# Technical Annex

**Wind and solar benchmarks for a 1.5°C world**

November 2023

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# A1: The use of global pathways in the analysis

## Selecting pathways

Using the IPCC's AR6 Scenario Explorer and Database of IAMs , we select 32 scenarios which meet five criteria key criteria .

- Scenarios are compatible with limiting warming to 1.5ºC with no or low overshoot.
- Scenarios represent the latest evidence on limiting warming to 1.5ºC. This means they are published after 2018 (i.e. post- the Special Report on 1.5ºC), with the exception of the low energy demand scenario . This scenario is retained as it offers a unique perspective on a 1.5ºC aligned demand-side transition.
- Scenarios have good regional resolution (provide global data split into 10 different macro regions). This was needed to enable downscaling to the country-level with sufficient confidence.
- A sustainable amount of carbon dioxide removal is used—specifically, BECCS deployment is restricted to be less than 5 $GtCO_2$/yr over the 2040–60 period, and carbon removal from afforestation and reforestation is limited to be less than 3.6 $GtCO_2$/yr over 2040–2060 and less than 4.4 $GtCO_2$/yr over 2050–2100.
- Scenarios are consistent with achieving net-zero GHG emissions in the second half of the century, as stated in Article 4.1 of the Paris Agreement.
- Importantly, none of these scenarios represent a fair distribution of the effort required to mitigate emissions. Instead, they explore the most cost-effective routes that limit warming to 1.5°C. Achieving the targets derived from these modelled scenarios would require that substantial financial transfers are made from developed countries to support emissions reductions in less wealthy countries.

### Downscaling global pathways

IAMs provide results at the regional, rather than national level. In the IPCC AR6, global pathways are broken up into 10 major world regions, or "macro-regions". These 'macro-region' results then needed to be downscaled to the national level.

We do this via the Simplified Integrated Assessment Model with Energy System Emulator (SIAMESE) . SIAMESE takes data at a regional level from IAMs and converts it to the national level, providing a perspective on what each country within a given region would need to do to achieve the overarching macro-region pathway. SIAMESE does this by allocating energy consumption to each country in a way that maximises the welfare of the macro-region as a whole. This simulates the cost-optimising logic of IAMs.

## A2: National costs scenarios for different renewable technologies

A key input to the production of wind and solar benchmarks is the cost of the technologies involved. Here it is important to consider regional differences and future developments. The following section summaries the cost projections for wind and solar used in this work which account for regional variations in costs and the potential for future cost reductions.

In this first report, six countries were focused on: China, India, Indonesia, Brazil, South Africa and Germany. These countries illustrate how the method was applied. However, the method can be extended to provide regional cost data for other countries also.

### Historic costs data

The starting point for projecting renewable costs is an understanding of their current costs, and how these vary across regions. To do this, we use the data by international renewable energy agency (IRENA) to capture the current cost trends of renewable technologies in different countries. In particular, we use two key publications: Renewable Power Generation Costs in 2021 and Renewable Power Generation Costs in 2019 . These reports include data on global trends in wind and solar costs as well as country level data.

IRENA's reports provide comprehensive detail at the global scale. The 2021 report provides historical capital cost (CAPEX) curves for onshore wind, offshore wind, and open-field PV (assimilated to utility-scale PV). The report provides global weighted average costs, as well as 5th percentile and 95th percentile costs, which we apply as low and high costs, respectively. For rooftop PV, no data is available from the IRENA 2021 report, but weighted average costs for commercial and residential PV for the year 2019 or before can be found in the report from 2019. We then use the average of these two technologies to estimate the global medium costs of Rooftop PV.

However, the level of information available at national level varies strongly across technologies and countries. In the following section we provide a summary of what historic costs data for different technologies is available at a national level from the IRENA reports.

- → Onshore wind: medium costs is available from the IRENA report 2021 for all countries except Indonesia. Low and high costs is available from for all countries (except Indonesia, South Africa, and Germany, for which we have the corresponding macro-region data, see → **Table A1**).

**Table A1**

**Availability of low/medium/high costs data for onshore wind technology at national/regional level from IRENA 2021 report**

| Country | Medium cost | High/low cost |
|---|---|---|
| **Brazil** | Country data available | Country data available |
| **China** | Country data available | Country data available |
| **Germany** | Country data available | 'Europe' data used |
| **India** | Country data available | Country data available |
| **Indonesia** | 'Other Asia' data used | 'Other Asia' data used |
| **South Africa** | Country data available | 'Africa' data used |

- → Offshore wind: medium, low and high costs are available from the IRENA 2021 report. This is available at the national level for China and Germany and the macro-region level for India and Indonesia. For South Africa and Brazil, no data is available at all all **(see → Table A2)**.

