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The Spatiality of Standard Evolution â?? Standardization in the Wind Industry from a Spatial View

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Abstract

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on

The Spatiality of Standard Evolution â?? Standardization in the Wind Industry from a Spatial View

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Standards play an important role in industry evolution. The co-evolution of standards and clusters, however, is less scrutinized. The paper shows how different clusters participate in standardization, while standards again affect clusters. Standardization in the relatively young and dynamically globalizing wind industry will be used. A framework by Menzel and Grillitsch (2014) is applied to show differing interrelations between cluster and standard evolution during standards formation, diffusion and impact.
Data is collected via documentary research of standard documents and guidelines as well as academic and industry literature. Supplemental qualitative interviews with standard setting institutions and certification companies are conducted.
Results show, that standard development started in countries with a strong industry, especially in Denmark, whose manufacturers dominated the early market. Due to joint efforts of public and industrial actors, standardization often was spatially connected to wind industry clusters.
Standardization in further European markets resulted in the coexistence of various national standards, which later were

re-combined to create international ones. These are today especially developed by the International Electrotechnical Commission (IEC), located in Switzerland. Thus, their definition is spatially no longer connected with a strong market. Standards today influence the whole industry, as, for examples, Global Value Chains are being modularized and industry relations change accordingly. These impacts again affect wind clusters in different regions.
The paper thus shows the distinct spatiality and interrelation between standard and cluster evolution.

Literature

Menzel /Grillitsch (2014) Divergent Spatialities and Interdependencies between the Evolution of Standards and Clusters. Paper presented at the Workshop on Cluster Life Cycles in Kiel, September 15-16. 18 pages

Jelcodes:L15,L23

The Spatiality of Standard Evolution – Standardization and Certification in the Wind Industry from a Spatial View

December 2014

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Abstract:

Interrelations between standards and industry evolution are underrepresented in literature from a spatial point of view. Standards Evolution nonetheless has a distinct spatiality, which differs between its different phases of formation, diffusion and impact. Standards form in specific places, whereas their impact is rather ubiquitous. It furthermore is interrelated with the respective industry evolution, as standards play varying roles in different industry phases. The history of standards evolution in the wind industry and specific processes of standards formation and diffusion will therefore be reflected on their respective geographical context.

JEL Codes: L15, L23, (L50?) (L64?), (J80?)

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Introduction

Processes of codification are dependent on interactions that are facilitated by geographic proximity. However, the codification process itself is less important than the judgment as to which knowledge should be codified (Storper und Venables 2004). General standards and definitions usually arise at specific locations, in which the negotiations about standards take place. These processes, in particular the allocation of meaning which knowledge should be codified, take place in specific space (Amin und Cohendet 1999). Sturgeon (2003, 200) describes this as follows: „what gets worked out within spatial clusters is exactly the codification schemes that are required to create and manage spatially dispersed but tightly integrated production systems."

Additionally "[i]t is common for a standard-setting organization to develop a standard that includes a patented invention. When an industry standard includes technology covered by patents, the patents are referred to as "standard-essential patents" (SEPs)." (Nix and Bassolino 2013) It thus is important for technology companies as well as for standard-setting organizations to be close to each other.

As clusters are positioned at "the interface between industrial and local dynamics" (Menzel und Fornahl 2010, 2015), standards affect clusters as they alter the industrial environment and thus the rational under which clusters and firms within clusters evolve. On the other hand, standards formation is linked to specific places and might occur in clusters, which thus again affect industrial dynamics.

The wind turbine industry, although still relatively young, has undergone many and dynamic changes up to now. While the wind energy in its beginning was characterized by quiet local market developments, it today forms a rather global market. Standard development followed a similar pattern.

Similar to the globalization of the industry itself, the standardization and standards have come a long way from a national to international or even global reach. First standards were being set by national institutions as the Danish Wind Turbine Test Center (DWTS) in the 1970s, the British Standards

Institution or the Certification Committee for Wind Turbines in the Netherlands. Additionally certification companies such as Lloyds Register (United Kingdom) and Det Norske Veritas (Norway) or Germanischer Lloyd (Germany) started to develop guidelines for turbine testing. Nowadays international institutions, especially the International Electrotechnical Commission (IEC) and international associations, such as the Measuring Network of Wind Energy Institutes (MEASNET) are responsible for increasing the reach of guidelines and standards.

This paper will show these processes of industry and standards evolution for the wind turbine industry. It will reflect especially on the spatiality of standards as Menzel and Grillitsch (2014, 1) point out, that "there is a lack of a coherent framework to analyze the interrelation between standard and industry evolution from a spatial perspective. However, the uneven geography of standard formation, diffusion, and impact makes it necessary to integrate standards as research topic into the literature on cluster evolution."

The present paper focuses on the respective spatial pattern of standards and industry evolution, especially during standards formation and diffusion.

The following section therefore elucidates some definitions of different forms of standards and their distinctive features. The third part of the paper describes processes, strategies and reasons of standard evolution and their formation, diffusion and effects in general. After that the example of the wind industry will be used. First the spatial evolution of the industry will be shortly outlined. Following this, the formation and diffusion of standards in the wind industry will be described. Following the way of some standards, the spatial diffusion of standards will be shown in more detail. The last section concludes.

Standards and Standardization

Standardization can occur via the selection of market participants, through the activities of independent industry standard committees or resulting of actions by governments (Farrell und Saloner 1992). The different ways of standards formation lead to different types of standards. While de facto standards are (generally) chosen by the market and thus become a dominant design of a certain product, de jure standards are developed by (political) committees or by standard setting organizations (David und Greenstein 1990) and are referenced in law.[1] In terms of the process of standardization this means, that products are first commercialized before a de facto standard arises, while de jure standards are generally determined prior to the commercialization of a product.

Standards can thus be defined by the type of process of the underlying standardization. Another way in which standards might differentiate is the object the respective standard refers to. A product standard can hence refer to the quality of a product (e.g. specific minimum requirements) as well as to the product architecture (definition of interfaces).

While differences in quality are reflected by price, where there is clarity about the quality of a product. Quality defining standards decrease uncertainty about the quality and reduce complexity and transaction costs related to information (Ponte und Gibbon 2005).

