

WINSENT - open wind energy research platform in complex terrain

IEA TEM # 101, Hybrid Power Plants: Challenges and Opportunities
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Motivation

Expansion of onshore wind energy

- All over Europe and the world -

- Increasingly, more **exposed locations** are developed
- Increased deployment of turbines in areas with **complex flow** due to the topography and forests
- **Difficulties** in **determining the wind potential** and in **estimating mechanical loading**
- **Further technological developments** of wind turbines



Demands on wind energy test site

- **Accessible, open-source research turbines** only in USA, but in **flat terrain** (NREL)
- Test sites in Europe for **large commercial Multi-MW** wind turbines (ECN, DTU) and an **experimental wind turbine in flat terrain** (DTU)
- Planned test site in Northern Germany “DFWind”: two large multi-MW research turbines as well as an **experimental wind turbine in flat terrain**
- **Spanish test site Aláiz** in mountainous terrain, operated by CENER, use by **commercial wind turbines**
- **Lack of accessible, open-source, modifiable research turbines in complex terrain**

→ **Several letters of support and expressions of interest** by national and international research institutions as well as by companies



WINSENT - Realization of the wind energy research facility

- Research Project “WINSENT”
(**WIN**d **S**cience & **E**ngineering Test Site in Complex **T**errain)
- Starting Dec 2016
- Duration: 3.5+ years
- Project lead and operator of test site: WindForS member
ZSW (Center for Solar Energy and Hydrogen Research
Baden-Württemberg)
- Four sub-projects
 - 1) Coordination
 - 2) Installation and Operation
 - 3) Mikroklima - accompanying research project
 - 4) FoWEA - accompanying research project

Supported by:



Federal Ministry
for Economic Affairs
and Energy

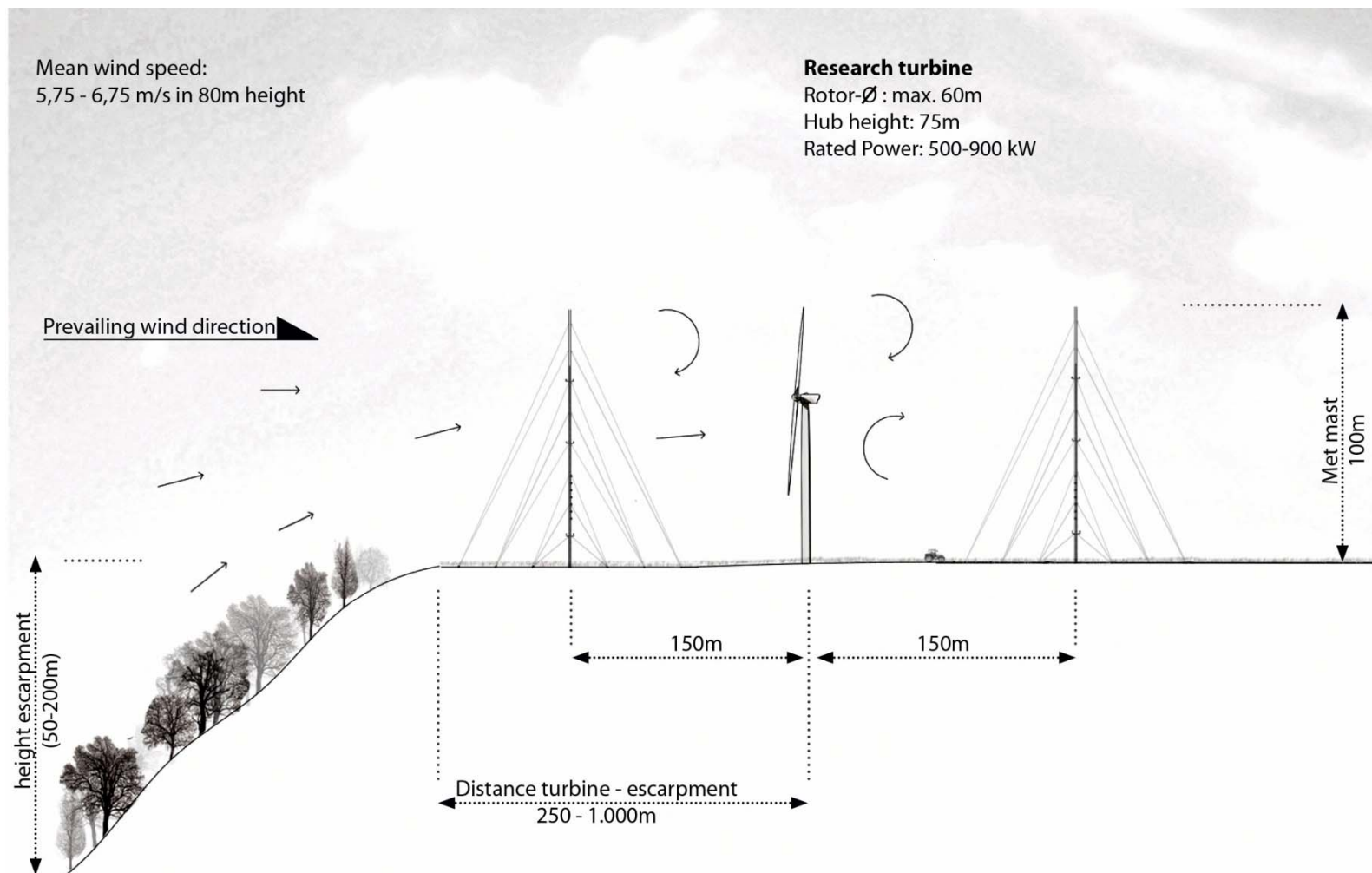
on the basis of a decision
by the German Bundestag