**Table A2**

**Availability of low/medium/high costs data for offshore wind at national/regional level from IRENA 2021 report**

| Country | Medium cost | High/low cost |
|---|---|---|
| **Brazil** | No data available | No data available |
| **China** | Country data available | Country data available |
| **Germany** | Country data available | Country data available |
| **India** | 'Asia' data used | 'Asia' data used |
| **Indonesia** | 'Asia' data used | 'Asia' data used |
| **South Africa** | No data available | No data available |

- Open-field PV: only medium costs are available from IRENA 2021 report. These are available for all countries at national level except South Africa (see → Table A3).

**Table A3**

**Availability of low/medium/high costs data for Open-field PV at national level from IRENA 2021 report**

| Country | Medium cost | High/low cost |
|---|---|---|
| **Brazil** | Country data available | No data available |
| **China** | Country data available | No data available |
| **Germany** | Country data available | No data available |
| **India** | Country data available | No data available |
| **Indonesia** | Country data available | No data available |
| **South Africa** | No data available | No data available |

- Rooftop PV: same as open-field PV, we have only medium costs from Table 3.1 of the 2019 IRENA report. The data is available for every country except Indonesia (see → Table A4).

**Table A4**

**Availability of low/medium/high costs data for Rooftop PV at national level from IRENA 2019 report**

| Country | Medium cost | High/low cost |
|---|---|---|
| **Brazil** | Country data available | No data available |
| **China** | Country data available | No data available |
| **Germany** | Country data available | No data available |
| **India** | Country data available | No data available |
| **Indonesia** | No data available | No data available |
| **South Africa** | Country data available | No data available |

We use the medium costs data at the national level available in Table 3.1 for every country, except Indonesia where we have no data at all.

Next, we derive estimates of future cost trends to 2050 for different renewable technologies based on IRENA's Future of Wind 2019 and Future of Solar 2019 reports. These reports provide low, medium, and high costs projections at global level for 2030 and 2050.

## Future national costs projections

For countries where data was lacking, we had to make our own estimates for future technology costs trends. Before going into details, we introduce the notation we will use for this section.

$$Capex(c, y, t, s)$$

Is the function for the costs, with:

- c the country (or global)
- y the year
- t the technology
- s the scenario (low, medium or high)

Also, we will use 'ratios', which are defined for each country, each year and each technology.

$$r_{high}(c,y,t) = \frac{Capex(c,y,t,High)}{Capex(c,y,t,Medium)}$$

With the same principle for r (low).

The first step is to provide for each technology and country, cost data for the base year (2021 for onshore wind, offshore wind and Open-field PV and 2019 for Rooftop PV). To do this, we use the costs data presented in the previous section. As seen here, not all countries have cost data for all technologies.

Where no country data is available (e.g. South Africa offshore wind costs), we apply the global cost data from IRENA. Where only medium cost data is available (e.g. Brazilian open-field PV), we take the medium cost and scale it by and  at the global level to produce the low and high cost estimates. This means we take the ratio between high/medium/low costs at the global level and apply this at the national level.

When doing this, we apply bounds to ensure that the country-level high cost estimate is between 120% of the medium cost estimate, and the global high-cost estimate, while the country-level low cost estimate is between 80% of the medium cost estimate and the global low-cost estimate. This ensures that country level costs do not fall below the global low-cost estimate or above the global high-cost estimate.

In the case of rooftop PV, there is medium costs data for the base year 2019 for all countries, except Indonesia where we have no data at all. However, there is no estimate of the high/low costs, at either a global or national level. We focus first on producing high/low cost estimates for rooftop PV at the global level. For this, we use the  and  for open-field PV in 2010 (at the global level) and applied them to rooftop PV. After that, we applied the evolution rate of the rooftop PV's historic medium costs to the low and high curves. Now we have global low, medium, and high global costs data for rooftop PV for 2019. Then, we use the same principle that we applied to the other technologies, this time in order to have low and high costs data for rooftop PV at the national level.

At this stage, for all technologies and all countries, we have low, medium, and high costs data for the base year (2021 for onshore wind, offshore wind, Open-field PV and 2019 for Rooftop PV).