Standards referring to the product architecture apply, for example, where interfaces are important for the communication between components, especially in modular products (Murmann und Frenken 2006). Even if each component of a modular product exists in a variety of different forms, such interface standards can lead to the existence of dominant designs. As the product architecture due to the interface standard results in a standardized architecture, despite the mentioned variety.

Another form of standards represents the meta-standards. Instead of referring to the product the object here is the company itself. The ISO9000 series, for example, thus applies to certification of quality management systems. Standards that relate to the production process, like fair-trade standards, do also fall in this category (Henson und Humphrey 2010).

The described differences in standardization processes and resulting standard types also implicate differences in the effects the standards have on the industry. De facto standards as the result of a

[1] Yet not all standards from committees or formal standard organizations are referenced in law and become de jure standards. Thus some committee based standards can also turn into de facto standards. http://www.iec.ch/about/globalreach/academia/pps/lect2007_1.pps (25.11.2014)

selection process in the market do not necessarily require to be codified. Since a de facto standard might refer to a specific product, this product itself contains the respective standard. A dominant design emerging during the evolution of an industry would be such a de facto standard. De jure standards on the other hand are being developed by private or public standard-setting institutions. These institutions prepare standards (e.g. guidelines for certification processes) to be published for use in the industry. The standards are thus codified in guidelines or rules (Menzel and Grillitsch 2014). As mentioned before, these standards are usually developed ex ante to the introduction of a certain product on the market. In other cases, anyhow, de jure standards follow the introduction of a product and might turn a given product into a standard. The QWERTY keyboard is such an example, as it was used in a typewriter and later provided a basis for an ISO (International Organization for Standardization) standard (Botzem und Dobusch 2012).

Menzel and Grillitsch (2014) show an overview of examples for different kind of standards, distinguishing de facto and de jure standards on the one hand and the objects (product, interface and process) on the other.

	Product	**Interface**	**Process**
De facto	3-bladed wind turbine	IBM-architecture	Assembly line
De jure	Requirements in health products	USB	Organic food

Table 1: Forms and examples of Standards (Menzel and Grillitsch 2014, 4)

The Spatiality of Standards and Industry Evolution

As mentioned before the interrelations between standards and industry evolution are underrepresented in literature from a spatial point of view. Although researchers found that standards and industry evolution are interrelated (Metcalfe und Miles 1994) and standards evolution thus has an inherent spatiality - as the formation occurs in particular places whereas standards affect firms in other places - literature on the spatiality of standards evolution in different phases is rather scarce.

Literature in the field of economics “especially distinguishes between economic effects different standards have, as reduction of transaction costs and facilitating increasing returns […] and discusses the evolution of standards (e.g. Suarez and Utterback 1995; Metcalfe and Miles 1994)” (Menzel and Grillitsch 2014, 1)

While the literature on Global Value Chains and Global Production Networks does deal with standards from a spatial perspective, it usually focuses on individual value chains. The role of standards for the governance of value chain refers in particular to the way in which standards affect different sections of value chains and production networks. (Ponte und Gibbon 2005; Ponte und Sturgeon 2014) Also standards are seen as one aspect that allows for the alteration of value chains and thus for the change of spatiality of Global Value Chains, which might result in a new dispersion of centers and periphery (Sturgeon 2003).

Nonetheless “[S]uch a chain-based perspective neglects the wider organizational spaces of the definition, codification, and negotiation of standards, as is the case with sector-based standards.” (Ouma 2010, 203-204)

As Menzel and Grillitsch (2014) point out the uneven geography in the three phases of standard formation, diffusion, and impact, their framework tries to show the distinct interrelation of these three phases with regional clusters. This idea bases on the assumption that there is a distinct spatiality within each of these three phases.

The formation of standards requires various steps, as the definition of which knowledge should be codified (Storper und Venables 2004), the negotiation of the standards as well as the codification process itself (Ouma 2010). The required knowledge about the object of the codification is embedded in specific places (Maskell und Malmberg 1999).

During the diffusion of standards, not only the increasing reach of a given standard but also the way it takes during this diffusion has a distinct spatiality. Standards can follow different paths during their diffusion. On the one hand, international standard setting institutions can start to develop international standards or can decide to implement former national standards as international ones. In the latter case, national standard setting institutions take the opportunity to introduce their own national standards as draft international standards to organizations such as the ISO or the IEC. Another way that allows standards to diffuse is described in institutional theory literature, where different forms of pressures are shown to play an important role during the diffusion of standards and lead to their adoption by further actors (Brunsson et al. 2012). The three forms of coercive, normative and mimetic isomorphic pressure reflect different reasons for organizations to adopt a certain standard. Coercive pressure describes the process in which, in a hierarchical way, a state (e.g. when EU norms have to be adopted by member state to formulate national standards), civil society organizations (e.g. in the case of social or environmental standards) or firms (e.g. when a buyer obliges its suppliers to adopt standards) demand the diffusion of standards (Brunsson et al. 2012, Henson und Humphrey 2010). Since the pressure is linked to the locations of political institutions, organizations of the civil society and firms, the diffusion via coercive pressure exhibits certain spatiality. Normative pressure again occurs, when a firm through the adoption of a standard shows it professional character and becomes part of a group that adheres to specific rules (e.g. in cases of standards for training processes of professionals) (Menzel and Grillitsch 2014). This form of pressure might be stronger between firms within clusters or spatial proximity (Menzel and Grillitsch 2014). When companies observe other firms and learn from their behavior, resulting in the adoption of standards mimetic isomorphism takes place. Since one benefit of firms in clusters is the possibility to monitor other firms behavior closely (Menzel und Fornahl 2010), spatial proximity seems to be of use in this kind of diffusion process.

Finally, as standards affect the economic environment of an industry, the resulting effects (as transaction costs reduction or facilitated increase of returns) enable alterations in the rationale and environments in which the industry as well as clusters evolve. On the other hand, how these changes effect clusters also depends on the specific qualities of the respective clusters (Menzel and Grilitsch 2014). These interrelations between the spatiality of standards formation, diffusion and impacts and regional clusters will in the following be shown for the standardization in the wind industry.

