Cost of energy and market assessment

Phase 2 spatial analysis to support commercialisation strategy

BVGassociates

Revision	Description	Circulation classification	Authored	Checked	Approved	Date
2	Report for client	Commercial in confidence	ALO	GGO	GGO	30 Nov 2018

Circulation classification	Description
Strictly confidential to *XX (name person(s) or group)*	Not to be circulated beyond the named persons or group within client
Commercial in confidence	Not to be circulated beyond client (or BVG Associates if no client specified)
Supplied under NDA	Not to be circulated beyond client or other organisation party to an non-disclosure agreement (NDA) with the client (subject to any additional terms agreed with the client in *[state details of agreement]*)
Client discretion	Circulation is at the discretion of the client (subject to any terms agreed with the client in *[state details of agreement]*)
Unrestricted	No restriction on circulation

Note: Circulation classification may not be changed on a document. Only BVGA may issue a revised document with a revised circulation classification.

Contact information

Andy Logan is the main point of contact for this subject.
Email: alo@bvgassociates.com
Tel: +44 (0) 141 212 0803
Mob: +44 (0) 07921 377 668

Cost of energy and market assessment

Agenda

Contents

BVG Associates

Business

- Market assessment
- Market entry and comms strategy
- Industry and stakeholder introductions
- Mergers and acquisitions / investor relations
- Tendering support
- Voice of the customer review

Economics

- Levelised cost of energy
- Economic impacts
- Local content
- Supply chain
- Policy
- Modelling and forecasting

Technology

- Asset management
- Engineering services
- Life extension
- Due diligence
- Technology roadmaps
- Technical review

Cost of energy and market assessment

Introduction

Part 1 - LCOE modelling and global spatial analysis

The purpose of this study is to explore the market potential and target national markets for KPS 500kW onshore technology by using a global spatial analysis.

Part 1 modelling was undertaken to compare KPS 500kW onshore technology with equivalent scale HAWT, solar and diesel generation. This was done at current expected cost levels for a 500KW device (100% cost) and a future best case scenario cost (SWAG cost).

Following validation of the KPS SWAG cost estimate, a global LCOE analysis was completed that showed the increased size of opportunity moving from 100% cost to SWAG cost, and LCOE comparison with other technologies. The analysis produced LCOE maps of the world and comparative technology LCOE heat maps that were the baseline for further discussion with KPS and for Part 2 of the study.

Part 1 was discussed with KPS in August 2018 and this discussion subsequently informed the work in Part 2.

Part 2 – Acquisition and application of data filters

Following review of Part 1 with KPS, Part 2 required the application of data filters to the baseline global LCOE layers. The purpose of this was to further refine the spatial analysis to account for relevant accessibility, environmental, social and political considerations where possible.

Additional considerations discussed with KPS were global datasets of corruption perception and installed generation capacities. These were assessed to qualify results of the spatial LCOE analysis.

During discussion with KPS, six target countries were also raised as being potential priority markets: Australia, Brazil, Canada, Ethiopia, India and The Philippines. The results of the analysis for these countries were highlighted for comparison with one another alongside global results.

GeoSpatial Enterprises provided the GIS analysis and output for Part 1. However, they ceased trading during the completion of Part 2 and BVGA subsequently undertook the majority of GIS analysis thereafter. As a result, the maps completed in Part 2 this work have slightly different formatting.

Cost of energy and market assessment

Introduction

Levelised cost of energy

Levelised cost of energy (LCOE) (or simply cost of energy) is defined as the revenue required (from whatever source) to earn a rate of return on investment equal to the discount rate (also referred to as the WACC) over the life of the wind farm. Tax and inflation are not modelled. The technical definition is:

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + M_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Where:

I_t - Investment expenditure in year *t*

M_t - Operation, maintenance and service expenditure in year *t*

E_t - Energy generation in years *t*

r - Discount rate, and

n - Lifetime of the project in years.

Assumptions

Simplifications
It is recognised that several necessary simplifications have been taken to support this global analysis.

Global assumptions
Real (2018) prices.
Commodity prices fixed at the average for 2018.
Exchange rates fixed at the average for 2018 (for example, €1 = £0.88).

Technology assumptions
500kW devices as part of a small scale (5MW) array.
Projects with 20 year lifetime with first operation 2020.
Design and costs of technologies installed anywhere in the world are constant irrespective of local market conditions (e.g. actual local labour costs, supply chain capability etc.).

Site assumptions
With the exception of the wind speed and solar irradiation inputs, site conditions were assumed to be standard across the globe.
This included distribution of wind speed with Weibull shape factor 2.0 and an air density of 1.225kg/m^3.

1. Part 1 – LCOE modelling and global spatial analysis

Inputs - costs

Baseline KPS 500kW onshore SWAG cost estimate and LCOE calculation

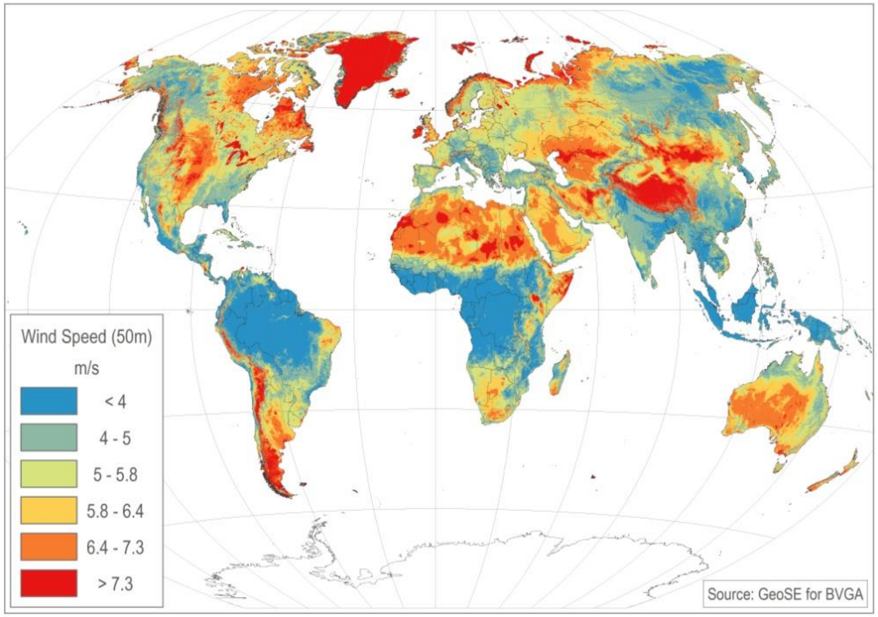
Onshore 500kW		100% cost element values*	SWAG improvement	SWAG Element values	Initial impact - project size inc to 25MW, other factors are the same
			%		Comment
Development	£000s/MW	129	-25%	96.5	Large project does not cost 2* to develop
Principal flight components and avionics	£000s/MW	379	-25%	284.3	Increased learning rate to 20% and sourced components from lower cost countries
Base station and system assembly	£000s/MW	995	-18%	815.9	Change from Artemis drivetrain and use of capstan winch reduces cost by £180k/MW
Foundation	£000s/MW	67	-30%	46.6	Reduced cost of labour and materials in low cost country
Array electrical system	£000s/MW	54	0%	53.7	No cost reduction at this scale
Installation	£000s/MW	67	-8%	61.7	Cost reduction for 2* volume, learning on the job, some bespoke equipment becomes cost effective
Contingency % of other CAPEX	%	5%	-25%	3.9%	Assumes we plan well and manage issues well
Total CAPEX	£000s/MW	1778		1412	
Planned maintenance excl flight components	£000s/MW/year	11	-8%	10.2	Large project enables slicker planned maintenance, greater learning on the job
Unplanned service - excl flight components	£000s/MW/year	11	-25%	8.3	Reliability achieves 33% higher level than planned
Flight components - planned and unplanned	£000s/MW/year	33	-38%	20.6	Components last 60% longer than currently planned for
Other OPEX	£000s/MW/year	16	-5%	15.6	Cost reduction for 2* volume
Transmission rental cost	£000s/MW/year	6	-10%	5.4	Transmission for large project does not cost 2* to make and install
Total OPEX	£000s/MW/year	77.4		60.0	
WACC	%	8%	-15%	6.8%	Lenders look on large kite project as favourably as HAWT
Project life	years	20	25%	25.0	Project life extended to typical HAWT project life
Decommissioning cost % of initial total CAPEX	%	2%	0%	2.0%	Will be lower cost but same as a % of reduced CAPEX
Annualisation factor for CAPEX	%	10.8%		8.9%	
Aerodynamic AEP	MWh/year	4661	2%	4754.2	Wing lift aerodynamic improvements at same cost
Overlap AEP	MWh/year	600	20%	720.0	AEP generated and output during overlap increased based on dynamic array cable rating
Drivetrain losses	%	8%	-25%	6.0%	Move to standard electro-mechanical drivetrain increases efficiency
Pull-in energy	MWh/year	244	0%	244.0	No SWAG improvement proposed
Planned maintenance downtime	%	2%	-8%	1.9%	Large project enables slicker planned maintenance, greater learning on the job
Unplanned service downtime	%	2%	-25%	1.5%	Reliability achieves 33% higher level than planned
Gross AEP	MWh/year	4,414.1		4738.9	
Other losses	%	6.4%	0%	6.4%	No change
Net AEP	MWh/year	4,130.7		4434.7	
LCOE	£/MWh	65.2		41.7	

* From previous work with BVGA, June 2018, after 100 off, in 6MW farm (12 systems), 9m/s average wind speed at 100m above mean site level.

1. Part 1 – LCOE modelling and global spatial analysis

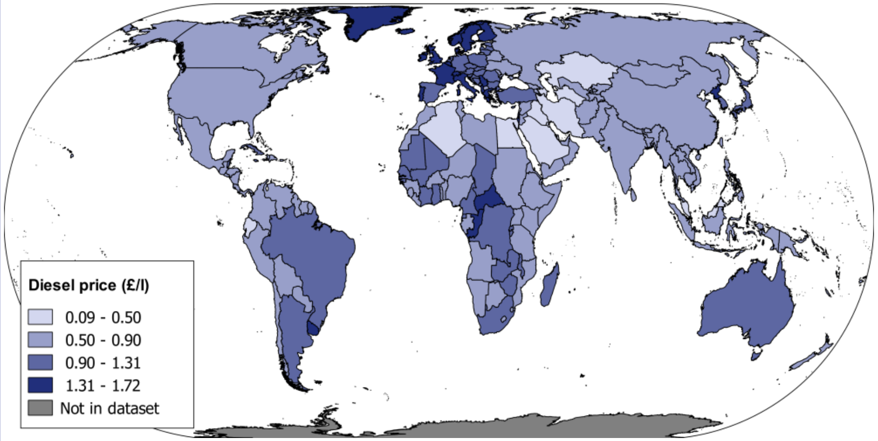
Inputs – wind speed and diesel cost data

1.1 Global onshore wind speed (50m)



- Wind speed from Global wind atlas v1.0 (DTU and IRENA)

1.2 Global diesel costs

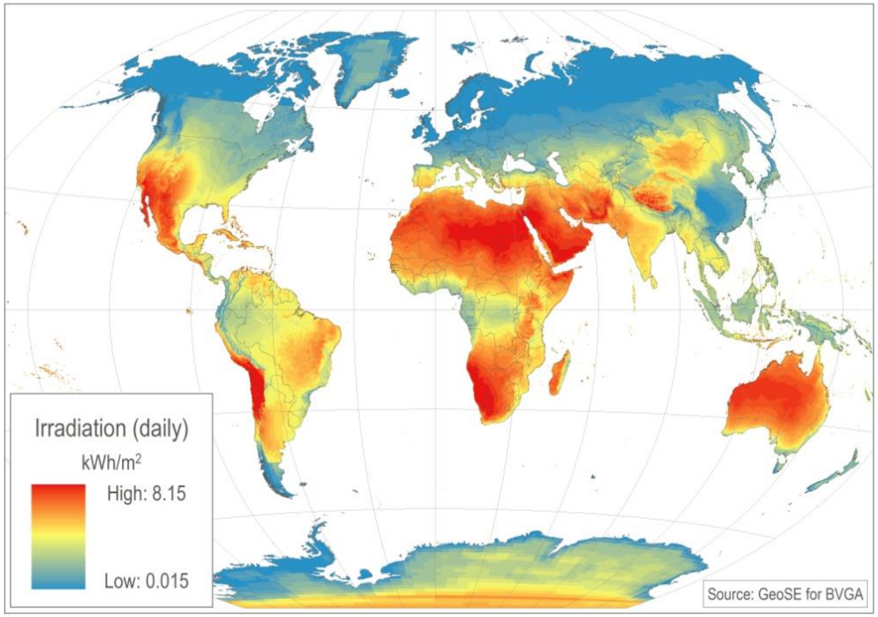


- Diesel data from World Bank

1. Part 1 – LCOE modelling and global spatial analysis

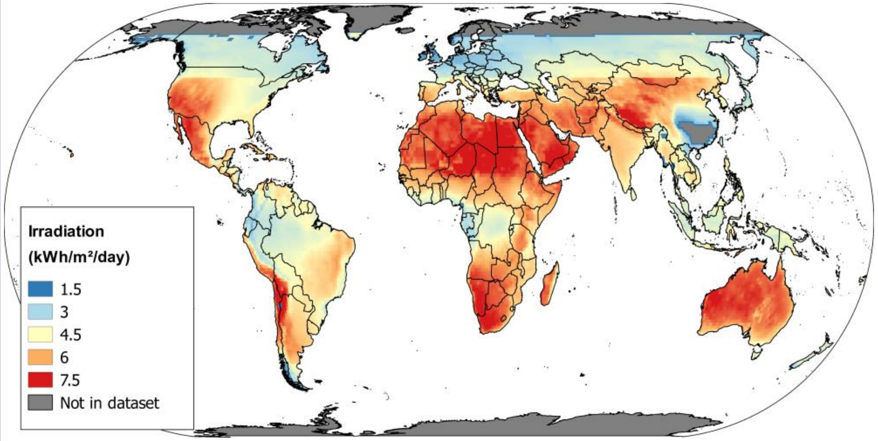
Inputs – Solar irradiation

1.3.1 Global solar irradiation (Part 1)



- Original map and data provided by GeoSE.
- Global onshore solar irradiation for an optimally tilted surface (annual average kWh/sqm/day), from Nasa's Prediction of Worldwide Energy Resource (POWER).
- We believe data for some areas (such as above 60°N where the incline of satellite imagery prohibits an accurate assessment of cloud cover) was obtained by extrapolation from nearby data points.

1.3.2 Global solar irradiation (Part 2)

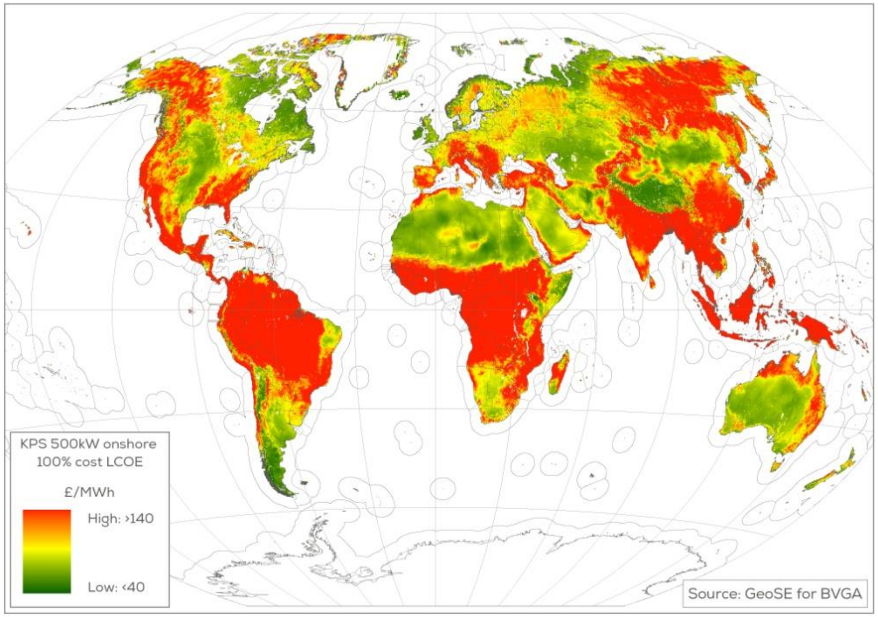


- As the original solar irradiation data could not be obtained, data for Part 2 instead comes from the Surface meteorology and Solar Energy (SSE) project, based on POWER project data.
- The solar dataset for Part 2 is incomplete, notably above 60°N and for a large region in China. However, the LCOE results for solar generation in these regions (from Part 1) indicate very high values and therefore the results are not significantly affected.

1. Part 1 – LCOE modelling and global spatial analysis

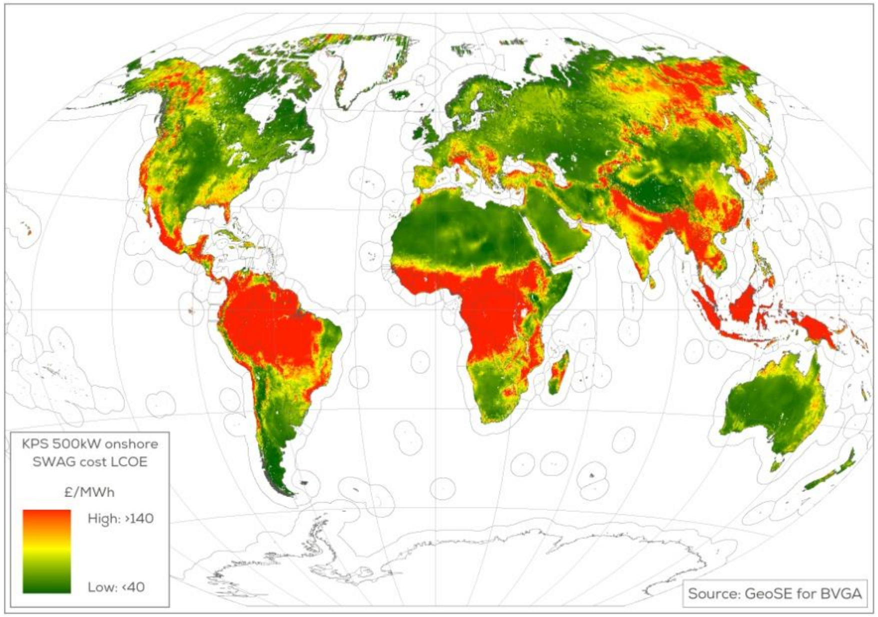
Outputs – Global LCOE maps

1.4 KPS 500kW onshore 100% cost LCOE



- KPS LCOE at 100% cost is below £80/MWh across ~20% of global onshore surface area.
- KPS LCOE at 100% cost is below £60/MWh across less than 1% of global onshore surface area.

1.5 KPS 500kW onshore SWAG cost LCOE

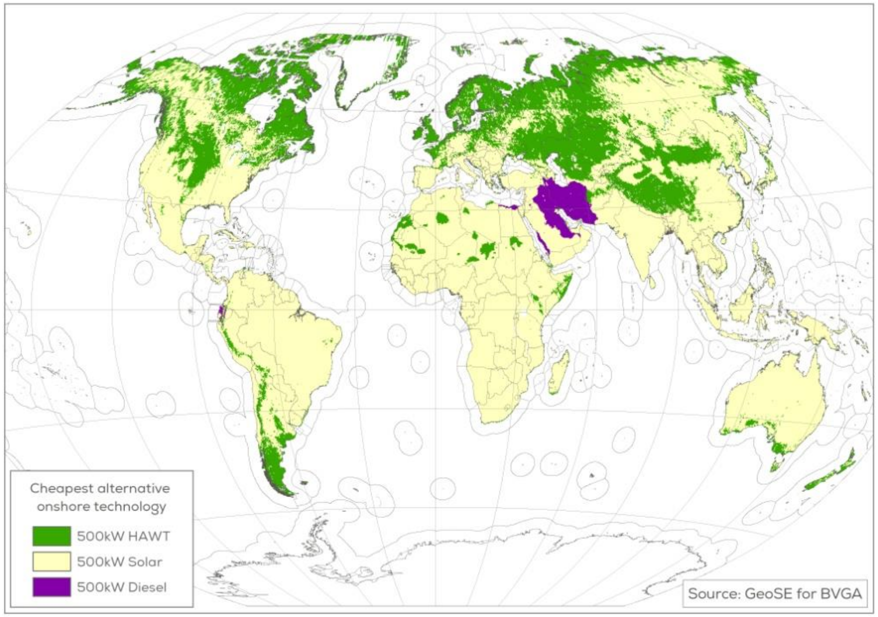


- KPS LCOE at SWAG cost is below £80/MWh across ~55% of global onshore surface area.
- KPS LCOE at SWAG cost is below £60/MWh across ~40% of global onshore surface area.

1. Part 1 – LCOE modelling and global spatial analysis

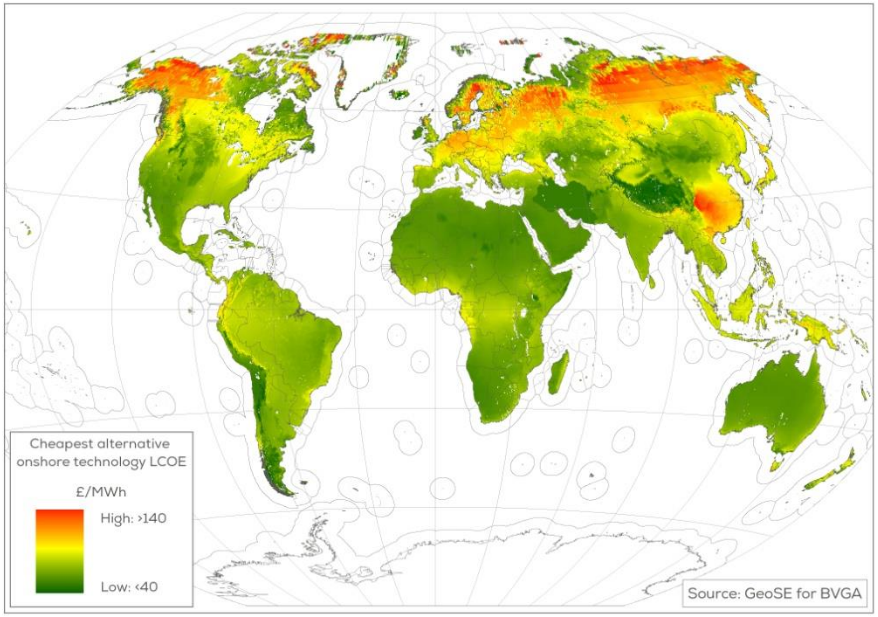
Outputs – Global LCOE maps

1.6 Cheapest alternative onshore technology



- Solar is the predominant lowest-LCOE technology globally by surface area.
- Diesel limited to the Middle East and Ecuador.
- HAWT is cheapest in regions of good wind resource such as central North America, as well as regions of poor solar irradiation and high diesel cost such as Scandinavia and the Baltic states.

1.7 Cheapest alternative onshore LCOE

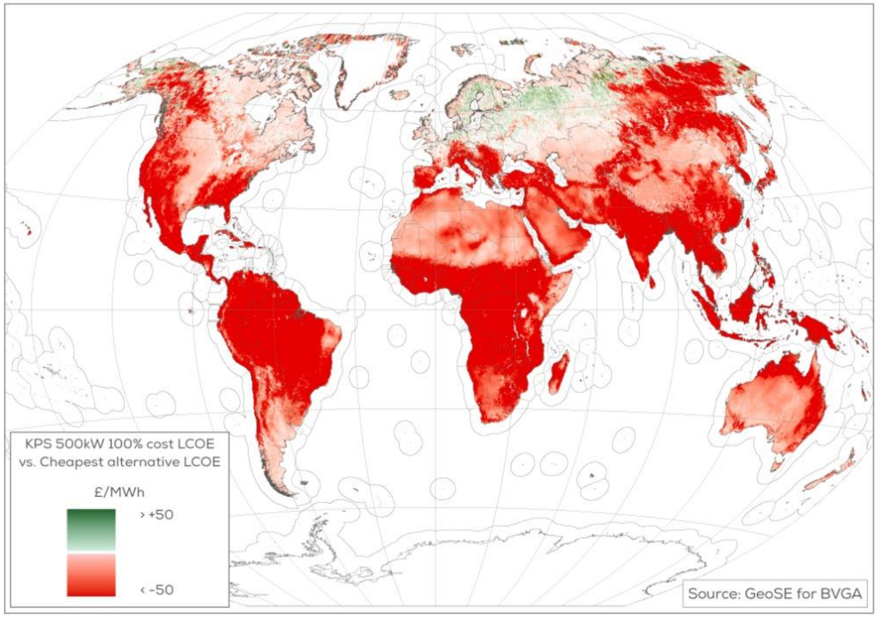


- Cheapest alternative technology LCOE is below £80/MWh across ~75% of global onshore surface area.
- Cheapest alternative technology LCOE is below £60/MWh across ~25% of global onshore surface area.