Now, we need to estimate the projected cost curves, starting with the projection of the medium curves. The same method is applied for all technologies. To do this, for a given country, we determine the relative position of the medium point compared to global data for the same year for the same technology. We then apply an evolution rate composed of a linear combination of the global evolution rates according to the relative position determined below.

$$
\begin{aligned}
&Capex(c, y, t, Medium) \\
&\quad = Capex(c, y - 10, t, Medium) \\
&\quad * \left(a * \frac{Capex\ (World, y, t, Medium)}{Capex\ (World, y - 10, t, Medium)} + b * \frac{Capex\ (World, y, t, s')}{Capex\ (World, y - 10, t, s')}\right)
\end{aligned}
$$

- c is the country
- y is the year
- t is the technology
- s' is low or high, depending on if the national capex is below the global capex (low) or above it (high)

And $b = \frac{Capex(c, y - 10, t, Medium) - Capex(Global, y - 10, t, s')}{Capex(Global, y - 10, t, Medium) - Capex(Global, y - 10, t, s')}$

$$a = b - 1$$

Finally, for the low and high curves, we use the global ratios for the same technology and year on the medium value calculated in the previous step. The value obtained is again bounded according to the constraint that the high cost should be between 120% of the medium country-level cost and the global high cost, and the low cost should be between 80% of the medium country-level cost and the global low cost. The low-to-high envelope is then also consistent with global trends, while taking into account the specificity of each country.

# Results

→ Table A5 summarizes the data used at the end for the model, with costs in 2021USD/kW.

**Table A5**
**Capex data**

| Country | Technology | Scenario | 2021 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Brazil | Onshore | Low | 842 | 825 | 736 | 647 |
| | | Medium | 1150 | 1031 | 920 | 808 |
| | | High | 1960 | 1294 | 1138 | 979 |
| | Offshore | Low | 2052 | 1802 | 1643 | 1484 |
| | | Medium | 2858 | 2597 | 2412 | 2226 |
| | | High | 5641 | 3392 | 3180 | 2968 |
| | Open-field PV | Low | 577 | 360 | 268 | 175 |
| | | Medium | 824 | 588 | 453 | 318 |
| | | High | 1885 | 836 | 657 | 475 |
| | Rooftop PV | Low | 920 | 500 | 387 | 275 |
| | | Medium | 1150 | 624 | 483 | 343 |
| | | High | 1875 | 1018 | 788 | 559 |
| China | Onshore | Low | 968 | 828 | 739 | 649 |
| | | Medium | 1157 | 1036 | 923 | 811 |
| | | High | 1514 | 1300 | 1143 | 983 |
| | Offshore | Low | 2406 | 1802 | 1643 | 1484 |
| | | Medium | 2857 | 2596 | 2411 | 2225 |
| | | High | 3474 | 3391 | 3179 | 2967 |
| | Open-field PV | Low | 502 | 323 | 242 | 160 |
| | | Medium | 628 | 403 | 302 | 200 |
| | | High | 1436 | 573 | 438 | 299 |
| | Rooftop PV | Low | 616 | 334 | 258 | 183 |
| | | Medium | 770 | 418 | 323 | 229 |
| | | High | 1255 | 681 | 526 | 373 |
| Germany | Onshore | Low | 1127 | 980 | 881 | 779 |
| | | Medium | 1712 | 1317 | 1153 | 989 |
| | | High | 2182 | 1580 | 1384 | 1187 |
| | Offshore | Low | 3603 | 2105 | 1929 | 1753 |
| | | Medium | 3739 | 3034 | 2832 | 2630 |
| | | High | 4452 | 3640 | 3399 | 3156 |
| | Open-field PV | Low | 554 | 360 | 268 | 175 |
| | | Medium | 693 | 462 | 349 | 235 |
| | | High | 1585 | 656 | 506 | 351 |
| | Rooftop PV | Low | 1068 | 580 | 449 | 319 |
| | | Medium | 1335 | 725 | 561 | 399 |
| | | High | 2177 | 1181 | 915 | 649 |
| India | Onshore | Low | 755 | 698 | 632 | 565 |
| | | Medium | 926 | 873 | 790 | 706 |
| | | High | 1057 | 1096 | 977 | 855 |
| | Offshore | Low | 1859 | 1809 | 1650 | 1490 |
| | | Medium | 2876 | 2608 | 2422 | 2236 |
| | | High | 6917 | 3392 | 3180 | 2968 |
| | Open-field PV | Low | 472 | 297 | 221 | 145 |
| | | Medium | 590 | 371 | 277 | 181 |
| | | High | 1349 | 527 | 401 | 270 |
| | Rooftop PV | Low | 638 | 346 | 268 | 190 |
| | | Medium | 797 | 433 | 334 | 237 |
| | | High | 1299 | 705 | 545 | 387 |