	Formation	Diffusion	Impact

Processes	• which knowledge should be codified (Storper 2004)
	• negotiation of the standards
	• codification (Ouma 2010)
		• Diffusion of standards, due to
		  • Coercive pressure
		  • Normative pressure
		  • Mimetic Isomorphism
		• Diffusion via standard setting organizations or committees
			• reduction of transaction costs
			• facilitated increase of returns
			• altered value chain governance

Spatiality/ Role of clusters	• Decision, which knowledge should be codified takes place in specific space (Amin and Cohendet 1999) • „[W]hat gets worked out within spatial clusters is exactly the codification schemes […]" (Sturgeon 2003, 200)	• „Clusters affect the diffusion of standards via providing institutional and relational environment for firms" (Menzel and Grillitsch 2014) • Normative pressure can be assumed to have an effect on firms behavior within a cluster • Benefit of being in a cluster is the possibility to observe the other firms behavior (mimetic isomorphism)	• enable alterations in the rational and environments in which clusters evolve • changes effect clusters, depending on the specific qualities of the respective clusters

Table 2: The spatiality of standards formation, diffusion and impact

Although standards spatiality seems to be different in all of these three phases, the paper will describe especially the phases of formation and diffusion. As it wants to show particularly how standards formation and diffusion differ in their spatiality in different phases of the industry evolution, the investigation of the impact of standards is not part of this paper.

The Spatiality of the Wind Turbine Industry´s Evolution

As mentioned in the beginning the standard evolution showed similar patterns as the evolution of the industry itself.

The wind energy industry is one of the most dynamic industries in the last decade. Thus, the amount of newly installed MW per year rose from 1.280 MW in 1996 to 35.289 MW in 2013 (gwec.net 2014). The industry development can be divided into three phases, representing changes in market and industry structure.

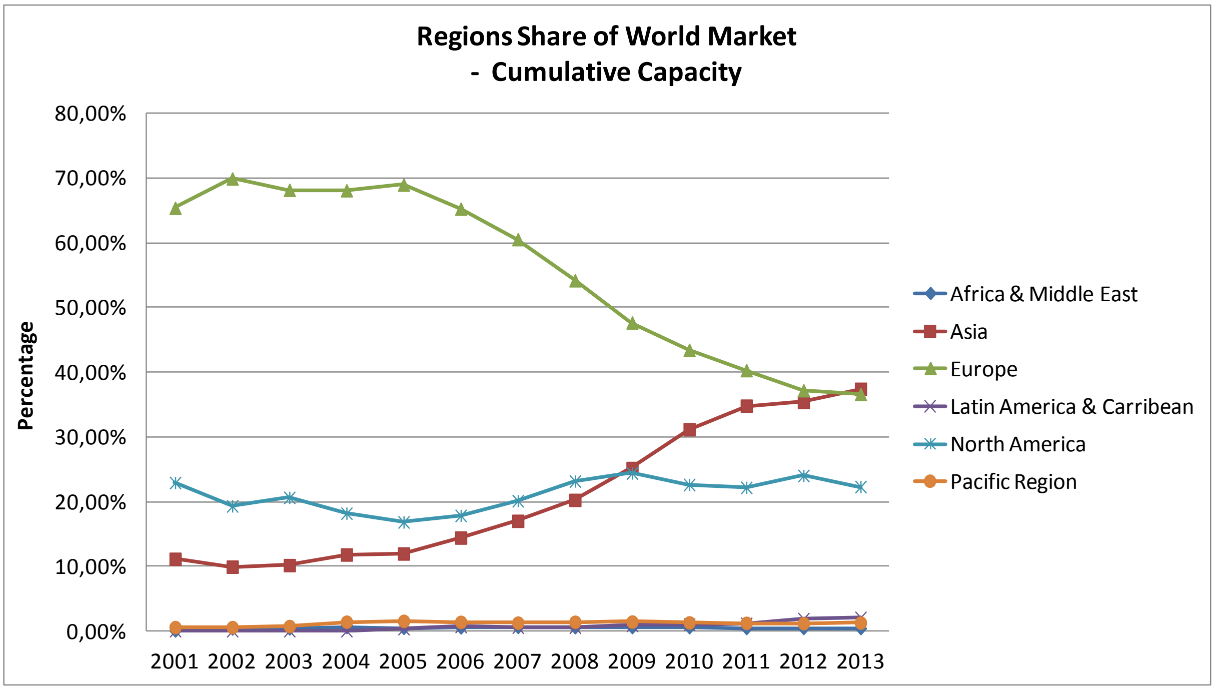

Figure 1: Market development from 2001 to 2013

The first phase of the industry evolution began in the 1970s and lasted until the mid-1980s. During this time, 97% percent of the worldwide installed wind turbines were located in California (Karnøe 1999, 183). In this market Danish and American companies competed. The "California Wind Rush", initiated by government funding led to a strong growth of the industries in both countries. Towards the end of the "Californian Wind Rush" anyhow more than 68% (Karnøe 1999, 183) of the turbines were delivered by Danish manufacturers. Due to these developments, it was especially the Danish industry that started to grow outside of its home market quite early. In 1986, the funding of wind energy in California ended, what led both to an end of this boom as well as to the decline of U.S. industry (Karnoe and Garud 2012)

After that, a second phase began in the early 1990s. In this phase, in addition to the Danish companies mainly companies from other European countries, like the Netherlands, Germany and Spain, entered the market as a result of increased demand in the respective countries. In the 1990s European companies had a global market share of over 80%, while the market was mostly limited to the mentioned countries. The market was organized oligopolistic with the four largest companies sharing up to 60% of the world market (BTM 2005).

The third phase began around 2005 with the increased entry of Asian companies, especially from China (Kammer 2011; Lema et al. 2011). This was due to the securing of energy supply in the fast-growing emerging markets. As in the European countries, an independent Industry emerged, also due to market entry barriers and specific support mechanisms (Klagge et al. in press).

