

Austrian Wind Potential Analysis - AuWiPot

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Project overview



USTRIAN WIND TIAL ANALYSIS

The project AuWiPot

- Funded by Austrian Promotion Agency (FFG)
- Run time 3 years (March 2009 to April 2011)
- Team:



www.windatlas.at

Verein energiewerkstatt^o

Energiewerkstatt°, Austria Project lead, technical/economical criteria, observation data



Wegener Center, University of Graz, Austria Wind field modelling, observational data



Meteotest, Switzerland Wind field modelling, observational data

Sa Research Studios Austria Forschungsgesellschaft mbH iSpace, Austria web-GIS modelling, data analysis



1. Introduction and Motivation

- 2. Methodology
- **3.** Results
- 4. Conclusion

Introduction



Potential estimations so far



- Broad spectrum of estimations ranging between 3TWh/a and 20TWh/a, depending on the methods applied and underlying assumptions
- e.g. Pokorny (1981): 6.6 TWh/a 10 TWh/a based on 150'000 50 kW turbines

Introduction



Current status (end of 2011)



(from IG Windkraft, 2011)

- Current status lies far behind any estimated potential
- Economical constraints have changed (e.g. feed-in tariff)
- New technological possibilities are available (e.g. turbine sizes have increased)
- Limiting factors can be considered much more in detail (wind, land use, feed-in tariff, ...)



→ Austrian Wind Potential Analysis – AuWiPot



Aims:

- Calculation of a detailed (100 m × 100 m grid spacing) wind map for the Austrian territory with known uncertainty
- Comprehensive modelling of the theoretically achievable wind potential under changing economic/technologic conditions
- Provision of a flexible potential estimation tool to the general public via a web-based GIS application capable of fast "on-the-fly" calculations





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Methodology



Problem of scales

>1000 km

gobal circulation, ocean / atmosphere oscillations (e.g., Monsoon, ENSO)

- 100 km to 1000 km
 Rossby Waves,
 high/low pressure systems,
 Hurricanes
- 10 km to 100 km
 frontal systems, thunderstorms, cumulus nimbus
 Föhn, Bora
- 10 m to 10 km cumulus, slope flows, local circulations, turbulence, Tornadoes



(Barry and Carleton, 2001)

Methodology



Dynamical model

- Regional climate model (RCM): MM5
- Driving data: ERA-40 (~100 km)
- Three nesting steps:
 30 km (A1) → 10 km (A2) (reclip:more)
 → 2 km (A2) (Loibl et al., 2007)
- Periods: 1981 to 1990 (from reclip:more)
- Evaluation: observation data from 65 ZAMG stations
- Output: mean annual wind speeds and frequency distributions

Geo-statistical model (Kunz et al., 2004)

- Observational data from MetServices (ZAMG, DWD, MeteoSwiss), local governments, University of Innsbruck, research projects (MAP, Alpine Windharvest), private observations from wind projects
 - + data from 254 surface stations+ results from dynamical model (A2)
- simple bias correction included



(Truhetz et al., 2010)



Output: highly resolved (100 m) wind maps (mean annual wind speeds, Weibull parameters) in several heights a.g.l.

Methodology



Potential estimations and GIS application

First step (technical criteria)

- Surface altitude
- Terrain slope
- Land use
- Protection areas (national parks and other nature protection areas)
- Distances to settlements, buildings, streets and rail roads
- (access roads and socio-political limitations excluded)

Second step (economical criteria – derived from expert consultations via workshops)

- Calculate site-specific production costs (per grid cell) from
 - ightarrow mean annual energy yield

(wind conditions, specific power curves, distances between turbines, technical and wake losses)

- → costs (Installation costs, costs of operation, capital costs, machine life, …)
- ightarrow site-specific production costs / feed-in tariff
- \rightarrow web-based GIS application









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Evaluation of the dynamic modelling step (1981 to 1990)

- Station averaged (65 ZAMG stations)
- Deviations from observations are reduced

mean absolute error: ERA-40 2.6 m/s 10 km 2.2 m/s 2 km 1.7 m/s

- frequency distributions are improved
- \rightarrow overestimation of wind speeds
- → added value due to the increasing resolution of the dynamic model
- → Output from dynamic models need to be "post-processed" (bias correction, MOS, etc.)



Results





- Cross-validation (leave one out) over more than 200 stations
- \rightarrow spatially distributed standard deviations of biases (~0.8 m/s on average)
- \rightarrow roughly correlates with the density of the stations
- \rightarrow uncertainty in energy yield < ±15% (for stddev 0.4 m/s) at single sites





web GIS application



Available at <u>http://www.windatlas.at</u>

Results



Theoretically achievable wind potential (on a district level)

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Realistically achievable wind potential

- Socio-political constraints have not been considered in AuWiPot (acceptance by the population, conflicting interests, praxis in awaiting approvals, ...)
 - \rightarrow difficult to implement
- First attempt (conducted by Energiewerkstatt[°] as an add-on): expert consultations within the Austrian wind energy community wind farms installed in 2011 estimation of planned wind farms under realistic conditions
- Comparison

Current status (observed)	theoretical potential (objective)	expert consultations (subjective)
~1 GW	12.8 GW	2.8 GW
~4%	~50%	~11%



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Wind field modelling

- Highly resolved wind maps have been generated and published via www.windatlas.at
- Added value due to increasing resolution of dynamic model
- Output from dynamic model needs to be post-processed
- An overall uncertainty of ~0.8 m/s is reached

Potential modelling

- Austria's wind potential estimated with respect to technical/economical constraints reflecting current state
- Flexible web-based GIS application with fast on-the-fly calculations implemented taking care of the complexity of wind potential estimations
- Wind potential analysis gives an upper limit per construction (access roads not considered; socio-political influences excluded)
- Realistically achievable potential is multiple times larger than currently installed wind energy turbines
- The modelling approach is ready to use for climate impact studies



Danke für Ihre Aufmerksamkeit!







→ Combined dynamical/geo-statistical modelling approach

Dynamical models (as used in NWP and climate research)

- Simulation of the temporal evolution of atmospheric processes
- Land/atmosphere interaction, planetary boundary layer processes, ...
- + independent from observational data
- + generation of time series
- limited spatial resolution (~km); small scales are unresolved
- time consuming calculations (\sim months) \rightarrow high performance computing systems

(Geo)-statistical models

- Interpolation of observational data based on empirical background information
- Small scale features are considered (land use, orography, ...)
- + very high resolutions are achievable
- + short run times (desktop PCs are sufficient)
- density and quality of observational data are crucial
- generation of mean values; no sophisticated frequency distributions





Evaluation of the dynamic modelling step (1981 to 1990)

Single stations show high variability



 → Output from dynamic models need to be "post-processed" (bias correction, MOS, etc.)





Statistical modelling step

• Application of a spatially distributed scaling factor













14 Modelle (18 km Auflösung) aus dem ENSEMBELS Projekt