1. Part 1 – LCOE modelling and global spatial analysis

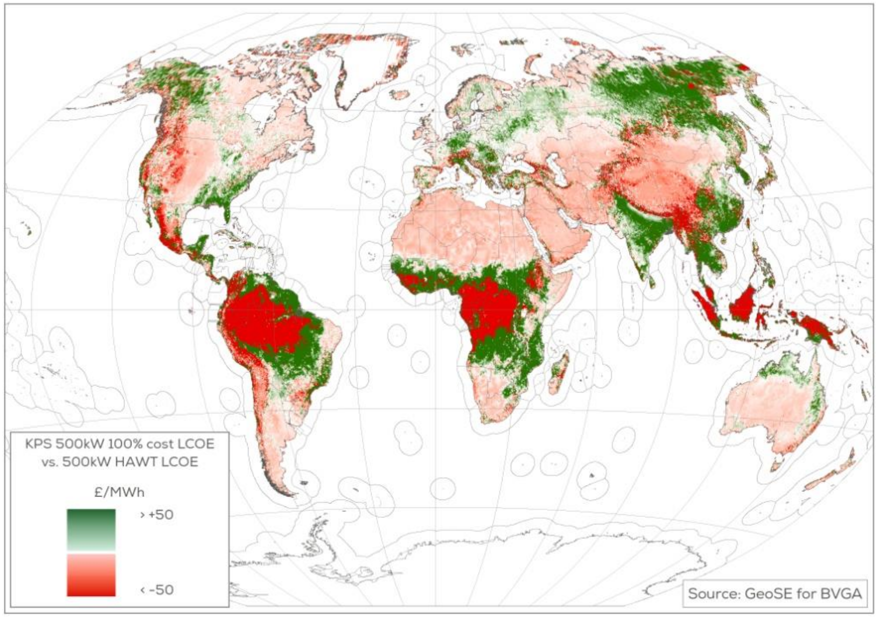
Outputs – Comparative heat maps

1.8 KPS 500kW 100% cost LCOE vs. Cheapest alternative LCOE



- KPS device is the lowest-LCOE technology across ~10% of the global onshore surface, predominantly in northern Europe and Russia.
- Solar technology is the lowest-LCOE technology across ~70% of the surface, with HAWT at ~20%. Diesel accounts for very little.

1.9 KPS 500kW 100% cost LCOE vs. 500kW HAWT LCOE

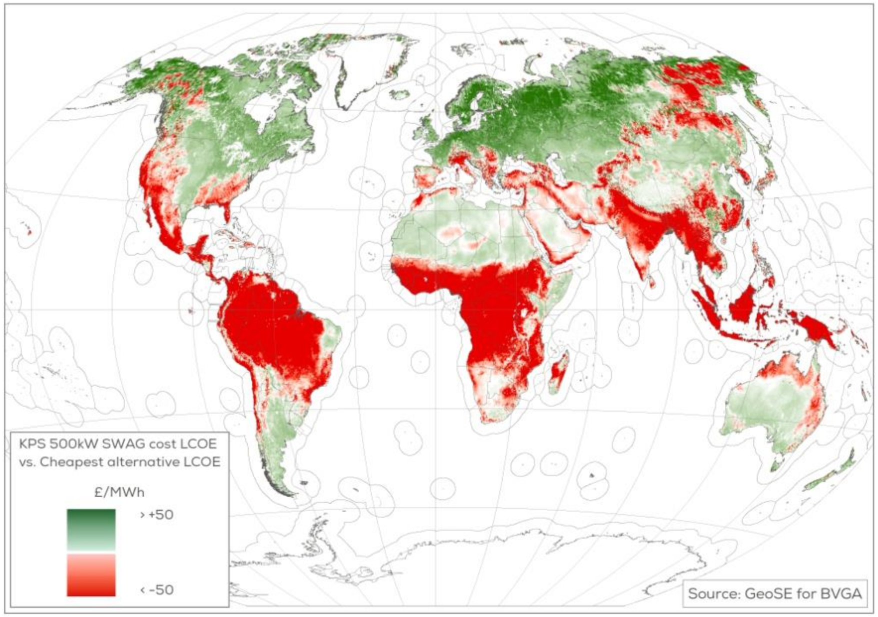


- KPS device is cheaper than HAWT across ~40% of the global onshore surface.
- However, LCOE for both KPS and HAWT is high in the extreme “hot” and “cold” mapped areas (i.e. equatorial regions, SE Asia, NE Asia, NW North America).

1. Part 1 – LCOE modelling and global spatial analysis

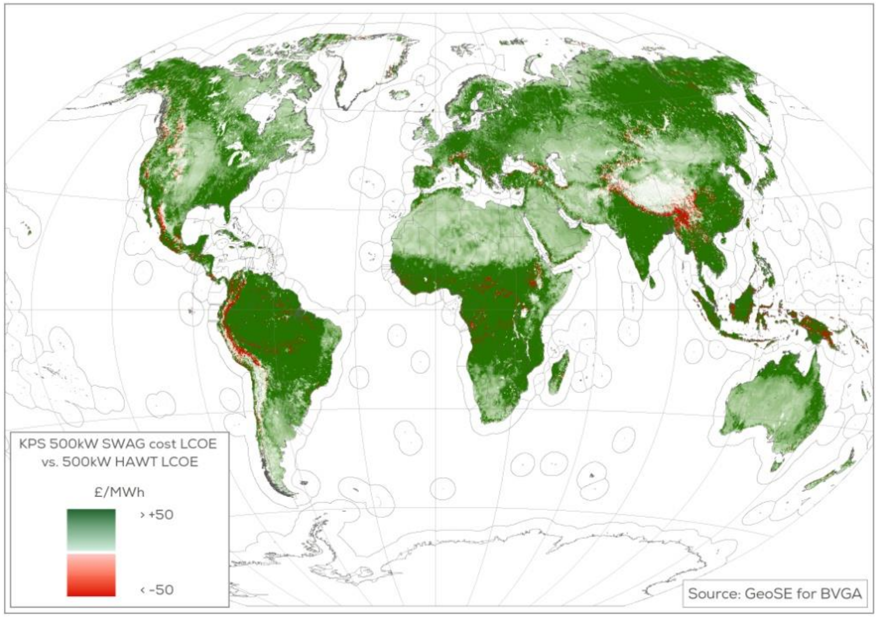
Outputs – Comparative heat maps

1.10 KPS 500kW SWAG cost LCOE vs. Cheapest alternative LCOE



- At SWAG cost, KPS device is the lowest-LCOE technology across ~50% of the global onshore surface.
- Compared to KPS at 100% cost, KPS at SWAG cost replaces nearly all HAWT and over one-third of solar technology.

1.11 KPS 500kW SWAG cost LCOE vs. 500kW HAWT LCOE



- KPS device at SWAG cost is cheaper than HAWT across nearly all of the global onshore surface.
- HAWT remains the cheaper alternative only in areas of poor wind resource that affect the LCOE of both technologies.

2. Part 2 – Acquisition and application of data filters

Inputs – exclusion zones

Exclusions applied

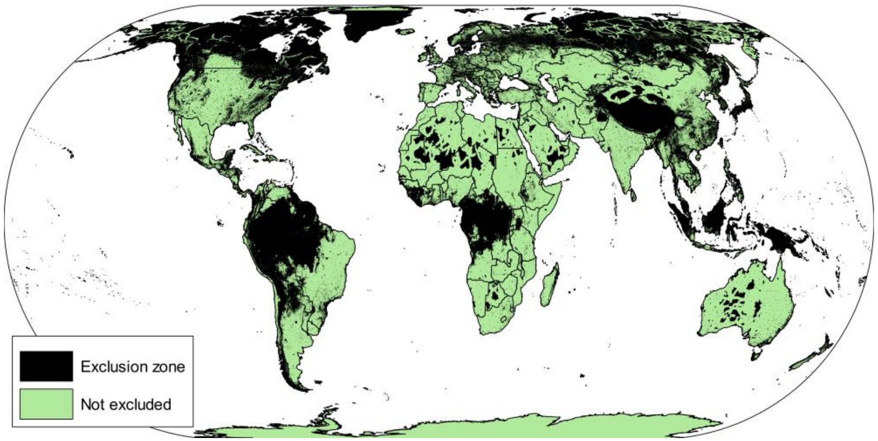
- In order to better assess the most attractive markets within the total global surface area, a series of filters were applied to exclude geographically inaccessible areas.

- Excluded areas were:
  - Not within 50km of any recorded road. Data from NASA SEDAC's Global Roads project.
  - Within 15km of an airport. Data from OpenFlights airports database.
  - Urban and built up areas. Data from the Natural Earth project.
  - Unsuitable land cover consisting of: bodies of water, snow and ice, permanent wetlands and dense forestry. Data from U.S. Geological Survey Land Cover Institute and WWF Global Lakes and Wetlands Database.
  - Protected areas in IUCN category 1a and 1b. Data from World Database on Protected Areas.
  - With an elevation above 3000m or gradient above 7.5º. Data from NOAA National Centres for Environmental Information.
  - With a wind speed at 200m below 4m/s. Data from Global Wind Atlas produced by DTU and IRENA.

- Individual exclusion layers maps located in report appendix.

Note that these are global datasets and more sophisticated datasets are generally available at country level.

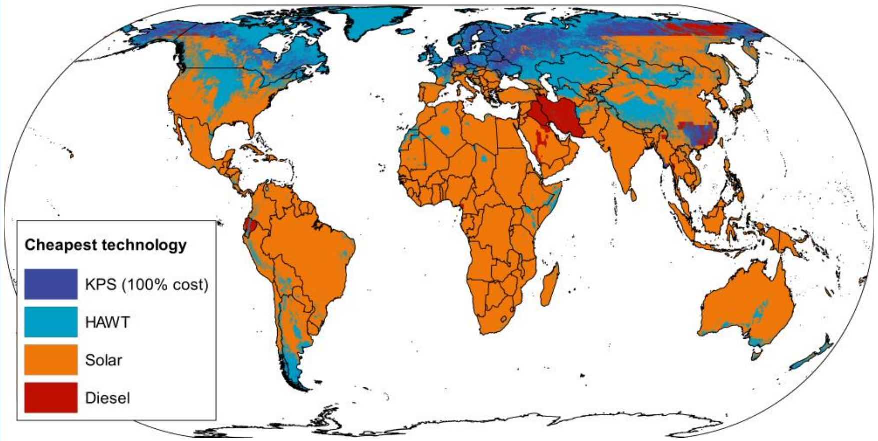
2.1 Combined exclusion zones



2. Part 2 – Acquisition and application of data filters

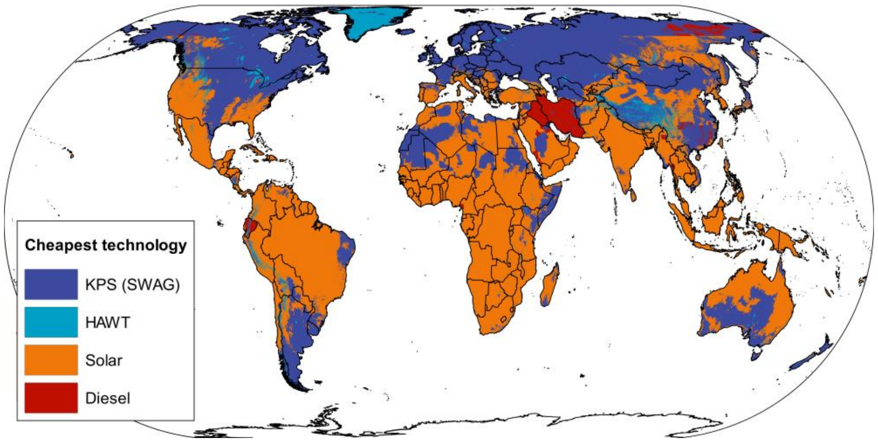
Inputs – Lowest onshore technology LCOE

2.2 Lowest onshore technology LCOE, KPS 100% cost



- Before application of exclusion zones, the most attractive markets for KPS at 100% cost appear to be Northern and Eastern Europe.
- Appearance of additional areas of KPS technology as lowest LCOE is from change in solar data source as described on slide 7. While KPS is the lowest LCOE technology in additional regions at high northern latitude, the LCOE values for all technologies here, including KPS, is high.

2.3 Lowest onshore technology LCOE, KPS SWAG cost

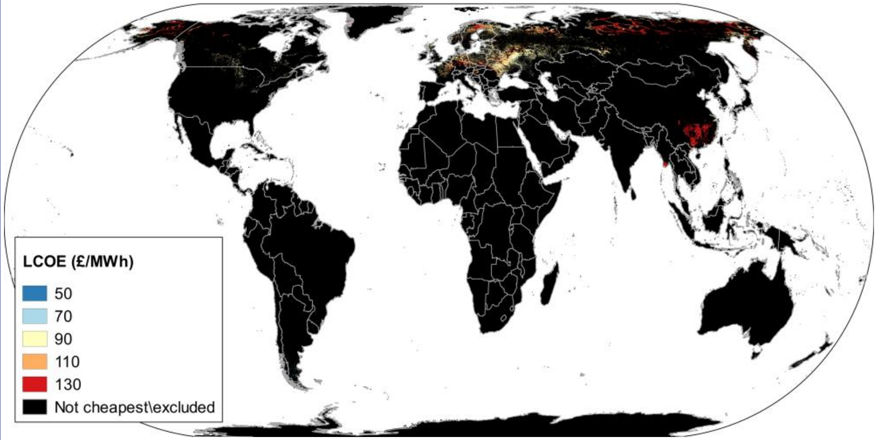


- Before application of exclusion zones, there are attractive markets for KPS at SWAG cost on every continent.

2. Part 2 – Acquisition and application of data filters

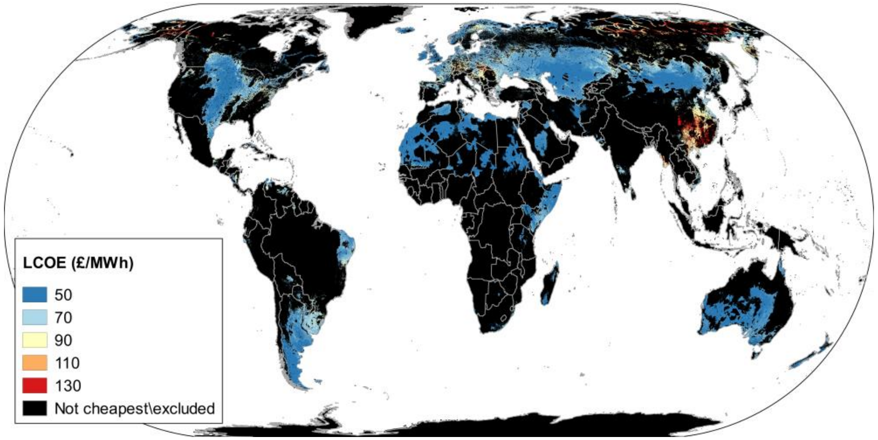
Outputs – KPS lowest LCOE onshore technology areas

2.4 KPS 100% cost LCOE with exclusion zones



- After applying exclusions zones over half of the area where KPS at 100% cost is the lowest LCOE technology is filtered out.
- The remaining areas have relatively high LCOE with the lowest LCOE values found in Russia and Canada, with small scattered areas found in South America and Europe.

2.5 KPS SWAG cost LCOE with exclusion zones

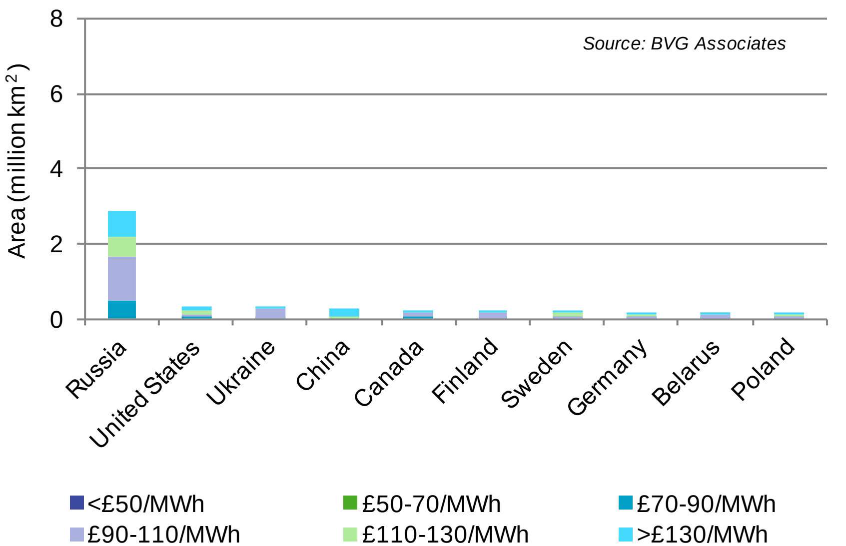


- After applying exclusions zones a significant amount of land area where KPS at SWAG cost is the lowest LCOE technology remains on every continent.
- These remaining areas show favourable LCOE in almost every region in large amounts.

2. Part 2 – Acquisition and application of data filters

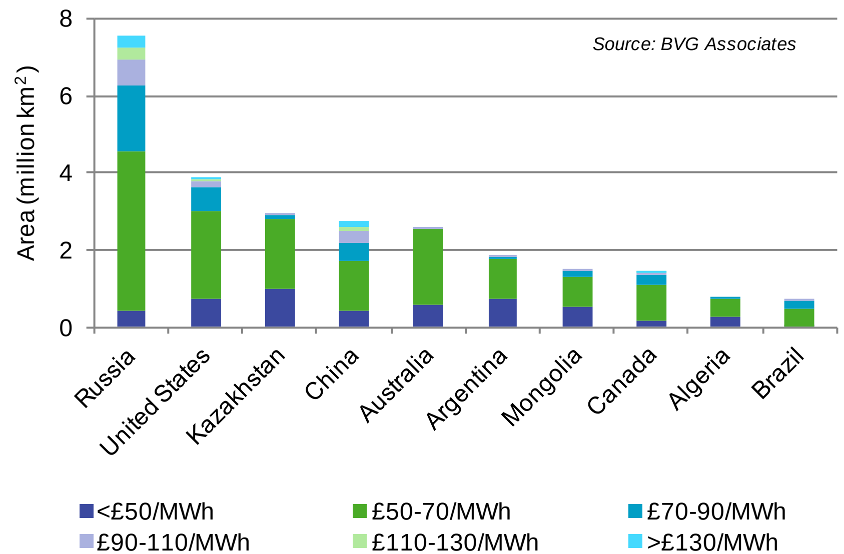
Outputs – KPS opportunity markets

2.6 KPS 100% cost opportunity markets



- When ranking the market opportunity simply by land area and LCOE, Russia comes out on top for KPS at 100% cost. For the other 9 countries shown, the opportunity is of a similar size in each country.
- No countries show areas where KPS device at 100% cost could be deployed with an LCOE below £50/MWh.
- Assuming a minimum area threshold of 500km^2 for the deployment of 500 KPS devices, five countries meet this criteria at an LCOE between £50-70/MWh: Argentina, Canada, Chile, Iceland and Russia.

2.7 KPS SWAG cost opportunity markets

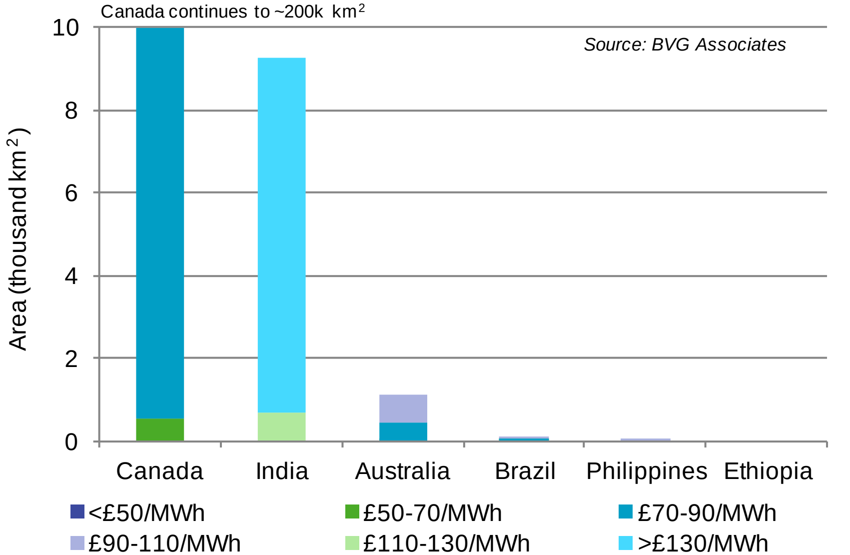


- Russia still leads the market opportunity by area, primarily due to having a large land mass; however there are several countries with a greater area of the lowest LCOE band.
- Results show very large areas available globally for the deployment of KPS device at SWAG cost.
- While there is more variation in the size of opportunity across the top 10 countries, the total areas for all countries (and many additional not shown) are far above the minimum area threshold for KPS market opportunity of 500 devices.

2. Part 2 – Acquisition and application of data filters

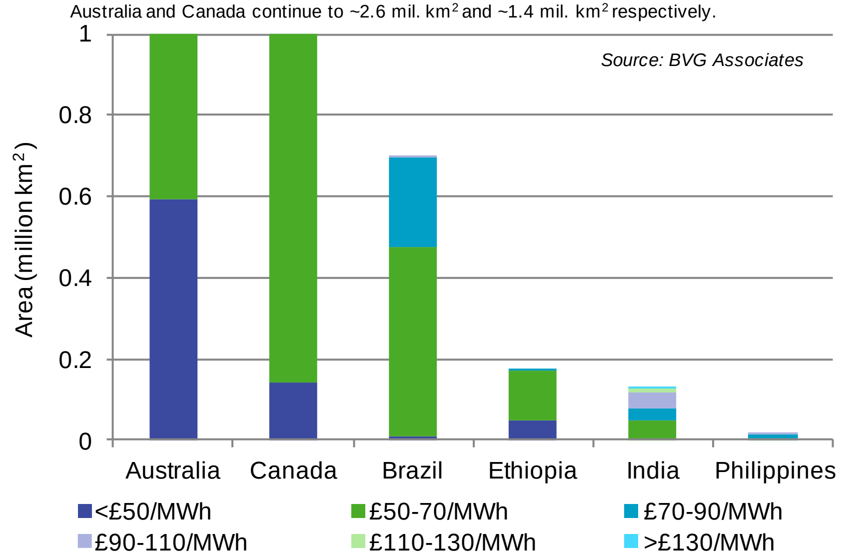
Outputs – KPS opportunity markets

2.8 KPS target countries at 100% cost



- The six target countries listed by total opportunity area after application of exclusions show Canada to have the largest opportunity by total area and by largest opportunity by lowest LCOE area for KPS at 100% cost.
- India has a reasonable opportunity by total area but this is at a high LCOE. Australia has a lower opportunity by total area compared to India but the opportunity is at a lower LCOE.
- Brazil and The Philippines have low opportunity by total area. KPS at 100% is not found to be the lowest LCOE technology anywhere in Ethiopia.

2.9 KPS target countries at SWAG cost



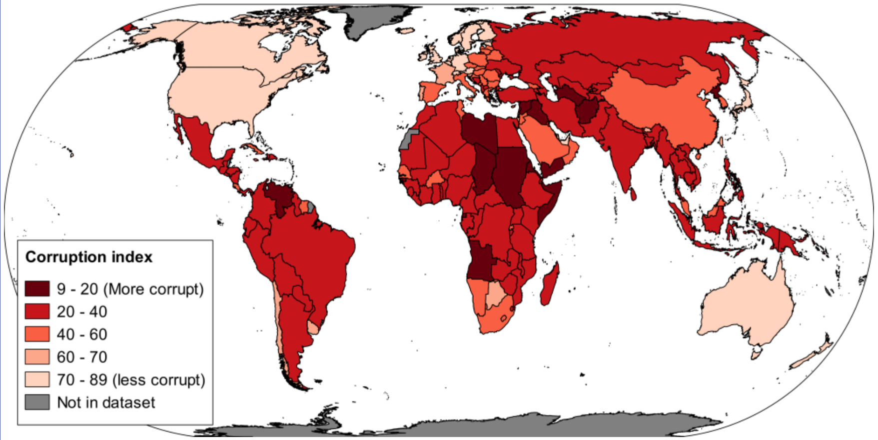
- At SWAG cost the order of magnitude and level of LCOE opportunity is significantly improved for each target country compared to 100% cost.
- In moving to SWAG cost Australia becomes the largest opportunity market by total area and by largest opportunity by lowest LCOE area. The transition to SWAG cost also opens up significant opportunity in Ethiopia. The Philippines continues to look less attractive compared to the other target countries.
- It can be reasoned that the full SWAG cost won't be required to be achieved to leverage a greater opportunity in target countries.

Maps of spatial results for each target country are located in the appendix.

2. Part 2 – Acquisition and application of data filters

Other factors

2.10.1. Corruption Perceptions Index



- The Corruption Perceptions Index (CPI)* ranks 180 countries and territories by their perceived levels of public sector corruption using a scale of 0 to 100, where 0 is “highly corrupt” and 100 is “very clean”.
- The CPI aggregates data from a number of different sources that provide perceptions by business people and country experts of the level of corruption in the public sector.
- The best performing region is Western Europe with an average score of 66. The worst performing regions are Sub-Saharan Africa (avg. score 32) and Eastern Europe and Central Asia (avg. score 34).
- While not necessarily an indication that a project cannot be undertaken in these countries, KPS may wish to consider the increased difficulty and complexity doing business in some regions.