Figure 2 shows, that these phases are reflected in the number of WTG-manufacturers in different countries. Industry evolution was thus a result of expanding markets. Yet while in phases 1 and 2 the industry actors were active especially in their home markets or the countries in their proximity, the industry today is rather global, with manufacturers installing turbines around the globe.

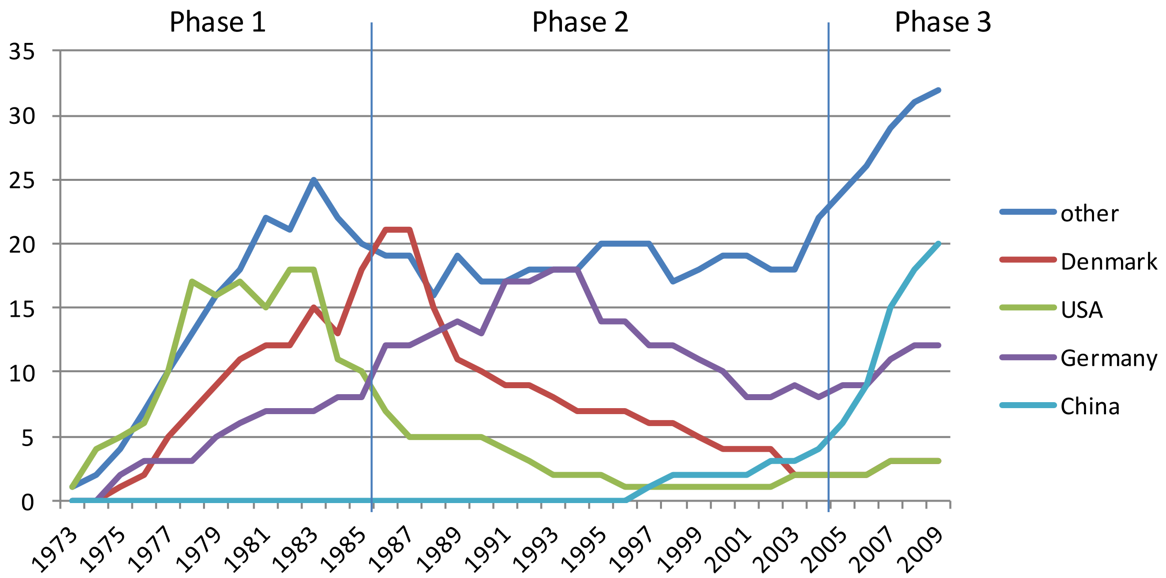

Figure 2: Number of wind turbine manufacturers by country (Menzel and Kammer 2011, 9)

The Spatiality of Standards Evolution in the Wind Industry

The first steps – national standardization

Certain standardization in the wind industry began almost 30 years ago as part of certification activities. “It has been applied differently in scope, requirements and depth only in Denmark, Germany and the Netherlands each on the basis of their own rules.” (Woebbeking 2008)

From the beginning on important drivers were - similar to shipbuilding - insurance companies. Due to that, major players developed particularly from the traditional classification societies for marine certification (e.g. GL and DNV).[2]

Generally, one can distinguish between type certification of WTGs as well as component certification on one side[3] and project certification as well as type tests in the context of building permit process on the other side. During the evolution of standards in the wind industry, however, this distinction was not as explicit as it is today. Guideline development went hand in hand with industry development and changing market environments and requirements. Thus, the mentioned present-day distinction is the result of the evolution of standards.

The arguably first steps towards the creation of testing guidelines for turbines were taken by dedicated engineers of the Reactor Technology Department at Risø from 1975 on. The Risø was founded in the mid 1950s and officially inaugurated in 1958 as the Atomenergikommisionens Forsøgsanlæg Risø (Atomic Energy Commission's research facility Risø), named after the small peninsula Risø, were it was located. (Nielsen et al. 1998) The work of the engineers resulted in the foundation of a National Test Station for Small Windmills in 1978. This Danish Wind Turbine Test Station (DWTS) received a grant from the Danish Energy Agency to support the newly forming wind industry. (Karnøe 1999) To increase the interest of the industry to cooperate with the DWTS, the Danish government in 1979 passed a law by which turbines, tested and certified by the DWTS could receive a subsidy worth 30% of the respective turbine selling price. (Nielsen et al. 1998)

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[2] Source: Interview with Bureau Veritas at the Hannover Messe 2013 on 11.04.2013

[3] Type certification: to confirm that type of WTG is designed, documented, and manufactured conforming to design specifications, specific standards and other technical requirements. Component certification: confirms that core components have been designed, documented, and manufactured conforming to the design assumptions, specific standards and other technical requirements.

Although the SERI (Solar Energy Research Institute) test and research center in the US (now National Renewable Energy Laboratory (NREL)) started its activities on 5th of July 1977, the center as a top-down program was never really accepted by the industry. "Except for an initial test of the first wind turbines, there was no systematic testing of commercial wind turbines." (Karnøe 1999, 165) The strategy of SERI to support the industry was rather "to pursue fundamental engineering science research in order to establish the theoretical basis for the design of an "ideal" wind turbine." (Karnøe 1999, 166) Thus, no actual guidelines or standards were elaborated.

The, however, globally first guidelines that dealt with plants for electricity generation and which contained considerations for planning laws, procedural rules - inter alia, for test facilities – as well as explanations for structurally engineered testing, were the "Preliminary Guidelines for the design, installation and operation of wind power plants" by the Ministry of the Interior of Schleswig-Holstein, Germany. These guidelines were published on the 30th of March 1982 by a group of experts and test engineers established in 1981. (Rave und Richter 2008)

In the same year, the Energy research Centre of the Netherlands (ECN), in Petten published the "Voorschriften voor Windturbines"(regulations for wind turbines). These guidelines however did not cover requirements for planning. Like the Risø (DK) or Swedish initiatives, the ECN didn't have a direct relation to permitting authorities, as it was the case in Germany (Rave und Richter 2008).

