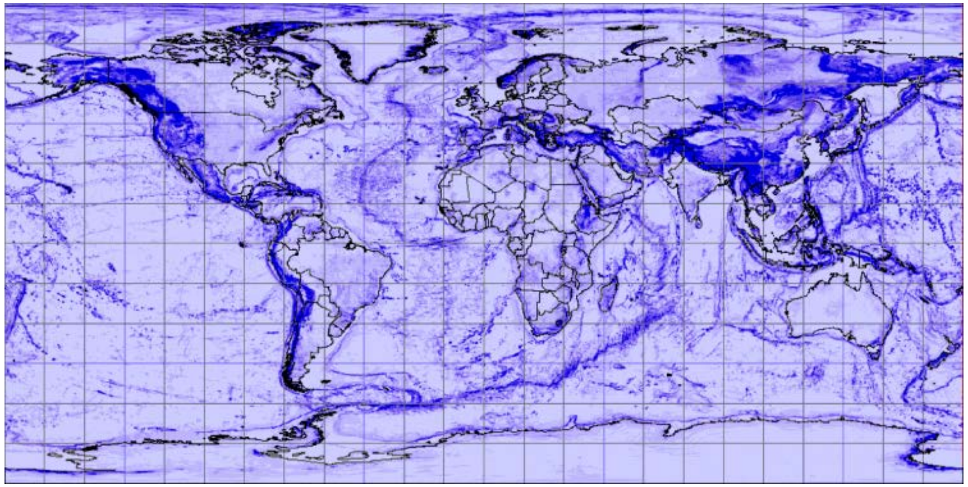
GIS Data (Elevation, Slope)



Elevation and Bathymetry Data
（GLOBE, GEBCO）

Source: National Geophysical Data Center (NGDC), NESDIS, NOAA, US.
Resolution: 30 sec × 30 sec
Source: General Bathymetric Chart of Oceans.
Resolution: 1 min × 1 min

Slope Data



Calculation Methods

Employing a grid cell approach using GIS data

Insolation, wind speed, land cover, elevation, constrained condition

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Calculation
Time resolution： 24 hours × 12 months
Area resolution： 30 arc-sec grid

↓

Technical potential

Solar PV and Onshore Wind Power

Calculation Methods

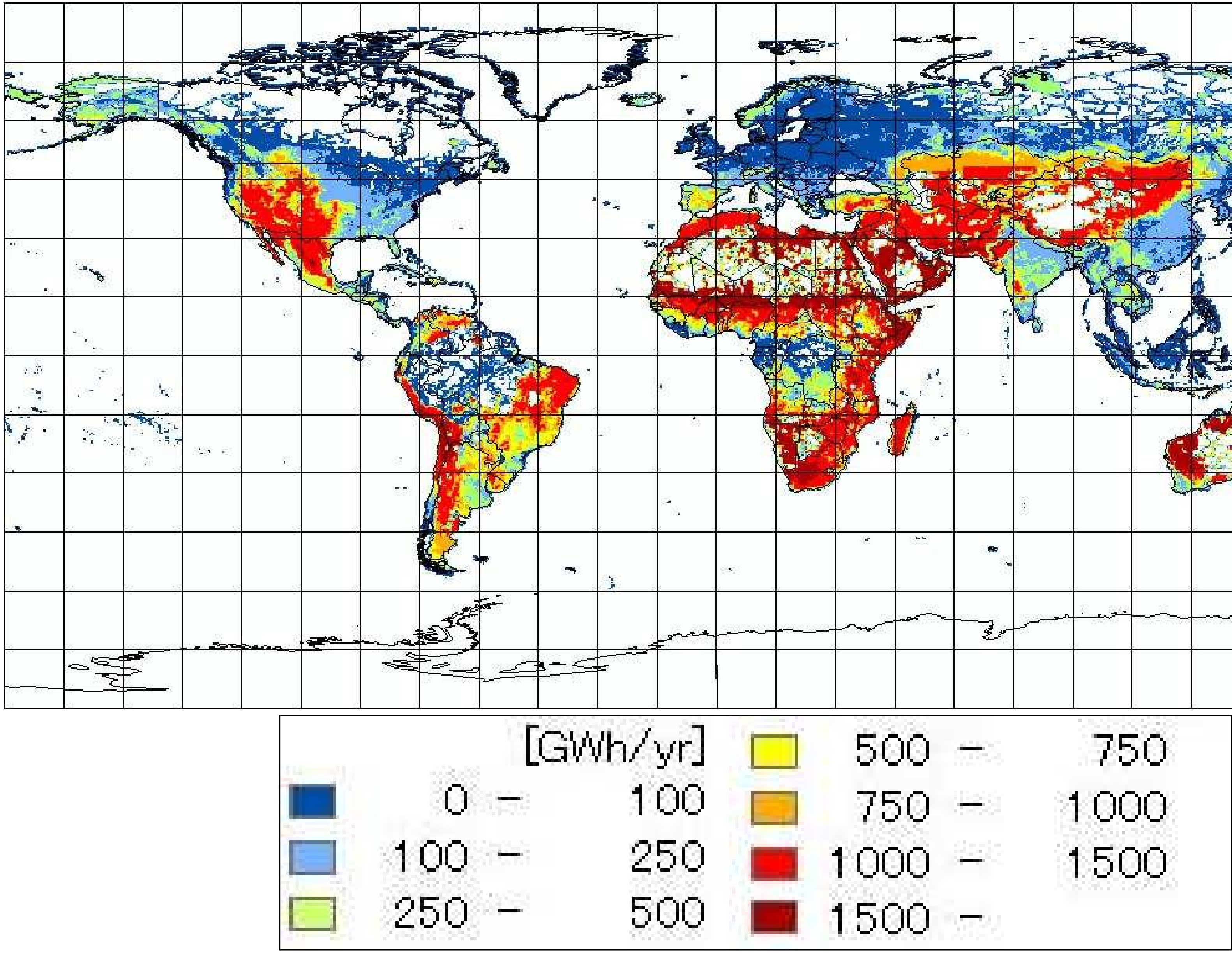
EPS = Solar PV energy potential [kWh/yr]
I = Insolation on optimum inclination angle [kW/m^2]
A = Avairable area [m^2]
e = Efficiency of solar PV module: 14.0 [%] (2020)

