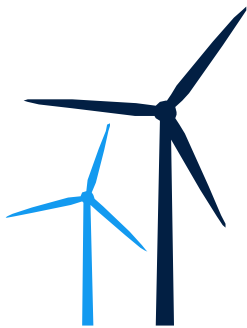


EXPLORING AFRICA'S UNTAPPED WIND POTENTIAL

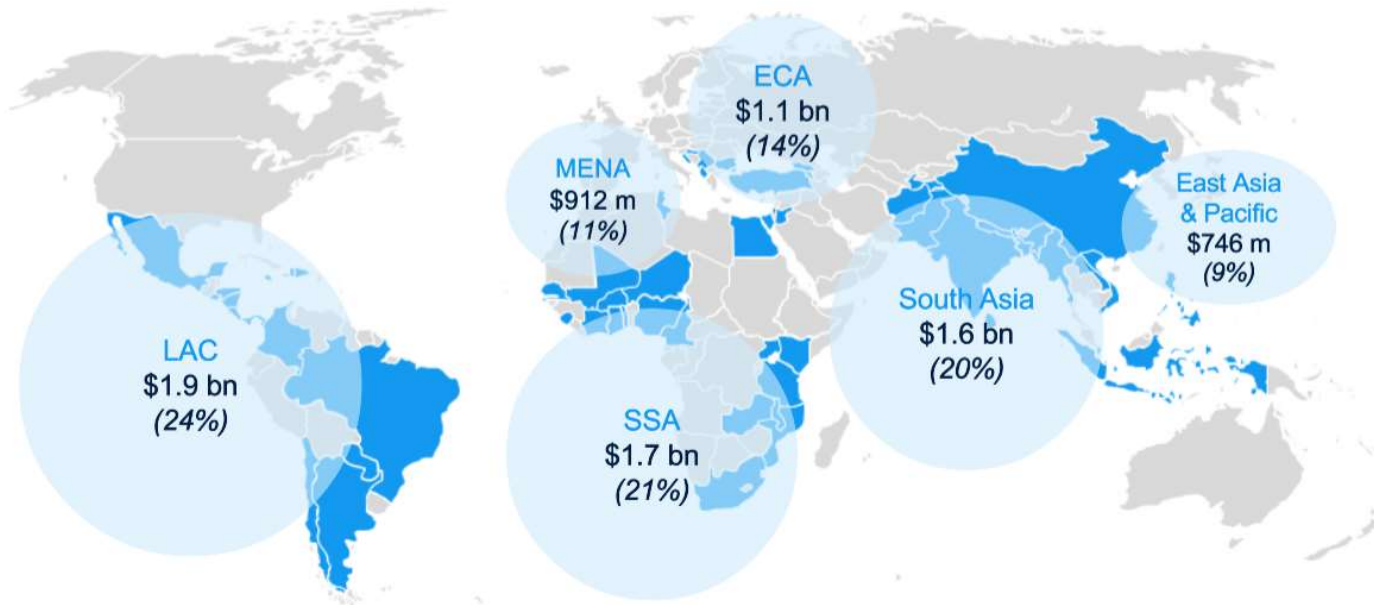


Sean Whittaker
Principal Industry Specialist, IFC

October 5, 2020

IFC's Energy Portfolio

\$8 billion energy portfolio (June 2020)



IFC's Wind Portfolio

From 2009 to 2019

38 projects in 19 countries
\$1.6 billion own account
3.9 GW total capacity

Europe and Central Asia

Kavarna (Bulgaria)
Cernavoda, Pestera (Romania)
Sibenik, Jelinak, Rudine (Croatia)
Rotor Elektrik (Turkey)
Alibunar, Dolovo (Serbia)

Middle East & North Africa

Daehan, Xenel, Tafila (Jordan)

Latin America & Caribbean

Norvind (Chile)
EVM, Eurus (Mexico)
Enel (Brazil)
BMR (Jamaica)
Penonome (Panama)
Pecasa (Dominican Rep)
Achiras, La Castellana (Argentina)

Sub Saharan Africa

Amakhala (South Africa)

East Asia & the Pacific

Guazhou (China)
Techno, NSL, Bhilwara, LNJ, Inox, DJ Energy & Uttar Urja, Green Infra, Ostro (India)
Senok (Sri Lanka)
Zorlu, Metro, Gul Ahmed, TGL, TriconBoston (Pakistan)

So, does Africa have a Good Wind Resource?