The first steps – The Example of Germany

Although the first formal guidelines in Germany were published by the Ministry of the Interior of Schleswig-Holstein (the core market of early wind energy development in Germany[4]), the first expert´s opinion for the reliability of operation, functionality and capacity for a wind turbine in Germany (of the MAN Project GROWIAN) was conducted by the Germanischer Lloyd in 1979

[4] Although the first commercial installation of wind turbines in Germany was dated back to 1982 by the DEWI Group, turbines were built sporadically until 1986. After Tschernobyl the numbers increased from 1987 on. Until 1997 SH was still the dominant market in terms of turbines and installed capacity, while Lower Saxony superseded SH from 1998 on. (http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_01/04.pdf (19.11.2014), http://www.dewi.de/dewi_res/fileadmin/pdf/publications/Magazin_14/03.pdf (19.11.2014)

(assigned in 1978). For the classification society GL this mandate marked the entry into the wind energy and resulted in the establishment of a Wind department in the GL (Rave und Richter 2008)

Nonetheless, the guidelines developed in Schleswig-Holstein (SH), revised repeatedly (1985, 1989 and 1991), were dominant until 1991. After that, federal guidelines shaped the wind industry.

One important player in this phase was the Institut für Bautechnik (IfBT - Institute for Building Technology, today DIBt) in Berlin. This facility has the object to establish nationwide uniform structural engineering regulations. Though it had basically no knowledge about turbines, it engaged strongly in the rotor blade material. In Germany all Construction Materials must be approved by IfBt or obtain approval in each individual case. In the beginning, blade manufacturers thus had to obtain individual approval for each manufactured blade, although the design and manufacturing did not change. Over time, the IfBt/DIBt improved this situation by implementing respective guidelines.

In 1986 the GL published its first guidelines for wind turbines. In its preparation several experts, especially also from the experienced authorities in SH offered their suggestions, so that the knowledge of previous guideline development was transferred into the GL guidelines. These German guidelines of the GL, which were revised several times in cooperation with SH and Hamburg were early applied internationally. The Austrian manufacturer Villas Construct, for examples, installed turbines in California in 1987 (3 x 500kW turbine) and on the Golan Heights (10 x 600kW) in 1992, which were tested under this guidelines.

In 1990 acoustic noise came to the center of attention. It again was SH that first ordered WINDTEST to develop respective guidelines, which were published in 1992 in cooperation with DEWI (German Wind Energy Institute). In the committees various national experts were involved and with WINDconsult another private institute later participated in the publishing of the guidelines.

Since this was a legal non-eligible group, a neutral organization was sought for. Therefore the FGW since then is responsible for this task. (Rave und Richter 2008)

The FGW was founded in 1985 as Fördergesellschaft Windenergie, a supporting foundation for the wind energy sector. This occurred at a time when the first large wind turbines were installed in Germany. At that time, the FGW has established itself as the institutional platform for the effective integration of the technical, economic and political aspects of wind energy use in Germany and beyond. (wind-fgw.de 2013)

Today, all these mentioned organizations are still actively involved in standards setting in Germany. Two examples of current important guidelines show the involvement of different interest groups in the formation of standards. One guideline, particular in the area of grid connection in Germany, which was developed by the FGW, is Part 8 of the Technical Guidelines for generating units and plants of the Society for the Promotion of Wind Energy (Fördergesellschaft Windenergie - FGW) „Zertifizierung der Elektrischen Eigenschaften von Erzeugungseinheiten und -anlagen am Mittel-, Hoch- und Höchstspannungsnetz“ (certification of the electrical properties of generating units and plants on the medium, high and extra high voltage network).

According to the FGW (wind-fgw.de 2011) representatives from the following groups have participated in the preparation of the above mentioned guideline (TR 8):

- Grid operators
- Manufacturers of generating units and components
- Institutes and Universities
- Certification authorities of generating units and components
- Plant certifiers and appraisers

Another current important guideline for wind turbines comes from the DIBt. The „Richtlinie für Windenergieanlagen - Einwirkungen und Standsicherheitsnachweise für Turm und Gründung“ (Guidelines for wind turbines - effects and stability surveys for tower and foundation), as amended from October 2012 as the revision of the 2004 version (See Series of the DIBt Series B, No. 8), "applies to the proof of stability of the tower and the foundation of wind turbines." (DIBt 2012)

In this Directive, inter alia, reference is made to DIN and GL, which shows that the guidelines of such private certification bodies have far-reaching meanings on standards, which are negotiated in standards committees with representatives of the industry. This shows the first signs of the diffusion of Standards as new standards use contents of existing standards as reference.

The guidelines have been prepared by the project group "Wind Turbines" in the DIBt. Representatives of institutes, certifiers, equipment manufacturers, suppliers and service providers as well as political actors have participated in it.

	Company/ Institution	Location
Institute	• Institut für Geotechnik, Leibniz Universität Hannover • Institut für Windenergietechnik, Fachhochschule Flensburg • Institut für Massivbau, RWTH Aachen, • Deutsches Institut für Bautechnik • Statik und Dynamik der Tragwerke, Bergische Universität Wuppertal • Institut für Stahlbau, Leibniz Universität Hannover	• Hannover • Flensburg • Aachen • Berlin • Wuppertal • Hannover
Certifier	• GL Industrial Services GmbH • TÜV SÜD Industrie Service GmbH • TÜV NORD CERT GmbH	• Hamburg • München • Essen
OEM/ Supplier	• ENERCON GmbH • REpower Systems SE • AMSC Austria GmbH	• Aurich • Hamburg • Klagenfurt
Service Provider	• Eusani-Hortmanns-Zahlten Ingenieurgesellschaft mbH	• Solingen
Politics	• Ministry of the Interior of Schleswig-Holstein	• Kiel

Table 3: Companies and Institutions of the project group „Wind Turbines“ in the DIBt[5]

International Standardization

First international efforts by the International Energy Agency (IEA) found entrance into the industry early in the form of recommendations. The first standards, anyhow as mentioned before were prepared by national institutions such as the British Standards Institution or the Certification Committee for Wind Turbines in the Netherlands. Another important role already back then played certification companies such as Lloyds Register (United Kingdom) and Det Norske Veritas (Norway),

[5] http://www.dibt.de/de/fachbereiche/data/Aktuelles_Ref_I_1_Richtlinie_Windenergieanlagen_Okt_2012.pdf (12.04.2013)

which began to develop their own guidelines based on their experiences from other industries. (windpowermonthly.com 2012)

For this reason, it is especially these countries, which still dominate the standard setting and the development of standards in the field of wind energy. But in the context of the globalization of the market and increasing investment in wind energy projects, the certification also gained importance in other countries (e.g. in China, Japan, India, South Korea, Spain and the United States (see Wöbbeking 2008) and started to play an important role for the banks.