$$EPS_g = \sum_{M,T} I_{g,M,T} \cdot A_g \cdot \frac{e}{100}$$

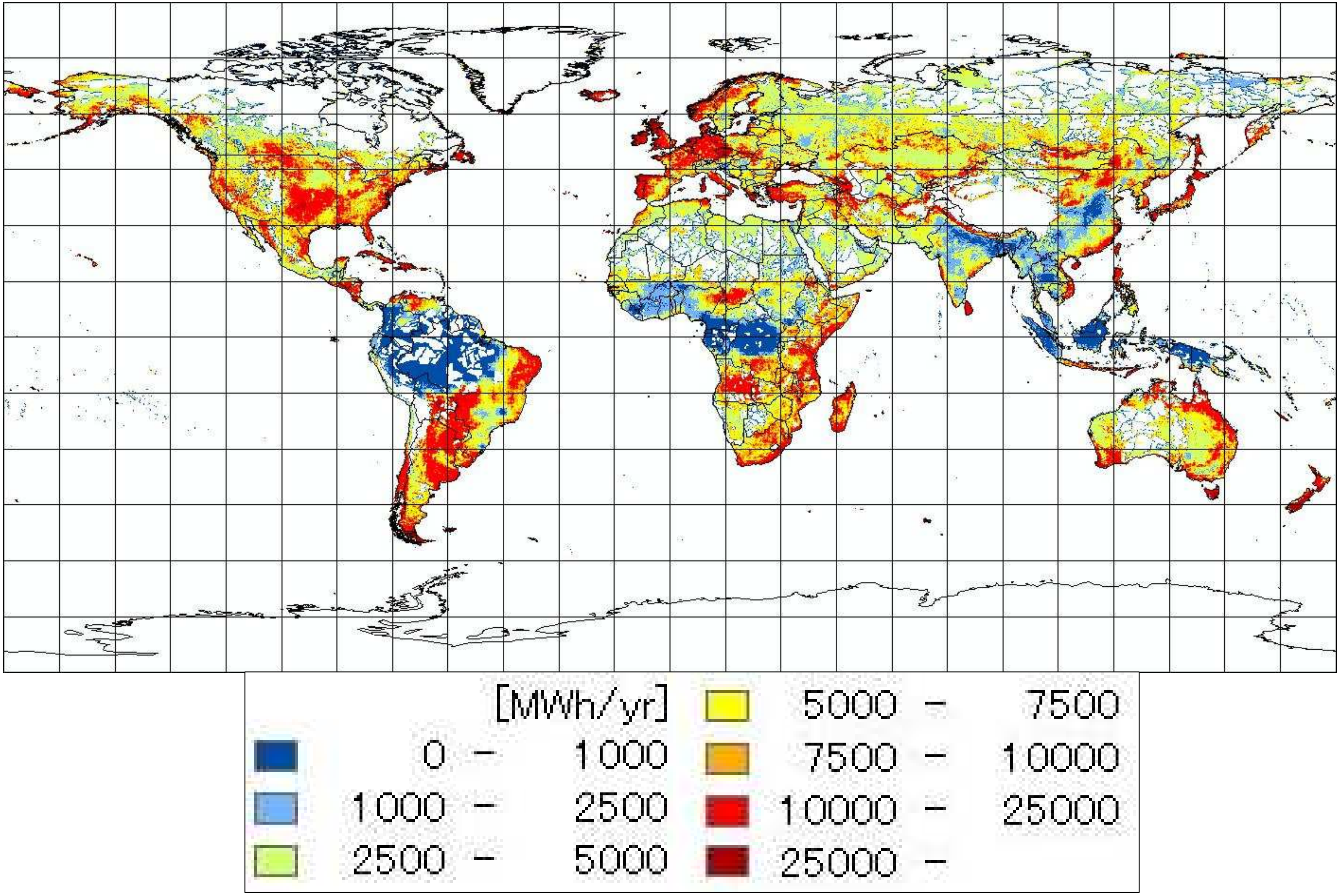
EPW = Onshore wind energy potential [kWh/yr]
$P(v)$ = Output power at v [m/s] wind speed
$R(v)$ = Incidence Rate of v [m/s] wind speed (Rayleigh Distribution)
j = Available rate of windmill: 95.0 %
k = Correction factor, l = Other losses: 5.0 %
Nw = Number of Windmill