2.10.2. Table of CPI scores

CPI ranking	Country	CPI Score 2017
1	New Zealand	89
2	Denmark	88
3	Finland	85
4	Norway	85
5	Switzerland	85
6	Singapore	84
7	Sweden	84
8	Canada	82
9	Luxembourg	82
10	Netherlands	82
11	United Kingdom	82
12	Germany	81
13	Australia	77
14	Hong Kong	77
15	Iceland	77
82	India	40
96	Brazil	37
108	Ethiopia	35
111	Philippines	34
142	Russia	29

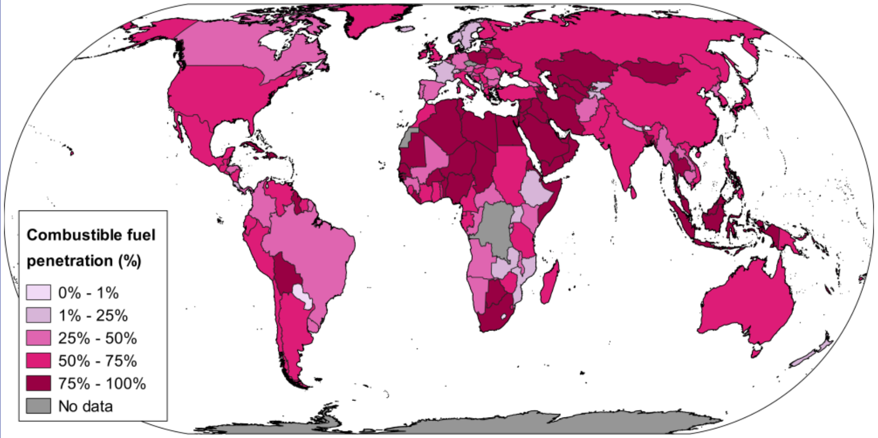
- Top 15 CPI scores plus selected others.
- Canada and Australia score within the 90th percentile of the dataset indicating these may be easier countries to do business in. The remaining target countries score between 40th and 55th percentiles.
- Some countries that ranked highly in terms of opportunity by total area, such as Russia and Kazakhstan, scored between the 20th and 30th percentile in the dataset indicating these may be more challenging countries to do business in.

* www.transparency.org/cpi

2. Part 2 – Acquisition and application of data filters

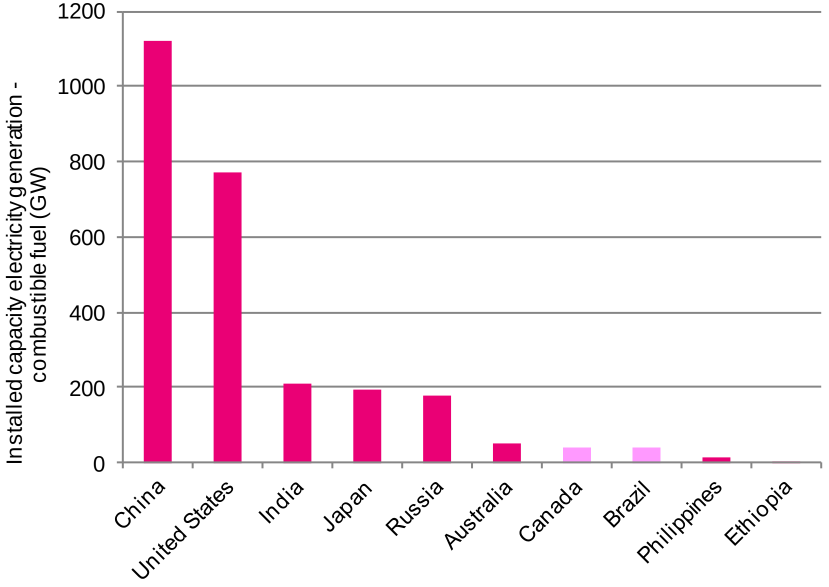
Other factors

2.11.1. Growth markets – combustible fuel reliance



- Map of electricity generation from combustible fuels as a percentage of a country's total installed electricity generation capacity. Data from United Nations Energy Statistics Database. Global dataset from 2015.
- The map shows which countries still rely predominantly on combustible fuels as a source of electricity generation and indicates where they may be stronger opportunities to displace fossil fuel generation. However, these countries may turn to forms of electricity generation other than wind energy to replace capacity.
- Regions in the Middle East, Central Asia and North Africa have the highest levels of combustible fuel capacity penetration. Of these regions, Kazakhstan and neighbouring countries were shown to have high market opportunity by total area and low LCOE, particularly at SWAG cost.

2.11.2. Growth markets – combustible fuel capacity

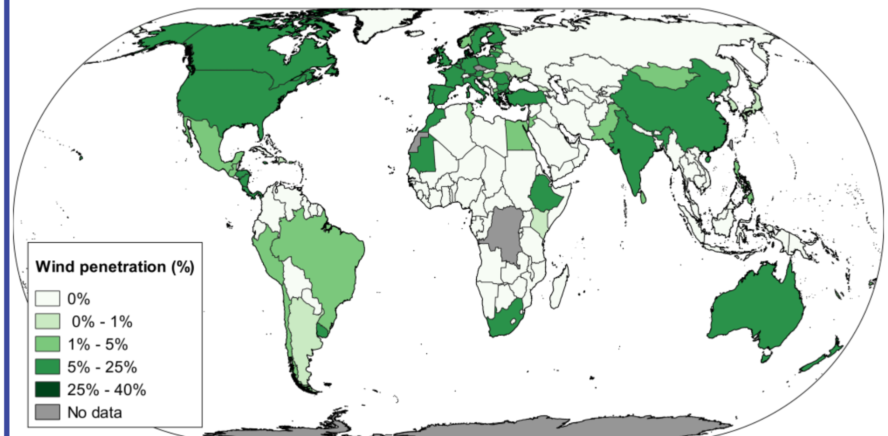


- Chart shows the top 5 countries by total installed capacity of combustible fuel power plants, plus remaining target countries.
- The total volume of combustible fuel generation capacity in each country indicates how much displaceable generation exists. Over 65% of the total global capacity in the dataset is provided by combustible fuel generation, with nearly 60% of countries having 1GW or more of installed capacity and 25% of countries having 10GW or more of installed capacity.
- Each of the target countries, with the exception of Ethiopia, have significant volumes of installed combustible fuel generation capacity.

2. Part 2 – Acquisition and application of data filters

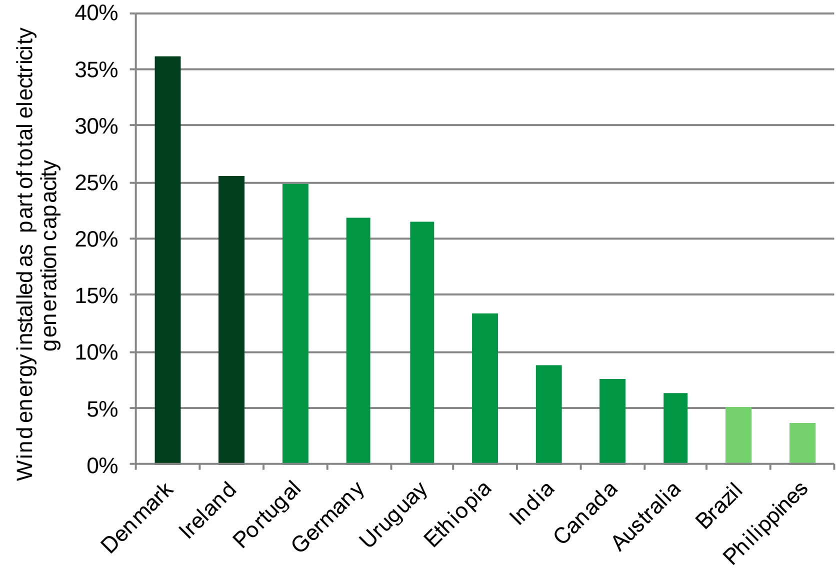
Other factors

2.12.1. Growth markets – wind energy support



- Map of electricity generation from wind energy as a percentage of a country's total installed electricity generation capacity. Data from United Nations Energy Statistics Database. Global dataset 2015.
- The map shows countries where wind energy is part of a country's electricity generation mix and indicates areas where some support exists for wind energy. In countries where there is no wind energy capacity currently installed this does not necessarily mean that there is no support for the technology. These countries may also become growth markets for wind energy in the future.
- Wind energy is well supported in Europe and the target countries Australia, Canada, Ethiopia and India. Brazil and The Philippines also show support for wind energy generation. Some countries that ranked highly in terms of opportunity by total area, such as Russia and Kazakhstan, have little to no currently installed wind capacity.

2.12.2. Growth markets – wind energy support



- Chart shows the top 5 countries by percentage of wind energy as part of total electricity generation mix, plus target countries.
- Several European countries demonstrate that wind energy can successfully account for over 20% of a country's electricity generation mix.
- While Ethiopia shows the most support for wind energy generation, it was also the target country with the least capacity of combustible fuel generation to potentially displace as it heavily relies on hydro power generation. The remaining target countries each have a much stronger reliance on combustible fuels for electricity generation.

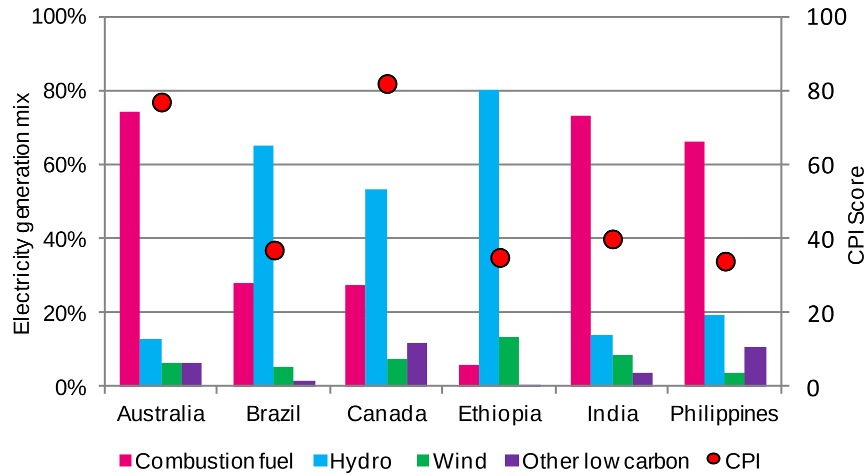
3. Summary of study

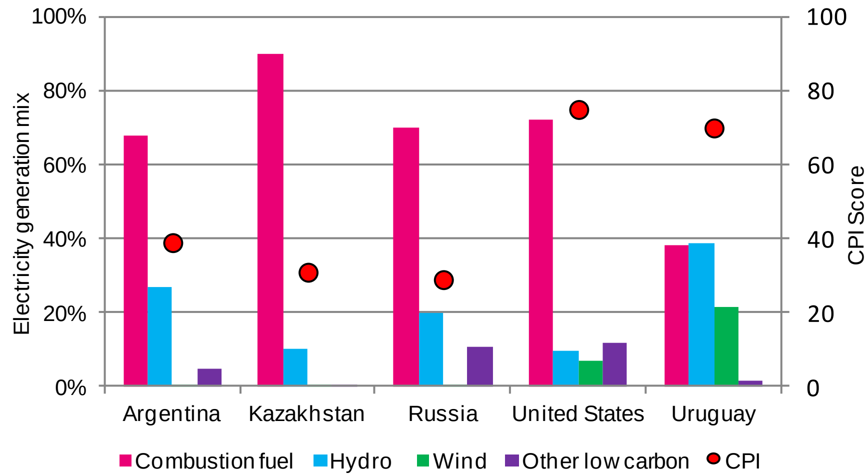
Cost of energy and market assessment

Target country summary

- **Australia** shows low market opportunity at 100% cost but becomes one of the largest potential markets at SWAG cost. Based on the considerations within this study, Australia is a highly attractive market for KPS to approach.
- **Brazil** shows little market opportunity at 100% cost. KPS at SWAG cost is the lowest LCOE technology on the west coast of Brazil but does not achieve the same low LCOE as found in other target countries.
- **Canada** shows market opportunity at 100% cost and a very large opportunity at SWAG cost. Based on the considerations within this study, Canada is a highly attractive market for KPS to approach.
- **Ethiopia** shows no opportunity at 100% cost but does achieve areas of low LCOE opportunity at SWAG cost. However, there may be limited opportunity to replace combustible fuel generation.
- **India** shows opportunity at 100% cost but at high LCOE. The opportunity at SWAG cost is less than other target countries. India has the third largest capacity of combustible fuel generation globally.
- **The Philippines** shows very little opportunity at 100% cost and relatively low opportunity at SWAG cost compared to other target countries.
- The study also showed potential growth markets in terms of opportunity by total area and low LCOE in additional countries such as Argentina, Kazakhstan, Russia, United States and Uruguay. Just as with the target countries, other factors should be considered when approaching these markets.

3.1 Summary of other factors for target countries





3. Summary of study

Cost of energy and market assessment

Results and conclusions

• 500kW KPS technology at 100% cost has a lower LCOE than equivalent capacity HAWT, solar and diesel technologies for around 10% of the global onshore area. However, the LCOE for the 100% cost KPS device in the majority of these areas is still relatively high. A small number of countries could provide enough area for 500 KPS units at 100% cost at an LCOE between £50-70/MWh, but this would assume the unlikely scenario of little to no attrition of potential development sites.

• The benefit of achieving SWAG cost for the 500kW KPS device is substantial. At SWAG cost, the KPS device is the lowest-LCOE technology compared with HAWT, solar and diesel across half of the global onshore surface. After accounting for exclusion zones based on a number of accessibility, social and environmental considerations, the SWAG cost KPS 500kW technology has large regions of opportunity at an LCOE below £50/MWh present on every continent. These regions are far above any minimum area threshold for KPS market opportunity of 500 units.

• This study does not assess the likelihood of achieving SWAG cost or perform a spatial analysis of any cost between 100% and SWAG. However, the dramatic improvement in results when transitioning from 100% to SWAG cost indicate that significant market opportunities could become available without the SWAG cost being realised in its entirety.

• The results of the spatial LCOE analysis show very large areas available globally for the deployment of KPS device at SWAG cost. However, assessment of market opportunity requires some qualification of spatial LCOE analysis results. Some additional consideration of other factors was given to further support the market assessment. Datasets of the corruption perception and of installed generation capacity were used to compare six specific target countries with one another, alongside the countries found to have the largest low-LCOE areas. Of the six target countries, Australia and Canada appear to be the most attractive markets for KPS.

• Further spatial analysis could be undertaken to assess target countries in greater detail. More sophisticated datasets are generally available at country level than at global level. Potentially useful input data that was not found at global level included spatial datasets of transmission and distribution systems, and electricity consumption. Should these datasets and others be accessible on a country by country basis then a further study of specific target countries is recommended. This could be supported by a market review to account for important aspects not easily shown using a spatial analysis, such as the availability of financial support mechanisms.

Appendix

Large view maps

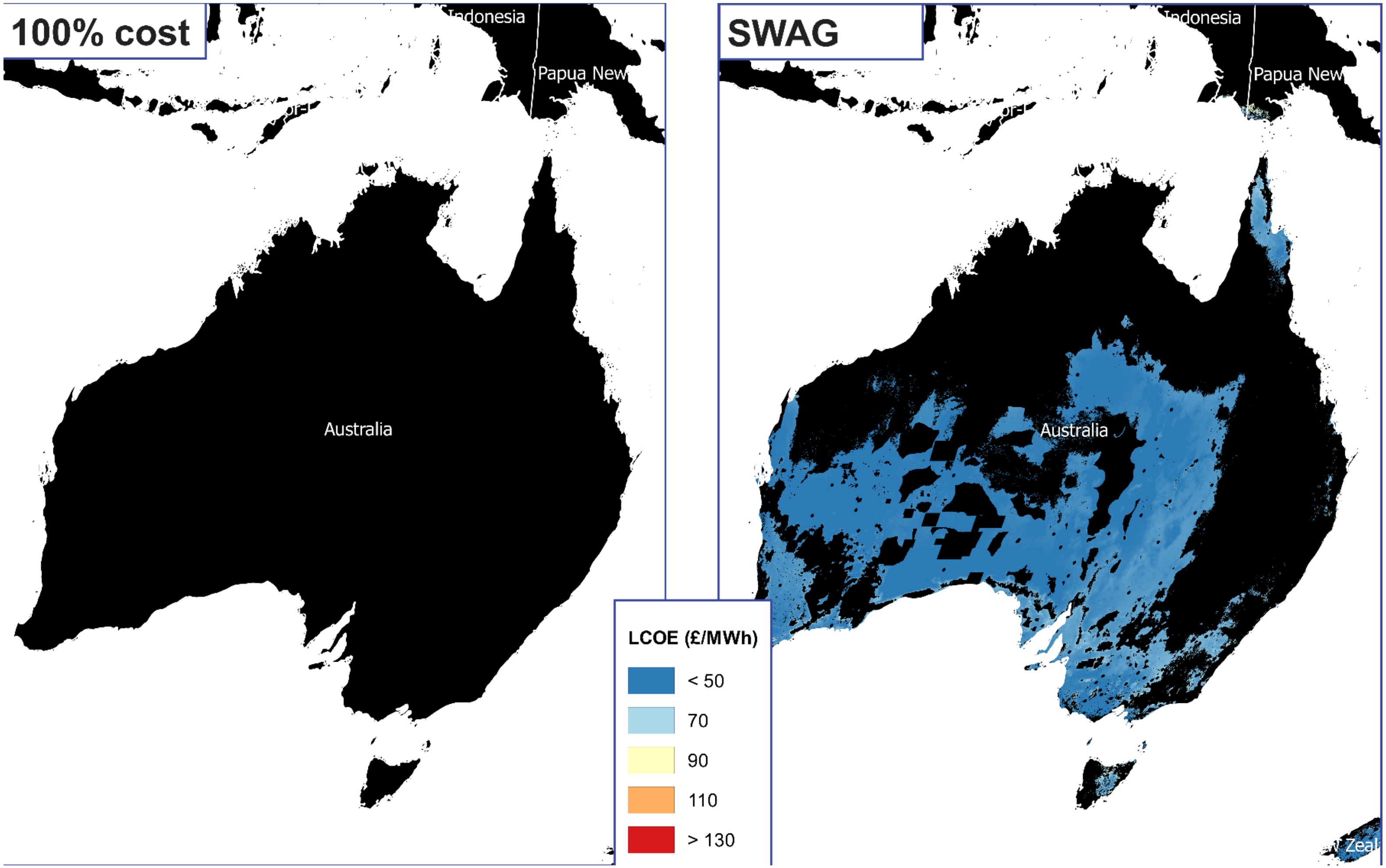
Appendix contents

- KPS lowest LCOE result maps for target countries and areas of interest:
  - Australia
  - Brazil
  - Canada
  - Ethiopia
  - India
  - The Philippines
  - Europe
  - North America
  - Central Asia
  - South America
- Input maps Part 1:
  - Global onshore wind speed
  - Global diesel costs
  - Global solar irradiation
- Output maps Part 1:
  - KPS 500kW onshore 100% cost LCOE
  - KPS 500kW onshore SWAG cost LCOE
  - Cheapest alternative onshore technology
  - Cheapest alternative onshore LCOE
  - KPS 500kW 100% cost LCOE vs. Cheapest alternative LCOE
  - KPS 500kW 100% cost LCOE vs. 500kW HAWT
  - KPS 500kW SWAG cost LCOE vs. Cheapest alternative LCOE
  - KPS 500kW SWAG cost LCOE vs. 500kW HAWT
- Input maps Part 2:
  - Lowest onshore technology LCOE, KPS 100% cost
  - Lowest onshore technology LCOE, KPS SWAG cost
- Output maps Part 2:
  - KPS 100% cost lowest onshore technology LCOE with exclusion zones
  - KPS SWAG cost lowest onshore technology LCOE with exclusion zones
- Exclusion layers:
  - Combined exclusion layer
  - Roads exclusion layer
  - Airports exclusion layer
  - Elevation exclusion layer
  - Slope exclusion layer
  - Land cover exclusion layer
  - Urban areas exclusion layer
  - Protected areas exclusion layer
  - Wind speed exclusion layer

Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

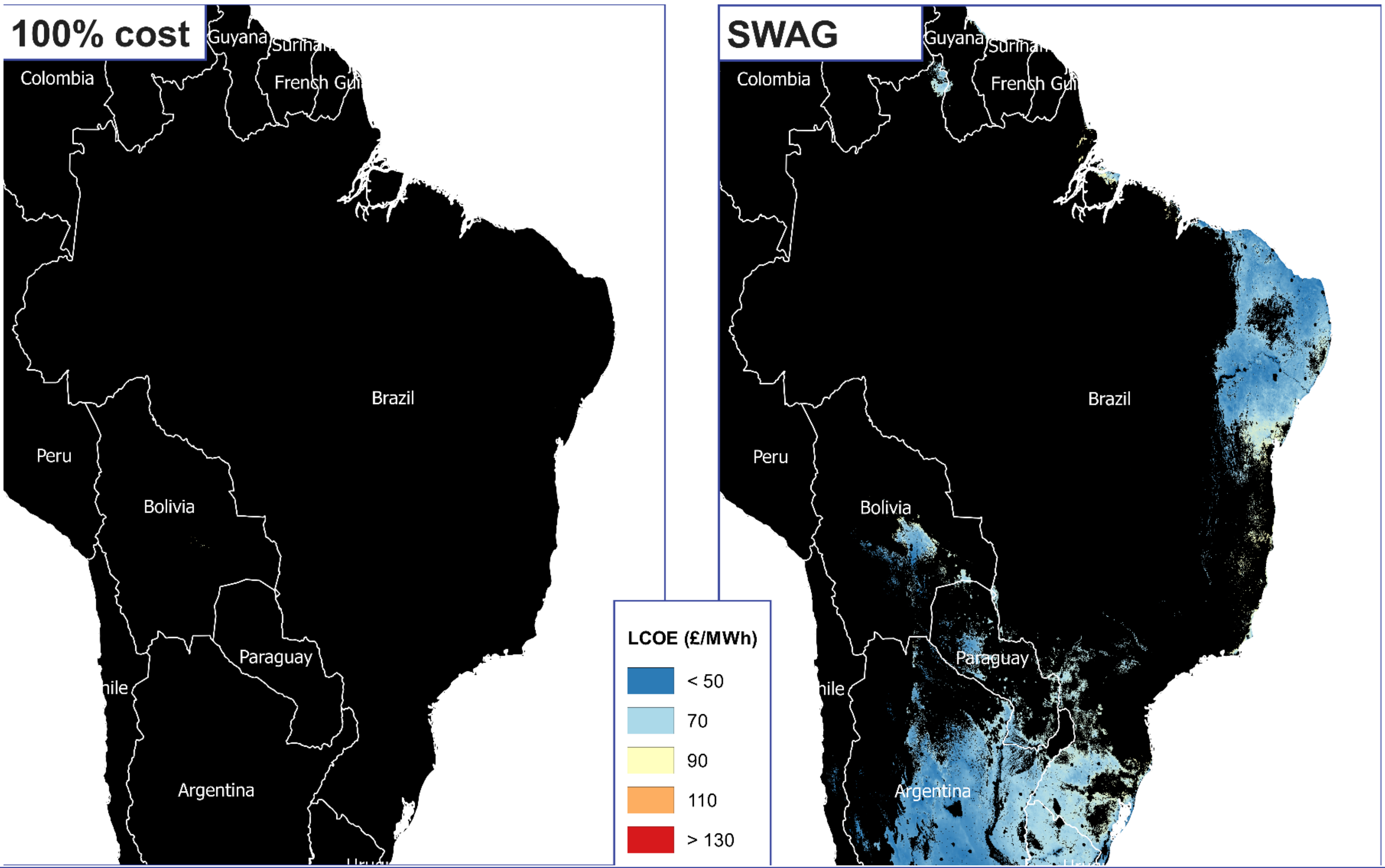
Australia



Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

Brazil

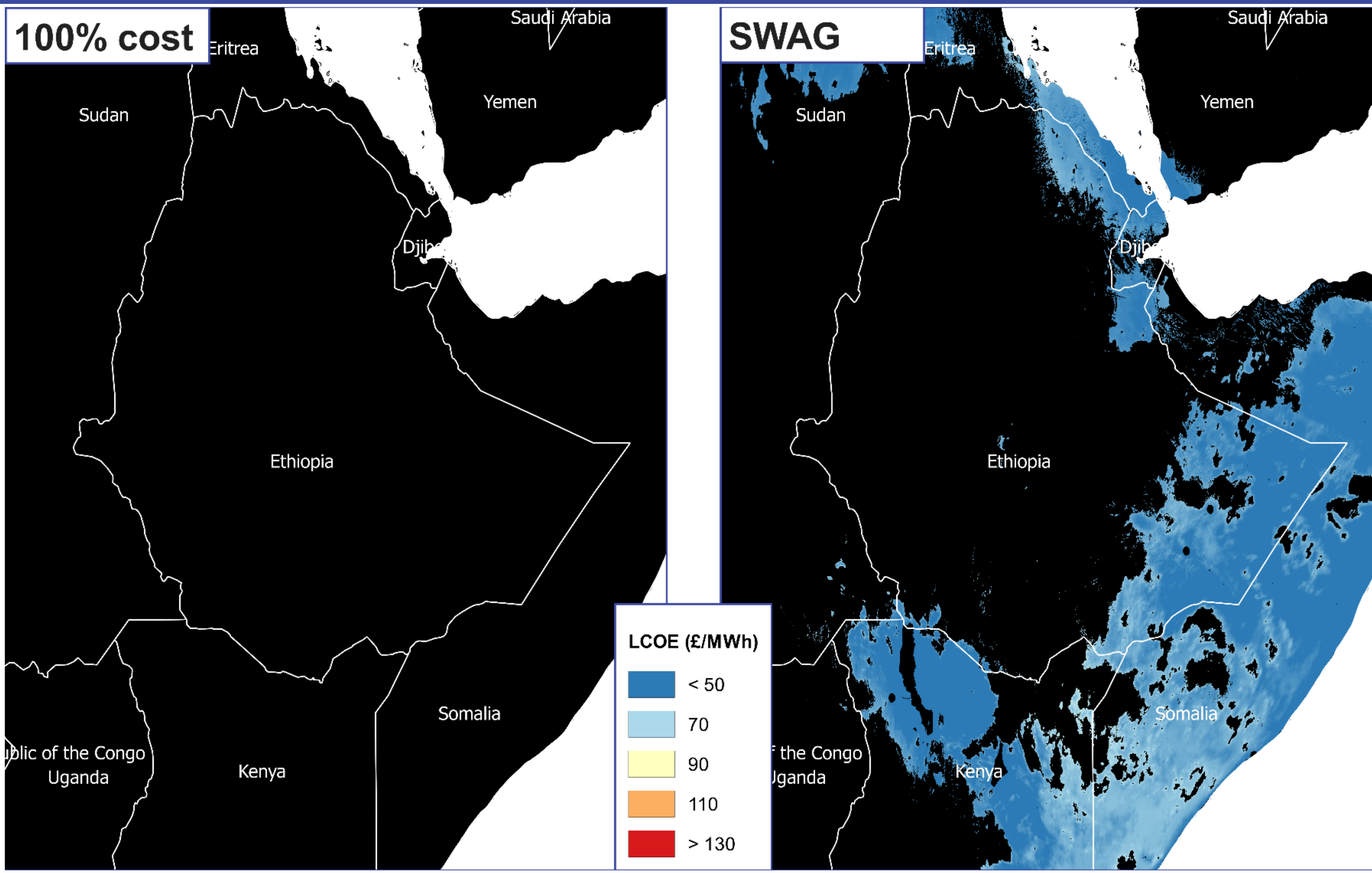


BVGassociates

Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

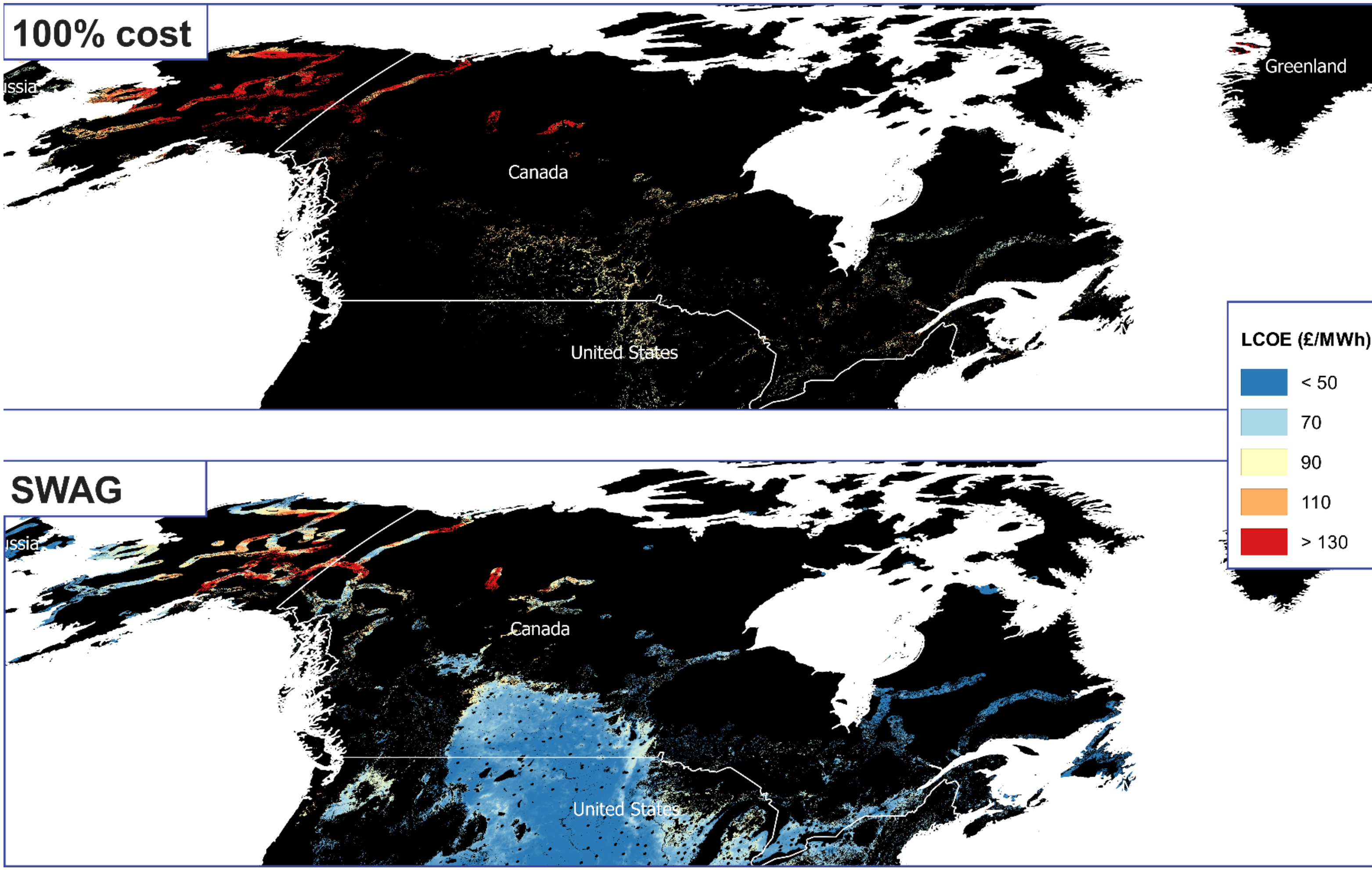
Ethiopia



Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

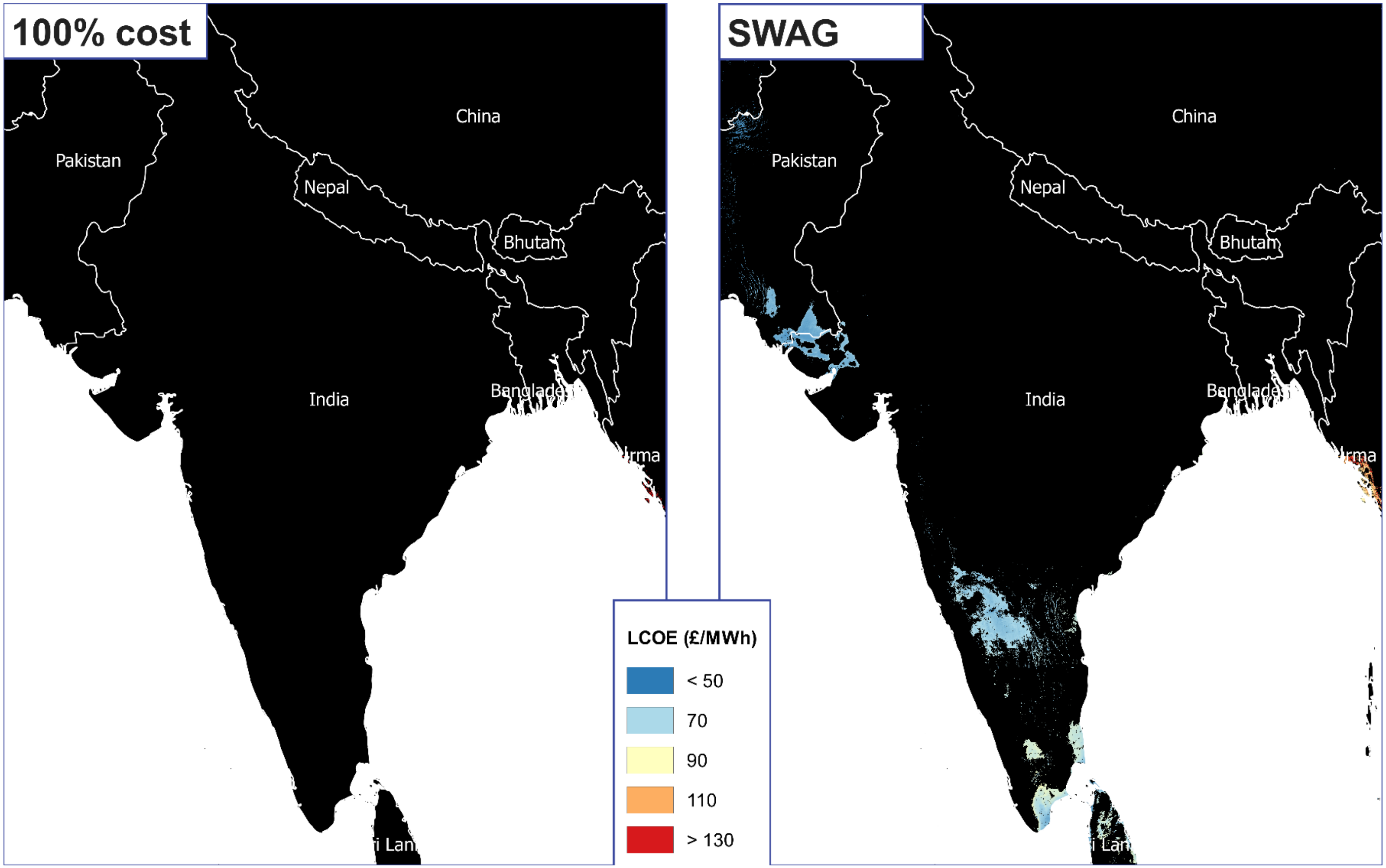
Canada



Appendix

KPS lowest LCOE onshore technology areas: specific areas

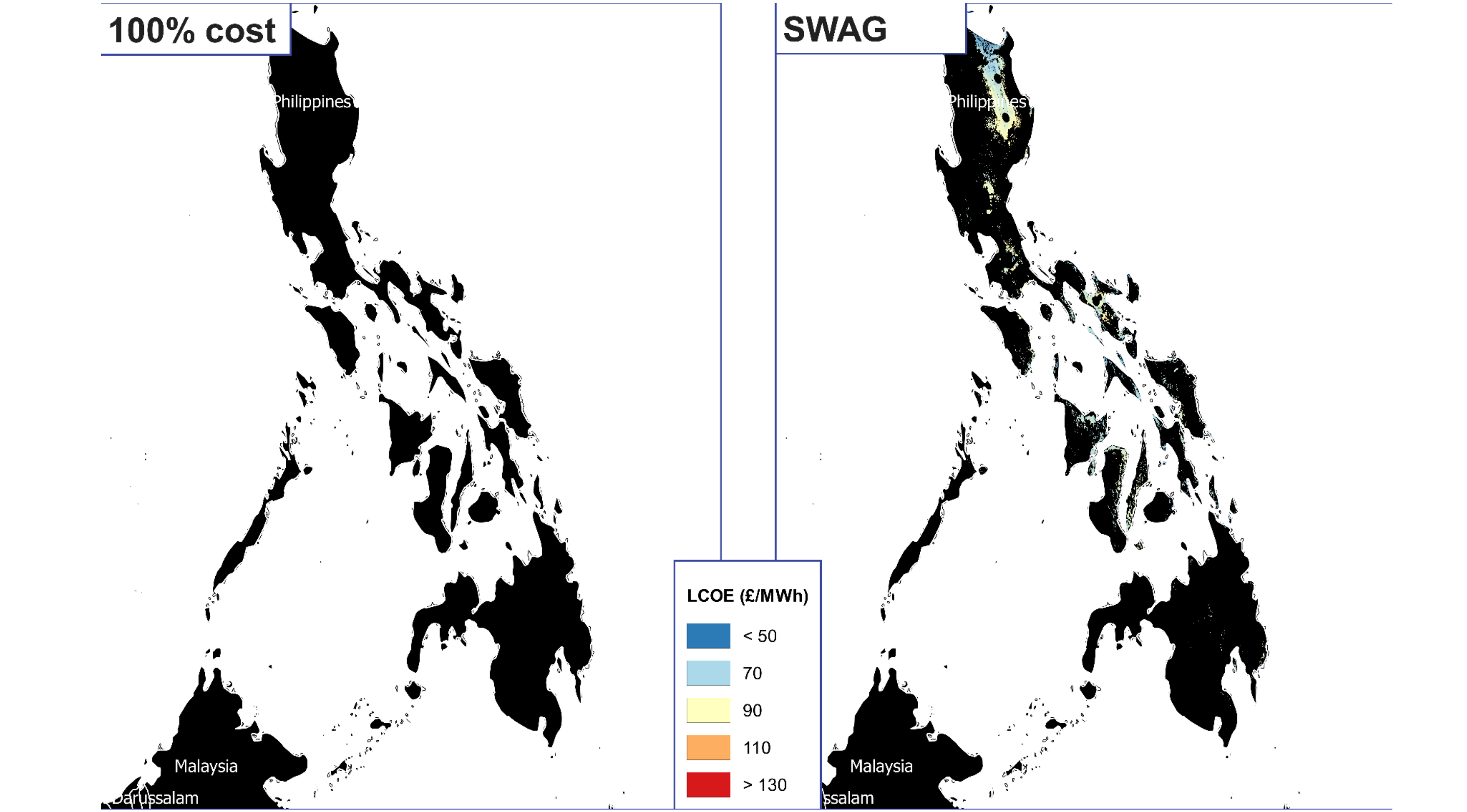
India



Appendix

KPS lowest LCOE onshore technology areas: specific areas

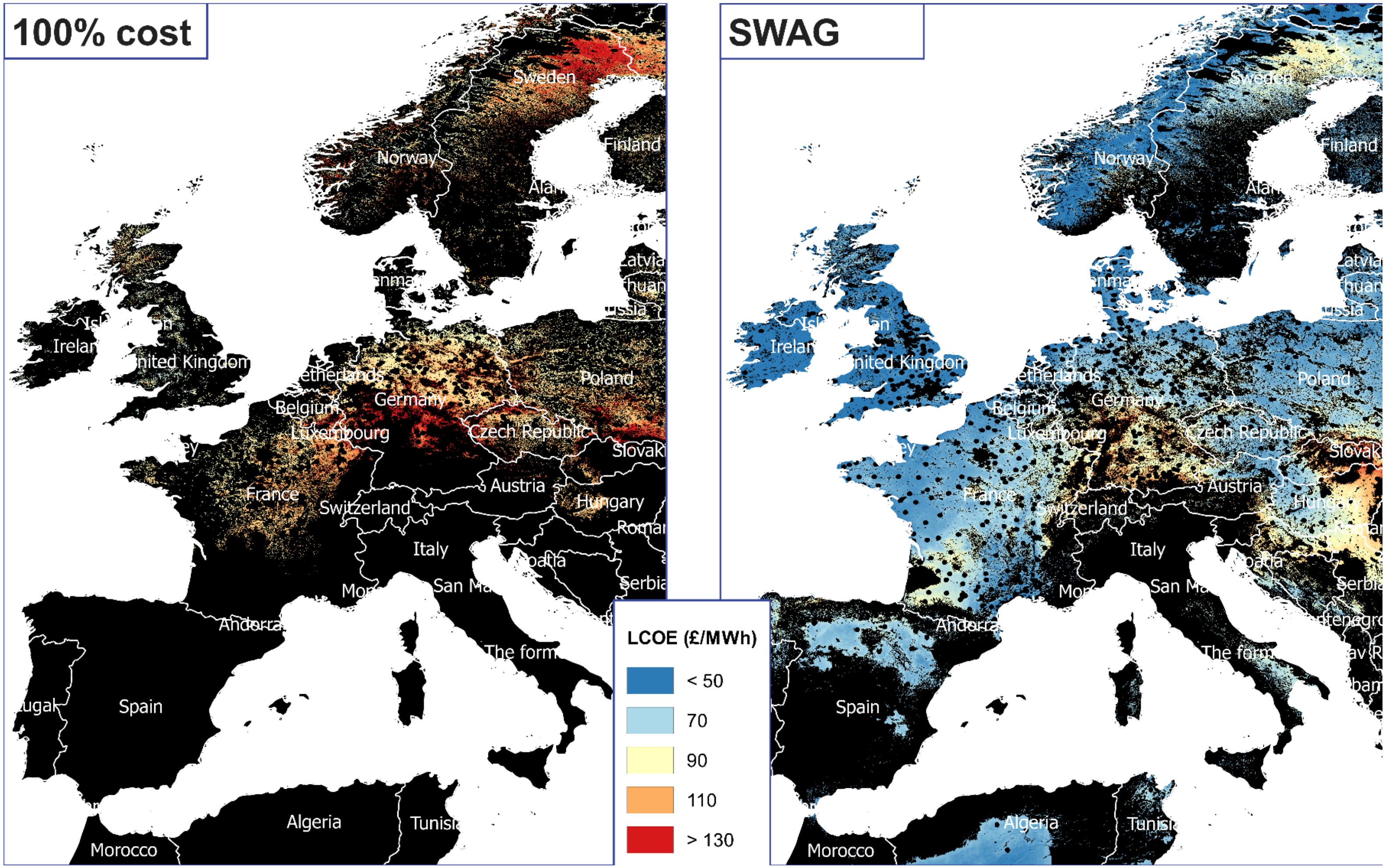
The Philippines



Appendix

KPS lowest LCOE onshore technology areas: specific areas

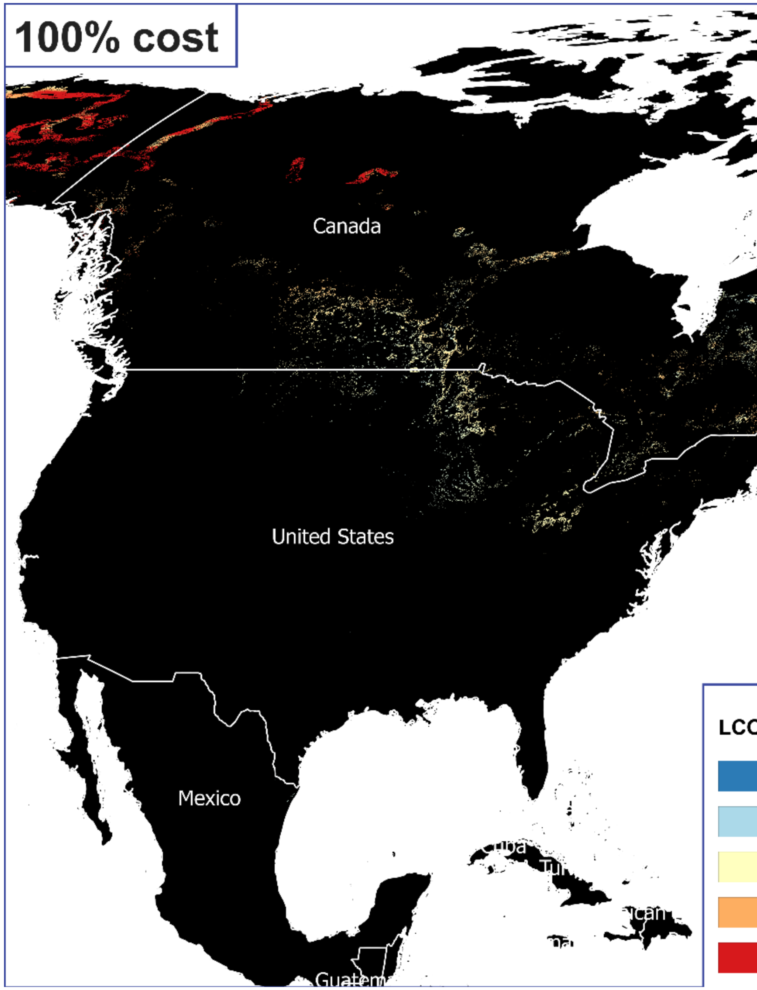
Europe

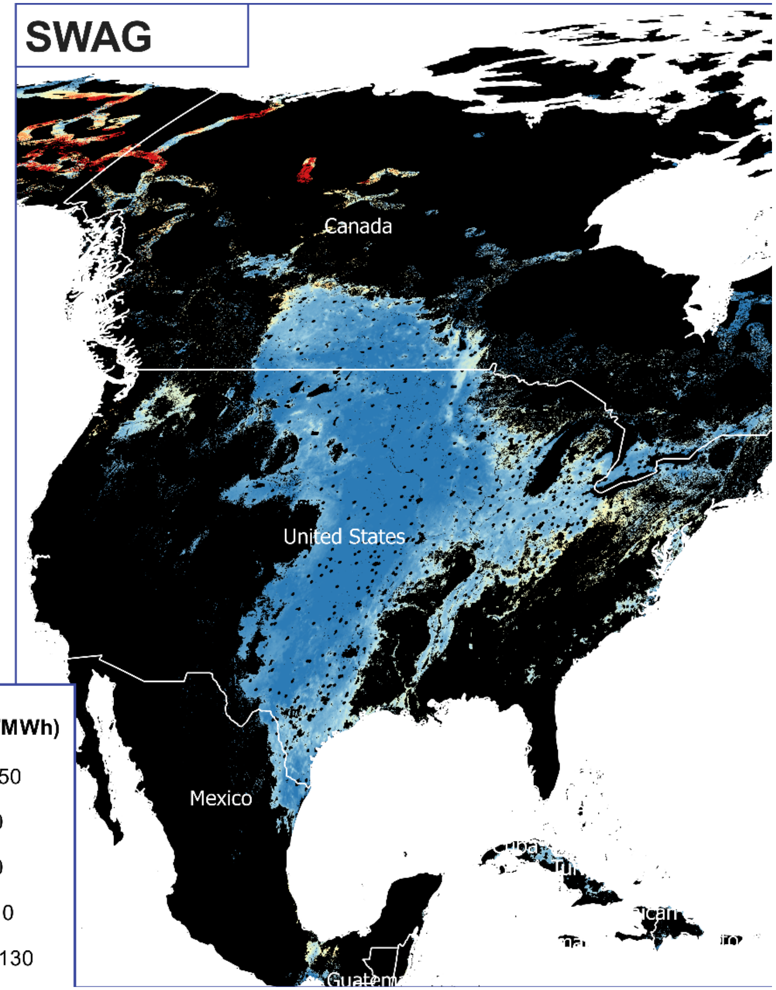


Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

North America

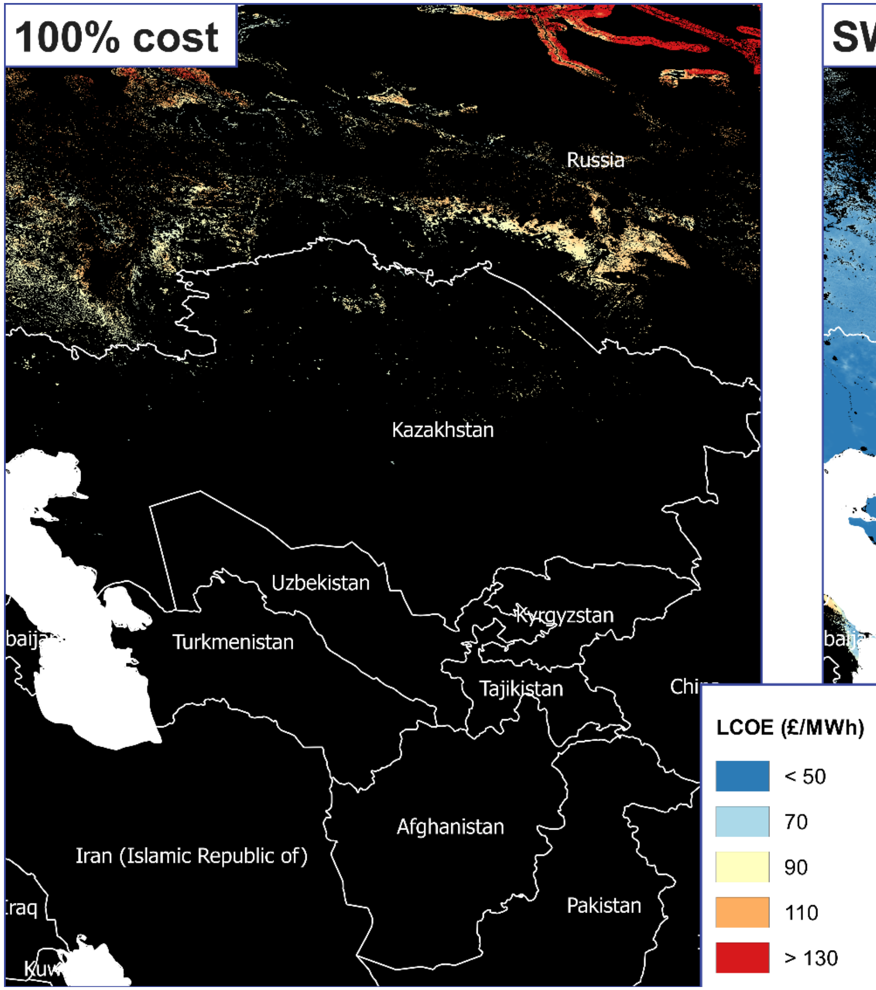


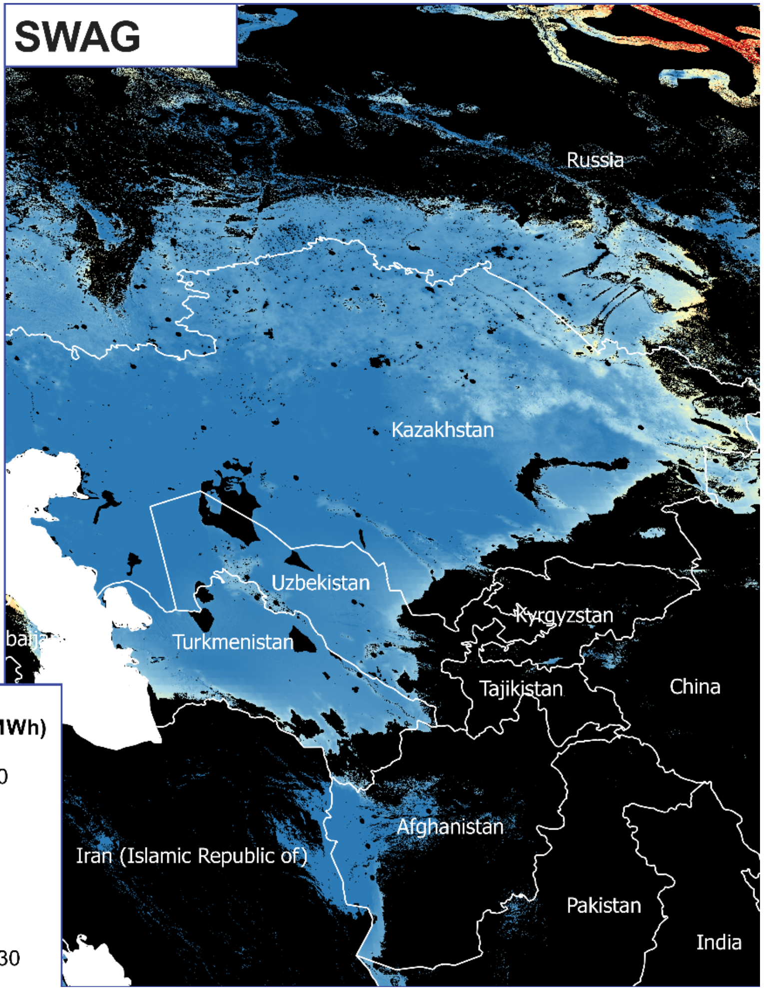


Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

Central Asia

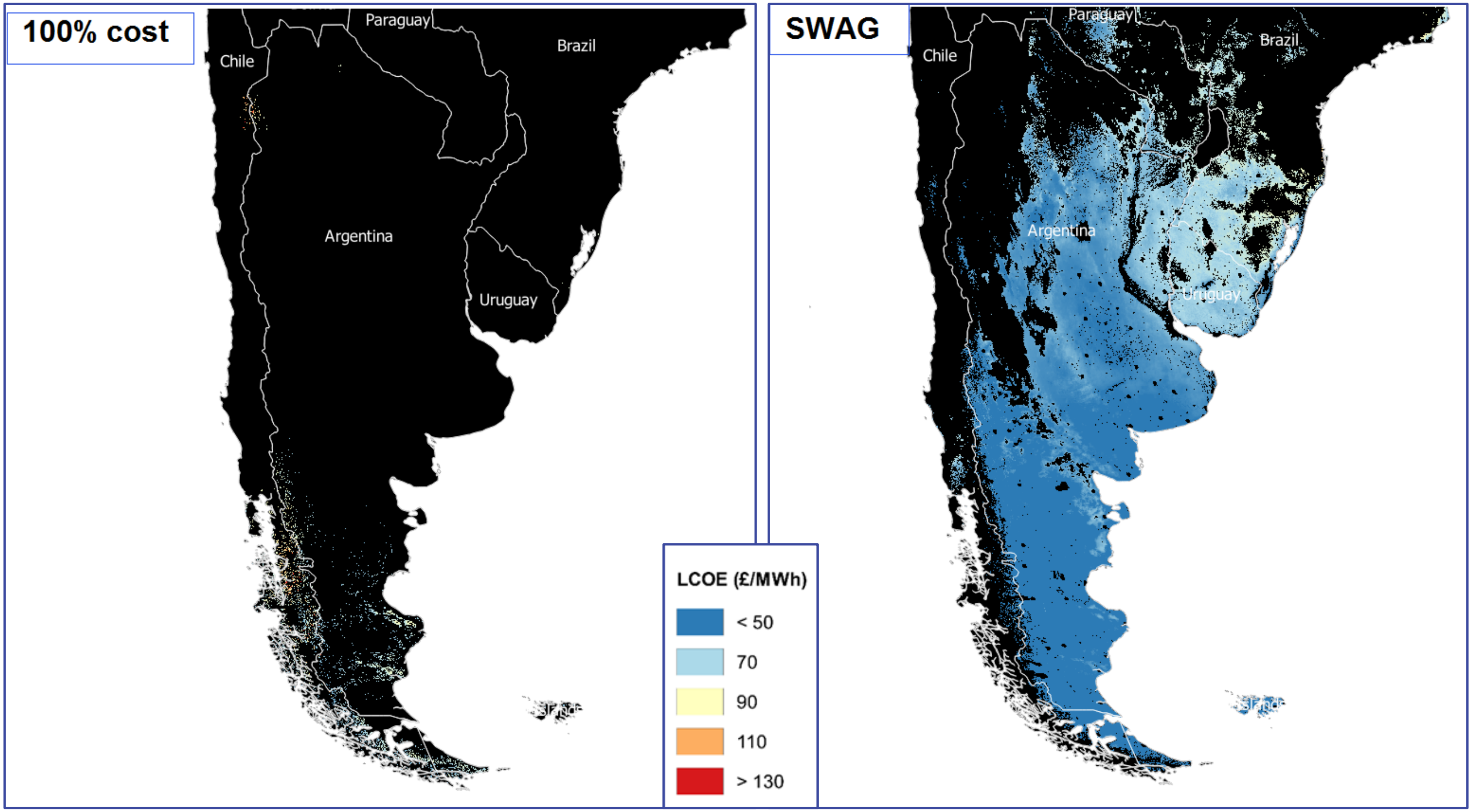




Appendix

KPS lowest LCOE onshore technology for target countries and areas of interest

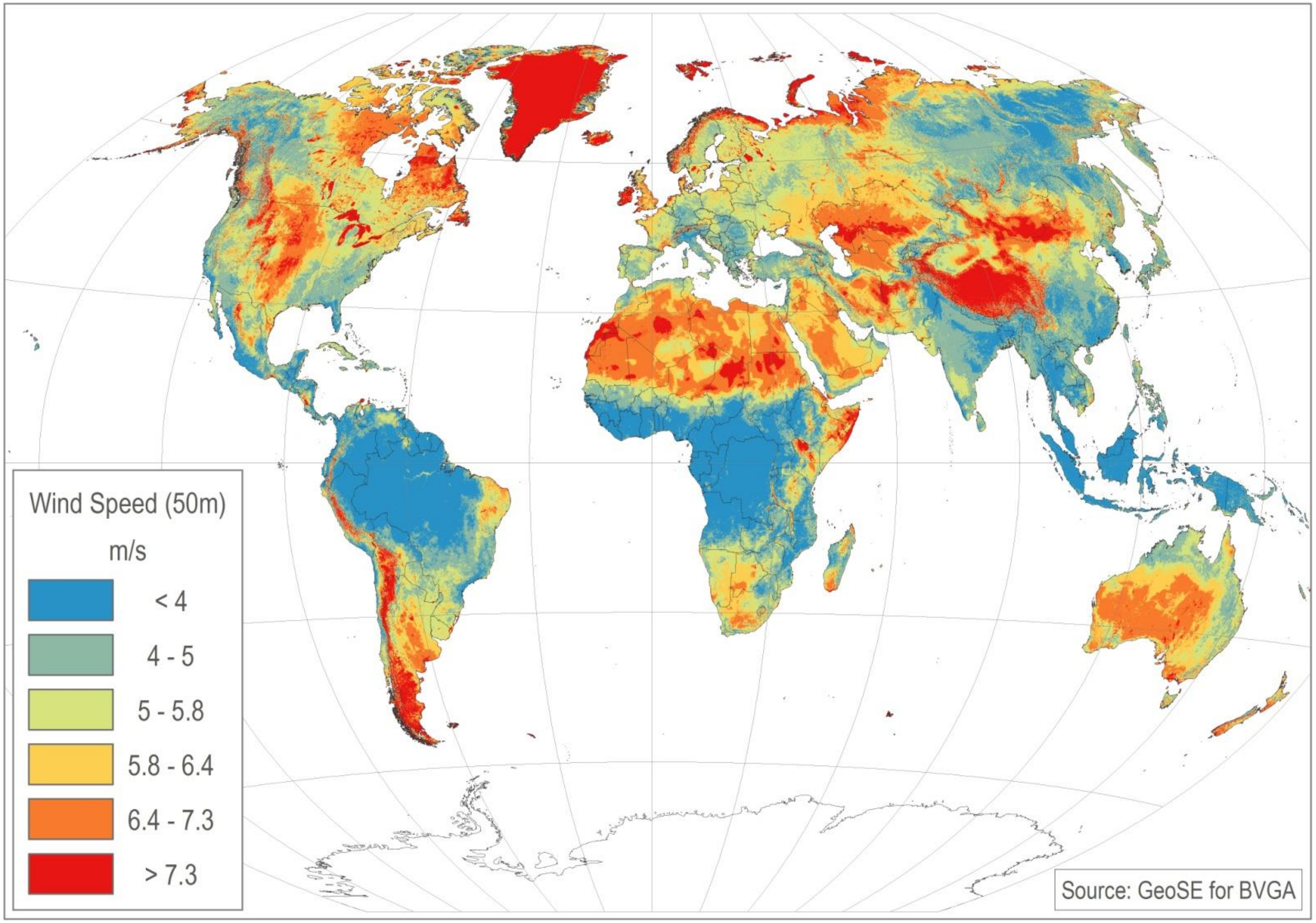
South America



Appendix

Input maps Part 1

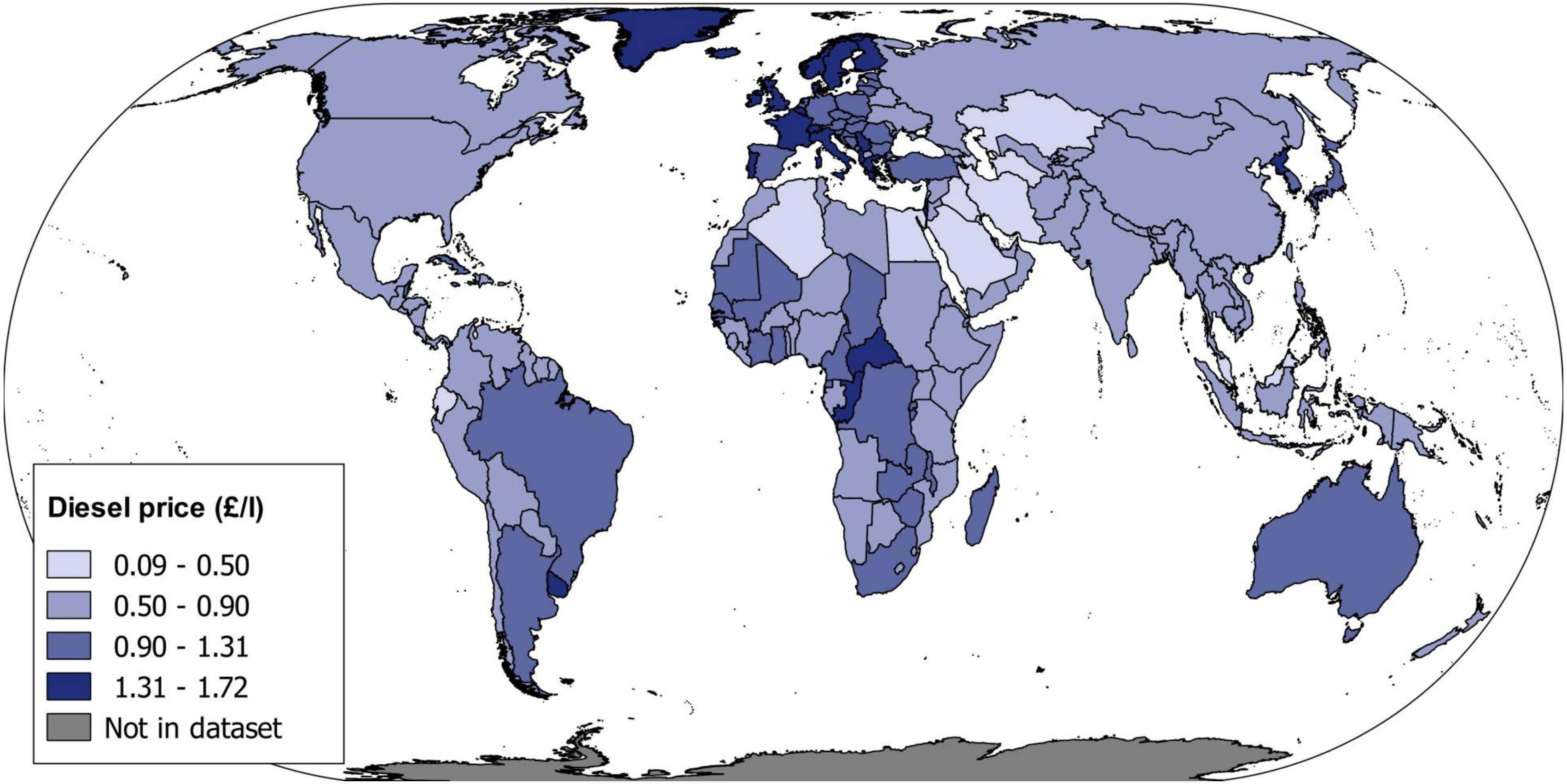
1.1 Global onshore wind speed



Appendix

Input maps Part 1

1.2 Global diesel costs

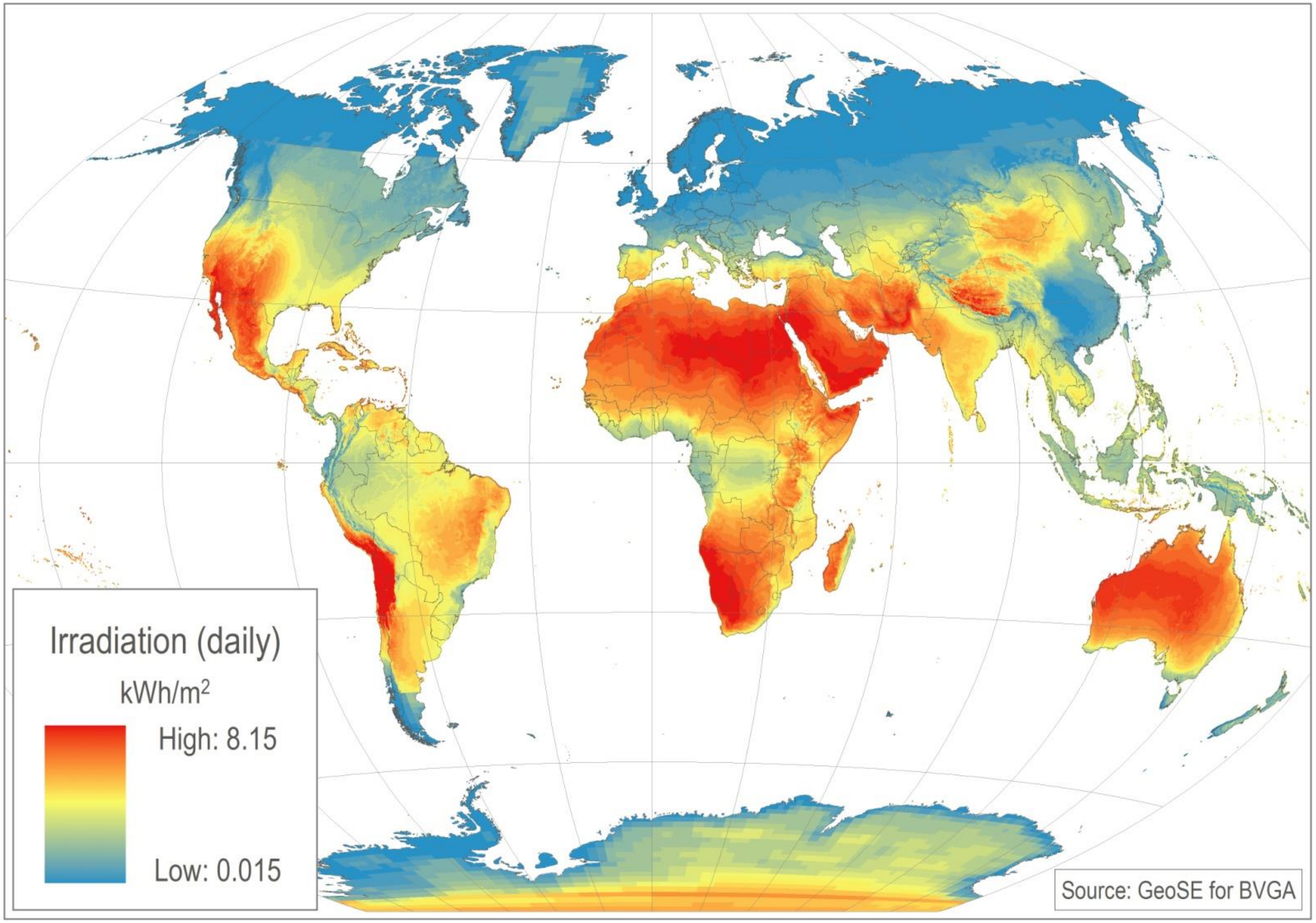


BVGassociates

Appendix

Input maps Part 1

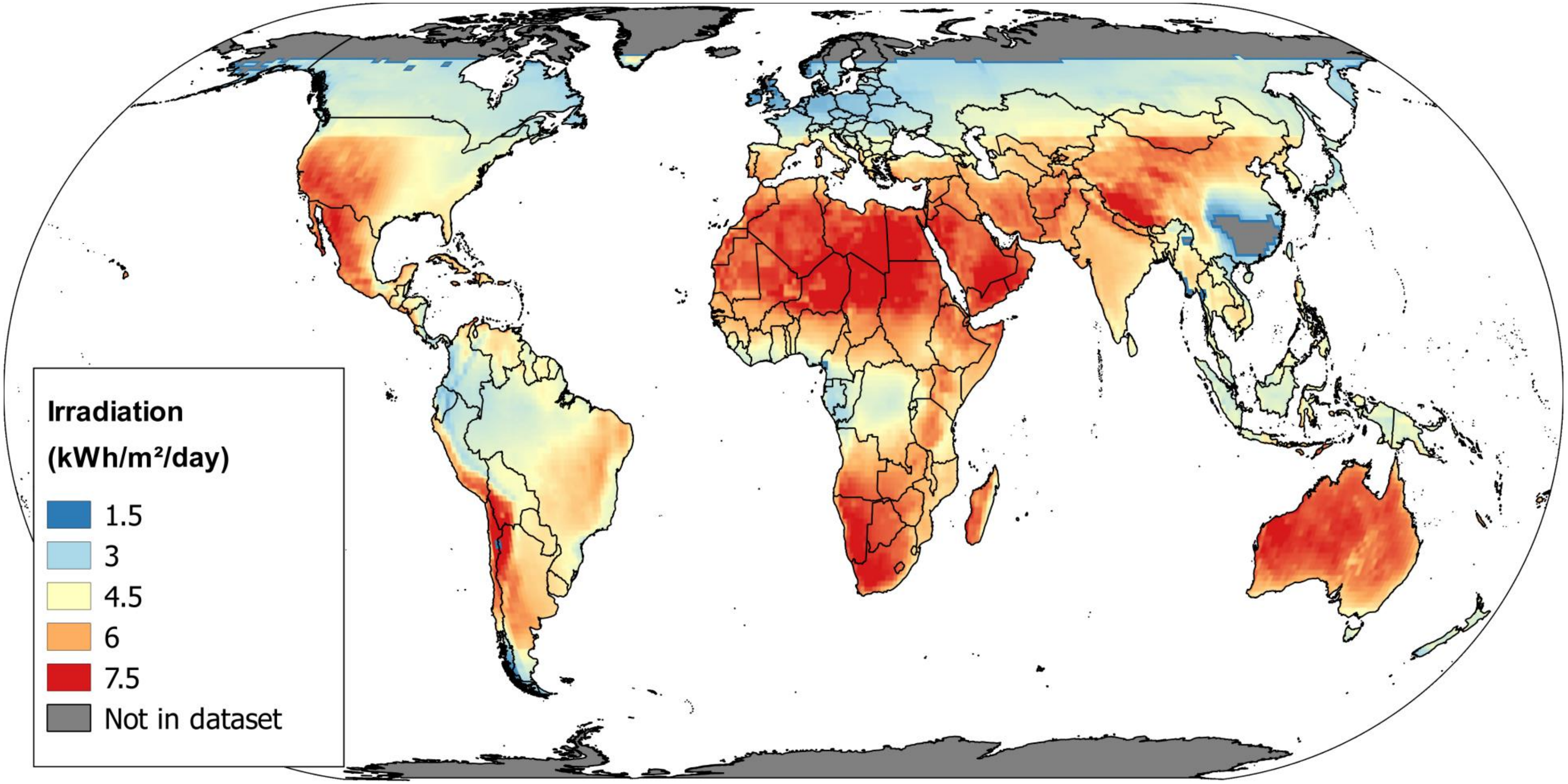
1.3.1 Global solar irradiation



Appendix

Input maps Part 1

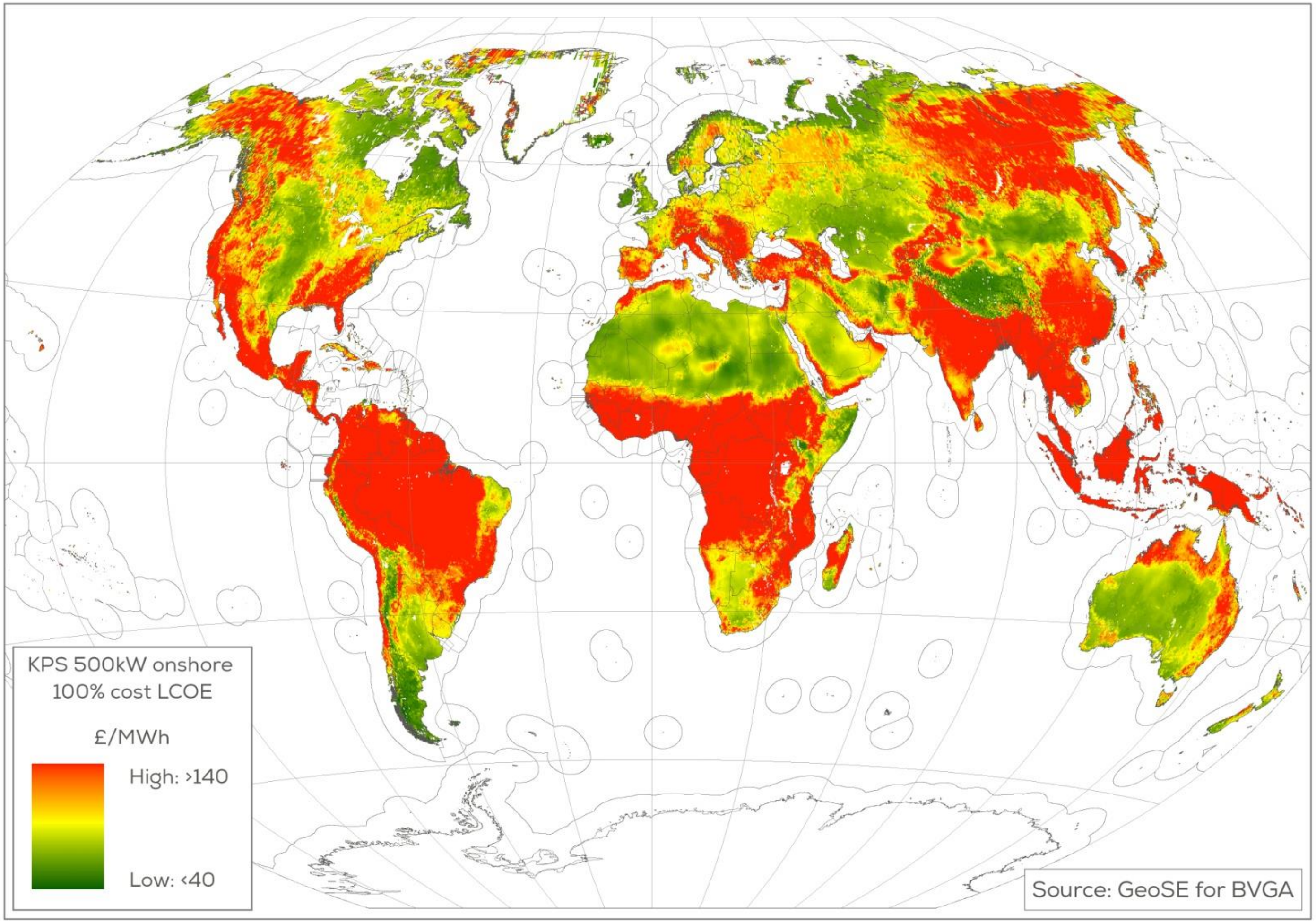
1.3.2 Global solar irradiation