Today, there are standards for testing of wind turbines at the international, regional or national level.

The international work to develop a standard for the process of the certification of wind turbines began in 1995 in the Technical Committee 88 (TC 88) of the International Electrotechnical Commission (IEC). The TC 88 had started already in 1988 with the standardization of wind turbines and has ever since completed standards on the safety of wind turbines, on the measurement of performance curves and noise, stress measurements, grid compatibility measurements, rotor blade testing and lightning protection. (Wöbbeking 2008) Today, there are 24 nations represented in the committees and are thus involved in the standardization work of TC 88. (windpowermonthly.com, 2012)

Thus, the international standardization began essentially with the start of the standard work in the field of wind energy by the IEC 1995. The first resulting publication (IEC WT 01 by the Conformity Assessment Board (CAB)) was released in April 2001.

On the international level similar requirements apply, as in Germany. Thus, in several countries type tests are required for the approval of the installation of wind turbines. Internationally recognized basis for certification are for example guidelines for the Certification of Wind Turbines by the Germanischer Lloyd [10] and the IEC WT 01 [11], which will be replaced in the future by the IEC 61400-22 [12]"(Maxion, n.d.). Again, guidelines developed by the GL in a formerly national context diffused over time in their spatiality and are now being applied on an international level.

Looking at the further publications and working groups in the IEC, it becomes apparent that the publication of standards, particularly from 2005 onwards has intensified significantly. (see iec.ch)

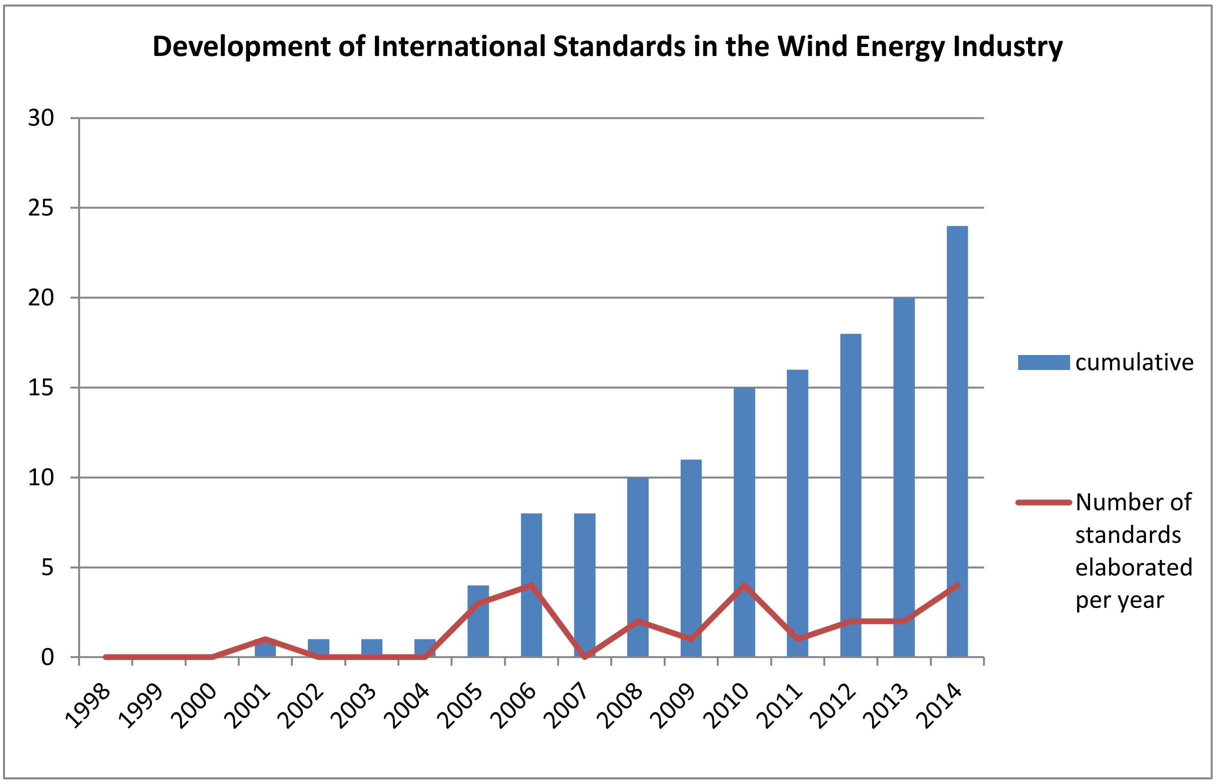


Figure 3: Development of international standards for wind energy in the IEC. Own Figure based on iec.ch (2014)

The IEC standards "have been adopted worldwide by many countries, or used as a basis for the development of national standards." (Hauschild 2006)

Thus, for example, the United States recognized as early as 1988 - thus, even prior to the first international wind standards development in the IEC - the need "to harmonize US-standards to the standards of the International Electrotechnical Commission (IEC), to enable the American wind industry to move into foreign markets without the need to switch their products to new standards"(exportinititative.bmwi.de, 2009).

Nevertheless, there are to this day in some areas, differences in the general energy system between the traditionally strong wind markets in the USA and Europe, which make a common standardization difficult. The U.S. electricity system, for example, is based on 60 hertz, while in Europe 50 hertz are applied. „The main precursor to all these complications between markets today goes back 100-plus years in both regions, and it is tied to a definition of what “low-voltage equipment” should be.” (windenergyupdate.com, 2012)

The EU defines low voltage to minor then 1000 volts, compared to 600 volts in the United States. A wind power plant in Europe with 690 volts is thus well suited for the local conditions. In the United States, anyhow it can cause problems, since operator and a service provider only have access to local components.