Engaged Everoze & Vortex to answer this question:

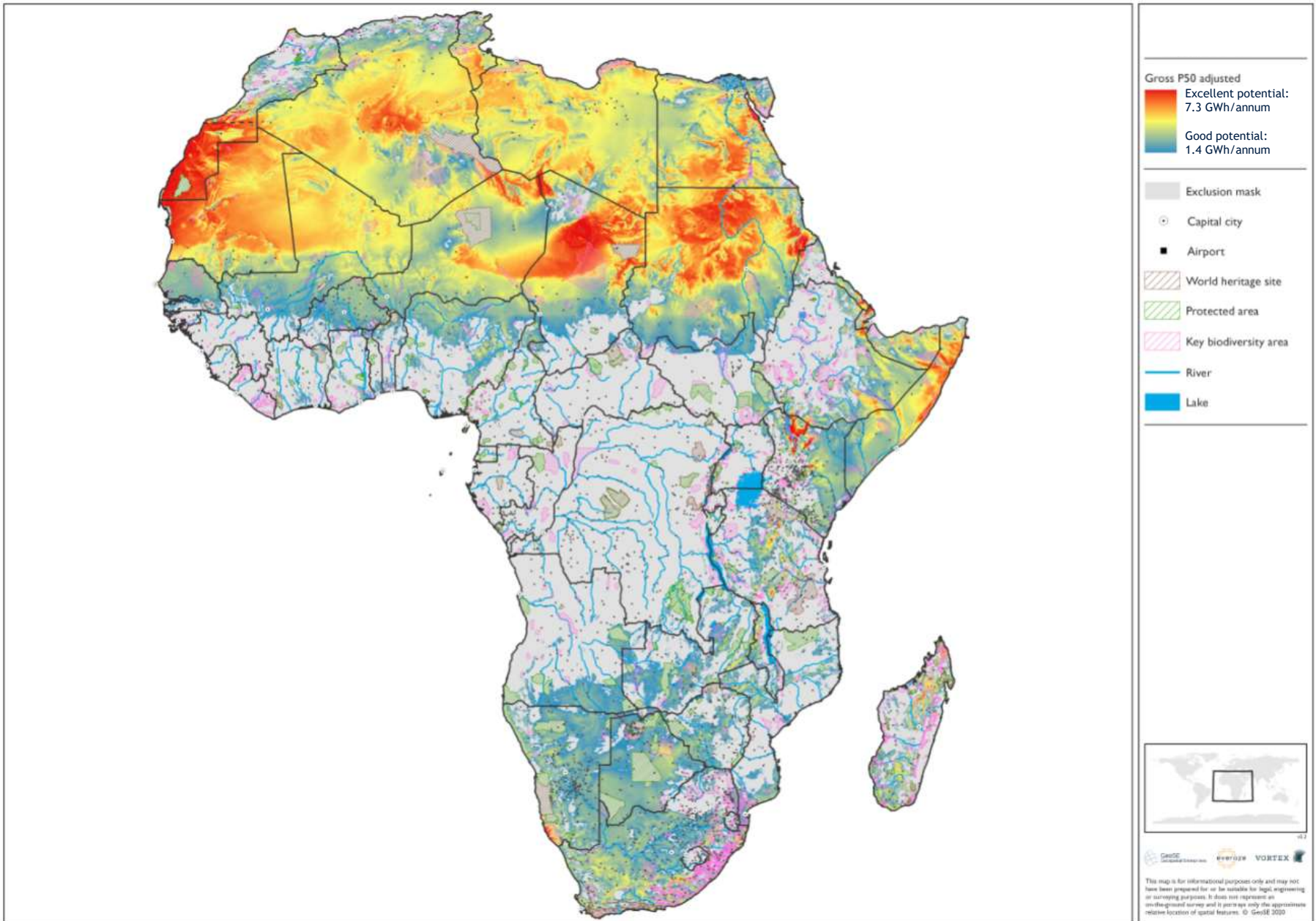
1. Assessment of technical potential for entire continent using basic constraints
2. Identify short-list of countries for detailed assessment
3. Detailed analysis of target countries using deeper constraints

Everoze assumptions:

- Use high resolution wind data:
 - Global Wind Atlas: 250m x 250m resolution
- Modern turbines matched to site conditions:
 - Hub height = 125 meters
 - Rotors = 120 to 158 meter diameter
 - Rated power = 4.3 to 5.3 MW
- Apply basic constraints for technical and E&S:
 - Wind speed, elevation, slope, urban areas
 - High population density, protected areas
- More detailed constraints will come later