Appendix

Output maps Part 1

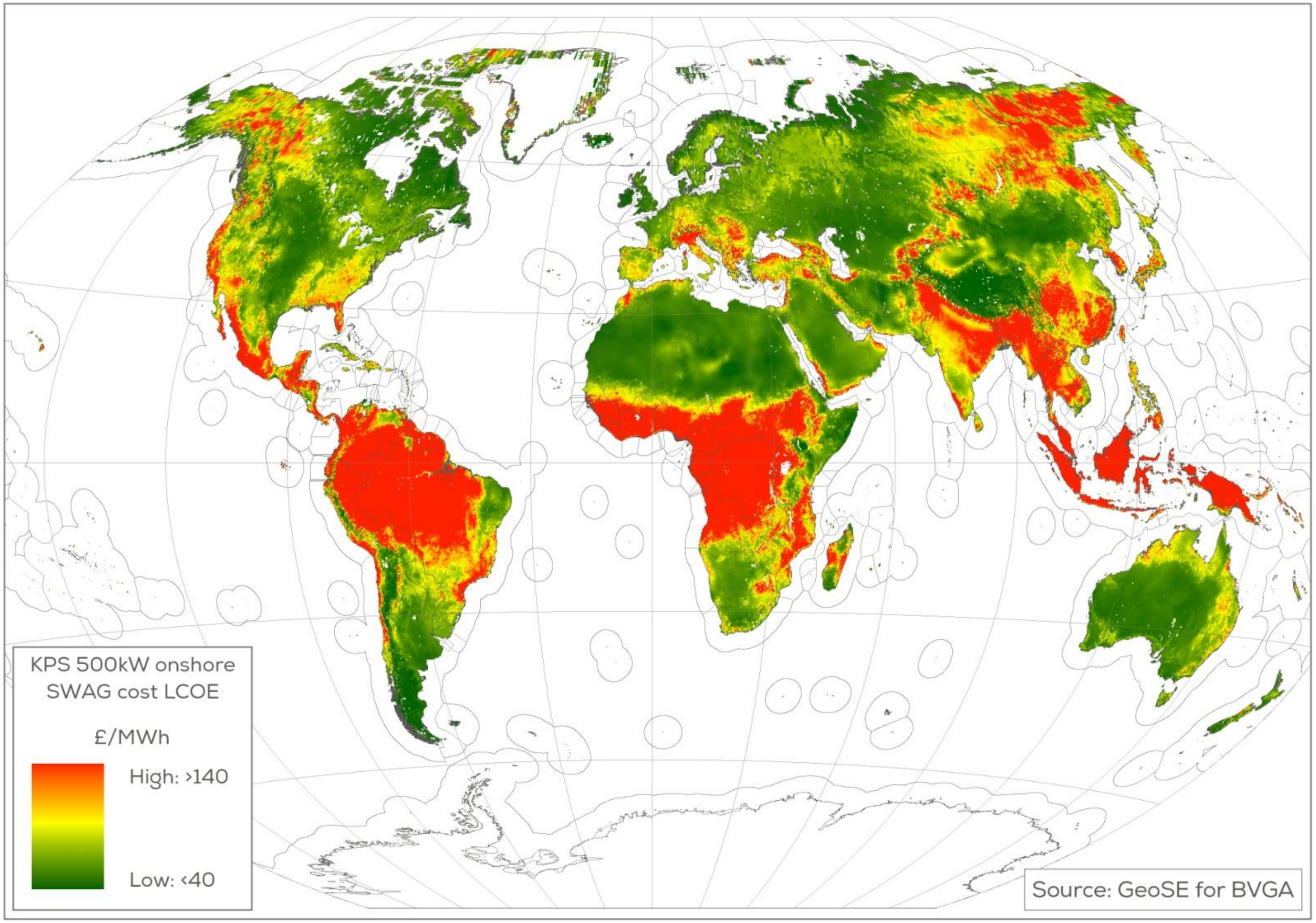
1.4 KPS 500kW onshore 100% cost LCOE



Appendix

Output maps Part 1

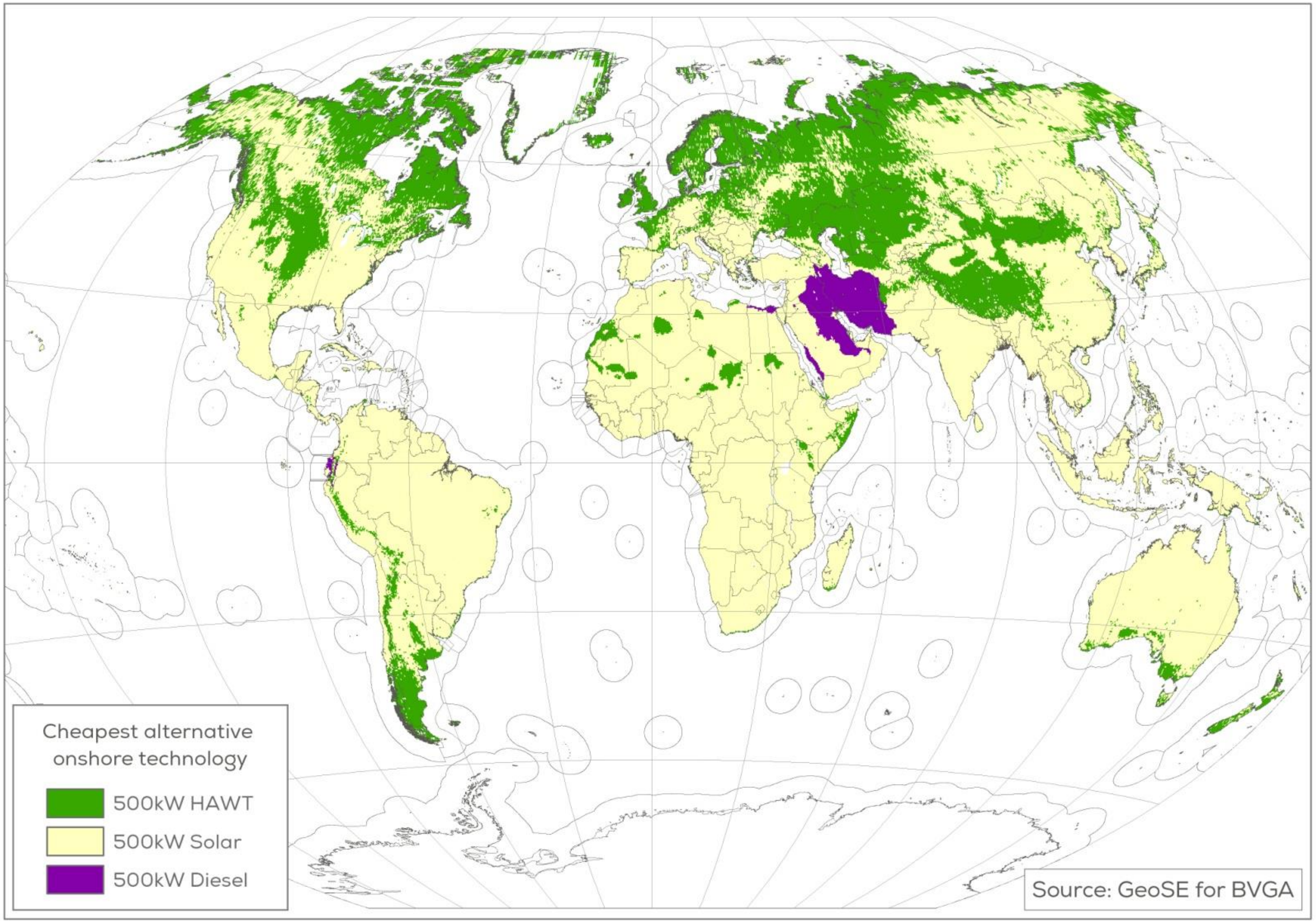
1.5 KPS 500kW onshore SWAG cost LCOE



Appendix

Output maps Part 1

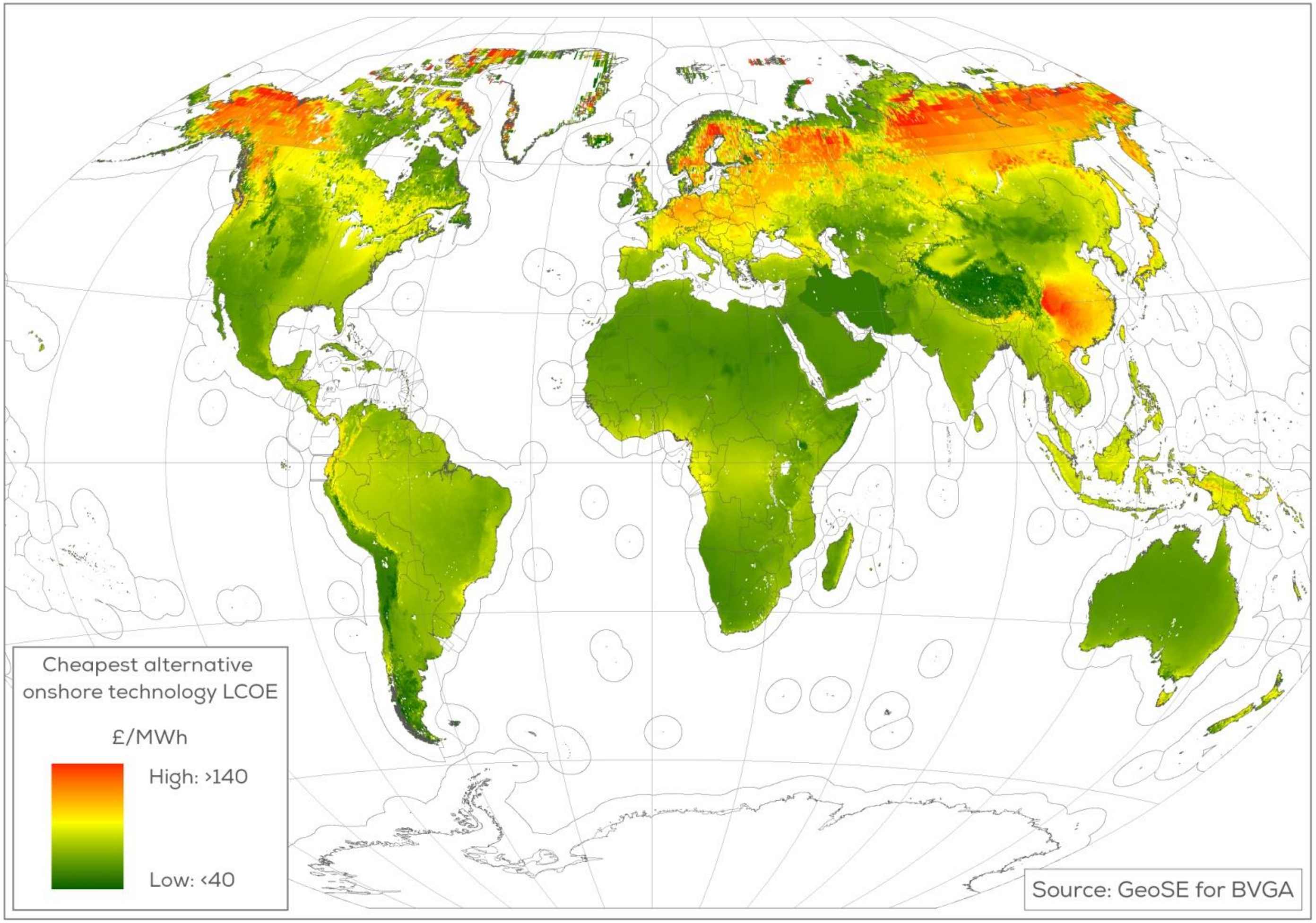
1.6 Cheapest alternative onshore technology



Appendix

Output maps Part 1

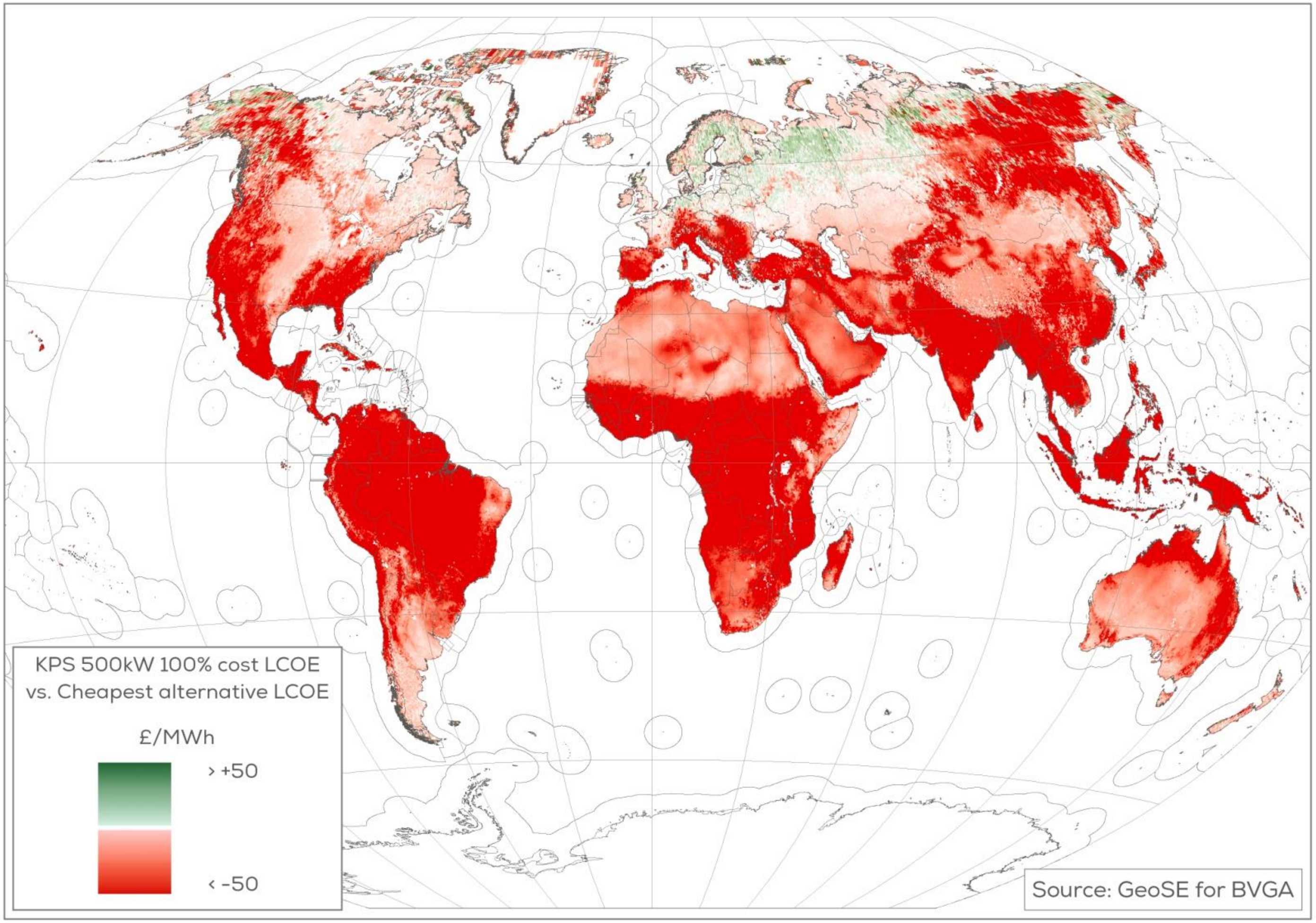
1.7 Cheapest alternative onshore LCOE



Appendix

Output maps Part 1

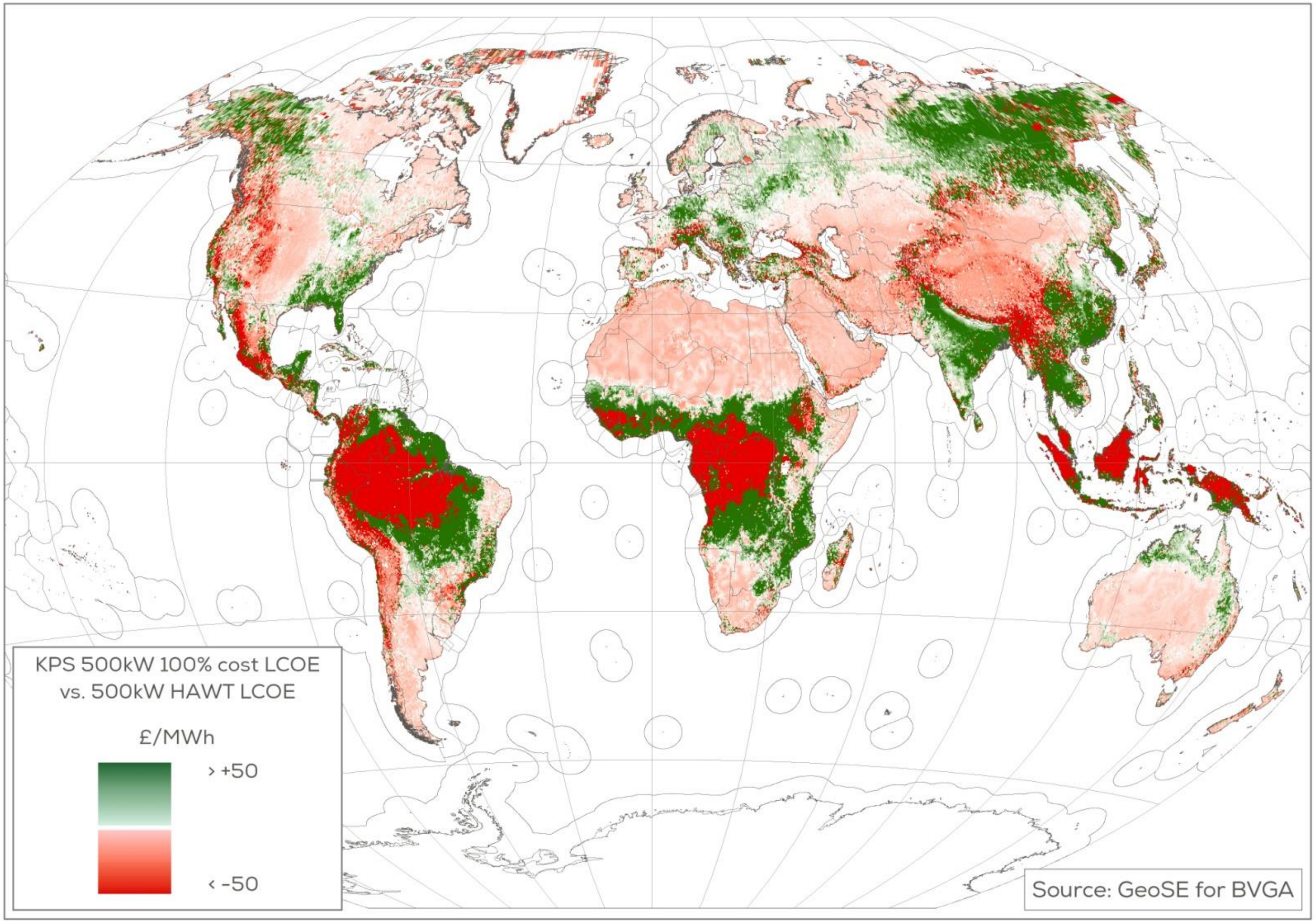
1.8 KPS 500kW 100% cost LCOE vs. Cheapest alternative LCOE



Appendix

Output maps Part 1

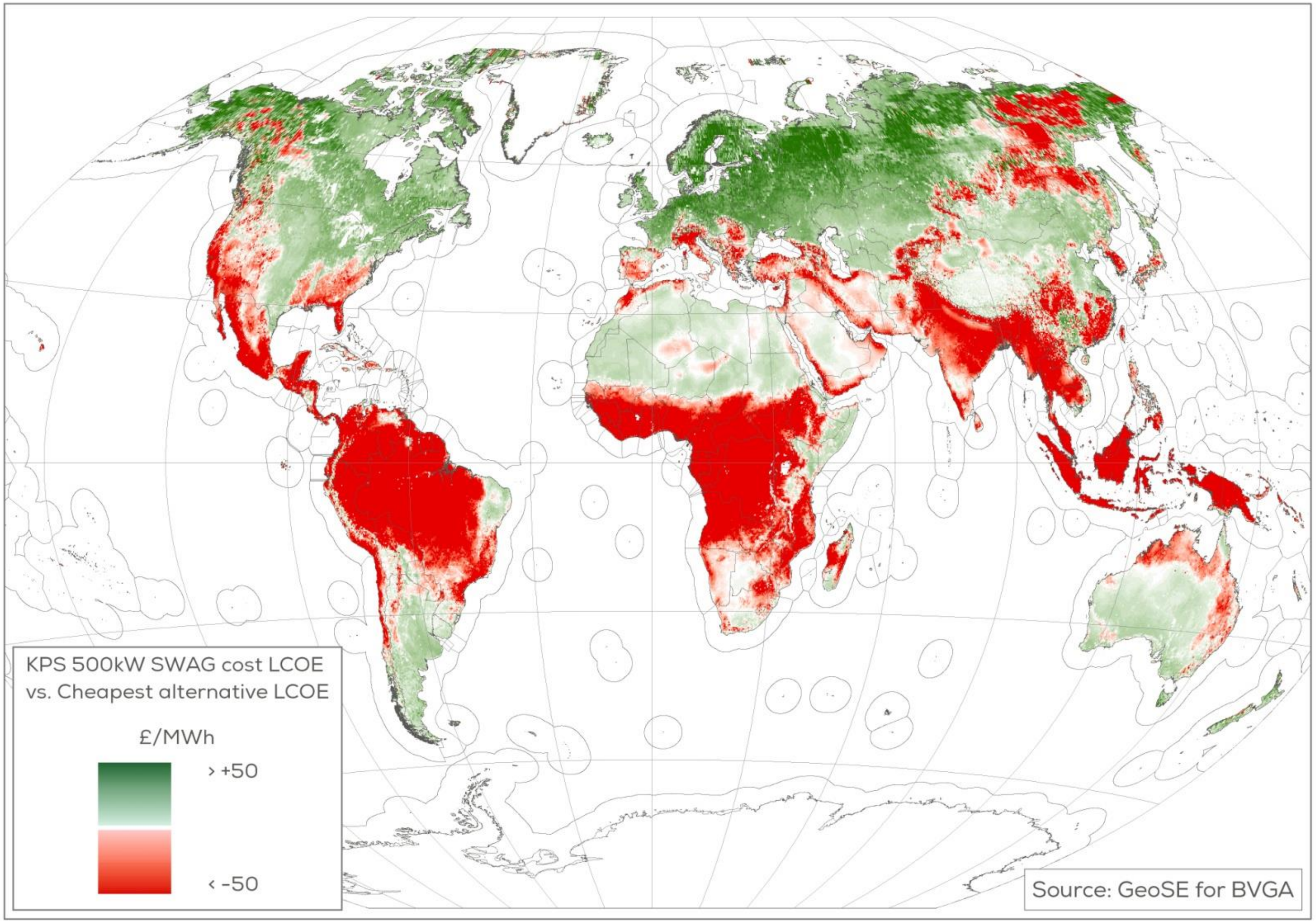
1.9 KPS 500kW 100% cost LCOE vs. 500kW HAWT LCOE



Appendix

Output maps Part 1

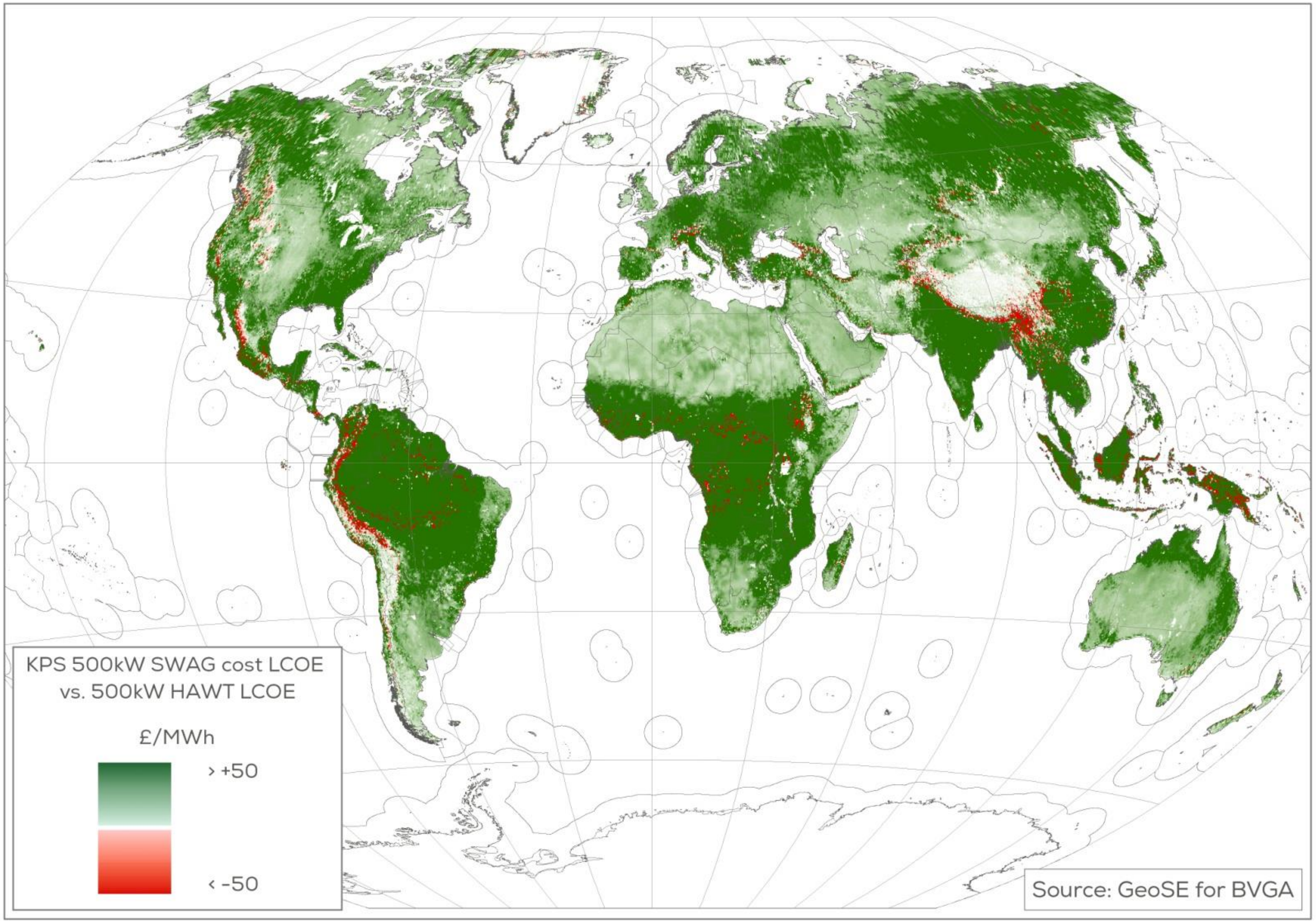
1.10 KPS 500kW SWAG cost LCOE vs. Cheapest alternative LCOE