| Country | Technology | Scenario | 2021 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|
| Indonesia | Onshore | Low | 1232 | 929 | 838 | 745 |
| | | Medium | 1545 | 1249 | 1098 | 946 |
| | | High | 2260 | 1499 | 1317 | 1135 |
| | Offshore | Low | 1859 | 1809 | 1650 | 1490 |
| | | Medium | 2876 | 2608 | 2422 | 2236 |
| | | High | 6917 | 3392 | 3180 | 2968 |
| | Open-field PV | Low | 852 | 457 | 344 | 229 |
| | | Medium | 1265 | 790 | 619 | 448 |
| | | High | 1960 | 947 | 743 | 537 |
| | Rooftop PV | Low | 1206 | 655 | 507 | 360 |
| | | Medium | 1656 | 899 | 697 | 495 |
| | | High | 2700 | 1465 | 1136 | 806 |
| South Africa | Onshore | Low | 1149 | 1023 | 917 | 808 |
| | | Medium | 1892 | 1375 | 1201 | 1026 |
| | | High | 2924 | 1650 | 1441 | 1231 |
| | Offshore | Low | 2052 | 1802 | 1643 | 1484 |
| | | Medium | 2858 | 2597 | 2412 | 2226 |
| | | High | 5641 | 3392 | 3180 | 2968 |
| | Open-field PV | Low | 577 | 360 | 268 | 175 |
| | | Medium | 857 | 622 | 482 | 342 |
| | | High | 1960 | 884 | 698 | 510 |
| | Rooftop PV | Low | 1292 | 702 | 543 | 386 |
| | | Medium | 1774 | 963 | 747 | 530 |
| | | High | 2700 | 1465 | 1136 | 806 |

# A3: Existing capacities

We use existing capacity to parameterise the PyPSA model. To do this, we use IEA data from their Renewable 2022 report . We treat PV utility-scale as open-field PV and PV commercial and residential as rooftop PV. → **Table A6** shows the data used.

**Table A6**

**Current installed capacities used**

| Country | Technology | Capacity in 2021 (MW) |
|---|---|---|
| Brazil | Onshore | 20800 |
| | Offshore | 0 |
| | Rooftop PV | 8600 |
| | Open-field PV | 4500 |
| China | Onshore | 303700 |
| | Offshore | 25900 |
| | Rooftop PV | 107600 |
| | Open-field PV | 200200 |
| Germany | Onshore | 56400 |
| | Offshore | 7500 |
| | Rooftop PV | 43800 |
| | Open-field PV | 15200 |
| India | Onshore | 40300 |
| | Offshore | 0 |
| | Rooftop PV | 9400 |
| | Open-field PV | 41200 |
| Indonesia | Onshore | 200 |
| | Offshore | 0 |
| | Rooftop PV | 100 |
| | Open-field PV | 100 |
| South Africa | Onshore | 3100 |
| | Offshore | 0 |
| | Rooftop PV | 400 |
| | Open-field PV | 2200 |

# A4: Bottom-up assessment of technical potential of renewable energy sources

To assess the technical potential of renewable energy sources for different countries, we developed a python-based simulation pipeline, applying the temporally and spatially-resolved simulation models of the open-source python packages GLAES (Geospatial Land Eligibility for Energy Systems) and RESKit (Renewable Energy Simulation Toolkit) .

At first, the land eligibility analysis, evaluates the amount and distribution of suitable area of land/ocean for installing wind turbines and PV modules. The land eligibility assessment considers a comprehensive set of exclusion factors and constraints informed by the literature review. These reflect the most common (socio-political, physical, conservation, pseudo-economic) constraints for placement of wind turbines and PV modules commonly considered in renewable potential studies. → **Table A7** provides an overview of exclusion factors applied in our analysis for different renewable technologies.