Baden-Württemberg

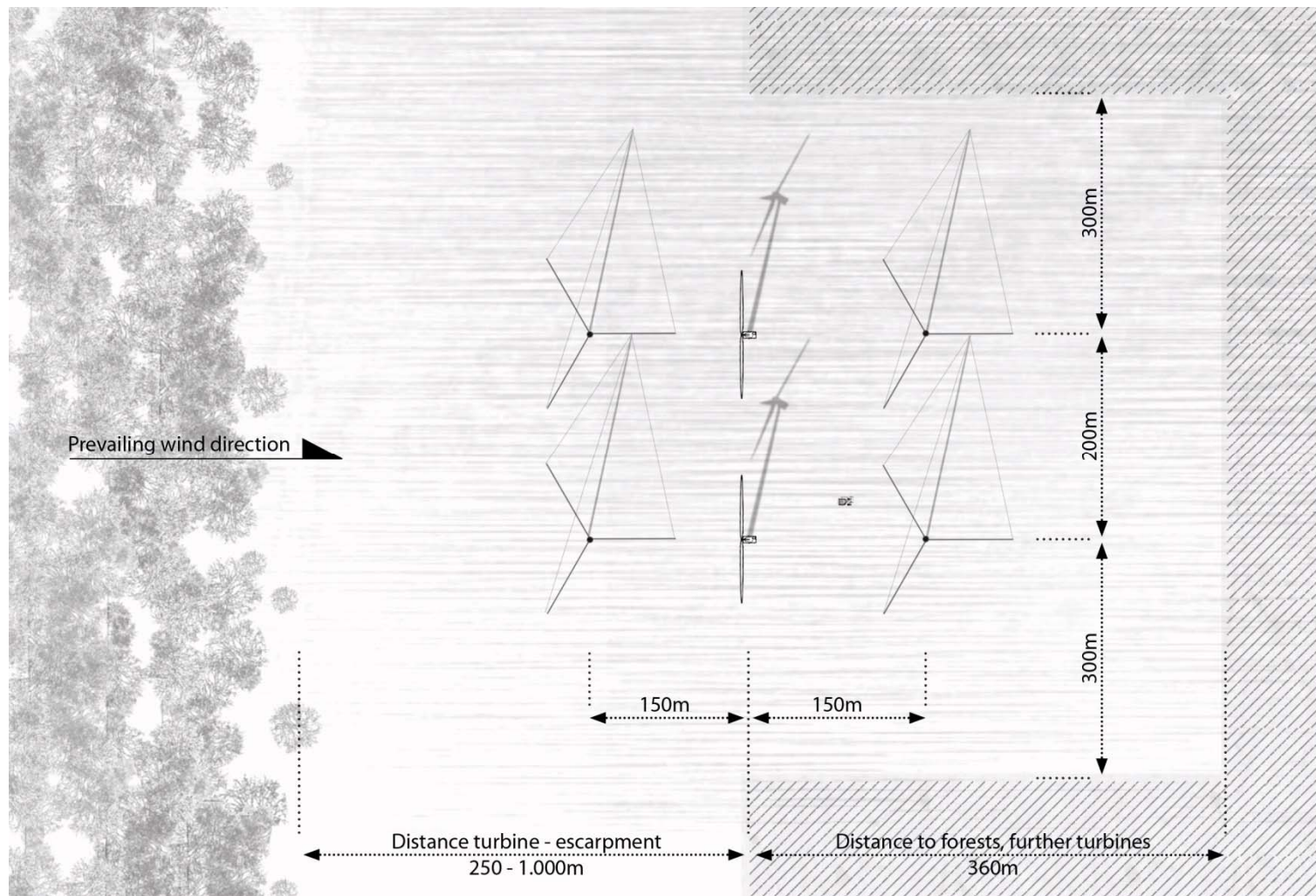
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