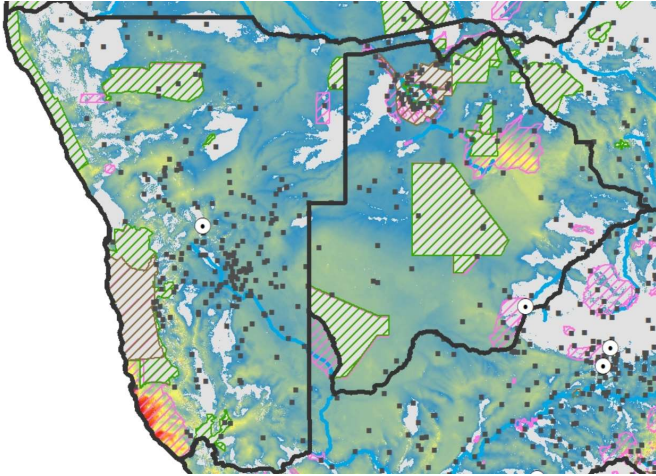
Constraints	Exclusions
Wind resource quality	Exclude if wind speed < 6.0m/s at 150m Exclude if wind speed > 16.0m/s at 150m
Elevation	Exclude if elevation > 2,000m
Slopes	Exclude if slopes > 20%
Land use cover	Exclude urban areas and airports (2km)
Population density	Exclude if population density > 200 people/km ²
Water bodies	Exclude
Protected areas	Exclude if UNESCO World Heritage site Exclude if IUCN Protected Area Management codes Ia, Ib and II.

Technical Potential – All locations meeting criteria

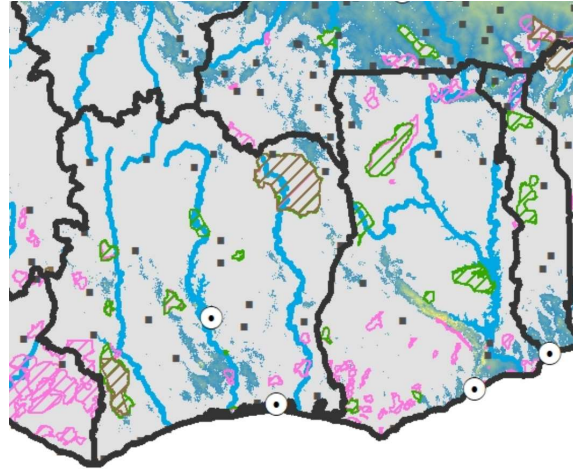


Technical Potential – All locations meeting criteria

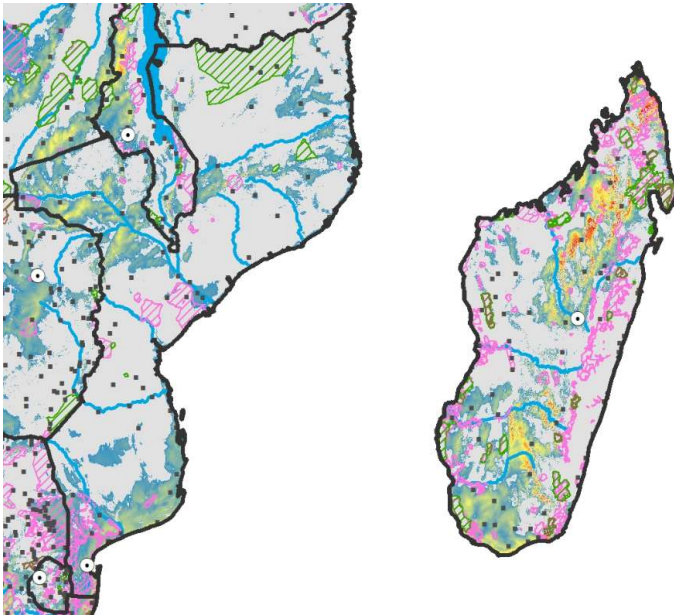
Namibia, Botswana



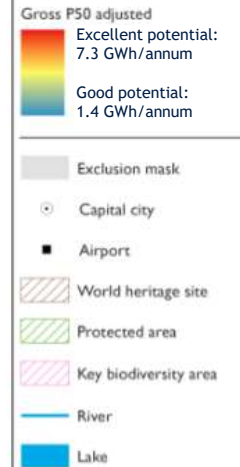
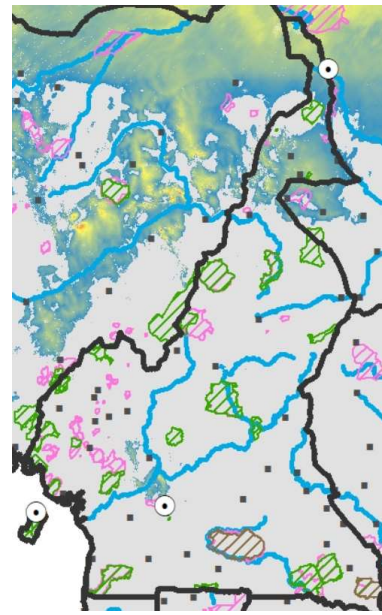
Cote d'Ivoire, Ghana, Togo