Appendix

Output maps Part 1

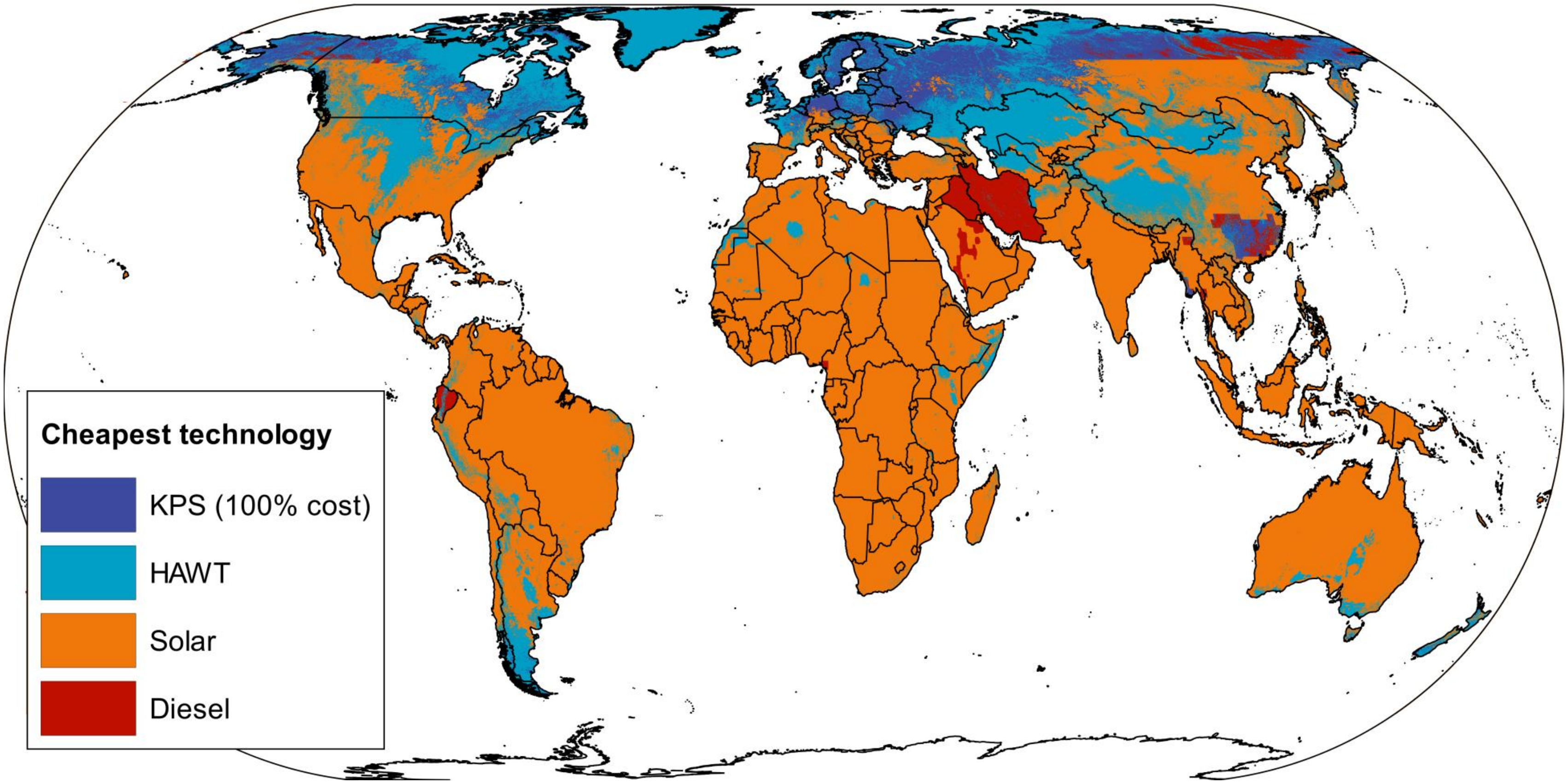
1.11 KPS 500kW SWAG cost LCOE vs. 500kW HAWT LCOE



Appendix

Input maps Part 2

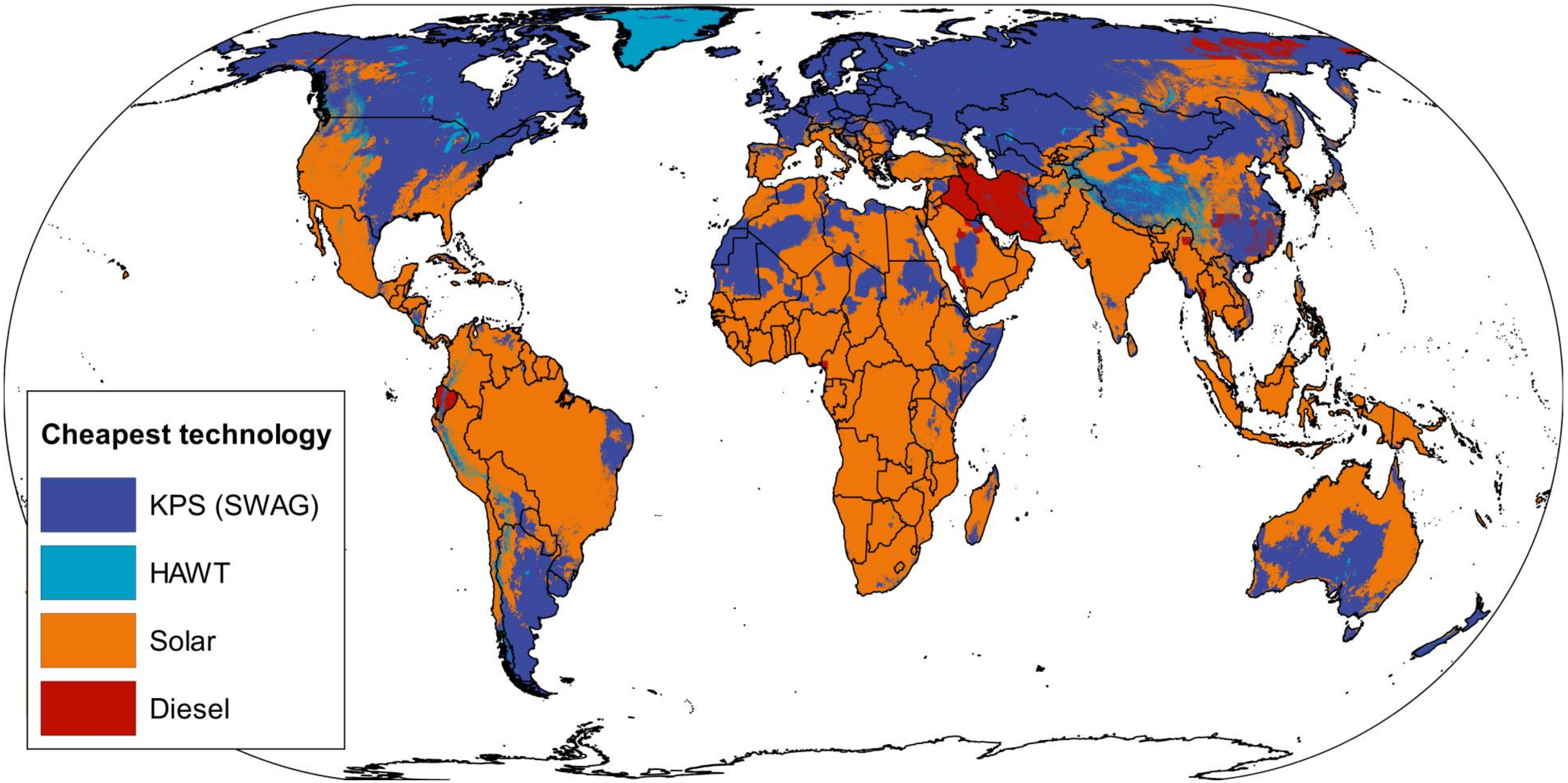
2.2 Lowest onshore technology LCOE, KPS 100% cost



Appendix

Input maps Part 2

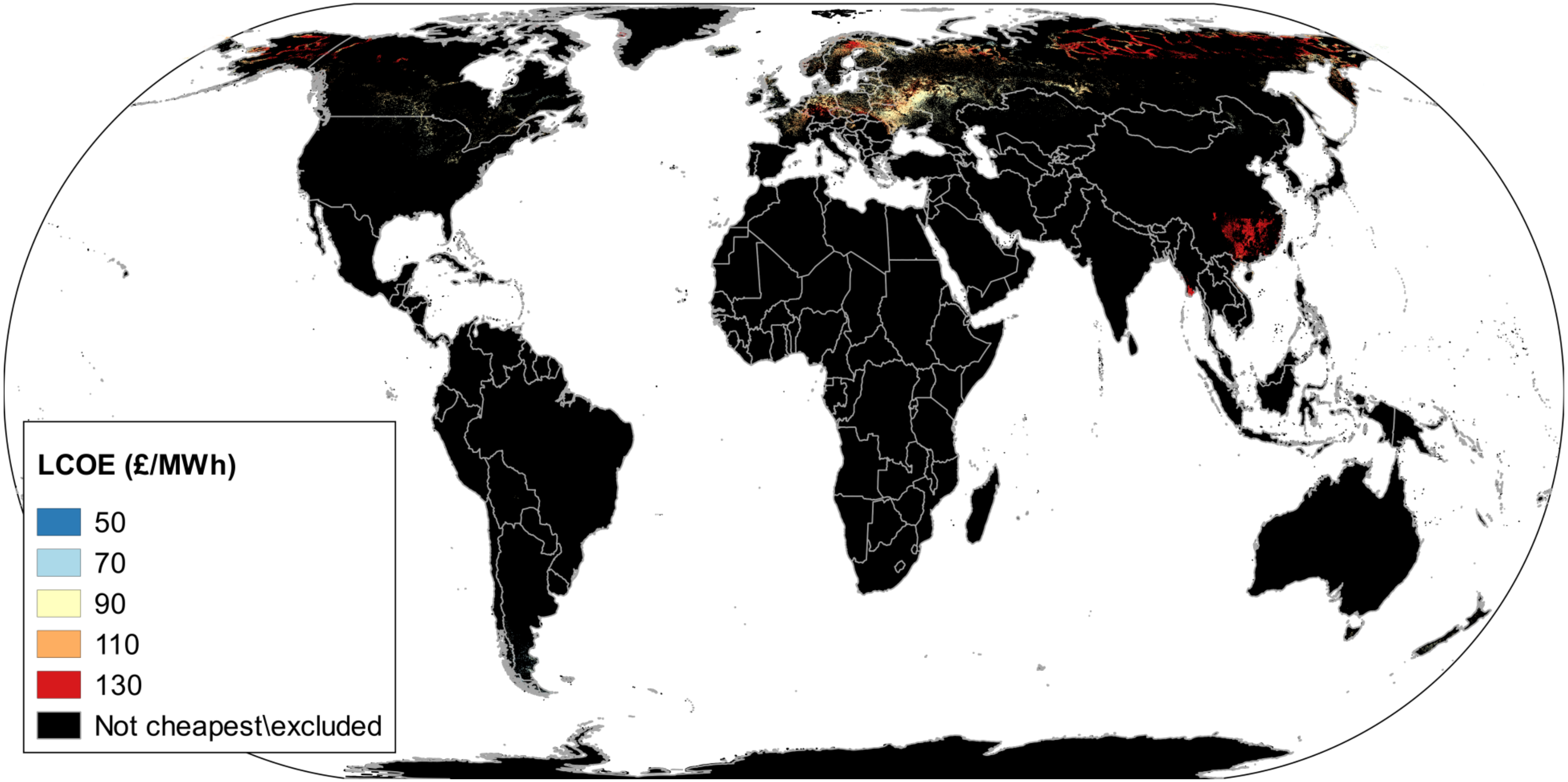
2.3 Lowest onshore technology LCOE, KPS SWAG cost



Appendix

Output maps Part 2

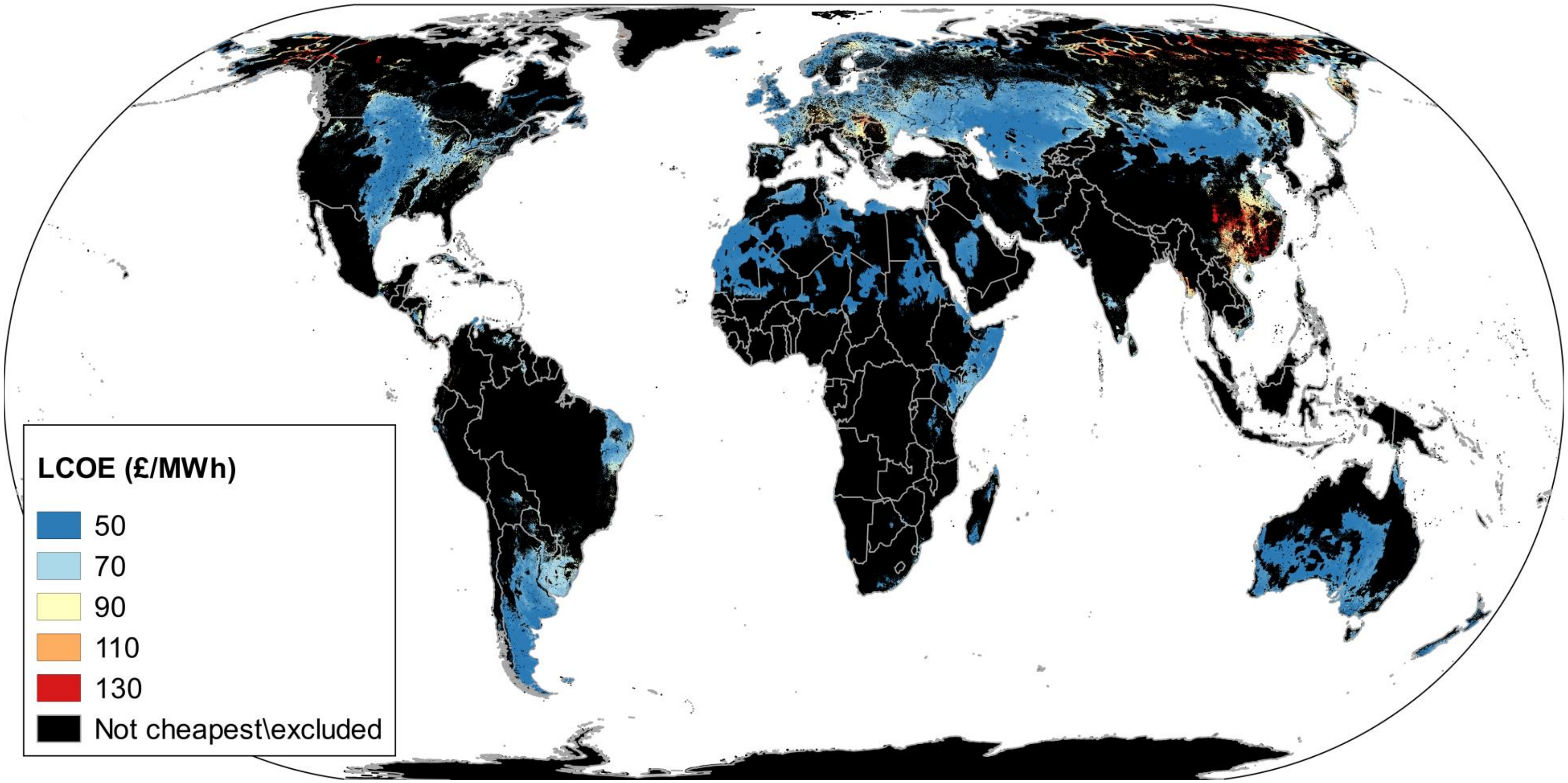
2.4 KPS 100% cost lowest onshore technology LCOE with exclusion zones



Appendix

Output maps Part 2

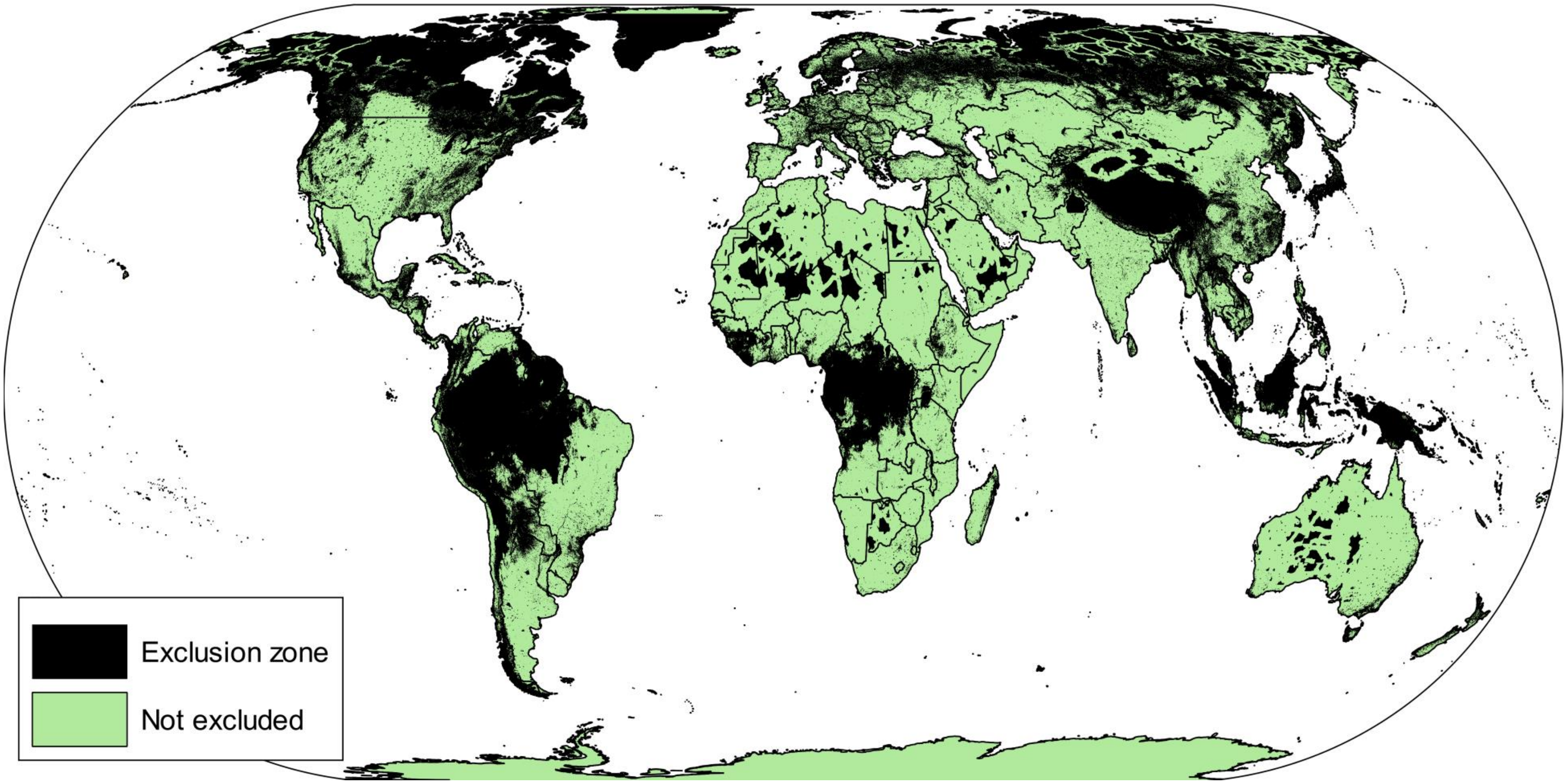
2.5 KPS SWAG cost lowest onshore technology LCOE with exclusion zones



Appendix

Exclusion layers

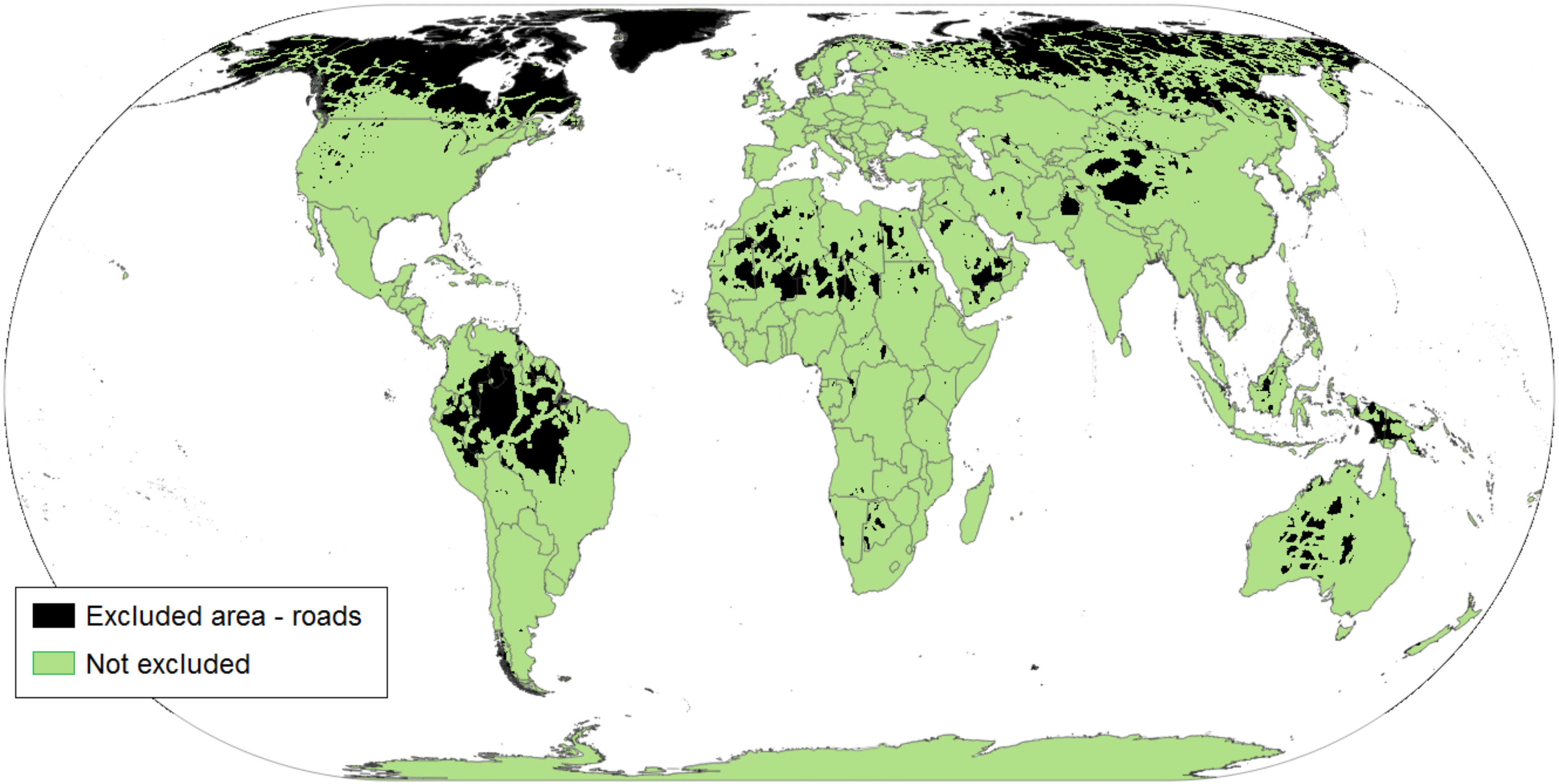
Combined total exclusion layer



Appendix

Exclusion layers

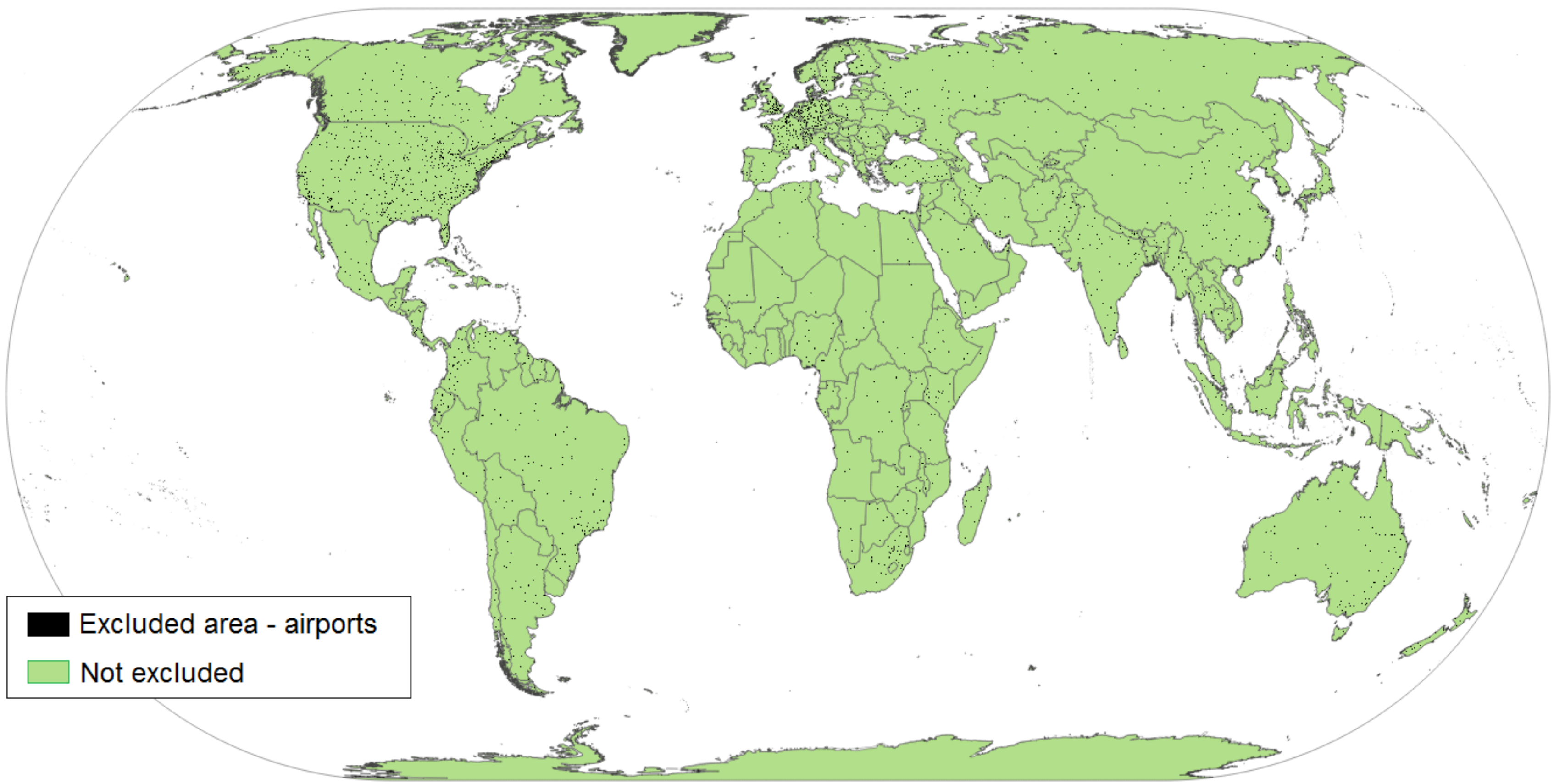
Roads exclusion layer – excluded area not within 50km of any recorded road