Especially the Chinese wind industry could also play important role in facilitating the development of common (global) standards, since it emerged particularly through in-licensing of predominantly European technology, further co-design with European companies as well as the acquisition of European manufacturers.

„Asian countries tend to follow the EU standard for components manufacturing, Erdman [Elektro-Ingenieur bei DNV] said, and install turbines in their own countries under the 1000-volt rule.” (windenergyupdate.com, 2012)

By 2011, 10 standards adapted from IEC ones and one based on AWEA standards made up one quarter of 40 national wind relating standards in China.[6]

Moreover, at the end of 2013 the China Electric Power Research Institute (CEPRI) became a member of the Measuring Network of Wind Energy Institutes (Measnet). Measnet, is a group of “the most experienced wind energy institutes”(measnet.com, 2014). It is working to realize several tasks to support the wind energy industry, as it wants “to ensure high quality measurements, uniform interpretation of standards and recommendations as well as interchangeability of results” (measnet.com, 2014). This membership of the CEPRI helps the Chinese Wind Industry in several ways. First, the domestic manufacturers can now test their equipment in terms of international standards within the own country and thus can lower the test overheads substantially (in the past they had to test their turbines for international markets in foreign testing centers, which took up to

[6] http://www.gwec.net/wp-content/uploads/2012/11/China-Outlook-2012-EN.pdf (24.11.2014)

two years to finish certification). Secondly, the Measnet has a prominent role in the IEC, since the majority of the experts in its wind turbine technical committee come from Measnet-accredited members (e.g. DNV-GL, DEWI, NREL, ECN).

International Standardization – Following Standards Diffusion

As mentioned before, former national standards (e.g. guidelines by GL) diffuse over time to become of international significance. Another example is the "ANSI/AGMA/AWEA[7] 6006-A03 Standard for Design and Specification of Gearboxes for Wind Turbines" (Bradley 2009, 37). The AGMA released its first standard in 1919 and the first quality standard for gears in the 1930s. The standards development peaked in the 60s and 70s "when much of the technical content for today´s gear standards was documented." AGMA was accredited by the ANSI to be the responsible developer for national gear related standards in the 1980s. In 1993 it was furthermore appointed as the secretariat of the TC (Technical Committee) 60 in the ISO (International Standards Organization). The ISO/TC 60 Gears` Scope is the "Standardization in the field of gears, including terminology, nominal dimensions, tolerances, and tools for manufacturing and control." (iso.org 2014) In the same year a committee of the AGMA and AWEA gathered to develop the information sheet AGMA 921-A97 - "Recommended Practices for Design and Specification of Gearboxes for Wind Turbine Generator Systems". The Committee approved the final document on October 25th 1996, followed three days later by the AGMA Technical Division Executive Committee. Since gearbox failures were a considerable problem in the wind turbine industry in the 1990s the need for a compensating standard was evident, especially since the AGMA 921-A97 recommendations had no legal relevance (Grzybowski and Steingröver 2007). The Committee thus started the work for the ANSI/AGMA/AWEA 6006-A03 standard in March 2000. After approval by the AGMA in late 2003 it became a national standard in January 2004. In a way this standard was a quasi international one, since experts[8] from 10 countries

[7] ANSI – American National Standards Institute/ AGMA – American Gear Manufacturers Association/ AWEA – American Wind Energy Association
[8] Among them Gearbox manufacturers, wind turbine manufacturers, bearing manufacturers, lubricant manufacturers, classification societies and experts involved in research and consulting (Grzybowski and Steingröver 2007)

participated in its development (ibid.). Therefore ANSI took the opportunity to introduce it to the ISO as a draft international standard. Already in October of the following year the ANSI/AGMA/AWEA 6006-A03 was adopted in the ISO 81400-4:2005 which today is part of the 61400 Wind Turbine Series of the IEC (IEC 61400-4:2012) and thus made its way on the international level.[9] (Grzybowski and Steingröver 2007; Bradley 2009)

In this case, the time span between the development of a national standard and its approval on an international level was quiet small.

While it was, nonetheless, previously difficult - based on individual economic interests - to develop common (global) standards in international committees, it might become easier in the context of the globalization of the industry. „As component manufacturing companies become more global, consensus agreements on global standards will likely be easier to attain“ (windenergyupdate.com, 2012).

This dynamic can be seen in the diffusion process of another Standard that spread quite rapidly. The Global Wind Organisation's (GWO) Standard for Basic Safety Training (BST) was initiated by the industry rather than national organizations. The GWO was established in Esbjerg (DK) on the 24th of November 2009 during a meeting initiated and hosted by Falck Nutec. Companies involved were Repower (now Senvion), Vestas, Siemens Wind Power and Suzlon.[10] The aim of that meeting was to find an objective organization in which information of the manufacturers could be gathered. While in the beginning Falck Nutec took over the secretary functions, the secretariat since 2014 is hosted by the Danish Wind Industry Association. “The aim of GWO is to strive for an injury free work environment in the wind turbine industry, through cooperation among the members, in setting common standards safety training and emergency procedures.” (gwo-safety.org, 2014)

[9] Due to some controversy about the responsibility for the development of gear related standards, the ISO/TC 60 and the IEC/TC 88 formed a Joint Working Group in May 2004.