**Table A7**

**Exclusion factors and underlying assumptions in land eligibility analysis**

| Technology | Aspect | Description | Exclusion buffer limits | Source |
|---|---|---|---|---|
| Onshore wind | Regional boundaries | 500m buffer distance from regional boundaries excluded | ≤500 m | |
| | Primary roads | 500m buffer distance from primary roads excluded | ≤500 m | |
| | Railways | 500m buffer distance from railways excluded | ≤500 m | xi |
| | Waterways (Rivers) | 150m buffer distance from waterways excluded | ≤150 m | xi |
| | Airports | 5000m buffer distance from airports excluded | ≤5000 m | xi |
| | Urban settlements | 1000m buffer distance from urban settlements excluded | ≤1000 m | |
| | Woodlands | Base assumption: 300m buffer distance from woodlands (tree cover, broadleaved, needle leaved, mixed leaf type) excluded | ≤300 m | xi |
| | Woodlands | Sensitivity: 300m buffer distance from naturally regenerating forests | ≤300 m | xi |
| | Water bodies | 1000m buffer distance from water bodies excluded | ≤1000 m | viii |
| | Protected areas | 1000m buffer distance from protected parks, monuments, reserves, and wildernesses excluded | ≤1000 m | xi |
| | Bird protected areas | 1500m buffer distance from protected habitats and bird areas excluded | ≤1500 m | xii |
| | Elevation | Terrain elevation above 1500 m excluded | ≥1500 m | xi |
| | Terrain Slope | Areas with a terrain slope angle above 17° excluded | ≥17° | xi |
| | Water depth | Water depths greater than the maximum (200m) excluded | ≥200 m | xii |
| | Distance to shore | 5000 m buffer distance from shore excluded | ≤5000 m | Own assumption based on ranges given in literature |
| | Protected areas | 3000 m buffer distance from protected areas excluded | ≤3000 m | Own assumption based on regional aspects and ranges given in literature |
| | Bird protected areas | 5000 m buffer distance from bird protected areas excluded | ≤5000 m | xiii |
| | Shipping routes | 2600m buffer distance from shipping routes | <= 2600 m | xiii |

| Technology | Aspect | Description | Exclusion buffer limits | Source |
|---|---|---|---|---|
| Open-field PV | Primary roads | 50m buffer distance from primary roads included | ≤50 m | Own assumption |
| | Railways | 50m buffer distance from railways included | ≤50 m | Own assumption |
| | Airports | 0m buffer distance from airports excluded | ≤0 m | Own assumption |
| | Urban settlements | 500m buffer distance from urban area excluded | ≤500 m | Own assumption |
| | Woodlands | 0m buffer distance from woodlands (tree cover, broadleaved, needle leaved, mixed leaf type) excluded | ≤0 m | Own assumption |
| | Water bodies | 0m buffer distance from water bodies excluded | ≤0 m | Own assumption |
| | Protected areas | 0m buffer distance from protected parks, monuments, reserves, and wildernesses excluded | ≤0 m | Own assumption |
| | Agricultural areas | 0m buffer distance from agricultural land, (cropland (rainfed), cropland (rainfed with tree or shrub cover), cropland (irrigated), cropland (mosaic), natural vegetation (mosaic)) excluded | ≤0 m | Own assumption based on x |
| | Elevation | Terrain elevation higher than 1750m excluded | ≥1750 m | x |
| | Slope: Total | Areas with a terrain slope angle above 10° excluded | ≥10° | x |
| | Slope: Northward | Areas with a north-facing slope angle above 3° excluded | ≥3° | x |
| Rooftop PV | Population density | Only areas with a non-zero population density taken into account | - | x |

The land eligibility analysis is performed step-wise, where different constraints and exclusion criteria, as indicated in → **Table A7**, are applied one after the other.

After the land eligibility analysis conducted by GLAES, the placement algorithm RESkit identifies locations of individual turbines/PV modules within the eligible areas. For wind turbines, the algorithm also includes an optimisation which varies the technical design parameters of turbine over a given range to derive the cost-optimal level of hub height and rotor diameter which leads to the minimum levelized cost of electricity (LCOE) for each location. This is followed by hourly simulation of generation profiles for each location, accounting for wind speed/solar irradiance data at the location. As an output of this modelling step, installed capacity, generation profiles as well as LCOEs are determined for each location. The results are aggregated to a national context to get the country's maximum technical potential for different renewable energy sources.

→ **Table A8** provides an overview of assumptions made in this work regarding the baseline turbine design for onshore and offshore applications. → **Table A9** gives an overview on range of assumptions made for different possible levels of turbine's technical design parameters in the optimisation algorithm embedded in our renewable potential analysis framework. → **Table A10** provides the characteristics of PV modules applied in this study for open-field and roof-top applications as well as the economic assumptions.