Mozambique, Madagascar



Cameroon



Total potential = 180,000 TWh/year = 250x continental demand

Country	Potential net energy generation [TWh/annum]	Potential installed capacity [GW]	Average capacity factor [%]	Exclusion ¹ [%]	Country	Potential net energy generation [TWh/annum]	Potential installed capacity [GW]	Average capacity factor [%]	Exclusion ¹ [%]
Algeria	24,980.2	7,717.4	36.9%	8.5%	Egypt	10,837.9	3,389.2	36.5%	6.5%
Angola	1,379.2	651.2	24.2%	83.5%	Equatorial Guinea	0.0	0.0	28.8%	100.0%
Benin	163.4	79.4	23.5%	78.5%	Eritrea	528.0	180.6	33.4%	57.8%
Botswana	3,116.7	1,298.8	27.4%	29.7%	! Ethiopia	3,207.6	1,171.1	31.2%	68.8%
Burkina Faso	1,550.2	638.4	27.7%	26.4%	• Gabon	0.3	0.1	24.0%	100.0%
Burundi	2.5	1.2	24.8%	98.7%	Gambia	58.3	27.3	24.4%	18.2%
! Cameroon	277.1	114.1	27.7%	92.3%	! Ghana	149.5	67.8	25.2%	91.1%
Central African Republic	85.0	42.3	22.9%	97.8%	• Guinea	13.9	6.6	23.9%	99.1%
Chad	11,954.3	3,607.4	37.8%	25.5%	Guinea Bissau	5.4	2.7	22.4%	97.4%
Democratic Republic of the Congo	196.0	92.4	24.2%	98.8%	! Ivory Coast	97.9	49.0	22.8%	95.2%
! Djibouti	187.9	58.5	36.7%	27.5%	Kenya	2,918.2	1,073.5	31.0%	44.9%
Lesotho	16.7	7.4	25.9%	92.4%	Senegal	1,270.1	492.1	29.4%	21.2%
Liberia	0.1	~0.0	25.1%	~100.0%	Sierra Leone	0.5	0.2	25.1%	99.9%
Libya	19,180.4	5,855.4	37.4%	0.7%	Somalia	5,052.0	1,625.7	35.5%	2.9%
! Madagascar	1,920.0	704.4	31.1%	64.5%	Somaliland	1,513.3	504.5	34.2%	13.2%
Malawi	322.6	128.2	28.7%	67.2%	South Africa	6,970.3	2,712.4	29.3%	31.3%
! Mali	12,426.1	4,047.9	35.0%	9.7%	South Sudan	801.6	356.6	25.6%	82.2%
Mauritania	14,548.3	4,229.4	39.2%	0.9%	Sudan	20,950.4	6,508.4	36.7%	7.0%
Morocco	2,074.4	719.3	32.9%	49.2%	Swaziland	53.5	23.0	26.5%	57.8%
! Mozambique	1,569.9	681.1	26.3%	72.9%	! Togo	62.9	30.6	23.5%	83.1%
! Namibia	4,399.5	1,842.3	27.2%	30.2%	Tunisia	1,596.6	512.3	35.6%	8.1%
Niger	11,897.3	3,846.7	35.3%	7.5%	! Uganda	44.2	20.4	24.7%	97.4%
! Nigeria	3,165.6	1,261.1	28.6%	56.5%	• United Republic of Tanzania	1,564.8	620.4	28.8%	80.1%
Republic of Congo	6.0	2.8	24.0%	99.7%	! Zambia	2,020.5	930.0	24.8%	61.2%
Rwanda	~0.0	~0.0	21.0%	~100.0%	• Zimbabwe	1,073.6	468.7	26.1%	62.2%
Sao Tome and Principe	~0.0	~0.0	28.2%	99.9%					

