Offshore~WMEP – Monitoring offshore wind energy use

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Abstract – Offshore wind energy use is commonly suggested to play an important role in future electricity supply. However, long-term experience with thousands of onshore wind turbines explicitly hint on possible barriers for a save, efficient, economic and user friendly supply relying on offshore wind energy. A national German programme shall on the one hand support the wind energy branch improving technology and O&M procedures towards higher reliability and availability, and on the other hand monitor the development in terms of techniques, electricity yields and cost. In the following, this scientific monitoring programme, the 'Offshore~WMEP' (OWMEP), is presented. The actual challenge of this programme is to convince numerous players with diverse points of interest to collaborate in gathering data and providing it for a jointly utilized database.

I. Introduction

20 years ago the German government made renewable energies a priority. Especially wind energy became a leading role and experienced an enormous upturn due to the Electricity Feed-in Act. The wind energy utilization is on its way to become the most important renewable energy source. With the "Scientific Measurement and Evaluation Programme" (WMEP) [1], included in the German subsidy measure "250 MW Wind" and funded by the federal government, the deployment of this technology was monitored over a period of more than fifteen years. The resulting data base of this programme contains a quantity of detailed information about reliability and availability of wind turbines (WTs) and subassemblies and provides the most comprehensive study of long-term behaviour of WTs worldwide. It provides the opportunity to gain basic insights into wind energy and to address larger political questions.

Today, the offshore wind energy faces similar challenges as the wind energy on land at the beginning of the WMEP. It can not be considered as assured that the wind energy use up to 100 kilometres off the coast in water depths up to 40 metres fulfils the technical and economic hopes. Several years after the erection of first offshore wind farms decision-makers in politics and in the energy and finance sector will need to rely on detailed information for defining the future of offshore wind energy in Germany. For further development, data and insights on technology and cost developments must be available. Risks in the range of installation, logistic, operation, and grid integration of large offshore wind farms should be minimized by means of verifiable analyses and results.

Additionally, a trend to decreasing reliability of large WTs with high rated power and more complex technical concept can be recognized [2]. The availability of different offshore wind farms in UK, Denmark, or Netherlands does not reach in the least the availability onshore of about 97%. Obviously, in terms of reliability and availability the optimization of maintenance processes and component design is urgent. To accomplish these challenges, reliability and availability of WTs for offshore use has to improve and hints at the feasibility and economic efficiency of offshore wind energy are required. The findings of the OWMEP shall support all players in wind industry and enable the general public to evaluate the offshore wind energy use.

II. OWMEP Concept

The OWMEP is part of the research initiative 'Research at Alpha Ventus' (RAVE) funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). On the one hand fundamental questions concerning the use of offshore wind energy shall be answered by a general monitoring, and on the other hand operating experience shall be collected and analysed systematically in collaboration with operators and manufacturers.

After a certain time of operation investors, grid operators, banks, insurance companies, and politicians will need reasonable data and findings to decide on the next investments or to provide economy with adequate frame conditions respectively. Gathering data will generate a large database which will contribute to political decision-making processes and facilitate further technological progress. The generation of a common database will, due to its size, enable statistically reliable predictions concerning the success of operational concepts. Furthermore, based on anonymous benchmarking and weakness analyses, operators and manufacturers have the opportunity to test and, if necessary, to optimize the performance of their offshore wind farms.