Test site setup

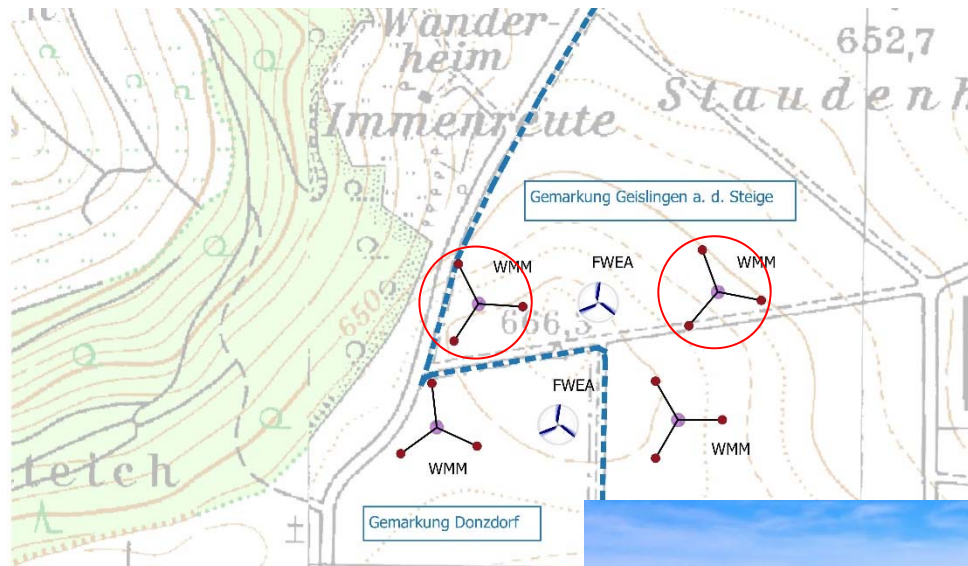


[Fig. WindForS]

Test site setup



[Fig. WindForS]



[Fig. ZSW]

Construction of WMM-NE
September 2018 in addition
to open field measurements
(Lidar, Eddy-Covariance
stations)



Research Wind Turbine: ATB 750.54

- Designed by S&G Engineering GmbH, Germany
- Build by ATB RIVA Calzoni SpA, Italy
- 73m hub height, 54 m rotor diameter
- Rated power: 750 kW
- Variable speed, individually driven pitch motors
- Acquisition of the turbines and their know-how as well as their future operation by ZSW

Modifications

- Fully equipped with measurement sensors acc. to IEC 61400-13
- Installation of measurement equipment as e.g.
 - load sensors (strain gauges, fibre Bragg gratings) in tower, hub, blades,...;
 - seismic and acoustic sensors
- Platform on the roof for installation of e.g. nacelle-lidar
- Electrical components
- Baseline turbine controller

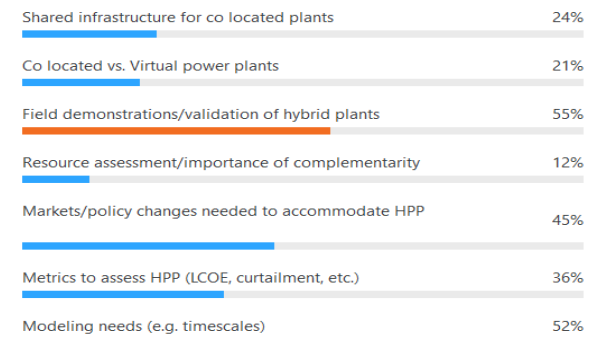


[Fig. ATB RIVA CALZONI SpA]

Possible future field demonstrator of a hybrid power plant?

- Would the size fit?
 - 2.7 MW maximum possible connected load at the transfer station
 - 1.5 MW rated power of both research wind turbines 750kW each
 - 1.2 MW margin for further sources
- How could the mix out of wind, PV and storage look like?
 - Simulation and optimization of Hybrid Power Plants with e.g. ZSW-tool P²IONEER or others
 - PV in the surrounding: open space and/or roof installation
 - Implementation of hydrogen storage devices, electrolyzer, P2G, accumulators and others

1. After discussion, which are the 2 topics you feel are most important for international collaboration within IEA Wind? (Mehrfachauswahl)



IEA TEM#101 survey 1st day

Possible future field demonstrator of a hybrid power plant?