Appendix

Exclusion layers

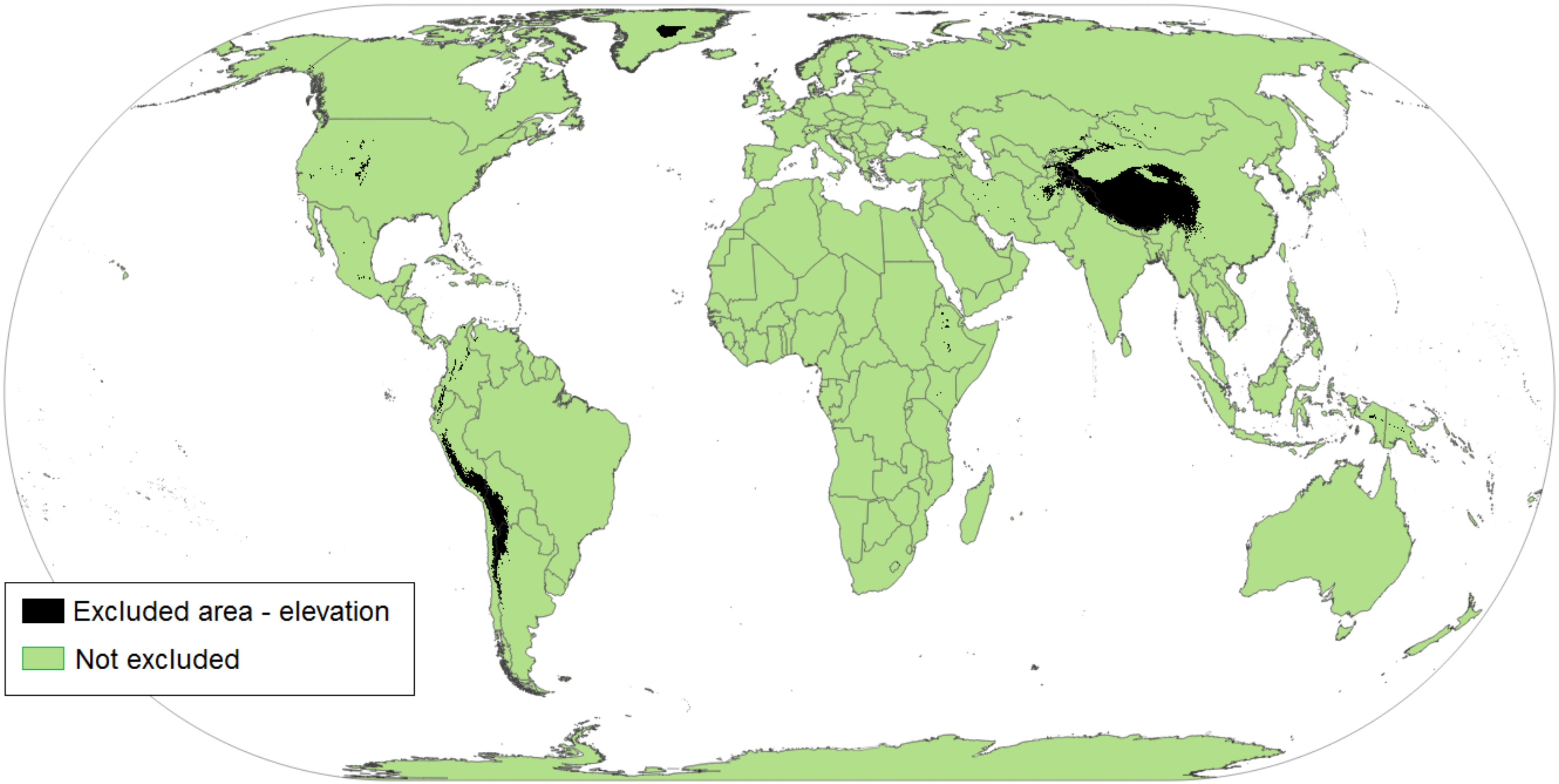
Airports exclusion layer – excluded area with 15km of an airport



Appendix

Exclusion layers

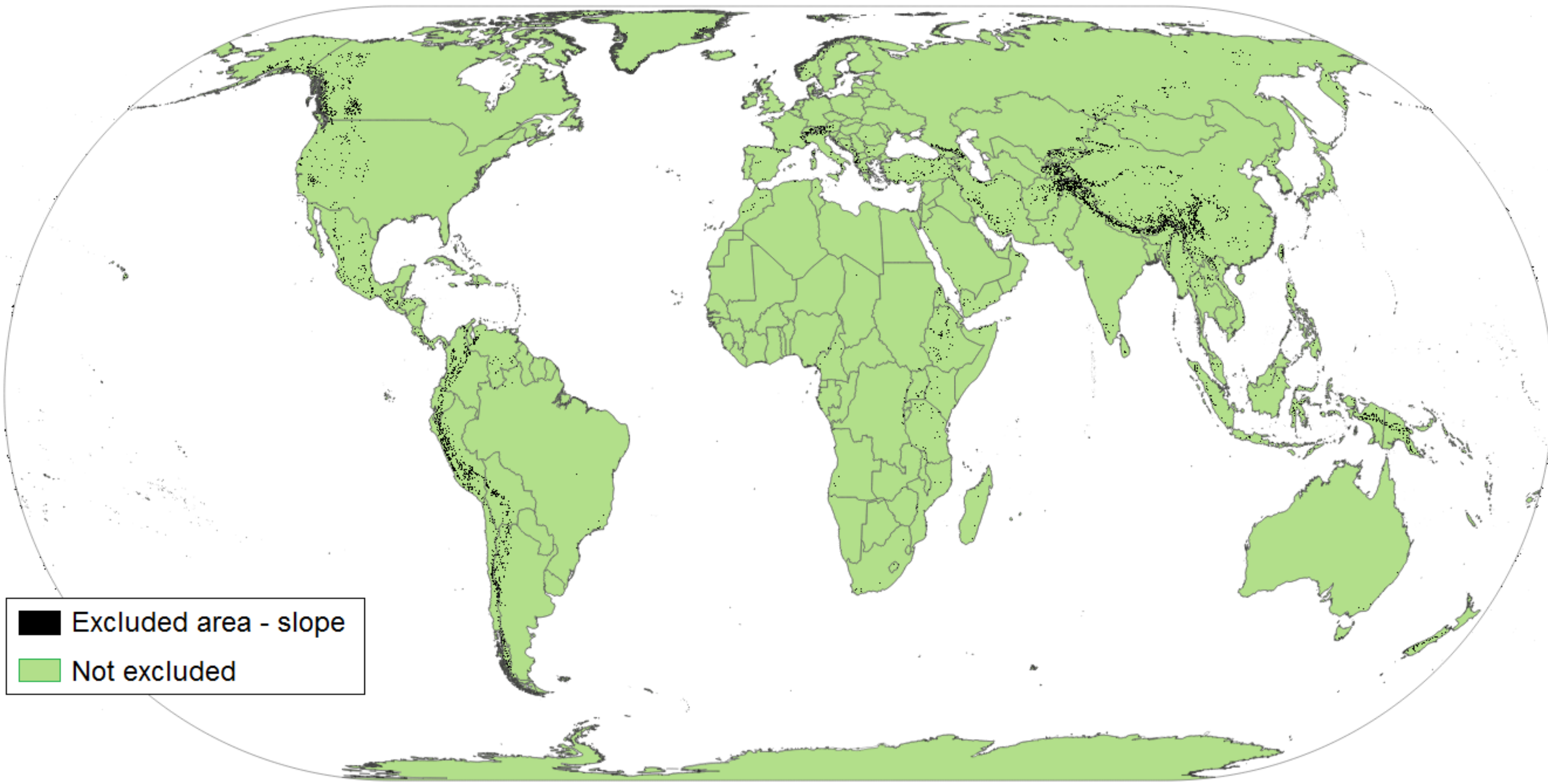
Elevation exclusion layer – excluded area above 3000m



Appendix

Exclusion layers

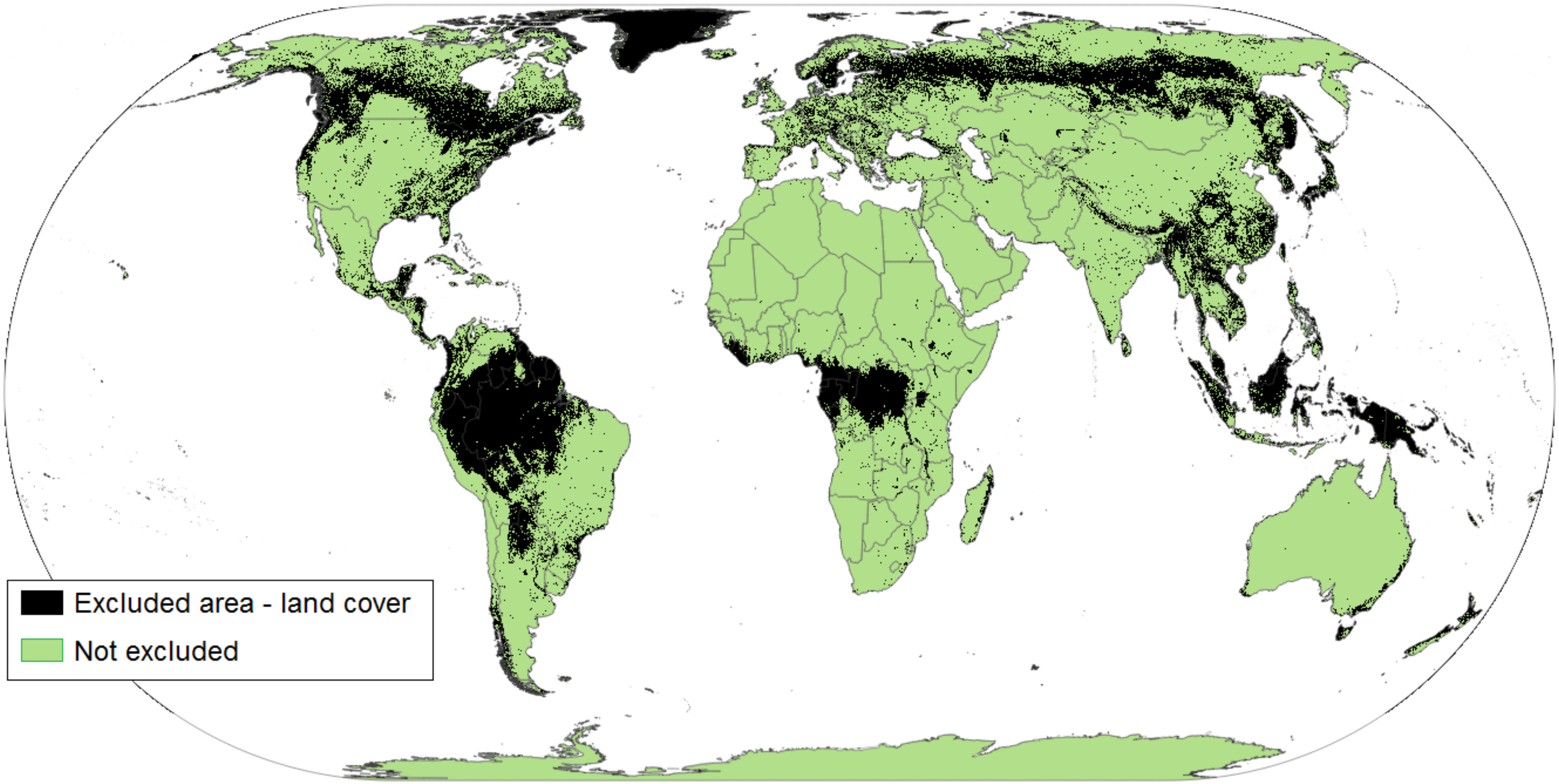
Slope exclusion layer – excluded area gradient above 7.5º



Appendix

Exclusion layers

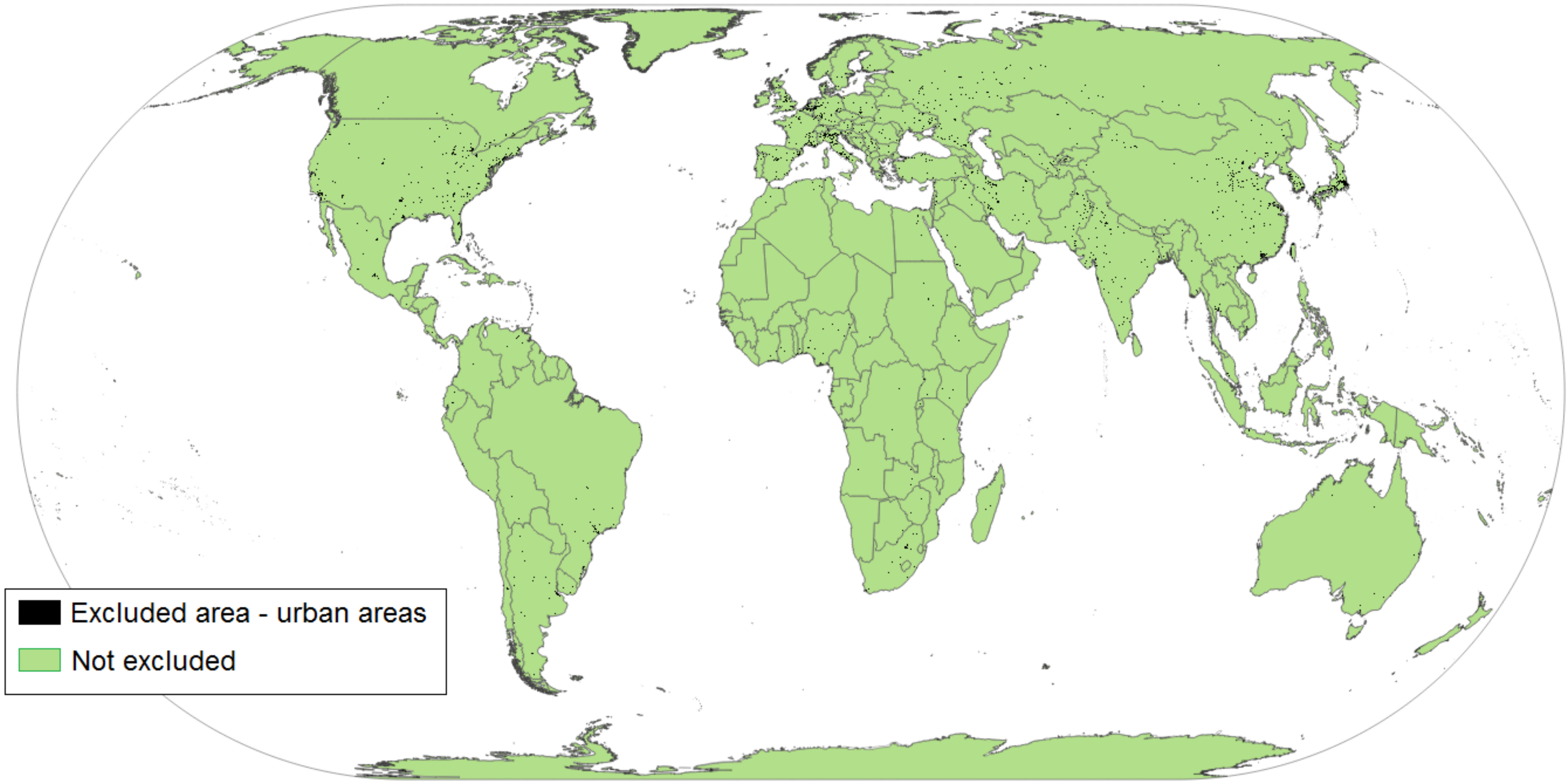
Land cover exclusion layer – excluded area incl. water, ice, permanent wetlands and dense forest



Appendix

Exclusion layers

Urban areas exclusion layer – excluded area includes urban and built up areas

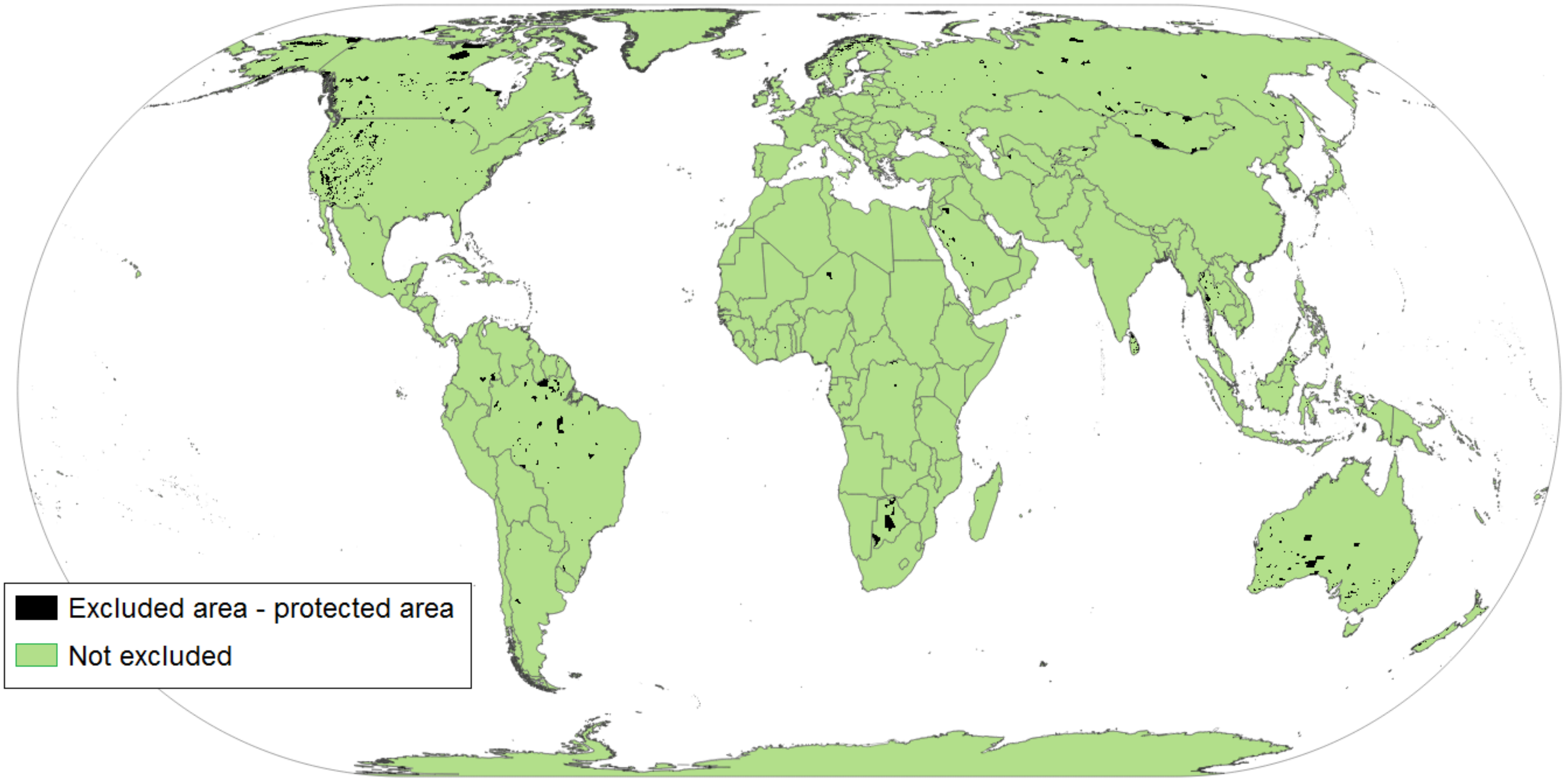


BVGassociates

Appendix

Exclusion layers

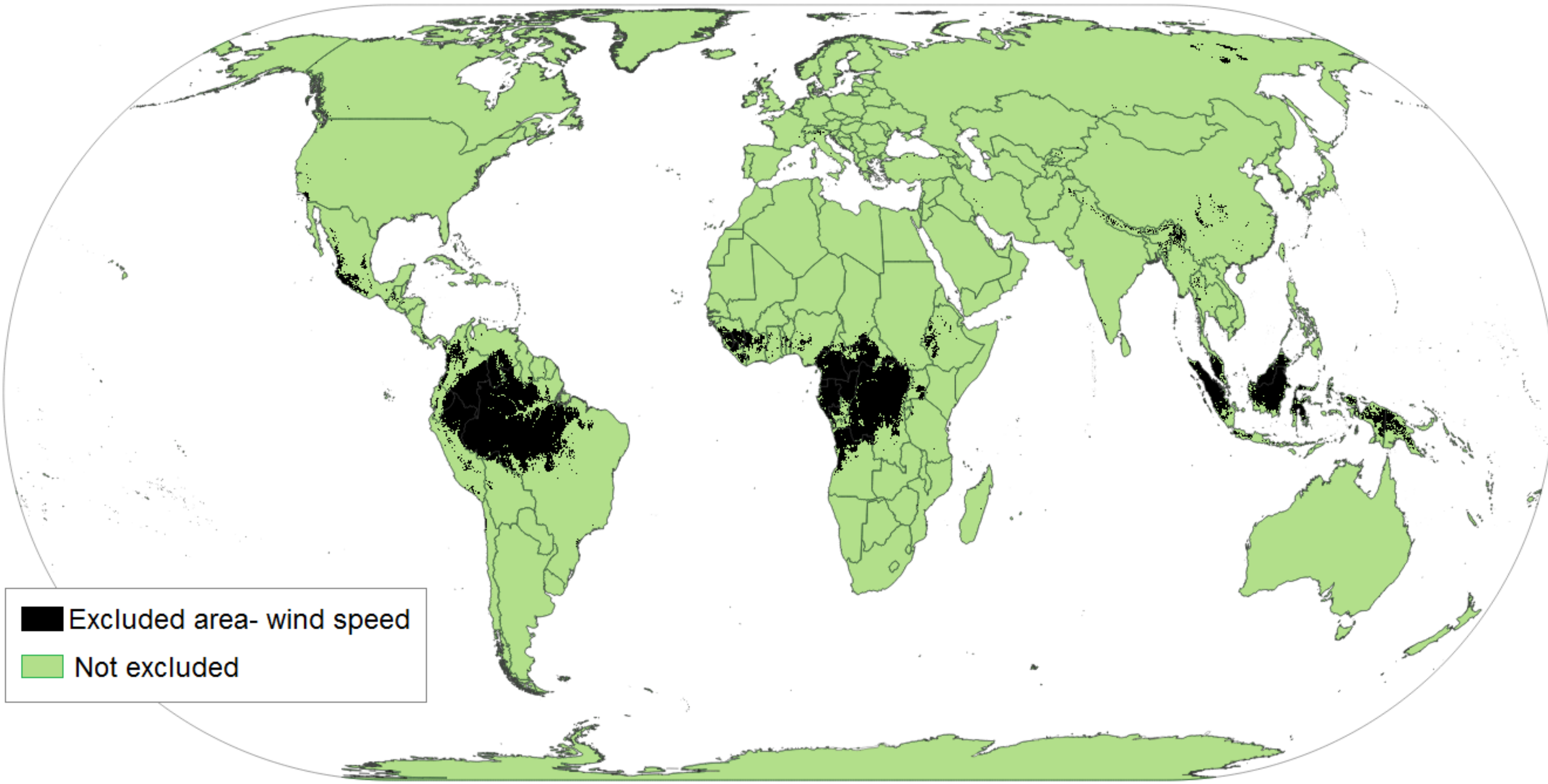
Protected areas exclusion layer – excluded area covers IUCN category 1a and 1b areas



Appendix

Exclusion layers

Wind speed exclusion layer – excluded area below 4m/s wind speed at 200m



Thank you

BVG Associates Ltd
The Blackthorn Centre
Purton Road
Cricklade, Swindon
SN6 6HY UK
tel +44 (0) 1793 752 308

BVG Associates Ltd
Inovo
121 George Street
Glasgow
G1 1 RD UK
tel +44 (0) 44 212 0800

BVG Associates LLC
874 Walker Road
Suite C
Dover
Delaware
19904 USA
tel +1 (313) 462 0673

info@bvgassociates.com
@bvgassociates
www.bvgassociates.com