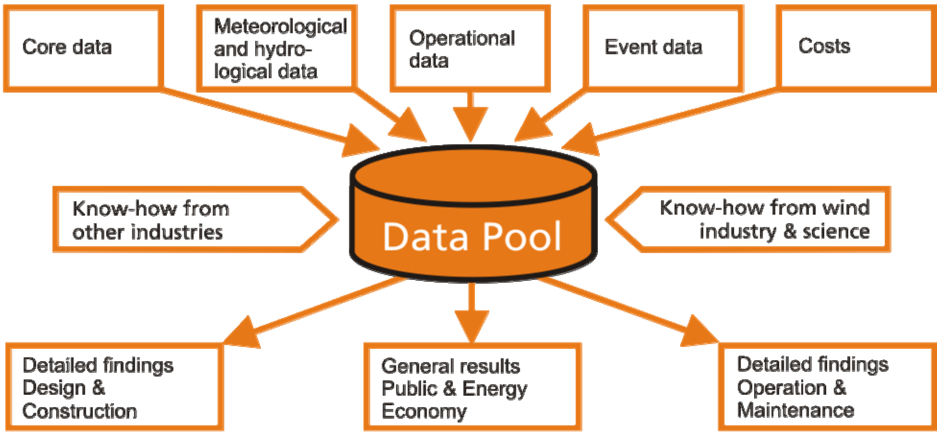

Figure 1: Offshore-WMEP data pool

In order to get a large statistical basis for evaluations and therefore results with strong validity, it is planned to include as many German wind farms as possible and even wind farms abroad. Leading operators have already shown interest to include data of their international wind farms. The incentive for the operators consists of a systematic preparation of operating and maintenance data that should indicate weak points of technology and non-effective maintenance processes. The participants of the programme provide a data pool held in trust by the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES, former ISET) with their data and get scientifically substantiated analyses of their offshore wind farm performance in return.

III. Standardized Database

As mentioned above a large database for results with strong validity is indispensable. To obtain a large statistical basis for analyses, information has to be stored in a standardized form [3]. Even databases like WMEP reach their limits of statistical capacity due to the parameter diversity. Hence, a common and broad database as well as a standardized data structure is absolutely essential. Empirical experience with as many as possible WTs of similar design running under similar operational conditions should get evaluated jointly, to increase the statistical basis. Therefore, OWMEP collaborates with several partners in a project named ‘EVW - Erhoehung der Verfuegbarkeit von Windenergieanlagen’ (Improving reliability of WTs) [4], in which a standardized data structure was developed. This structure has been adapted for specific offshore conditions.

For an optimisation of reliability and availability a clear and unambiguous database is needed. The data structure consists basically of three parts: core data, working data, and result data, whereas the working data include information of all failures and damages. Wind turbine subassemblies are part of the core data. They have to get designated and structured by all players in a standardised way to correctly identify the subassembly affected. A 'Reference Designation System for Power Plants' (RDS-PP) [5][6], which is commonly used by operators of conventional plants, is going to be adopted by wind turbine operators.

Failures and damages are part of the working data. Appropriate data sets about failures and causes also include information about the current operational conditions at the very moment of occurrence. Thus, besides climatic and operational parameters also the status of operation has to get stored. Current work is aiming at adapting an existing designation system for failure attributes from German association VGB Power Tech [7] to the necessities of wind energy use. Conclusively, data have to be systematically collected, subassemblies consistently designated and operating conditions, failures and damages comparably described.

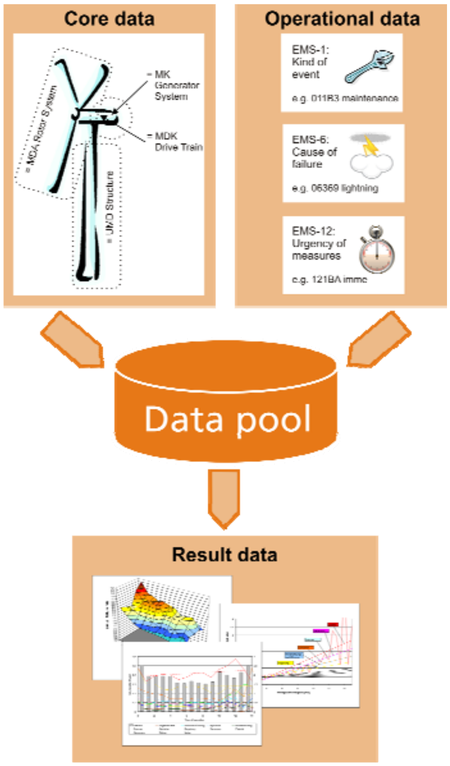

Figure 2: Data structure

IV. Research Topics

The main areas of research in the context of OWMEP, with particular emphasis on special features of the offshore technology and future development potentials, are shortly described in the following. The results will be divided into two groups. The first group of results will mainly be interesting for the public and politicians. The second group will be provided especially for operators and manufacturers, and therefore not going to be published.

