Lessons from German On-shore wind farm planning

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Abstract. China continuously maintains the first place of global wind energy with the national installed capacity of 188GW at the end of 2017, accounting for over 34.8% of the total world capacity. With the continuous increase both in number and height of wind turbines, the spatial planning has the task to provide suitable places for wind farms. Thus the rising demand for good locations is increasingly causing conflicts. The “13th Five-Year-Plan” of China aims to optimize the spatial layout of wind energy, resolving wind curtailment problems in North China and encouraging the construction of distributed, low-speed wind farms in South China for consumer near energy production. The ecological and social impacts caused by wind farms become more prominent in the densely populated areas of South China, which brings challenges to spatial planning and land use coordination. As a pioneer of wind industry, Germany is faced with similar problems and very early paid attention on spatial planning issues like wind farm site selection, environmental protection and land use planning. This paper compares the spatial planning systems of two countries and draws experiences from Germany to optimize the Chinese wind farm planning procedures. Planning principles and specific planning procedures for the integration of wind farm and spatial planning both in regional and local levels will be proposed according to the developing status of China. An on-shore wind farm planning framework will be set up implemented at each planning level, and coordinated with other land use and space functions to ensure the synchronous development of renewable energy and surrounding ecological and human environment.

Keywords. On-shore wind farm planning, German spatial planning system, Chinese spatial planning system, wind farm planning procedures

1. Introduction
China maintains the global first place of wind energy continuously with the national installed capacity of 188GW at the end of 2017, accounting over 34.8% of the world [1]. However, new challenges turn up with rapid expansion: serious “wind curtailment” in North China has seriously threatened the wind energy industry by the average “wind curtailment rate” over 17% in 2016 [2]. Chinese government has to slow down the pace and adjust the development strategy. Meanwhile, China has the arduous task of energy transformation by developing renewable energy. The “13th Five-Year-Plan” stipulates that at least 210 GW wind energy shall be installed to supply 6% of electricity consumption in 2020 [3]. The newly increased jobs will reach 300,000 from 2016 to 2020, reaching totally 800,000 jobs in wind energy industry of China.
In order to achieve the aim, the future focus shifts from large-scale wind farms in North China to low-speed, distributed wind farms in South China and for near consumption, which brings new issues in spatial planning field. Different from scarcely populated areas of North China, land use conflicts and various environmental impacts caused by wind farms will be more serious in densely populated areas of South China. Researches about specific wind farm planning procedures at the regional and local level as well as their combination with comprehensive planning are of urgent necessity in China. German wind industry with its advanced wind technologies as well as standard planning regulations and procedures is taken as a reference for China. This paper analyzes the contradiction between existing problems and wind energy targets of China, and difficulties to be encountered in the developing process. Then it elaborates from the aspects of spatial planning to compare the spatial planning systems between China and Germany. The planning procedures and experiences of wind farm in Germany are analyzed to put forward feasible suggestions for optimizing wind farm planning procedures in China.

2. Wind energy development status and difficulties in China
Since the promulgation of "Renewable Energy Law" in 2006, China has accelerated the development speed of renewable energy. As an efficient and clean substitution of fossil fuels, wind energy is stipulated as a priority project and enjoys subsidy policies. Since 2010, China has surpassed the United States and became the biggest wind energy market globally [4]. By the end of 2017, the cumulative wind capacity has reached 188 GW. In terms of quantity, China is undoubtedly a strong country in the wind industry. However, due to the huge domestic electricity demand, wind energy accounts for only 4% of the national electricity consumption. There is still much space for improvement. Figure 2 shows the rapid development period of China from 2010 to 2015 with the peak growth rate over 100%. Since 2016, wind energy development has entered an adjustment phase with a reduced growth rate. Newly emerging issues like wind curtailment in North China
need to be solved urgently. Except the technology reasons, improper spatial planning without sufficient analysis and standard planning procedures has caused serious problems like “wind curtailment”.