- Are the chosen turbine components prepared for HPP?
 - The converter systems of both turbines are located in the transformer stations outside the tower (as part of the modifications) → with enough space for extensions
 - The converter systems allow to implement further renewable sources or storage systems to the DC link interface
 - The main wind turbine controller is directly integrated with the controller of the converter
 - The turbine controller is self-developed (USTUTT-SWE) within the WINSSENT project and will be open-source afterwards

Future Research Objectives at WindForS Test Site

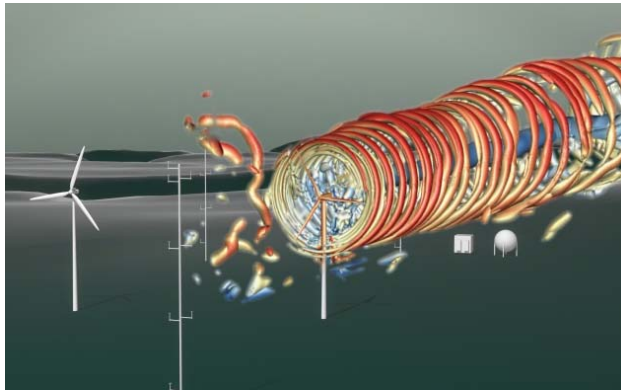
- **Testing and validation of new technologies**
Design, aerodynamics, aero-acoustics, aero-elasticity, manufacturing engineering, operation, measurement sensors, monitoring, noise reduction, ...
- **In-depth basic research in meteorology** for wind energy use in mountainous complex terrain, including icing
- **Development and verification of simulation software**
 - for the **design of wind turbines** as a complete system
 - for **wind field modeling in mountainous, complex terrain** (incl. meso-microscale coupling)
- **Energy storage** (e.g. Power-to-Gas, Batteries) **and grid connection**, further development to a **hybrid power plant (?)**
- **Nature conservation research**
- **Collaboration** with other universities, research institutes, industry, etc.

Vision: Research turbines on different sites and in different terrain

- Same turbine type at different sites: flat terrain, forested terrain, mountainous terrain, offshore, floating etc.
- Collaboration and international exchange
- Comparison of turbine behaviour, turbine control, meteorology, HPP, etc.

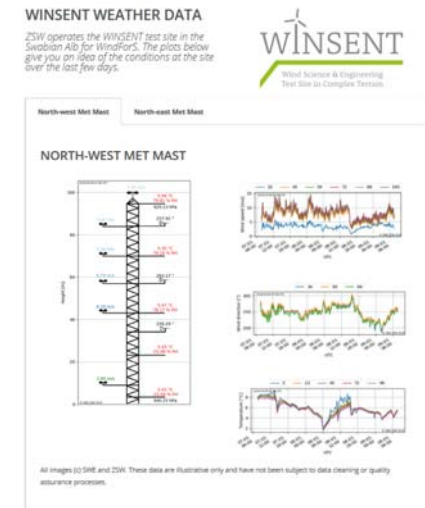


Thank you for your attention!



Video

www.windfors.de/en/projects/test-site



Weather at the site

www.windfors.de/en/projects/test-site/winsent-weather

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Additional slides

**Center for Solar Energy and Hydrogen Research
Baden-Württemberg**

**Zentrum für Sonnenenergie- und Wasserstoff-
Forschung Baden-Württemberg (ZSW)**

Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW)

1988: ZSW was established as a non-profit foundation under the civil code.

2019: 275 employees work at 3 locations in the State of Baden-Württemberg (Turnover 2019: 48 m. EUR)



Goal of the foundation:

Industry-oriented research and technology transfer in the field of renewable energies.