A. Research Topics of Public Interest

Offshore wind energy deployment

Preconditions for offshore wind energy use in German seas differ in many points from application in other countries. As shown in Figure 3 German offshore sites are situated from 20 up to more than 100 km off the coast and WTs will be installed in water depths up to 40 m.

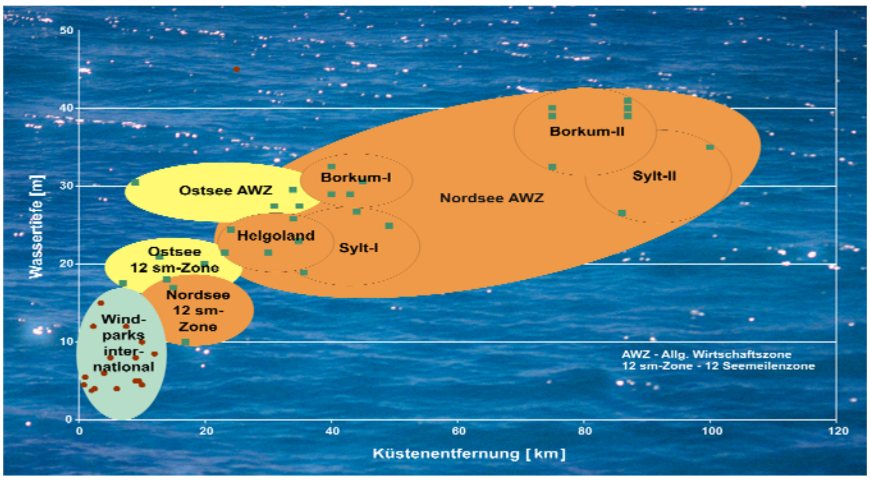

Figure 3: Comparison of the planned German offshore sites to international locations

Also, environmental conditions as wave and wind loads will differ. Thus, OWMEP will monitor the offshore wind energy deployment in terms of installation of wind farms and capacities, WT technology, sites in use, development of technology for foundation, and for installation as well as development of maintenance processes.

Site-specific offshore conditions

Offshore sites provide high wind speeds and therefore higher energy yields than onshore sites. OWMEP will collect measuring data on wind, climatic, and hydrographical data, by providing evaluations of mean wind speeds, vertical wind speed profiles, turbulence spectra, meteorological conditions, etc.

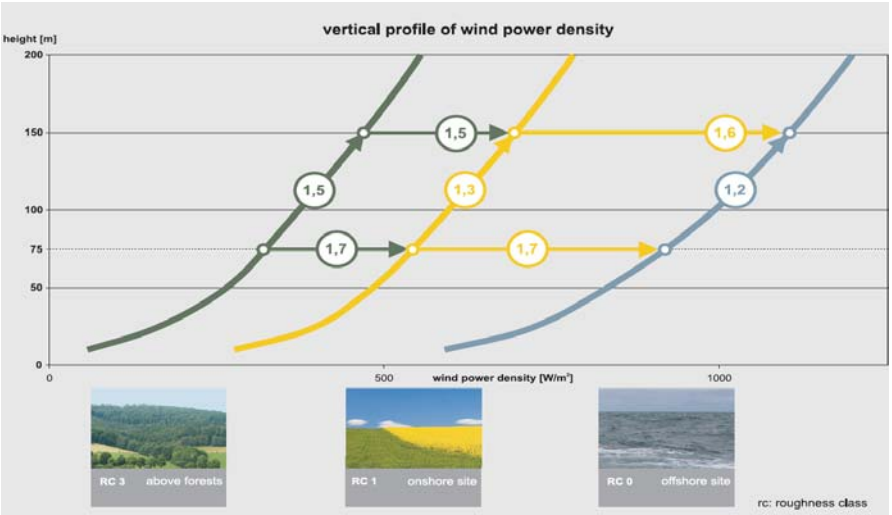

Figure 4: Wind energy potential according on hub height and location in general

Typical differences to onshore conditions as well as characteristic values for offshore full-load hours, specific energy yield, etc. will be presented anonymously to prevent from identifying results for single manufacturer or operator.