**Table A8**

**Baseline turbine's technical design and economic parameters**

| Technology | Aspect | Assumption & parameter choice | Source |
|---|---|---|---|
| Onshore wind | Hub height | 101m | vi and https://en.wind-turbine-models.com/turbines/1719-ge-general-electric-ge-4.8-158-cypress |
| | Rotor diameter | 158m | v |
| | Capacity | 4.8MW | v |
| | Specific power | 245 W $m^{-2}$ | v |
| | Annual operating cost | 2% capex | vi |
| | Economic lifetime | 20 years | https://www.nrel.gov/analysis/tech-footprint.html |
| Offshore wind | Hub height | 94m | xiv |
| | Rotor diameter | 140m | v |
| | Capacity | 5.5MW | v |
| | Specific power | 357 W $m^{-2}$ | - |
| | Foundation type | Monopile/ fixed | - |
| | Annual operating cost | 2% capex | vi |
| | Economic lifetime | 20 years | https://www.nrel.gov/analysis/tech-footprint.html |

**Table A9**

**Range of assumptions and parameter choices made for turbine technical design parameters**

| Technology | Aspect | Assumption & parameter choice | Source |
|---|---|---|---|
| Onshore wind | Hub height | 80m, 99m | Own assumptions based on the typical ranges and the optimal value derived from sensitivity analysis |
| | Rotor diameter | 80, 100, 117, 136 | Same as above |
| | Capacity | 0.8MW, 1 MW, 2MW, 2.4MW, 3MW | Same as above |
| Offshore wind | Hub height | 110m, 130m, 150m | Same as above |
| | Rotor diameter | 141, 180, 200, 220 | Same as above |
| | Capacity | 3MW, 5MW, 7MW, 9MW | Same as above |
| | Foundation type | Fixed foundation (<100 m depth), floating foundation (≥100m depth) | Own assumption |

**Table A10**

**Selected PV module characteristics for open-field and roof-top applications**

| Technology | Aspect | Assumption & parameter choice | Source |
|---|---|---|---|
| Open-field PV | Module name | LG_Electronics_Inc__LG350Q1C_A5 | xv |
| | $P_{mp}$ | 350 W | xv |
| | Area | 1.7272 $m^2$ | xv |
| | Efficiency | 20%[3] | xvi |
| | Technology | Mono-crystalline / N-type | xv |
| | Coverage | 30 $m^2_{land}$ $kWp^{-1}$ | Own assumption based on the insights from viii |
| | Type (fixed tilt/single axis tracking) | Fixed-tilt | viii |
| | Operating Cost | 1.7% capex | viii |
| | Economic lifetime | 25 years | https://www.nrel.gov/analysis/tech-footprint.html |
| Rooftop PV | Module name | LG_Electronics_Inc__LG350Q1C_A5 | xv |
| | $P_{mp}$ | 350 W | xv |
| | Area | 1.7272 $m^2$ | xv |
| | Efficiency | 20% | xvi |
| | Technology | Mono-crystalline / N-type | xv |
| | Coverage | 9.57 $m^2_{land}$ $kWp^{-1}$ | Own assumption based on the insights from xxii |
| | Type (fixed tilt/single axis tracking) | Fixed-tilt | viii |
| | Operating Cost | 1.7% capex | xiii |
| | Economic lifetime | 25 years | https://www.nrel.gov/analysis/tech-footprint.html |

# A5: Results from renewable potential analysis for selected countries

This section shows the final results from renewable potential analysis for India, to provide an example of the possible results of the work.

→ **Figure A1** shows the results from land eligibility analysis for India.