$$EPW_g = \sum_{v,LC} P(v) \cdot R(v) \cdot 8760 \cdot j \cdot k_{LC} \cdot (1-l) \cdot Nw_{g,LC}$$

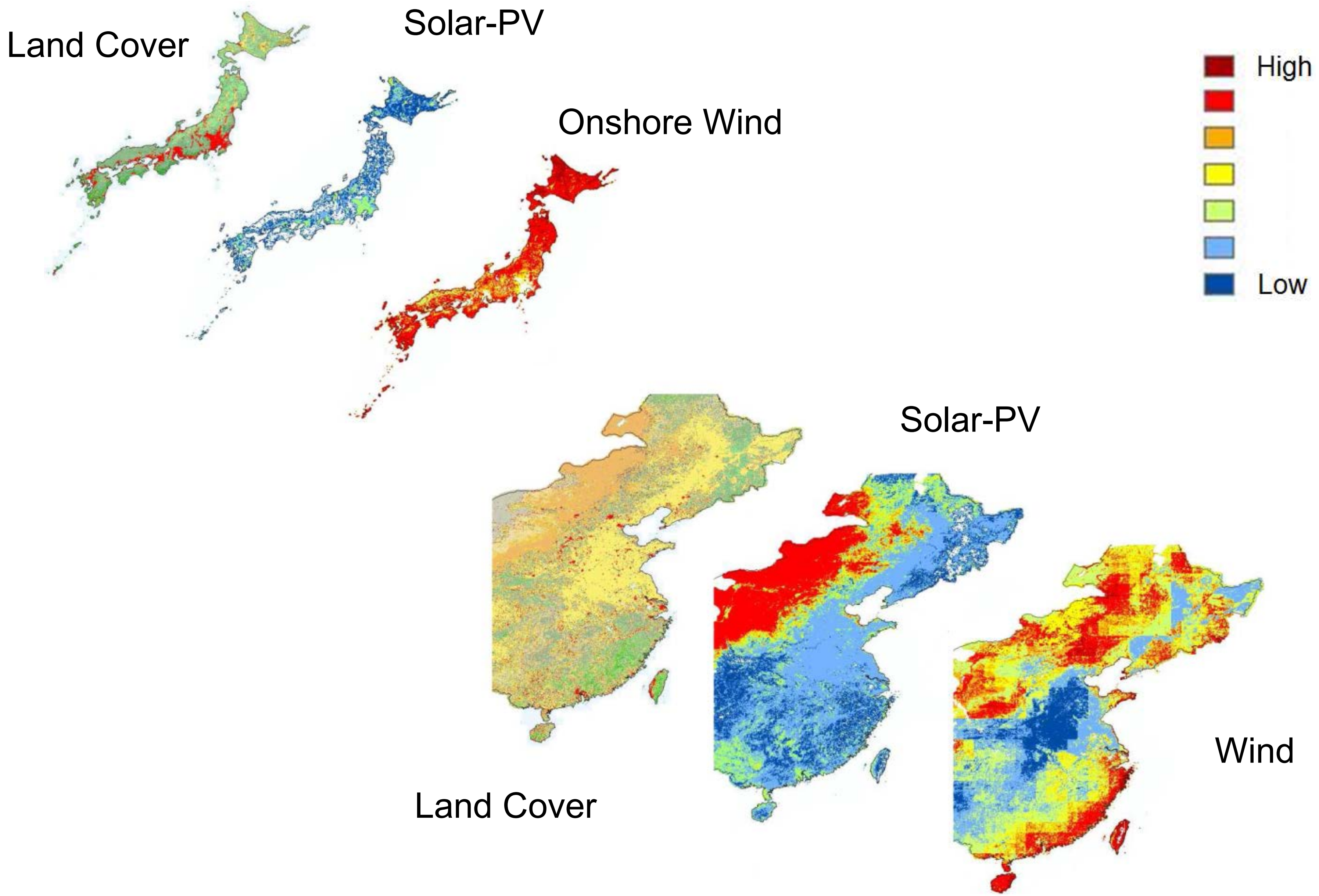
Solar PV Technical Potential



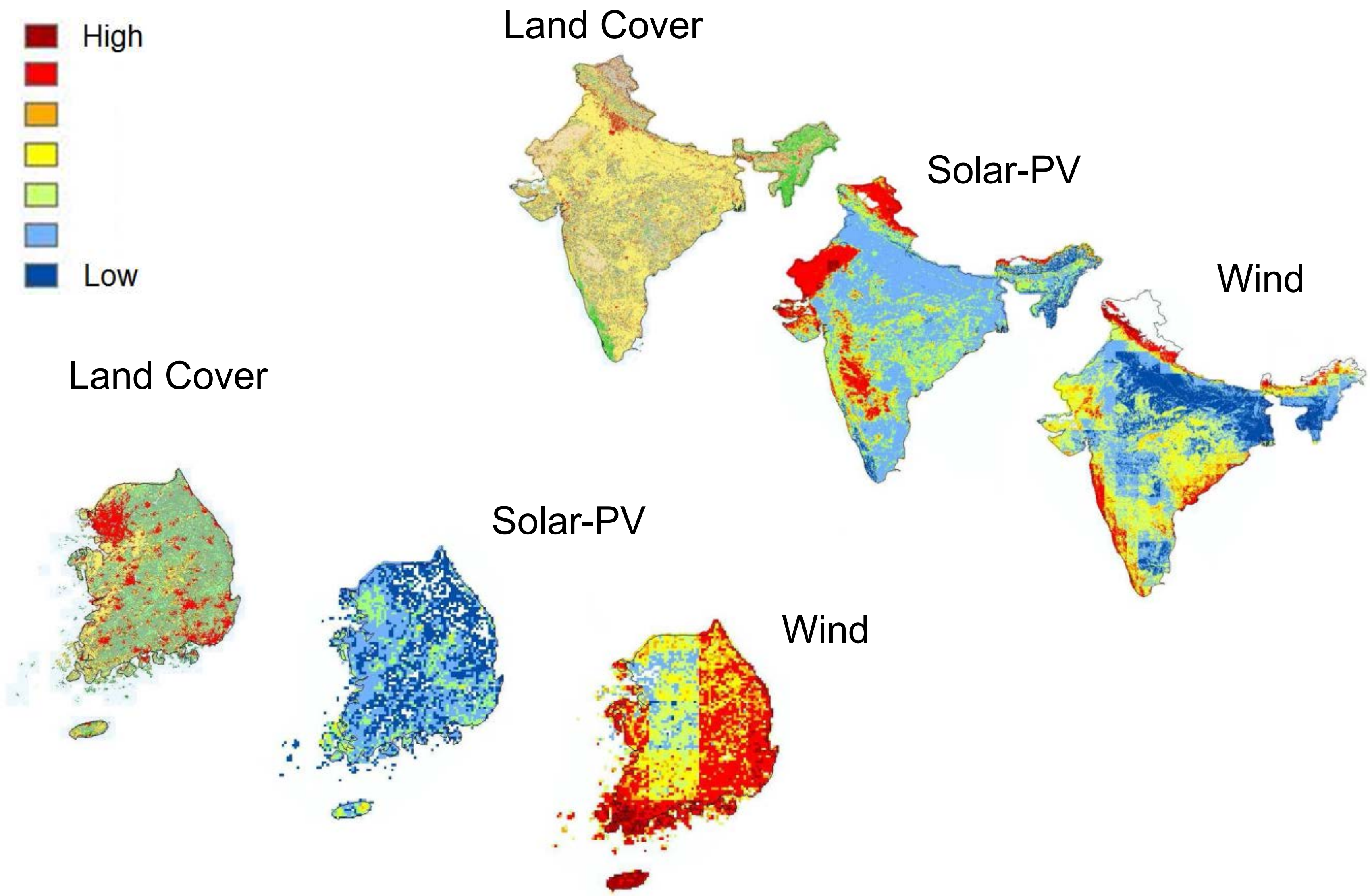
Onshore Wind Technical Potential



Technical Potential in Japan, China



Technical Potential in India, Korea



Calculation Methods