Economic development

An economic feasibility study of offshore wind energy should be carried out. The offshore wind energy use has to prove its profitability in the future. Investment costs and operating costs provide the basis to determine the yield-specific price.

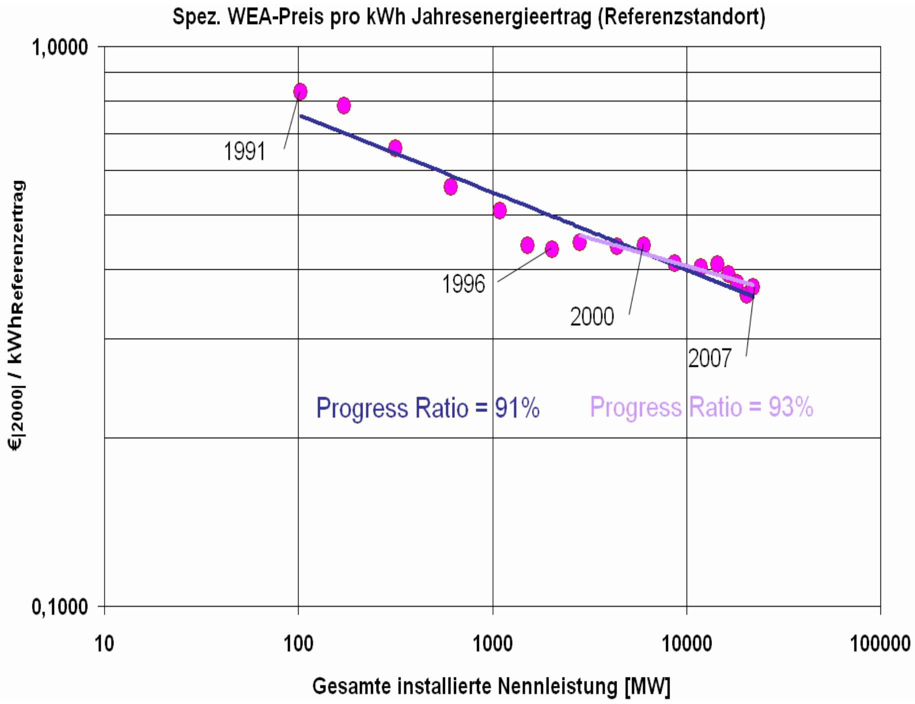

Figure 5: Specific WT price per kWh of annual energy yield at the EEG reference site in c€/kWh

The technique of calculating so called learning curves is used to evaluate the development of cost in terms of produced units and also to conclude on future potential for further declining with increasing production and installation.

Grid integration

The integration of offshore wind energy is a central issue and has still to be resolved. Matters like how the fluctuating nature of the wind power output from large offshore wind farms can be characterised with regard to its integration into the electricity supply system have to be settled.