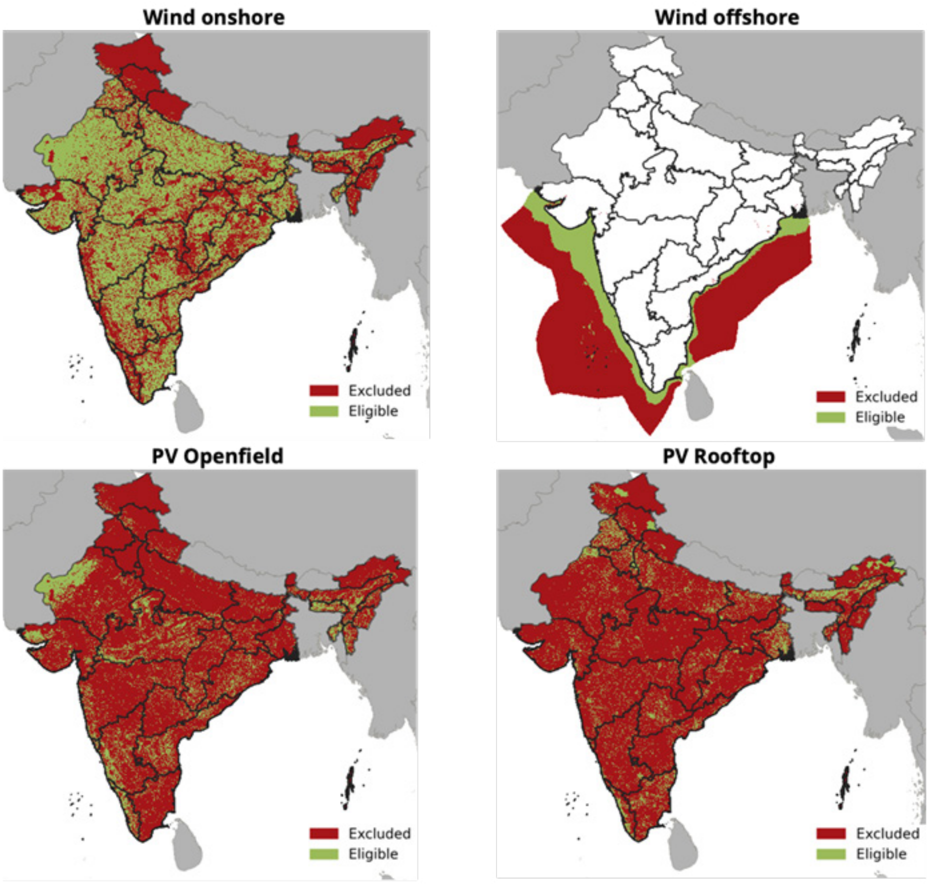
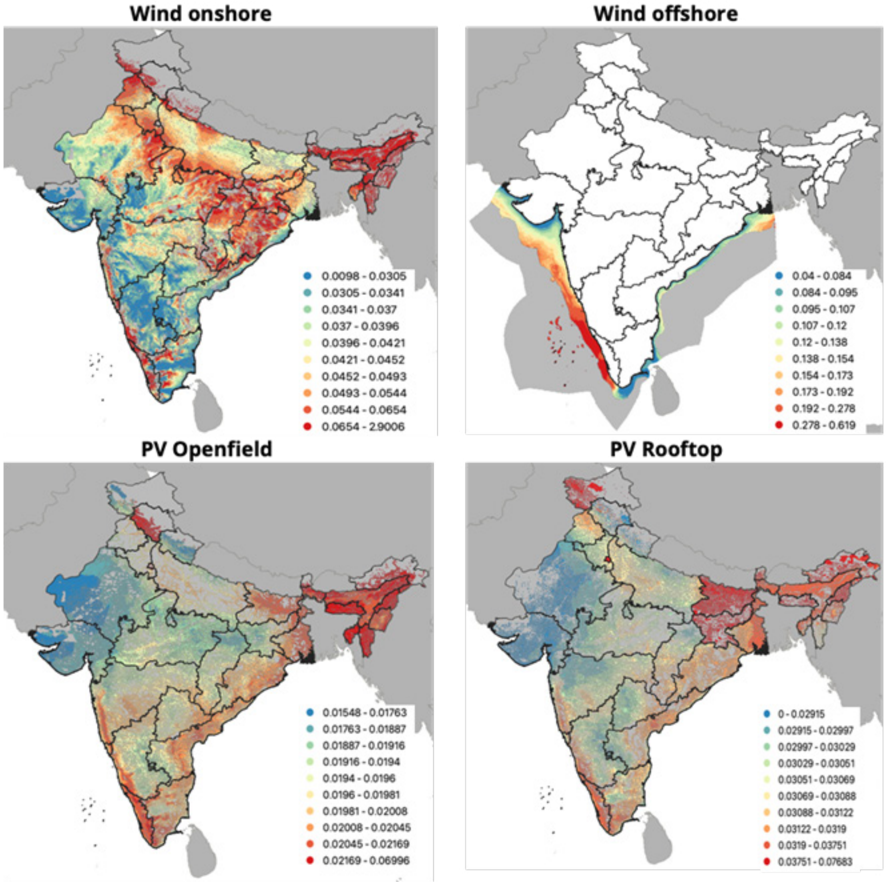



**Figure A1**
**Land eligibility analysis results of different renewable technologies for India**

In addition, the renewable potential assessment framework derives the distribution of full load hours (FLH) as well as levelized costs of electricity (LCOE) for different renewable energy sources. For instance, → **Figure A2** visualises the LCOE distribution over eligible areas for onshore wind, offshore wind, Open-field PV and PV residential/Rooftop for India.