CS = Power generation cost of solar PV
$INVS$ = Installation cost: 560 [USD/m^2] (4[USD/Wp]) (2020)
OM = O&M cost: 3% of Installation cost
LS = Expected lifetime: 25 [years] (2020)
r = Discount rate: 5%

$$CS_g = \frac{r}{1-(1+r)^{-LS}} \cdot \frac{(1+OM) \cdot INVS \cdot A_g}{EPS_g}$$

CW = Power generation cost of Solar PV
$INVW$ = Installation cost: 1500 [USD/kW] (2020)
OM = O&M cost: 3% of Installation cost
LW = Expected lifetime: 20 [years] (2020)
r = Discount rate: 5%

$$CW_g = \frac{r}{1-(1+r)^{-LW}} \cdot \frac{(1+OM) \cdot INVW \cdot 2000}{EPW_g}$$

Solar PV

Wooden House in Denmark (Courtesy Energimidt, DK)

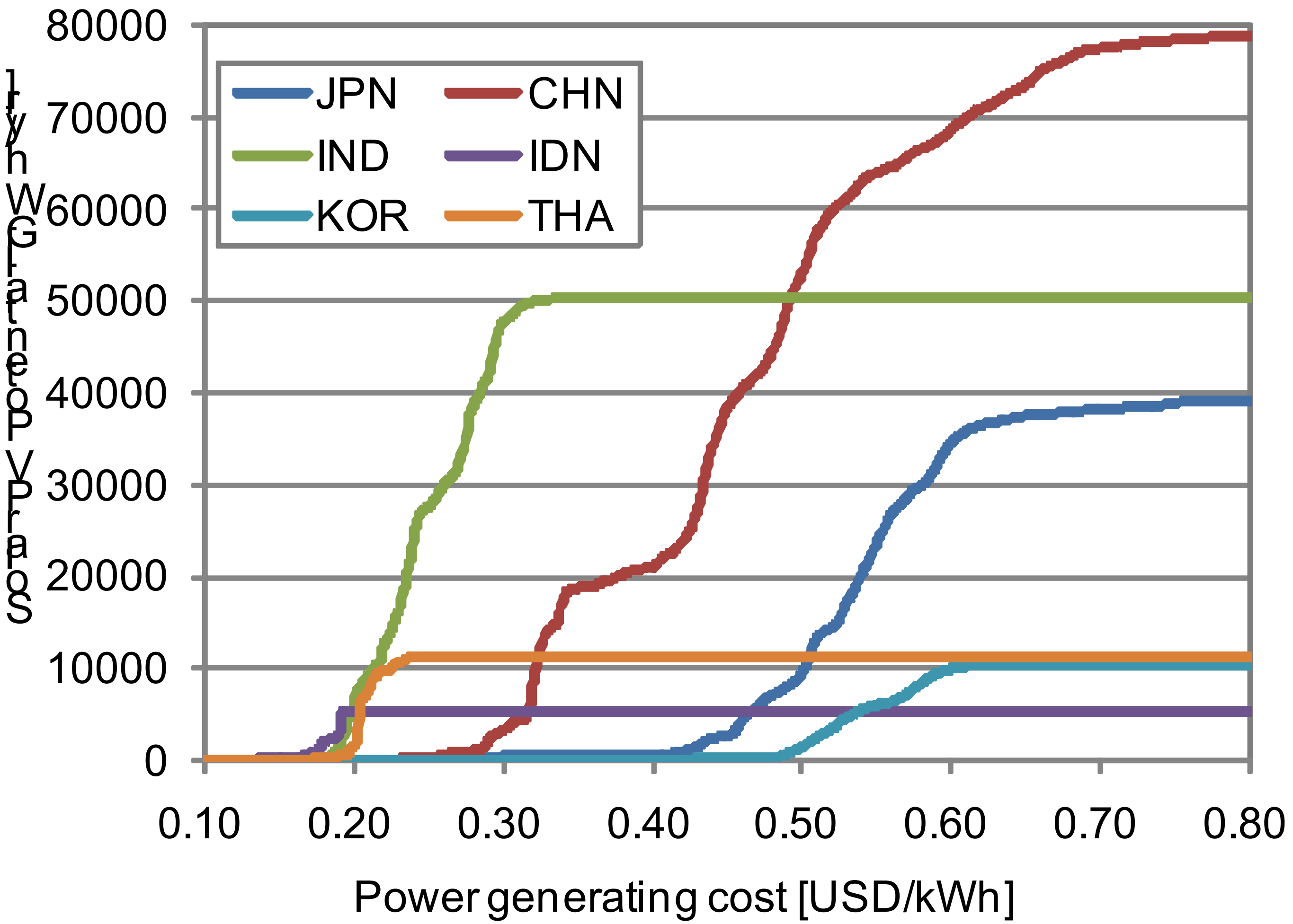
PV system at parking lot in Fujipream, Japan