Research Topics



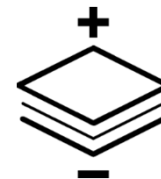
Research Topics



PHOTOVOLTAICS



RENEWABLE FUELS



H₂ AND FUEL CELLS



BATTERIES



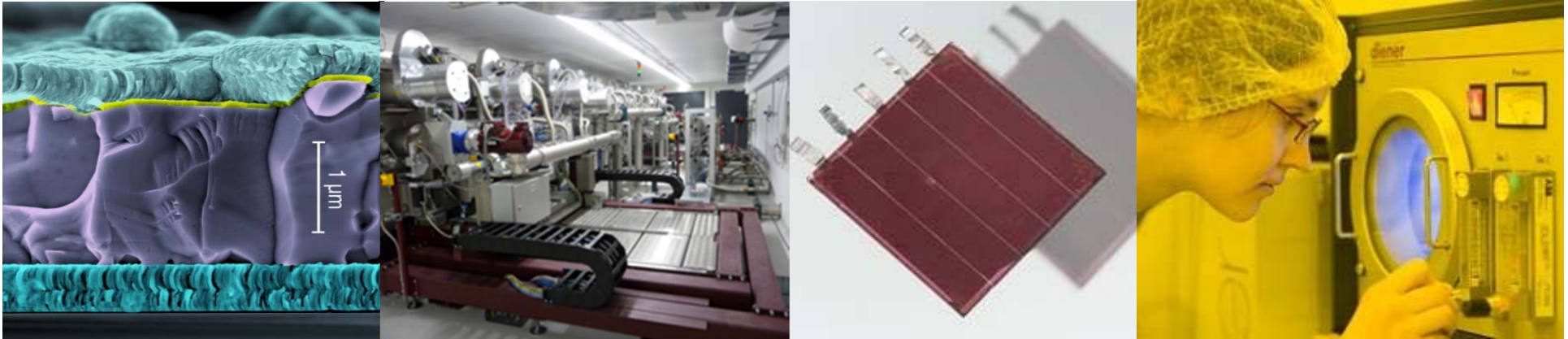
SYSTEMS ANALYSIS



GRID INTEGRATION
AND MOBILITY

<https://www.zsw-bw.de/en/research.html>

Photovoltaics: Materials Research



- Semiconductor development
- Thin films
- Manufacturing processes
- Flexible solar modules
- New materials for solar cells

Photovoltaics: System Technology



- Module technology
- System measurements
- Yield estimates and site appraisals / consulting
- Customer-specific indoor and outdoor testing
- Solar testing facility in Widderstall
- Grid integration of PV plants with energy storage and self-consumption

Renewable Fuels



- P2X electrolysis
- CO₂ generation from biomass and air
- P2X on-site support
- Carbon from residues
- Raw material recycling in fluidized bed processes

Hydrogen & Fuel Cells



- Catalysts & Membrane-Electrode-Assemblies (MEAs)
- Stack-technology, modelling and simulation, stack integration
- Fuel cell test centre & fuel cell systems
- Electrolysis & hydrogen for mobility
- New energy storage concepts

HyFaB
Forschungsfabrik für H₂ und
Brennstoffzellen

HyLaB
Labor für Wasserstoffqualität

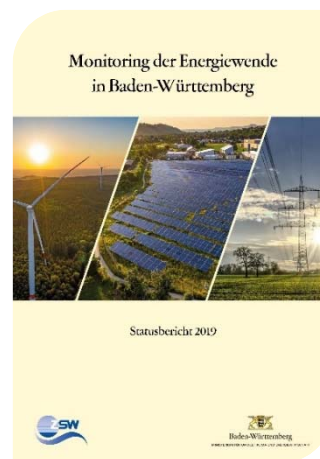


Batteries



- Materials research and post-mortem analysis (Li-ion, Post-lithium)
- Electrode and cell manufacturing from laboratory scale to close-to-series production (round, pouch & PHEV-1 cells)
- Battery test center, parameters, life-time and safety
- Battery management, modeling and simulation

Systems Analysis



Exzellenzinitiative zum Monitoring-Prozess „Energie der Zukunft“
Stellungnahme zum
zweiten Fortschrittsbericht
der Bundesregierung für
das Berichtsjahr 2017
Berlin • Münster • Stuttgart, Mai 2018
• Prof. Dr. Andreas Lischke (Vizepräsident)
• Prof. Dr. Ingrid Isenhardt
• Prof. Dr. Ingrid Isenhardt
• Dr. Hans-Joachim Lischke
Zusammenfassung

ENERGIE DER ZUKUNFT
Exzellenzinitiative zum Monitoring-Prozess „Energie der Zukunft“
Stellungnahme zum
zweiten Fortschrittsbericht
der Bundesregierung für
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Berlin • Münster • Stuttgart, Mai 2018

- Subsidies for renewable power
- Monitoring and evaluation
- Sustainable mobility
- Heat and efficiency
- Scenarios and feasibility studies
- Wind Energy
- Machine learning, forecasting, optimization