**Figure A2**

**Techno economic potential of variable renewable energy sources in India: spatial distribution of LCOE for different renewable technologies**

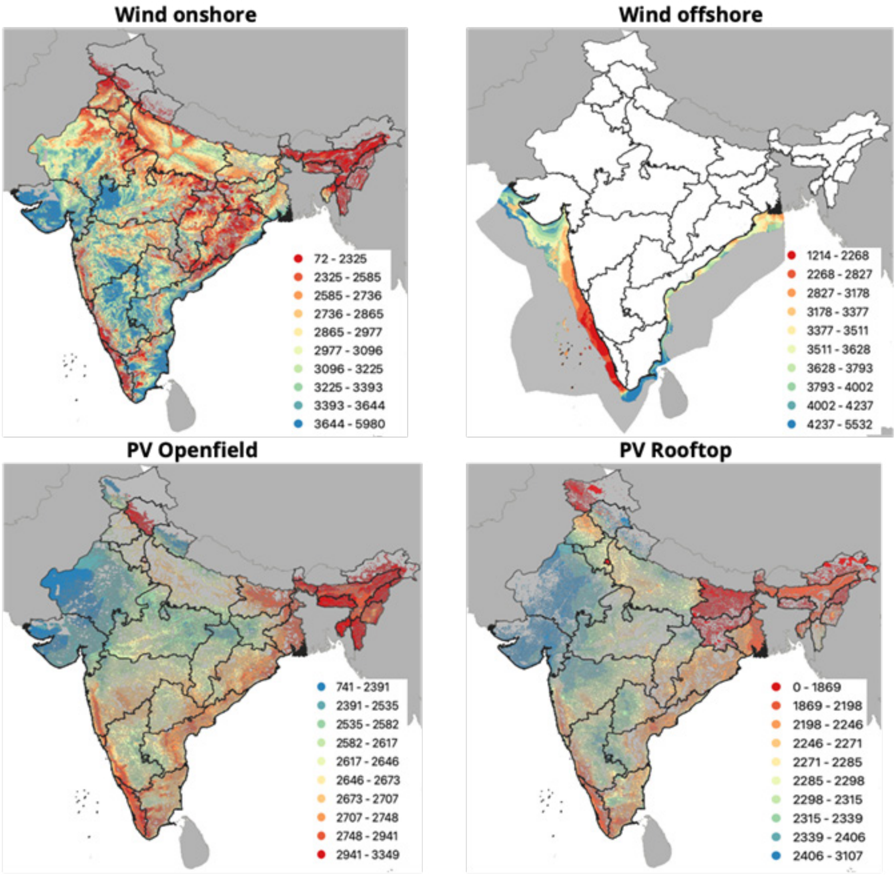



Note: This is based on medium cost scenario assumptions for 2021 and legend unit is 2021$/kWh.

The sites with higher LCOE mainly correspond to those locations with lower full load hours and vice versa. → **Figure A3** visualises the distribution of full load hours over eligible areas.

**Figure A3**

**Technoeconomic potential of variable renewable energy sources in India: Spatial distribution of Full load hours for different renewable technologies**




Note: Legend unit is hour/yearunit is 2021$/kWh

Finally, → **Table A11** provides an overview of maximum technical potential in terms of GW capacity and TWh / yr of generation for different renewable technologies and for all selected countries.

**Table A11**

**Maximum country's technical potential in terms of GW capacity and TWh/yr of generation for different renewable technologies**

| Country | Technology | Capacity in 2021 (MW) | Generation (TWh/yr) |
|---|---|---|---|
| **Brazil** | Onshore | 4 585 | 14 898 |
| | Offshore | 2 111 | 9 768 |
| | Open-field PV | 57 555 | 160 260 |
| | Rooftop PV | 251 | 479 |
| **China** | Onshore | 4 703 | 15 892 |
| | Offshore | 1 747 | 7 688 |
| | Open-field PV | 65 766 | 199 333 |
| | Rooftop PV | 1 307 | 2 331 |
| **Germany** | Onshore | 216 | 774 |
| | Offshore | 95 | 496 |
| | Open-field PV | 1 376 | 3 245 |
| | Rooftop PV | 139 | 153 |

| Country | Technology | Capacity in 2021 (MW) | Generation (TWh/yr) |
|---|---|---|---|
| India | Onshore | 2 681 | 7 949 |
| | Offshore | 1 242 | 4 372 |
| | Open-field PV | 8 935 | 23 513 |
| | Rooftop PV | 724 | 1 557 |
| Indonesia | Onshore | 667 | 1 546 |
| | Offshore | 4 008 | 13 970 |
| | Open-field PV | 9 475 | 11 293 |
| | Rooftop PV | 276 | 291 |

# Endnotes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