(Courtesy Ohta City Land Development Corporation, Japan)

PV cladding is part of the new Manchester College of Arts and Technology (MANCAT) building, UK

Generating cost of Solar PV

Case of Installing in 1% of Urban Area



Generating cost of Solar PV

Case of Installing in 1% of Urban Area

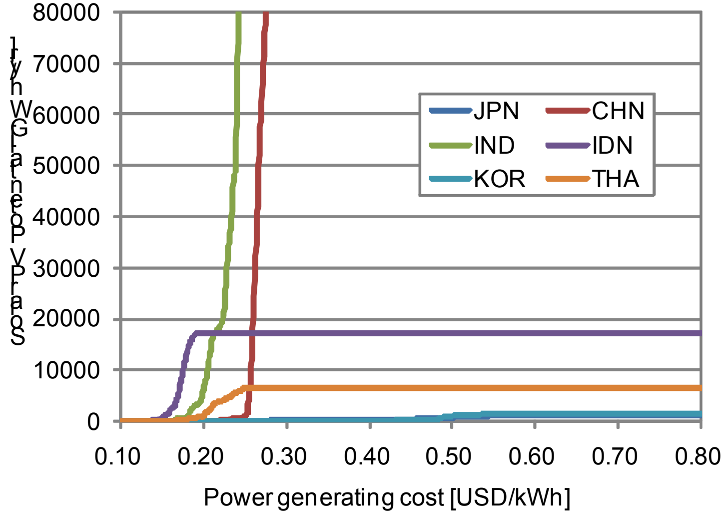
	<20 [USD/kWh]	<30 [USD/kWh]	<40 [USD/kWh]
JPN	0	180	477
CHN	0	3085	20922
IND	5341	47530	50514
IDN	5283	5328	5328
KOR	0	0	0
THA	1305	11203	11203