The Chinese “13th Five-Year-Plan” of wind energy has issued policies and measures to develop low-speed, distributed on-shore wind farms in South China. It stipulates that during 2016 to 2020 the newly installed wind capacity in South China should be over 57% and the total capacity over 1/3 (Figure 1). With the new development strategy, wind curtailment rate and grid burden can be reduced by nearby consumption, but more emphasis should be put on the wind farm planning procedures to control the negative influences on local residents’ life, visual landscape quality and environment [5]. These negative influences are mainly analyzed and avoided by wind farm planning procedures, while this part is just the weakness of the Chinese wind industry. For establishing detailed planning procedures at regional and local levels, the spatial planning systems of China and Germany have to be compared first.

3. Planning systems comparison between Germany and China

As Figure 3 shows, Germany and China have similar multilevel structures of spatial planning systems. German spatial planning system characterizes with clear vertical and horizontal structure (Figure 3). Vertically, it divides into federal-, state- and municipal levels with the regulation of decentralization, statutory division, competence and responsibilities respectively [6]. Horizontally, close combination between comprehensive planning and sectoral planning ensures a reasonable comprise in spatial planning and functional land use. As a developed country with mature spatial planning system, Germany has its own complete planning legislation, authorities and implementation dealing with various kinds of projects. German planning system emphasizes more on statutory division and equal rights in each state, which reflects by a mutual feedback mechanism in spatial planning system. The detailed regulations and implementations dealing with wind farm planning are gradually completed.
More elaborate site selection and planning procedures can be carried out on the basis of a detailed legal system and shared data. In contrast, China is still under urbanization process with a constantly adjusted and revised spatial planning system for adapting to emerging issues. Because of the huge territory and more government departments, the complex spatial planning system exacerbates the difficulty of integrating wind farm planning into spatial planning system. The Chinese spatial planning system has a clear multi-hierarchy structure with national-, provincial-, regional-, municipal-, town-, village levels. While the horizontal comprehensive planning consists of “Urban and Rural Construction Planning”, “Development planning”, “Land and Resource Planning”, “Eco-environmental Planning” and “Infrastructure Planning”, which are self-contained under different departments [7]. Compared with German, Chinese planning system places more emphasis on centralized arrangements and lacks local autonomy, which is reflected in the top-down planning mechanism. The coordination between various planning departments is difficult because of different regulations, management departments and implementation standards. The complexity of the planning system has brought about management conflicts among various departments, information inequality and inconsistent implementation standards, resulting in low planning efficiency and low adaptability to new planning projects.

As a newly emerging planning project, wind farm planning should set up communication and coordination mechanisms with comprehensive planning at each level. Germany can offer experiences and inspiration in dealing with wind farm planning procedures and related spatial planning issues.

4. Lessons from German on-shore wind farm planning

In Germany, wind farm planning belongs to the sectoral planning, which should have accurate correspondence with the comprehensive planning at each level (Figure 4). During the popularization process of wind energy, the wind farm planning will meet more conflicts with other land use and special protection areas. The normalization of wind farm planning procedures and integration into comprehensive planning is of urgent necessary. Several federal states like North Rhine Westphalia and Bavaria have already launched protocol platforms for coordinating wind farm planning and other sectoral planning, especially near the ecologically sensitive areas [8]. Figure 4 shows how the renewable energy planning fits into spatial planning system at each planning level. When meeting conflicts, clear and operational guidance is provided according to related regulations, which is supported by a complete legislation basement. Figure 5 chronologically lists the five phases of Chinese on-shore wind farm planning, which are effective and operational enough to ensure the totally 188GW wind capacity installation.

**Figure 4.** The planning system of landscape, renewable energy in Germany [6]
4.1 Macro Site Selection
The first phase is macro site selection by preliminary detecting the wind energy resource, available land, construction condition of the selected sites after getting agreement from local government, and drafting a report for further planning procedures. Before high accuracy wind energy resource conducted, the wind speed and wind direction can be estimated by topography and vegetation status as prejudge. The respective procedures are taken charge by different parties for fairness of project review. In Germany, the implementation of site selection is more refined with a nation-wide wind resource census (Wind Atlas Analysis and Application Program of Germany) and detailed available space classification. Germany has assigned 2% of the country’s land area as “concentration zones” for wind farm projects, which are priority areas for wind farm construction with legal effect after approval of the comprehensive planning. Other areas are assigned as suitable areas or restricted areas according to adjustable evaluation criteria for future development. This phase corresponds to federal- and state-level energy strategies, and it has a basic framework with adjustable flexibility.