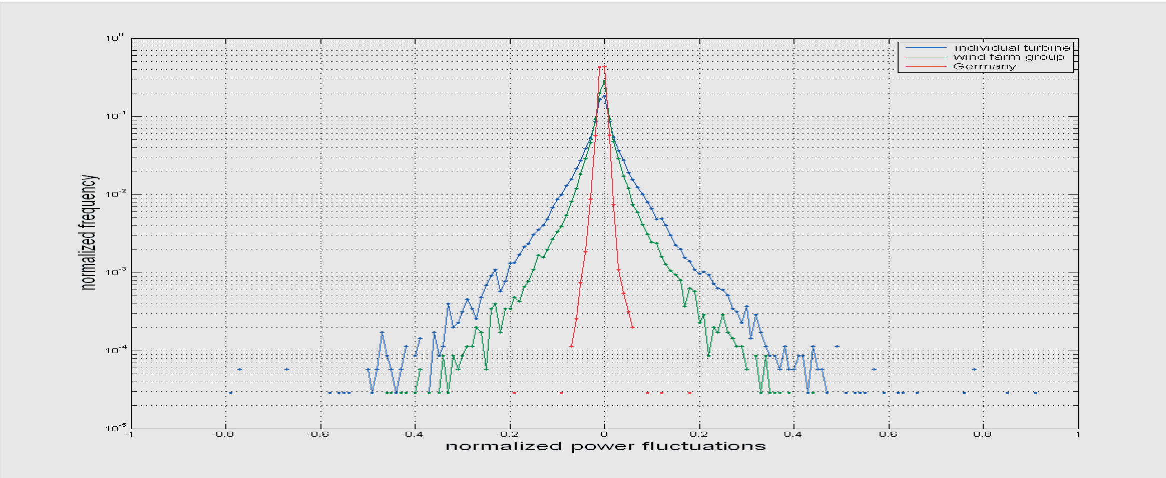

Figure 6: Power fluctuations of an individual plant, a group of wind farms and all the WTs in Germany

The OWMEP will monitor the deployment of different grid connection concepts with emphasis on advantages and disadvantages. Influences of black outs, windstorm cutoffs, integration of short-term fluctuation and fluctuating power generation into the grid as well as the development of the future offshore grid should be evaluated, monitored and cross-national compared.

B. Research Topics of Interest for Operators and Manufacturers

Reliability

Trends have shown that reliability of large WTs with high rated power and more complex technical concept declines. In terms of reliability the optimization of maintenance processes and component design is urgent.

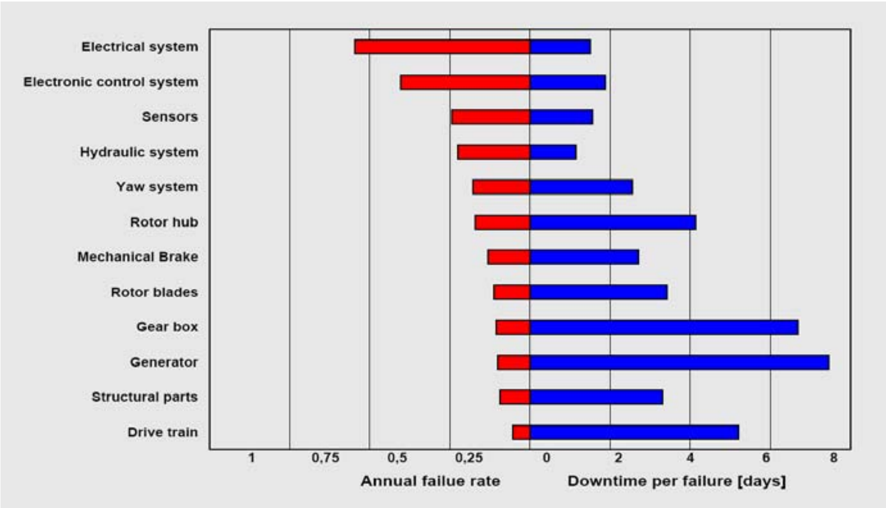

Figure 7: Frequency of failures of the subassemblies and typical downtime per failure

The decreasing reliability causes particularly with regard to the limited accessibility of offshore sites long downtimes and enormous financial losses. Therefore the reliability, focussing on failure rates of WT and subassemblies as well as on typical damages and reliability characteristics, should be improved in collaboration with operators and manufactures.

Availability

International wind farms are already in operation and deliver first experience concerning availability. For existing offshore application a drop of availability can be recognized and this can also be expected for future wind farms. To improve availability of offshore WTs it is necessary to analyse operational experience with onshore application for identifying problems, which can boost offshore.