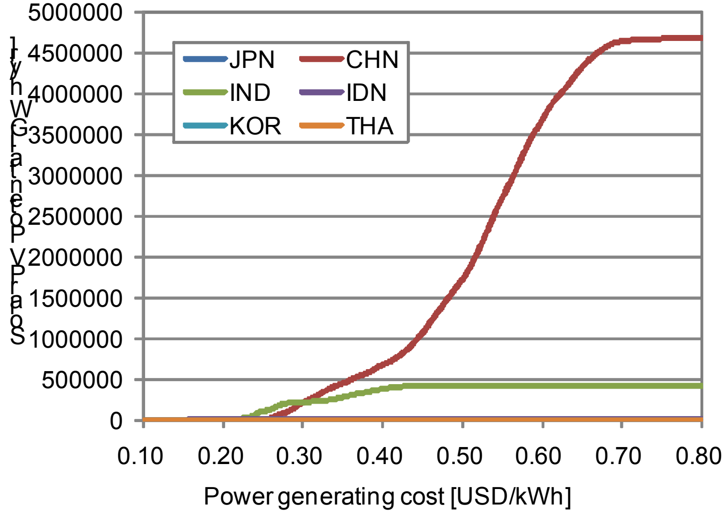
Solar PV

The Largest Solar PV Power Plant in the world（20MW, Spain）

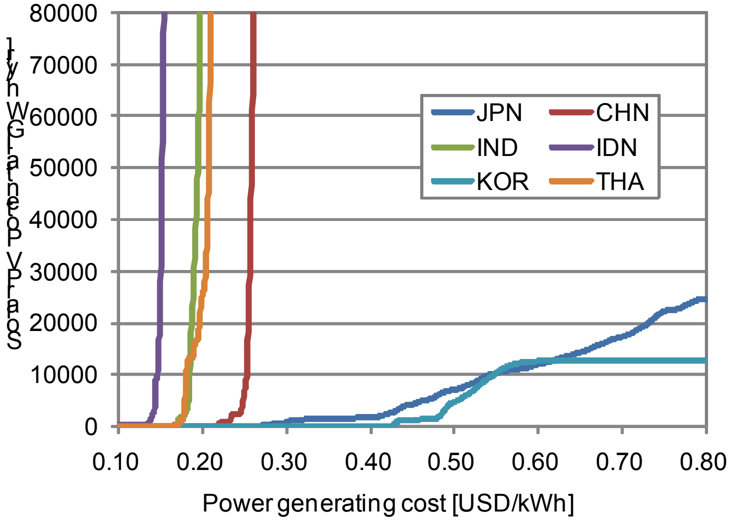
Generating cost of Solar PV

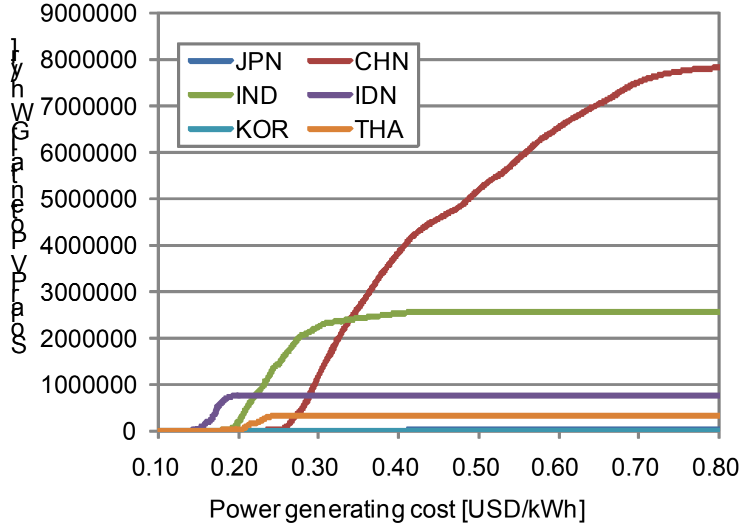
Case of Installing in 3% of Barren or Sparsely Vegetated Area