4.2 Wind Energy Resource Measurement and Assessment
The second phase deals with wind resource measurement and assessment. In China, a wind resource test over 1 year and over 90% effective data is mandatory before wind farm project planning. A series of field work, test tower layout design, installation and data collection are the main task in this phase. Since the growing height of wind hubs, the latest wind resource measurements should be carried out at higher altitudes (e.g. 80 to 120 meters, at least 2/3 of the hub height). The latest equipments for wind measurements are IEC 61400-12 compliant calibrated wind transmitters, wind measuring mast and measuring computer. Wind resource simulation models are developed for high accuracy and less test towers. In Germany, European-wide wind measurement has already been carried out completed and shared by Wind Atlas Analysis and Application Program (WAsP) with high accuracy and long-term corrected statistics [9].

4.3 Wind Farm Project Planning
The third phase of Chinese wind farm planning is the wind farm project planning, which differs from German wind farm planning. Chinese wind farm planning is more engineering-orientation, concerning grid connection, wind capacity distribution, construction safety analysis as well as transportation condition. The environmental impact assessment and staging development are also included in wind farm project planning. But the coordination with other land use and reserve regions is mentioned only in the planning principle without detailed guidance, which is mainly because most already installed wind farms of China are located in wilderness without conflicts with other functions.

While Germany pays more attention to overall spatial planning coordination. Privileged projects like wind farm must be justified by a general plan. The municipal land use plan aims to balance the various aspects to find a reasonable compromise. Wind farm planning will be integrated as part of sectoral planning and should meet the demands of regional comprehensive planning. With the local announcement and Land Use Plan, the legal effect of Federal Building Code occurs, which means that wind farms are only in the designated concentration zones approved.

4.4 Feasibility Research Report
The Feasibility Research Report is investigated and drafted by the third party, usually the consulting company commissioned by the project company. This phase is a preparation for approval by analyzing project feasibility. Three most important indicators are “hours of wind farm operation yearly”, “cost of wind farm per KW” and “return on capital”. Environmental Impact Assessment is compulsory in this phase for evaluating potential impacts and finding variable solutions. The negative impacts like noise, shadow flicker, impacts on wild life should meet the basic legal requirements. But unified, detailed standards for preventing environmental impacts have not been drafted yet in China. Most current standards are referenced and studied from case study.

4.5 Approval and Construction
Difficulties in approval are usually in the vicinity of nature reserves and inhabited buildings or towns. After approved, a project construction permit will be issued to the project company. In the last phase, the implementation of the plan by construction management determines the project quality and actual impacts on the surrounding environment. It is seen as a part of planning for feedback and adjustment.

These five phases of Chinese wind farm planning are under the responsibility of corresponding planning companies and authorities, with clear tasks and outcomes. The division of wind energy planning procedures also facilitates project evaluation, implementation and financial investment. In terms of comprehensive comparison, the phases of wind farm planning in Germany and China are similar. Germany's strength lies in a more coordinated planning system, shared wind resource measurement data and extensive public participation. China's is still in the initial stage of wind farm planning development, more attention is paid to technical indicators, production and financial issues. There are insufficient researches on the environmental and planning system issues. With the new strategy of constructing more distributed, low-speed wind farms in South China, the wind farm planning will face more coordination problems in spatial planning systems.

![Lessons from Germany - Chinese On-shore Wind Farm Planning Procedures](image)

**Potential Surface Analysis**
- Setting “Hard taboo” and “Soft taboo” for different restriction requirements.
- Early Participation in site selection
- Total area analysis in GIS

**Wind Atlas Analysis and Application Program**
- Open official data for wind farm projects
- Unified test standards
- Update data in time

**Municipal Land Use Plan**
- Public Participation (Public, authorities, neighbouring communities and other bodies of public interests)
- Consideration of opinions and reinterpretation

**Pollution Control License**
- Protection of species
- Public interpretation and discussion
- Announcement of the approval

