Application for planning purposes: Interim High-Resolution Wind Resource Map for Strategic Environmental Assessment in South Africa

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Publication date:
2018

Document Version
Peer reviewed version

Link back to DTU Orbit

Citation (APA):

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WASA 2 Application for planning purposes: Interim High-Resolution Wind Resource Map for Strategic Environmental Assessment in South Africa

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DTU Wind Energy

Eugéne Mabille and Eric Prinsloo
CSIR

WASA 2 Mid-term Workshop
Cape Town, South Africa
Updated wind resource mapping methodology

- *Frogfoot* implementation of WASP
  - Database of wind climates
  - Database of elevation maps
  - Database of roughness maps

- Principle of operation
  - Batch mode operation
  - Distributed computing
  - Wind atlas interpolation to every prediction site.
  - Results in MySQL database
  - Export to GIS formats

- WASP 11 standard modelling
  - Industry-standard model
  - Linearized IBZ flow model
  - Default parameters
Available input data for modelling

- Validated Numerical Wind Atlas
  - WRF mesoscale model
  - Virtual mast for every 3/5 km
  - WASA 1 domain: 3 km
  - All of South Africa: 5 km

- Elevation
  - 100-m elevation grid from space shuttle Endeavour (SRTM+, NASA version 3).

- Land cover
  - 300-m land cover grid derived from ESA GlobCover 2009.
  - Transformation table for $z_0$
WRF 5-km simulated winds

WASA2, mean wind speed (m/s)  Oct 2005 - Sept 2013
South Africa wind speed @ 100 m
South Africa power density @ 100 m
WRF 3-km simulated winds

WASA1, mean wind speed (m/s)  Oct 2005 - Sept 2013
WASA1 wind speed @ 100 m
Interim High-Resolution Wind Resource Map

Detailed wind resource maps
- 250 × 250 m grid results
- Modelling resolution ~1 m
- 50, 100 and 200 m a.g.l.
- ArcGIS ASC output format

- Mean wind speed $U$
  - 10 min average in $[\text{ms}^{-1}]$

- Mean power density $P$
  - 10 min average in $[\text{Wm}^{-2}]$
  - Site-specific air density

- Elevation $z$
  - Meters above sea level [m]

- Ruggedness index RIX
  - WAsP standard parameters

Database of wind climates
- For each province
  - 250 × 250 m grid results
  - 50, 100 and 200 m a.g.l.
  - Sector-wise results (×12)
  - ASCII TXT output format

- For each site, height and sector
  - Weibull $A$ parameter $[\text{ms}^{-1}]$
  - Weibull $k$ parameter
  - Frequencies of occurrence

- Data for calculation of
  - Specific power density
  - Wind turbine energy yield
  - Wind turbine capacity factor
  - and much more...
Metadata documents for wind resource data sets

- Metadata for data sets
  - Data set specifications
  - Data provider
  - Contact information
- Data set parameters
- Coordinate system
- Technology (models & data)
- Detailed notes
  - Purpose
  - Methodology
  - Limitations
  - Available documentation
  - Acknowledgements
  - Disclaimer
- Four maps of $U$, $P$, $z$ and RIX

**Interim High-Resolution Wind Resource Map for South Africa**

Metadata and further information

October 2017

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The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.
Metadata documents for wind resource data sets

- Metadata for data sets
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  - Four maps of $U$, $P$, $z$ and RIX

- Limitations
  - Operational envelope of WAsP
  - Validated numerical wind atlas (WRF mesoscale model)
  - Input topographical data
  - Complex terrain (RIX > 5%)
  - Built-up areas
  - Forested areas

The wind resource maps are subject to change without notice if and when more accurate and reliable data, models and procedures become available.
DEA National Wind and Solar PV SEAs (Phase 1)

SEA Data available for download & public comments

http://www.csir.co.za/nationalwindsolarenergy/

- National Wind Datasets Download
- Wind and Solar PV SEA Phase I Study Areas Download
- National Solar Datasets Download
- Renewable Energy EIA Applications Map and Comment Form Download

Global Horizontal Irradiance
Global Horizontal Irradiance (GHI):
- kWh/m2/annum

Photovoltaic Yield Static
Photovoltaic Yield on fixed tilt plane
- kWh(electrical)/kWpeak(installed)/a.

PV Yield tracking
Photovoltaic Yield with single axis tracking
- kWh(electrical)/kWpeak(installed)/a.

Optimal Inclination
Optimal inclination for solar panels
WASA data used to identify Wind Technical Areas to inform the Phase 2 Strategic Environmental Assessment for wind and solar energy
Wind farm planning and development (caution!)

- Identification and ranking of potential wind farm sites.
- Initial analyses and design
- Project planning
- Pre-feasibility studies
  - Resource assessment
  - Some site assessment
- Design of measurement campaign
  - Number of masts
  - Siting of masts
  - Orientation of sensor booms
  - Mounting of lightning rod and navigation lights.
Summary and conclusions

• Wind resources in South Africa
  – Large-scale: ~1.22 mio. km²
  – High-resolution: 250-m grids
  – Results in public domain

• Data sets available
  – Detailed wind resource maps
  – Database of wind climates
  – Three heights at every site

• Data sets specifically developed for
  – Strategic Environmental Assessment (SEA)
  – WF planning and development

• Validation and QA in progress
  – Software development phase
  – Comparisons at WASA masts

• Preliminary validation of WASA1 (3-km) to WASA2 (5-km):
  – Mean absolute percentage error (MAPE) decreases 15%
  – Spread decreases by 40%
  – Bias is almost 0%!

• WASA 2 and 3 focus areas
  – Land cover data & modelling
  – Long-term extrapolation
  – Atmospheric stability
  – Adaptation of modelling
  – Uncertainty modelling

• WASA 2 ends by end of 2018
  – 3-km mesoscale modelling
  – Updated data and reports
Acknowledgements

The Wind Atlas for South Africa (WASA) project is an initiative of the South African Government – Department of Energy (DoE) – and the project is co-funded by

- GEF through South African Wind Energy Programme
- Danish Support to RE Development in the RSA

WASA Project Steering Committee:
DoE (chair), DEA, DST, UNDP, Danish Embassy, SANEDI
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SANEDI WASA site
www.wasaproject.info

CSIR Online
www.wasa.csir.co.za

WASA download site
wasadata.csir.co.za/wasa1
# Results folder – available files

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Database folder – available files