Case of Installing in 3% of Grasslands

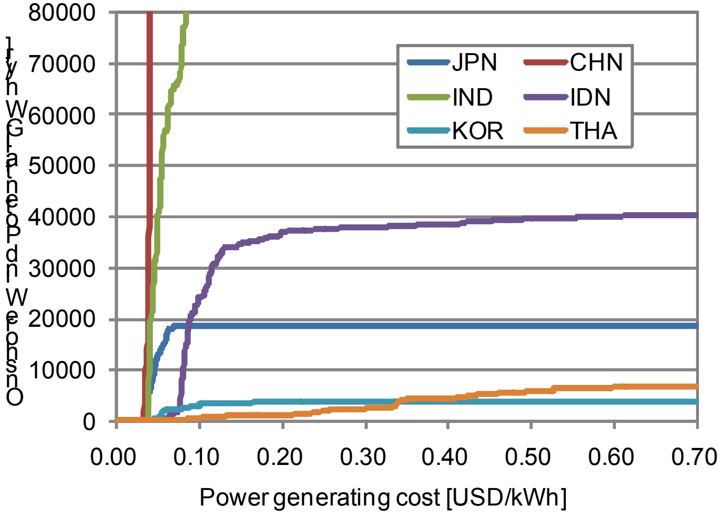


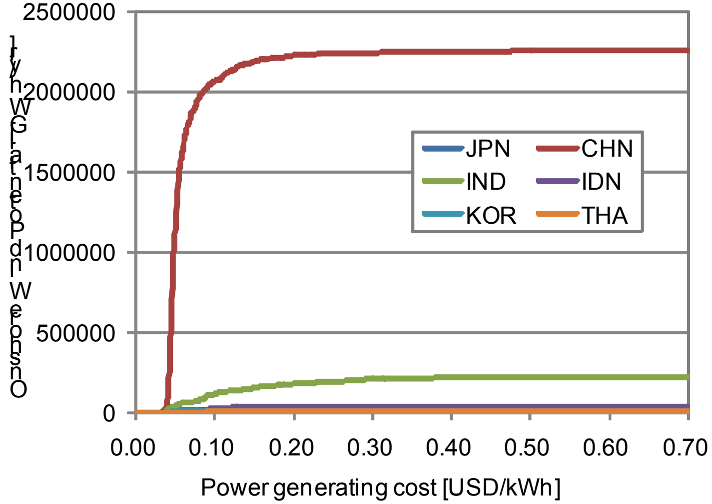


Onshore Wind Power

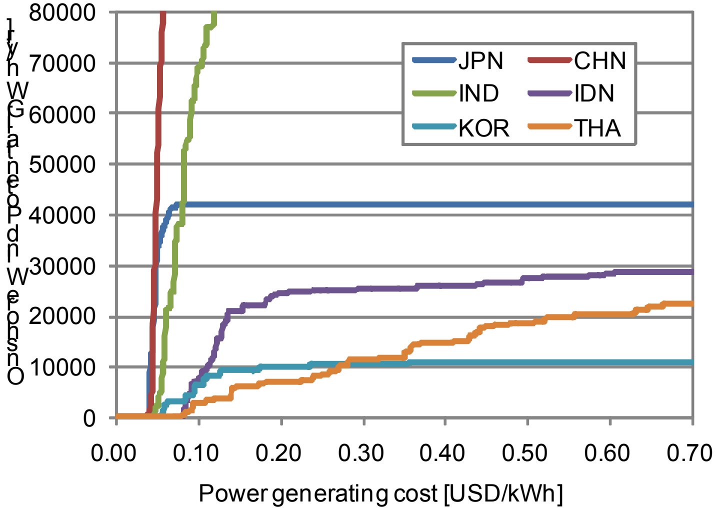
Generating cost of Onshore Wind

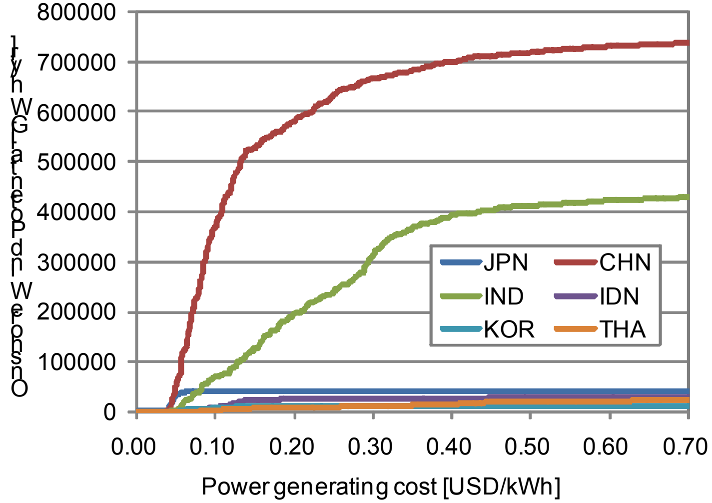
Case of Installing in 20% of Grasslands





Case of Installing in 20% of Croplands





Conclusion and Next Step

- ✓ Calculated power generating costs of PV or onshore wind are widely different region by region.
- ✓ Appropriate goal setting, appropriate amount of subsidy, appropriate policy are needed country by country and energy by energy.

- ✓ Influences of subsidies and other policy incentives

  → please teach me some information about your country's policy
- ✓ Link to GCM or RCM output data (insolation, wind speed) to evaluate futuer potentials

Thank you for your attention

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