**Construction and Operation**
- Compensation measures
- Dismantling and Repowering

**Macro Site Selection**
- Preliminary Site Selection Plan
- Wind Farm Development Agreement
- Collecting Data
- Site Survey
- Macro Site Selection Report

**Wind Energy Resource Measurement and Assessment**
- Wind Resource Test Tower Layout Design
- Site Survey
- Wind Resource Test Tower Tender
- Wind Resource Test Tower Installation
- Test Data Collection (Over 1 year)

**Wind Farm Project Planning**
- Site Comparison
- Wind Turbine Layout and Capacity Design
- Access to the Power Grid
- Environmental Impact Assessment
- Phased Development

**Feasibility Research Report**
- Feasibility Research
- Coordination with Comprehensive Planning
- Coordination with other sectoral planning
- Feasibility Research Report Review
- Feasibility Research Report Modification

**Project Approval and Construction**
- Approval Documents Submission
- Approval Process
- Project Construction Permit
- Construction
- Test and Operation

Fig.5 Lessons from German on-shore wind farm planning (Drawn by author)
5 Conclusion
Due to the new development strategy, China will face more restrictions and challenges in on-shore wind farm planning. In this paper, a problem-oriented comparative study provides some suggestions for solving conflicts in spatial planning, protecting natural resources and environment, improving the efficiency of administrative approval, and optimizing public participation and supervision mechanism.

1) Statistical standards of basic data should be unifies. An open information communication platform in pre-planning phase should be set up to avoid duplication measurements and waste of social resources. A nationwide wind measurement standard and wind atlas can greatly improve the efficiency of macro wind farm site selection.

2) An authoritative, legally effective available land analysis is necessary to divided areas into different application levels like priority, suitable and restricted areas. Refine filter conditions and multi-level outcomes replaced single "wind energy area" is conducive to more rational and orderly development.

3) Coordination mechanism is necessary in land use plan to avoid the conflicts with e.g. natural protection areas, cultural heritage areas, landscape conservation and wildlife habitats. Amendment of related regulations and planning guidelines are necessary for preventing new impacts from new projects like wind farm.

4) Setting universal standards and procedures for wind farm planning, such as publishing laws and regulations at national level, designating concentration zones and buffer zones at regional level, stipulating technical indicators at local level.

5) Planning procedures should be adapted to local conditions and flexibly adjusted.
Wind industry is a comprehensive industry with multidisciplinary cooperation. In this paper, the importance of spatial planning is emphasized in optimizing wind energy distribution, improving wind energy production efficiency as well as sustainable developing with surrounding land use. A profound idea should be kept in mind that we should balance the wind energy profits and the costs paid for environment. Reasonable planning procedures can ensure the long-term development of wind energy.

6. Reference
[1] Global Wind Energy Council. 2017. The Evaluation of Wind Power. [http://gwec.net/global-figures/interactive-map/] [29.03.2018]

[2] National Bureau of Statistics of China. 2016. China Statistical Yearbook. [http://www.stats.gov.cn/tjsj/ndsj/2016/indexeh.htm]. [15.03.2018]

[3] National Development and Reform Commission. 2016. 13th Five-Year Wind Energy Plan. Wind power "13th Five-Year Plan". [http://www.ndrc.gov.cn/tzgggz/tzgh/gwhb/gjgh/201708/20170809_857302.html]. [18.03.2018]. 7-9.

[4] Global Wind Energy Council. 2010. Global Wind Report Annual Market Update. [www.gwec.net].

[5] Manyoky M. et.al. 2016. Evaluating a visual-acoustic simulation for wind park assessment. Landscape and Urban Planning. 153. 180-197

[6] Gerd Turowski. 2002. Spatial Planning in Germany. Structure and Concepts. Hannover.11-26

[7] Wang, XD. & Liu, WD. 2012. China's Spatial Planning System: Status Quo, Problems and Reconstruction. Economic Geography. 32 (5). 7-15.

[8] Schöbel. S. 2012. Windenergie und Landschaftsästhetik. Zur landschaftsgerechten Anordnung von Windfarmen. München. 128-142.

[9] Heier. S., 2016. Nutzung der Windenergie. Bonn. 107-110.