[10] Today 13 companies take part in the GWO (AES, Acciona Energy, Dong Energy, eon Climate and Renewables, Gamesa, GE Energy, Senvion, Siemens Wind Power, Suzlon, Statoil, MHI Vestas Offshore Wind, Vestas, Vattenfall)

The BST Standard was first published in 2012[11] and is today already available in its sixth revision. Training centers can be found in seventeen countries around the globe. Although most of them can be found in Europe (especially in the UK, Denmark and Germany) centers can also be found in Korea, the USA, New Zealand and Australia. The velocity of the diffusion of the BST Standard can be explained through the market power of the corporate members of the GWO. The training facilities of Siemens in Denmark, Germany, the UK, and the US, for example, are certified by the GWO, to offer in-house training as well as training to third parties.[12] Also, employees of firms willing to work for companies as Siemens or Dong Energy generally have to be trained according to the GWO guidelines. (sunwindenergy.com, 2014)

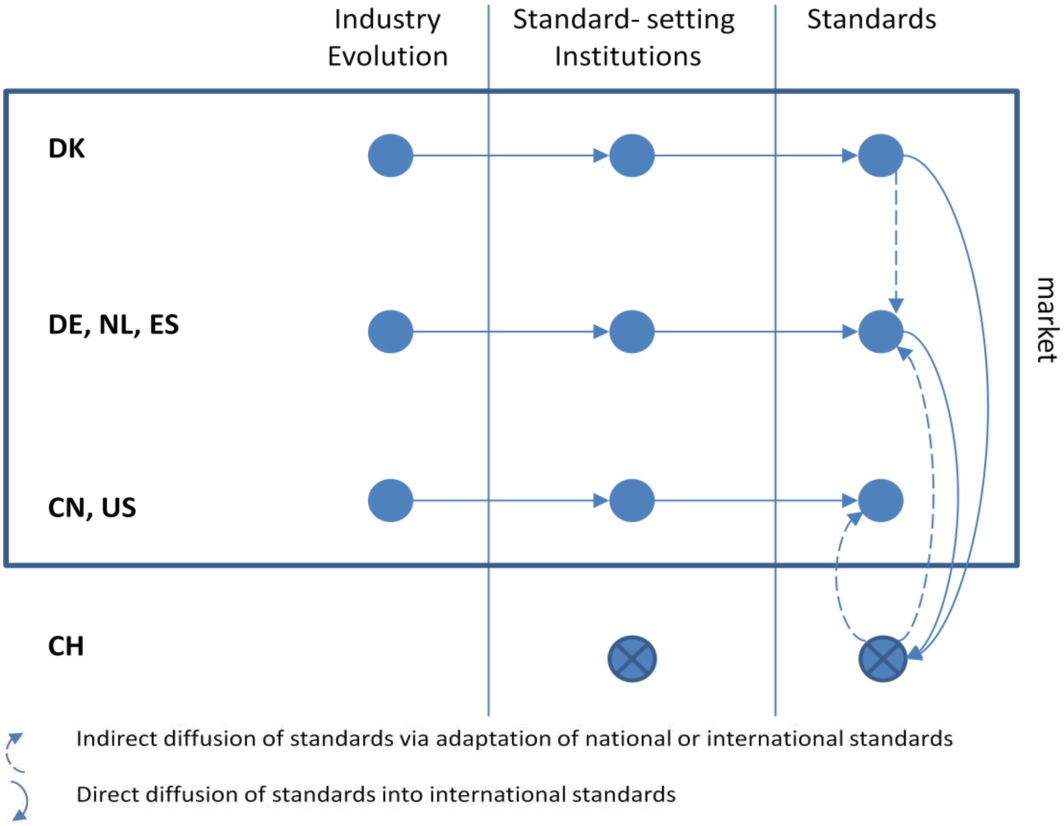
Conclusion

The paper first shortly described standards and the processes of standardization. Following this it was shown, that standards and industry evolution are interrelated to each other and they both exhibit certain spatiality. Since the spatiality of these interrelations is underrepresented in literature, the case of the wind industry was used to show that standards evolution has a distinct spatiality correlating with the evolution of the industry.

Standard development started in countries with a strong industry, especially in Denmark, whose manufacturers dominated the early market. Due to joint efforts of public and industrial actors, standardization often was spatially connected to the wind industry. Standardization in further European markets resulted in the coexistence of various national standards, which often formed the basis for international ones as these again party resulted from a re-combination of such national standards. International standardization today especially occurs in the International Electrotechnical Commission (IEC), located in Switzerland. Thus, the definition of these standards is spatially no longer connected as closely with a strong market as in the early phase of standards evolution. In recent years new actors as, for examples, from China are becoming more involved in the international

[11] http://www.windpower.org/download/2289/GWO_BST_Introduction.pdf (05.11.2014)
[12] http://www.siemens.com/press/en/pressrelease/?press=/en/pressrelease/2013/energy/energy-service/ese201303024.htm&content[]=ES&content[]=PS (18.11.2014)

standardization on the one hand, while they intensify the adoption of international standards on the other.



Although not part of the paper, the impacts of standards in the wind industry can be seen in the form of direct or indirect ones. Direct impacts occur as companies have to adopt committee-based (e.g. IEC 61400-4:2012) but also market-based standards (as the BST-Standard). By changing the market environment and the relations in the industries (e.g. modularization of the value chains) on the other hand, standards have an indirect effect, as new forms of tasks become more important for companies. How standards change the rational of the industry, affects actors and impact the industry structure would be worth to be investigated in more detail. This becomes obvious, as standards today influence the globalization of the industry. The harmonization of standards due to the implementation of international ones which again form the basis for new national standards as well as the increased application of standards – such as the IEC wind Series – in emerging markets and by new actors (e.g. Chinese manufacturers to enter international markets) facilitates the globalization of the industry.

Clusters, connecting industrial with local dynamics, are highly affected by changes in the institutional and economic environment of the industry. Alterations in the rational under which firms and the industry evolve, resulting from the implementation of a variety of de jure, de facto and meta-standards have to have a spatial and organizational consequence within clusters. As, for example, the modularization of value chains leads to increased coordination tasks within the supply chain, this tasks by changing the firms themselves result in organizational shifts within clusters or might even form new ones. Thus further work should look into clusters and standards in more detail.

As indicated during the paper, participation in standardization in some cases seems to be the result of strategic decisions of companies and private or public organizations. To introduce and diffuse standards can thus be seen as a game of power and politics (see e.g. Metcalfe und Miles 1994 on a set of Open Systems interconnection). Yet, how strongly the standards evolution in the wind industry and thus the interrelated industry evolution are affected by such strategic decisions and therefore results of political and power relations was not the purpose of this paper. Further questions arise from the spatial view on standards and industry evolution, which also would be worth to investigate. Which role do standards play as barriers of innovation? Do new players in the industry change the current standards and standardization processes? And how does the spatiality of standards and industry evolution would be affected?

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