Technical potential: Only locations with wind > 7.5 m/s

Rank	Country	P50 [TWh/annum]	Capacity [GW]	Average CF [%]
1	Algeria	20,876.5	6,191.1	38.5%
2	Libya	16,909.7	5,079.1	38.0%
3	Sudan	16,129.8	4,627.9	39.8%
4	Mauritania	13,741.4	3,955.1	39.6%
5	Chad	9,618.9	2,646.8	41.5%
6	Mali	9,103.3	2,758.4	37.6%
7	Egypt	7,913.3	2,319.1	38.9%
8	Niger	7,751.7	2,347.8	37.7%
9	Somalia	3,197.0	946.2	38.5%
10	South Africa	1,279.7	404.2	36.1%
11	Ethiopia	1,203.8	375.2	36.6%
12	Tunisia	1,058.5	314.7	38.4%
13	Morocco	992.4	289.8	39.1%
14	Somaliland	949.4	291.9	37.1%
15	Kenya	862.1	242.6	40.5%
16	Madagascar	706.7	210.0	38.4%
17	United Republic of Tanzania	484.3	152.0	36.3%
18	Namibia	410.0	124.1	37.7%
19	Eritrea	276.8	79.4	39.8%
20	Nigeria	239.7	77.5	35.3%
21	Botswana	183.5	59.0	35.5%
22	Djibouti	134.0	37.4	40.9%
23	Zambia	98.1	31.9	35.1%
24	Malawi	88.4	28.2	35.8%
25	Mozambique	70.2	22.2	36.0%
26	Zimbabwe	34.9	11.7	34.0%
27	South Sudan	27.4	8.8	35.5%
28	Cameroon	12.5	4.1	34.8%
29	Senegal	8.7	2.9	34.8%
30	Ghana	8.7	2.7	36.3%

Not Surprising

Total potential for all locations > 7.5 m/s:
= 34,700 GW
= 118,700 GWh/year

Slightly surprising

Very surprising!

Technical potential: Only locations with wind > 8.5 m/s

Rank	Country	P50 [TWh/annum]	Capacity [GW]	CF [%]
1	Sudan	11,705.8	3,294.4	40.5%
2	Mauritania	11,515.5	3,307.1	39.7%
3	Algeria	8,591.8	2,602.2	37.7%
4	Chad	7,470.8	1,994.7	42.7%
5	Libya	5,373.6	1,659.9	36.9%
6	Egypt	4,021.2	1,164.4	39.4%
7	Mali	3,654.0	1,173.6	35.5%
8	Niger	3,174.1	940.8	38.5%
9	Somalia	1,652.3	477.1	39.5%
10	Kenya	533.2	139.6	43.6%
11	Morocco	519.1	143.0	41.4%
12	Tunisia	503.0	150.8	38.1%
13	Ethiopia	355.2	107.4	37.7%
14	Somaliland	324.7	97.4	38.1%
15	Madagascar	320.3	91.2	40.0%
16	South Africa	246.9	75.1	37.5%
17	United Republic of Tanzania	184.7	55.9	37.7%
18	Eritrea	179.3	49.5	41.3%
19	Namibia	139.1	38.3	41.4%
20	Djibouti	97.0	26.0	42.5%
21	Malawi	21.3	6.8	35.7%
22	Nigeria	9.4	2.9	36.9%
23	Zambia	7.7	2.5	35.3%
24	Mozambique	7.2	2.2	37.4%
25	South Sudan	3.5	1.1	37.5%
26	Botswana	1.9	0.6	33.4%
27	Zimbabwe	1.9	0.6	36.0%
28	Democratic Republic of the Congo	0.6	0.2	35.6%
29	Ghana	0.6	0.2	36.3%
30	Cameroon	0.6	0.2	36.9%

Total potential for high-wind only
 = 16,600 GW
 = 64,700 TWh/year



Observations

Turns out that Africa has a great wind resource!

- Looking at all locations, total wind potential = 180,000 TWh/yr = 250x current continental demand
- Two-thirds is in locations with wind > 7.5 m/s
- One-third is in locations with wind > 8.5 m/s, yielding very high productivity

Wind resource is surprisingly distributed:

- 27 countries on their own could satisfy the entire continental electricity demand (17 of these have average capacity factors over 30%)
- Many countries with no projects have great potential:
 - Algeria: 24,980 TWh (34% in high wind)
 - Tanzania: 1,564 TWh potential (12% in high wind)
 - Malawi: 322 TWh potential (7% in high wind)
 - Namibia: 4,399 TWh (3% in high wind)
 - Nigeria, Cameroon, Mozambique, Ivory Coast ...



Conclusions

Why Wind for Africa?

1. Tremendous untapped wind potential
2. Competitively-priced power
3. Complementarity with solar
4. Minimal disruption of land use
5. Opportunity for community benefit sharing

Key pieces of the puzzle:

1. Follow environmental & social good practice
2. Need strong policies and clear targets
3. Transmission and energy access
4. Smart integration of variable power
5. Transparent tenders with a focus on bankability
(building on Scaling Solar success?)



Local Benefit Sharing in Large-Scale Wind and Solar Projects

Discussion Paper
June 2019