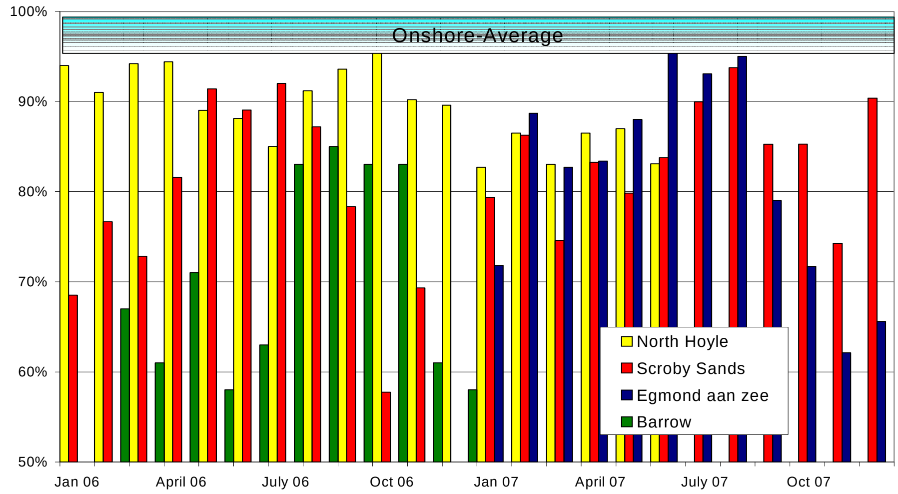

Figure 8: Availability onshore vs. offshore

Availability is dependent on failure rates, on downtimes for recovery after failures, as well as on downtimes for planned maintenance measures. Beyond that, specific meteorological situations, interferences, non-accessibility, lack of spare parts and logistic problems will influence availability. Different WT concepts as well as advantages and disadvantages of different maintenance concepts will therefore be analysed.

Weakness analysis

For optimising design and construction and for the choice of appropriate materials detailed knowledge about the stresses and strains of the subassemblies is mandatory. Weakness analyses would be the necessary input for deciding, which subassembly should be improved preferentially.

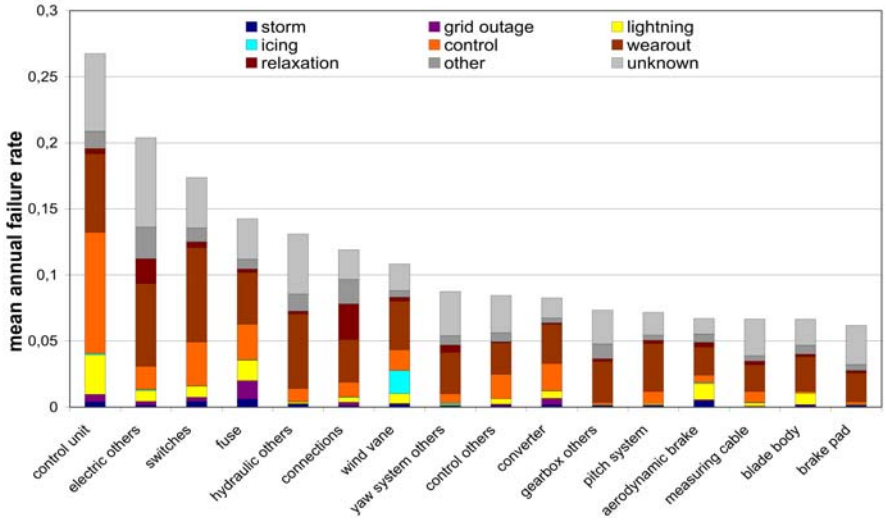

Figure 9: Weakness analysis for WT subassemblies including failure causes

Analyses of failure causes and failure modes would be necessary for improving details of component design. An example for a weakness analysis in combination with failure causes is shown in Figure 9 for an assortment of subassemblies.

V. Confidentiality

The OWMEP will collect, process, analyze, and disseminate essential data and results respectively to the public, government, operator, manufacturer, etc. Wind turbine manufacturers and wind farm operators will consider at least parts of the information required as sensible and may remain reluctant to provide it. Thus, one of the most important issues of OWMEP first phase is to maintain credibility and trust with the participants and to develop a concept of confidentiality, which will allow even competing parties to participate and to support the project actively. The confidentiality of data and analyses is central to accomplishing the OWMEP. Therefore an essential characteristic of the project is that only anonymous and non-confidential results are made available to the public. To avoid unauthorized transfer and access from third parties, compliance with the confidential treatment of data and results are secured by contractual arrangements and technical measures.

The confidentiality concept clarifies which data and which results will be publicly accessible, which information will be available for certain parties only and which will be provided to the wind farm operators or manufactures solely.

A. Confidentiality of data and analyses

The resulting data pool will consist of a variety of data, of confidential or non-confidential nature, which provide the basis of confidential or non-confidential results in turn and will be held in trust by the Fraunhofer Institute for Wind Energy and Energy System Technology (IWES).

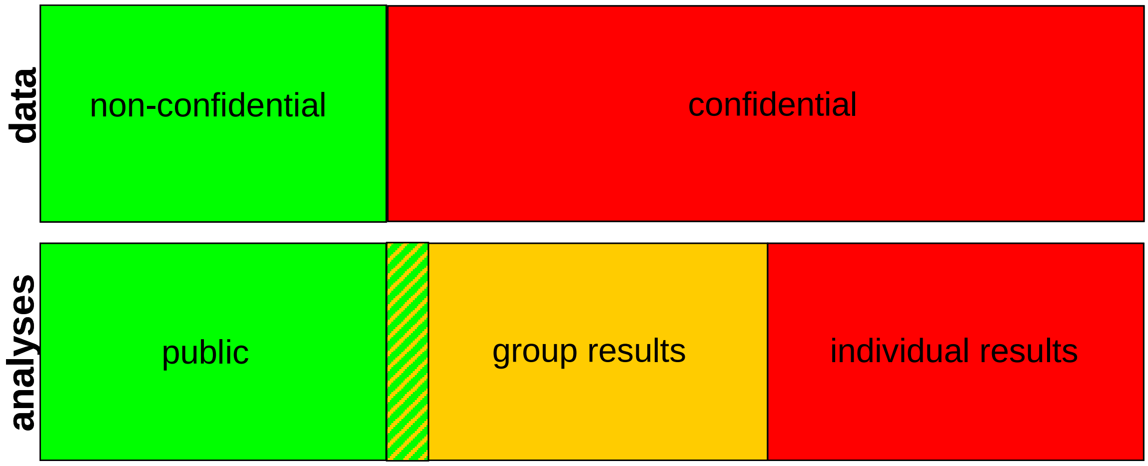

Figure 10: Concept of confidentiality

The results are basically divided into three categories:

Individual results

Results for a single participant are usually based on confidential data and are only available for this particular participant.

Group results

Results for groups of participants are always, if not unanimously decided otherwise, anonymized by aggregating. Thus, a certain group receives the same analyses in which their group is compared to a benchmark.

Results for the public

Only non-confidential data and results from non-confidential data may be published by IWES without further agreement. Certain results for the interested public that are partly or entirely based on confidential information must be approved by the participants in principle.

B. Safety

To prove the confidentiality, various approaches to protect information and data will be used, including computer technologies, statistical methodologies, and security procedures. The security measures ensure that only a restricted number of authorized people can access confidential information and data and that access is only granted to conduct the project work exclusively.

VI. Current status of the project

The work was started in late 2007. Firstly advantages of a monitoring programme for operators and manufacturers as well as for politicians and the public were identified in collaboration with all parties concerned. A quite successful workshop was held in 2008, in which more than 70% of the designated future operators (in Germany) stated their interest in the general concept and in participating. Currently, the data base has been worked out and the concrete way of collecting, transferring and evaluating data is discussed. After settling concept and processes, additionally to German offshore wind farms international ones shall get included. First operators from Scandinavia and Great Britain have already shown interest. Start of the first phase of operating is planned for 2010.

VII. Acknowledgements

The projects OWMEP (www.offshore-wmep.de) and EVW (www.evw-wind.de) are funded by the German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety. Besides, the partners 'Ingenieurgesellschaft für Zuverlaessigkeit und Prozessanalyse' (IZP), Dresden, and 'Foerdergesellschaft Windenergie und andere erneuerbare Energien' (FGW), Kiel, support by contributing to technical aspects as well as by implementing the results into guidelines and standards.

VIII. References

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